UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

TECHNOLOGY LICENSING CORPORATION, Plaintiff, v. WESTINGHOUSE DIGITAL, LLC; ASUS COMPUTER INTERNATIONAL; and ASUSTEK COMPUTER, INC., Defendants.	CIVIL ACTION NO. 11cv5920 **JURY TRIAL DEMANDED**

FILED
3/21/2012
THOMAS G. BRUTON
CLERK, U.S. DISTRICT COURT

AMENDED COMPLAINT FOR PATENT INFRINGEMENT

In this action for patent infringement, Plaintiff Technology Licensing Corporation ("TLC") hereby amends its Complaint against Defendant Westinghouse Digital, LLC. ("Westinghouse"); TLC's allegations of infringement against Defendants Asus Computer International ("Asus Int'l"), and ASUSTeK Computer, Inc. ("ASUSTeK") remain unchanged, (collectively, "Defendants") as follows:

JURISDICTION AND VENUE

1. This is a claim for patent infringement arising under the patent laws of the United States, Title 35 of the United States Code § 1 *et seq*. This Court has exclusive original jurisdiction over the subject matter of this Complaint under 28 U.S.C. §§ 1331 and 1338(a).

2. Venue is proper under 28 U.S.C. §§ 1391 and 1400(b) because Defendants are subject to personal jurisdiction, do business in this judicial district, and have committed acts of infringement in this judicial district.

PARTIES

3. TLC is a Nevada corporation and has its principal place of business at 711 South Carson Street, Suite 6, Carson City, NV 89701. TLC owns the full and exclusive right, title and interest in and has standing to sue for infringement of United States Patent Nos. 6,870,964 ("the '964 Patent"), 7,382,929 ("the '929 Patent"), and 7,986,851 ("the '851 Patent").

4. Westinghouse is a Delaware Corporation having a principal place of business at 500 N. State College Blvd., Suite 1300, Orange, CA 92868. Westinghouse designs, develops, offers for sale, and sells nationwide, including substantial business in this judicial district, products that are covered by at least claim 1 of the '964 Patent claims 1, 16, 32 and 48 of the '929 Patent and claims 1, 13 and 23 of the '851 Patent, including video display monitors such as television model nos. LVM-37w3, LVM-37wl, LVM-42w2, LD-4258 and monitors incorporating Faroudja DCDi or Broadcom Xilleon Technology.

5. Asus Int'l is a California Corporation having a principal place of business at 800 Corporate Way, Fremont, CA 94539. Asus designs, develops, offers for sale, and sells nationwide, including substantial business in this judicial district, products that are covered by at least claim 1 of the '964 Patent, claim 1 of the '929 Patent and claim 1 of the '851 Patent, including video display monitors such as Asus VK 266H and VW266HMonitors incorporating Faroudja DCDi.

6. ASUSTeK is an alien corporation organized and existing under the laws of Taiwan, and having its primary place of business at Nr. 15 Li-Te Rd., Peitou, Taipei 112, Taiwan. ASUSTeK designs, develops, offers for sale, and sells nationwide, including substantial business in this judicial district, products that are covered by at least claim 1 of the '964 Patent,

claim 1 of the '929 Patent and claim 1 of the '851 Patent, including video display monitors such as Asus VK 266H and VW266HMonitors incorporating Faroudja DCDi.

PATENT INFRINGEMENT

7. TLC owns all right, title, and interest in and has standing to sue for damages for any past, present and future infringement of the '964 Patent entitled "Spatial Scan Replication Circuit." The '964 Patent issued on March 22, 2005. Further, the '964 Patent was reexamined and reissued on August 4, 2009. A true and correct copy of the '964 Patent and reexamination certificate is attached as Exhibit A.

8. TLC owns all right, title and interest in and has standing to sue for damages for any past, present, and future infringement of the '929 Patent entitled "Spatial Scan Replication Circuit." The '929 Patent was issued on June 3, 2008. A true and correct copy of the '929 Patent is attached as Exhibit B.

9. TLC owns all right, title and interest in and has standing to sue for damages for any past, present, and future infringement of the '851 Patent entitled "Spatial Scan Replication Circuit." The '851 Patent was issued on July 26, 2011. A true and correct copy of the '851 Patent is attached as Exhibit C.

10. Upon information and belief, Westinghouse has made, used, offered for sale, sold, and/or imported products which possess video processing technology and methods, including but not limited to Directional Correctional Interlacing ("DCDi") and Broadcom Xilleon Technology on models including, but not limited to its LVM-37w1, LVM-37w3, LVM-42w2, and LD-4258 products ("Westinghouse Devices"). These acts by Westinghouse have directly infringed at least independent method claim 1 of the '964 Patent and claims 1, 16, 32 and 48 of the '929 Patent, and claims 1, 13 and 23 of the '851 Patent within the meaning of 35 U.S.C. §271(a).

11. Upon information and belief, Westinghouse has also committed, and unless ceased upon filing of this Amended Complaint, will continue to commit acts that constitute, with its knowledge of the '964, '929 and '851 Patents, knowing and intentional inducement of infringement of at least independent method claim 1 of the '964 Patent and claims 1, 16, 32 and 48 of the '929 Patent, and claims 1, 13 and 23 of the '851 Patent by others within the meaning of 35 U.S.C. §271(b) through, among other things, its acts of providing technologies and methods in accordance with the inventive aspects of the '964, '929 and '851 Patents through at least the Westinghouse Devices. Exemplary claim charts demonstrating Westinghouse's infringement are attached as Exhibit D. Westinghouse has had this knowledge of the '964 Patent, and of the related Patent Family in general, since January 25, 2007. Specifically, Mr. Richard Houng, Westinghouse's Chief Executive Officer was sent a letter explaining Westinghouse's potential infringement. Users of the Westinghouse Devices, in turn, who have used such products directly infringe at least independent method claim 1 of the '964 Patent and claims 1, 16, 32, and 48 of the '929 Patent, and claims 1, 13 and 23 of the '851 Patent within the meaning of 35 U.S.C. §271(a) through the use and operation of the Westinghouse Devices.

12. Westinghouse's direct infringement of and/or inducement to infringe the '964, '929 and '851 Patents has injured TLC, and TLC is entitled to recover damages adequate to compensate it for such infringement, but in no event less than a reasonable royalty.

13. Upon information and belief, Asus Int'l has made, used, offered for sale, sold, and/or imported products which possess video processing technology and methods in accordance with the inventive aspects of the '964, '929, and '851 Patents, including, including video display monitors such as Asus VK 266H and VW266HMonitors incorporating Faroudja DCDi ("Asus

Devices"). These acts by Asus Int'l have directly infringed at least independent method claim 1 of the '964, '929, and '851 Patents within the meaning of 35 U.S.C. §271(a).

14. Asus Int'l's direct infringement of the '964, '929, and '851 Patents has injured TLC, and TLC is entitled to recover damages adequate to compensate it for such infringement, but in no event less than a reasonable royalty.

15. Upon information and belief, ASUSTeK has made, used, offered for sale, sold, and/or imported products which possess video processing technology and methods in accordance with the inventive aspects of the '964, '929, and '851 Patents, including, including video display monitors such as Asus VK 266H and VW266HMonitors incorporating Faroudja DCDi ("ASUSTeK Devices"). These acts by Asus have directly infringed at least independent method claim 1 of the '964, '929, and '851 Patents within the meaning of 35 U.S.C. §271(a).

16. ASUSTeK's direct infringement of the '964, '929, and '851 Patents has injured TLC, and TLC is entitled to recover damages adequate to compensate it for such infringement, but in no event less than a reasonable royalty.

RELIEF SOUGHT

WHEREFORE, TLC respectfully requests this Court enter judgment against each Defendant, and against their subsidiaries, successors, parents, affiliates, officers, directors, agents, servants, employees, and all persons in active concert or participation with them, as follows:

A. The entry of final judgment in favor of TLC.

B. An award to TLC of such damages as it shall prove at trial against Defendants Westinghouse, Asus International, and ASUSTeK that is adequate to compensate for their infringement of the '964, '929, and '851 Patents, said damages to be no less than a reasonable

royalty, together with prejudgment interest from the date infringement of the '964, '929, and '851 Patents began;

C. A determination that this case is exceptional pursuant to 35 U.S.C. § 285 and an award to TLC of the costs of this action and its reasonable attorneys' fees; and

D. Such other relief as TLC is entitled to recover under any applicable law and as this Court and/or a jury may determine to be proper and just.

JURY DEMAND

TLC hereby demands a trial by jury on all issues triable to a jury in this case.

Dated

Respectfully submitted,

/s/

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Paul C. Gibbons
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Technology Licensing Corp.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that on _____ the foregoing **AMENDED COMPLAINT FOR PATENT INFRINGEMENT** was filed with the Clerk of Court pursuant the Court's CM/ECF procedures.

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I certify that all parties in this case are represented by counsel who are CM/ECF participants.

/s/_____
Attorneys for Technology Licensing Corporation

EXHIBIT A

US006870964B1

(12) **United States Patent**
Cooper

(10) **Patent No.: US 6,870,964 B1**
(45) **Date of Patent: Mar. 22, 2005**

(54) **SPATIAL SCAN REPLICATION CIRCUIT**

(75) Inventor: **Carl Cooper**, Monte Sereno, CA (US)

(73) Assignees: **Pixel Instruments Corporation**, Los Gatos, CA (US); **IP Innovation LLC**, Northbrook, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/573,284**

(22) Filed: **May 18, 2000**

Related U.S. Application Data

(62) Division of application No. 08/398,383, filed on Mar. 3, 1995, now Pat. No. 6,529,637, which is a continuation-in-part of application No. 08/119,610, filed on Sep. 13, 1993, now Pat. No. 5,424,780, which is a continuation of application No. 07/355,461, filed on May 22, 1989, now abandoned.

(51) **Int. Cl.**[7] **G06K 9/40**

(52) **U.S. Cl.** **382/254**; 382/267; 348/607; 358/1.2

(58) **Field of Search** 382/205, 254, 382/258, 260, 299, 300, 267, 266, 307; 348/607, 616, 625, 245, 246, 267, 269; 358/426.1, 1.2, 3.07, 3.27

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,573,070	A *	2/1986	Cooper	358/36
4,684,985	A *	8/1987	Nakagaki et al.	358/140
4,989,090	A *	1/1991	Campbell et al.	358/140
5,146,333	A *	9/1992	Chaplin	358/182
5,182,633	A *	1/1993	Antonio et al.	358/11
5,504,815	A *	4/1996	Ryan et al.	348/663

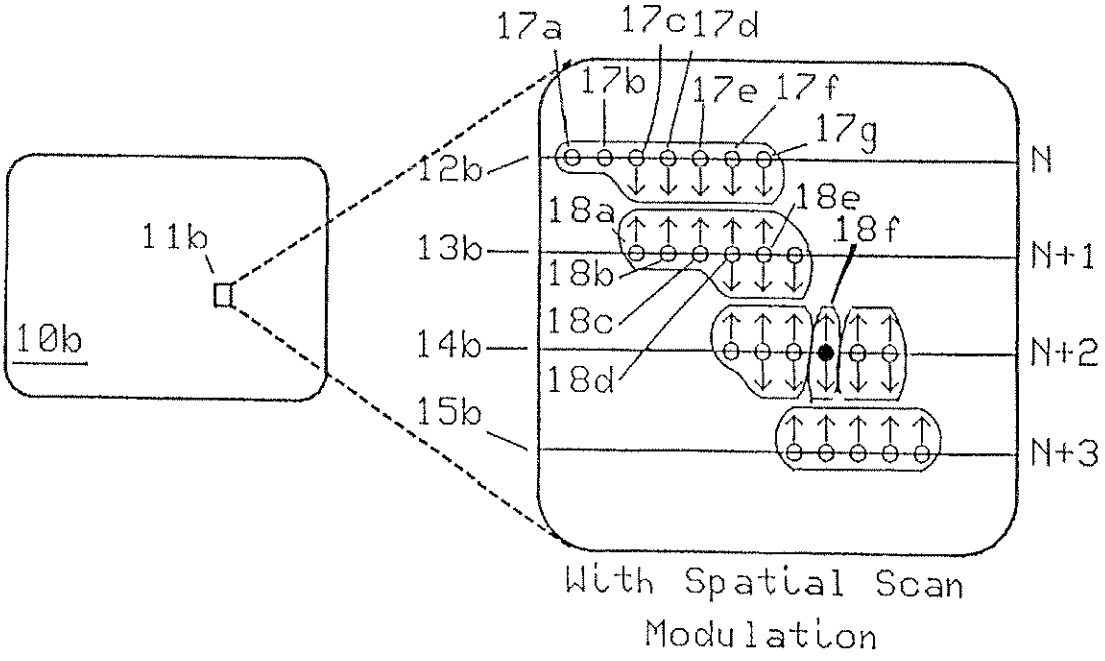
* cited by examiner

Primary Examiner—Yon J. Couso

(57) **ABSTRACT**

In an image replication circuit, the improvement of replicating a given element at a certain location with the most similar of surrounding sets of image elements.

38 Claims, 5 Drawing Sheets



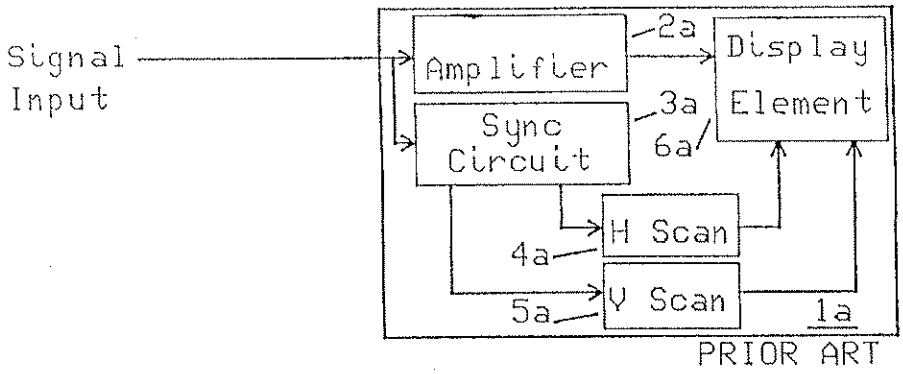


FIGURE 1

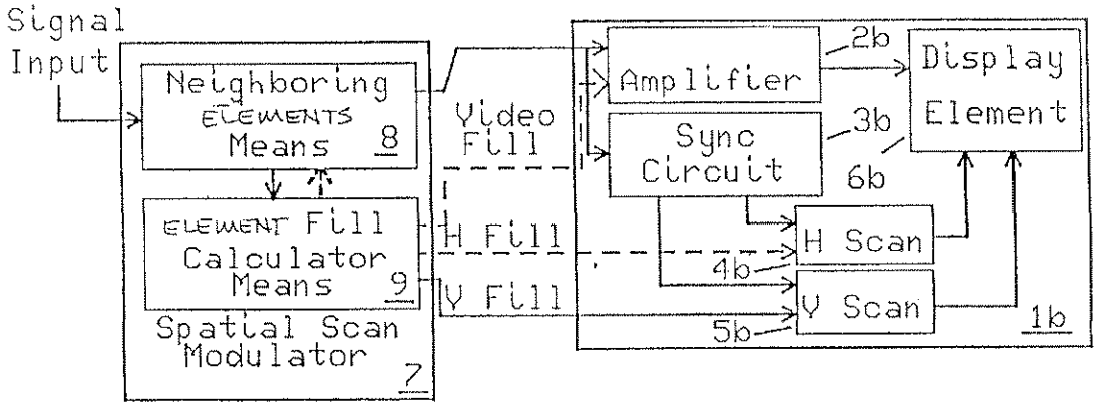


FIGURE 2

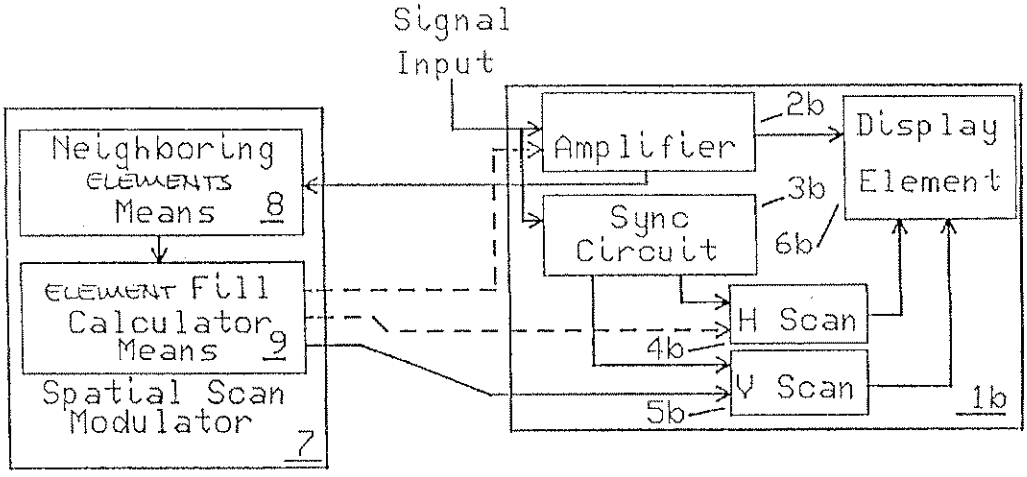
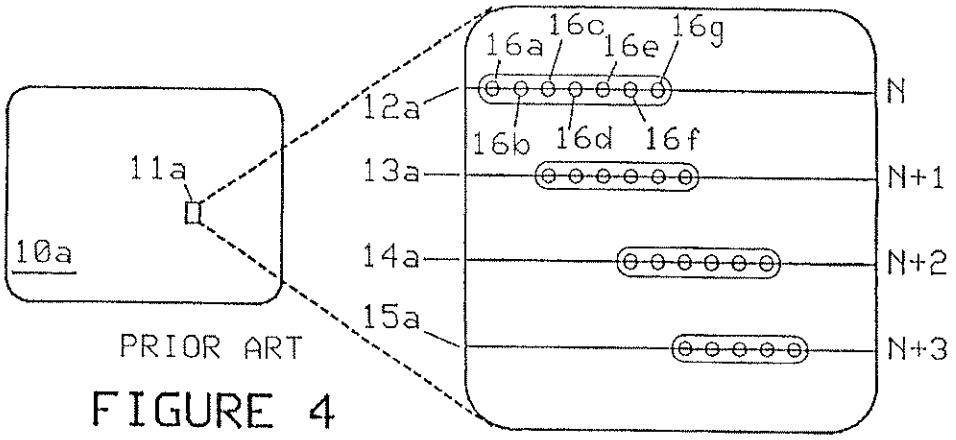


FIGURE 3



PRIOR ART

FIGURE 4

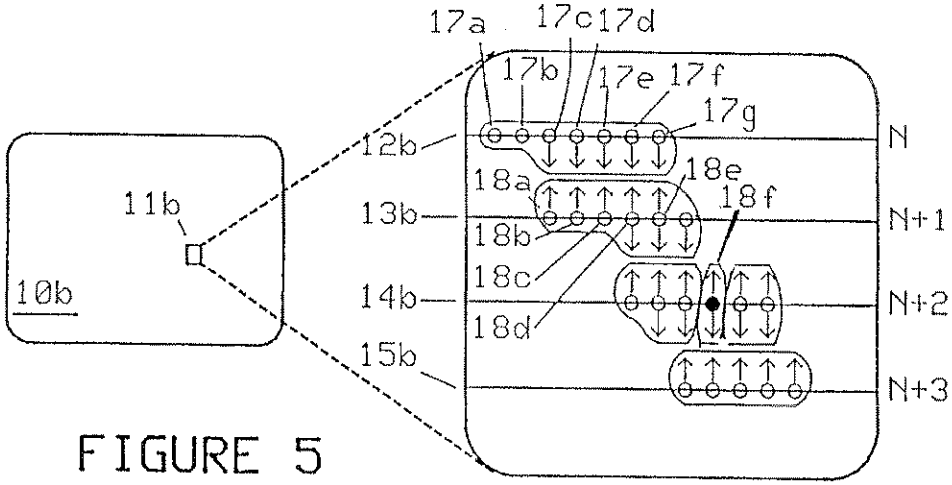


FIGURE 5

With Spatial Scan Modulation

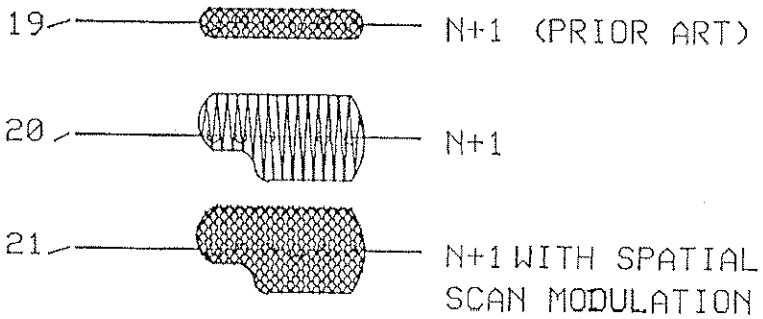
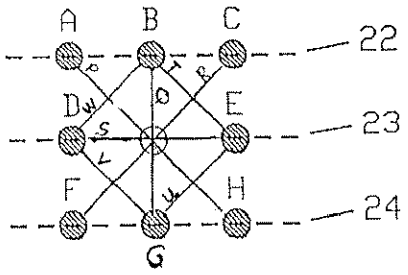


FIGURE 6



X FILL DIRECTION(S):

VERT.	IF	|B-G| < |A-H| or |C-F| or |D-E| or |B-E| or |E-G| or |G-D| or |D-B|
HORIZ.	IF	|D-E| < |B-G| or |A-H| or |C-F| or |B-E| or |E-G| or |G-D| or |D-B|
R. DIAG.	IF	|C-F| < |B-G| or |A-H| or |D-E| or |B-E| or |E-G| or |G-D| or |D-B|
L. DIAG.	IF	|A-H| < |B-G| or |C-F| or |D-E| or |B-E| or |E-G| or |G-D| or |D-B|
U. LEFT	IF	|D-B| < |B-E| or |E-G| or |G-D| or |B-G| or |A-H| or |C-F| or |D-E|
U. RIGHT	IF	|B-E| < |E-G| or |G-D| or |D-B| or |B-G| or |A-H| or |C-F| or |D-E|
L. LEFT	IF	|E-G| < |G-D| or |D-B| or |B-E| or |B-G| or |A-H| or |C-F| or |D-E|
L. RIGHT	IF	|G-D| < |D-B| or |B-E| or |E-G| or |B-G| or |A-H| or |C-F| or |D-E|

FIGURE 7

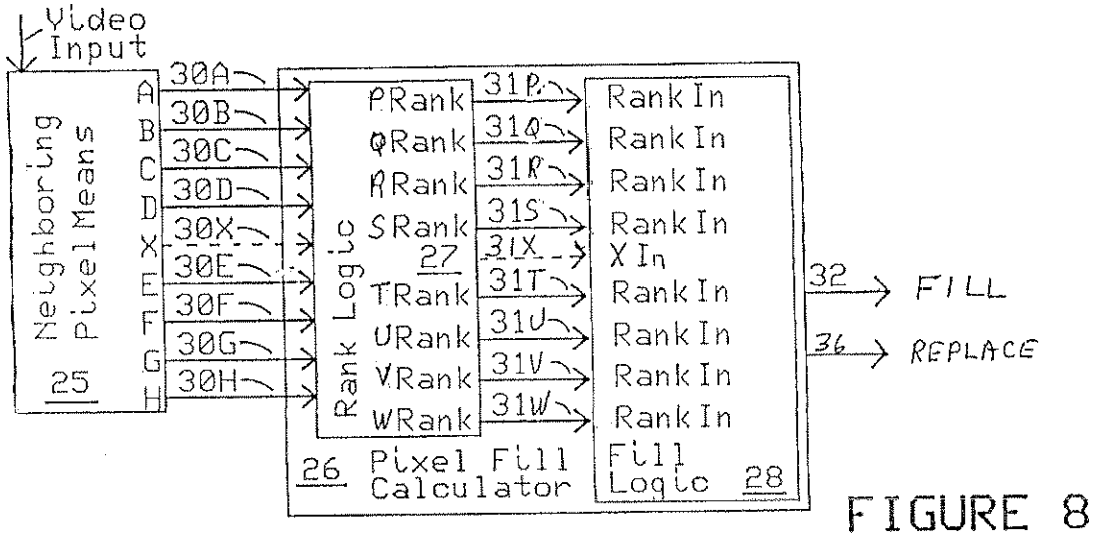


FIGURE 8

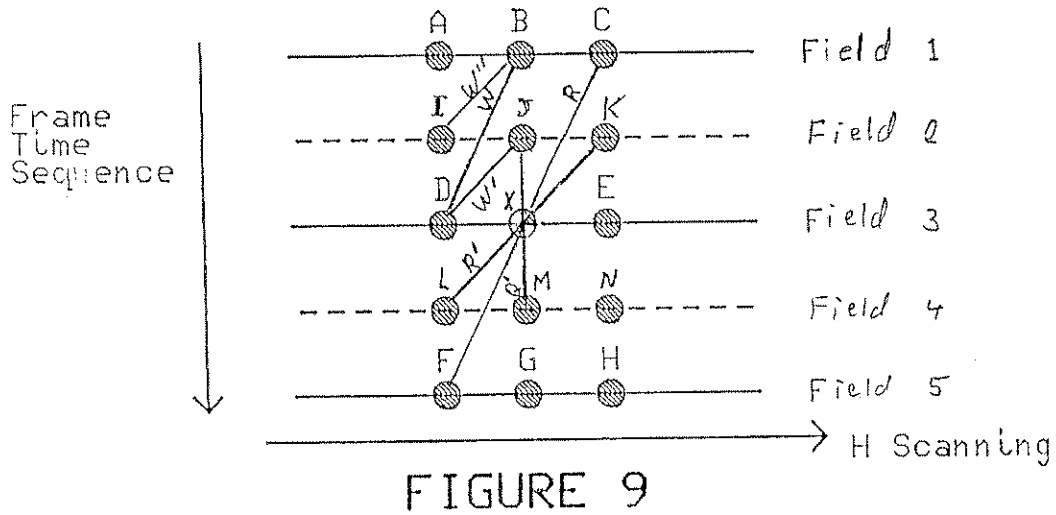


FIGURE 9

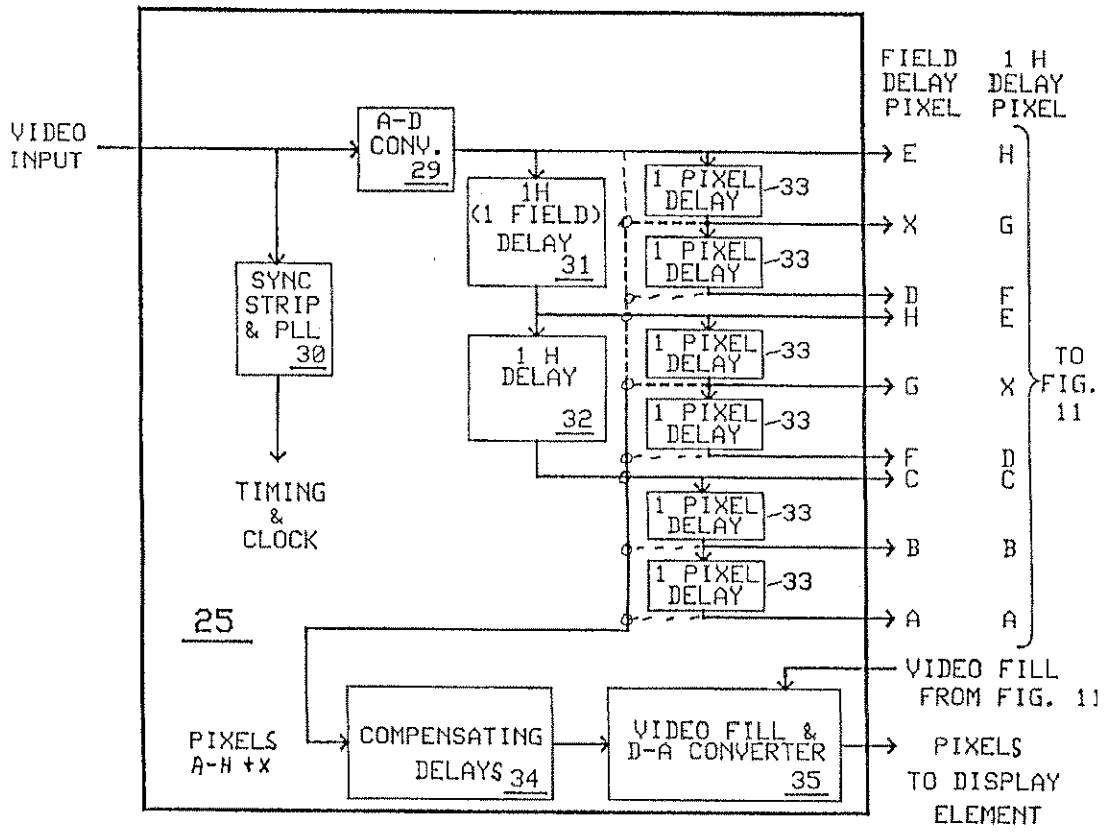


FIGURE 10

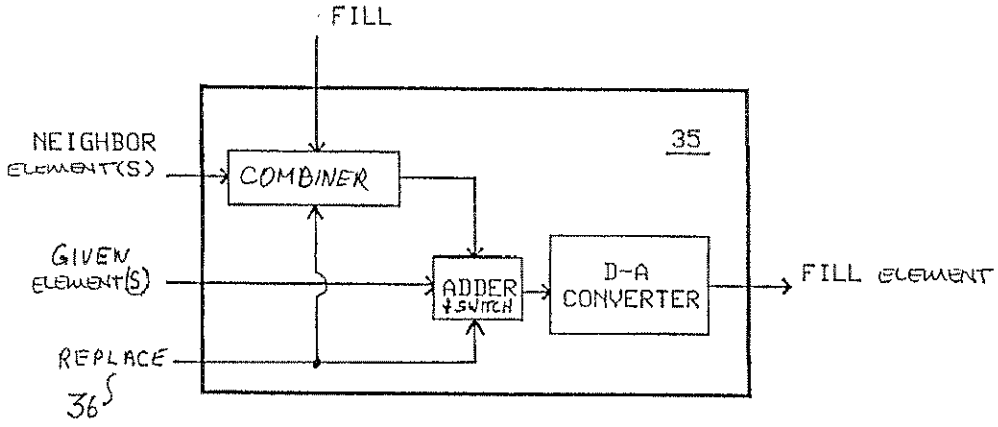
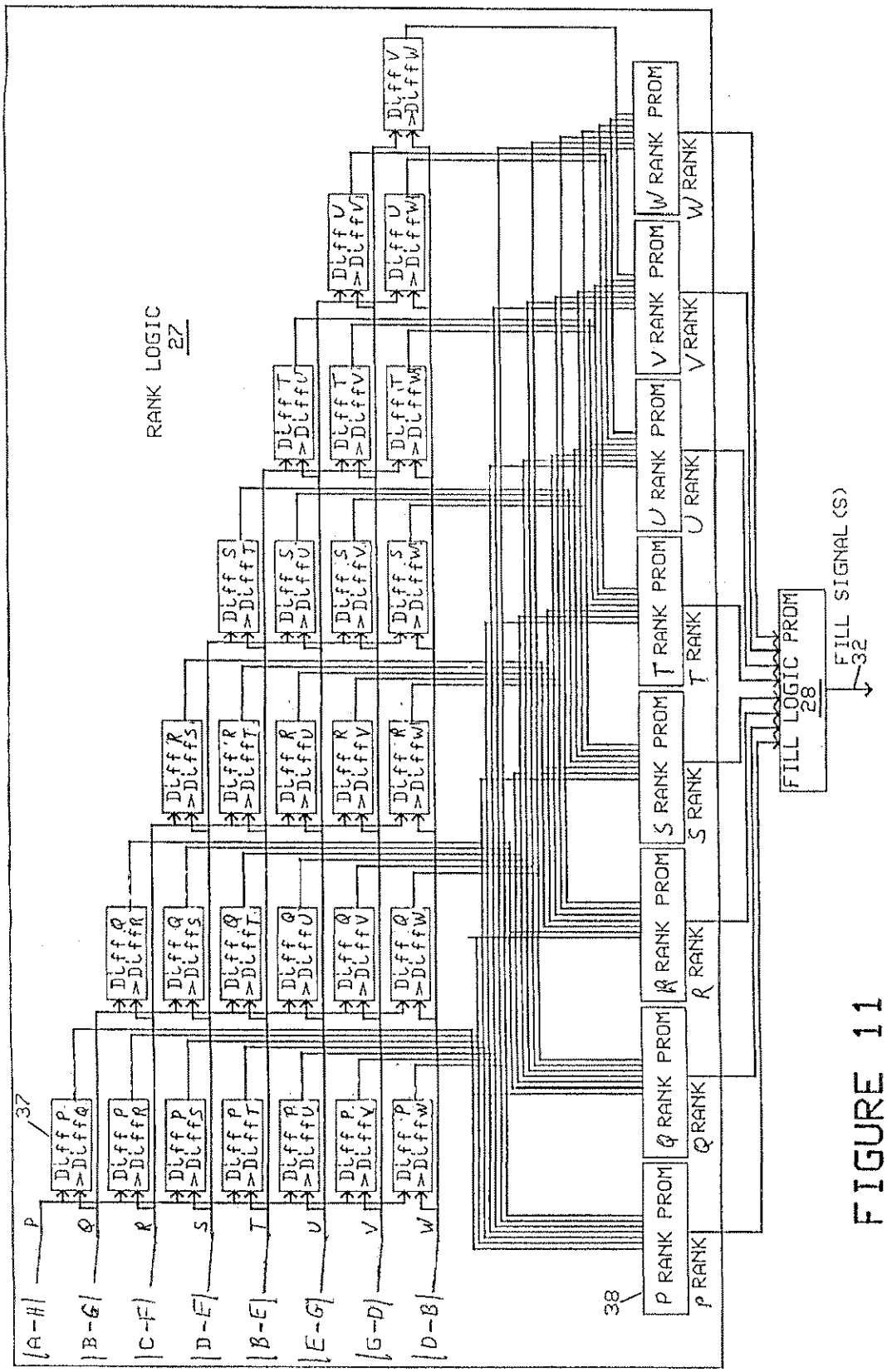


FIGURE 12


RANK LOGIC
27
37
38
FILL LOGIC PROM
28
FILL SIGNAL (S)
32
P RANK PROM
Q RANK PROM
R RANK PROM
S RANK PROM
T RANK PROM
U RANK PROM
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G-D
D-B

FIGURE 11

SPATIAL SCAN REPLICATION CIRCUIT

The present application is a division of U.S. Ser. No. 08/398,383 filed Mar. 3, 1995 (now U.S. Pat. No. 6,529,637 issued Mar. 4, 2003) which claims the benefit of and is a continuation-in-part of application U.S. Ser. No. 08/119,610 filed Sep. 13, 1993 (now U.S. Pat. No. 5,424,780 issued Jun. 13, 1995) which claims the benefit of and is continuation of application Ser. No. 07/355,461 filed May 22, 1989 (now abandoned) priority of these applications is herein claimed.

FIELD OF THE INVENTION

An apparatus and method is shown for modifying the creation and/or presentation of image information displayed, printed or created on a raster or matrix image or graphic display or printer, thereby increasing the apparent image quality. Means for deriving a plurality of neighboring image elements or elements of the video signal which neighbor in time or space to a common location, and means for determining the image elements replication at such location in response thereto, are also shown. Particular embodiments relation to increasing the apparent temporal and spatial resolution of raster scanned television computer and permanent copy devices are shown.

BACKGROUND OF THE INVENTION

This invention relates to increasing the apparent temporal or spatial resolution of a created and/or displayed image which is typically produced by ordered groups of elements such as by a raster or matrix element or device, without a required increase in the number of image elements of the image. The application is a continuation-in part- of the copending U.S. application Ser. No. 08/119,610 filed Sep. 13, 1993 for Apparatus and Method for Spatial Scan Modulation of a Video Display which U.S. Pat. No. 119,610 application is a continuation of U.S. Pat. No. 355,461 filed May 22, 1989—now abandoned. The Notice of Allowance for the U.S. Pat. No. 119,610 application was mailed to the applicant on Dec. 22, 1994 and the issue fee has been paid. The content of this U.S. Pat. No. 119,610 application is incorporated by reference.

DESCRIPTION OF THE PRIOR ART

As television, computer, graphics, printers, fax machines and related image technology develops, there is increasing emphasis on improving the quality of created, displayed, or stored images in order that they appear more real and pleasing to the human observer. Two of the parameters which affect image quality, and therefore are subject to improvement, are spatial and temporal resolution. Spatial resolution, simply put, is the number of image elements which are used to make up an image, normally static, and correspondingly, temporal resolution is the number of elements per unit time which make up an image, normally moving. Desirable qualities of an image system, such as television camera, scanner, broadcast television, computer display printer, permanent copy device, etc. will ideally include having as many elements per image or frame and, in the case of moving images, as many elements or frames per unit time as is economically feasible. Unfortunately, increasing the number of image elements per frame or the number of frames per second is a costly improvement. Therefore many schemes have been developed to improve the resolution of the image, while reducing the number of elements used.

Other improvement systems, such as various Scanner Interpolation Techniques, improved Definition Television Systems (IDTV), Advanced Television Systems (ATV), and High Definition Television Systems (HDTV), Hewlett Packard's Laser Printer Resolution Enhancement System, and other Image Enhancers typically operate to increase the resolution and other quality related aspects of image systems. Many of these systems resort to various techniques for such quality improvements, some of which generate unwanted artifacts.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide an apparatus and method for improving the apparent quality of a created and/or displayed image by altering the size, shape or position of the elements of the image.

It is an object of this invention to allow usage of a low resolution camera and/or recorder in a high resolution video distribution and/or display system.

It is another object of this invention to provide an apparatus and method to alter the size, shape or position of the elements of a scanned or presented image in response to the relationship between a plurality of elements of the image.

It is a yet further object of this invention to provide a means and method for inspecting a plurality of elements of an image to determine the presence of a need for filling of areas between the elements.

It is yet another object of this invention to provide a means and method for simultaneously providing a plurality of elements of said image for inspection and comparison means to determine proper altering of areas between the elements or voids created by defective or unneeded elements.

It is an additional object of this invention to provide a means and method for inspecting a certain element or location with respect to one or more surrounding or neighboring elements of an image to determine the desirability for changing the shape, position or size of other elements to improve the spatial and/or temporal resolution relationship between the elements, which may neighbor in time or space.

It is an additional object of this invention to provide a means and method for inspecting neighboring elements with respect to one or more other elements of an image to determine a need for changing the shape, position or size of elements to improve the spatial or temporal resolution relationship with the other elements, especially when one other element is defective.

It is yet still another object of this invention to provide a means and method to improve the quality of an image by inspecting a plurality of neighboring elements to generate replication elements in response thereto.

It is a further object of this invention to provide a means for replicating non-defective image elements while producing no ascertainable artifacts.

It is still yet another object of the invention to apply the above objects to any physical phenomena or signal which can be represented as a matrix of discrete elements.

It is still another object of this invention to provide an image creation device utilizing the above objects.

According to an aspect of this invention, the inventive concepts disclosed herein show an apparatus and method for modifying the creation storage and/or production of an image by device in response to the image content thereof as carried by an image bearing signal, in order to create an image having apparently higher quality than normal.

The preferred embodiment of the present invention describes a neighboring element means for providing a

plurality of neighboring elements, and an element replication means responsive to said plurality of neighboring elements to selectively fill a location, which may be a void, or artifacts, between elements, or to replace elements in the spatial or time dimensions or both. The inventive concepts disclosed herein may be utilized to improve the apparent resolution of the created and/or displayed image spatially, temporally, or both, or to conceal, by replication including modification, and/or creation of otherwise non-existent, defective or unneeded image elements or artifacts. The invention will find considerable use in the reduction of spatial or temporal (motion) artifacts of improved television systems like HDTV.

It will be understood that the term image as used herein is meant to apply to the creation and/or presentation of any phenomena by a raster or matrix of discrete or adjoining elements, and that the raster or matrix may be either a single one, or a given one of a plurality or sequence of rasters or matrices, for example as used in temporal portraits of such physical phenomena. The image can be visible on a display (such as a computer monitor or regular television set), viewable after creation (such as a laser printer or fax machine) or otherwise exist (such as in memory for subsequent use or on a recorder tape). The term image is applicable to the creation of an image (for example at a low resolution to camera); on recording (for example on a VHS machine for HDTV transmission), on receipt (for example NTSC reception on an HDTV monitor) or otherwise.

It will be further understood that invention has application to a group, or series of such elements, whether transmitted or stored, in time sequential or parallel arrangement or in any other form. The more important aspect of the invention is the operations on the elements which have some spatial or temporal coherence or probability of similarity. It is of lesser importance what the elements represent or how the elements are conveyed, or of the particular nature or make up of the form of the elements.

It will be also understood that although the word void is used in this specification, the invention is directed towards replicating new image information utilizing neighboring image elements, which new image information is utilized at a certain location(s). These locations might or might not have previously had image information available therefor. The void may exist at the point of image creation, before/after storage and/or at the point of presentation. Examples of voids would include such things as defects, unwanted elements, improper elements, corrupted elements, valid but replaceable elements, locations with no image information, and/or other locations or elements which may be in question or need for improvement. The term void is used to cover all these and similar situations for uniformity.

It will also be understood that although the word combination "filling in" is used in the specification and claims, the invention is directed towards replicating an image element at a particular location—again, an image element which might or might not have previously had information available therefor. This replication includes creating, modifying, replacing, substituting, adding to, providing and/or filling in for the element at this location. This term filling in is used to cover all these and similar situations for uniformity.

It will also be understood that although the word "similarity" is used in the specification, the invention is directed towards the use of any of the various element characteristics to determine similarity, which characteristics can be used alone or in combination thereof. For example, the elements both may be of the same color, but of different brightness; they both may be of same brightness, but of different hue; they both may be of the same luminescence but of different color saturation; they both may be of same saturation and luminescence; they both may be the same size; they both may have the same relationship to their surroundings; or otherwise be similar in some one or combination of characteristics. Characteristics by which similarity can be determined include color, hue, color saturation, luminescence (brightness), size, detail, pattern, spacial frequency component in horizontal or vertical or diagonal or time or other dimensions, temporal frequency, content, relationship of neighboring elements, noise, and/or other external measures such can be derived from a detection circuit which would provide a flag or measure and/or other indication that an element or group of elements are suitable for processing. The element or location which is being processed may or may not be a valid or erroneous element: It might even have had no image information or not previously existed.

It will also be understood that although the word "replication" is used in the specification, the invention is directed towards modifying, correcting, improving, substituting for, adding to, replacing or otherwise processing the image so as to provide for an overall, more pleasing or apparently higher quality image. As previously set forth the word "fill in" is used in this specification for similar attributes as replication.

It should be understood that the word "surrounding" is used in this specification to describe elements which have some relationship to other image elements, be the relationship spacial or temporal. The word surrounding could include elements which are neighboring on one side thereof, neighboring on all sides, adjacent thereto, spaced from diagonally with intervening elements between (such as in a interlaced field scan device wherein alternating fields are paired), immediately adjacent or spaced elements which have a statistical ability of being similar, or merely elements that have a greater than minimal statistical probability of being similar. However, in respect to this latter it is preferred that the percentage of similarity, is over 50%.

It should be understood that the invention has application during the creation of an image (for example at a video camera), at the storage of an image (for example before or after a video tape or disk) and/or in the production of an image (for example a video monitor).

The objects and features of the invention will be apparent to one skilled in the art from a consideration of the following description and claims, when read in conjunction with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

The structure, operation, and advantages of the presently disclosed preferred embodiment of the invention will become apparent when consideration of the following description taken in conjunction with the accompanying drawings wherein:

FIG. **1** is a block diagram of a typical prior art image generating device.

FIG. **2** is a block diagram of the device of FIG. **1** including the present invention.

FIG. **3** shows a modification of the drawings of FIG. **2** wherein the spatial scan modulator is FIG. **4** shows a typical prior art scanned image display with a portion expanded for clarity.

FIG. **5** shows a typical scanned image display as would occur with the use of the present invention, with a portion expanded for clarity.

FIG. **6** shows a detailed diagram of a given scan line of an image in prior art form and in improved form resulting from the present invention.

FIG. **7** shows a group of nine neighboring image elements which may be operated on by the present invention.

FIG. **8** shows a diagram of the present invention including the use of a ranking means.

FIG. **9** shows a diagram of 15 elements taken from scan line of 5 successive image fields.

FIG. **10** shows a detailed diagram of an embodiment of a neighboring means for a image display.

FIG. **11** shows a detailed diagram of an embodiment of a element calculator means.

FIG. **12** shows an alternate embodiment of a fill and D-A converter.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is a block diagram of a prior art image display device la which may be improved by the addition of the present invention. The invention is set forth in its preferred embodiment in primary reference to a image display, in this specification a video display. However, this device may be any of those which are well known in the art which create, store and/or convey physical phenomena by use of ordered groups of elements, such as various matrix and raster type displays or hard copy generating display devices such as various cameras, scanners, televisions, laser printers, fax machines and the like. For the purpose of the present description and explanation it will be primarily presented with the device la that is a raster scanned display such as an electron beam scanned CRT or a laser scanned photo sensitive surface operating in a progressive (non-interlaced) mode. This device may also operate in interlaced fashion as will be apparent from the present disclosure and in other creation, recording and presentation forms. However for the purpose of the present explanation of the invention, by way of example, it will be assumed that it is a video display operating in a progressive mode.

This display device normally contains an amp **2***a* which receives, clamps, amplifies and couples the signal to the display element **6***a*, which is most commonly a CRT or modulated laser but which also could be modulated LED's or LCD's or other image creation device.

The device shown is a video device also contained in the device **1***a* is a sync circuit **3***a* which receives the signal, strips the composite sync therefrom, separates the composite sync into H and V components and couples these components to the H scan **4***a* and V scan **5***a* circuits respectively. The scan circuits **4***a* and **5***a* provide the scanning control of the display element **6***a*, for example by providing the ramp drive waveforms to the CRT yoke or displacing the laser beam, or modulating the imaging devices suitable modifications would have to be made for an image creation device like a camera.

It will be recognized by one skilled in the art that the device shown by way of simple example in FIG. **1** has many practical variations which are commonly used. The single connecting lines shown between elements will be understood to carry multiple signals as required, and other configurations may be made. For example, the sync circuit **3***a* is sometimes configured to receive one or more sync waveforms separate from the image signal. The actual scanning process may be by alternate methods as well, operating in progressive or interlaced fashion, including magnetic and electrostatic deflection of an electron beam such as in a CRT or E.B. recorder, electro-optical or mechanical deflection of a light beam such as in a laser projector, fax machine, printer or electro-optic display device, or by address or pixel selection as with thermal, ink jet, flat panel, florescent, LED or LCD type displays or printers. The device might also be an image creation device, whether video tube, CCD or otherwise. Further the processing may occur at imaging prior to recording, after recording, in or out of memory or at any other time the image information is available.

One skilled in the art will be able to utilize the present invention with any of the many image creation, recording, memory and/or display devices which utilize ordered groups of image elements to eventually set forth image phenomena as are known in the art.

The description given herein is by way of example with primary respect to a video monitor. As previously mentioned, video refers to the groups of elements irrespective of their use or form of existence or creation and will be understood to mean such even though described with primary respect to television elements.

FIG. **2** is a block diagram of a display device **1***b* like **1***a* of FIG. **1**, including amp **2***b* corresponding to **2***a*, sync circuit **3***b* corresponding to **3***a*, H scan circuit **4***b* corresponding to **4***a*, V scan circuit **5***b* corresponding to **5***a* and display element **6***b* corresponding to **6***a*. FIG. **2** also shows the spatial scan modulator **7** as an embodiment of the present invention containing neighboring element means **8** responsive to the signal to provide a plurality of neighboring elements to the element replication means **9**. Neighboring element means **8** may also be responsive to element replication means **9**, as will be discussed with respect to FIGS. **10** and **11**. The neighboring element means **8** also provides a delayed version of the signal of the amp **2***b* and sync circuit **3***b* in order to make up for processing delays as will become apparent to one skilled in the art from the discussion below.

Delay will be understood to encompass deriving different elements in time and/or space by a variety of well known means, including the specific example of delaying a time sequential series of image elements.

The element replication means **9** provides a V fill signal to the V scan circuit **5***b* in response to the plurality of neighboring elements from **8** in order to cause a vertical filling or dithering of the element scan or addressing at the proper times. The spatial scan modulator **7** therefore operates to determine where voids or elements to be replicated exist between elements or are created between or on elements by defective elements, and how these voids (as previously defined) are to be filled in the image. This determination made by an inspection of a plurality of neighboring elements, and then causing the creation and/or display device to replicate, fill, replace, or otherwise modify the appropriate location in response to the fill signal. Shown as optional is an H fill signal provided by **9** and coupled to **4***b* to cause horizontal filling, and a further optional video fill provided by **9** and coupled to **2***b* to cause modulation or filling. The device can also be utilized to replicate non-defective image elements with no ascertainable artifacts (again the term void covers all situations).

As with the various display and creation devices known in the art, the fill signals (as previously defined) provided by **9** will take on different connections to the devices **2***b*, **4***b* and **5***b*, resulting from the differences in those devices.

It is the object of the fill signals from **9** to cause the appropriate filling of locations in the image by whatever means is suitable for the particular imaging device being

used, whether during creation, recording, and/or presentation of the image. These locations which may be voids in the image which may be filled with all or a portion of a element, or all portions of combinations of elements, or otherwise as will be described in greater detail later, especially with respect to the specific video display embodiment FIGS. **10** and **12**.

In the present example, the voids or element locations are filled by slightly dithering the example electron, light beam or other imaging device away from its normal scan position by manipulation of the sweep circuits of the scan circuitry during creation and/or presentation of the image element.

For a light beam type device the voids may be filled by dithering, modulating or focusing the beam. For addressing type devices the dithering may be accomplished by manipulating addressing and filling as may be accomplished by such dithering. In all devices, filling may be caused by modification of existing elements.

For the device described by way of example, the V fill signal will cause the electron, light beam, imaging or creation device to be modulated vertically, either upward, downward or sideways or both to cause given scan line to become wider in an upward, downward, sideways and/or all directions. In a video circuit this can be simply accomplished by adding or subtracting a small amount of high frequency pulsating current in the sweep or scanning driver circuit in a video circuit, thus broadening the electron or laser beam slightly upward or downward from its normal position on the face of the CRT or photo sensitive surface. Similarly, the H fill signal can cause a slight horizontal displacement of the beam position by adding or subtracting a small amount of high frequency current from the H sweep or scanning driver circuit. In order to accomplish diagonal or angular displacement of the electron beam, a modulation of both H and V deflection circuits may be made. Such modulation of the electron beam position is relatively easy to accomplish in terms of circuitry requiring only a bidirectional current source, or a pair of unidirectional current sources, which are switched on and off at high frequency rate in response to the fill signals, and add or subtract current in the sweep or scanning circuit, thereby slightly modulating the current flowing in the driver and thus altering the electron beam deflection. The operation thus causes a dither of the beam modulation, which will be explained in greater detail with respect to FIG. **5**.

In alternate creation/presentation circuits the signals to/from various circuits would be appropriately modified.

The beam modulation of any image conveying beam such as electron or light can also be achieved by changing the deflection, intensity, shape, duration, focus or astigmatism of the beam, and/or scanning, thereby changing the spot size and/or shape. The modulation of the conveying beam may be caused to take place in various directions as well, for example in diagonal directions, in response to the pixel replication means **9**. Such improvements will be understood and may be made by one skilled in the art in view of the present teachings.

The art of changing electron beam deflection by small amounts has been previously practiced, for the purpose of geometric scan correction. In general the exact method of effecting the modulation of the display will be determined by the nature of the display printing, or imaging device; however, one skilled in the art will be able to devise proper circuitry to practice the present invention for a given desired type of creation and/or display device, in view of the teachings herein.

The fill signal may be utilized to generate the desired elements (which may be including additional elements replication) on the input signal in response to **9**, with or without scan modulation, thus providing elements to fill in the desired blank areas of the image (which may be blank as in voids, unneeded, unwanted, or otherwise).

Filling may be accomplished by simply adding the fill signal to the signal in a monitor device so that the electron beam is caused to illuminate the CRT phosphor in response to the fill signal as well as the signal.

Illumination may be caused to occur in the absence of a signal generated illumination, or may cause the signal generated illumination to be modified, such as by being increased or decreased. The image fill signal may also be utilized to perform other image functions as will become apparent, such as reducing the bandwidth of the signal, or by changing the element or spot size for example by de-focusing the electron beam, repeating a displayed element, or generating a new element (especially in non-direct scanning devices).

New elements used for filling of voids including the substitution or replication of existing elements may be comprised of all or a portion of a element or group of elements.

FIG. **3** shows the same elements as in FIG. **2**, however the neighboring element means **8** is coupled to amp **2***b* to receive the input signal, rather than directly to the input, as in FIG. **2**. Several other embodiments relating to coupling and arrangement of elements will be possible, as will be apparent to one skilled in the art, and are intended to be considered within the scope of the invention as herein described and claimed.

FIG. **4***a* shows a typical scanned image **10***a* (whether creation and/or reproduction) with a small portion **11***a* which is expanded for clarity in **4***b*. The small portion **11***a* shows four scan lines **12***a*, **13***a*, and **15***a*. The scan lines may be considered consecutive for the purpose of the present explanation, but may also be alternate as in an interlaced display, or otherwise non-consecutive. The scan lines are shown thicker during the higher illuminated portion, the thickness representing the width or intensity of the scanning beam, with the narrow line representing the scan track normally followed by the beam, as is common for laser beam projection and recording devices and CRTs. Also this scan line is representative of what exists in alternate imaging devices.

With more modern creation and/or presentation devices the modification is more theoretical-occurring in electronic form during and/or after creation instead of during presentation.

Scan line **12***a* has seven illuminated element points **16***a* through **16***g* identified for clarity. As with many systems, the individual elements typically blend together when sequentially aligned along a scan line, due to both the width of the beam, and the limited bandwidth of the video amplifiers in the device, giving rise to the continuous highlighted areas shown. It will be understood that the individual elements may also represent a matrix display rather than a scanned display. The four scan lines show a diagonal bright area which can be seen to take on a rather stair stepped appearance. The stair stepping and the space between the scanning lines make up picture artifacts that viewers find objectionable in viewing the image, whether created during creation and/or presentation.

It is one object of the present invention to fill in the voids of the stair stepping and voids between consecutive scanning

lines, for example by modulating the scanning of the electron beam in a video device, thus reducing these objectionable artifacts.

FIG. **5***a* shows the same display **10***b* as **10***a* in FIG. **4***a*, with expanded portion **11***b* corresponding to **11***a*, and showing scan lines **12***b*, **13***b*, **14***b*, and **15***b* corresponding to **12***a*, **13***a*, **14***a*, and **15***a* respectively. Again the creation/alteration presentation circuits would be appropriately modified.

Illuminated elements **17***a–g* corresponding to **16***a–g* are shown as well as illuminated pixels **18***a–e*. For each element which is to be partially modulated during creation or during production, an up or down arrow is shown indicating the direction(s) of modulation. For example, element **17***b* is modulated downward to fill the void between **17***b* and **18***a*. Likewise elements **17***c–g* are all modulated downward. Elements **18***a* and **18***b* are modulated upward to fill the same void and **18***c–e* are modulate both upward and downward. One skilled in the art will recognize that the image of FIG. **5** has a higher apparent resolution than that of FIG. **4**, the improvement being a result of the filling of voids (even if previously occupied by valid elements). This modulation can occur in the original image scanning circuitry, modifying the element signal during or after storage, or otherwise. The same type of image modification would also occur in alternate imaging devices such as scanners, laser printers or fax machines.

With respect to FIG. **2**, when element **18***a* is being scanned, the neighboring element means **8** would provide the elements adjacent to **18***a*, including **17***b*, **17***c* **17***d*, and **18***b*, for inspection by element replication means **9**. The element replication means **9** will determine that there is a void between **17***c* and **18***a* which should be filled, thus causing **18***a* to be modulated upward into the void. The void may be actual or artificial (as when the device ignores valid elements).

It can be seen from inspection of FIG. **5** that a good portion of the voids between scanning lines or matrix elements, as well as a portion of the stair stepped edge void have been filled in. Element **18***f* is shown as being a defective element which has been replaced thus causing filling of the void which otherwise would have been present to be filled.

It may be noted that an object of the present invention is to provide a method of filling voids without restriction to the nature of how such voids arise, although it will be appreciated that the nature of such filling may very will be optimized in response to the nature of the void and that the voids might discard valid image elements at the involved location. For example the filling of voids between elements may be performed differently than the filling of voids created by defective elements. As another example, assuming **18***f* were defective due to a defective video element, the element may be replaced to cure the defect. If, on the other hand, the element for **18***f* were not defective by itself, the artifacts produced by a defective florescent element, the location could be filled by lighting, or increasing the lighting of the neighboring elements. Further, the invention may be utilized to replicate valid, non-defective image elements due to the probability of similarity. This allows continual processing of a signal through a circuit without on/off switching while producing minimal artifacts.

FIG. **6** shows a typical prior art scan line **19**, corresponding to **13***a* of FIG. **4***b*, having an illuminated section of **6** elements shown as a wider portion of the line. The elements may be created in any known way such as by scanning light or electron beams, LED's, LCD's or laser beams, by spatial addressing an imaging device or by signal alteration.

As with the previous example of FIGS. **4** and **5**, the individual elements have blended together gaining a continuous illuminated section. The presented scan line **20** shows the same line as **19**, except that it has been spatially modulated in accord with the present invention thus corresponding to **13***b* of FIG. **5***b*. The track of the beam is shown in **20** as a sinusoidal path, or spatial modulation, which deviates from the straight scanning line of the prior art. This same result could be provided by alternate means.

Note that for the left two elements the deviation takes place both above and below the line. In the preferred embodiment of the invention the electron beam or memory laser path is such that the track pitch, the spacing between the points where the track crosses the normal scan line, is less than the electron or reproduction beam width. Therefore the electron or beam width will illuminate a solid area. The illuminated area created by the beam path shown in **20** is shown as a solid are in **21**. It will be noted that the ability to fill in chosen directions only, such as only up to **21**, is an important feature.

A note should be made about the relative brightness of the spatially modulated scan of **21** versus the area of the prior art scan **19**. The brightness of a given area is a function of the flux density of the electron, light beam or image signal striking that area, that is a given number of electrons or photons or other image creating energy will tend to provide a given number of photons of visible light or particles of dye or pigment, independent of the area which it strikes. For a given electron or beam intensity, the area of **21** will therefore appear dimmer in terms of visible photons or particles per unit area than the area of **19**. If a given spatial scan modulated area of the image is large enough to be resolved as a distinct element, the viewer may notice this decreased intensity. In order to overcome this decreased brightness, it will be desirable to increase the intensity of the image creating beam, therefore restoring proper brightness in those areas where the spatial modulation is occurring. The brightness increase will typically be a function of the amount of modulation. For example while the beam is modulated only upward for the left two elements of **20**, a first given increase should be made, and for the remaining elements where the beam is modulated both up and down with a second, higher, increase made. This increase in beam intensity can be made in response to element replication means **9** shown in FIG. **2**, via the fill signal. It may also be desirable to utilize the fill signal to increase the number of illuminated elements, in conjunction with the spatial scan modulation. For example, the illuminated area of line **20** (**13***b* of FIG. **5**) can be tuned on one element early in order to further reduce the stair stepping of the diagonal edge. This may be accomplished by time or spatial modulation of the image creating beam.

Alternate imaging devices would similarly operate, albeit with adaptations for their special properties. For exampled, with a LED or LCD imaging device (such as a printer), modifications of the brightness of successive lines of image information and/or the modulation of the image elements in what would otherwise be spaces between lines would be one way to produce the image improvement of the present invention.

FIG. **7** shows a group of 9 elements which are located on 3 scan lines of a raster or alternatively in 9 matrix locations. These nine elements are provided by the neighboring element means and may be utilized by a element replication circuit in order to determine if spatial scan modulation or other filling should be enabled. In the following discussion it will be assumed that element X (the central element) is defective or wanted to be replaced, as is known from error

detecting circuitry or as determined by the element replication **26**, or is otherwise to be replicated. It will be assumed for the purpose of the present example that element X in the center of the 9 elements, is the element about to be displayed or created by the display element. Scanning will be assumed to be from left to right, top to bottom. However it will be understood that the present explanation will apply equally well to any image creating and/or displaying device or system independent of the manner in which the image elements are scanned or placed as well as to any point of the image for example element A in FIG. **7** could be processed.

For the described scan, elements A–D will have occurred in time before X, and elements E–H occur in time after X. The 9 elements are all made simultaneously available to the elements replication by the neighboring elements means (**8** of FIG. **2**). The neighboring elements means in the preferred embodiment is made up of memories, delay lines, shift registers or other delay devices which are well known to one skilled in the art, which allow all nine of the elements to be present simultaneously. A different number of elements could also be present.

A device which can be utilized for the neighboring elements means function is described, with respect to FIGS. 9 and 10, in U.S. Pat. No. 4,573,070 issued Feb. 25, 1986. Other arrangements and circuits to perform this function will be apparent to one skilled in the art from the present disclosure, for example, retrieving elements from RAM as in matrix displays. In order that elements X can be the about to be currently displayed elements, it is necessary that neighboring elements means make elements available to the display device, which is shown by the connection from **8** to **2***b* and **3***b* of FIG. **2**, which replaces the video input to the display device.

FIG. **7** shows eight possible replication direction differences which can determine the direction of replication for an element X. This element X could be defective, non-existent merely unnecessary, or disposable (even if valid) —the latter most particularly in respect to an unswitched, constantly operating device. The major factor is the desire to have element, replication, or substitution. The eight differences are represented by eight lines P–W. Line P represents the difference of elements A and H, Q of elements B and G, T of elements B and E, etc.

Element X may well be replicated from any direction, including those of the third dimension, which would represent a frame to frame or time direction, or a combination of time and spatial dimensions. Replication in the time dimension is useful in improving motions artifacts. Time replication is accomplished by using delays of one picture period (field or frame in a monitor device) or more to provide elements in the time axis, which may be used to fill temporal voids. It is particularly useful in a video imaging device.

Element X will thus modulated in response to elements which are present in field or frames other than the one containing X. U.S. Pat. No. 4,573,070 which is incorporated herein by reference describes more fully various embodiments of neighboring elements means which may be suitable for use in this fashion, and particular FIGS. 13, 15 and 16 and the description thereof teach detection of a defective element X. Alternatively, the detection of a defective element X may be performed by various defect or error checking circuitry as is well known in the art.

It will be immediately recognized that by comparing elements on the opposite sides of X, it is possible to determine which pair of surrounding or neighboring elements which are most similar. The most similar pair thus represents the pair of image elements most likely to provide the least noticeable replication value for an element X, and also indicate the direction(s) of modulation of X to fill voids adjacent thereto. For example if A–B=9, B–G=7, C–F=8, and D–E=3, the preferred pair of elements for replicating X would be pairs D and E and either could be chosen for replication. Alternatively, a normalized combination of the two pairs such as an average can be used.

This logic holds true if in fact X is related to elements on two opposite sides. However X may be related only to the elements in the corners, that is to elements A, B, and D (upper left), B, C, and E (upper right), E, H, and G (lower right), or G, H, and D (lower left). The logic conditions shown below thus preferably takes all eight conditions into account, selecting the lowest difference pair of opposite or corner elements to determine the direction(s) of modulation of X, to fill voids adjacent to X, or giving the direction or pair of elements most likely to provide the least noticeable replication value for an element X in FIG. **7**.

For the purpose of the present description and the purpose of explanation, it will be assumed that only the two dimensions, and the replication directions indicated by the 7 differences are to be considered.

A group of similar elements is easily implemented by logic operations as may be utilized to determine which if any of the 8 spatial replication directions should be enabled for a given elements X. Logic operations that may be used to enable the modulations according to the following table include:

MODULATION DIRECTION	CONDITION
VERT.	B-G < A-H or C-F or D-E or B-E or E-G or G-D or D-B
HORIZ.	D-E < B-G or A-H or C-F or B-E or E-G or G-D or D-B
R.DIAG.	C-F < B-G or A-H or D-F or B-E or E-G or G-D or D-B
L.DIAG.	A-H < B-G or C-F or D-E or B-E or E-G or G-D or D-B
U.LEFT	D-B < B-E or E-G or G-D or B-G or A-H or C-F or D-E
U.RIGHT	B-F < E-G or G-D or D-B or B-G or A-H or C-F or D-E
L.LEFT	E-G < G-D or D-B or B-E or B-G or A-H or C-F or D-E
L.RIGHT	G-D < D-B or B-E or E-G or B-G or A-H or C-F or D-E

FIG. **8** shows by way of example an embodiment of the present invention which may be utilized with image elements. The FIG. **8** embodiment contains a neighboring element means **25** similar to **8** of FIG. **2**, and an element replication means **26** similar to **9** of FIG. **2**.

The element replication **26** contains a rank logic means **28** which cooperates to inspect the 9 neighboring elements A–H and X presented on lines **30**A–H and X respectively, and provides a fill signal on line **32** and replaces signals on line **36** respectively, which device operates to control the spatial modulation of element X. It should be noted that in FIGS. **8** and **12** the fill and replace lines are shown as single lines for clarity, and further that the connection which provides element X to the display device as well as the video fill connection to the display amp are not shown for clarity. One skilled the art will however recognize the need for, and be able to provide the proper coupling of, element X and element fill and replace functions to the image device via multiple connections and couplings with the element replication as appropriate for a given application.

As will be apparent from the present teachings, many of the functions of the present invention can be implemented with various forms of hardware including ASICS, program-

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mable logic and analog or optical circuitry and software running on any of the various well known platforms. For example, microprocessors with suitable software may be utilized. As a further example, a read only memory may be utilized. In particular, a ROM or programmable logic would be well suited to implement part or all of the elements replication means **26**.

The determination of which neighboring elements are related to element X is a ranking process, which is described in one form in some detail in the aforementioned U.S. Pat. No. 4,573,070 with respect to video noise reduction. The '070 patent does describe and claim the replication of defective elements, for example at column 4 line 49 et. seq. and column 8 line 45 et. seq. The ranking circuitry shown in FIGS. 15 and 16 of the '070 patent can be utilized for the rank logic means of **27** of FIG. **8** of the present invention, but the rank logic means of the present disclosure has been found to provide superior performance when utilized for applications to replace defective or unneeded elements. The rank logic means **27** operates in response to the elements A–H and if needed X provided via **30**A–H and **30**X to determine each of elements A–H relative closeness to all the others. For example if elements C–F were determined to be closest to each other, then signifying a rank of 0 (that no other element pairs are closer) would be output on line **31**R. If 2 other elements were closer than elements C and F, a 2 would be output on line **31**R. Each element pair will be ranked by **27**, with that pair's respective rank provided on line **31** P–W. The fill logic means operates to select a given number, for example 2 or 4 of those elements which are closest and identifies them. The logic equations given above for the example of FIG. **7** are then used to determine the modulation and/or replication directions to be enabled. This ranking may occur by comparing all groups for similarity (parallel processing) or by comparing each group to the next group sequentially retaining the most similar (serial processing). This latter is more efficient.

Further the rank logic means may also operate to rank elements in respect to their dissimilarity, thus not utilizing elements that do not meet a minimum criteria for similarity ranking. This recognizes that elements that are known to be largely dissimilar do not have to be ranked for similarity. This provides considerable saving (of most particularly processing time) and circuit complexity since the complexity of calculations increases exponentially as to the number of elements utilized. Preferably therefore the ranking of elements would be a multiple-step process: first discard dissimilar groups of elements not sufficiently similar in respect to each other and/or other sets so as to not warrant subsequent processing providing at least one set remains and then second ranking of the groups of similar elements. A threshold to establish similarity is particularly effective in the initial step.

Note that more than two elements may be compared in a group, for example groups of 3 or more may be compared. For example, group ABD, BCE, EHG, and GFD may be compared to determine the total difference, for example A–B+A–D+B–D as the difference for ABD.

As an example, assume that the element pairs have the following ranks:

P = 0	Q = 1
R = 7	S = 2
T = 6	U = 5
V = 4	W = 3

From the above chart it can be seen that pairs P, Q, and S are closest thus indicating element X is most likely related to a diagonal from element A to H. The three closest elements will be identified as A and H, and of the above logic equations the following will be satisfied:

VERT
HORIZ
L. DIAG

These equations being satisfied, the modulate VERT signal, and modulate HORIZ signal, and modulate LEFT DIAGONAL signal will be activated. As a result of the above analysis, the void between elements A, B, D, and X and E, G, H, and X would be caused to be replicated by spatial modulation of elements X if X were not defective. Alternatively, the voids and/or element X could be replicated by elements A, B, D, and E, G, and H, or combinations thereof respectively. As an improvement to the spatial modulation, the amplitude or spatial intensity of the modulation may be changed in response to the ranking of the neighboring elements. For example, if the difference between X and A is small, a large amplitude of modulation is used; and if the difference were large, a small modulation used. The amount of modulation is therefore caused to vary in response to the difference, in either spatial or temporal embodiments. Of course, intensity or other attribute modulation may also be provided as well, as previously discussed. Additionally, if element X is defective or unneeded, it may be deleted, thus creating a void, and the void may be replicated with a combination of those element pairs having the closest values, in the above example, pair A–H or Pairs A–H and B–G. For a continually operating device, element X could be replicated even if not defective.

It is important to note that by ranking the various element pair differences P–W that a very accurate prediction of the value of X may be made in the event X is defective. By inspecting the differences and their ranking, the individual surrounding elements, in space and time, which are most closely associated with X may be determined with a high probability. A combination of a plurality of those most closely associated elements may then be utilized to replace element X, to fill any voids near a good or defective X, or even to totally replace a valid element X (which would treat X as a void irrespective of its true nature).

Such combinations which have proven suitable for use include any of the various averages which are well known, including arithmetic and geometric averages, means, medians, weighted combinations, spatial and temporally filtered combinations and various interpolations and curve fittings. It has also been found that selecting a single element from the group of most closely associated elements to use for fill or replication works quite well. In particular, choosing a median value element of the most similar group has been shown to offer quite good performance. In particular, choosing the two most closely associated groups of elements, and choosing one of the two median elements of the groups, the one closest to the average of the four, has been found to give quite good performance.

In summary then, the preferred operation begins by selecting a location for image enhancement. This location may be anywhere in the image including along the edges and corners thereof. Once the location is ascertained, the plurality of groups of two or more elements having a relationship to the location are ascertained. These groups may be adjoining, neighboring, having a theoretical similarity, and may be present with a time or space variable or combination thereof. After the groups are ascertained, each image element in the group is compared to the other elements in the same group to determine the similarity or how closely the individual elements within each group match. Note that this

is possible for a single element to be in more than one group. This similarity is preferably typically determined by the absolute value of A minus B or similar function (to increase operating speed and reduce circuit/software complexity). This comparison could include a preliminary dissimilarity threshold which would in operation not process elements which are significantly dissimilar to other sets or to a predetermined theoretical or percentage value of difference. This dissimilarity threshold could be by ranking of the groups of elements or by comparison of the differences between image elements in each group.

Once the similarity within each group has been ascertained, the similarity of each group is compared to the similarity of all the other groups to ascertain which groups have the most closely matching image elements or most similar image elements. This can be accomplished by sequentially comparing the similarity of each group to a subsequent group, discarding the most dissimilar before repeating the process, by ranking the groups outright according to their similarity, or otherwise.

Once the most similar group, or groups, have been ascertained, then one or more elements within the most similar group are used to generate a replication, value for use at the particular location. The image element(s) chosen can be one of the most similar pair, an average of the most similar pair, an average of the image elements in a group of closely related image elements, an average of the most similar of the image elements within groups of associated image elements, an average of all of the image elements within the associated groups or otherwise. Further, the image elements can be replacing an otherwise valid image element, replacing a defective image element, or filling in empty spaces in time or space around the location. All this is separate of the need to determine whether or not whatever may exist at the particular location is defective, or missing since replication provides very good estimate of the noise free value of a given image element at a particular location.

FIG. **9** shows an element configuration which results from one embodiment of the present invention. From the above description it can be seen that it will be relatively easy to configure the invention to operate in time to generate new lines, rows or new fields or frames of video. Such a configuration may be envisioned by assuming that elements A, B, and C are from a first field (or row or line); D, X, and E from a third, generated field (or row or line); and elements F, G, and H from a fifth field (or scan line). Intermediate fields or rows or lines with elements I J K and L M N can also be utilized. Such a system is shown in FIG. **9** where elements A–C, I–K, L–M are taken from the incoming video signal and elements D, E, and X are fill or synthesized elements which are generated in response to the operation of the elements which are generated in response to the operation of the elements replication.

The new element X would be the value calculated for element X as described above, which is stored in a field or other memory matrix and displayed in the prior time or space sequence by the display element. Alternately, the new elements could be a calculated value derived from a plurality of the elements, as will be discussed with respect to FIG. **12**.

FIG. **10** shows the preferred embodiment of the neighboring element means **25** of FIG. **8** in greater detail in a video application. Input video is coupled to an A-D converter **29** where it is digitized and output as a digital video data stream. The input video is also coupled to a sync stripper and PLL circuit **30**, which provides all of the required clock and timing signals for the elements of **25** and also the circuit of FIG. **11**. The connection of the various clock and timing signals are not shown here for clarity. The A-D converter **29**, and sync stripper and PLL **30** are will know in the art, and are commonly found in such devices as time base correctors and other video processing devices. One skilled in the art will be able to utilize any of a number of well known circuits and I.C.s to implement **29** and **30**. For example, the AD9502 Hybrid Video Digitizer, provided by Analog Devices of Norwood, Mass., Provides all of the PLL and digitizing functions of **29** and **30**. The digitized video is output at a fixed number of samples per line depending on the particular version of the AD9502. Digital Delays **31**, **32** and **33** are coupled to the digital video output from **29** in order to provide a plurality, in this example 9, of delayed versions of the digital video signal. 1 H delay I.C.s, suitable for **31** and **32**, are available, such as the N.E.C. UPD41101, and 1 field delay I.C.s suitable for **31**, are also available, such as the N.E.C. UPD41221. Application notes on the use of these I.C.s are available form N.E.C. Electronics Inc. in Mountain View, Calif. A 1 element delay I.C. suitable for **33** is the 74HCT374 Octal Latch, available from multiple sources. At any instant, nine different elements will then be present at the output.

Referring to FIG. **10**, one skilled in the art will note that if delays **31** and **32** are 1 scan line (1H) and delays **33** are 1 elements each, then the elements labeled A–H and X in FIG. **7** will be present at the right side output of **25**. In this example, the display of FIG. **7** is assumed to be either a progressive display, or an interlaced display without the second field shown.

Assuming, for another example, that FIG. **7** shows scan lines **22** and **24** from an earlier field of interlaced scanning, and line **23** is from a present field of scanning, one skilled in the are will recognize that if delay **31** is one field, the output from **25** will correspond to the elements depicted by FIG. **7**.

One skilled in the art will realize that the one field delay **31** will be required to make available at H, the previous field scanning line above the present field scanning line available at E. It should be noted that in many interlaced systems, the actual length of the delay will vary by one line from field to field, depending on whether the even or odd field is being delayed. In the use of the N.E.C. UPD41221 I.C., the proper alignment of input and delayed video is simply accomplished by use of the increment (INC) and decrement (DEC) controls. One skilled in the art will however, be able to construct such a delay, as is well known in the art. When used with matrix or other types of non time scanned video, RAM memories may be substituted as will be known from these teachings.

Of course the invention may be utilized with digital data, such as in D1 or D2 digital video or with fax, modem or laser printer data as will be apparent to one of ordinary skill in the art from the teachings herein. The invention is particularly useful with compressed data, and provides considerable image enhancement and reduction of both random noise and defective elements noise for such digital images, especially for JPEG and MPEG compression systems.

In order to make elements X available in analog form for use by a display element, as shown in FIG. **2**, digital elements X is displayed by a compensating delay **34**, and then coupled to a digital to analog converter and video fill circuit **35**, where it is converted to an analog signal. The N.E.C. UPD41101, or a combination of 74LS374 I.C. s, can be used for **34**. The Analog Device s HDG-0805 Hybrid Video D-A is a suitable part for the D–A function of **35**. In addition, the HDG-0805 has a 10% bright control which increases the video signal level by 10%. This 10% bright

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control may be coupled to the video fill signal from the elements replication. Alternatively, a separate video gain circuit may be utilized to control the video fill signal. Such gain circuits are will known in the art. In the preferred embodiment, the analog elements X may be coupled directly to the CRT. The D–A converter also maybe caused to vary the intensity of analog elements X in response to a video fill signal coupled from the fill logic circuit **28** of FIG. **11**. The purpose of the compensating delay **34** is to ensure that element X is delayed by the proper time with respect to the element replication generation of fill signals. The compensating delay may also be used in a temporal embodiment of the present invention to provide element X at the proper time (i.e. to place element X in the proper location in the displayed element sequence) for display in response to the element replication means. One skill in the art will recognize that it will be possible to combine delay **34** with the delays **31–33** which provide the neighboring elements. For example, if **34** is to have a delay of 1 element, then element D can be coupled directly to **35**, eliminating **34**.

FIG. **11** shows the preferred embodiment of **26**, the element replication means, of FIG. **8**. The rank logic means **27** of FIG. **11** receives element A–H and computes pair differences P–W from the neighboring element means **25** of FIG. **10**. Each element A–H is compared to its corresponding partner to determine the relative difference by a difference determining circuit. Each difference is then compared to all of the other differences by a difference comparison circuits **37**. For the 8 elements A–H there are then 8 difference determining circuits and 28 difference comparison circuits **37**. Any pair(s) that has a dissimilarity to the other pairs are preferably disregarded in subsequent processing. The 7 outputs of the difference comparison circuits which are responsive to a given elements pair(s) difference comparisons are coupled to an individual ranking circuit **38**, which in the preferred embodiment is chosen to be a PROM. The PROM outputs a binary number which corresponds to the number of other differences a given difference is larger than. For example, if the difference is larger than 3 other differences, the output of the P rank P PROM would be 3.

The rank values from each ranking PROM are coupled to the fill logic circuit **28**, which in the preferred embodiment is made up of PROM I.C.s. The fill or replication logic circuit **29** generates the previously discussed replication signals and/or chooses appropriate matching elements in response to the 8 rank values. The replication signals are then coupled to replication circuit of **35** in FIG. **10**, as well as the display element, as previously described.

FIG. **12** shows as an alternate embodiment of the video fill and D–A converter **35** of FIG. **10** in applications depicted by FIG. **9**. The function of the preferred embodiment of FIG. **12** is to generate a fill element which is similar or equivalent to element X. This embodiment of FIG. **12** generates a fill element, for use as element X of FIG. **7** or **9**, in response to the video fill or replication signal from FIG. **11**. The fill element may be a combination of a plurality of elements. The fill elements may be caused to be only a single elements, or a combination of elements in response to the video fill signal. The embodiment of FIG. **12** operates to generate a combination of elements in response to the video fill signal, and combine that combination with voids around element X in the adder. The combination is then converted to analog by the D–A converter. Alternatively, a replication from element X may also be generated by the combiner, in response to the video fill signal. The replace signal **36** causes the adder and switch to replace X with the combination from the combiner. The normalization of the replication combination may also be adjusted. Various types of combinations and weighted averages can be utilized for this combination, including the use of more than two elements in the combination to generate the fill elements(s).

While the above preferred embodiment of the invention has been described by way of example, many other embodiments may be utilized to operate in a given video system. For example the invention may be utilized with interlace scanning systems, or with multiple channel displays such as RGB color displays. A matrix of less or more than the suggested 9 elements may be utilized, which picture elements may be adjacent or non-adjacent, and may be symmetrically or non-symmetrically chosen. To one skilled in the art it will be apparent from the present teachings that there are numerous variations, configurations and embodiments of the above described invention which variations may be tailored into a specific embodiment to maximize effectiveness with a particular display device and video system without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. Apparatus for improving the apparent resolution of an image displayed by a video display device, including in combination, a neighboring pixel means responsive to the signal which carries said image to provide a plurality of image elements,

and a fill calculator means responsive to said plurality of image elements, which may be pixels, to generate a fill signal, said fill signal indicating where said display device may alter voids between image elements.

2. The apparatus of claim **1** wherein said image is improved by said neighboring pixel means which operates to generate fill pixels in said image in response to said fill calculator means.

3. The apparatus of claim **1** wherein said neighboring pixel means is responsive to said fill signal from said fill calculator means to generate fill pixels which are combined with said video signal to fill said voids.

4. An improved display apparatus for displaying an enhanced version of an image conveyed by a signal,

said apparatus including in combination a neighboring element circuit responsive to said signal and operable to recover and temporarily store known ones of picture elements of said image so as to provide a group of neighboring elements including a central element,

fill calculator circuit coupled to said neighboring circuit to determine if said neighboring elements, including said central element match known patterns of elements,

video fill circuit coupled to at least said fill calculator circuit to modify the value of said central element in response thereto thereby providing enhancement of said image, and display means coupled to said video fill circuit and operative to display said enhanced image.

5. An apparatus as claimed in claim **4** wherein said signal is a digital video type signal conveying said image in raster form,

said neighboring element circuit stores digital data bytes corresponding to said picture elements to provide a matrix of stored elements as said group with said central element being central to said matrix,

and said fill calculator circuit determines if said neighboring elements match said known patterns of elements thereby indicating that modifying said central element is likely to enhance the perceived quality of said image when it is displayed.

6. An apparatus as claimed in claim **4** wherein said signal is a digital signal representing said image in raster like form,

said neighboring element circuit stores digital data bytes corresponding to said picture elements to provide a matrix of M×N stored elements as said group with N being a number of lines of said raster and M being a number of elements in said lines and with said central element being central to said matrix,

and said full calculator circuit utilizes digital logic operations to compare the pattern formed by said central element and the remaining said neighboring elements with a plurality of predetermined digital logic patterns to determine if there are any matches therebetween said matches indicating that modifying said central element is likely to enhance the perceived quality of said image.

7. An apparatus as claimed in claim **4** wherein said signal is a digital signal representing said image in raster type form,

said neighboring element circuit stores digital data bytes corresponding to said picture elements to provide a matrix of M×N stored elements as said group with M being a number of elements in a line and M being a number of lines of said raster and with said central element being central to said matrix,

said full calculator circuit utilizes digital logic operations to compare said neighboring elements with a plurality of predetermined digital logic patterns to determine if modifying said central element is likely to enhance the perceived quality of said image,

said video fill circuit operates whenever said modification is indicated to increase or decrease the brightness of said central element in response to said digital logic operations.

8. An apparatus as claimed in claim **4** wherein said signal is a digital signal representing said image in raster type form,

said neighboring element circuit stores digital data bytes corresponding to said picture elements to provide a matrix of M×N stored elements as said group with M being a number of elements in a line and M being a number of lines of said raster and with said central element being central to said matrix,

said fill calculator utilizes digital logic operations to compare said neighboring elements with a plurality of predetermined digital logic patterns to determine if modifying said central element is likely to enhance the perceived quality of said image,

said video fill circuit operates whenever said modification is indicated to modify the size and/or shape of the display of said central element in response to said digital logic operations.

9. An apparatus as claimed in claim **4** wherein said enhanced version appears to have increased resolution and detail resulting from the filling in of voids.

10. A method for displaying an enhanced version of an image conveyed by a signal,

said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element,

determining if said neighboring elements, including said central element match known patterns of elements,

modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image.

11. The method as claimed in claim **10** wherein said signal is a digital video type signal conveying said image in raster form,

and characterized by said recovering and temporarily storing digital data bytes corresponding to said picture elements to provide a matrix of stored elements with said central element being central to said matrix,

and determining if said neighboring elements match said known patterns of elements thereby indicating that modifying said central element is likely to enhance the perceived quality of said image when it is displayed.

12. The method as claimed in claim **10** wherein said signal is a digital signal representing said image in raster like form,

said recovering and temporarily storing digital data bytes corresponding to said picture elements to provide a matrix of M×N stored elements as said group with N being a number of lines of said raster and M being a number of elements in said lines and with said central element being central to said matrix,

and utilizing digital logic operations to compare the pattern formed by said central element and the remaining said neighboring elements with a plurality of predetermined digital logic patterns to determine if there are any matches therebetween said matches indicating that modifying said central element is likely to enhance the perceived quality of said image.

13. The method as claimed in claim **10** wherein said signal a digital signal representing said image in raster type form,

said recovering and temporarily storing digital data bytes corresponding to said picture elements to provide a matrix of M×N stored elements as said group with M being a number of elements in a line and N being a number of lines of said raster and with said central element being central to said matrix,

utilizing digital logic operations to compare said neighboring elements with a plurality of predetermined digital logic patterns to determine if modifying said central element is likely to enhance the perceived quality of said image,

and modifying the value of said central element whenever said modification is indicated to increase or decrease the brightness of said central element in response to said digital logic operations.

14. The method as claimed in claim **10** wherein said signal is a digital signal representing said image in raster type form,

said recovering and temporarily storing digital data bytes corresponding to said picture elements to provide a matrix of M×N stored elements as said group with M being a number of elements in a line and N being a number of lines of said raster and with said central element being central to said matrix,

utilizing digital logic operations to compare said neighboring elements with a plurality of predetermined digital logic patterns to determine if modifying said central element is likely to enhance the perceived quality of said image,

and modifying the value of said central element whenever said modification is indicated to modify the size and/or shape of the display of said central element in response to said digital logic operations.

15. The apparatus of claim **4** characterized in that said video fill circuit modifies the value of said central element includes replacing an existing image element.

16. The apparatus of claim **4** characterized in that said video fill signal can replicate an image element at a location where one was previously non-existent.

17. The apparatus of claim **4** characterized in that said fill signal replicates new image information utilizing surrounding image elements.

18. The apparatus of claim **4** characterized in that said fill calculator means utilizes multiple sets of image surrounding elements.

19. The apparatus of claim 18 characterized in that said fill calculator means includes ranking the multiple sets of surrounding image elements by similarity.

20. The apparatus of claim 19 characterized in that said fill calculator means discards dissimilar sets.

21. The apparatus of claim 4 characterized in that said video fill signal modulates said central element only sideways.

22. The apparatus of claim 4 characterized in that said video fill signal can alter the shape of said central element.

23. The apparatus of claim 4 characterized in that said video fill signal replicates additional elements.

24. The apparatus of claim 4 characterized in that said video fill signal replicates a defective element.

25. The apparatus of claim 4 characterized in that said neighboring element circuit provides pairs of elements.

26. The apparatus of claim 4 characterized in that said video fill circuit operates in real time on said central element of the image.

27. The apparatus of claim 4 characterized in that the display means includes a light beam and said video fill circuit deflects said light beam.

28. The apparatus of claim 4 characterized in that said central element is stored in a memory and said video fill circuit modifies the value of said central element as it is read out of said memory.

29. The method of claim 10 characterized in that said modifying the value of said central element includes replacing an existing image element.

30. The method of claim 10 characterized in that said modifying the value of said central element can replicate an image element at a location where one was previously non-existent.

31. The method of claim 10 characterized in that said modifying the value of said central element replicates new image information utilizing surrounding image.

32. The method of claim 10 characterized by storing said central element is stored in a memory and said modifying the value of said central element modifies the value of said central element as it is read out of said memory.

33. The method of claim 10 characterized in that said modifying the value of said central element modulates said central element only sideways.

34. The method of claim 10 characterized in that said modifying the value of said central element can alter the shape of said central element.

35. The method of claim 10 characterized in that said modifying the value of said central element replicates additional elements.

36. The method of claim 10 characterized in that said modifying the value of said central element replaces a defective element.

37. The method of claim 10 characterized in that said recovering and temporarily storing known ones of picture elements provides pairs of elements.

38. The method of claim 10 characterized in that said modifying the value of said central element operates in real time on said central element of the image.

* * * * *

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(54) **SPATIAL SCAN REPLICATION CIRCUIT**

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(58) **Field of Classification Search** .... None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,921,128 A	1/1960	Gibson
3,009,016 A	11/1961	Graham
3,479,453 A	11/1969	Townsend
3,568,163 A	3/1971	Osborne
3,573,789 A	4/1971	Sharp
3,680,076 A	7/1972	Duffek et al.
3,700,812 A	10/1972	Springett
3,718,833 A	2/1973	Martone et al.
3,737,855 A	6/1973	Cutara
3,786,478 A	1/1974	King, Jr.
3,788,478 A	1/1974	King, Jr.
3,875,584 A	4/1975	Fletcher
3,878,536 A	4/1975	Gilliam
3,914,538 A	10/1975	Perreault et al.
3,921,164 A	11/1975	Anderson

(Continued)

FOREIGN PATENT DOCUMENTS

EP	0192 292	8/1986
EP	0192292 A1	8/1986
EP	0 192 292 A1	8/1986
EP	0 192 292 1 B	8/1986
FR	2269270	11/1975
GB	2197152 A	5/1988
JP	56-140461	11/1981
JP	58-75192	5/1983
JP	58-160986	9/1983
JP	58-162984	9/1983

(Continued)

OTHER PUBLICATIONS

J. R. Kinghorn, "Character Rounding for Alphanumeric Video Display," Mullard Technical Communications, No. 126, Apr. 1976, pp. 230–239.
M. A. Isnardi, "Modeling the Television Process," Ph.D. Thesis, Massachusetts Institute of Technology, May 1986.
G. Goertzel and G. R. Thompson, "Digital halftoning on the IBM 4250 Printer," IBM J. Res. Develop., vol. 31, No. 1, Jan. 1987, pp. 2–15.

(Continued)

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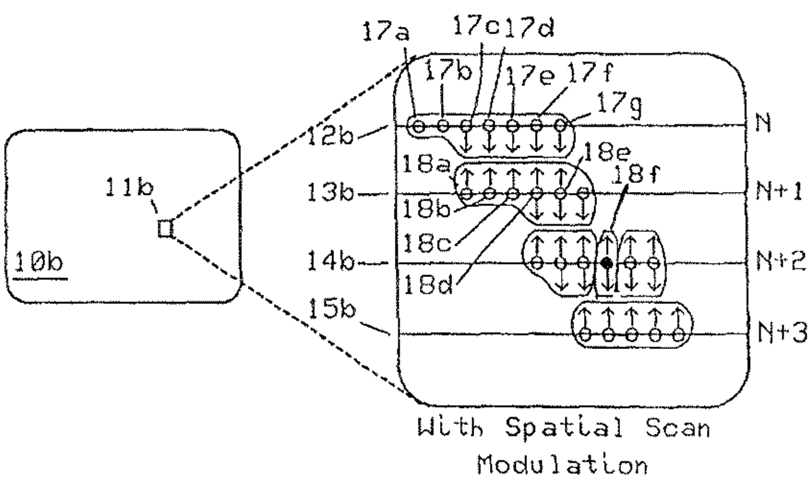
(57) **ABSTRACT**

In an image replication circuit, the improvement of replicating a given element at a certain location with the most similar of surrounding sets of image elements.



U.S. PATENT DOCUMENTS

3,946,266	A		3/1976	Saito et al.
3,949,166	A		4/1976	Fuse
3,952,296	A		4/1976	Bates
3,961,223	A		6/1976	Ray et al.
3,969,716	A		7/1976	Roberts
3,980,819	A		9/1976	Schwartz
3,995,108	A		11/1976	Morrison
4,009,334	A		2/1977	Sypula
4,018,990	A		4/1977	Long
4,032,977	A	*	6/1977	Liao 382/238
4,034,408	A		7/1977	Starkweather
4,038,668	A		7/1977	Quarton
4,047,248	A		9/1977	Lyman et al.
4,050,084	A		9/1977	Rossi
4,058,836	A		11/1977	Drewery
4,063,232	A		12/1977	Fernald
4,064,530	A		12/1977	Kaiser et al.
4,068,310	A		1/1978	Friauf
4,072,984	A		2/1978	Kaiser
4,079,367	A		3/1978	Yonezawa et al.
4,095,216	A		6/1978	Spicer
4,109,276	A		8/1978	Hopkins, Jr.
4,110,785	A		8/1978	Dischert
4,119,954	A		10/1978	Seitz et al.
4,119,956	A		10/1978	Murray
4,124,870	A		11/1978	Schatz et al.
4,152,697	A		5/1979	Rider et al.
4,198,154	A		4/1980	Masegi et al.
4,240,105	A		12/1980	Faroudja
4,240,113	A		12/1980	Michael et al.
4,241,341	A		12/1980	Thorson
4,251,871	A		2/1981	Yu
4,268,871	A		5/1981	Kawamura
4,279,002	A		7/1981	Rider
4,282,546	A		8/1981	Reitmeier
4,293,202	A		10/1981	Ohnishi et al.
4,314,154	A		2/1982	Minoura et al.
4,322,750	A		3/1982	Lord et al.
4,355,337	A		10/1982	Sekigawa
4,356,475	A		10/1982	Neumann et al.
4,356,555	A		10/1982	Ejiri et al.
4,361,394	A		11/1982	Sakai et al.
4,361,853	A		11/1982	Remy et al.
4,364,090	A		12/1982	Wendland
4,367,533	A		1/1983	Wiener
4,375,079	A		2/1983	Ricketts et al.
4,386,272	A		5/1983	Check, Jr. et al.
4,386,367	A	*	5/1983	Peterson et al. 348/446
4,387,272	A		6/1983	Castro et al.
4,389,668	A		6/1983	Favreau
4,400,719	A		8/1983	Powers
4,409,591	A		10/1983	Simkovitz
4,415,931	A		11/1983	Dischert
4,419,693	A		12/1983	Wilkinson
4,435,792	A		3/1984	Bechtolsheim
4,437,122	A		3/1984	Walsh et al.
4,450,483	A		5/1984	Coviello
4,460,909	A		7/1984	Bassetti et al.
4,464,686	A		8/1984	Reitmeier
4,468,706	A		8/1984	Cahill
4,481,594	A		11/1984	Staggs et al.
4,484,230	A		11/1984	Pugsley
4,485,402	A		11/1984	Serby
4,506,382	A		3/1985	Hada et al.
4,506,587	A		3/1985	Tanaka
4,517,607	A		5/1985	Ohkouchi et al.
4,521,803	A		6/1985	Gittinger
4,527,145	A		7/1985	Hausmann
4,533,951	A		8/1985	Powers
4,544,264	A		10/1985	Bassetti et al.
4,544,922	A		10/1985	Watanabe et al.
4,560,980	A		12/1985	Tillich
4,563,056	A		1/1986	Tagawa et al.
4,573,070	A		2/1986	Cooper
4,578,689	A		3/1986	Spencer et al.
4,589,012	A		5/1986	Songer
4,613,877	A		9/1986	Spencer et al.
4,616,219	A		10/1986	Tanaka et al.
4,620,217	A		10/1986	Songer
4,623,922	A		11/1986	Wischermann
4,625,219	A		11/1986	Horiuchi
4,625,222	A		11/1986	Bassetti et al.
4,626,838	A		12/1986	Tsujioka et al.
4,630,309	A		12/1986	Karow
4,636,857	A		1/1987	Achiha et al.
4,639,766	A		1/1987	Schine
4,642,622	A		2/1987	Ito et al.
4,646,076	A		2/1987	Wiedenman et al.
4,646,355	A		2/1987	Petrick et al.
4,648,045	A		3/1987	Demetrescu
4,648,119	A		3/1987	Wingfield et al.
4,651,169	A		3/1987	Muka
4,656,514	A		4/1987	Wilkinson et al.
4,661,850	A		4/1987	Strolle et al.
4,672,369	A		6/1987	Preiss et al.
4,673,978	A		6/1987	Dischert et al.
4,675,735	A		6/1987	Wilkinson et al.
4,677,493	A		6/1987	Shinya
4,679,039	A		7/1987	Neil et al.
4,679,086	A		7/1987	May
4,684,937	A		8/1987	Schine
4,697,177	A		9/1987	Schine
4,698,664	A		10/1987	Nichols
4,698,675	A		10/1987	Casey
4,698,843	A		10/1987	Burt et al.
4,703,318	A		10/1987	Haggerty
4,703,363	A		10/1987	Kitamura
4,703,513	A		10/1987	Gennery
4,704,605	A		11/1987	Edelson
4,707,715	A		11/1987	Miura
4,710,799	A		12/1987	Songer
4,713,672	A		12/1987	Horihata et al.
4,715,006	A		12/1987	Nagata
4,719,509	A		1/1988	Sakamoto
4,720,705	A		1/1988	Gupta et al.
4,720,745	A		1/1988	DeForest et al.
4,723,163	A		2/1988	Skinner
4,723,166	A		2/1988	Stratton
4,725,966	A		2/1988	Darby et al.
4,725,967	A		2/1988	Aiba
4,731,648	A		3/1988	Bernard et al.
4,734,715	A		3/1988	Shiraishi
4,737,858	A		4/1988	DeBaryshe
4,742,363	A		5/1988	Shiraishi
4,758,965	A		7/1988	Liang et al.
4,761,819	A		8/1988	Denison
4,780,711	A		10/1988	Doumas
4,783,840	A		11/1988	Song
4,786,923	A		11/1988	Shimizu
4,786,963	A		11/1988	McNeely
4,791,582	A		12/1988	Ueda et al.
4,791,679	A		12/1988	Barski
4,805,117	A		2/1989	Fiore et al.
4,805,226	A		2/1989	Guebey
4,809,021	A		2/1989	Check et al.
4,812,783	A		3/1989	Honjo
4,816,905	A		3/1989	Tweedy et al.
4,817,175	A		3/1989	Tenenbaum et al.
4,843,380	A		6/1989	Oakley et al.
4,847,641	A		7/1989	Tung
4,851,909	A		7/1989	Noske et al.

4,853,970	A	8/1989	Ott
4,860,119	A	8/1989	Maniwa
4,870,599	A	9/1989	Hempel et al.
4,870,611	A	9/1989	Martin et al.
4,897,805	A	1/1990	Wang
4,905,166	A	2/1990	Schuerman
4,908,866	A	3/1990	Goldwasser et al.
4,914,459	A	4/1990	Mama et al.
4,920,491	A	4/1990	Eberhard et al.
4,926,248	A	5/1990	Kobayashi et al.
4,933,689	A	6/1990	Yoknis
4,941,045	A	7/1990	Birch
4,941,186	A	7/1990	Massmann et al.
4,952,921	A	8/1990	Mosier
4,965,678	A	10/1990	Yamada
4,985,764	A	1/1991	Sato
4,989,090	A	1/1991	Campbell
4,992,804	A	2/1991	Roe
4,992,874	A	2/1991	Willis
5,005,139	A	4/1991	Tung
5,019,903	A	5/1991	Dougall et al.
5,023,919	A	6/1991	Wataya
5,029,108	A	7/1991	Lung
5,032,899	A	7/1991	Sato
5,047,955	A	9/1991	Shope
5,068,914	A	11/1991	Klees
5,072,291	A	12/1991	Sekizawa
5,087,973	A	2/1992	Kawahara
5,097,517	A	3/1992	Holt
5,099,319	A	3/1992	Esch et al.
5,101,274	A	3/1992	Yoshimura
5,132,992	A	7/1992	Yurt et al.
5,133,079	A	7/1992	Ballantyne et al.
5,146,333	A	9/1992	Chaplin
5,182,633	A	1/1993	Antonio et al.
5,229,868	A	7/1993	Kanno et al.
5,241,428	A	8/1993	Goldwasser et al.
5,287,420	A	2/1994	Barrett
5,294,984	A	3/1994	Mori
5,303,326	A	4/1994	Deal et al.
5,353,121	A	10/1994	Young et al.
5,365,604	A	11/1994	Kwok
5,387,943	A	2/1995	Silver
5,392,075	A	2/1995	Gai
5,406,626	A	4/1995	Ryan
5,408,329	A	4/1995	Mailloux
5,424,780	A	6/1995	Cooper
5,430,485	A	7/1995	Lankford et al.
5,442,407	A	8/1995	Iu
5,442,636	A	8/1995	Bontekoe
5,504,815	A	4/1996	Ryan et al.
5,523,796	A	6/1996	Marshall et al.
5,524,051	A	6/1996	Ryan
5,544,262	A	8/1996	Pagallo
5,544,264	A	8/1996	Bellegarda
5,555,463	A	9/1996	Staron
5,563,963	A	10/1996	Kaplan
5,583,937	A	12/1996	Ullrich et al.
5,590,195	A	12/1996	Ryan
5,710,601	A	1/1998	Marshall et al.
5,802,240	A	9/1998	Asai
5,815,671	A	9/1998	Morrison
5,838,298	A	11/1998	Shirasaka
5,877,815	A	3/1999	Tsujimura
5,887,114	A	3/1999	Nakantani et al.
5,893,062	A	4/1999	Bhadkamkar et al.
5,940,190	A	8/1999	Overall et al.
5,970,205	A	10/1999	Nakamura et al.
RE36,801	E	8/2000	Logan et al.
6,133,957	A	10/2000	Campbell
6,181,383	B1	1/2001	Fox et al.
6,215,526	B1	4/2001	Barton et al.
6,233,389	B1	5/2001	Barton et al.
6,310,886	B1	10/2001	Barton
6,324,337	B1	11/2001	Goldwasser
6,324,338	B1	11/2001	Wood et al.
6,327,418	B1	12/2001	Barton

FOREIGN PATENT DOCUMENTS

JP	59210774	11/1984
JP	60-202474	10/1985
JP	60-204177	10/1985
JP	60-206318	10/1985
JP	61-75682	4/1986
JP	61-156980	7/1986
JP	61-214073	9/1986
JP	61-214661	9/1986
JP	62-20076	1/1987
JP	62-140182	6/1987
JP	62-43989	9/1987
JP	62-232087	10/1987
JP	62-274472	11/1987
JP	62-279477	12/1987
JP	62-296280	12/1987
JP	63-18877	1/1988
JP	63-24369	2/1988
JP	63-38381	2/1988
JP	63038381	2/1988
JP	63048088	2/1988
JP	63-73479	4/1988
JP	63-82077	4/1988
JP	63-138876	6/1988
JP	63-213084	9/1988
JP	63-245174	10/1988
JP	63-307954	12/1988
JP	01-84385	3/1989
JP	1084385	3/1989
JP	64-77384	3/1989
JP	1-125070	5/1989
JP	2-131689	5/1990
JP	2-177683	7/1990
JP	6-133280	5/1994
JP	6-153169	5/1994
WO	WO 9222060	12/1992
WO	WO9222060	12/1992

OTHER PUBLICATIONS

IP Innovation L.L.C., Technology Licensing Corporation, New Medium Technologies LLC and AV Technologies, LLC vs. *Sony Electronics, Inc.*, Memorandum Opinion and Order, Aug. 18, 2005 [Claim Construction], Case No. 04 C 6388, Judge Kennelly, Dist. Ct. N.D. of ILL, E.D., 39 pgs.

Randolph Sanders et al., Behind Hewlett–Packard's Patent on Resolution Enhancement Technology, 1997.

Richard Iredale, High Definition NTSC Broadcast Protocol, 1987.

S. Naimpally, Integrated Ditigital IDTV Receiver with Features, Aug. 1988.

J.R. Kinghorn, Character Rounding for Alphanumeric Video Display, Apr. 1975.

Y.L. Yao, High Resolution Display and Printing Technique, Apr. 1981.

Allen Tucker, The Computer Science and Engineering Handbook, Second Edition, CD–ROM.

J.M. Fleisher et al., Laser Optical System of the IBM 3800 Printer, Sep. 1977.

IBM Technical Disclosure Bulletin, Raster Scanned CRT Spot Shaping, Jun. 1979, pp. 327, 373.

"Interfaced to Sequential Conversion for EDTA Applications," by T. Doyle, Proceedings of the Second International Workshop on Signal Processing of HDTV, 1988.

"Raster Scanned CRT Spot Shaping," A. S. Murphy, IBM Technical Disclosure Bulletin, Jun. 1979, pp. 372–373.

"Improvement of Digital Typeface Printing," IBM Technical Disclosure Bulletin, Feb. 1985, pp. 5047–5048.

"The Computer Science and Engineering Handbook," by Allen Tucker, Jun. 19, 1997.

"Adaptive Intra–Field Progressive Scan Converter," by Sato et al., 1989 National Convention of the Institute of Television Engineers of Japan (ITEJ). (English Translation also attached).

Zue, Kefu; Winans, Ann; Walowil, Eric, An Edge–restricted special interpolation Algorithm, Journal of Electronic Imaging, 1(2), 152–161 (BAR–003386–95).

Jensen, Kris, Anastasslou, Dimitris, "Spatial Resolution Enhancement of Images Using Nonlinear Interpolation," 1990 International Conference on Acoustics, Speech and Signal Processing (Apr. 1990) (BAR–003365–69).

Masuda, Michio, Okamoto, Kaneyuki, Nishijima, Hideo; Ono, Koichi, Otsubo, Hiroyasu, Otsuka, Susumu, "Picture in Picture System with a Digital Memory for VCRS," IEEE Transactions of Consumer Electronics, vol. CE–33, No. 3 (Aug. 1987) (BAR–00370–79).

* cited by examiner

EX PARTE REEXAMINATION CERTIFICATE ISSUED UNDER 35 U.S.C. 307

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

Matter enclosed in heavy brackets [ ] appeared in the patent, but has been deleted and is no longer a part of the patent; matter printed in italics indicates additions made to the patent.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

Claim **10** is cancelled.

New claims **39–47** are added and determined to be patentable.

Claims **1–9** and **11–38** were not reexamined.

39. A method for displaying an enhanced version of an image conveyed by a signal, said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element, determining if said neighboring elements, including said central element, match known patterns of elements, modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image, wherein at least one of the neighboring elements is temporally different from another of the neighboring elements.

40. A method for displaying an enhanced version of an image conveyed by a signal, said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element, determining if said neighboring elements, including said central element, match known patterns of elements, modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image, wherein the enhancement comprises filling a temporal void.

41. A method for displaying an enhanced version of an image conveyed by a signal, said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element, determining if said neighboring elements, including said central element, match known patterns of elements, modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image, wherein the modifying comprises replicating the central element in at least a time dimension.

42. A method for displaying an enhanced version of an image conveyed by a signal, said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element, determining if said neighboring elements, including said central element, match known patterns of elements, modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image, wherein at least two of the neighboring elements are from different frames of the image.

43. A method for displaying an enhanced version of an image conveyed by a signal, said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element, determining if said neighboring elements, including said central element, match known patterns of elements, modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image, generating at least one new line that is inserted in said enhanced image, said new line being temporally located between existing lines of said image.

44. A method for displaying an enhanced version of an image conveyed by a signal, said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element, determining if said neighboring elements, including said central element, match known patterns of elements, modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image, generating at least one new row that is inserted in said enhanced image and wherein said new row is temporally located between existing rows of said image.

45. A method for displaying an enhanced version of an image conveyed by a signal, said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element, determining if said neighboring elements, including said central element, match known patterns of elements, modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image, generating at least one new field for said enhanced image, wherein said new field is temporally located between fields of said image.

46. A method for displaying an enhanced version of an image conveyed by a signal, said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element, determining if said neighboring elements, including said central element, match known patterns of elements, modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image, generating at least one new frame for said enhanced image, wherein said new frame is temporally located between frames of said image.

47. A method for displaying an enhanced version of an image conveyed by a signal, said method including recovering and temporarily storing known ones of picture elements of said image so as to provide a group of neighboring elements including a central element, determining if said neighboring elements, including said central element, match known patterns of elements, modifying the value of said central element in response thereto thereby providing enhancement of said image, displaying said enhanced image wherein the enhancement comprises improving temporal resolution.

* * * * *

EXHIBIT B

US007382929B2

(12) **United States Patent**
Cooper

(10) **Patent No.: US 7,382,929 B2**
(45) **Date of Patent: Jun. 3, 2008**

(54) **SPATIAL SCAN REPLICATION CIRCUIT**

(75) Inventor: **Carl Cooper**, Monte Sereno, CA (US)

(73) Assignees: **Pixel Instruments Corporation**, Los Gatos, CA (US); **IP Innovation LLC**, Northbrook, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1280 days.

(21) Appl. No.: **09/968,291**

(22) Filed: **Oct. 1, 2001**

(65) **Prior Publication Data**

US 2002/0085125 A1 Jul. 4, 2002

Related U.S. Application Data

(60) Division of application No. 08/398,383, filed on Mar. 3, 1995, now Pat. No. 6,529,637, which is a continuation-in-part of application No. 08/119,610, filed on Sep. 13, 1993, now Pat. No. 5,424,780, which is a continuation of application No. 07/355,461, filed on Mar. 22, 1989, now abandoned.

(51) **Int. Cl.**
G06K 9/40 (2006.01)
H04N 5/00 (2006.01)
H04N 5/21 (2006.01)

(52) **U.S. Cl.** **382/267**; 382/275; 382/299; 348/607; 348/625

(58) **Field of Classification Search** 382/254, 382/266, 298, 299, 300, 205, 267, 275; 348/616, 348/245, 246, 248, 428.1, 458, 625, 607
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,921,128	A	1/1960	Gibson	
3,009,016	A	11/1961	Graham	
3,479,453	A	11/1969	Townsend	
3,568,163	A	3/1971	Osborne	
3,573,789	A	4/1971	Sharp et al.	340/324
3,680,076	A	7/1972	Duffek et al.	
3,700,812	A	10/1972	Springett	
3,718,833	A	2/1973	Martone et al.	
3,737,855	A	6/1973	Cutaia	
3,786,478	A	1/1974	King, Jr.	
3,788,478	A	1/1974	King, Jr.	340/324
3,875,584	A	4/1975	Fletcher	

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0 192 292 (1B) 8/1986

(Continued)

OTHER PUBLICATIONS

IP Innovation L.L.C., Technology Licensing Corporation, New Medium Technologies LLC and AV Technologies, LLC vs. Sony Electronics, Inc., Memorandum Opinion and Order, Aug. 18, 2005 [Claim Construction], Case No. 04 C 6388, Judge Kennelly, Dist. Ct. N.D. of ILL, E.D., 39 pgs.

(Continued)

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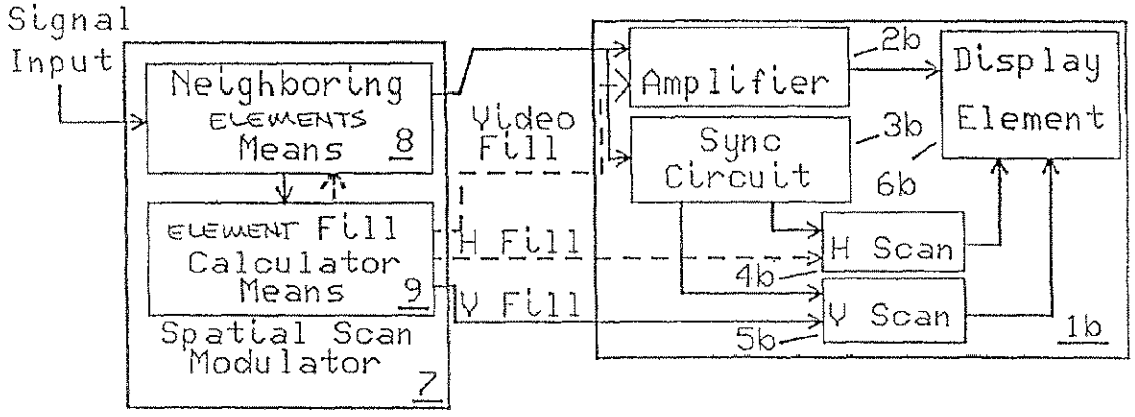
(57) **ABSTRACT**

In an image replication circuit, the improvement of replicating a given element at a certain location with the most similar of surrounding sets of image elements.

192 Claims, 5 Drawing Sheets



U.S. PATENT DOCUMENTS

3,878,356	A	4/1975	Gilliam	
3,878,536	A	4/1975	Gilliam	
3,914,538	A	10/1975	Perreault et al.	
3,921,164	A	11/1975	Anderson	
3,946,266	A	3/1976	Saito et al.	
3,949,166	A	4/1976	Fuse	
3,952,296	A	4/1976	Bates	
3,961,223	A	6/1976	Ray et al.	
3,969,716	A	7/1976	Roberts	
3,980,819	A	9/1976	Schwartz	178/7.5
3,995,108	A	11/1976	Morrison	
4,009,334	A	2/1977	Sypula	
4,018,990	A	4/1977	Long et al.	
4,034,408	A	7/1977	Starkweather	
4,038,668	A	7/1977	Quarton	
4,047,248	A	9/1977	Lyman et al.	
4,050,084	A	9/1977	Rossi	
4,058,836	A	11/1977	Drewery	
4,063,232	A	12/1977	Fernald	
4,064,530	A	12/1977	Kaiser et al.	
4,068,310	A	1/1978	Friauf	
4,072,984	A	2/1978	Kaiser	
4,079,367	A	3/1978	Yonezawa et al.	
4,095,216	A	6/1978	Spicer	340/324
4,109,276	A	8/1978	Hopkins, Jr. et al.	
4,110,785	A	8/1978	Dischert et al.	
4,119,954	A	10/1978	Seitz et al.	
4,119,956	A	10/1978	Murray	
4,124,870	A	11/1978	Schatz et al.	
4,152,697	A	5/1979	Rider et al.	
4,198,154	A	4/1980	Masegi et al.	
4,240,105	A	12/1980	Faroudja	
4,240,113	A	12/1980	Michael et al.	
4,241,341	A	12/1980	Thorson	
4,251,871	A	2/1981	Yu	
4,268,871	A	5/1981	Kawamura	
4,279,002	A	7/1981	Rider	
4,282,546	A	8/1981	Reitmeir	
4,293,202	A	10/1981	Ohnishi et al.	
4,314,154	A	2/1982	Minoura et al.	
4,322,750	A	3/1982	Lord et al.	
4,355,337	A	10/1982	Sekigawa	
4,356,475	A	10/1982	Neumann et al.	
4,356,555	A	10/1982	Ejiri et al.	
4,361,394	A	11/1982	Sakai et al.	
4,361,853	A	11/1982	Remy et al.	
4,364,090	A	12/1982	Wendland	
4,367,533	A	1/1983	Wiener	
4,375,079	A	2/1983	Ricketts et al.	
4,386,272	A	5/1983	Check, Jr. et al.	
4,387,272	A	6/1983	Castro et al.	
4,389,668	A	6/1983	Favreau	
4,400,719	A	8/1983	Powers	
4,409,591	A	10/1983	Simkovitz	
4,415,931	A	11/1983	Dischert	
4,419,693	A	12/1983	Wilkinson	
4,435,792	A	3/1984	Bechtolsheim	
4,437,122	A	3/1984	Walsh et al.	358/166
4,450,483	A	5/1984	Coviello	358/166
4,460,909	A	7/1984	Bassetti et al.	
4,464,686	A	8/1984	Reitmeir	
4,468,706	A	8/1984	Cahill	
4,481,594	A	11/1984	Staggs et al.	
4,484,230	A	11/1984	Pugsley	
4,485,402	A	11/1984	Searby	
4,506,382	A	3/1985	Hada et al.	
4,506,587	A	3/1985	Tanaka	
4,517,607	A	5/1985	Ohkouchi et al.	
4,521,803	A	6/1985	Gittinger	
4,527,145	A	7/1985	Haussmann et al.	
4,533,951	A	8/1985	Powers	
4,544,264	A	10/1985	Bassetti et al.	
4,544,922	A	10/1985	Watanabe et al.	340/728
4,560,980	A	12/1985	Tillich	
4,563,056	A	1/1986	Tagawa et al.	
4,573,070	A	2/1986	Cooper	
4,578,689	A	3/1986	Spencer et al.	
4,589,012	A	5/1986	Songer	
4,613,877	A	9/1986	Spencer et al.	
4,616,219	A	10/1986	Tanaka et al.	
4,620,217	A	10/1986	Songer	
4,623,922	A	11/1986	Wischermann	
4,625,219	A	11/1986	Horiuchi	
4,625,222	A	11/1986	Bassetti et al.	
4,626,838	A	12/1986	Tsujioka et al.	
4,630,309	A	12/1986	Karow	
4,636,857	A	1/1987	Achiha	
4,639,766	A	1/1987	Schine	
4,642,622	A	2/1987	Ito et al.	
4,646,076	A	2/1987	Wiedenman et al.	
4,646,355	A	2/1987	Petrick et al.	
4,648,045	A	3/1987	Demetrescu	
4,648,119	A	3/1987	Wingfield et al.	
4,651,169	A	3/1987	Muka	
4,656,514	A	4/1987	Wilkinson et al.	
4,661,850	A	4/1987	Strolle et al.	
4,672,369	A	6/1987	Preiss et al.	
4,673,978	A	6/1987	Dischert et al.	
4,675,735	A	6/1987	Wilkinson et al.	
4,677,493	A	6/1987	Shinya	358/283
4,679,039	A	7/1987	Neil et al.	
4,679,086	A	7/1987	May	
4,684,937	A	8/1987	Schine	
4,684,985	A	8/1987	Nakagaki et al.	
4,686,937	A	8/1987	Schine	340/728
4,697,177	A	9/1987	Schine	
4,698,664	A	10/1987	Nichols et al.	
4,698,675	A	10/1987	Casey	
4,698,843	A	10/1987	Burt et al.	
4,703,318	A	10/1987	Haggerty	
4,703,363	A	10/1987	Kitamura	358/284
4,703,513	A	10/1987	Gennery	
4,704,605	A	11/1987	Edelson	
4,707,715	A	11/1987	Miura	
4,173,672	A	12/1987	Horibata et al.	
4,710,799	A	12/1987	Songer	
4,715,006	A	12/1987	Nagata	
4,719,509	A	1/1988	Sakamoto	
4,720,705	A	1/1988	Gupta et al.	
4,720,745	A	1/1988	DeForest et al.	358/166
4,723,163	A	2/1988	Skinner	
4,723,166	A	2/1988	Stratton	
4,725,966	A	2/1988	Darby et al.	
4,725,967	A	2/1988	Aiba	
4,731,648	A	3/1988	Bernard et al.	
4,734,715	A	3/1988	Shiraishi	
4,737,858	A	4/1988	DeBaryshe	
4,742,363	A	5/1988	Shiraishi	
4,758,965	A	7/1988	Liang et al.	
4,761,819	A	8/1988	Denison et al.	
4,780,711	A	10/1988	Doumas	
4,783,840	A	11/1988	Song	
4,786,923	A	11/1988	Shimizu	
4,786,963	A	11/1988	McNeely	
4,791,582	A	12/1988	Ueda et al.	
4,791,679	A	12/1988	Barski et al.	
4,805,117	A	2/1989	Fiore et al.	
4,805,226	A	2/1989	Guebey	
4,809,021	A	2/1989	Check et al.	
4,812,782	A	3/1989	Honji et al.	
4,816,905	A	3/1989	Tweedy et al.	
4,817,175	A	3/1989	Tenenbaum et al.	
4,843,380	A	6/1989	Oakley et al.	
4,847,641	A	7/1989	Tung	

4,851,909	A		7/1989	Noske et al.
4,853,970	A		8/1989	Ott et al.
4,860,119	A		8/1989	Maniwa
4,870,599	A		9/1989	Hempel et al.
4,870,611	A		9/1989	Martin et al.
4,897,805	A		1/1990	Wang
4,905,166	A		2/1990	Schuerman
4,908,866	A		3/1990	Goldwasser et al.
4,914,459	A		4/1990	Mama et al.
4,920,491	A		4/1990	Eberhard et al.
4,926,248	A		5/1990	Kobayashi et al.
4,933,689	A		6/1990	Yoknis
4,941,045	A		7/1990	Birch
4,941,186	A		7/1990	Massmann et al.
4,952,921	A		8/1990	Mosier 340/278
4,965,678	A		10/1990	Yamada
4,985,764	A		1/1991	Sato
4,989,090	A		1/1991	Campbell et al.
4,992,804	A		2/1991	Roe
4,992,874	A		2/1991	Willis et al.
5,005,139	A		4/1991	Tung
5,019,903	A		5/1991	Dougall
5,023,919	A		6/1991	Wataya 382/54
5,029,108	A		7/1991	Lung
5,032,899	A		7/1991	Sato
5,047,955	A		9/1991	Shope et al.
5,068,914	A		11/1991	Klees 382/54
5,072,291	A		12/1991	Sekizawa
5,087,973	A		2/1992	Kawahara
5,097,517	A		3/1992	Holt
5,099,319	A		3/1992	Esch et al.
5,101,274	A		3/1992	Yoshimura et al.
5,132,993	A		7/1992	Yurt et al.
5,133,079	A		7/1992	Ballantyne et al.
5,146,333	A		9/1992	Chaplin
5,182,633	A		1/1993	Antonio et al.
5,229,868	A		7/1993	Kanno et al.
5,241,428	A		8/1993	Goldwasser et al.
5,287,420	A		2/1994	Barrett
5,294,984	A		3/1994	Mori et al.
5,303,326	A		4/1994	Dean et al.
5,353,121	A		10/1994	Young et al.
5,365,604	A		11/1994	Kwok et al.
5,387,943	A		2/1995	Silver
5,392,075	A		2/1995	Gai
5,406,626	A		4/1995	Ryan
5,408,329	A		4/1995	Mailloux et al.
5,424,780	A		6/1995	Cooper
5,430,485	A		7/1995	Lankford et al.
5,442,407	A		8/1995	Iu
5,442,636	A		8/1995	Bontekoe
5,504,815	A		4/1996	Ryan et al.
5,523,796	A		6/1996	Marshall et al.
5,524,051	A		6/1996	Ryan
5,544,264	A		8/1996	Bellegarda et al.
5,555,463	A		9/1996	Staron
5,555,557	A	*	9/1996	Mailloux 382/299
5,563,963	A		10/1996	Kaplan et al.
5,583,937	A		12/1996	Ullrich et al.
5,590,195	A		12/1996	Ryan
5,710,601	A		1/1998	Marshall et al.
5,802,240	A		9/1998	Asai
5,815,671	A		9/1998	Morrison
5,838,298	A		11/1998	Shirasaka
5,845,008	A	*	12/1998	Katoh et al. 382/217
5,875,268	A	*	2/1999	Miyake 382/276
5,887,114	A		3/1999	Nakatani et al.
5,893,062	A		4/1999	Bhadkamkar et al.
5,940,190	A		8/1999	Overall et al.
5,970,205	A		10/1999	Nakamura et al.
RE36,801	E		8/2000	Logan et al.
6,133,957	A		10/2000	Campbell
6,181,383	B1		1/2001	Fox et al.
6,215,526	B1		4/2001	Barton et al.
6,233,389	B1		5/2001	Barton et al.
6,310,886	B1		10/2001	Barton
6,324,337	B1		11/2001	Goldwasser
6,324,338	B1		11/2001	Wood et al.
6,327,418	B1		12/2001	Barton
6,360,029	B1	*	3/2002	Moller 382/298

FOREIGN PATENT DOCUMENTS

EP	0192 292	8/1986
FR	2269270	11/1975
GB	2 120 899(7)	12/1983
GB	2197152 A	5/1988
JP	56-140461	11/1981
JP	58-75192	5/1983
JP	58-160986	9/1983
JP	58-162984	9/1983
JP	60-202474	10/1985
JP	60-204177	10/1985
JP	60-206318	10/1985
JP	61-75682	4/1986
JP	61-156980	7/1986
JP	61-214073	9/1986
JP	61-214661	9/1986
JP	62-20076	1/1987
JP	62-140182	6/1987
JP	62-43989	9/1987
JP	62-232087	10/1987
JP	62-274472	11/1987
JP	62-279477	12/1987
JP	62-296280	12/1987
JP	63-18877	1/1988
JP	63-24369	2/1988
JP	63-38381	2/1988
JP	63-48088	2/1988
JP	63-73479	4/1988
JP	63-82077	4/1988
JP	63-138876	6/1988
JP	63-213084	9/1988
JP	63-245174	10/1988
JP	63-307954	12/1988
JP	01-84385	3/1989
JP	64-77384	3/1989
JP	1-125070	5/1989
JP	2-131689	5/1990
JP	2-177683	7/1990
JP	6-133280	5/1994
JP	6-153169	5/1994
WO	WO 9222060	12/1992

OTHER PUBLICATIONS

J.M. Fleisher et al., "Laser Optical System of the IBM 3800 Printer", *IBM Journal of Res. Develop.*, Sep. 1977, pp. 479-483.

J. R. Klinghorn, "Character Rounding for Aphanumeric Video Display", *Mullard Technical Communications*, No. 126, Apr. 1975, pp. 230-239.

"Interlaced to Sequential Conversion for EDTA Applications," by T. Doyle, Proceedings of the Second International Workshop on Signal Processing of HDTV, 1988.

"Raster Scanned CRT Spot Shaping," by A. S. Murphy, IBM Technical Disclosure Bulletin, Jun. 1979, pp. 372-373.

"Improvement of Digital Typeface Printing," IBM Technical Disclosure Bulletin, Feb. 1985, pp. 5047-5048.

"The Computer Science and Engineering Handbook," by Allen Tucker, Jun. 19, 1997.

"Adaptive Intra-Field Progressive Scan Converter," by Sato et al., 1989 National Convention of the Institute of Television Engineers of Japan (ITEJ). (English Translation also attached.).

Jensen, Kris, Anastassiou, Dimitris, "Spatial Resolution Enhancement of Images Using Nonlinear Interpolation," 1990 International Conference on Acoustics, Speech and Signal Processing (Apr. 1990) (BAR-003365-69).

Masuda, Michio, Okamoto, Kaneyuki, Nishijima, Hideo; Ono, Koichi, Otsubo, Hiroyasu, Otsuka, Susumu, "Picture in Picture System with Digital Memory for VCRS," IEEE Transactions of Consumer Electronics, vol. CE-33, No. 3 (Aug. 1987) (BAR-00370-79).

M. A. Isnardi, "Modeling the Television Process," Ph.D. Thesis, Massachusetts Institute of Technology, May 1986;.

G. Goertzel and G.R. Thompson, "Digital halftoning on the IBM 4250 Printer," IBM J. Res. Develop., vol. 31, No. 1, Jan. 1987, pp. 2-15.

* cited by examiner

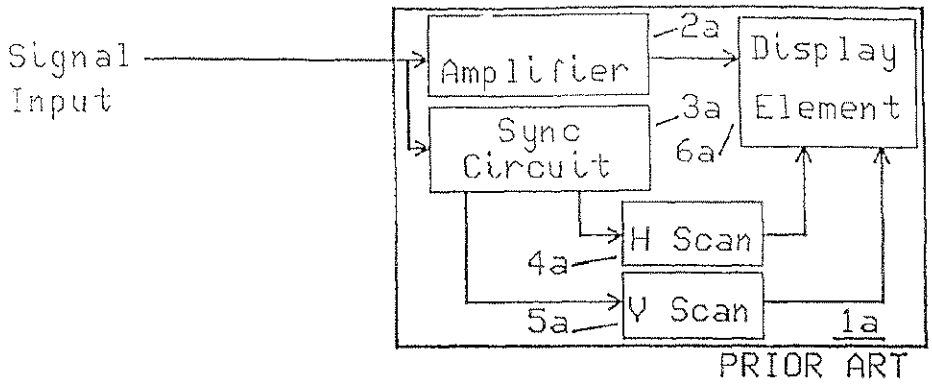


FIGURE 1

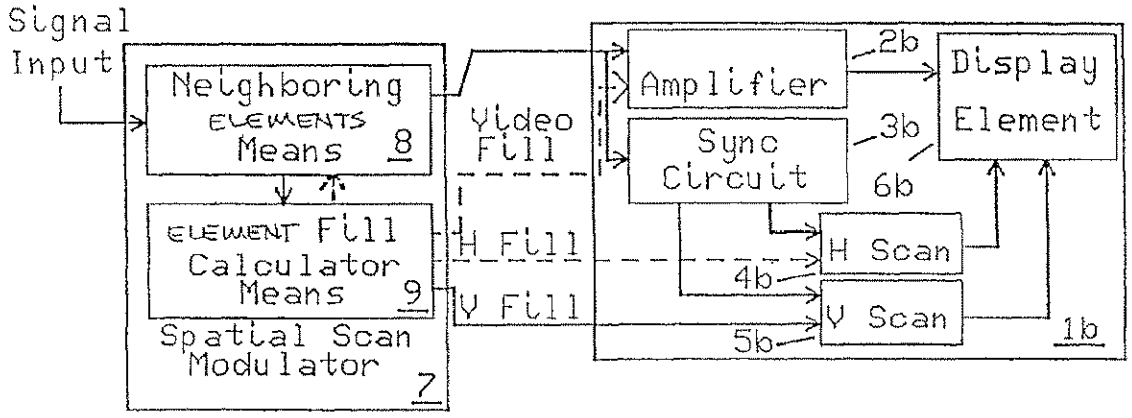


FIGURE 2

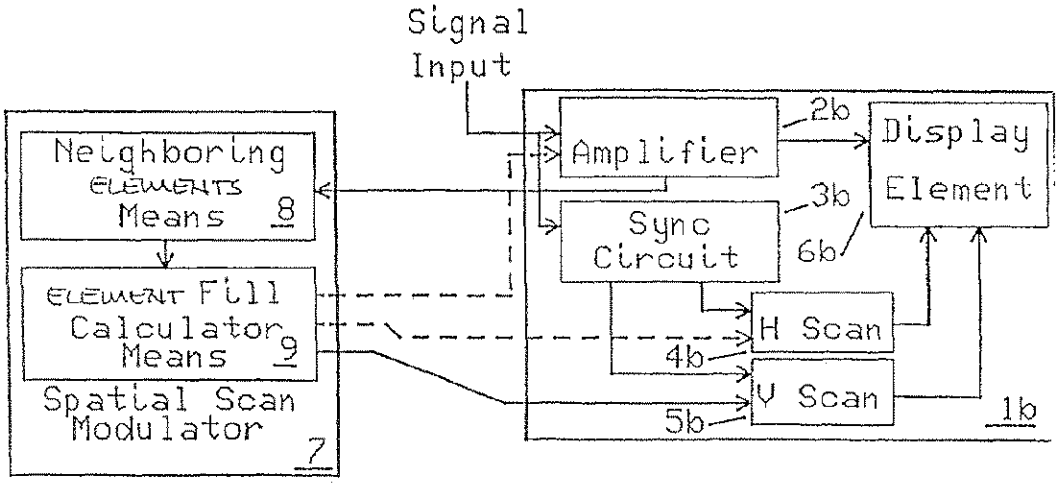
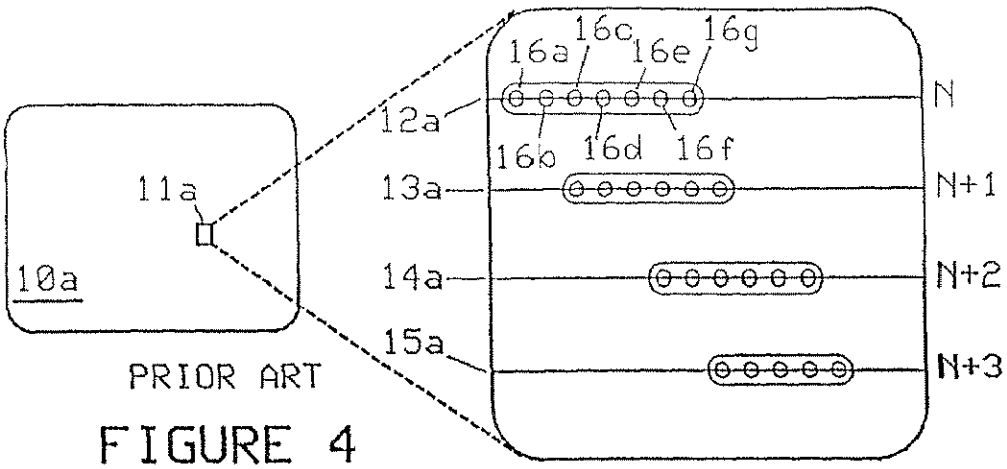


FIGURE 3



PRIOR ART

FIGURE 4

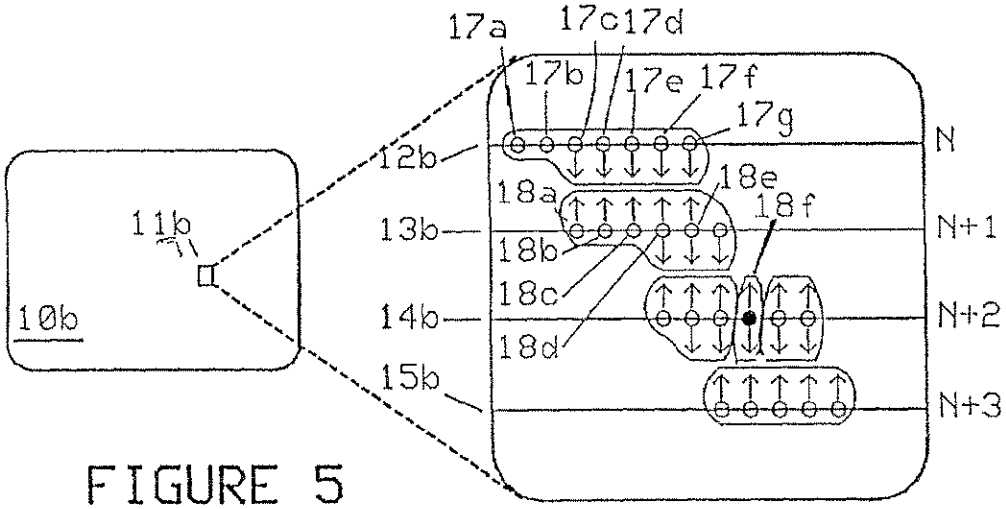


FIGURE 5

With Spatial Scan Modulation

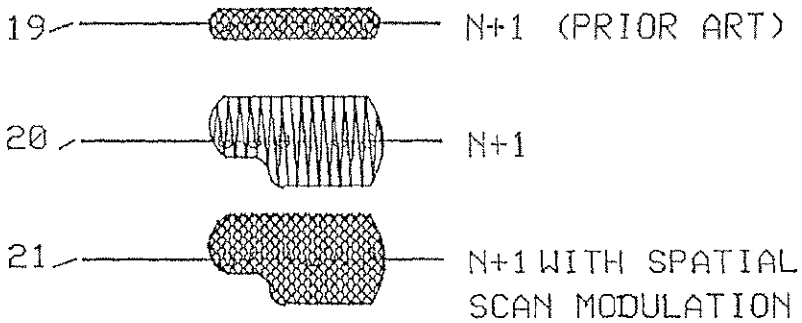
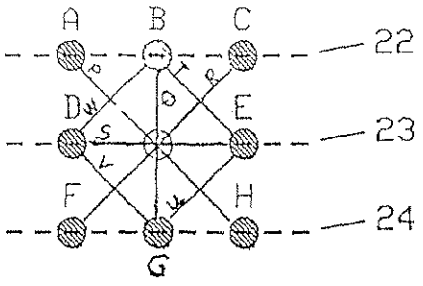


FIGURE 6



X FILL DIRECTION(S):

VERT.	IF	|B-G| < |A-H| or |C-F| or |D-E| or |B-E| or |E-G| or |G-D| or |D-B|
HORIZ.	IF	|D-E| < |B-G| or |A-H| or |C-F| or |B-E| or |E-G| or |G-D| or |D-B|
R. DIAG.	IF	|C-F| < |B-G| or |A-H| or |D-E| or |B-E| or |E-G| or |G-D| or |D-B|
L. DIAG.	IF	|A-H| < |B-G| or |C-F| or |D-E| or |B-E| or |E-G| or |G-D| or |D-B|
U. LEFT	IF	|D-B| < |B-E| or |E-G| or |G-D| or |B-G| or |A-H| or |C-F| or |D-E|
U. RIGHT	IF	|B-E| < |E-G| or |G-D| or |D-B| or |B-G| or |A-H| or |C-F| or |D-E|
L. LEFT	IF	|E-G| < |G-D| or |D-B| or |B-E| or |B-G| or |A-H| or |C-F| or |D-E|
L. RIGHT	IF	|G-D| < |D-B| or |B-E| or |E-G| or |B-G| or |A-H| or |C-F| or |D-E|

FIGURE 7

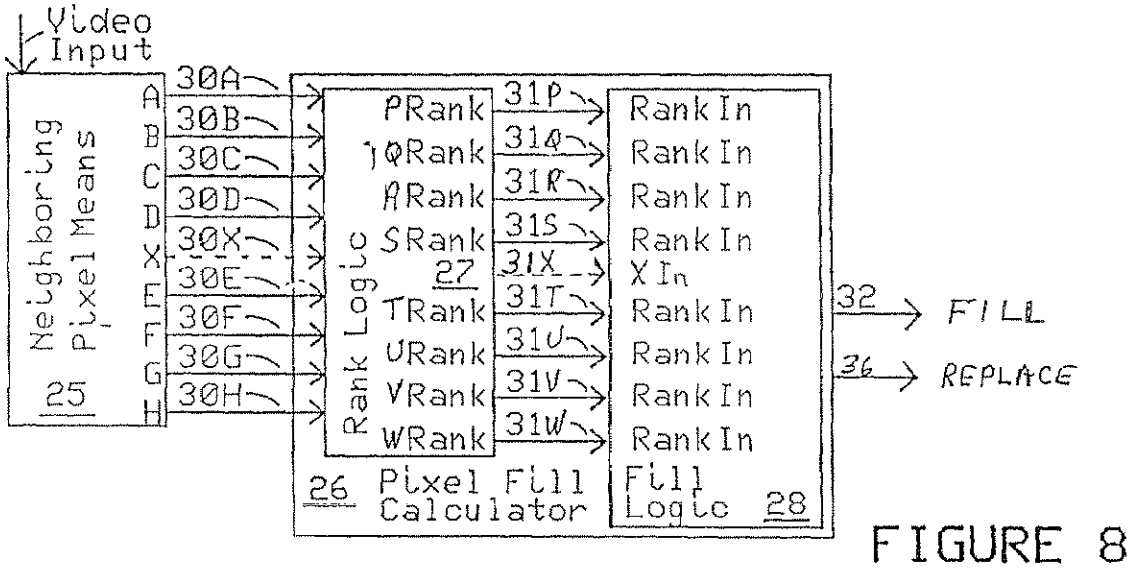


FIGURE 8

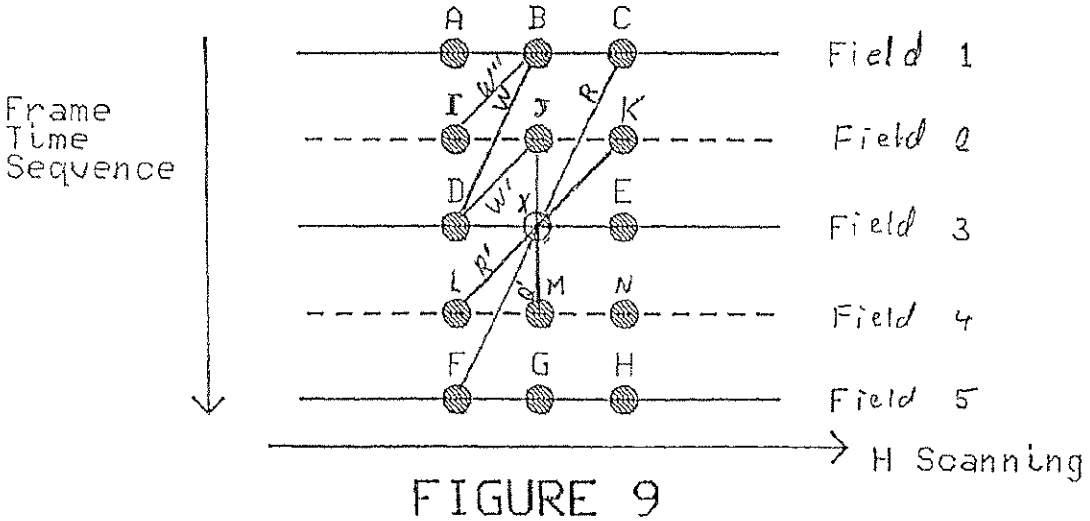


FIGURE 9

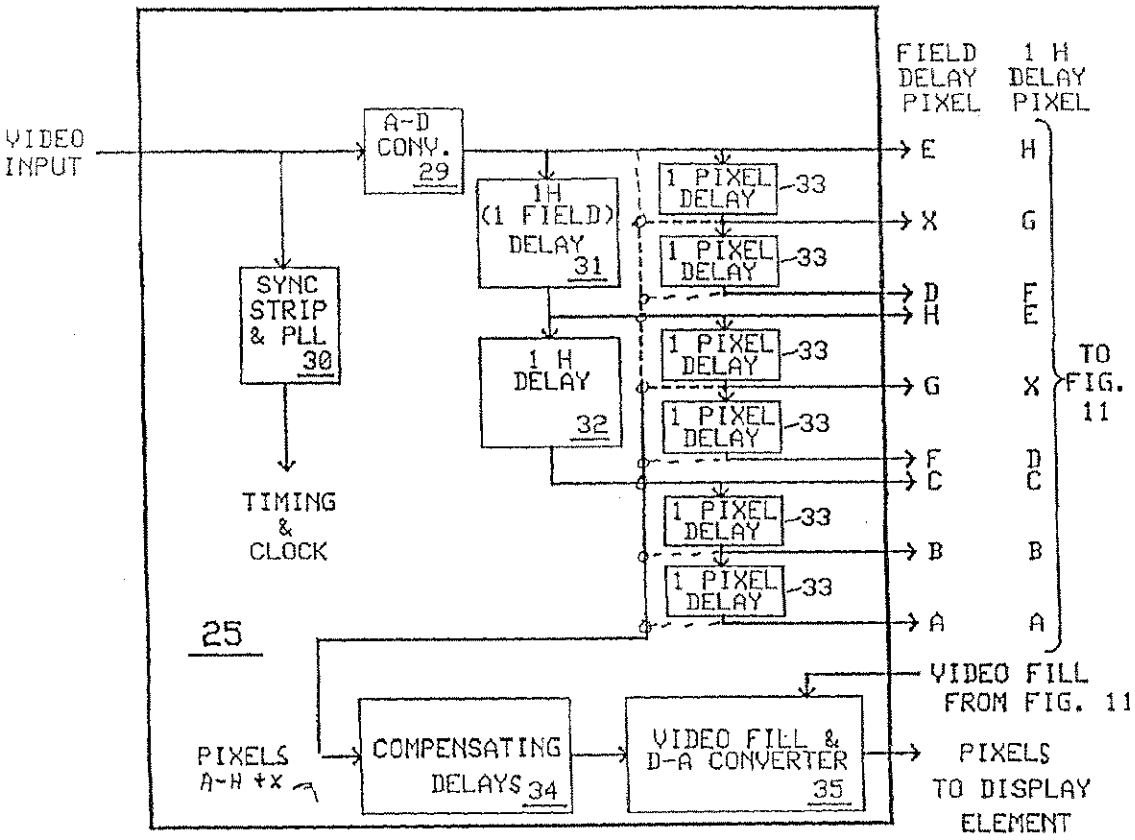


FIGURE 10

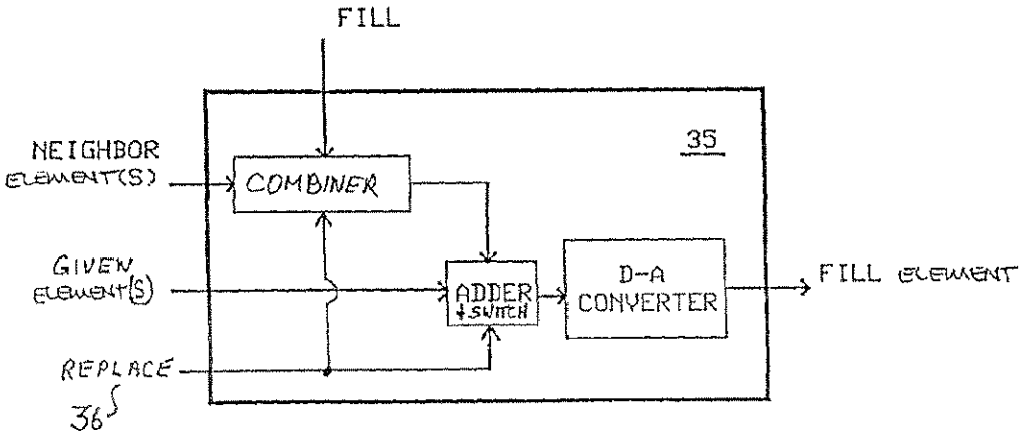


FIGURE 12

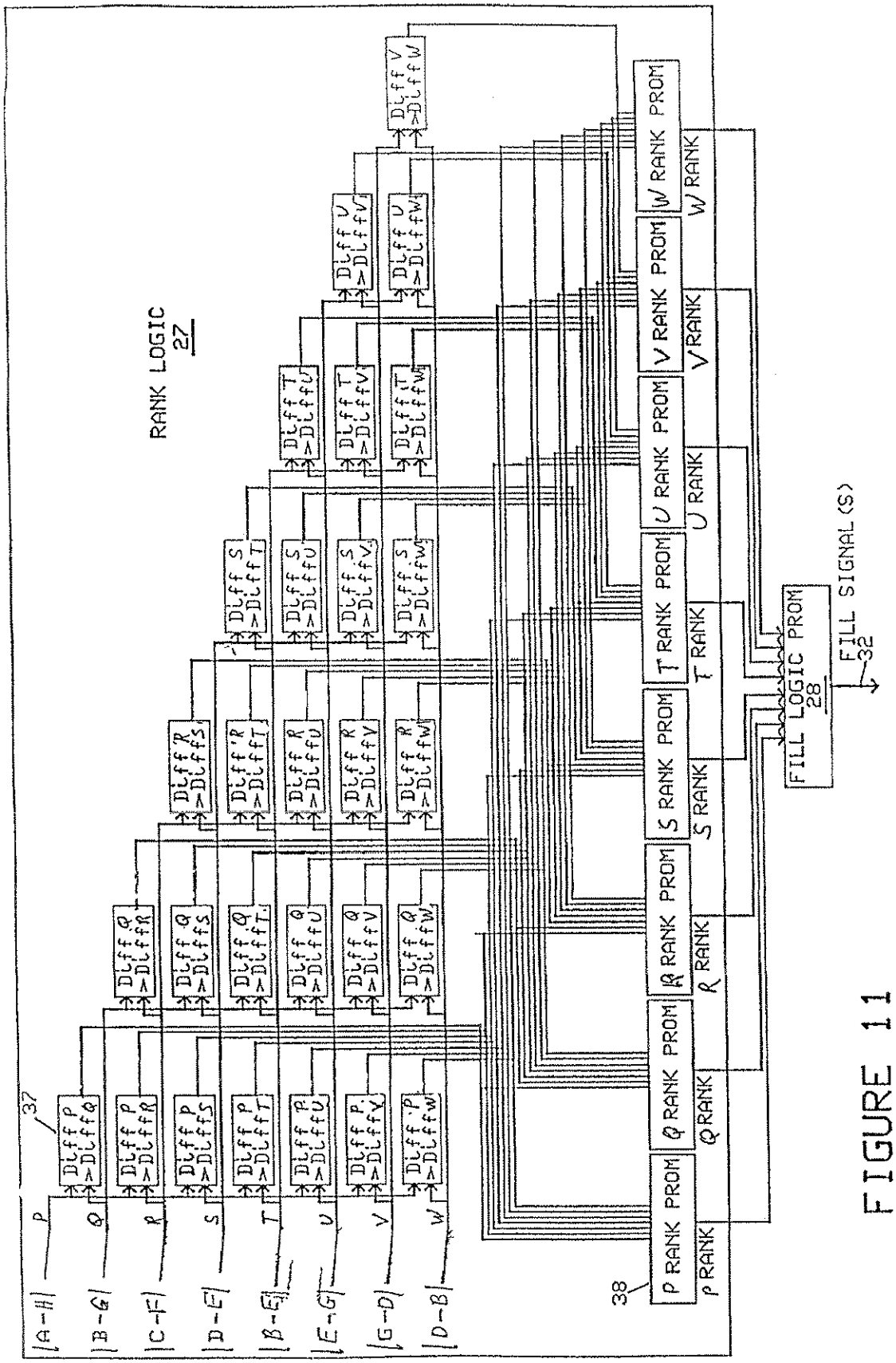

RANK LOGIC
27
37
38
P RANK PROM
Q RANK PROM
R RANK PROM
S RANK PROM
T RANK PROM
U RANK PROM
V RANK PROM
W RANK PROM
P RANK
Q RANK
R RANK
S RANK
T RANK
U RANK
V RANK
W RANK
FILL LOGIC PROM
28
FILL SIGNAL (S)
32
A-H
B-G
C-F
D-E
B-E
E-G
G-D
D-B

FIGURE 11

SPATIAL SCAN REPLICATION CIRCUIT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional application of U.S. patent application Ser. No. 08/398,383 filed Mar. 3, 1995, now U.S. Pat. No. 6,529,637 which is a continuation in part of U.S. patent application Ser. No. 08/119,610 filed Sep. 13, 1993 (now U.S. Pat. No. 5,424,780), which is a continuation of U.S. patent application Ser. No. 07/355,461 filed Mar. 22, 1989 (now abandoned), priority of which is claimed.

FIELD OF THE INVENTION

An apparatus and method is shown for modifying the creation and/or presentation of image information displayed, printed or created on a raster or matrix image or graphic display or printer, thereby increasing the apparent image quality. Means for deriving a plurality of neighboring image elements or elements of the video signal which neighbor in time or space to a common location, and means for determining the image elements replication at such location in response thereto, are also shown. Particular embodiments relation to increasing the apparent temporal and spatial resolution of raster scanned television computer and permanent copy devices are shown.

BACKGROUND OF THE INVENTION

This invention relates to increasing the apparent temporal or spatial resolution of a created and/or displayed image which is typically produced by ordered groups of elements such as by a raster or matrix element or device, without a required increase in the number of image elements of the image.

DESCRIPTION OF THE PRIOR ART

As television, computer, graphics, printers, fax machines and related image technology develops, there is increasing emphasis on improving the quality of created, displayed, or stored images in order that they appear more real and pleasing to the human observer. Two of the parameters which affect image quality, and therefore are subject to improvement, are spatial and temporal resolution. Spatial resolution, simply put, is the number of image elements which are used to make up an image, normally static, and correspondingly, temporal resolution is the number of elements per unit time which make up an image, normally moving. Desirable qualities of an image system, such as television camera, scanner, broadcast television, computer display printer, permanent copy device, etc. will ideally include having as many elements per image or frame and, in the case of moving images, as many elements or frames per unit time as is economically feasible. Unfortunately, increasing the number of image elements per frame or the number of frames per second is a costly improvement. Therefore many schemes have been developed to improve the resolution of the image, while reducing the number of elements used.

Other improvement systems, such as various Scanner Interpollation Techniques, improved Definition Television Systems (IDTV), Advanced Television Systems (ATV), and High Definition Television Systems (HDTV), Hewlett Packard's Laser Printer Resolution Enhancement System, and other Image Enhancers typically operate to increase the resolution and other quality related aspects of image systems. Many of these systems resort to various techniques for such quality improvements, some of which generate unwanted artifacts.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide an apparatus and method for improving the apparent quality of a created and/or displayed image by altering the size, shape or position of the elements of the image.

It is an object of this invention to allow usage of a low resolution camera and/or recorder in a high resolution video distribution and/or display system.

It is another object of this invention to provide an apparatus and method to alter the size, shape or position of the elements of a scanned or presented image in response to the relationship between a plurality of elements of the image.

It is a yet further object of this invention to provide a means and method for inspecting a plurality of elements of an image to determine the presence of a need for filling of areas between the elements.

It is yet another object of this invention to provide a means and method for simultaneously providing a plurality of elements of said image for inspection and comparison means to determine proper altering of areas between the elements or voids created by defective or unneeded elements.

It is an additional object of this invention to provide a means and method for inspecting a certain element or location with respect to one or more surrounding or neighboring elements of an image to determine the desirability for changing the shape, position or size of other elements to improve the spatial and/or temporal resolution relationship between the elements, which may neighbor in time or space.

It is an additional object of this invention to provide a means and method for inspecting neighboring elements with respect to one or more other elements of an image to determine a need for changing the shape, position or size of elements to improve the spatial or temporal resolution relationship with the other elements, especially when one other element is defective.

It is yet still another object of this invention to provide a means and method to improve the quality of an image by inspecting a plurality of neighboring elements to generate replication elements in response thereto.

It is a further object of this invention to provide a means for replicating non-defective image elements while producing no ascertainable artifacts.

It is still yet another object of the invention to apply the above objects to any physical phenomena or signal which can be represented as a matrix of discrete elements.

It is still another object of this invention to provide an image creation device utilizing the above objects.

According to an aspect of this invention, the inventive concepts disclosed herein show an apparatus and method for modifying the creation storage and/or production of an image by device in response to the image content thereof as carried by an image bearing signal, in order to create an image having apparently higher quality than normal.

The preferred embodiment of the present invention describes a neighboring element means for providing a plurality of neighboring elements, and an element replication means responsive to said plurality of neighboring elements to selectively fill a location, which may be a void, or artifacts, between elements, or to replace elements in the

spatial or time dimensions or both. The inventive concepts disclosed herein may be utilized to improve the apparent resolution of the created and/or displayed image spatially, temporally, or both, or to conceal, by replication including modification, and/or creation of otherwise non-existant, defective or unneeded image elements or artifacts. The invention will find considerable use in the reduction of spatial or temporal (motion) artifacts of improved television systems like HDTV.

It will be understood that the term image as used herein is meant to apply to the creation and/or presentation of any phenomena by a raster or matrix of discrete or adjoining elements, and that the raster or matrix may be either a single one, or a given one of a plurality or sequence of rasters or matrices, for example as used in temporal portraits of such physical phenomena. The image can be visable on a display (such as a computer monitor or regular television set), viewable after creation (such as a laser printer or fax machine) or otherwise exist (such as in memory for subsequent use or on a recorder tape). The term image is applicable to the creation of an image (for example at a low resolution to camera); on recording (for example on a VHS machine for HDTV transmission), on receipt (for example NTSC reception on an HDTV monitor) or otherwise.

It will be further understood that invention has application to a group, or series of such elements, whether transmitted or stored, in time sequential or parallel arrangement or in any other form. The more important aspect of the invention is the operations on the elements which have some spatial or temporal coherence or probability of similarity. It is of lesser importance what the elements represent or how the elements are conveyed, or of the particular nature or make up of the form of the elements.

It will be also understood that although the word void is used in this specification, the invention is directed towards replicating new image information utilizing neighboring image elements, which new image information is utilized at a certain location(s). These locations might or might not have previously had image information available therefor. The void may exist at the point of image creation, before/after storage and/or at the point of presentation. Examples of voids would include such things as defects, unwanted elements, improper elements, corrupted elements, valid but replacable elements, locations with no image information, and/or other locations or elements which may be in question or need for improvement. The term void is used to cover all these and similar situations for uniformity.

It will also be understood that although the word combination "filling in" is used in the specification and claims, the invention is directed towards replicating an image element at a particular location—again, an image element which might or might not have previously had information available therefor. This replication includes creating, modifying, replacing, substituting, adding to, providing and/or filling in for the element at this location. This term filling in is used to cover all these and similar situations for uniformity.

It will also be understood that although the word "similarity" is used in the specification, the invention is directed towards the use of any of the various element characteristics to determine similarity, which characteristics can be used alone or in combination thereof. For example, the elements both may be of the same color, but of different brightness; they both may be of same brightness, but of different hue; they both may be of the same luminance but of different color saturation; they both may be of same saturation and luminance; they both may be the same size; they both may have the same relationship to their surroundings; or otherwise be similar in some one or combination of characteristics. Characteristics by which similarity can be determined include color, hue, color saturation, luminance (brightness), size, detail, pattern, special frequency component in horizontal or vertical or diagonal or time or other dimensions, temporal frequency, content, relationship of neighboring elements, noise, and/or other external measures such can be derived from a detection circuit which would provide a flag or measure and/or other indication that an element or group of elements are suitable for processing. The element or location which is being processed may or may not be a valid or erroneous element: It might even have had no image information or not previously existed.

It will also be understood that although the word "replication" is used in the specification, the invention is directed towards modifying, correcting, improving, substituting for, adding to, replacing or otherwise processing the image so as to provide for an overall, more pleasing or apparently higher quality image. As previously set forth the word "fill in" is used in this specification for similar attributes as replication.

It should be understood that the word "surrounding" is used in this specification to describe elements which have some relationship to other image elements, be the relationship special or temporal. The word surrounding could include elements which are neighboring on one side thereof, neighboring on all sides, adjacent thereto, spaced from diagonally with intervening elements between (such as in a interlaced field scan device wherein alternating fields are paired), immediately adjacent or spaced elements which have a statistical ability of being similar, or merely elements that have a greater than minimal statistical probability of being similar. However, in respect to this latter it is preferred that the percentage of similarity, is over 50%.

It should be understood that the invention has application during the creation of an image (for example at a video camera), at the storage of an image (for example before or after a video tape or disk) and/or in the production of an image (for example a video monitor).

The objects and features of the invention will be apparent to one skilled in the art from a consideration of the following description and claims, when read in conjunction with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

The structure, operation, and advantages of the presently disclosed preferred embodiment of the invention will become apparent when consideration of the following description taken in conjunction with the accompanying drawings wherein:

FIG. **1** is a block diagram of a typical prior art image generating device.

FIG. **2** is a block diagram of the device of FIG. **1** including the present invention.

FIG. **3** shows a modification of the drawings of FIG. **2** wherein the spatial scan modulator is

FIG. **4** shows a typical prior art scanned image display with a portion expanded for clarity.

FIG. **5** shows a typical scanned image display as would occur with the use of the present invention, with a portion expanded for clarity.

FIG. **6** shows a detailed diagram of a given scan line of an image in prior art form and in improved form resulting from the present invention.

FIG. **7** shows a group of nine neighboring image elements which may be operated on by the present invention.

FIG. **8** shows a diagram of the present invention including the use of a ranking means.

FIG. **9** shows a diagram of 15 elements taken from scan line of 5 sucessive image fields.

FIG. **10** shows a detailed diagram of an embodiment of a neighboring means for a image display.

FIG. **11** shows a detailed diagram of an embodiment of a element calculator means.

FIG. **12** shows an alternate embodiment of a fill and D-A converter.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is a block diagram of a prior art image display device **1***a* which may be improved by the addition of the present invention. The invention is set forth in its preferred embodiment in primary reference to a image display, in this specification a video display. However, this device may be any of those which are well known in the art which create, store and/or convey physical phenomena by use of ordered groups of elements, such as various matrix and raster type displays or hard copy generating display devices such as various cameras, scanners, televisions, laser printers, fax machines and the like. For the purpose of the present description and explanation it will be primarily presented with the device **1***a* that is a raster scanned display such as an electron beam scanned CRT or a laser scanned photo sensitive surface operating in a progressive (non-interlaced) mode. This device may also operate in interlaced fashion as will be apparent from the present disclosure and in other creation, recording and presentation forms. However for the purpose of the present explanation of the invention, by way of example, it will be assumed that it is a video display operating in a progressive mode.

This display device normally contains an amp **2***a* which receives, clamps, amplifies and couples the signal to the display element **6***a*, which is most commonly a CRT or modulated laser but which also could be modulated LED's or LCD's or other image creation device.

The device shown is a video device also contained in the device **1***a* is a sync circuit **3***a* which receives the signal, strips the composite sync therefrom, separates the composite sync into H and V components and couples these components to the H scan **4***a* and V scan **5***a* circuits respectively. The scan circuits **4***a* and **5***a* provide the scanning control of the display element **6***a*, for example by providing the ramp drive waveforms to the CRT yoke or displacing the laser beam, or modulating the imaging devices suitable modifications would have to be made for an image creation device like a camera.

It will be recognized by one skilled in the art that the device shown by way of simple example in FIG. **1** has many practical variations which are commonly used. The single connecting lines shown between elements will be understood to carry multiple signals as required, and other configurations may be made. For example, the sync circuit **3***a* is sometimes configured to receive one or more sync waveforms separate from the image signal. The actual scanning process may be by alternate methods as well, operating in progressive or interlaced fashion, including magnetic and electrostatic deflection of an electron beam such as in a CRT or E.B. recorder, electro-optical or mechanical deflection of a light beam such as in a laser projector, fax machine, printer or electro-optic display device, or by address or pixel selection as with thermal, inkjet, flat panel, florescent, LED or LCD type displays or printers. The device might also be

an image creation device, whether video tube, CCD or otherwise. Further the processing may occur at imaging prior to recording, after recording, in or out of memory or at any other time the image information is available.

One skilled in the art will be able to utilize the present invention with any of the many image creation, recording, memory and/or display devices which utilize ordered groups of image elements to eventually set forth image phenomena as are known in the art.

The description given herein is by way of example with primary respect to a video monitor. As previously mentioned, video refers to the groups of elements irrespective of their use or form of existence or creation and will be understood to mean such even though described with primary respect to television elements.

FIG. **2** is a block diagram of a display device **1***b* like **1***a* of FIG. **1**, including amp **2***b* corresponding to **2***a*, sync circuit **3***b* corresponding to **3***a*, H scan circuit **4***b* corresponding to **4***a*, V scan circuit **5***b* corresponding to **5***a* and display element **6***b* corresponding to **6***a*. FIG. **2** also shows the spatial scan modulator **7** as an embodiment of the present invention containing neighboring element means **8** responsive to the signal to provide a plurality of neighboring elements to the element replication means **9**. Neighboring element means **8** may also be responsive to element replication means **9**, as will be discussed with respect to FIGS. **10** and **11**. The neighboring element means **8** also provides a delayed version of the signal of the amp **2***b* and sync circuit **3***b* in order to make up for processing delays as will become apparent to one skilled in the art from the discussion below.

Delay will be understood to encompass deriving different elements in time and/or space by a variety of well known means, including the specific example of delaying a time sequential series of image elements.

The element replication means **9** provides a V fill signal to the V scan circuit **5***b* in response to the plurality of neighboring elements from **8** in order to cause a vertical filling or dithering of the element scan or addressing at the proper times. The spatial scan modulator **7** therefore operates to determine where voids or elements to be replicated exist between elements or are created between or on elements by defective elements, and how these voids (as previously defined) are to be filled in in the image. This determination made by an inspection of a plurality of neighboring elements, and then causing the creation and/or display device to replicate, fill, replace, or otherwise modify the appropriate location in response to the fill signal. Shown as optional is an H fill signal provided by **9** and coupled to **4***b* to cause horizontal filling, and a further optional video fill provided by **9** and coupled to **2***b* to cause modulation or filling. The device can also be utilized to replicate non-defective image elements with no ascertainable artifacts (again the term void covers all situations).

As with the various display and creation devices known in the art, the fill signals (as previously defined) provided by **9** will take on different connections to the devices **2***b*, **4***b* and **5***b*, resulting from the differences in those devices.

It is the object of the fill signals from **9** to cause the appropriate filling of locations in the image by whatever means is suitable for the particular imaging device being used, whether during creation, recording, and/or presentation of the image. These locations which may be voids in the image which may be filled with all or a portion of a element, or all portions of combinations of elements, or otherwise as will be described in greater detail later, especially with respect to the specific video display embodiment FIGS. **10** and **12**.

In the present example, the voids or element locations are filled by slightly dithering the example electron, light beam or other imaging device away from its normal scan position by manipulation of the sweep circuits of the scan circuitry during creation and/or presentation of the image element.

For a light beam type device the voids may be filled by dithering, modulating or focusing the beam. For addressing type devices the dithering may be accomplished by manipulating addressing and filling as may be accomplished by such dithering. In all devices, filling may be caused by modification of existing elements.

For the device described by way of example, the V fill signal will cause the electron, light beam, imaging or creation device to be modulated vertically, either upward, downward or sideways or both to cause given scan line to become wider in an upward, downward, sideways and/or all directions. In a video circuit this can be simply accomplished by adding or subtracting a small amount of high frequency pulsating current in the sweep or scanning driver circuit in a video circuit, thus broadening the electron or laser beam slightly upward or downward from its normal position on the face of the CRT or photosensitive surface. Similarly, the H fill signal can cause a slight horizontal displacement of the beam position by adding or subtracting a small amount of high frequency current from the H sweep or scanning driver circuit. In order to accomplish diagonal or angular displacement of the electron beam, a modulation of both H and V deflection circuits may be made. Such modulation of the electron beam position is relatively easy to accomplish in terms of circuitry requiring only a bidirectional current source, or a pair of unidirectional current sources, which are switched on and off at high frequency rate in response to the fill signals, and add or subtract current in the sweep or scanning circuit, thereby slightly modulating the current flowing in the driver and thus altering the electron beam deflection. The operation thus causes a dither of the beam modulation, which will be explained in greater detail with respect to FIG. **5**.

In alternate creation/presentation circuits the signals to/from various circuits would be appropriately modified.

The beam modulation of any image conveying beam such as electron or light can also be achieved by changing the deflection, intensity, shape, duration, focus or astigmatism of the beam, and/or scanning, thereby changing the spot size and/or shape. The modulation of the conveying beam may be caused to take place in various directions as well, for example in diagonal directions, in response to the pixel replication means **9**. Such improvements will be understood and may be made by one skilled in the art in view of the present teachings.

The art of changing electron beam deflection by small amounts has been previously practiced, for the purpose of geometric scan correction. In general the exact method of effecting the modulation of the display will be determined by the nature of the display printing, or imaging device; however, one skilled in the art will be able to devise proper circuitry to practice the present invention for a given desired type of creation and/or display device, in view of the teachings herein.

The fill signal may be utilized to generate the desired elements (which may be including additional elements replication) on the input signal in response to **9**, with or without scan modulation, thus providing elements to fill in the desired blank areas of the image (which may be blank as in voids, unneeded, unwanted, or otherwise).

Filling may be accomplished by simply adding the fill signal to the signal in a monitor device so that the electron beam is caused to illuminate the CRT phosphor in response to the fill signal as well as the signal.

Illumination may be caused to occur in the absence of a signal generated illumination, or may cause the signal generated illumination to be modified, such as by being increased or decreased. The image fill signal may also be utilized to perform other image functions as will become apparent, such as reducing the bandwidth of the signal, or by changing the element or spot size for example by defocusing the electron beam, repeating a displayed element, or generating a new element (especially in non-direct scanning devices).

New elements used for filling of voids including the substitution or replication of existing elements may be comprised of all or a portion of a element or group of elements.

FIG. **3** shows the same elements as in FIG. **2**, however the neighboring element means **8** is coupled to amp **2***b* to receive the input signal, rather than directly to the input, as in FIG. **2**. Several other embodiments relating to coupling and arrangement of elements will be possible, as will be apparent to one skilled in the art, and are intended to be considered within the scope of the invention as herein described and claimed.

FIG. **4***a* shows a typical scanned image **10***a* (whether creation and/or reproduction) with a small portion **11***a* which is expanded for clarity in **4***b*. The small portion **11***a* shows four scan lines **12***a*, **13***a*, and **15***a*. The scan lines may be considered consecutive for the purpose of the present explanation, but may also be alternate as in an interlaced display, or otherwise non-consecutive. The scan lines are shown thicker during the higher illuminated portion, the thickness representing the width or intensity of the scanning beam, with the narrow line representing the scan track normally followed by the beam, as is common for laser beam projection and recording devices and CRTs. Also this scan line is representative of what exists in alternate imaging devices.

With more modern creation and/or presentation devices the modification is more theoretical-occuring in electronic form during and/or after creation instead of during presentation.

Scan line **12***a* has seven illuminated element points **16***a* through **16***g* identified for clarity. As with many systems, the individual elements typically blend together when sequentially aligned along a scan line, due to both the width of the beam, and the limited bandwidth of the video amplifiers in the device, giving rise to the continuous highlighted areas shown. It will be understood that the individual elements may also represent a matrix display rather than a scanned display. The four scan lines show a diagonal bright area which can be seen to take on a rather stair stepped appearance. The stair stepping and the space between the scanning lines make up picture artifacts that viewers find objectional in viewing the image, whether created during creation and/or presentation.

It is one object of the present invention to fill in the voids of the stair stepping and voids between consecutive scanning lines, for example by modulating the scanning of the electron beam in a video device, thus reducing these objectional artifacts.

FIG. **5***a* shows the same display **10***b* as **10***a* in FIG. **4***a*, with expanded portion **11***b* corresponding to **11***a*, and showing scan lines **12***b*, **13***b*, **14***b*, and **15***b* corresponding to **12***a*, **13***a*, **14***a*, and **15***a* respectively. Again the creation/alteration presentation circuits would be appropriately modified.

Illuminated elements **17***a-g* corresponding to **16***a-g* are shown as well as illuminated pixels **18***a-e*. For each element

which is to be partially modulated during creation or during production, an up or down arrow is shown indicating the direction(s) of modulation. For example, element **17***b* is modulated downward to fill the void between **17***b* and **18***a*. Likewise elements **17***c-g* are all modulated downward. Elements **18***a* and **18***b* are modulated upward to fill the same void and **18***c-e* are modulate both upward and downward. One skilled in the art will recognize that the image of FIG. **5** has a higher apparent resolution than that of FIG. **4**, the improvement being a result of the filling of voids (even if previously occupied by valid elements). This modulation can occur in the original image scanning circuitry, modifying the element signal during or after storage, or otherwise. The same type of image modification would also occur in alternate imaging devices such as scanners, laser printers or fax machines.

With respect to FIG. **2**, when element **18***a* is being scanned, the neighboring element means **8** would provide the elements adjacent to **18***a*, including **17***b*, **17***c*, **17***d*, and **18***b*, for inspection by element replication means **9**. The element replication means **9** will determine that there is a void between **17***c* and **18***a* which should be filled, thus causing **18***a* to be modulated upward into the void. The void may be actual or artificial (as when the device ignores valid elements).

It can be seen from inspection of FIG. **5** that a good portion of the voids between scanning lines or matrix elements, as well as a portion of the stair stepped edge void have been filled in. Element **18***f* is shown as being a defective element which has been replaced thus causing filling of the void which otherwise would have been present to be filled.

It may be noted that an object of the present invention is to provide a method of filling voids without restriction to the nature of how such voids arise, although it will be appreciated that the nature of such filling may very will be optimized in response to the nature of the void and that the voids might discard valid image elements at the involved location. For example the filling of voids between elements may be performed differently than the filling of voids created by defective elements. As another example, assuming **18***f* were defective due to a defective video element, the element may be replaced to cure the defect. If, on the other hand, the element for **18***f* were not defective by itself, the artifacts produced by a defective florescent element, the location could be filled by lighting, or increasing the lighting of the neighboring elements. Further, the invention may be utilized to replicate valid, non-defective image elements due to the probability of similarity. This allows continual processing of a signal through a circuit without on/off switching while producing minimal artifacts.

FIG. **6** shows a typical prior art scan line **19**, corresponding to **13***a* of FIG. **4***b*, having an illuminated section of 6 elements shown as a wider portion of the line. The elements may be created in any known way such as by scanning light or electron beams, LED's, LCD's or laser beams, by spatial addressing an imaging device or by signal alteration.

As with the previous example of FIGS. **4** and **5**, the individual elements have blended together gaining a continuous illuminated section. The presented scan line **20** shows the same line as **19**, except that it has been spatially modulated in accord with the present invention thus corresponding to **13***b* of FIG. **5***b*. The track of the beam is shown in **20** as a sinusoidal path, or spatial modulation, which deviates from the straight scanning line of the prior art. This same result could be provided by alternate means.

Note that for the left two elements the deviation takes place both above and below the line. In the preferred embodiment of the invention the electron beam or memory laser path is such that the track pitch, the spacing between the points where the track crosses the normal scan line, is less than the electron or reproduction beam width. Therefore the electron or beam width will illuminate a solid area. The illuminated area created by the beam path shown in **20** is shown as a solid are in **21**. It will be noted that the ability to fill in chosen directions only, such as only up to **21**, is an important feature.

A note should be made about the relative brightness of the spatially modulated scan of **21** versus the area of the prior art scan **19**. The brightness of a given area is a function of the flux density of the electron, light beam or image signal striking that area, that is a given number of electrons or photons or other image creating energy will tend to provide a given number of photons of visible light or particles of dye or pigment, independent of the area which it strikes. For a given electron or beam intensity, the area of **21** will therefore appear dimmer in terms of visible photons or particles per unit area than the area of **19**. If a given spatial scan modulated area of the image is large enough to be resolved as a distinct element, the viewer may notice this decreased intensity. In order to overcome this decreased brightness, it will be desirable to increase the intensity of the image creating beam, therefore restoring proper brightness in those areas where the spatial modulation is occurring. The brightness increase will typically be a function of the amount of modulation. For example while the beam is modulated only upward for the left two elements of **20**, a first given increase should be made, and for the remaining elements where the beam is modulated both up and down with a second, higher, increase made. This increase in beam intensity can be made in response to element replication means **9** shown in FIG. **2**, via the fill signal. It may also be desirable to utilize the fill signal to increase the number of illuminated elements, in conjunction with the spatial scan modulation. For example, the illuminated area of line **20** (**13***b* of FIG. **5**) can be tuned on one element early in order to further reduce the stair stepping of the diagonal edge. This may be accomplished by time or spatial modulation of the image creating beam.

Alternate imaging devices would similarly operate, albeit with adaptions for their special properties. For expample, with a LED or LCD imaging device (such as a printer), modifications of the brightness of successive lines of image information and/or the modulation of the image elements in what would otherwide be spaces between lines would be one way to produce the image improvement of the present invention.

FIG. **7** shows a group of 9 elements which are located on 3 scan lines of a raster or alternatively in 9 matrix locations. These nine elements are provided by the neighboring element means and may be utilized by a element replication circuit in order to determine if spatial scan modulation or other filling should be enabled. In the following discussion it will be assumed that element X (the central element) is defective or wanted to be replaced, as is known from error detecting circuitry or as determined by the element replication **26**, or is otherwised to be replicated. It will be assumed for the purpose of the present example that element X in the center of the 9 elements, is the element about to be displayed or created by the display element. Scanning will be assumed to be from left to right, top to bottom. However it will be understood that the present explanation will apply equally well to any image creating and/or displaying device or system independent of the manner in which the image

elements are scanned or placed as well as to any point of the image for example element A in FIG. **7** could be processed.

For the described scan, elements A-D will have occurred in time before X, and elements E-H occur in time after X. The 9 elements are all made simultaneously available to the elements replication by the neighboring elements means (**8** of FIG. **2**). The neighboring elements means in the preferred embodiment is made up of memories, delay lines, shift registers or other delay devices which are well known to one skilled in the art, which allow all nine of the elements to be present simultaneously. A different number of elements could also be present.

A device which can be utilized for the neighboring elements means function is described, with respect to FIGS. **9** and **10**, in U.S. Pat. No. 4,573,070 issued Feb. 25, 1986. Other arrangements and circuits to perform this function will be apparent to one skilled in the art from the present disclosure, for example, retrieving elements from RAM as in matrix displays. In order that elements X can be the about to be currently displayed elements, it is necessary that neighboring elements means make elements available to the display device, which is shown by the connection from **8** to **2***b* and **3***b* of FIG. **2**, which replaces the video input to the display device.

FIG. **7** shows eight possible replication direction differences which can determine the direction of replication for an element X. This element X could be defective, non-existant merely unnecessary, or disposable (even if valid)—the latter most particularly in respect to an unswitched, constantly operating device. The major factor is the desire to have element, replication, or substitution. The eight differences are represented by eight lines P-W. Line P represents the difference of elements A and H, Q of elements B and G, T of elements B and E, etc.

Element X may well be replicated from any direction, including those of the third dimension, which would represent a frame to frame or time direction, or a combination of time and spatial dimensions. Replication in the time dimension is useful in improving motions artifacts. Time replication is accomplished by using delays of one picture period (field or frame in a monitor device) or more to provide elements in the time axis, which may be used to fill temporal voids. It is particularly useful in a video imaging device.

Element X will thus modulated in response to elements which are present in field or frames other than the one containing X. U.S. Pat. No. 4,573,070 which is incorporated herein by reference describes more fully various embodiments of neighboring elements means which may be suitable for use in this fashion, and particular FIGS. **13**, **15** and **16** and the description thereof teach detection of a defective element X. Alternatively, the detection of a defective element X may be performed by various defect or error checking circuitry as is well known in the art.

It will be immediately recognized that by comparing elements on the opposite sides of X, it is possible to determine which pair of surrounding or neighboring elements which are most similar. The most similar pair thus represents the pair of image elements most likely to provide the least noticeable replication value for an element X, and also indicate the direction(s) of modulation of X to fill voids adjacent thereto. For example if A-B=9, B-G=7, C-F=8, and D-E=3, the preferred pair of elements for replicating X would be pairs D and E and either could be chosen for replication. Alternatively, a normalized combination of the two pairs such as an average can be used.

This logic holds true if in fact X is related to elements on two opposite sides. However X may be related only to the elements in the corners, that is to elements A, B, and D (upper left), B, C, and E (upper right), E, H, and G (lower right), or G, H, and D (lower left). The logic conditions shown below thus preferably takes all eight conditions into account, selecting the lowest difference pair of opposite or corner elements to determine the direction(s) of modulation of X, to fill voids adjacent to X, or giving the direction or pair of elements most likely to provide the least noticeable replication value for an element X in FIG. **7**.

For the purpose of the present description and the purpose of explanation, it will be assumed that only the two dimensions, and the replication directions indicated by the 7 differences are to be considered.

A group of similar elements is easily implemented by logic operations as may be utilized to determine which if any of the 8 spatial replication directions should be enabled for a given elements X. Logic operations that may be used to enable the modulations according to the following table include:

MODULATION DIRECTION	CONDITION
VERT.	B-G < A-H or C-F or D-E or B-E or E-G or G-D or D-B
HORIZ.	D-E < B-G or A-H or C-F or B-E or E-G or G-D or D-B
R.DIAG.	C-F < B-G or A-H or D-F or B-E or E-G or G-D or D-B
L.DIAG.	A-H < B-G or C-F or D-E or B-E or E-G or G-D or D-B
U.LEFT	D-B < B-E or E-G or G-D or B-G or A-H or C-F or D-E
U.RIGHT	B-E < E-G or G-D or D-B or B-G or A-H or C-F or D-E
L.LEFT	E-G < G-D or D-B or B-E or B-G or A-H or C-F or D-E
L.RIGHT	G-D < D-B or B-E or E-G or B-G or A-H or C-F or D-E

FIG. **8** shows by way of example an embodiment of the present invention which may be utilized with image elements. The FIG. **8** embodiment contains a neighboring element means **25** similar to **8** of FIG. **2**, and an element replication means **26** similar to **9** of FIG. **2**.

The element replication **26** contains a rank logic means **28** which cooperates to inspect the 9 neighboring elements A-H and X presented on lines **30** A-H and X respectively, and provides a fill signal on line **32** and replaces signals on line **36** respectively, which device operates to control the spatial modulation of element X. It should be noted that in FIGS. **8** and **12** the fill and replace lines are shown as single lines for clarity, and further that the connection which provides element X to the display device as well as the video fill connection to the display amp are not shown for clarity. One skilled the art will however recognize the need for, and be able to provide the proper coupling of, element X and element fill and replace functions to the image device via multiple connections and couplings with the element replication as appropriate for a given application.

As will be apparent from the present teachings, many of the functions of the present invention can be implemented with various forms of hardware including ASICS, programmable logic and analog or optical circuitry and software running on any of the various well known platforms. For example, microprocessors with suitable software may be utilized. As a further example, a read only memory may be utilized. In particular, a ROM or programmable logic would be well suited to implement part or all of the elements replication means **26**.

The determination of which neighboring elements are related to element X is a ranking process, which is described in one form in some detail in the aforementioned U.S. Pat. No. 4,573,070 with respect to video noise reduction. The

'070 patent does describe and claim the replication of defective elements, for example at column 4 line 49 et. seq. and column 8 line 45 et. seq. The ranking circuitry shown in FIGS. **15** and **16** of the '070 patent can be utilized for the rank logic means of **27** of FIG. **8** of the present invention, but the rank logic means of the present disclosure has been found to provide superior performance when utilized for applications to replace defective or unneeded elements. The rank logic means **27** operates in response to the elements A-H and if needed X provided via 30A-H and 30X to determine each of elements A-H relative closeness to all the others. For example if elements C-F were determined to be closest to each other, then signifying a rank of 0 (that no other element pairs are closer) would be output on line 31R. If 2 other elements were closer than elements C and F, a 2 would be output on line 31R. Each element pair will be ranked by **27**, with that pair's respective rank provided on line 31 P-W. The fill logic means operates to select a given number, for example 2 or 4 of those elements which are closest and identifies them. The logic equations given above for the example of FIG. **7** are then used to determine the modulation and/or replication directions to be enabled. This ranking may occur by comparing all groups for similarity (parallel processing) or by comparing each group to the next group sequentially retaining the most similar (serial processing). This latter is more efficient.

Further the rank logic means may also operate to rank elements in respect to their dissimilarity, thus not utilizing elements that do not meet a minimum criteria for similarity ranking. This recognizes that elements that are known to be largely dissimilar do not have to be ranked for similarity. This provides considerable saving (of most particularly processing time) and circuit complexity since the complexity of calculations increases exponentially as to the number of elements utilized. Preferably therefore the ranking of elements would be a multi-step process: first discard dissimilar groups of elements not sufficiently similar in respect to each other and/or other sets so as to not warrant subsequent processing providing at least one set remains and then second ranking of the groups of similar elements. A threshold to establish similarity is particularly effective in the initial step.

Note that more than two elements may be compared in a group, for example groups of 3 or more may be compared. For example, group ABD, BCE, EHG, and GFD may be compared to determine the total difference, for example A-B+A-D+B-D as the difference for ABD.

As an example, assume that the element pairs have the following ranks:

P = 0	Q = 1
R = 7	S = 2
T = 6	U = 5
V = 4	W = 3

From the above chart it can be seen that pairs P, Q, and S are closest thus indicating element X is most likely related to a diagonal from element A to H. The three closest elements will be identified as A and H, and of the above logic equations the following will be satisfied:

VERT

HORIZ

L. DIAG

These equations being satisfied, the modulate VERT signal, and modulate HORIZ signal, and modulate LEFT DIAGONAL signal will be activated. As a result of the above analysis, the void between elements A, B, D, and X and E, G, H, and X would be caused to be replicated by spatial modulation of elements X if X were not defective. Alternatively, the voids and/or element X could be replicated by elements A, B, D, and E, G, and H, or combinations thereof respectively. As an improvement to the spatial modulation, the amplitude or spatial intensity of the modulation may be changed in response to the ranking of the neighboring elements. For example, if the difference between X and A is small, a large amplitude of modulation is used; and if the difference were large, a small modulation used. The amount of modulation is therefore caused to vary in response to the difference, in either spatial or temporal embodiments. Of course, intensity or other atribute modulation may also be provided as well, as previously discussed. Additionally, if element X is defective or unneeded, it may be deleted, thus creating a void, and the void may be replicated with a combination of those element pairs having the closest values, in the above example, pair A-H or Pairs A-H and B-G. For a continually operating device, element X could be replicated even if not defective.

It is important to note that by ranking the various element pair differences P-W that a very accurate prediction of the value of X may be made in the event X is defective. By inspecting the differences and their ranking, the individual surrounding elements, in space and time, which are most closely associated with X may be determined with a high probability. A combination of a plurality of those most closely associated elements may then be utilized to replace element X, to fill any voids near a good or defective X, or even to totally replace a valid element X (which would treat X as a void irrespective of its true nature).

Such combinations which have proven suitable for use include any of the various averages which are well known, including arithmetic and geometric averages, means, medians, weighted combinations, spatial and temporally filtered combinations and various interpolations and curve fittings. It has also been found that selecting a single element from the group of most closely associated elements to use for fill or replication works quite well. In particular, choosing a median value element of the most similar group has been shown to offer quite good performance. In particular, choosing the two most closely associated groups of elements, and choosing one of the two median elements of the groups, the one closest to the average of the four, has been found to give quite good performance.

In summary then, the preferred operation begins by selecting a location for image enhancement. This location may be anywhere in the image including along the edges and corners thereof. Once the location is ascertained, the plurality of groups of two or more elements having a relationship to the location are ascertained. These groups may be adjoining, neighboring, having a theoretical similarity, and may be present with a time or space variable or combination thereof. After the groups are ascertained, each image element in the group is compared to the other elements in the same group to determine the similarity or how closely the individual elements within each group match. Note that this is possible for a single element to be in more than one group. This similarity is preferably typically determined by the absolute value of A minus B or similar function (to increase operating speed and reduce circuit/software complexity). This comparison could include a preliminary dissimilarity threshold which would in operation not process elements which are significantly dissimilar to other sets or to a predetermined theoretical or percentage value of difference.

This dissimilarity threshold could be by ranking of the groups of elements or by comparison of the differences between image elements in each group.

Once the similarity within each group has been ascertained, the similarity of each group is compared to the similarity of all the other groups to ascertain which groups have the most closely matching image elements or most similar image elements. This can be accomplished by sequentially comparing the similarity of each group to a subsequent group, discarding the most dissimilar before repeating the process, by ranking the groups outright according to their similarity, or otherwise.

Once the most similar group, or groups, have been ascertained, then one or more elements within the most similar group are used to generate a replication, value for use at the particular location. The image element(s) chosen can be one of the most similar pair, an average of the most similar pair, an average of the image elements in a group of closely related image elements, an average of the most similar of the image elements within groups of associated image elements, an average of all of the image elements within the associated groups or otherwise. Further, the image elements can be replacing an otherwise valid image element, replacing a defective image element, or filling in empty spaces in time or space around the location. All this is separate of the need to determine whether or not whatever may exist at the particular location is defective, or missing since replication provides very good estimate of the noise free value of a given image element at a particular location.

FIG. **9** shows an element configuration which results from one embodiment of the present invention. From the above description it can be seen that it will be relatively easy to configure the invention to operate in time to generate new lines, rows or new fields or frames of video. Such a configuration may be envisioned by assuming that elements A, B, and C are from a first field (or row or line); D, X, and E from a third, generated field (or row or line); and elements F, G, and H from a fifth field (or scan line). Intermediate fields or rows or lines with elements I J K and L M N can also be utilized. Such a system is shown in FIG. **9** where elements A-C, I-K, L-M are taken from the incoming video signal and elements D, E, and X are fill or synthesized elements which are generated in response to the operation of the elements which are generated in response to the operation of the elements replication.

The new element X would be the value calculated for element X as described above, which is stored in a field or other memory matrix and displayed in the prior time or space sequence by the display element. Alternately, the new elements could be a calculated value derived from a plurality of the elements, as will be discussed with respect to FIG. **12**.

FIG. **10** shows the preferred embodiment of the neighboring element means **25** of FIG. **8** in greater detail in a video application. Input video is coupled to an A-D converter **29** where it is digitized and output as a digital video data stream. The input video is also coupled to a sync stripper and PLL circuit **30**, which provides all of the required clock and timing signals for the elements of **25** and also the circuit of FIG. **11**. The connection of the various clock and timing signals are not shown here for clarity. The A-D converter **29**, and sync stripper and PLL **30** are will know in the art, and are commonly found in such devices as timebase correctors and other video processing devices. One skilled in the art will be able to utilize any of a number of well known circuits and I.C.s to implement **29** and **30**. For example, the AD9502 Hybrid Video Digitizer, provided by Analog Devices of Norwood, Mass., Provides all of the PLL and digitizing functions of **29** and **30**. The digitized video is output at a fixed number of samples per line depending on the particular version of the AD9502. Digital Delays **31**, **32** and **33** are coupled to the digital video output from **29** in order to provide a plurality, in this example 9, of delayed versions of the digital video signal. 1 H delay I.C.s, suitable for **31** and **32**, are available, such as the N.E.C. UPD41101, and 1 field delay I.C.s suitable for **31**, are also available, such as the N.E.C. UPD41221. Application notes on the use of these I.C.s are available form N.E.C. Electronics Inc. in Mountain View, Calif. A 1 element delay I.C. suitable for **33** is the 74HCT374 Octal Latch, available from multiple sources. At any instant, nine different elements will then be present at the output.

Referring to FIG. **10**, one skilled in the art will note that if delays **31** and **32** are 1 scan line (1H) and delays **33** are 1 elements each, then the elements labeled A-H and X in FIG. **7** will be present at the right side output of **25**. In this example, the display of FIG. **7** is assumed to be either a progressive display, or an interlaced display without the second field shown.

Assuming, for another example, that FIG. **7** shows scan lines **22** and **24** from an earlier field of interlaced scanning, and line **23** is from a present field of scanning, one skilled in the are will recognize that if delay **31** is one field, the output from **25** will correspond to the elements depicted by FIG. **7**.

One skilled in the art will realize that the one field delay **31** will be required to make available at H, the previous field scanning line above the present field scanning line available at E. It should be noted that in many interlaced systems, the actual length of the delay will vary by one line from field to field, depending on whether the even or odd field is being delayed. In the use of the N.E.C. UPD41221 I.C., the proper alignment of input and delayed video is simply accomplished by use of the increment (INC) and decrement (DEC) controls. One skilled in the art will however, be able to construct such a delay, as is well known in the art. When used with matrix or other types of non time scanned video, RAM memories may be substituted as will be known from these teachings.

Of course the invention may be utilized with digital data, such as in D1 or D2 digital video or with fax, modem or laser printer data as will be apparent to one of ordinary skill in the art from the teachings herein. The invention is particularly useful with compressed data, and provides considerable image enhancement and reduction of both random noise and defective elements noise for such digital images, especially for JPEG and MPEG compression systems.

In order to make elements X available in analog form for use by a display element, as shown in FIG. **2**, digital elements X is displayed by a compensating delay **34**, and then coupled to a digital to analog converter and video fill circuit **35**, where it is converted to an analog signal. The N.E.C. UPD41101, or a combination of 74LS374 I.C. s, can be used for **34**. The Analog Device s HDG-0805 Hybrid Video D-A is a suitable part for the D-A function of **35**. In addition, the HDG-0805 has a 10% bright control which increases the video signal level by 10%. This 10% bright control may be coupled to the video fill signal from the elements replication. Alternatively, a separate video gain circuit may be utilized to control the video fill signal. Such gain circuits are will known in the art. In the preferred embodiment, the analog elements X may be coupled directly to the CRT. The D-A converter also maybe caused to vary the intensity of analog elements X in response to a video fill signal coupled from the fill logic circuit **28** of FIG. **11**. The

purpose of the compensating delay **34** is to ensure that element X is delayed by the proper time with respect to the element replication generation of fill signals. The compensating delay may also be used in a temporal embodiment of the present invention to provide element X at the proper time (i.e. to place element X in the proper location in the displayed element sequence) for display in response to the element replication means. One skill in the art will recognize that it will be possible to combine delay **34** with the delays **31-33** which provide the neighboring elements. For example, if **34** is to have a delay of 1 element, then element D can be coupled directly to **35**, eliminating **34**.

FIG. **11** shows the preferred embodiment of **26**, the element replication means, of FIG. **8**. The rank logic means **27** of FIG. **11** receives element A-H and computes pair differences P-W from the neighboring element means **25** of FIG. **10**. Each element A-H is compared to its corresponding partner to determine the relative difference by a difference determining circuit. Each difference is then compared to all of the other differences by a difference comparison circuits **37**. For the 8 elements A-H there are then 8 difference determining circuits and **28** difference comparison circuits **37**. Any pair(s) that has a dissimilarity to the other pairs are preferably disregarded in subsequent processing. The 7 outputs of the difference comparison circuits which are responsive to a given elements pair(s) difference comparisons are coupled to an individual ranking circuit **38**, which in the preferred embodiment is chosen to be a PROM. The PROM outputs a binary number which corresponds to the number of other differences a given difference is larger than. For example, if the difference is larger than 3 other differences, the output of the P rank P PROM would be 3.

The rank values from each ranking PROM are coupled to the fill logic circuit **28**, which in the preferred embodiment is made up of PROM I.C.s. The fill or replication logic circuit **29** generates the previously discussed replication signals and/or chooses appropriate matching elements in response to the 8 rank values. The replication signals are then coupled to replication circuit of **35** in FIG. **10**, as well as the display element, as previously described.

FIG. **12** shows as an alternate embodiment of the video fill and D-A converter **35** of FIG. **10** in applications depicted by FIG. **9**. The function of the preferred embodiment of FIG. **12** is to generate a fill element which is similar or equivalent to element X. This embodiment of FIG. **12** generates a fill element, for use as element X of FIG. **7** or **9**, in response to the video fill or replication signal from FIG. **11**. The fill element may be a combination of a plurality of elements. The fill elements may be caused to be only a single elements, or a combination of elements in response to the video fill signal. The embodiment of FIG. **12** operates to generate a combination of elements in response to the video fill signal, and combine that combination with voids around element X in the adder. The combination is then converted to analog by the D-A converter. Alternatively, a replication from element X may also be generated by the combiner, in response to the video fill signal. The replace signal **36** causes the adder and switch to replace X with the combination from the combiner. The normalization of the replication combination may also be adjusted. Various types of combinations and weighted averages can be utilized for this combination, including the use of more than two elements in the combination to generate the fill elements(s).

While the above preferred embodiment of the invention has been described by way of example, many other embodiments may be utilized to operate in a given video system. For example the invention may be utilized with interlace scanning systems, or with multiple channel displays such as RGB color displays. A matrix of less or more than the suggested 9 elements may be utilized, which picture elements may be adjacent or non-adjacent, and may be symmetrically or non-symmetrically chosen. To one skilled in the art it will be apparent from the present teachings that there are numerous variations, configurations and embodiments of the above described invention which variations may be tailored into a specific embodiment to maximize effectiveness with a particular display device and video system without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. A method for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, including the steps of:

comparing said central pixel and said one or more neighboring pixels in said first image;

generating one or more additional pixels to create increased image resolution, at least in part in response to said comparison; and

said additional pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

2. The method of claim **1** wherein at least one of said additional pixels is a combination including at least one of all of said central pixel and an additional portion of said central pixel and at least one of more of said neighboring pixels, all and a portion of one or more of said neighboring pixels.

3. The method of claim **1** wherein at least one of said additional pixels is generated in response to the average of two or more of said compared pixels.

4. The method of claim **1** wherein at least one of said additional pixels is generated in response to the weighted average of two or more of said compared pixels.

5. The method of claim **1** wherein said additional pixels are generated in one or more temporal dimensions relative to said central pixel.

6. The method of claim **1** where said additional pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

7. The method of claim **1** wherein said additional pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

8. The method of claim **1** wherein said device for displaying said improved image includes a flat panel.

9. The method of claim **1** wherein said device for displaying said improved image includes an LCD.

10. The method of claim **1** wherein said device for displaying said improved image includes a CRT.

11. The method of claim **1** wherein said device for displaying said improved image includes a computer.

12. The method of claim **1** wherein said device for displaying said improved image includes a television.

13. The method of claim **1** wherein said device for displaying said improved image includes a graphic display.

14. The method of claim **1** wherein said device for displaying said improved image includes a raster device.

15. The method of claim **1** wherein said device for displaying said improved image includes a printer.

16. A method for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, including the steps of:

comparing said central pixel and said one or more neighboring pixels in said first image;

illuminating one or more pixels to create increased resolution at least in part in response to said comparison, which illuminated pixels may include one or more of said central pixel and/or said neighboring pixels; and

said one or more pixels are spatially positioned and modulated in said improved image in one or more directions from said central pixel.

17. The method of claim 16 wherein at least one of said illuminated pixels is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

18. The method of claim 16 wherein at least one of said illuminated pixels is generated in response to the average of two or more of said compared pixels.

19. The method of claim 16 wherein at least one of said illuminated pixels is generated in response to the weighted average of two or more of said compared pixels.

20. The method of claim 16 wherein said illuminated pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

21. The method of claim 16 wherein said illuminated pixels are generated in one or more temporal dimensions relative to said central pixel.

22. The method of claim 16 where said illuminated pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

23. The method of claim 16 wherein said illuminated pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

24. The method of claim 16 wherein said device for displaying said improved image includes a flat panel.

25. The method of claim 16 wherein said device for displaying said improved image includes an LCD.

26. The method of claim 16 wherein said device for displaying said improved image includes a CRT.

27. The method of claim 16 wherein said device for displaying said improved image includes a computer.

28. The method of claim 16 wherein said device for displaying said improved image includes a television.

29. The method of claim 16 wherein said device for displaying said improved image includes a graphic display.

30. The method of claim 16 wherein said device for displaying said improved image includes a raster device.

31. The method of claim 16 wherein said device for displaying said improved image includes a printer.

32. A method for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, including the steps of:

comparing said central pixel and said one or more neighboring pixels in said first image;

turning on one or more pixels to create increased resolution at least in part in response to said comparison, which turned on pixels may include one or more of said central pixel and/or said neighboring pixel; and

said turned on pixels are spatially positioned and modulated in said improved image in one or more directions from said central pixel.

33. The method of claim 32 wherein at least one of said turned on pixels is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

34. The method of claim 32 wherein at least one of said turned on pixels is generated in response to the average of two or more of said compared pixels.

35. The method of claim 32 wherein at least one of said turned on pixels is, generated in response to the weighted average of two or more of said compared pixels.

36. The method of claim 32 wherein said turned on pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

37. The method of claim 32 wherein said turned on pixels are generated in one or more temporal dimensions relative to said central pixel.

38. The method of claim 32 where said turned on pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

39. The method of claim 32 wherein said turned on pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scab line including one or more of said neighboring pixels or other pixels.

40. The method of claim 32 wherein said device for displaying said improved image includes a flat panel.

41. The method of claim 32 wherein said device for displaying said improved image includes an LCD.

42. The method of claim 32 wherein said device for displaying said improved image includes a CRT.

43. The method of claim 32 wherein said device for displaying said improved image includes a computer.

44. The method of claim 32 wherein said device for displaying said improved image includes a television.

45. The method of claim 32 wherein said device for displaying said improved image includes a graphics display.

46. The method of claim 32 wherein said device for displaying said improved image includes a raster device.

47. The method of claim 32 wherein said device for displaying said improved image includes a printer.

48. A method for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, including the steps of:

comparing said central pixel and said one or more neighboring pixels in said first image;

changing the value of one or more pixels to create increased resolution from a first value to a second value, at least in part in response to said comparison, which pixels with changed values may include one or more of said central pixel and/or said neighboring pixel; and

said pixels with changed value are spatially positioned and modulated in said improved image in one or more directions from said central pixel.

49. The method of claim 48 wherein said change in the value of said pixels is caused at least in put by a change in the intensity and/or amplitude of the electron beam comprising a part of said device and used in displaying said pixels.

50. The method of claim 48 wherein at least one of said pixels with changed values is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

51. The method of claim 48 wherein at least one of said pixels with changed values is generated in response to the average of two or more of said compared pixels.

52. The method of claim 48 wherein at least one of said pixels with changed values is generated in response to the weighted average of two or more of said compared pixels.

53. The method of claim 48 wherein said pixels with changed values are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

54. The method of claim 48 wherein said pixels with changed values are generated in one or more temporal dimensions relative to said central pixel.

55. The method of claim 48 where said additional pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

56. The method of claim 48 wherein said pixels with changed values are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

57. The method of claim 48 wherein said device for displaying said improved image includes a flat panel.

58. The method of claim 48 wherein said device for displaying said improved image includes an LCD.

59. The method of claim 48 wherein said device for displaying said improved image includes a CRT.

60. The method of claim 48 wherein said device for displaying said improved image includes a computer.

61. The method of claim 48 wherein said device for displaying said improved image includes a television.

62. The method of claim 48 wherein said device for displaying said improved image includes a graphic display.

63. The method of claim 48 wherein said device for displaying said improved image includes a raster device.

64. The method of claim 48 wherein said device for displaying said improved image includes a printer.

65. A method for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, wherein at least a portion of said first image contains one or more shades, including the steps of:

comparing the shade of said central pixel with the shade of said one or more neighboring pixels in said first image to determine the difference in the shade between said central pixel and said one or more neighboring pixels;

if said difference is below a threshold, comparing said central pixel and said one or more neighboring pixels; and

generating one or more additional pixels to create increased resolution, at least in part in response to said comparison, wherein the shade of said one or more additional pixels is based at least in part on the shade of said cetral pixel and/or the shade of one or more of said neighboring pixels in said first image.

66. The method of claim 65 wherein at least one of said additional pixels is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

67. The method of claim 65 wherein at least one of said additional pixels is generated in response to the average of two or more of said compared pixels.

68. The method of claim 65 wherein at least one of said additional pixels is generated in response to the weighted average of two or more of said compared pixels.

69. The method of claim 65 wherein said additional pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

70. The method of claim 65 wherein said additional pixels are generated in one or more temporal dimensions relative to said central pixel.

71. The method of claim 65 where said additional pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

72. The method of claim 65 wherein said additional pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

73. The method of claim 65 wherein said device for displaying said improved image includes a flat panel.

74. The method of claim 65 wherein said device for displaying said improved image includes an LCD.

75. The method of claim 65 wherein said device for displaying said improved image includes a CRT.

76. The method of claim 65 wherein said device for displaying said improved image includes a computer.

77. The method of claim 65 wherein said device for displaying said improved image includes a television.

78. The method of claim 65 wherein said device for displaying said improved image includes a graphic display.

79. The method of claim 65 wherein said device for displaying said improved image includes a raster device.

80. The method of claim 65 wherein said device for displaying said improved image includes a printer.

81. A method for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, wherein at least a portion of said first image includes color information, including the steps of:

comparing the color information of said central pixel with the color information of said one or more neighboring pixels to determine the difference in the color information between said central pixel and said one or more neighboring pixels;

if said difference is below a threshold, comparing said central pixel and said one or more neighboring pixels in said first image; and,

generating one or more additional pixels to create increased resolution, at least in part in response to said comparison, wherein the color information of said one or more additional pixels is based at least in part on the color information of said central pixel and/or the color information of one or more of said neighboring pixels in said first image.

82. The method of claim 81 wherein at least one of said additional pixels is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

83. The method of claim 81 wherein at least one of said additional pixels is generated in response to the average of two or more of said compared pixels.

84. The method of claim 81 wherein at least one of said additional pixels is generated in response to the weighted average of two or more of said compared pixels.

85. The method of claim 81 wherein said additional pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

86. The method of claim 81 wherein said additional pixels are generated in one or more temporal dimensions relative to said central pixel.

87. The method of claim 81 where said additional pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

88. The method of claim 81 wherein said additional pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

89. The method of claim 81 wherein said device for displaying said improved image includes a flat panel.

90. The method of claim 81 wherein said device for displaying said improved image includes an LCD.

91. The method of claim 81 wherein said device for displaying said improved image includes a CRT.

92. The method of claim 81 wherein said device for displaying said improved image includes a computer.

93. The method of claim 81 wherein said device for displaying said improved image includes a television.

94. The method of claim 81 wherein said device for displaying said improved image includes a graphic display.

95. The method of claim 81 wherein said device for displaying said improved image includes a raster device.

96. The method of claim 81 wherein said device for displaying said improved image includes a printer.

97. An apparatus for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, including the following:

ranking circuitry for comparing said central pixel and said one or more neighboring pixels in said first image; and

an element fill calculator for generating one or more additional pixels to create increased resolution at least in part in response to said comparison.

98. The apparatus of claim 97 wherein at least one of said additional pixels is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

99. The apparatus of claim 97 wherein at least one of said additional pixels is generated in response to the average of two or more of said compared pixels.

100. The apparatus of claim 97 wherein at least one of said additional pixels is generated in response to the weighted average of two or more of said compared pixels.

101. The apparatus of claim 97 wherein additional pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

102. The apparatus of claim 97 wherein said additional pixels are generated in one or more temporal dimensions relative to said central pixel.

103. The apparatus of claim 97 where said additional pixels are included, in said improved image; in as one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

104. The apparatus of claim 97 wherein said additional pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

105. The apparatus of claim 97 wherein said device for displaying said improved image includes a flat panel.

106. The apparatus of claim 97 wherein said device for displaying said improved image includes an LCD.

107. The apparatus of claim 97 wherein said device for displaying said improved image includes a CRT.

108. The apparatus of claim 97 wherein said device for displaying said improved image includes a computer.

109. The apparatus of claim 97 wherein said device for displaying said improved image includes a television.

110. The method of claim 97 wherein said device for displaying said improved image includes a graphic display.

111. The method of claim 97 wherein said device for displaying said improved image includes a raster device.

112. The method of claim 97 wherein said device for displaying said improved image includes a printer.

113. An apparatus for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, including the following:

ranking circuitry for comparing said central pixel and said one or more neighboring pixels in said first image; and,

an element fill calculator for illuminating one or more pixels to create increased resolution, at least in part in response to said comparison, which illuminated pixels may include one or more of said central pixel and/or said neighboring pixels.

114. The apparatus of claim 113 wherein at least one of said illuminated pixels is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

115. The apparatus of claim 113 wherein at least one of said illuminated pixels is generated in response to the average of two or more of said compared pixels.

116. The apparatus of claim 113 wherein at least one of said illuminated pixels is generated in response to the weighted average of two or more of said compared pixels.

117. The apparatus of claim 113 wherein said illuminated pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

118. The apparatus of claim 113 wherein said illuminated pixels are generated in one or more temporal dimensions relative to said central pixel.

119. The apparatus of claim 113 where said illuminated pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

120. The apparatus of claim 113 wherein said illuminated pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

121. The apparatus of claim 113 wherein said device for displaying said improved image includes a flat panel.

122. The apparatus of claim 113 wherein said device for displaying said improved image includes an LCD.

123. The apparatus of claim 113 wherein said device for displaying said improved image includes a CRT.

124. The apparatus of claim 113 wherein said device for displaying said improved image includes a computer.

125. The apparatus of claim 113 wherein said device for displaying said improved image includes a television.

126. The method of claim 113 wherein said device for displaying said improved image includes a graphic display.

127. The method of claim 113 wherein said device for displaying said improved image includes a raster device.

128. The method of claim 113 wherein said device for displaying said improved image includes a printer.

129. An apparatus for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, including the following:

ranking circuitry for comparing said central pixel and said one or more neighboring pixels in said first image; and,

an element fill calculator for turning on one or more pixels to create increased resolution, at least in part in response to said comparison, which turned on pixels may include one or more of said central pixel and/or said neighboring pixels.

130. The apparatus of claim 129 wherein at least one of said turned on pixels is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

131. The apparatus of claim 129 wherein at least one of said turned on pixels is generated in response to the average of two or more of said compared pixels.

132. The apparatus of claim 129 wherein at least one of said turned on pixels is generated in response to the weighted average of two or more of said compared pixels.

133. The apparatus of claim 129 wherein said turned on pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

134. The apparatus of claim 129 wherein said turned on pixels are generated in one or more temporal dimensions relative to said central pixel.

135. The apparatus of claim 129 where said turned on pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

136. The apparatus of claim 129 wherein said turned on pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

137. The apparatus of claim 129 wherein said device for displaying said improved image includes a flat panel.

138. The apparatus of claim 129 wherein said device for displaying said improved image includes an LCD.

139. The apparatus of claim 129 wherein said device for displaying said improved image includes a CRT.

140. The apparatus of claim 129 wherein said device for displaying said improved image includes a computer.

141. The apparatus of claim 129 wherein said device for displaying said improved image includes a television.

142. The method of claim 129 wherein said device for displaying said improved image includes a graphic display.

143. The method of claim 129 wherein said device for displaying said improved image includes a raster device.

144. The method of claim 129 wherein said device for displaying said improved image includes a printer.

145. An apparatus for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, including the following:

ranking circuitry for comparing said central pixel and said one or more neighboring pixels in said first image; and,

an element fill calculator for changing the value of one or more pixels to create increased resolution from a first value to a second value, at least in part in response to said comparison, which pixels with changed values may include one or more of said central pixel and/or said neighboring pixels.

146. The apparatus of claim 145 wherein at least one of said pixels with changed values is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

147. The apparatus of claim 145 wherein at least one of said pixels with changed values is generated in response to the average of two or more of said compared pixels.

148. The apparatus of claim 145 wherein at least one of said pixels with changed values is generated in response to the weighted average of two or more of said compared pixels.

149. The apparatus of claim 145 wherein said pixels with changed values are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

150. The apparatus of claim 145 wherein said pixels with changed values are generated in one or more temporal dimensions relative to said central pixel.

151. The apparatus of claim 145 where said pixels with changed values are included, in such improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

152. The apparatus of claim 145 wherein said pixels with changed values are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

153. The apparatus of claim 145 wherein said device for displaying said improved image includes a flat panel.

154. The apparatus of claim 145 wherein said device for displaying said improved image includes an LCD.

155. The apparatus of claim 145 wherein said device for displaying said improved image includes a CRT.

156. The apparatus of claim 145 wherein said device for displaying said improved image includes a computer.

157. The apparatus of claim 145 wherein said device for displaying said improved image includes a television.

158. The method of claim 145 wherein said device for displaying said improved image includes a graphic display.

159. The method of claim 145 wherein said device for displaying said improved image includes a raster device.

160. The method of claim 145 wherein said device for displaying said improved image includes a printer.

161. An apparatus for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, wherein at least a portion of said first image contains one or more shades, including the following:

ranking circuitry for comparing the shade of said central pixel with the shade of said one or more neighboring

pixels in said first image to determine the difference in the shade between said central pixel and said one or more neighboring pixels;

if said difference is threshold, means for comparing said central pixel and said one or more neighboring pixels; and,

an element fill calculator for generating one or more additional pixels to create increased resolution, at least in part in response to said comparison, wherein the shade of said one or more additional pixels is based at least in part on the shade of said central pixel and/or the shade of one or more of said neighboring pixels in said first image.

162. The apparatus of claim **161** wherein at least one of said additional pixels is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

163. The apparatus of claim **161** wherein at least one of said additional pixels is generated in response to the average of two or more of said compared pixels.

164. The apparatus of claim **161** wherein at least one of said additional pixels is generated in response to the weighted average of two or more of said compared pixels.

165. The apparatus of claim **161** wherein said additional pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

166. The apparatus of claim **161** wherein said additional pixels are generated in one or more temporal dimensions relative to said central pixel.

167. The apparatus of claim **161** where said additional pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

168. The apparatus of claim **161** wherein said additional pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

169. The apparatus of claim **161** wherein said device for displaying said improved image includes a flat panel.

170. The apparatus of claim **161** wherein said device for displaying said improved image includes an LCD.

171. The apparatus of claim **161** wherein said device for displaying said improved image includes a CRT.

172. The apparatus of claim **161** wherein said device for displaying said improved image includes a computer.

173. The apparatus of claim **161** wherein said device for displaying said improved image includes a television.

174. The method of claim **161** wherein said device for displaying said improved image includes a graphic display.

175. The method of claim **161** wherein said device for displaying said improved image includes a raster device.

176. The method of claim **161** wherein said device for displaying said improved image includes a printer.

177. An apparatus for displaying a first image on a device as an improved image with increased resolution, which first image includes a central pixel and one or more neighboring pixels, wherein at least a portion of said first image includes color information, including the following:

ranking circuitry for comparing the color information of said central pixel with the color information of said one or more neighboring pixels to determine the difference in the color information between said central pixel and said one or more neighboring pixels;

if said difference is below a threshold, means for comparing said central pixel and said one or more neighboring pixels in said first image; and,

an element fill calculator for generating one or more additional pixels to create increased resolution, at least in part in response to said comparison, wherein the color information of said one or more additional pixels is based at least in part on the color information of said central pixel and/or the color information of one or more of said neighboring pixels in said first image.

178. The apparatus of claim **177** wherein at least one of said additional pixels is a combination including at least one of all and a portion of said central pixel and at least one of none, all and a portion of one or more of said neighboring pixels.

179. The apparatus of claim **177** wherein at least one of said additional pixels is generated in response to the average of two or more of said compared pixels.

180. The apparatus of claim **177** wherein at least one of said additional pixels is generated in response to the weighted average of two or more of said compared pixels.

181. The apparatus of claim **177** wherein said additional pixels are spatially positioned in said improved image in one or more directions, including a diagonal direction from said central pixel and/or positions along a sinusoidal path.

182. The apparatus of claim **177** wherein said additional pixels are generated in one or more temporal dimensions relative to said central pixel.

183. The apparatus of claim **177** where said additional pixels are included, in said improved image, in one or more intermediate image frames between an image frame including said central pixel and an image frame including one or more of said neighboring pixels or other pixels.

184. The apparatus of claim **177** wherein said additional pixels are included, in said improved image, in one or more scan lines between a scan line including said central pixel and a scan line including one or more of said neighboring pixels or other pixels.

185. The apparatus of claim **177** wherein said device for displaying said improved image includes a flat panel.

186. The apparatus of claim **177** wherein said device for displaying said improved image includes an LCD.

187. The apparatus of claim **177** wherein said device for displaying said improved image includes a CRT.

188. The apparatus of claim **177** wherein said device for displaying said improved image includes a computer.

189. The apparatus of claim **177** wherein said device for displaying said improved image includes a television.

190. The apparatus of claim **177** wherein said device for displaying said improved image includes a graphic display.

191. The apparatus of claim **177** wherein said device for displaying said improved image includes a raster device.

192. The apparatus of claim **177** wherein said device for displaying said improved image includes a printer.

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