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NEWSPIN SPORTS, LLC

UNITED STATES DISTRICT COURT

SOUTHERN DISTRICT OF CALIFORNIA

NEWSPIN SPORTS, LLC,

Plaintiff,

v.

BLAST MOTION, INC., and TAYLORMADE GOLF COMPANY, INC.,

Defendants.

Case No. **'18CV2273 BAS JLB**

COMPLAINT FOR PATENT INFRINGEMENT

JURY TRIAL DEMANDED

Plaintiff NEWSPIN SPORTS, LLC files this Original Complaint against Defendants BLAST MOTION, INC. and TAYLORMADE GOLF COMPANY, INC. alleging as follows:

I. THE PARTIES

1. NEWSPIN SPORTS, LLC ("Plaintiff" or "NewSpin") is a limited liability company organized and existing under the laws of the State of Illinois, with a principal place of business at 8468 Chicory Court, Darien, Illinois 60561.

2. Defendant BLAST MOTION, INC. ("Blast") is a corporation organized and existing under the laws of the State of California, with a principal place of business at 5803 Newton Drive, Suite D, Carlsbad, California 92008, within the Southern District of California. Blast may be served with process by serving Jodi Allison at 5803 Newton Drive, Suite D, Carlsbad, California 92008.

3. Defendant TAYLORMADE GOLF COMPANY, INC. ("TaylorMade") is a corporation organized and existing under the laws of the State of Delaware, with a principal place of business at 5545 Fermi Court, Carlsbad, California 92008-7324, within the Southern District of California. TaylorMade may be served with process by serving William Reimus at 5545 Fermi Court, Carlsbad, California 92008-7324.

4. Blast and TaylorMade are sometimes herein referred to collectively as "Defendants."

II. JURISDICTION AND VENUE

5. This is an action for infringement of several United States patents. Federal question jurisdiction is conferred to this Court over such action under 28 U.S.C. §§ 1331 and 1338(a).

6. Upon information and belief, Defendants have sufficient minimum contacts with the Southern District of California such that this venue is fair and reasonable. Defendants have committed such purposeful acts and/or transactions in this District that it reasonably should know and expect that they could be hailed into this Court as a consequence of such activity. Defendants have transacted and, at the

time of the filing of this Complaint, continue to transact business within the Southern District of California.

7. Further, upon information and belief, Defendants, respectively, make or sell products that are and have been used, offered for sale, sold, and/or purchased in the Southern District of California. Defendants directly and/or through their respective distribution networks, place infringing products or systems within the stream of commerce, which is directed at this district, with the knowledge and/or understanding that those products will be sold and/or used in the Southern District of California.

8. Blast maintains an established and regular place of business within the Southern District of California at 5803 Newton Drive, Suite D, Carlsbad, California 92008. Upon information and belief, Blast develops, tests, and provides training for its motion sensing hardware and software products, including the accused Blast Baseball, Blast Softball, and Blast Golf products, at this location within this District. Blast sells these products through its website at URL: https://store.blastmotion.com, which is accessible to consumers within the Southern District of California, as well as through third party retailers within this District.

9. TaylorMade maintains an established and regular place of business within the Southern District of California at 55545 Fermi Court, Carlsbad, California 92008-7324. Upon information and belief, TaylorMade co-developed with Blast its Spider Interactive Powered by Blast putters and associated software application described herein at this location. TaylorMade sells the Spider Interactive putters through its website at URL: https://taylormadegolf.com/taylormade-putters, which is accessible to customers within Southern District of California, as well as through third party retailers within this District.

10. For these reasons, personal jurisdiction exists and venue is proper in this Court under 28 U.S.C. §§ 1391(b) and (c) and 28 U.S.C. § 1400(b), respectively.

III. BACKGROUND AND FACTS

11. NewSpin brings this action to seek relief arising out of Blast's infringement of NewSpin's U.S. Patents Nos. 9,656,122 B2 ("the '122 Patent"), 8,831,905 B2 ("the '905 Patent"), and 8,589,114 B2 ("the '114 Patent"). These patents are sometimes referred to collectively, hereinafter, as "the NewSpin Patents."

12. NewSpin is the owner of all rights and title in and to the NewSpin Patents. The technology disclosed and claimed in the NewSpin Patents was invented and developed by Angelo Papadourakis, the Chief Executive Officer of NewSpin (formerly NewSpin Golf LLC) as part of the design and subsequent manufacture of the SwingSmart golf swing analyzer product.

13. Mr. Papadourakis began playing golf at the age of nine and has remained an avid golfer throughout his life. This passion for the sport led to his conception and development of the SwingSmart product embodying several of the inventive concepts disclosed in the NewSpin Patents.

14. In August 2006, Mr. Papadourakis attended the PGA Championship tournament. While there he noted how the professional tour golfers benefitted from the constant feedback and instruction received from their swing coaches. Every swing was observed and analyzed. Mr. Papadourakis realized that the availability of this constant and immediate feedback was key to both improving swing mechanics and avoidance of the onset of bad habits. Prior to this, in an effort to improve his swing Mr. Papadourakis had taken lessons from golf professionals and tried many of the training aids then available. Mr. Papadourakis recognized that although lessons from a golf professional were helpful, they were limited in their effectiveness because the professional was only available during the lessons and not during his many trips to the driving range where he took the majority of his practice swings. Further, Mr. Papadourakis observed that other training aids available at the time were rarely used by golfers at the golf range or course because they required too much setup and/or interfered with golf play. Intent on improving his own game and swing mechanics,

Mr. Papadourakis undertook to develop a training aid usable to capture motion data for every swing of the club that was small and easily implemented such that it could capture the desired data while not interfering with the actual playing of the game.

15. At the time he conceived of the inventions disclosed in the NewSpin Patents, Mr. Papadourakis was working as a stock index trader at the Chicago Mercantile Exchange. Mr. Papadourakis worked in his spare time to transform his ideas into a working prototype. In or around late August 2007, Mr. Papadourakis developed the first working prototype to demonstrate the concept. Around this time, Mr. Papadourakis decided to leave his job as a stock index trader to start NewSpin Golf LLC (which would later be renamed NewSpin Sports LLC) to develop his prototype into a commercial product. Iterative improvements to the design led to the development of seven additional generations of prototypes between 2008 and 2011, with the first commercial version of the SwingSmart product being created in March 2012. The SwingSmart, which was one of the first swing analyzers on the market, was first demonstrated at the PGA Tour Show in January 2012 and was first released for sale on August 31, 2012.

16. The SwingSmart was configured for attachment to the shaft of a golf club near the grip to capture swing data (or at the handle end of a bat, racket, or other motion object). The captured data was wirelessly transmitted to a computer or mobile device, such as a laptop, smart phone, or tablet, running the corresponding software. Execution of the software effected processing of the captured data from the sensor at the grip end of club to derive swing metrics describing the motion of the head of the golf club, including swing tempo, shaft lean, swing speed, and club face angle, among others. These metrics were displayed on the display of the computer or mobile device to provide feedback to the user about their swing.

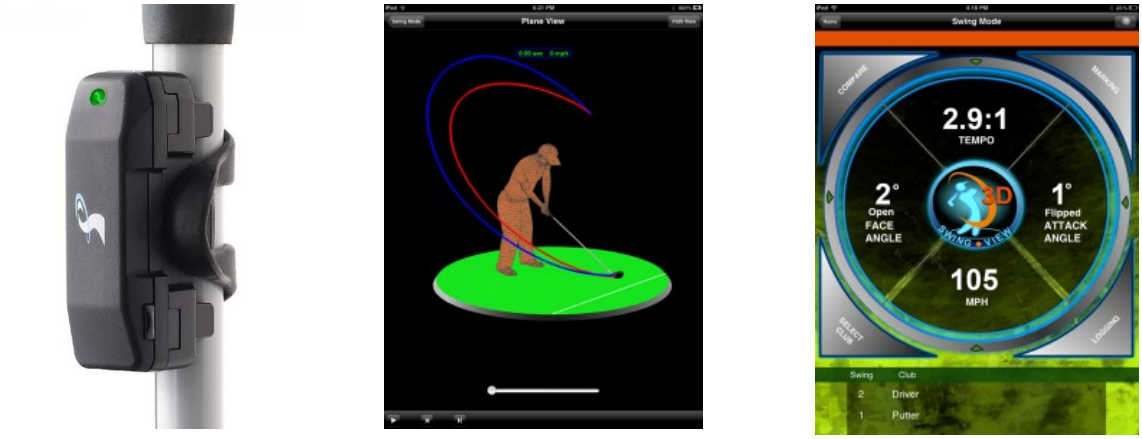

Fig. 1: SwingSmart Motion Sensor, Mount, and Mobile Application

17. NewSpin sold the SwingSmart through its website from its initial release on August 31, 2012 through October 2015, and through third party retailers, including Amazon, from its release until February 2016. The SwingSmart product was virtually marked since at least 2014 upon the issuance of NewSpin's first patent via presentation of the issued patent numbers and corresponding patent application serial numbers, as applicable, on NewSpin's SmartSwing website at least at URL: http://www.swingsmart.com/index.php/gear.

18. Blast develops motion sensing hardware and software, including the Blast Baseball Swing Analyzer, the Blast Softball Swing Analyzer, and the Blast Golf Swing and Stroke Analyzer. These products are referred to collectively hereinafter as "the Accused Blast Products." The Accused Blast Products accommodate capture of motion data relating to use of bats and golf clubs, respectively.

19. The Accused Blast Products are sold in kits comprising at least a Blast motion sensor, an attachment means for securing the motion sensor to a bat or club, and instructions to access and download a corresponding mobile application developed by Blast.

Fig. 2: Blast Motion Sensor, Mount, and Mobile Application

20. The Blast motion sensor is described on Blast's website as a "precision swing motion sensor" comprising inertial measurement unit. Upon information and belief, the Blast Motion sensor is implemented with at least an accelerometer and a gyroscope for sensing and capturing motion data. Each of the Accused Blast Products described herein comprise a Blast Motion sensor.

21. The Blast Motion sensor is configured to dynamically power up in response to detecting swing motion to capture swing motion data in real time relating to the knob or grip end of the bat or club, respectively. The Blast Motion sensor must be coupled to a movement object, such as a bat or golf club, to detect and capture swing motion data.

22. According to Blast's website, the Blast Baseball and Softball motion sensor "easily and securely attaches to the knob of nearly any bat" while the Blast Golf motion sensor "easily and securely attaches to the grip of nearly any regulation putter, driver, iron or wedge" to capture motion data relating to swings of the bat or club. The attachment means provided by Blast for removably securing the respective Blast motion sensors to these locations on the bat or club comprises and adjustable attachment mechanism configured to stretch over and grip the knob of a bat or grip of a club to secure it in place. Blast provides product instructions demonstrating use of the respective attachment means to secure the motion sensor to the bat or club. Using

the adjustable attachment means, the Blast Motion sensor may be moved between bats or between clubs during training or play.

23. The Blast motion sensor comprises a wireless Bluetooth transmitter for transmitting captured data from the motion sensor to a paired mobile device, such as a smart phone, tablet, or Apple watch running the corresponding Blast mobile application. Blast's website states that "[t]he sensor transmits metrics to your iPhone, iPad, or Android phone via Low Energy Bluetooth" and notes that "[t]he sensor stores actions when your mobile phone is out of range or disconnected." Likewise, Blast describes the Blast Motion sensor as "us[ing] Bluetooth Smart technology to connect to your Android device" and notes that the Blast Motion sensor "stores data on the sensor when your mobile device is out of range and downloads your actions to the Blast app as soon as you reconnect" on the Google Play Store page for the Blast Baseball mobile application. The pages for Blast's Softball and Golf mobile applications include these same statements.

24. The corresponding mobile applications, each developed by Blast, include Blast Baseball, Blast Softball, and Blast Golf. Apple and Android versions of these mobile applications are available for free download at the Apple iTunes store and the Google Play store. Blast provides links to these sites from its website and from instructions provided to users of its Accused Blast Products to download the respective mobile application.

25. The Blast mobile applications are executable on mobile devices comprising at least a wireless transceiver, a processor, and a display. Execution of the Blast mobile applications effects syncing of the captured data between the Blast motion sensor and the mobile device via a wireless Bluetooth connection. The paired mobile device running a Blast mobile application processes the received motion data which describes movement of the bat or club at the location which the motion sensor is attached, and translates that data to a second location at or near the opposite end of the bat or club, namely, the barrel of the bat or head of the club. The translated data

represents one or more metrics describing movement of the bat barrel or club head, including at least swing speed, tempo, and path of travel. The paired mobile device running the Blast mobile application displays some or all of these derived metrics on the display of the mobile device to provide feedback to users.

26. Downloading and execution of a Blast mobile application configures the mobile device for use in the manner claimed in one or more claims of the NewSpin Patents. The Blast motion sensor cannot and does not process and display the derived metrics to a user by itself. The captured data is transmitted to a mobile device executing a Blast mobile application for processing and display whereby the user may receive the intended benefit of the respective Accused Blast Products.

Fig. 3: Displays from Blast Mobile Applications

27. TaylorMade is a manufacturer of golf equipment that has recently co-developed and began selling Spider Interactive Powered by Blast (the "Spider Interactive Product"). The Spider Interactive Product includes motion sensor hardware and software along with a TaylorMade Spider model golf putter to accommodate capture of motion data relating to use of a putter.

28. The Spider Interactive Product is sold as a kit comprising a TaylorMade Spider Tour or Spider L-Neck Tour putter, a Blast motion sensor, a Super Stroke Mid Slim 2.0 grip with an attachment means for removably securing the motion sensor to its end, and the Spider Interactive mobile application developed and sold by Blast. Instructions for attaching the motion sensor to the SuperStroke grip of a Spider putter

and for accessing and downloading the corresponding Spider Interactive mobile application are provided by TaylorMade in its product literature and through its website.

Fig. 4: TaylorMade Spider Interactive Product

29. TaylorMade commercially released its Spider Interactive Product for first shipments on or around April 27, 2018 and was accepting pre-orders since the announcement of this product on or around January 18, 2018. The Spider Interactive mobile application was first made available for download through Blast's seller page from the iTunes App Store on or around March 1, 2018 and from the Google Play Store on or around April 27, 2018.

30. The Blast motion sensor included within the Spider Interactive Product is identical or substantially identical to the motion sensor described above within the Accused Blast Products. The Blast motion sensor has the same or substantially the same components, features, and functionality when attached to a TaylorMade Spider putter and when wirelessly connected to a mobile device running the Spider Interactive mobile application as it does in the Accused Blast Products described above.

31. The Spider Interactive mobile application comprises substantially identical features and functionality as those of the Blast mobile applications described above. Execution of the Spider Interactive mobile application effects syncing of the captured data between the motion sensor and the mobile device via a wireless

Bluetooth connection. The paired mobile device running the Spider Interactive mobile application processes the received motion data, which describes movement of

at the grip end of the club, and then translates that data to a location at the club head. The translated data represents one or more metrics describing movement of the club head, including at least impact speed and stroke length, among others. The paired mobile device running the Spider Interactive mobile application graphically displays some or all of the derived metrics on the display of the mobile device to provide feedback to users.

Fig. 5: Displays from TaylorMade Spider Interactive Mobile Application

32. Downloading and execution of the TaylorMade Spider Interactive mobile application configures the mobile device for use in the manner claimed in one or more claims of the NewSpin Patents. The Blast motion sensor mounted on a Spider TaylorMade Spider putter cannot and does not process and display the derived metrics to a user by itself. The captured data is transmitted to a mobile device executing a TaylorMade Spider Interactive mobile application, developed by Blast, for processing and display whereby the user may receive the intended benefit of the Spider Interactive Product.

33. On March 23, 2018, NewSpin sent letters and claim charts via Federal Express to Blast and TaylorMade providing each with actual knowledge of the existence and scope of the NewSpin Patents and alleging infringement thereof via Blast and TaylorMade's making, using, selling, and/or importing of the Accused Blast

Products and the Spider Interactive Product described herein. The allegations and infringement claims made in the March 23, 2018 letter are consistent with those presented herein. NewSpin invited Blast and TaylorMade to contact NewSpin with a response to the allegations made in an effort to resolve the dispute without the need for filing of the present Complaint. Delivery confirmation was received from Federal Express for Blast and TaylorMade on March 26, 2018. Blast and TaylorMade subsequently retained counsel to discuss NewSpin's patent infringement claims but those discussion did not lead to a resolution of the present dispute.

34. It is proper to join all named Defendants in this suit because each makes, uses, sells, and/or imports products comprising hardware (the Blast Motion Sensor) and software (the respective mobile applications) produced or developed by Blast. In each of the Accused Blast Products and the Spider Interactive Product, these hardware and software components accommodate substantially identical features and functionality, which forms the basis for each entities' infringing actions.

COUNT I

PATENT INFRINGEMENT

U.S. Patent No. 9,656,122 B2

35. NewSpin repeats and re-alleges all preceding paragraphs of this Complaint, as though fully set forth herein.

36. On May 23, 2017, United States Patent No. 9,656,122 B2 ("the '122 Patent") was duly and legally issued for "Motion Capture and Analysis." As of the filing of this Complaint, the '122 Patent remains in force. A true and correct copy of the '122 Patent is attached hereto as Exhibit "A" and made a part hereof.

37. NewSpin is the owner of all right and title in the '122 Patent, including all rights to enforce and prosecute action for infringement of the '122 Patent and to collect damages for all relevant times against infringers of the '122 Patent. Accordingly, NewSpin possesses the exclusive right and standing to prosecute the present action for infringement of the '122 Patent by Defendants.

38. The '122 Patent discloses and claims systems and methods implementing a motion sensor unit to capture motion data relating to movement of an object, such as a baseball bat or golf club, for example. The motion sensor unit is attachable to the object at a first location. Captured data is wirelessly transmitted to a processor for processing to determine one or more values describing movement of the object with respect to a second location, whereby data or values corresponding to the first location are translated to the second location. At least one of the data or values is graphically displayed.

39. Defendants have had actual knowledge of the existence of the '122 Patent since at least March 26, 2018, the date that NewSpin's notice letters and claim charts detailing the infringement allegations made herein were received by Defendants, respectively.

Infringement by Blast

40. Blast, without authority, consent, right, or license, and in infringement of the '122 Patent, makes, uses, sells, offers to sell, and/or imports the Accused Blast Products for use in combination with mobile devices running the corresponding Blast mobile application which practice the inventions claimed in at least claims 15-22 of the '122 Patent.

41. Blast's making, using, selling, offering to sell, and/or importing of the Accused Blast Products directly infringes at least Claims 15-22 of the '122 Patent, and Blast is therefore liable for direct infringement, either literally or under the doctrine of equivalents, of the '122 Patent pursuant to 35 U.S.C. § 271(a). By way of example only, Blast employees, representatives, and/or agents use the Accused Blast Products for product testing, product demonstrations, and training sessions in the manner described above, as evidenced by at least the hundreds of videos uploaded by Blast Motion to its YouTube channel demonstrating use of the Accused Blast Products.

42. Blast provides step-by-step instructions for assembling and using the Accused Products in ways that infringe claims of the '122 Patent in the form of user

guides, online content, video tutorials, and live customer support available through Blast's website and product literature. Instructions are provided for attaching the motion sensor to the knob end of a bat or grip end of a golf club. Links and instructions are provided for accessing and downloading the corresponding Blast and Spider Interactive mobile applications for configuring a mobile device or computer to perform the required processing and displaying of the swing data and values.

43. Customers, resellers, retailers and end users use the Blast Products and the Spider Interactive Product to analyze swing data of a bat or golf club. The Blast motion sensor of the Blast Products and the Spider Interactive Product automatically collects motion data at the location where it is coupled to a bat or golf club. The motion data is wirelessly transmitted to a mobile device or computer running the corresponding Blast or Spider Interactive mobile application. The data is processed by the mobile application to determine one or more values describing movement of the bat or golf club at the location of the sensor, the data and/or values are translated to describe movement at a second location on the bat or golf club, and the data and/or values are subsequently graphically displayed in the manner described above.

44. Use by customers, resellers, retailers and end users of the Accused Products in this manner as proscribed by Blast on its website and product literature constitutes direct infringement of at least claims 15-22 of the '122 Patent.

45. Blast actively induces infringement of at least claims 15-22 of the '122 Patent by its customers and end users of the Accused Blast Products. End users and customers of Blast's are provided a motion sensor, attachment means for removably attaching the motion sensor to a bat or club, and a mobile application to be installed on their smartphone or tablet to assemble the systems comprising the Accused Blast Products. By attaching the Blast Motion sensor to a bat or club and installing and running the mobile application on a mobile device, both done in accordance with instructions provided by Blast via product literature and online demonstration videos, end users assemble the Accused Blast Products and subsequently use the Accused

Blast Products in manners that directly infringe at least claims 15-22 of the '122 Patent. Blast therefore intentionally directs and encourages end users and customers to make, use, sell, and/or offer to sell and/or to import the Accused Products in an infringing manner, and is therefore liable for induced infringement under 35 U.S.C. § 271(b).

46. Blast contributes to the infringement of at least claims 15-22 of the '122 Patent by its customers and end users of the Accused Blast Products. Blast makes and sells to its end users and customers a motion sensor and attachment means for removably attaching the motion sensor to a bat or club. Blast additionally provides a mobile application to be installed on a user's smartphone or tablet which configures the smartphone or tablet to: use its wireless transceiver to communicate with the Blast Motion sensor to sync swing data; use its processors to process the synced data to determine various metrics relating to captured swings and translate the metrics and/or data to be descriptive of a second location on the bat or club; and, use it's graphics card and screen to generate and display images presenting the translated metrics and/or data.

47. As such, use of the Accused Blast Products in the manner proscribed by Blast results in a combination that is especially suited for infringing at least claims 15-22 of the '122 Patent. This use comprises the fundamental operation of the Accused Blast Products upon which all other features and functionality are based. The Accused Blast Products are, therefore, not staple articles of commerce as they have no substantial non-infringing uses.

48. Blast therefore contributes to the direct infringement of at least claims 15-22 of the '122 Patent by end users and customers of Blast and is liable for contributory infringement under 35 U.S.C. § 271(c).

49. NewSpin expressly reserves the right to assert additional claims of the '122 Patent against Blast.

50. NewSpin has been damaged as a result of Blast's infringing conduct. Blast is, thus, liable to NewSpin in an amount that adequately compensates for their infringement, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

51. Based on Blast's actual knowledge of the '122 Patent and specific knowledge of NewSpin's infringement claims presented herein since at least March 26, 2018, if not earlier, as well as Blast's objective recklessness in continuing to make, use, and sell the Blast Products since that time, Blast's infringement of the '122 Patent has been willful since at least March 26, 2018. Therefore, NewSpin is further entitled to enhanced damages under 35 U.S.C. § 284.

Infringement by TaylorMade

52. TaylorMade, without authority, consent, right, or license, and in infringement of the '122 Patent, makes, uses, sells, offers to sell, and/or imports the Spider Interactive Product for use in combination with mobile devices running the corresponding TaylorMade mobile application which practice the inventions claimed in at least claims 15-22 of the '122 Patent.

53. TaylorMade's making, using, selling, offering to sell, and/or importing of the Spider Interactive Product directly infringes at least Claims 15-22 of the '122 Patent, and TaylorMade is therefore liable for direct infringement, either literally or under the doctrine of equivalents, of the '122 Patent pursuant to 35 U.S.C. § 271(a). By way of example only, TaylorMade employees, representatives, and/or agents use the Spider Interactive Product for product testing, product demonstrations, and training sessions in the manner described above.

54. TaylorMade provides step-by-step instructions for assembling and using the Accused Products in ways that infringe claims of the '122 Patent in the form of user guides, online content, video tutorials, and live customer support available through TaylorMade's website and product literature. Instructions are provided for attaching the motion sensor to the specially designed SuperStroke grip end of a putter.

Links and instructions are provided for accessing and downloading the corresponding TaylorMade Spider Interactive mobile application, developed by Blast Motion, for configuring a mobile device or computer to perform the required processing and displaying of the swing data and values.

55. Customers, resellers, retailers and end users use the Spider Interactive Product to analyze swing data of a bat or golf club. The motion sensor of the Spider Interactive Product automatically collects motion data at the location where it is coupled to a bat or golf club. The motion data is wirelessly transmitted to a mobile device or computer running the corresponding TaylorMade Spider Interactive mobile application. The data is processed by the mobile application to determine one or more values describing movement of the putter at the location of the sensor, the data and/or values are translated to describe movement at a second location at the putter's face, and the data and/or values are subsequently graphically displayed in the manner described above.

56. Use by customers, resellers, retailers and end users of the Accused Products in this manner as proscribed by TaylorMade on its website and product literature constitutes direct infringement of at least claims 15-22 of the '122 Patent.

57. TaylorMade actively induces infringement of at least claims 15-22 of the '122 Patent by its customers and end users of the Spider Interactive Product. End users and customers of TaylorMade's are provided a motion sensor, SuperStroke grip with attachment means for removably attaching the motion sensor to a putter, and a mobile application to be installed on their smartphone or tablet to assemble the system comprising the Spider Interactive Product. By attaching the TaylorMade Motion sensor to a bat or club and installing and running the mobile application on a mobile device, both done in accordance with instructions provided by TaylorMade via product literature and online demonstration videos, end users assemble the Spider Interactive Product and subsequently use the Spider Interactive Product in manners that directly infringe at least claims 15-22 of the '122 Patent. TaylorMade therefore

intentionally directs and encourages end users and customers to make, use, sell, and/or offer to sell and/or to import the Accused Products in an infringing manner, and is therefore liable for induced infringement under 35 U.S.C. § 271(b).

58. TaylorMade contributes to the infringement of at least claims 15-22 of the '122 Patent by its customers and end users of the Spider Interactive Product. TaylorMade makes and sells to its end users and customers a motion sensor and specially designed grip with attachment means for removably attaching the motion sensor to a putter. TaylorMade additionally provides a mobile application to be installed on a user's smartphone or tablet which configures the smartphone or tablet to: use its wireless transceiver to communicate with the TaylorMade Motion sensor to sync data; use its processors to process the synced data to determine various metrics relating to captured swings and translate the metrics and/or data to be descriptive of a second location on the putter; and, use it's graphics card and screen to generate and display images presenting the translated metrics and/or data.

59. As such, use of the Spider Interactive Product in the manner proscribed by TaylorMade results in a combination that is especially suited for infringing at least claims 15-22 of the '122 Patent. This use comprises the fundamental operation of the Spider Interactive Product upon which all other features and functionality are based. The Spider Interactive Product is, therefore, not a staple article of commerce as it has no substantial non-infringing uses.

60. TaylorMade therefore contributes to the direct infringement of at least claims 15-22 of the '122 Patent by end users and customers of TaylorMade and is liable for contributory infringement under 35 U.S.C. § 271(c).

61. NewSpin expressly reserves the right to assert additional claims of the '122 Patent against TaylorMade.

62. NewSpin has been damaged as a result of TaylorMade's infringing conduct. TaylorMade is, thus, liable to NewSpin in an amount that adequately

compensates for their infringement, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

63. Based on TaylorMade's actual knowledge of the '122 Patent and specific knowledge of NewSpin's infringement claims presented herein since at least March 26, 2018, if not earlier, as well as TaylorMade's objective recklessness in continuing to make, use, and sell the TaylorMade Products since that time, TaylorMade's infringement of the '122 Patent has been willful since at least March 26, 2018. All sales consummated on or after the first shipping date of the Spider Interactive Product occurred over a month after the delivery of NewSpin's letter and claim chart providing TaylorMade with actual and specific knowledge of the '122 Patent and infringement claims of NewSpin. Therefore, NewSpin is further entitled to enhanced damages under 35 U.S.C. § 284.

COUNT II

PATENT INFRINGEMENT

U.S. Patent No. 8,831,905 B2

64. NewSpin repeats and re-alleges all preceding paragraphs of this Complaint, as though fully set forth herein.

65. On September 9, 2014, United States Patent No. 8,831,905 B2 ("the '905 Patent") was duly and legally issued for "Motion Capture and Analysis." As of the filing of this Complaint, the '905 Patent remains in force. A true and correct copy of the '905 Patent is attached hereto as Exhibit "B" and made a part hereof.

66. NewSpin is the owner of all right and title in the '905 Patent, including all rights to enforce and prosecute action for infringement of the '905 Patent and to collect damages for all relevant times against infringers of the '905 Patent. Accordingly, NewSpin possesses the exclusive right and standing to prosecute the present action for infringement of the '905 Patent by Defendants.

67. The '905 Patent discloses and claims systems and methods implementing a motion sensor unit to capture motion data relating to movement of an object usable

in a sport or leisure activity, such as a baseball bat or golf club, for example. The motion sensor unit is adjustably coupled to the object at a first location to capture data relating to movement of the object at the first location. Captured data is wirelessly transmitted to a processor for processing to determine one or more derived metrics describing movement of the object and translated to a second location on the object to provide derived metrics describing movement of the object at the second location. At least one of the data or values is graphically displayed as an image on a display unit.

68. Defendants have had actual knowledge of the existence of the '905 Patent since at least March 26, 2018, the date that NewSpin's notice letters detailing the infringement allegations made herein were received by Defendants, respectively.

Infringement by Blast

69. Blast, without authority, consent, right, or license, and in infringement of the '905 Patent, makes, uses, sells, offers to sell, and/or imports the Accused Blast Products for use in combination with mobile devices running the corresponding Blast mobile application which practice the inventions claimed in at least claims 16 and 17 of the '905 Patent.

70. Blast's making, using, selling, offering to sell, and/or importing of the Accused Blast Products directly infringes at least Claims 16 and 17 of the '905 Patent, and Blast is therefore liable for direct infringement, either literally or under the doctrine of equivalents, of the '905 Patent pursuant to 35 U.S.C. § 271(a). By way of example only, Blast employees, representatives, and/or agents use the Blast Accused Products for product testing, product demonstrations, and training sessions in the manner described above, as evidenced by at least the hundreds of videos uploaded by Blast Motion to its YouTube channel demonstrating use of the Accused Blast Products.

71. Blast provides step-by-step instructions for assembling and using the Accused Products in ways that infringe claims of the '905 Patent in the form of user guides, online content, video tutorials, and live customer support available through

Blast's website and product literature. Instructions are provided for attaching the motion sensor to the knob end of a bat or grip end of a golf club. Links and instructions are provided for accessing and downloading the corresponding Blast and Spider Interactive mobile applications for configuring a mobile device or computer to perform the required processing and displaying of the swing data and values.

72. Customers, resellers, retailers and end users use the Blast Products and the Spider Interactive Product to analyze swing data of a bat or golf club. The Blast motion sensor of the Blast Products and the Spider Interactive Product automatically collects motion data at the location where it is coupled to a bat or golf club. The motion data is wirelessly transmitted to a mobile device or computer running the corresponding Blast or Spider Interactive mobile application. The data is processed by the mobile application to determine one or more values describing movement of the bat or golf club at the location of the sensor, the data and/or values are translated to describe movement at a second location on the bat or golf club, and the data and/or values are subsequently graphically displayed in the manner described above.

73. Use by customers, resellers, retailers and end users of the Accused Products in this manner as proscribed by Blast on its website and product literature constitutes direct infringement of at least claims 16 and 17 of the '905 Patent.

74. Blast actively induces infringement of at least claims 16 and 17 of the '905 Patent by its customers and end users of the Accused Blast Products. End users and customers of Blast's are provided a motion sensor, attachment means for removably attaching the motion sensor to a bat or club, and a mobile application to be installed on their smartphone or tablet to assemble the systems comprising the Accused Blast Products. By attaching the Blast Motion sensor to a bat or club and installing and running the mobile application on a mobile device, both done in accordance with instructions provided by Blast via product literature and online demonstration videos, end users assemble the Accused Blast Products and subsequently use the Accused Blast Products in manners that directly infringe at least

claims 16 and 17 of the '905 Patent. Blast therefore intentionally directs and encourages end users and customers to make, use, sell, and/or offer to sell and/or to import the Accused Products in an infringing manner, and is therefore liable for induced infringement under 35 U.S.C. § 271(b).

75. Blast contributes to the infringement of at least claims 16 and 17 of the '905 Patent by its customers and end users of the Accused Blast Products. Blast makes and sells to its end users and customers a motion sensor and attachment means for removably attaching the motion sensor to a bat or club. Blast additionally provides a mobile application to be installed on a user's smartphone or tablet which configures the smartphone or tablet to: use its wireless transceiver to communicate with the Blast Motion sensor to sync swing data; use its processors to process the synced data to determine various metrics relating to captured swings and translate the metrics and/or data to be descriptive of a second location on the bat or club; and, use it's graphics card and screen to generate and display images presenting the translated metrics and/or data.

76. As such, use of the Accused Blast Products in the manner proscribed by Blast results in a combination that is especially suited for infringing at least claims 16 and 17 of the '905 Patent. This use comprises the fundamental operation of the Accused Blast Products upon which all other features and functionality are based. The Accused Blast Products are, therefore, not staple articles of commerce as they have no substantial non-infringing uses.

77. Blast therefore contributes to the direct infringement of at least claims 16 and 17 of the '905 Patent by end users and customers of Blast and is liable for contributory infringement under 35 U.S.C. § 271(c).

78. NewSpin expressly reserves the right to assert additional claims of the '905 Patent against Blast.

79. NewSpin has been damaged as a result of Blast's infringing conduct. Blast is, thus, liable to NewSpin in an amount that adequately compensates for their

infringement, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

80. Based on Blast's actual knowledge of the '905 Patent and specific knowledge of NewSpin's infringement claims presented herein since at least March 26, 2018, if not earlier, as well as Blast's objective recklessness in continuing to make, use, and sell the Blast Products since that time, Blast's infringement of the '905 Patent has been willful since at least March 26, 2018. Therefore, NewSpin is further entitled to enhanced damages under 35 U.S.C. § 284.

Infringement by TaylorMade

81. TaylorMade, without authority, consent, right, or license, and in infringement of the '905 Patent, makes, uses, sells, offers to sell, and/or imports the Spider Interactive Product for use in combination with mobile devices running the corresponding TaylorMade mobile application which practice the inventions claimed in at least claims 16 and 17 of the '905 Patent.

82. TaylorMade's making, using, selling, offering to sell, and/or importing of the Spider Interactive Product directly infringes at least claims 16 and 17 of the '905 Patent, and TaylorMade is therefore liable for direct infringement, either literally or under the doctrine of equivalents, of the '905 Patent pursuant to 35 U.S.C. § 271(a). By way of example only, TaylorMade employees, representatives, and/or agents use the Spider Interactive Product for product testing, product demonstrations, and training sessions in the manner described above.

83. TaylorMade provides step-by-step instructions for assembling and using the Accused Products in ways that infringe claims of the '905 Patent in the form of user guides, online content, video tutorials, and live customer support available through TaylorMade's website and product literature. Instructions are provided for attaching the motion sensor to the specially designed SuperStroke grip end of a putter. Links and instructions are provided for accessing and downloading the corresponding TaylorMade Spider Interactive mobile application, developed by Blast Motion, for

configuring a mobile device or computer to perform the required processing and displaying of the swing data and values.

84. Customers, resellers, retailers and end users use the Spider Interactive Product to analyze swing data of a bat or golf club. The motion sensor of the Spider Interactive Product automatically collects motion data at the location where it is coupled to a bat or golf club. The motion data is wirelessly transmitted to a mobile device or computer running the corresponding TaylorMade Spider Interactive mobile application. The data is processed by the mobile application to determine one or more values describing movement of the putter at the location of the sensor, the data and/or values are translated to describe movement at a second location at the putter's face, and the data and/or values are subsequently graphically displayed in the manner described above.

85. Use by customers, resellers, retailers and end users of the Accused Products in this manner as proscribed by TaylorMade on its website and product literature constitutes direct infringement of at least claims 16 and 17 of the '905 Patent.

86. TaylorMade actively induces infringement of at least claims 16 and 17 of the '905 Patent by its customers and end users of the Spider Interactive Product. End users and customers of TaylorMade's are provided a motion sensor, SuperStroke grip with attachment means for removably attaching the motion sensor to a putter, and a mobile application to be installed on their smartphone or tablet to assemble the system comprising the Spider Interactive Product. By attaching the TaylorMade Motion sensor to a bat or club and installing and running the mobile application on a mobile device, both done in accordance with instructions provided by TaylorMade via product literature and online demonstration videos, end users assemble the Spider Interactive Product and subsequently use the Spider Interactive Product in manners that directly infringe at least claims 16 and 17 of the '905 Patent. TaylorMade therefore intentionally directs and encourages end users and customers to make, use,

sell, and/or offer to sell and/or to import the Accused Products in an infringing manner, and is therefore liable for induced infringement under 35 U.S.C. § 271(b).

87. TaylorMade contributes to the infringement of at least claims 16 and 17 of the '905 Patent by its customers and end users of the Spider Interactive Product. TaylorMade makes and sells to its end users and customers a motion sensor and specially designed grip with attachment means for removably attaching the motion sensor to a putter. TaylorMade additionally provides a mobile application to be installed on a user's smartphone or tablet which configures the smartphone or tablet to: use its wireless transceiver to communicate with the TaylorMade Motion sensor to sync data; use its processors to process the synced data to determine various metrics relating to captured swings and translate the metrics and/or data to be descriptive of a second location on the putter; and, use it's graphics card and screen to generate and display images presenting the translated metrics and/or data.

88. As such, use of the Spider Interactive Product in the manner proscribed by TaylorMade results in a combination that is especially suited for infringing at least claims 16 and 17 of the '905 Patent. This use comprises the fundamental operation of the Spider Interactive Product upon which all other features and functionality are based. The Spider Interactive Product is, therefore, not a staple article of commerce as it has no substantial non-infringing uses.

89. TaylorMade therefore contributes to the direct infringement of at least claims 16 and 17 of the '905 Patent by end users and customers of TaylorMade and is liable for contributory infringement under 35 U.S.C. § 271(c).

90. NewSpin expressly reserves the right to assert additional claims of the '905 Patent against TaylorMade.

91. NewSpin has been damaged as a result of TaylorMade's infringing conduct. TaylorMade is, thus, liable to NewSpin in an amount that adequately compensates for their infringement, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

92. Based on TaylorMade's actual knowledge of the '905 Patent and specific knowledge of NewSpin's infringement claims presented herein since at least March 26, 2018, if not earlier, as well as TaylorMade's objective recklessness in continuing to make, use, and sell the TaylorMade Products since that time, TaylorMade's infringement of the '905 Patent has been willful since at least March 26, 2018. All sales consummated on or after the first shipping date of the Spider Interactive Product occurred over a month after the delivery of NewSpin's letter and claim chart providing TaylorMade with actual and specific knowledge of the '905 Patent and infringement claims of NewSpin. Therefore, NewSpin is further entitled to enhanced damages under 35 U.S.C. § 284.

COUNT III

PATENT INFRINGEMENT

U.S. Patent No. 8,589,114 B2

93. NewSpin repeats and re-alleges all preceding paragraphs of this Complaint, as though fully set forth herein.

94. On November 19, 2013, United States Patent No. 8,589,114 B2 ("the '114 Patent") was duly and legally issued for "Motion Capture and Analysis." As of the filing of this Complaint, the '114 Patent remains in force. A true and correct copy of the '114 Patent is attached hereto as Exhibit "C" and made a part hereof.

95. NewSpin is the owner of all right and title in the '114 Patent, including all rights to enforce and prosecute action for infringement of the '114 Patent and to collect damages for all relevant times against infringers of the '114 Patent. Accordingly, NewSpin possesses the exclusive right and standing to prosecute the present action for infringement of the '114 Patent by Defendants.

96. The '114 Patent discloses and claims systems and methods implementing a non-wearable motion sensor unit to capture motion data relating to movement of an object usable in a sport or leisure activity, such as a baseball bat or golf club, for example. The motion sensor unit is adjustably coupled to the object at a first location

using an adjustable attachment mechanism to capture data relating to movement of the object at the first location. Captured data is wirelessly transmitted to a processor for processing to determine one or more derived metrics describing movement of the object and translated to a second location on the object to provide derived metrics describing movement of the object at the second location. At least one of the data or values is graphically displayed as an image on a display unit.

97. Defendants have had actual knowledge of the existence of the '114 Patent since at least March 26, 2018, the date that NewSpin's notice letters detailing the infringement allegations made herein were received by Defendants, respectively.

Infringement by Blast

98. Blast, without authority, consent, right, or license, and in infringement of the '114 Patent, makes, uses, sells, offers to sell, and/or imports the Accused Blast Products for use in combination with mobile devices running the corresponding Blast mobile application which practice the inventions claimed in at least claim 22 of the '114 Patent.

99. Blast's making, using, selling, offering to sell, and/or importing of the Accused Blast Products directly infringes at least claim 22 of the '114 Patent, and Blast is therefore liable for direct infringement, either literally or under the doctrine of equivalents, of the '114 Patent pursuant to 35 U.S.C. § 271(a). By way of example only, Blast employees, representatives, and/or agents use the Blast Accused Products for product testing, product demonstrations, and training sessions in the manner described above, as evidenced by at least the hundreds of videos uploaded by Blast Motion to its YouTube channel demonstrating use of the Accused Blast Products.

100. Blast provides step-by-step instructions for assembling and using the Accused Products in ways that infringe claims of the '114 Patent in the form of user guides, online content, video tutorials, and live customer support available through Blast's website and product literature. Instructions are provided for attaching the motion sensor to the knob end of a bat or grip end of a golf club. Links and

instructions are provided for accessing and downloading the corresponding Blast and Spider Interactive mobile applications for configuring a mobile device or computer to perform the required processing and displaying of the swing data and values.

101. Customers, resellers, retailers and end users use the Blast Products and the Spider Interactive Product to analyze swing data of a bat or golf club. The Blast motion sensor of the Blast Products and the Spider Interactive Product automatically collects motion data at the location where it is coupled to a bat or golf club. The motion data is wirelessly transmitted to a mobile device or computer running the corresponding Blast or Spider Interactive mobile application. The data is processed by the mobile application to determine one or more values describing movement of the bat or golf club at the location of the sensor, the data and/or values are translated to describe movement at a second location on the bat or golf club, and the data and/or values are subsequently graphically displayed in the manner described above.

102. Use by customers, resellers, retailers and end users of the Accused Products in this manner as proscribed by Blast on its website and product literature constitutes direct infringement of at least claim 22 of the '114 Patent.

103. Blast actively induces infringement of at least claim 22 of the '114 Patent by its customers and end users of the Accused Blast Products. End users and customers of Blast's are provided a motion sensor, attachment means for removably attaching the motion sensor to a bat or club, and a mobile application to be installed on their smartphone or tablet to assemble the systems comprising the Accused Blast Products. By attaching the Blast Motion sensor to a bat or club and installing and running the mobile application on a mobile device, both done in accordance with instructions provided by Blast via product literature and online demonstration videos, end users assemble the Accused Blast Products and subsequently use the Accused Blast Products in manners that directly infringe at least claim 22 of the '114 Patent. Blast therefore intentionally directs and encourages end users and customers to make,

use, sell, and/or offer to sell and/or to import the Accused Products in an infringing manner, and is therefore liable for induced infringement under 35 U.S.C. § 271(b).

104. Blast contributes to the infringement of at least claim 22 of the '114 Patent by its customers and end users of the Accused Blast Products. Blast makes and sells to its end users and customers a motion sensor and attachment means for removably attaching the motion sensor to a bat or club. Blast additionally provides a mobile application to be installed on a user's smartphone or tablet which configures the smartphone or tablet to: use its wireless transceiver to communicate with the Blast Motion sensor to sync swing data; use its processors to process the synced data to determine various metrics relating to captured swings and translate the metrics and/or data to be descriptive of a second location on the bat or club; and, use it's graphics card and screen to generate and display images presenting the translated metrics and/or data.

105. As such, use of the Accused Blast Products in the manner proscribed by Blast results in a combination that is especially suited for infringing at least claim 22 of the '114 Patent. This use comprises the fundamental operation of the Accused Blast Products upon which all other features and functionality are based. The Accused Blast Products are, therefore, not staple articles of commerce as they have no substantial non-infringing uses.

106. Blast therefore contributes to the direct infringement of at least claim 22 of the '114 Patent by end users and customers of Blast and is liable for contributory infringement under 35 U.S.C. § 271(c).

107. NewSpin expressly reserves the right to assert additional claims of the '114 Patent against Blast.

108. NewSpin has been damaged as a result of Blast's infringing conduct. Blast is, thus, liable to NewSpin in an amount that adequately compensates for their infringement, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

109. Based on Blast's actual knowledge of the '114 Patent and specific knowledge of NewSpin's infringement claims presented herein since at least March 26, 2018, if not earlier, as well as Blast's objective recklessness in continuing to make, use, and sell the Blast Products since that time, Blast's infringement of the '114 Patent has been willful since at least March 26, 2018. Therefore, NewSpin is further entitled to enhanced damages under 35 U.S.C. § 284.

Infringement by TaylorMade

110. TaylorMade, without authority, consent, right, or license, and in infringement of the '114 Patent, makes, uses, sells, offers to sell, and/or imports the Spider Interactive Product for use in combination with mobile devices running the corresponding TaylorMade mobile application which practice the inventions claimed in at least claim 22 of the '114 Patent.

111. TaylorMade's making, using, selling, offering to sell, and/or importing of the Spider Interactive Product directly infringes at least claim 22 of the '114 Patent, and TaylorMade is therefore liable for direct infringement, either literally or under the doctrine of equivalents, of the '114 Patent pursuant to 35 U.S.C. § 271(a). By way of example only, TaylorMade employees, representatives, and/or agents use the Spider Interactive Product for product testing, product demonstrations, and training sessions in the manner described above.

112. TaylorMade provides step-by-step instructions for assembling and using the Accused Products in ways that infringe claims of the '114 Patent in the form of user guides, online content, video tutorials, and live customer support available through TaylorMade's website and product literature. Instructions are provided for attaching the motion sensor to the specially designed SuperStroke grip end of a putter. Links and instructions are provided for accessing and downloading the corresponding TaylorMade Spider Interactive mobile application, developed by Blast Motion, for configuring a mobile device or computer to perform the required processing and displaying of the swing data and values.

113. Customers, resellers, retailers and end users use the Spider Interactive Product to analyze swing data of a bat or golf club. The motion sensor of the Spider Interactive Product automatically collects motion data at the location where it is coupled to a bat or golf club. The motion data is wirelessly transmitted to a mobile device or computer running the corresponding TaylorMade Spider Interactive mobile application. The data is processed by the mobile application to determine one or more values describing movement of the putter at the location of the sensor, the data and/or values are translated to describe movement at a second location at the putter's face, and the data and/or values are subsequently graphically displayed in the manner described above.

114. Use by customers, resellers, retailers and end users of the Accused Products in this manner as proscribed by TaylorMade on its website and product literature constitutes direct infringement of at least claim 22 of the '114 Patent.

115. TaylorMade actively induces infringement of at least claim 22 of the '114 Patent by its customers and end users of the Spider Interactive Product. End users and customers of TaylorMade's are provided a motion sensor, SuperStroke grip with attachment means for removably attaching the motion sensor to a putter, and a mobile application to be installed on their smartphone or tablet to assemble the system comprising the Spider Interactive Product. By attaching the TaylorMade Motion sensor to a bat or club and installing and running the mobile application on a mobile device, both done in accordance with instructions provided by TaylorMade via product literature and online demonstration videos, end users assemble the Spider Interactive Product and subsequently use the Spider Interactive Product in manners that directly infringe at least claim 22 of the '114 Patent. TaylorMade therefore intentionally directs and encourages end users and customers to make, use, sell, and/or offer to sell and/or to import the Accused Products in an infringing manner, and is therefore liable for induced infringement under 35 U.S.C. § 271(b).

116. TaylorMade contributes to the infringement of at least claim 22 of the '114 Patent by its customers and end users of the Spider Interactive Product. TaylorMade makes and sells to its end users and customers a motion sensor and specially designed grip with attachment means for removably attaching the motion sensor to a putter. TaylorMade additionally provides a mobile application to be installed on a user's smartphone or tablet which configures the smartphone or tablet to: use its wireless transceiver to communicate with the TaylorMade Motion sensor to sync data; use its processors to process the synced data to determine various metrics relating to captured swings and translate the metrics and/or data to be descriptive of a second location on the putter; and, use it's graphics card and screen to generate and display images presenting the translated metrics and/or data.

117. As such, use of the Spider Interactive Product in the manner proscribed by TaylorMade results in a combination that is especially suited for infringing at least claim 22 of the '114 Patent. This use comprises the fundamental operation of the Spider Interactive Product upon which all other features and functionality are based. The Spider Interactive Product is, therefore, not a staple article of commerce as it has no substantial non-infringing uses.

118. TaylorMade therefore contributes to the direct infringement of at least claim 22 of the '114 Patent by end users and customers of TaylorMade and is liable for contributory infringement under 35 U.S.C. § 271(c).

119. NewSpin expressly reserves the right to assert additional claims of the '114 Patent against TaylorMade.

120. NewSpin has been damaged as a result of TaylorMade's infringing conduct. TaylorMade is, thus, liable to NewSpin in an amount that adequately compensates for their infringement, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

121. Based on TaylorMade's actual knowledge of the '114 Patent and specific knowledge of NewSpin's infringement claims presented herein since at least March

26, 2018, if not earlier, as well as TaylorMade's objective recklessness in continuing to make, use, and sell the TaylorMade Products since that time, TaylorMade's infringement of the '114 Patent has been willful since at least March 26, 2018. All sales consummated on or after the first shipping date of the Spider Interactive Product occurred over a month after the delivery of NewSpin's letter and claim chart providing TaylorMade with actual and specific knowledge of the '114 Patent and infringement claims of NewSpin. Therefore, NewSpin is further entitled to enhanced damages under 35 U.S.C. § 284.

IV. JURY DEMAND

122. Plaintiff hereby requests a trial by jury pursuant to Rule 38 of the Federal Rules of Civil Procedure.

V. PRAYER FOR RELIEF

WHEREFORE, Plaintiff respectfully requests that the Court find in its favor and against Defendants, and that the Court grant Plaintiff the following relief:

1. Judgment that one or more claims of the NewSpin Patents has been directly infringed, either literally or under the doctrine of equivalents, by Defendants, or judgment that one or more of the claims of the NewSpin Patents has been directly infringed by others and indirectly infringed by Defendants, to the extent Defendants contributed to or induced such direct infringement by others;

2. Judgment that Defendants account for and pay to Plaintiff all damages to and costs incurred by Plaintiff because of Defendants' infringing activities and other conduct complained of herein, including enhanced damages as permitted by 35 U.S.C. § 284;

3. Judgement that Defendants' infringement is willful from the time each respective Defendant became aware of the infringing nature of its products and methods and that the Court award treble damages for the period of such willful infringement pursuant to 35 U.S.C. § 284;

4. That Plaintiff be granted pre-judgment and post-judgment interest on the damages caused by Defendants' infringing activities and other conduct complained of herein;

5. That the Court declare this an exceptional case and award Plaintiff its reasonable attorney's fees and costs in accordance with 35 U.S.C. § 285; and

6. That Defendants, their officers, agents, servants and employees, and those persons in active concert and participation with any of them, be permanently enjoined from infringement of one or more claims of the NewSpin Patents or, in the alternative, if the Court finds that an injunction is not warranted, Plaintiff requests an award of post judgment royalty to compensate for future infringement; and

7. That Plaintiff be granted such other and further relief as the Court may deem just and proper under the circumstances.

Dated: September 28, 2018 **WILSON TURNER KOSMO LLP**

By: s/*Frederick W. Kosmo, Jr.*
FREDERICK W. KOSMO, JR.
HUBERT KIM
MORGAN P. SUDER
Attorneys for Plaintiff
NEWSPIN SPORTS. LLC

EXHIBIT A

US009656122B2

(12) **United States Patent**
Papadourakis

(10) **Patent No.: US 9,656,122 B2**
(45) **Date of Patent: *May 23, 2017**

(54) **MOTION CAPTURE AND ANALYSIS**

(71) Applicant: **New Spin Sports LLC**, Darien, IL (US)

(72) Inventor: **Angelo Gregory Papadourakis**, Darien, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 364 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/461,659**

(22) Filed: **Aug. 18, 2014**

(65) **Prior Publication Data**

US 2016/0107027 A1 Apr. 21, 2016

Related U.S. Application Data

(63) Continuation of application No. 13/972,908, filed on Aug. 22, 2013, now Pat. No. 8,831,905, which is a (Continued)

(51) **Int. Cl.**
A63B 24/00 (2006.01)
A63B 69/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A63B 24/0006*** (2013.01); ***A63B 24/0021*** (2013.01); ***A63B 24/0062*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A63B 24/0006; A63B 24/0062; A63B 24/0021; A63B 69/00; A63B 69/3632; G01P 15/00
See application file for complete search history.

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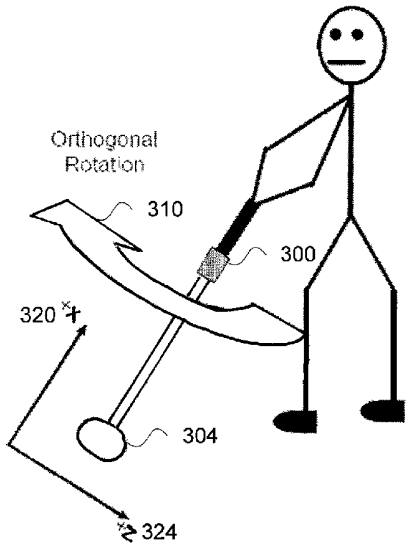
Primary Examiner — Toan Le
(74) *Attorney, Agent, or Firm* — Gavrilovoich, Dodd + Lindsey LLP

(57) **ABSTRACT**

A system for motion capture and analysis is described. The system may include a motion sensor unit configured to capture data associated with movement of an object. The motion sensor unit is configured to be directly or indirectly coupled to the movement object at a first location. The system also includes a processor to process the captured data to determine one or more values and to translate the data and/or values to correspond to a second location on the movement object located away from the first location. The data and/or values, including translated data and/or values, may be transmitted by wireless transmitter and displayed by a display unit.

22 Claims, 9 Drawing Sheets



Related U.S. Application Data

continuation of application No. 12/194,450, filed on Aug. 19, 2008, now Pat. No. 8,589,114.

(51) **Int. Cl.**

G01P 15/00	(2006.01)
A63B 69/36	(2006.01)
A63B 69/38	(2006.01)
A63B 71/06	(2006.01)
A63B 102/06	(2015.01)

(52) **U.S. Cl.**

CPC ***A63B 69/00*** (2013.01); ***A63B 69/3632*** (2013.01); ***G01P 15/00*** (2013.01); *A63B 69/0024* (2013.01); *A63B 69/0026* (2013.01); *A63B 69/3611* (2013.01); *A63B 69/3685* (2013.01); *A63B 69/38* (2013.01); *A63B 2024/0009* (2013.01); *A63B 2024/0028* (2013.01); *A63B 2024/0068* (2013.01); *A63B 2069/0006* (2013.01); *A63B 2069/0008* (2013.01); *A63B 2071/0647* (2013.01); *A63B 2102/06* (2015.10); *A63B 2102/065* (2015.10); *A63B 2220/40* (2013.01); *A63B 2220/44* (2013.01); *A63B 2220/80* (2013.01); *A63B 2220/803* (2013.01); *A63B 2220/833* (2013.01); *A63B 2225/50* (2013.01)

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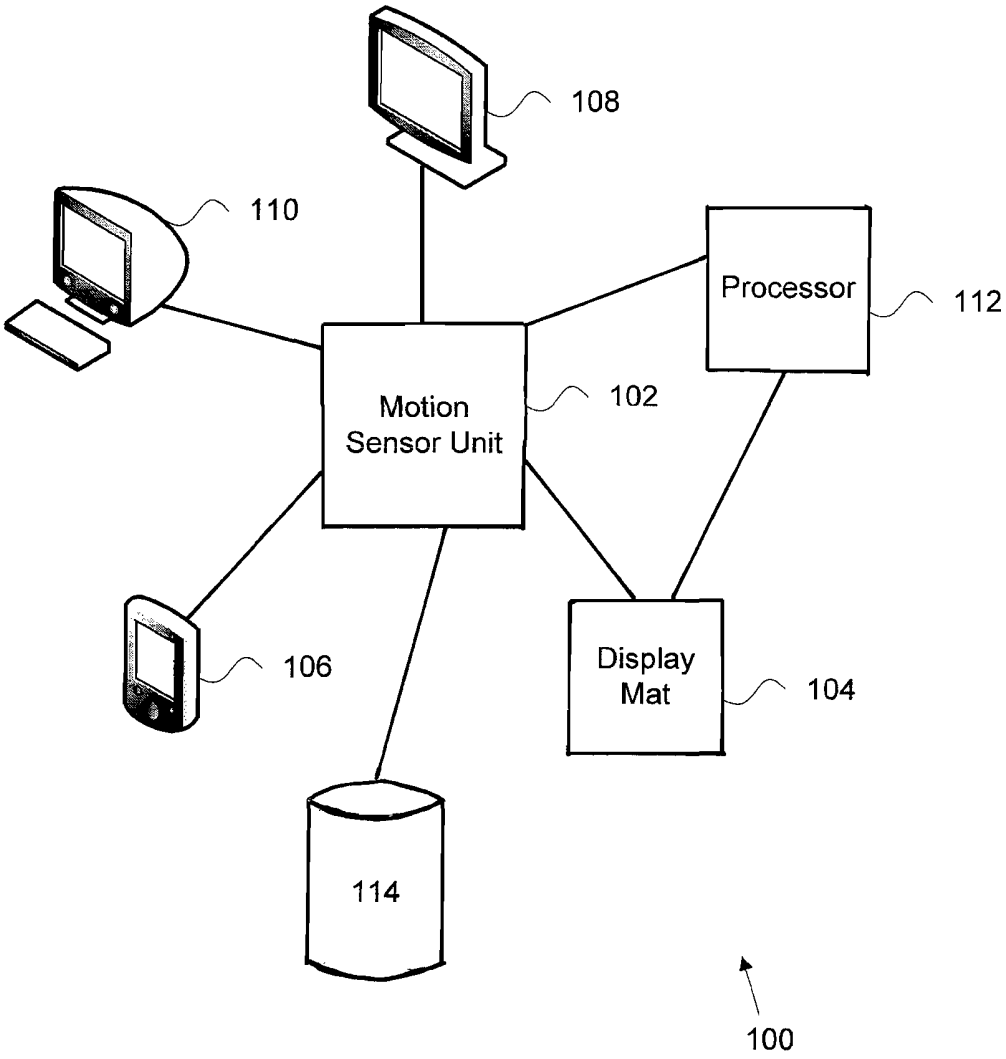
108
110
Processor
112
Motion
Sensor Unit
102
106
Display
Mat
104
114
100

FIG. 1A

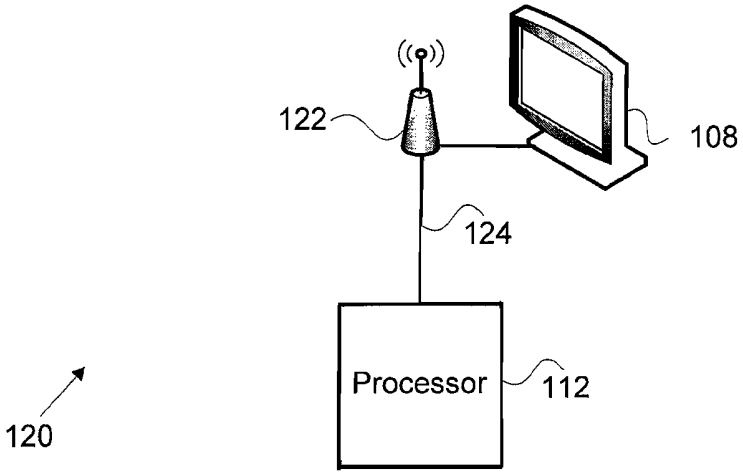
122
108
124
Processor
112
120

FIG. 1B

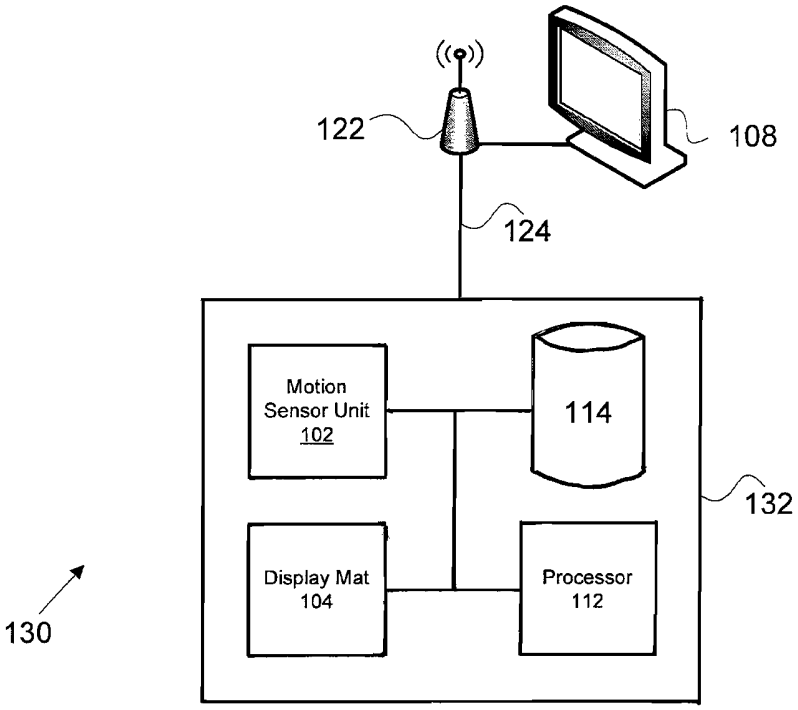
122
108
124
Motion Sensor Unit 102
114
132
Display Mat 104
Processor 112
130

FIG. 1C

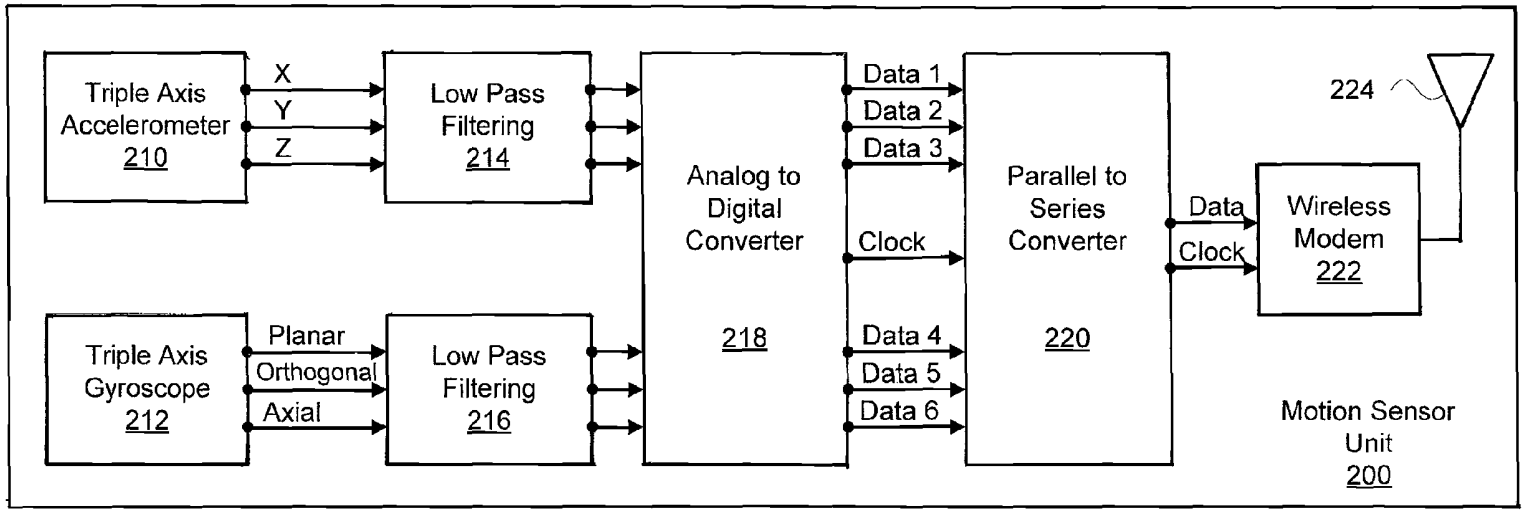
Triple Axis Accelerometer 210
X
Y
Z
Low Pass Filtering 214
Analog to Digital Converter 218
Data 1
Data 2
Data 3
Clock
Parallel to Series Converter 220
Data
Clock
Wireless Modem 222
224
Triple Axis Gyroscope 212
Planar
Orthogonal
Axial
Low Pass Filtering 216
Data 4
Data 5
Data 6
Motion Sensor Unit 200

FIG. 2A

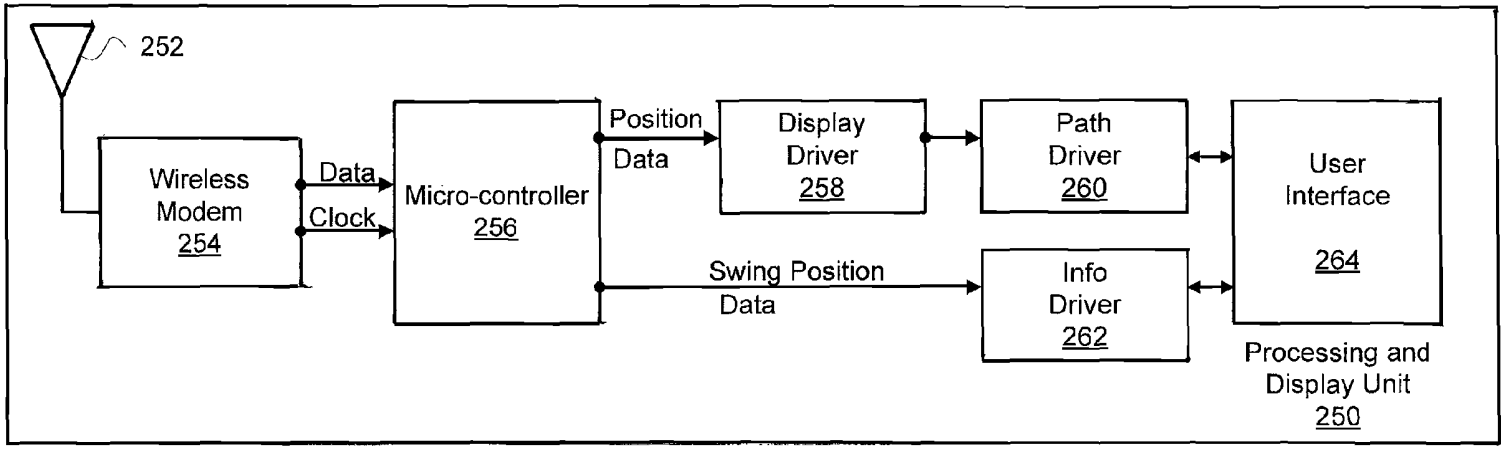
252
Wireless Modem 254
Data
Clock
Micro-controller 256
Position Data
Display Driver 258
Path Driver 260
User Interface 264
Swing Position Data
Info Driver 262
Processing and Display Unit 250

FIG. 2B

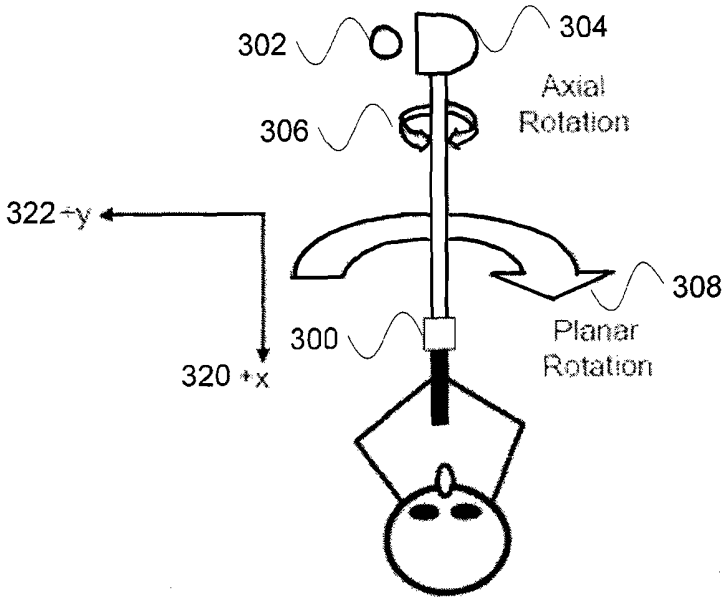
302
304
Axial
Rotation
306
322 +y
308
300
Planar
Rotation
320 +x

FIG. 3A

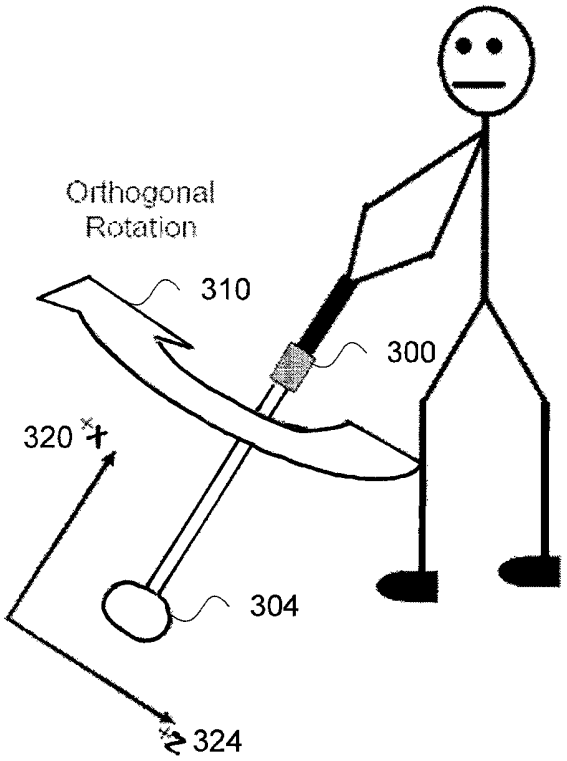

FIG. 3B

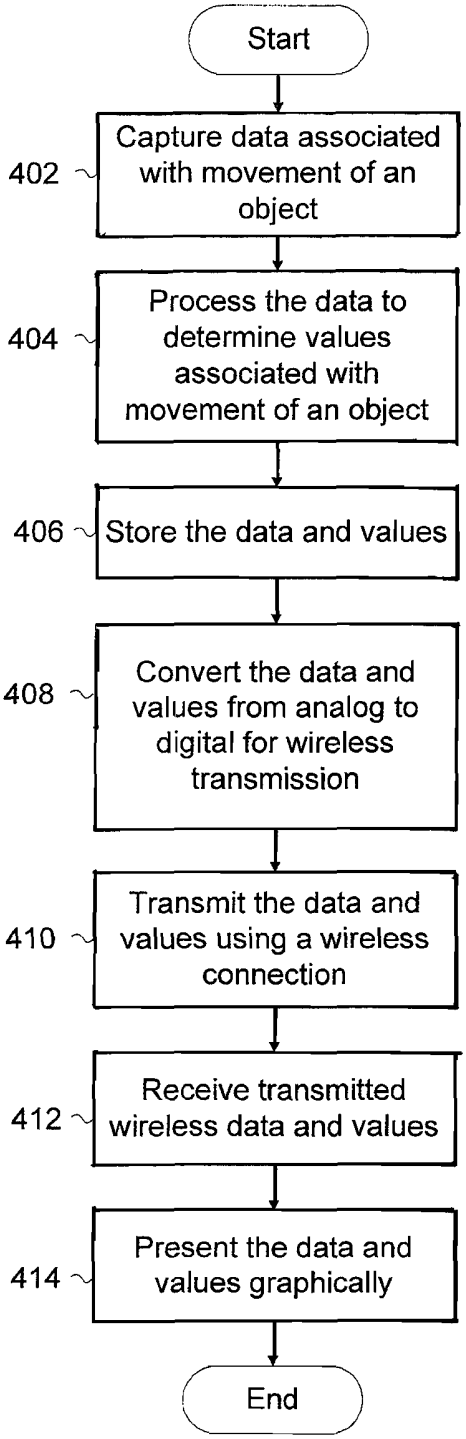
Start
402
Capture data associated with movement of an object
404
Process the data to determine values associated with movement of an object
406
Store the data and values
408
Convert the data and values from analog to digital for wireless transmission
410
Transmit the data and values using a wireless connection
412
Receive transmitted wireless data and values
414
Present the data and values graphically
End

FIG. 4A

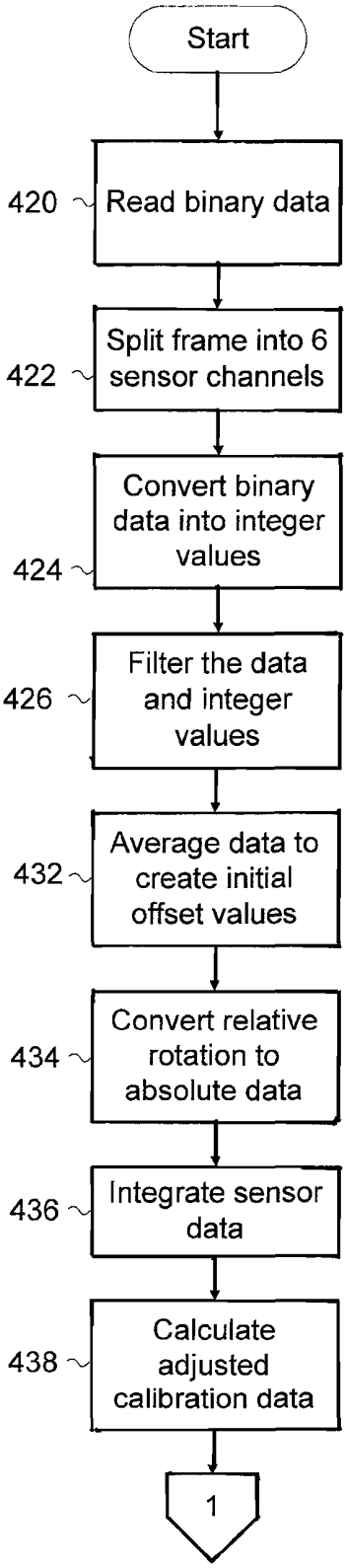
Start
420
Read binary data
422
Split frame into 6 sensor channels
424
Convert binary data into integer values
426
Filter the data and integer values
432
Average data to create initial offset values
434
Convert relative rotation to absolute data
436
Integrate sensor data
438
Calculate adjusted calibration data
1

FIG. 4B

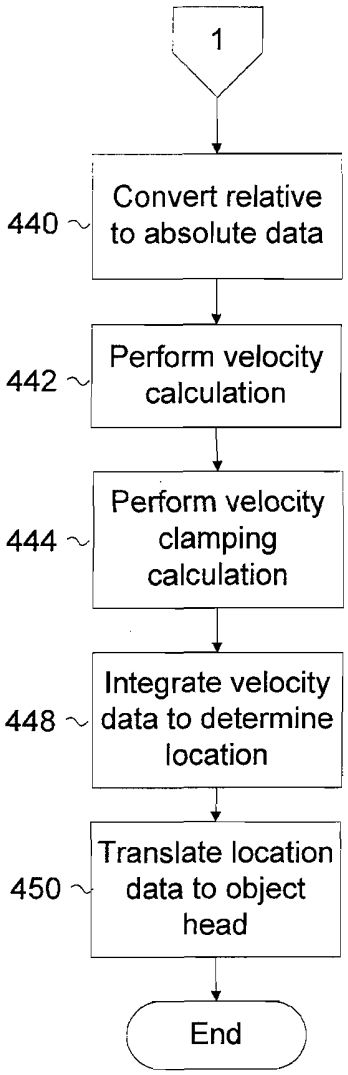
1
440
Convert relative to absolute data
442
Perform velocity calculation
444
Perform velocity clamping calculation
448
Integrate velocity data to determine location
450
Translate location data to object head
End

FIG. 4C

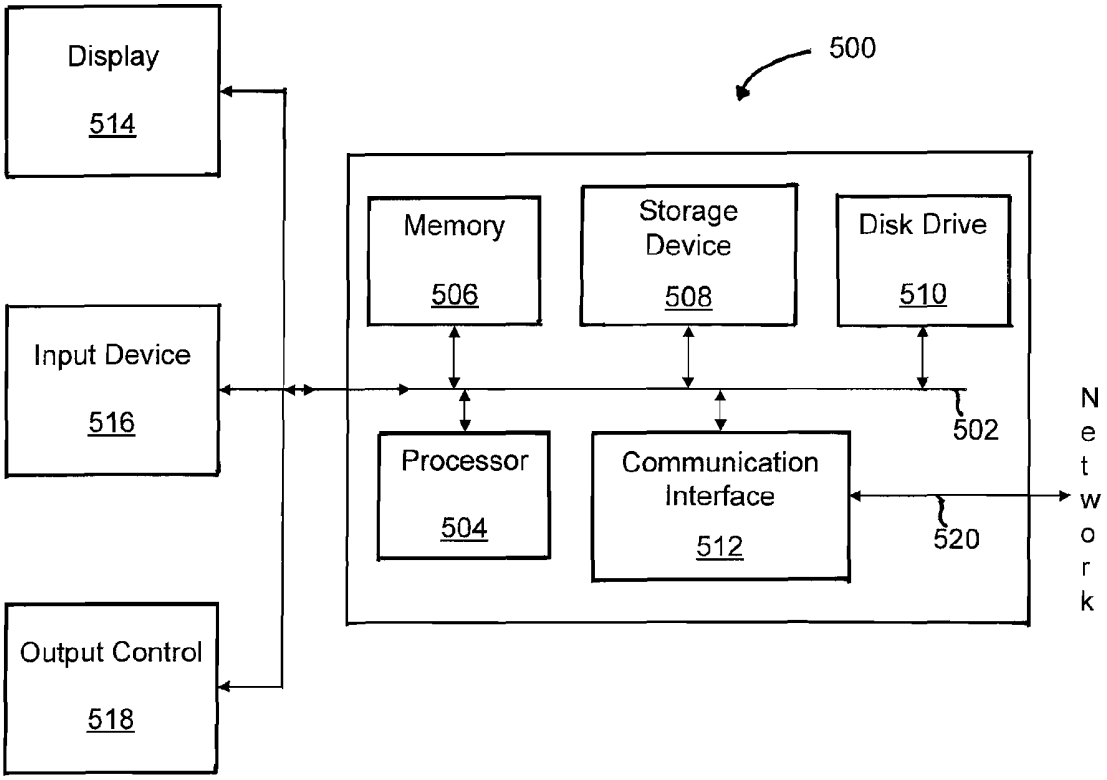
Display
514
500
Memory
506
Storage Device
508
Disk Drive
510
Input Device
516
502
Processor
504
Communication Interface
512
520
Network
Output Control
518

FIG. 5

MOTION CAPTURE AND ANALYSIS

This application is a continuation of Application No. 13/972,908, filed on Aug. 22, 2013 and entitled "Motion Capture and Analysis," which is a continuation of U.S. Pat. No. 8,589,114, filed on Aug. 19, 2008 and entitled "Motion Capture and Analysis." The foregoing are incorporated herein by reference.

FIELD

The present invention relates generally to computer software architecture and micro electro-mechanical devices and, more specifically, motion capture and analysis is described.

BACKGROUND

The evaluation of motion in various contexts and activities is a difficult and often problematic task using conventional solutions. Conventional solutions often have bulky, cumbersome, and inaccurate implementations that can affect the actual motion being evaluated. Further, many activities in which motion of, for example, a human body is evaluated require the use of specialized equipment that is often bulky and impractical. For example, motion evaluation of a combatant soldier wearing various types of gear and weapons may require, in conventional solutions, the use of bulky or heavy motion sensors. Conventional sensors and sensory systems may be coupled to processing units using either cumbersome wiring or heavy transmission equipment that requires a fixed and not portable system, minimizing both utility and effectiveness. As another convention example, a baseball bat may have a motion sensor that is heavy and attached to the bat, which could affect the detection and evaluation of certain motions. In other activities such as golf, motion (e.g., velocity, angle of impact of a club face against a ball, trajectory, and others) is typically not measured accurately nor easily measured using conventional solutions. As many golfers are aware, the trajectory of a golf ball depends upon the forward velocity, path, and relative club face angle of a golf club at the time of impact with the golf ball. Additionally, the ability to track and display the position and the forward velocity of the golf club through a full range of swing motion is vital to developing a successful and repeatable golf swing. While conventional techniques exist to capture motion of an object, there are various problems and limitations associated with conventional motion capture and analysis apparatus and techniques.

Limitations inherent to the conventional motion capture and analysis systems generally tend to preclude the everyday golfer from utilizing or benefiting from the training benefits imparted by such a system. For example, conventional motion capture and analysis systems tend to be complex, difficult to utilize and are not user friendly. Additionally, the conventional equipment is expensive, cumbersome and is limited in usability. Conventional equipment is not readily portable and must be used at a driving range or other training facility. Conventional equipment cannot be easily transported around a golf course, often becoming cumbersome for use throughout a round of golf. Conventional equipment lacks subjectivity and relies upon a universal standard in which to compare the user's particular swing motion. Conventional equipment does not account for variation in user's physiological characteristics.

Thus, what is needed is a solution for capturing and evaluating the swing motion of a golfer without the limitations of conventional techniques and equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, and like reference numerals designate like structural elements.

FIG. **1**A illustrates an exemplary system configured to implement motion capture and analysis;

FIG. **1**B illustrates an alternative exemplary system;

FIG. **1**C illustrates another alternative exemplary system;

FIG. **2**A illustrates an exemplary application architecture configured to implement motion capture and analysis;

FIG. **2**B further illustrates an exemplary application architecture configured to implement motion capture and analysis;

FIG. **3**A illustrates an exemplary motion sensor unit;

FIG. **3**B illustrates a further exemplary motion sensor unit;

FIG. **4**A illustrates an exemplary process for motion capture and analysis;

FIG. **4**B and FIG. **4**C illustrate an alternative exemplary process for motion capture and analysis; and

FIG. **5** illustrates an exemplary computer system suitable to implement motion capture and analysis.

DETAILED DESCRIPTION

Various embodiments or examples may be implemented in numerous ways, including as a system, a process, an apparatus, a user interface, or a series of program instructions on a computer readable medium such as a computer readable storage medium or a computer network where the program instructions are sent over optical, electronic, or wireless communication links. In general, operations of disclosed processes may be performed in an arbitrary order, unless otherwise provided in the claims.

A detailed description of one or more examples is provided below along with accompanying figures. The detailed description is provided in connection with such examples, but is not limited to any particular example. The scope is limited only by the claims and numerous alternatives, modifications and equivalents are encompassed. Numerous specific details are set forth in the following description in order to provide a thorough understanding. These details are provided for the purpose of example and the described techniques may be practiced according to the claims without some or all of these specific details. For clarity, technical material that is known in the technical fields related to the examples has not been described in detail to avoid unnecessarily obscuring the description.

In some examples, the described techniques may be implemented as a computer program or application ("application") or as a plug-in, module, or sub-component of another application. The described techniques may be implemented as software, hardware, firmware, circuitry, or a combination thereof. If implemented as software, the described techniques may be implemented using various types of programming, development, scripting, or formatting languages, frameworks, syntax, applications, protocols, objects, or techniques, including C, Objective C, C++, C#, Adobe® Integrated Runtime™ (Adobe® AIR™), ActionScript™, Flex™, Lingo™ Java™, Javascript™, Ajax, Perl, Python, COBOL, Fortran, ADA, XML, MXML, HTML, DHTML, XHTML, HTTP, XMPP, and others. Design, publishing, and other types of applications such as Dreamweaver®, Shockwave®, Flash®, and Fireworks® may also be used to implement the described techniques. The

described techniques may be varied and are not limited to the examples or descriptions provided.

An apparatus and techniques for motion capture and analysis are described herein. By using this motion capture and analysis apparatus, a golfer may be provided a visual tool to aid in analysis and development of their golf swing. This motion capture apparatus allows a user to save their personalized best swing as a reference for future comparison. The designation of a best swing is made by the user, and is not based upon an arbitrary universal conception of what constitutes a successful or productive swing motion. In other words, a motion capture and analysis apparatus may be used to assist the practice and perfection of a repeated dynamic motion, such as a golf swing. Various alternative implementations and modifications to the examples provided may be used and are not limited to the descriptions, dimensions, or other exemplary details provided herein.

FIG. **1**A illustrates an exemplary system configured to implement motion capture and analysis. Here, system **100** includes motion sensor unit **102**, display mat **104**, portable display **106**, display **108**, terminal **110**, processor **112**, and database **114**. In some examples, motion sensor unit **102** may be coupled, directly or indirectly, to a golf club, bat, racket, or other implement that may be used in a physical activity such as golf, baseball, tennis, or the like. Motion sensor unit **102** may include various types of devices or units (e.g., software, hardware, circuitry, or a combination thereof) for motion measurement (e.g., accelerometer, gyroscope, and others) may be used to gather data associated with the motion of a given implement that is processed using system **100**. Further, using processors and wireless data communication protocols and techniques, data may be transmitted from motion sensor unit **102** to display units (e.g., portable display **106**, display **108**, terminal **110**, or others), processor **112**, or devices that may be configured to use, analyze, evaluate, transform, or perform other operations on data from motion sensor unit **102**. Display **108**, in some examples, may be implemented using a liquid crystal display (LCD), projection tube television, digital television, or any type of analog or digital display. As an example, display **108** may receive data for display using various types of wireless, wired, optical, acoustic, or other video data transmission protocols (e.g., S-video, high definition multimedia interface (HDMI), or others). In other examples, a wireless receiving unit (not shown) may be coupled to display **108** and used to receive data from motion sensor unit **102**, processor **112**, display mat **104**, or other elements. In still other examples, processor **112** may be implemented as an element of a wireless receiving unit (not shown) coupled to display **108** in order to process data for generating and rendering an image or video on display **108**. In further examples, a wireless receiving unit (not shown) may be referred to as a sensor pod or dongle ("dongle") and, when coupled to display **108**, process data received from motion sensor unit **102** in order to generate and render an image for display. Further, the above-described techniques may be used to provide data processing capabilities of data received from motion sensor unit **102** and rendered on display **108**, terminal **110**, or other types of displays not shown. Still further, data may be transmitted from motion sensor unit **102**, received by a dongle (not shown), and processed, rendered, and displayed in real-time or substantially real-time on display **108**. In other examples, system **100** and the above-described elements may be varied in design, function, structure, configuration, implementation, or other aspects and are not limited to the examples described.

Here, processor **112** may be used to process data provided by motion sensor unit **102** in order to generate a display on, for example, portable display unit **106** or display mat **104**. As another example, processor **112** may be implemented in a separate device or in connection with motion sensor unit **102**, display mat **104**, portable display **106**, display **108**, terminal **110**, or any other type of device including, for example, a television (TV), monitor, display, or other type of device. For example, motion sensor unit **102** may be coupled to a golf club (not shown) and, when the golf club is swung, data may be captured by motion sensor unit **102** and transmitted to processor **112** using, for example, a wireless transmitter, transceiver, or the like (not shown). As another example, processor **112** may be implemented within a dongle or other type of wireless receiver coupled to display **108**. When data is received by a dongle, images or video of motion captured by motion sensor unit **102** may be recorded and/or processed to display an image or video on display **108**. In other examples, processor **112** may be implemented as part of display **108** without the use of a dongle or other wireless sensor pod coupled externally to display **108**. In some examples, database **114** may be implemented to store and retrieve data associated with motion (e.g., swinging motion of a golf club, bat, racket, or the like) captured by motion sensor unit **102**. For example, a golfer may wish to configure processor **112** to record and store data associated with a series of swings in database **114**, which may be implemented using a standalone or distributed database, repository, data warehouse, storage area network (SAN), network attached storage, or other type of data storage facility using hardware and/or software. Further, once stored, data may be retrieved from database **114**, which may be implemented with one, some, or none of the other elements shown in system **100**. In other words, database **114** may be implemented with processor **112** with display **108**. Database **114** may also be implemented with one or more of motion sensor unit **102**, display mat **104**, portable display unit **106**, display **108**, terminal **110**, processor **112**, or other elements (not shown). In some examples, data from motion sensor unit **102** may be transmitted to display mat **104**, portable display unit **106**, display **108**, or terminal **110** using one or more wireless, wired, optical, acoustic, or other types of data communication links or protocols.

Once transmitted, data may be interpreted and processed by, for example, processor **112**. Likewise, processor **112** may communicate data from motion sensor unit **102** to display mat **104** or other elements provided in system **100**. In some examples, display mat **104** may be configured to generate, render, and display an image on its surface. Display mat **104**, in some examples, may be configured for display on a horizontal, vertical, angled, or other type of surface. For example, display mat **104** be mounted on a vertical surface and used to display an image associated with a golf club, baseball bat, cricket bat, polo mallet, or others. Display mat **104** may also be configured to lie or be mounted to a horizontal surface (e.g., floor, ground, or the like) and used to present an image associated with motion under evaluation. Data for various types of motion may be evaluated and presented using the techniques described herein.

For example, motion associated with a portion of a body (e.g., human or otherwise) may be evaluated by system **100**, including detecting motion using motion sensor unit **102**, which is processed by processor **112** and stored in database **114** and/or presented on display mat **104**, the latter of which may be implemented using various types of displays (e.g., mats, screens, upright displays, liquid crystal displays, and others without limitation). Types of motion that may be

evaluated include movement by a boxer's punching motion, a pitcher's baseball-throwing motion, a football player's kicking motion (e.g., a punt), running motion, combat or martial arts-related hand and foot motion, a dancer's foot, arm, or other body motion, and others.

As another example, when data is transmitted from motion sensor unit **102**, an image of a golf club head being swung may be generated on display mat **104**. Further, display mat **104** may use various types of display resolution techniques and is not limited to any particular implementation. Further, display mat **104** may be implemented using a flexible LCD, active matrix, thin film transistor (TFT), or other types of display technologies. In other example, portable display **106**, display **108**, and terminal **110** may be used to display data generated by motion sensor unit **102**, stored and retrieved from database **114**, or processed by processor **112**. Links provided by and between elements **102-112** may be implemented as unidirectional, bidirectional, or other types of data communication links. In other examples, the number, type, configuration, and topology of system **100**, motion sensor unit **102**, display mat **104**, portable display **106**, display **108**, terminal **110**, and processor **112** may be varied and are not limited to the descriptions provided.

FIG. **1**B illustrates an alternative exemplary system. Here, system **120** includes display **108**, processor **112**, dongle **122**, and data connection **124**. In some examples, dongle **122** may be implemented as a wireless transceiver to receive and/or send data from processor **112** over data connection **124**, which may be implemented using wired, wireless, optical, acoustic, or other types of data communication protocols. In other examples, dongle **122** may be implemented using a wired data connection (not shown) in order to receive data for generating, rendering, and displaying an image on display **108**. In still other examples, processor **112** may be implemented as part of dongle **122**. Further, other elements (e.g., one or more of motion sensor unit **102**, processor **112**, database **114**, or others) may be implemented or integrated with dongle **122**. Still further, system **120** and the above-described elements may be varied in implementation, function, structure, or other aspects and are not limited to the examples provided above.

FIG. **1**C illustrates another alternative exemplary system. Here, system **130** includes motion sensor unit **102**, display mat **104**, display **108**, processor **112**, database **114**, dongle **122**, and data connection **124**, which may be implemented as described above or differently. Further, application **132** may include motion sensor unit **102**, display mat **104**, processor **112**, and database **114**, which may be implemented as described above or differently. Further, application **132** may be implemented using a standalone, distributed, or other type of application architecture or topology. Alternatively one or more elements (e.g., motion sensor unit **102**, display mat **104**, processor **112**, database **114**, or others) of application **132** may be implemented apart from or as part of dongle **122** or display **108**. In other examples, system **130** and the above-described elements may be varied in implementation, function, or structure and are not limited to the descriptions provided.

FIG. **2**A illustrates an exemplary application architecture configured to implement motion capture and analysis. Here, motion sensor unit **200** includes triple axis accelerometer **210**, triple axis gyroscope **212**, low pass filtering **214**, low pass filtering **216**, analog to digital converter **218**, parallel to series converter **220**, wireless modem **222** and wireless transceiver **224**. In some examples, motion sensor unit **200** may include a micro-controller (not shown) similar to micro-controller **256** (described below in connection with FIG. **2**B).

In some examples, motion sensor unit **200** may be detachably coupled to an object (e.g., golf club, tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or others). Motion sensor unit **200** may be various sizes and shapes to accommodate a static and secure attachment to the various shapes and sizes of the detachably coupled object. Motion sensor unit **200** may have an adjustable attachment mechanism to enable one unit to accommodate various shapes and sizes of attached objects. Motion sensor unit **200** may be lightweight and easily portable. Motion sensor unit **200** may be easily attached or detached from the object by the user, without the need for specialized tools or accessories. In other examples, motion sensor unit **200** and the above-described elements may be implemented differently and are not limited to the descriptions provided.

In some examples, a power supply (not shown) such as a battery or external AC/DC converter may be coupled to motion sensor unit **200**. Power supplies may be implemented as rechargeable, non-rechargeable, portable, or disposable batteries. In other examples, a battery (not shown) may be implemented as part of motion sensor unit **200**, supplying power to motion sensor unit **200** and its associated components. In still other examples, a power source may be implemented as another attachment to motion sensor unit **200**.

In some examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be configured to measure movement of an object (e.g., golf club, tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or others). In some examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be a micro electro-mechanical system (MEMS) device. In other examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be an analog or digital device. In some examples, triple axis accelerometer **210** may be configured to measure the acceleration of the object along the x-axis, y-axis and z-axis and triple axis gyroscope **212** may be configured to measure the rotational movement of the object along the planar, orthogonal and axial directions. In other examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be configured differently and are not limited to the descriptions provided.

Here, triple axis accelerometer **210** communicates the data signal to low pass filtering **214** and triple axis gyroscope **212** communicates the data signal to low pass filtering **216**. Further, low pass filtering **214** and low pass filtering **216** communicate the data signal to analog to digital converter **218**. In some examples, analog to digital converter **218** may be configured to convert the data from an analog signal to a digital signal. Here, analog to digital converter **218** communicates the data signal to parallel to series converter **220**. In some examples, parallel to series converter **220** is configured to convert the data signal from a parallel electrical signal to a series electrical signal.

Here, parallel to series converter **220** communicates the data signal to wireless modem **222**. Wireless modem **222** is coupled to wireless transceiver **224** for sending and receiving signals (e.g., RF) between motion sensor unit **200** and display unit (described below in connection with FIG. **2**B). In some examples, wireless transceiver **224** may be configured to send and receive communication signals using various wireless formats (e.g., ZigBee (i.e., IEEE 802.15.4

data communication protocol/standard/specification), radio frequency (RF) waves, IEEE 802.11, Bluetooth, UHF, or others).

FIG. **2**B further illustrates an exemplary application architecture configured to implement motion capture and analysis. Here, processing and display unit **250** includes wireless modem **254**, wireless transceiver **252**, micro-controller **256**, display driver **258**, path driver **260**, info driver **262** and user interface **264**. In some examples, processing and display unit **250** may be a remote device or system (e.g., display mat, portable display device, television monitor, computer, server, video recorder, or others) configured to present or display visual, graphical or numerical data measured by the motion sensor unit (described above in connection with FIG. **2**A) and values associated with object movement, which are calculated using the measured data. In some examples, processing and display unit **250** may be configured to save the graphic and numerical data and values associated with a user selected reference point (i.e., "best swing") for comparison with subsequent iterations of the object movement. In some examples, processing and display unit **250** may be configured to provide an acoustic indication or response. Processing and display unit **250** may be configured with a memory device (not shown here). The memory device may be a permanent or removable memory card or hard drive.

In some examples, processing and display unit **250** presents various parameters associated with the motion of an object such as measured data (e.g., three dimensional acceleration, three dimensional rotational acceleration, maximum acceleration, or others) or calculated values (e.g., three dimensional velocity, three dimensional rotational velocity, location coordinates, maximum velocity, impact velocity, relative angle of object at point of impact, or others). Still further, processing and display unit **250** may be configured to graphically present a directional path representing the actual movement of an object and graphically indicate various significant points of reference (e.g., point of maximum velocity, or others) along the object's path of movement. In other examples, processing and display unit **250** may be configured to present or display any number of different visual, graphical or numerical parameters associated with the movement of an object and are not limited to the descriptions provided.

In some examples, processing and display unit **250** may be a display mat for use on a horizontal and flat surface, which display mat may be various sizes, shapes or dimensions. A display mat (e.g., display mat **104** (FIG. **1**A)) may be configured such that the user stands on the mat while moving the object, or stands adjacent to the mat while moving the object. A display mat may also be made of a material that is durable, impact resistant and able to sustain the weight of a person. In some examples, a display mat may be made of a material that is easily rolled up and lightweight for easy portability. As an example, a display mat may be made of an array of surface mounted light emitting devices (LEDs). The display mat may be configured to present or display any or all of the visual, graphic or numerical parameters discussed above. In other examples, processing and display unit **250** may be implemented differently and is not limited to the descriptions provided.

In other examples, processing and display unit **250** may be a portable display device for handheld use. In some examples, a portable display device may be small, lightweight and easily transported by the user. In other examples, a portable display device may be various sizes, shapes or dimensions. A portable display device may also be configured to present or display any or all of the visual, graphic or numerical parameters discussed above. In other examples, processing and display unit **250** as a portable display device may be implemented differently and is not limited to the descriptions provided.

In some examples, a power supply (not shown) such as a battery or external AC/DC converter may be coupled to processing and display unit **250**. Power supplies may be implemented as rechargeable, non-rechargeable, portable, or disposable batteries. In other examples, a battery (not shown) may be implemented as part of processing and display unit **250**, supplying power to processing and display unit **250** and its associated components. In still other examples, a power source may be implemented as another attachment to processing and display unit **250**.

Here, wireless modem **254** is coupled to wireless transceiver **252** for sending and receiving signals (e.g., RF) between processing and display unit **250** and motion sensor unit **200** (described above in connection with FIG. **2**A). In some examples, wireless transceiver **252** may be configured to send and receive communication signals using various wireless formats (e.g., ZigBee, RF waves, IEEE 802.11, Bluetooth, UHF, or others).

Here, wireless modem **254** communicates the data signal to micro-controller **256**. In some examples, micro-controller **256** is configured to process the measured data captured by motion sensor unit **200** (described above in connection with FIG. **2**A). Micro-controller **256** may calculate values associated with movement of an object (e.g., three dimensional velocity, three dimensional rotational velocity, location coordinates, maximum velocity, impact velocity, relative angle of object at point of impact, or others) using the movement data captured by motion sensor unit **200** (described above in connection with FIG. **2**A).

Here, micro-controller **256** communicates a position data signal to display driver **258** and swing position data to info driver **262**. Here further, display driver **258** communicates the position data to path driver **260**. Finally, path driver **260** and info driver **262** communicate the position and swing position data to and from user interface **264**.

In some examples, user interface **264** may be configured to include user controls which allow user configuration of the system. User interface **264** controls may include various input mechanism and allow the user to save a selected reference point (i.e., "best swing") or select the desired display parameters. In some examples, user interface **264** may be configured to include an acoustic signal to provide an auditory indication. In other examples, user interface **264** may be configured differently and is not limited to the descriptions provided. Still further, processing and display unit **250** and the above-described elements may be implemented differently and is not limited to the descriptions or examples provided above.

FIG. **3**A illustrates an exemplary motion sensor unit. Here, a top view of an exemplary user of the motion sensor unit is shown. In this example, motion sensor unit **300**, impact object **302**, movement object **304**, axial rotation **306**, planar rotation **308**, x-axis **320** and y axis **322** are shown. Motion sensor unit **300** may be configured and implemented as described above as motion sensor unit **200** (described above in connection with FIG. **2**A). As shown here, motion sensor unit **300** may be used to measure and capture axial rotation **306**, planar rotation **308**, x-axis acceleration along x-axis **320** and y-axis acceleration along y-axis **322**. In other examples, motion sensor unit **300** may be configured to measure and capture other parameters associated with movement of an object and is not limited by the descriptions provided.

As shown here, motion sensor **300** is coupled to movement object **304**, as shown here as a golf club. In other examples, movement object **304** may be a tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or other moveable object. As shown here, movement object **304** is intended to make dynamic contact with impact object **302**, as shown here as a golf ball. In other examples, impact object **302** may be a baseball, softball, hockey puck, or other moving object. In other examples, movement object **304** and impact object **302** may be different and are not limited to the descriptions provided.

FIG. **3**B illustrates a further exemplary motion sensor unit. Here, a side view of an exemplary user of the motion sensor unit is shown. In this example, motion sensor unit **300**, movement object **304**, orthogonal rotation **310**, x-axis **320** and z-axis **324** are shown. Motion sensor unit **300** may be configured and implemented as described above as motion sensor unit **200** (described above in connection with FIG. **2**A). As shown here, motion sensor unit **300** may be used to measure and capture orthogonal rotation **310**, x-axis acceleration along x-axis **320** and z-axis acceleration along z-axis **324**. In other examples, motion sensor unit **300** may be configured to measure and capture other parameters associated with movement of an object and is not limited by the descriptions provided.

As shown here, motion sensor **300** is coupled to movement object **304**, as shown here as a golf club. In other examples, movement object **304** may be a tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or other moveable object. As shown here, movement object **304** is intended to make dynamic contact with impact object (not shown). In other examples, movement object **304** may be different and is not limited to the descriptions provided.

FIG. **4**A illustrates an exemplary process for motion capture and analysis. In some examples, data associated with movement of an object may be captured (**402**). The data may be processed to determine values associated with movement of the object (**404**). The data and the values may be stored (**406**). The data and values may be converted from analog to digital for a wireless transmission (**408**). The data and the values may be transmitted using a wireless connection (**410**). Once transmitted, data and values may be received using, for example, a wireless modem (FIG. **2**B) configured to modulate or demodulate transmitted data for processing and presentation on a display (e.g., display **108** (FIGS. **1**A-**1**C) (**412**). The data and values may be presented graphically (**414**). The above-described process may be varied in function, processes and performed in any arbitrary order and is not limited to the examples shown and described.

FIG. **4**B and FIG. **4**C illustrate an alternative exemplary process for motion capture and analysis. In some examples, binary data may be read (**420**). The frame may be split into 6 sensor channels (**422**). The binary data may be converted into integer values (**424**). The data and integer values may be filtered (**426**). Optionally, a "swing started" calculation may be performed (not shown) to determine when a swinging motion begins. A "swing started" calculation or determination may be performed, in some examples, after filtering data and integer values. Further, an optional operation for creating a lapsed time index may also be created (not shown). The data may be averaged to create initial offset values (**432**). Relative rotation may be converted to absolute data (**434**). The sensor data may be integrated (**436**). The adjusted calibration data may be calculated (**438**). Relative data may be converted to absolute data (**440**). A velocity calculation may be performed (**442**). A velocity clamping calculation may be performed (**444**). Optionally, a "swing end" calculation may be performed to determine when a swing motion ends or terminates (**446**). Velocity data may be integrated to determine location (**448**). Location data may be translated to object head (**450**). The above-described process may be varied in function, processes and performed in any arbitrary order and is not limited to the examples shown and described.

FIG. **5** illustrates an exemplary computer system suitable to implement motion capture and analysis. In some examples, computer system **500** may be used to implement computer programs, applications, methods, processes, or other software to perform the above-described techniques. Computer system **500** includes a bus **502** or other communication mechanism for communicating information, which interconnects subsystems and devices, such as processor **504**, system memory **506** (e.g., RAM), storage device **508** (e.g., ROM), disk drive **510** (e.g., magnetic or optical), communication interface **512** (e.g., modem or Ethernet card), display **514** (e.g., CRT or LCD), input device **516** (e.g., keyboard), and output control **518**.

According to some examples, computer system **500** performs specific operations by processor **504** executing one or more sequences of one or more instructions stored in system memory **506**. Such instructions may be read into system memory **506** from another computer readable medium, such as static storage device **508** or disk drive **510**. In some examples, hard-wired circuitry may be used in place of or in combination with software instructions for implementation.

The term "computer readable medium" refers to any tangible medium that participates in providing instructions to processor **504** for execution. Such a medium may take many forms, including but not limited to, non-volatile media and volatile media. Non-volatile media includes, for example, optical or magnetic disks, such as disk drive **510**. Volatile media includes dynamic memory, such as system memory **506**.

Common forms of computer readable media includes, for example, floppy disk, flexible disk, hard disk, magnetic tape, any other magnetic medium, CD-ROM, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, RAM, PROM, EPROM, FLASH-EPROM, any other memory chip or cartridge, or any other medium from which a computer can read.

Instructions may further be transmitted or received using a transmission medium. The term "transmission medium" may include any tangible or intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine, and includes digital or analog communications signals or other intangible medium to facilitate communication of such instructions. Transmission media includes coaxial cables, copper wire, and fiber optics, including wires that comprise bus **502** for transmitting a computer data signal.

In some examples, execution of the sequences of instructions may be performed by a single computer system **500**. According to some examples, two or more computer systems **500** coupled by communication link **520** (e.g., LAN, PSTN, or wireless network) may perform the sequence of instructions in coordination with one another. Computer system **500** may transmit and receive messages, data, and instructions, including program, i.e., application code, through communication link **520** and communication interface **512**. Received program code may be executed by processor **504** as it is received, and/or stored in disk drive **510**, or other non-volatile storage for later execution.

Although the foregoing examples have been described in some detail for purposes of clarity of understanding, the invention is not limited to the details provided. There are many alternative ways of implementing the invention. The disclosed examples are illustrative and not restrictive.

The invention claimed is:

1. A system, comprising:

a motion sensor unit configured to be directly or indirectly coupled to a movement object at a first location, the movement object being used in a physical sport or leisure activity, the motion sensor unit being further configured to capture data associated with movement of the movement object;

a processor to process the data to determine one or more values associated with movement of the movement object, and to translate the data or values to correspond to a second location on the movement object located away from the first location; and

a wireless transmitter to transmit at least one of the data and the values to a display unit configured to receive and graphically display at least one of the data and the values.

2. The system of claim **1**, wherein the movement object has a first end and a second end, and wherein the first location corresponds to a location at or adjacent to the first end of the movement object.

3. The system of claim **2**, wherein the second location corresponds to a location at or adjacent to the second end of the movement object.

4. The system of claim **1**, wherein the movement object is selected from the group consisting of a golf club, a baseball bat, a tennis racket, a hockey stick, a racquetball racquet and a squash racquet.

5. The system of claim **1**, wherein the motion sensor unit comprises an accelerometer and a gyroscope.

6. The system of claim **1**, wherein the at least one of the data and values to be displayed by the display unit comprise the translated data or values.

7. The system of claim **1**, wherein the translated data or values comprises information related to acceleration of the second location of the movement object.

8. The system of claim **1**, wherein the translated data or values comprises information related to a velocity of the second location of the movement object.

9. The system of claim **1**, wherein the translated data or values comprises information related to angular momentum of the second location of the movement object.

10. The system of claim **1**, wherein the translated data or values indicate a path of movement of the second location of the movement object.

11. A system, comprising:

a non-wearable motion sensor unit configured to be adjustably coupled to, but not mechanically integrated with, an outer surface at a first location on a movement object using an adjustable attachment mechanism, the movement object being used in physical activity,

the non-wearable motion sensor unit being further configured to be removed from the movement object and adjustably coupled to, but not mechanically integrated with, another outer surface of another movement object using the adjustable attachment mechanism,

the non-wearable motion sensor unit being further configured to capture data associated with movement of the movement object;

a processor to process the data to determine one or more values and to translate at least one of the data and the values to correspond to a second location on the movement object located away from the first location; and

a wireless transmitter to transmit at least one of the data and the values to a display unit configured to receive and graphically display at least one of the data and values.

12. The system of claim **11**, wherein the movement object has a first end and a second end, and wherein the first location corresponds to a location at or adjacent to the first end of the movement object.

13. The system of claim **12**, wherein the second location corresponds to a location at or adjacent to the second end of the movement object.

14. The system of claim **11**, wherein the at least one of the data and values to be displayed by the display unit comprise the translated data or values.

15. A system, comprising:

a motion sensor unit configured to be directly or indirectly coupled to a movement object at a first location, the movement object being used in a physical sport or leisure activity, the motion sensor unit being further configured to capture data associated with movement of the movement object;

a wireless transmitter to transmit the data to a processor;

a processor to process the data to determine one or more values associated with movement of the movement object, and to translate the data or values to correspond to a second location on the movement object located away from the first location; and

a display unit to graphically display at least one of the data and the values.

16. The system of claim **15**, wherein the movement object has a first end and a second end, and wherein the first location corresponds to a location at or adjacent to the first end of the movement object.

17. The system of claim **16**, wherein the second location corresponds to a location at or adjacent to the second end of the movement object.

18. The system of claim **15**, wherein the at least one of the data and values to be displayed by the display unit comprise the translated data or values.

19. A system, comprising:

a non-wearable motion sensor unit configured to be adjustably coupled to, but not mechanically integrated with, an outer surface at a first location on a movement object using an adjustable attachment mechanism, the movement object being used in physical activity,

the non-wearable motion sensor unit being further configured to be removed from the movement object and adjustably coupled to, but not mechanically integrated with, another outer surface of another movement object using the adjustable attachment mechanism,

the non-wearable motion sensor unit being further configured to capture data associated with movement of the movement object,

a wireless transmitter to transmit the data to a processor,

a processor to process the data to determine one or more values and to translate at least one of the data and the values to correspond to a second location on the movement object located away from the first location; and

a display unit to graphically display at least one of the data and values.

20. The system of claim **19**, wherein the movement object has a first end and a second end, and wherein the first location corresponds to a location at or adjacent to the first end of the movement object.

21. The system of claim **20**, wherein the second location corresponds to a location at or adjacent to the second end of the movement object.

22. The system of claim **21**, wherein the at least one of the data and values to be displayed by the display unit comprise the translated data or values.

* * * * *

EXHIBIT B

US008831905B2

(12) **United States Patent**
Papadourakis

(10) **Patent No.: US 8,831,905 B2**
(45) **Date of Patent: *Sep. 9, 2014**

(54) **MOTION CAPTURE AND ANALYSIS**

(71) Applicant: **Angelo Gregory Papadourakis**, Libertyville, IL (US)

(72) Inventor: **Angelo Gregory Papadourakis**, Libertyville, 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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/972,908**

(22) Filed: **Aug. 22, 2013**

(65) **Prior Publication Data**

US 2014/0032162 A1 Jan. 30, 2014

Related U.S. Application Data

(63) Continuation of application No. 12/194,450, filed on Aug. 19, 2008, now Pat. No. 8,589,114.

(51) **Int. Cl.**

G01P 15/00	(2006.01)
A63B 57/00	(2006.01)
A63B 69/36	(2006.01)
A63B 69/38	(2006.01)
A63B 69/00	(2006.01)
A63B 71/06	(2006.01)

(52) **U.S. Cl.**

CPC ***G01P 15/00*** (2013.01); *A63B 69/38* (2013.01); *A63B 69/0026* (2013.01); ***A63B 69/00*** (2013.01); *A63B 2243/0075* (2013.01); *A63B 2069/0008* (2013.01); *A63B 2220/40* (2013.01); *A63B 2225/50* (2013.01); ***A63B 69/3632*** (2013.01); *A63B 2220/833* (2013.01); *A63B 69/3611* (2013.01); *A63B 69/0024* (2013.01); *A63B 69/3685* (2013.01); *A63B 2071/0647* (2013.01); *A63B 2243/0079* (2013.01); *A63B 2069/0006* (2013.01); *A63B 2220/803* (2013.01)

USPC **702/141**; 473/223

(58) **Field of Classification Search**

USPC 702/141, 33, 41, 81, 84, 94–96, 127, 702/142, 145, 150–153, 182–183, 702/188–189; 473/131, 201–202, 206, 209, 473/212–213, 222–224, 228, 265–266, 282, 473/407, 409; 73/1.37–1.39, 1.79, 488, 73/493, 504.02–504.03, 510–511, 73/514.01–514.02, 1.37–1.39; 434/252; 703/2

See application file for complete search history.

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8,589,114	B2 *	11/2013	Papadourakis	702/145

* cited by examiner

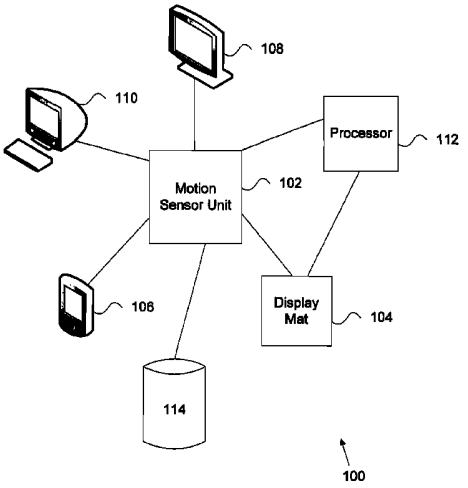
Primary Examiner — Toan Le

(74) *Attorney, Agent, or Firm* — Gavrilovich, Dodd and Lindsey LLP

(57) **ABSTRACT**

Motion capture and analysis is described, including a motion sensor unit configured to capture data associated with movement of an object, to process the data to determine one or more values, to store the data and the one or more values, and to convert the data and the one or more values from an analog signal to a digital signal associated with a wireless transmission, and a display unit configured to receive the data from the motion sensor unit, the data being transmitted using through the wireless transmission, to process the data to determine one or more values, to store the data, and to graphically present the data and the one or more values.

20 Claims, 9 Drawing Sheets



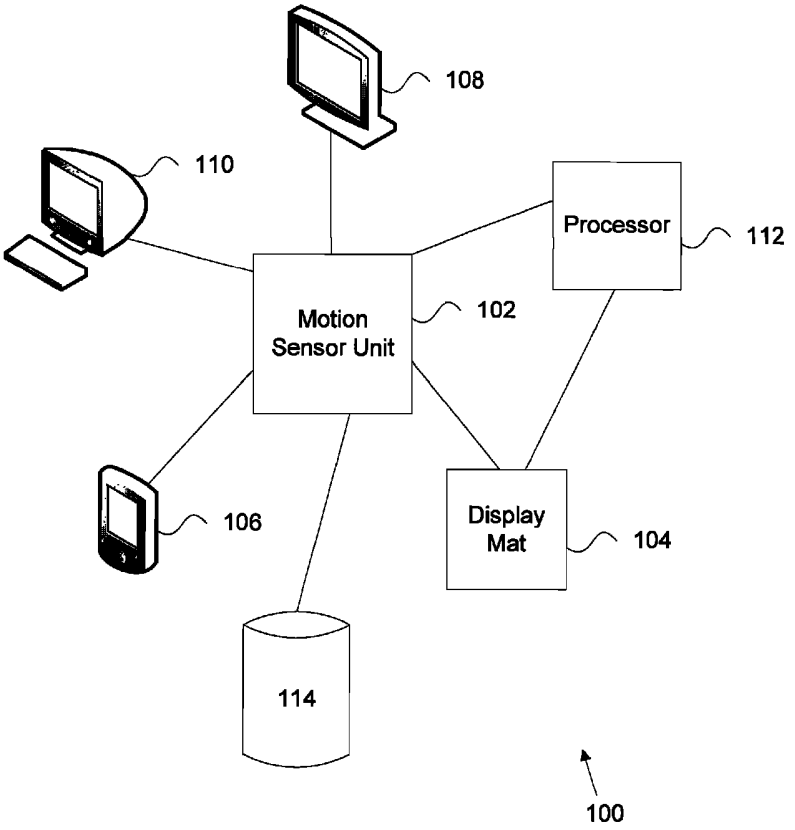

108
110
Processor
112
Motion
Sensor Unit
102
106
Display
Mat
104
114
100

FIG. 1A

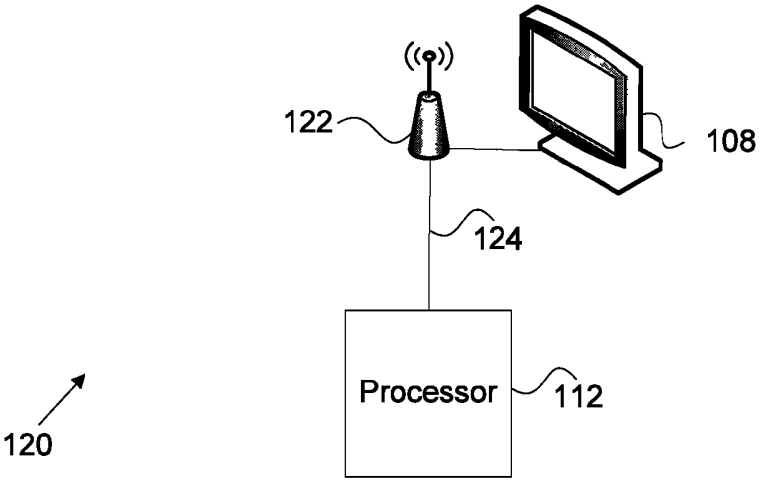

122
108
124
Processor
112
120

FIG. 1B

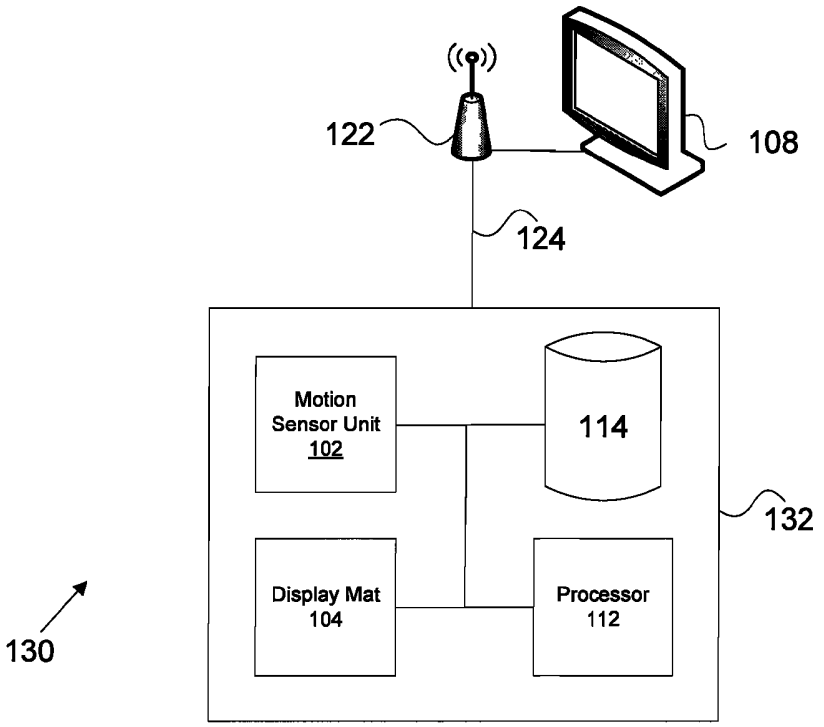

122
108
124
Motion Sensor Unit 102
114
132
Display Mat 104
Processor 112
130

FIG. 1C

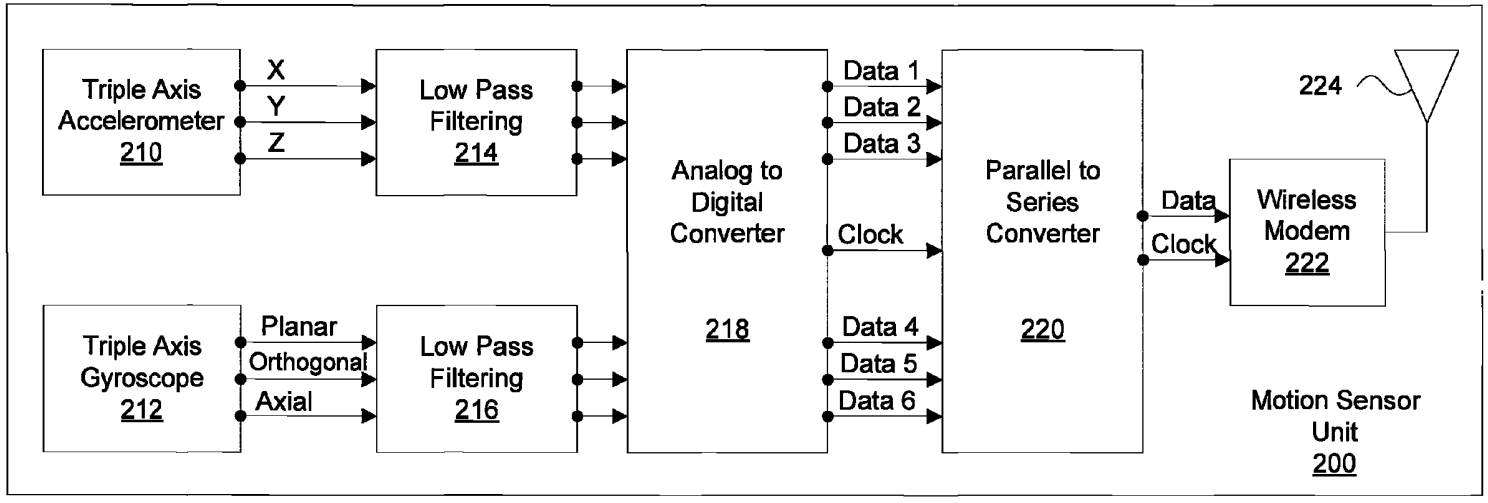

Triple Axis Accelerometer 210
X
Y
Z
Low Pass Filtering 214
Analog to Digital Converter 218
Data 1
Data 2
Data 3
Clock
Parallel to Series Converter 220
Data
Clock
Wireless Modem 222
224
Triple Axis Gyroscope 212
Planar
Orthogonal
Axial
Low Pass Filtering 216
Data 4
Data 5
Data 6
Motion Sensor Unit 200

FIG. 2A

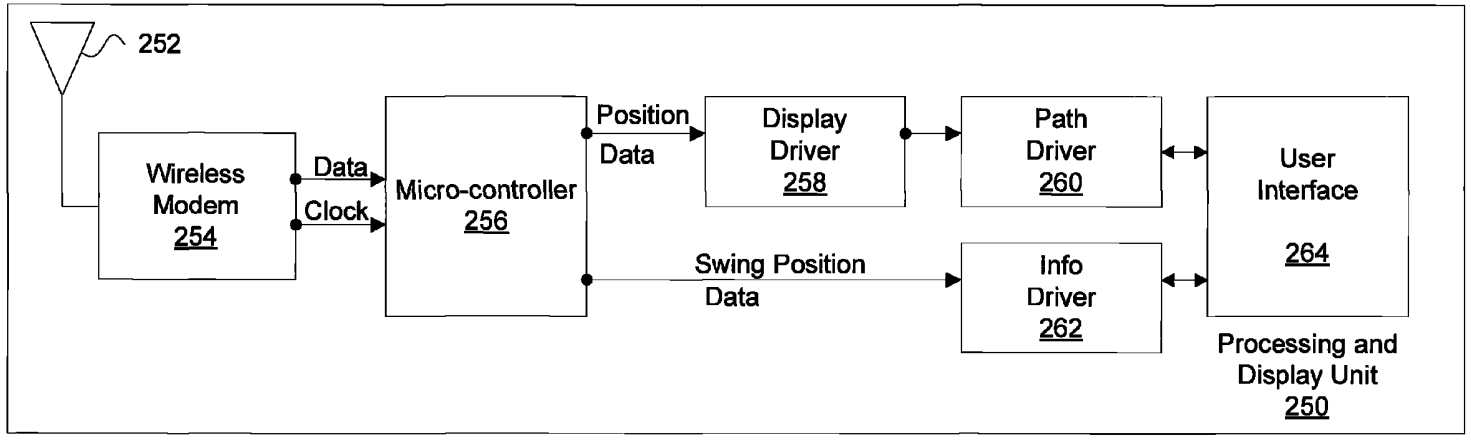

252
Wireless Modem 254
Data
Clock
Micro-controller 256
Position Data
Display Driver 258
Path Driver 260
User Interface 264
Swing Position Data
Info Driver 262
Processing and Display Unit 250

FIG. 2B

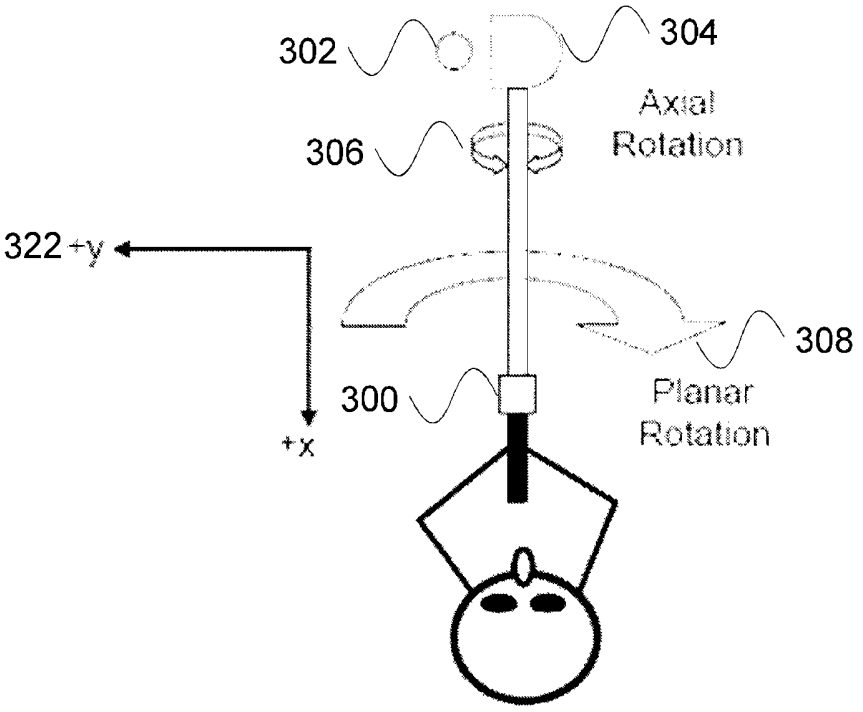


FIG. 3A

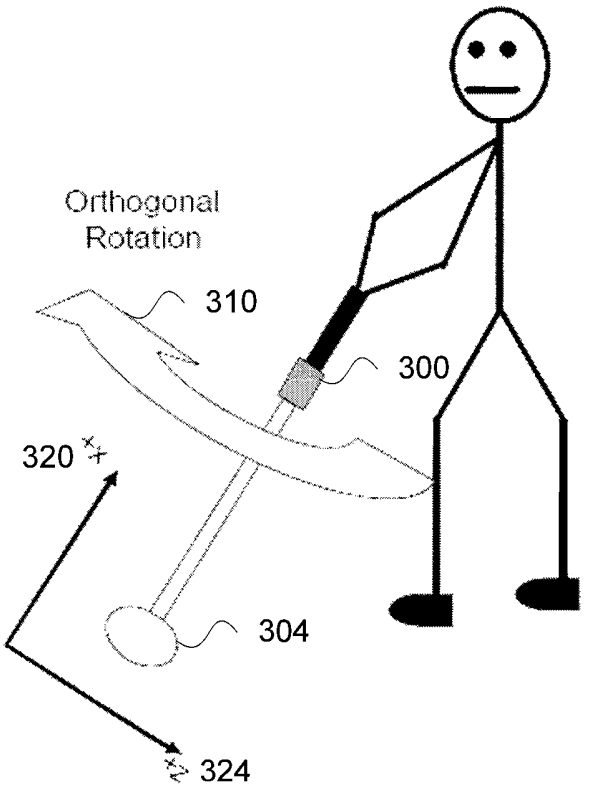


FIG. 3B

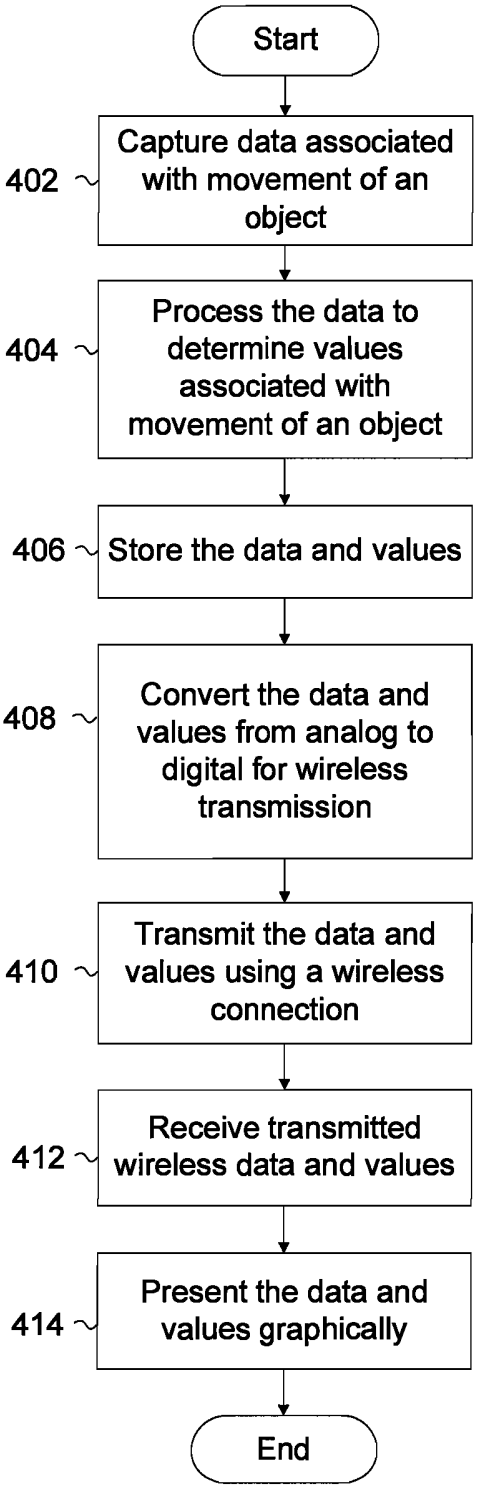

Start
402
Capture data associated with movement of an object
404
Process the data to determine values associated with movement of an object
406
Store the data and values
408
Convert the data and values from analog to digital for wireless transmission
410
Transmit the data and values using a wireless connection
412
Receive transmitted wireless data and values
414
Present the data and values graphically
End

FIG. 4A

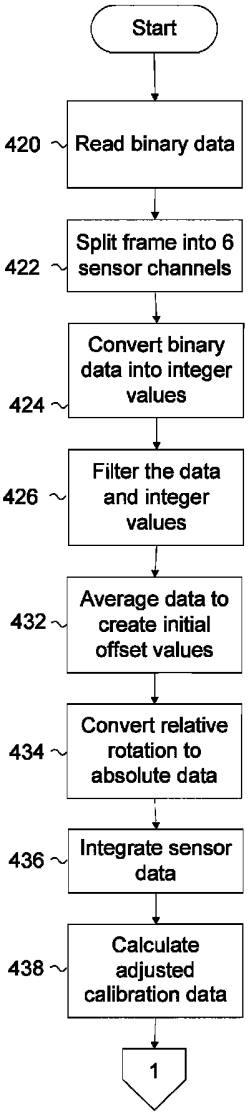

Start
420
Read binary data
422
Split frame into 6 sensor channels
424
Convert binary data into integer values
426
Filter the data and integer values
432
Average data to create initial offset values
434
Convert relative rotation to absolute data
436
Integrate sensor data
438
Calculate adjusted calibration data
1

FIG. 4B

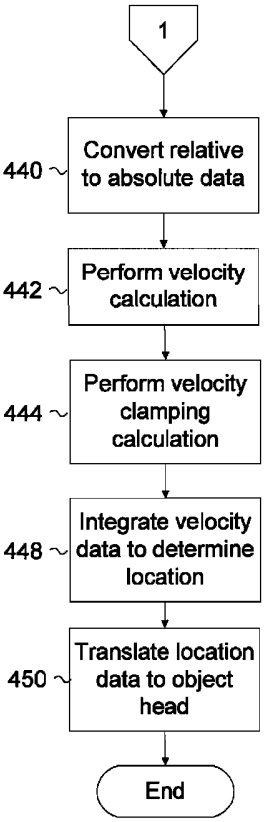

1
440
Convert relative to absolute data
442
Perform velocity calculation
444
Perform velocity clamping calculation
448
Integrate velocity data to determine location
450
Translate location data to object head
End

FIG. 4C

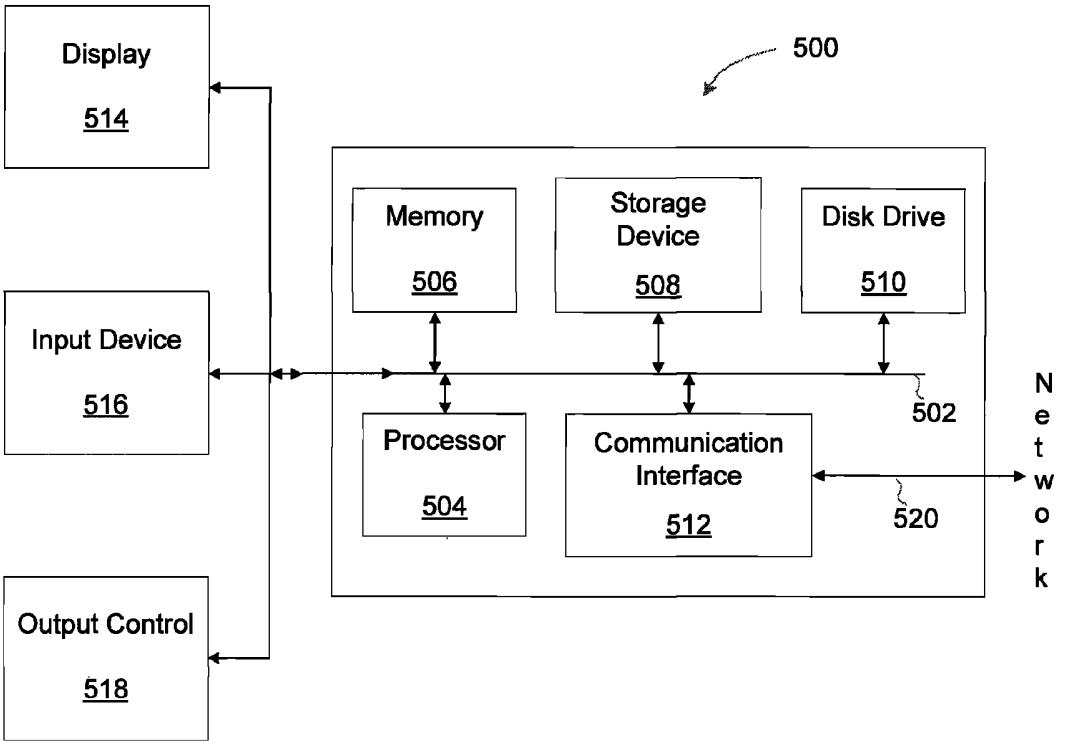

Display
514
500
Memory
506
Storage Device
508
Disk Drive
510
Input Device
516
502
Processor
504
Communication Interface
512
520
Network
Output Control
518

FIG. 5

MOTION CAPTURE AND ANALYSIS

This application is a continuation of application Ser. No. 12/194,450, filed on Aug. 19, 2008 and entitled "Motion Capture and Analysis," now U.S. Pat. No. 8,589,114, which is incorporated herein by reference.

FIELD

The present invention relates generally to computer software architecture and micro electro-mechanical devices and, more specifically, motion capture and analysis is described.

BACKGROUND

The evaluation of motion in various contexts and activities is a difficult and often problematic task using conventional solutions. Conventional solutions often have bulky, cumbersome, and inaccurate implementations that can affect the actual motion being evaluated. Further, many activities in which motion of, for example, a human body is evaluated require the use of specialized equipment that is often bulky and impractical. For example, motion evaluation of a combatant soldier wearing various types of gear and weapons may require, in conventional solutions, the use of bulky or heavy motion sensors. Conventional sensors and sensory systems may be coupled to processing units using either cumbersome wiring or heavy transmission equipment that requires a fixed and not portable system, minimizing both utility and effectiveness. As another convention example, a baseball bat may have a motion sensor that is heavy and attached to the bat, which could affect the detection and evaluation of certain motions. In other activities such as golf, motion (e.g., velocity, angle of impact of a club face against a ball, trajectory, and others) is typically not measured accurately nor easily measured using conventional solutions. As many golfers are aware, the trajectory of a golf ball depends upon the forward velocity, path, and relative club face angle of a golf club at the time of impact with the golf ball. Additionally, the ability to track and display the position and the forward velocity of the golf club through a full range of swing motion is vital to developing a successful and repeatable golf swing. While conventional techniques exist to capture motion of an object, there are various problems and limitations associated with conventional motion capture and analysis apparatus and techniques.

Limitations inherent to the conventional motion capture and analysis systems generally tend to preclude the everyday golfer from utilizing or benefitting from the training benefits imparted by such a system. For example, conventional motion capture and analysis systems tend to be complex, difficult to utilize and are not user friendly. Additionally, the conventional equipment is expensive, cumbersome and is limited in usability. Conventional equipment is not readily portable and must be used at a driving range or other training facility. Conventional equipment cannot be easily transported around a golf course, often becoming cumbersome for use throughout a round of golf. Conventional equipment lacks subjectivity and relies upon a universal standard in which to compare the user's particular swing motion. Conventional equipment does not account for variation in user's physiological characteristics.

Thus, what is needed is a solution for capturing and evaluating the swing motion of a golfer without the limitations of conventional techniques and equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, and like reference numerals designate like structural elements.

FIG. **1**A illustrates an exemplary system configured to implement motion capture and analysis;

FIG. **1**B illustrates an alternative exemplary system;

FIG. **1**C illustrates another alternative exemplary system;

FIG. **2**A illustrates an exemplary application architecture configured to implement motion capture and analysis;

FIG. **2**B further illustrates an exemplary application architecture configured to implement motion capture and analysis;

FIG. **3**A illustrates an exemplary motion sensor unit;

FIG. **3**B illustrates a further exemplary motion sensor unit;

FIG. **4**A illustrates an exemplary process for motion capture and analysis;

FIG. **4**B and FIG. **4**C illustrate an alternative exemplary process for motion capture and analysis; and

FIG. **5** illustrates an exemplary computer system suitable to implement motion capture and analysis.

DETAILED DESCRIPTION

Various embodiments or examples may be implemented in numerous ways, including as a system, a process, an apparatus, a user interface, or a series of program instructions on a computer readable medium such as a computer readable storage medium or a computer network where the program instructions are sent over optical, electronic, or wireless communication links. In general, operations of disclosed processes may be performed in an arbitrary order, unless otherwise provided in the claims.

A detailed description of one or more examples is provided below along with accompanying figures. The detailed description is provided in connection with such examples, but is not limited to any particular example. The scope is limited only by the claims and numerous alternatives, modifications and equivalents are encompassed. Numerous specific details are set forth in the following description in order to provide a thorough understanding. These details are provided for the purpose of example and the described techniques may be practiced according to the claims without some or all of these specific details. For clarity, technical material that is known in the technical fields related to the examples has not been described in detail to avoid unnecessarily obscuring the description.

In some examples, the described techniques may be implemented as a computer program or application ("application") or as a plug-in, module, or sub-component of another application. The described techniques may be implemented as software, hardware, firmware, circuitry, or a combination thereof. If implemented as software, the described techniques may be implemented using various types of programming, development, scripting, or formatting languages, frameworks, syntax, applications, protocols, objects, or techniques, including C, Objective C, C++, C#, Adobe® Integrated Runtime™ (Adobe® AIR™), ActionScript™, FIex™, Lingo™ Java™, Javascript™, Ajax, Perl, Python, COBOL, Fortran, ADA, XML, MXML, HTML, DHTML, XHTML, HTTP, XMPP, and others. Design, publishing, and other types of applications such as Dreamweaver®, Shockwave®, Flash®, and Fireworks® may also be used to implement the described techniques. The described techniques may be varied and are not limited to the examples or descriptions provided.

An apparatus and techniques for motion capture and analysis are described herein. By using this motion capture and analysis apparatus, a golfer may be provided a visual tool to aid in analysis and development of their golf swing. This motion capture apparatus allows a user to save their personalized best swing as a reference for future comparison. The designation of a best swing is made by the user, and is not based upon an arbitrary universal conception of what constitutes a successful or productive swing motion. In other words, a motion capture and analysis apparatus may be used to assist the practice and perfection of a repeated dynamic motion, such as a golf swing. Various alternative implementations and modifications to the examples provided may be used and are not limited to the descriptions, dimensions, or other exemplary details provided herein.

FIG. **1**A illustrates an exemplary system configured to implement motion capture and analysis. Here, system **100** includes motion sensor unit **102**, display mat **104**, portable display **106**, display **108**, terminal **110**, processor **112**, and database **114**. In some examples, motion sensor unit **102** may be coupled, directly or indirectly, to a golf club, bat, racket, or other implement that may be used in a physical activity such as golf, baseball, tennis, or the like. Motion sensor unit **102** may include various types of devices or units (e.g., software, hardware, circuitry, or a combination thereof) for motion measurement (e.g., accelerometer, gyroscope, and others) may be used to gather data associated with the motion of a given implement that is processed using system **100**. Further, using processors and wireless data communication protocols and techniques, data may be transmitted from motion sensor unit **102** to display units (e.g., portable display **106**, display **108**, terminal **110**, or others), processor **112**, or devices that may be configured to use, analyze, evaluate, transform, or perform other operations on data from motion sensor unit **102**. Display **108**, in some examples, may be implemented using a liquid crystal display (LCD), projection tube television, digital television, or any type of analog or digital display. As an example, display **108** may receive data for display using various types of wireless, wired, optical, acoustic, or other video data transmission protocols (e.g., S-video, high definition multimedia interface (HDMI), or others). In other examples, a wireless receiving unit (not shown) may be coupled to display **108** and used to receive data from motion sensor unit **102**, processor **112**, display mat **104**, or other elements. In still other examples, processor **112** may be implemented as an element of a wireless receiving unit (not shown) coupled to display **108** in order to process data for generating and rendering an image or video on display **108**. In further examples, a wireless receiving unit (not shown) may be referred to as a sensor pod or dongle ("dongle") and, when coupled to display **108**, process data received from motion sensor unit **102** in order to generate and render an image for display. Further, the above-described techniques may be used to provide data processing capabilities of data received from motion sensor unit **102** and rendered on display **108**, terminal **110**, or other types of displays not shown. Still further, data may be transmitted from motion sensor unit **102**, received by a dongle (not shown), and processed, rendered, and displayed in real-time or substantially real-time on display **108**. In other examples, system **100** and the above-described elements may be varied in design, function, structure, configuration, implementation, or other aspects and are not limited to the examples described.

Here, processor **112** may be used to process data provided by motion sensor unit **102** in order to generate a display on, for example, portable display unit **106** or display mat **104**. As another example, processor **112** may be implemented in a separate device or in connection with motion sensor unit **102**, display mat **104**, portable display **106**, display **108**, terminal **110**, or any other type of device including, for example, a television (TV), monitor, display, or other type of device. For example, motion sensor unit **102** may be coupled to a golf club (not shown) and, when the golf club is swung, data may be captured by motion sensor unit **102** and transmitted to processor **112** using, for example, a wireless transmitter, transceiver, or the like (not shown). As another example, processor **112** may be implemented within a dongle or other type of wireless receiver coupled to display **108**. When data is received by a dongle, images or video of motion captured by motion sensor unit **102** may be recorded and/or processed to display an image or video on display **108**. In other examples, processor **112** may be implemented as part of display **108** without the use of a dongle or other wireless sensor pod coupled externally to display **108**. In some examples, database **114** may be implemented to store and retrieve data associated with motion (e.g., swinging motion of a golf club, bat, racket, or the like) captured by motion sensor unit **102**. For example, a golfer may wish to configure processor **112** to record and store data associated with a series of swings in database **114**, which may be implemented using a standalone or distributed database, repository, data warehouse, storage area network (SAN), network attached storage, or other type of data storage facility using hardware and/or software. Further, once stored, data may be retrieved from database **114**, which may be implemented with one, some, or none of the other elements shown in system **100**. In other words, database **114** may be implemented with processor **112** with display **108**. Database **114** may also be implemented with one or more of motion sensor unit **102**, display mat **104**, portable display unit **106**, display **108**, terminal **110**, processor **112**, or other elements (not shown). In some examples, data from motion sensor unit **102** may be transmitted to display mat **104**, portable display unit **106**, display **108**, or terminal **110** using one or more wireless, wired, optical, acoustic, or other types of data communication links or protocols.

Once transmitted, data may be interpreted and processed by, for example, processor **112**. Likewise, processor **112** may communicate data from motion sensor unit **102** to display mat **104** or other elements provided in system **100**. In some examples, display mat **104** may be configured to generate, render, and display an image on its surface. Display mat **104**, in some examples, may be configured for display on a horizontal, vertical, angled, or other type of surface. For example, display mat **104** be mounted on a vertical surface and used to display an image associated with a golf club, baseball bat, cricket bat, polo mallet, or others. Display mat **104** may also be configured to lie or be mounted to a horizontal surface (e.g., floor, ground, or the like) and used to present an image associated with motion under evaluation. Data for various types of motion may be evaluated and presented using the techniques described herein.

For example, motion associated with a portion of a body (e.g., human or otherwise) may be evaluated by system **100**, including detecting motion using motion sensor unit **102**, which is processed by processor **112** and stored in database **114** and/or presented on display mat **104**, the latter of which may be implemented using various types of displays (e.g., mats, screens, upright displays, liquid crystal displays, and others without limitation). Types of motion that may be evaluated include movement by a boxer's punching motion, a pitcher's baseball-throwing motion, a football player's kicking motion (e.g., a punt), running motion, combat or martial arts-related hand and foot motion, a dancer's foot, arm, or other body motion, and others.

As another example, when data is transmitted from motion sensor unit **102**, an image of a golf club head being swung may be generated on display mat **104**. Further, display mat **104** may use various types of display resolution techniques and is not limited to any particular implementation. Further, display mat **104** may be implemented using a flexible LCD, active matrix, thin film transistor (TFT), or other types of display technologies. In other example, portable display **106**, display **108**, and terminal **110** may be used to display data generated by motion sensor unit **102**, stored and retrieved from database **114**, or processed by processor **112**. Links provided by and between elements **102-112** may be implemented as unidirectional, bidirectional, or other types of data communication links. In other examples, the number, type, configuration, and topology of system **100**, motion sensor unit **102**, display mat **104**, portable display **106**, display **108**, terminal **110**, and processor **112** may be varied and are not limited to the descriptions provided.

FIG. **1**B illustrates an alternative exemplary system. Here, system **120** includes display **108**, processor **112**, dongle **122**, and data connection **124**. In some examples, dongle **122** may be implemented as a wireless transceiver to receive and/or send data from processor **112** over data connection **124**, which may be implemented using wired, wireless, optical, acoustic, or other types of data communication protocols. In other examples, dongle **122** may be implemented using a wired data connection (not shown) in order to receive data for generating, rendering, and displaying an image on display **108**. In still other examples, processor **112** may be implemented as part of dongle **122**. Further, other elements (e.g., one or more of motion sensor unit **102**, processor **112**, database **114**, or others) may be implemented or integrated with dongle **122**. Still further, system **120** and the above-described elements may be varied in implementation, function, structure, or other aspects and are not limited to the examples provided above.

FIG. **1**C illustrates another alternative exemplary system. Here, system **130** includes motion sensor unit **102**, display mat **104**, display **108**, processor **112**, database **114**, dongle **122**, and data connection **124**, which may be implemented as described above or differently. Further, application **132** may include motion sensor unit **102**, display mat **104**, processor **112**, and database **114**, which may be implemented as described above or differently. Further, application **132** may be implemented using a standalone, distributed, or other type of application architecture or topology. Alternatively one or more elements (e.g., motion sensor unit **102**, display mat **104**, processor **112**, database **114**, or others) of application **132** may be implemented apart from or as part of dongle **122** or display **108**. In other examples, system **130** and the above-described elements may be varied in implementation, function, or structure and are not limited to the descriptions provided.

FIG. **2**A illustrates an exemplary application architecture configured to implement motion capture and analysis. Here, motion sensor unit **200** includes triple axis accelerometer **210**, triple axis gyroscope **212**, low pass filtering **214**, low pass filtering **216**, analog to digital converter **218**, parallel to series converter **220**, wireless modem **222** and wireless transceiver **224**. In some examples, motion sensor unit **200** may include a micro-controller (not shown) similar to micro-controller **256** (described below in connection with FIG. **2**B).

In some examples, motion sensor unit **200** may be detachably coupled to an object (e.g., golf club, tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or others). Motion sensor unit **200** may be various sizes and shapes to accommodate a static and secure attachment to the various shapes and sizes of the detachably coupled object. Motion sensor unit **200** may have an adjustable attachment mechanism to enable one unit to accommodate various shapes and sizes of attached objects. Motion sensor unit **200** may be lightweight and easily portable. Motion sensor unit **200** may be easily attached or detached from the object by the user, without the need for specialized tools or accessories. In other examples, motion sensor unit **200** and the above-described elements may be implemented differently and are not limited to the descriptions provided.

In some examples, a power supply (not shown) such as a battery or external AC/DC converter may be coupled to motion sensor unit **200**. Power supplies may be implemented as rechargeable, non-rechargeable, portable, or disposable batteries. In other examples, a battery (not shown) may be implemented as part of motion sensor unit **200**, supplying power to motion sensor unit **200** and its associated components. In still other examples, a power source may be implemented as another attachment to motion sensor unit **200**.

In some examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be configured to measure movement of an object (e.g., golf club, tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or others). In some examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be a micro electro-mechanical system (MEMS) device. In other examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be an analog or digital device. In some examples, triple axis accelerometer **210** may be configured to measure the acceleration of the object along the x-axis, y-axis and z-axis and triple axis gyroscope **212** may be configured to measure the rotational movement of the object along the planar, orthogonal and axial directions. In other examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be configured differently and are not limited to the descriptions provided.

Here, triple axis accelerometer **210** communicates the data signal to low pass filtering **214** and triple axis gyroscope **212** communicates the data signal to low pass filtering **216**. Further, low pass filtering **214** and low pass filtering **216** communicate the data signal to analog to digital converter **218**. In some examples, analog to digital converter **218** may be configured to convert the data from an analog signal to a digital signal. Here, analog to digital converter **218** communicates the data signal to parallel to series converter **220**. In some examples, parallel to series converter **220** is configured to convert the data signal from a parallel electrical signal to a series electrical signal.

Here, parallel to series converter **220** communicates the data signal to wireless modem **222**. Wireless modem **222** is coupled to wireless transceiver **224** for sending and receiving signals (e.g., RF) between motion sensor unit **200** and display unit (described below in connection with FIG. **2**B). In some examples, wireless transceiver **224** may be configured to send and receive communication signals using various wireless formats (e.g., ZigBee (i.e., IEEE 802.15.4 data communication protocol/standard/specification), radio frequency (RF) waves, IEEE 802.11, Bluetooth, UHF, or others).

FIG. **2**B further illustrates an exemplary application architecture configured to implement motion capture and analysis. Here, processing and display unit **250** includes wireless modem **254**, wireless transceiver **252**, micro-controller **256**, display driver **258**, path driver **260**, info driver **262** and user interface **264**. In some examples, processing and display unit **250** may be a remote device or system (e.g., display mat, portable display device, television monitor, computer, server, video recorder, or others) configured to present or display visual, graphical or numerical data measured by the motion

sensor unit (described above in connection with FIG. **2**A) and values associated with object movement, which are calculated using the measured data. In some examples, processing and display unit **250** may be configured to save the graphic and numerical data and values associated with a user selected reference point (i.e., "best swing") for comparison with subsequent iterations of the object movement. In some examples, processing and display unit **250** may be configured to provide an acoustic indication or response. Processing and display unit **250** may be configured with a memory device (not shown here). The memory device may be a permanent or removable memory card or hard drive.

In some examples, processing and display unit **250** presents various parameters associated with the motion of an object such as measured data (e.g., three dimensional acceleration, three dimensional rotational acceleration, maximum acceleration, or others) or calculated values (e.g., three dimensional velocity, three dimensional rotational velocity, location coordinates, maximum velocity, impact velocity, relative angle of object at point of impact, or others). Still further, processing and display unit **250** may be configured to graphically present a directional path representing the actual movement of an object and graphically indicate various significant points of reference (e.g., point of maximum velocity, or others) along the object's path of movement. In other examples, processing and display unit **250** may be configured to present or display any number of different visual, graphical or numerical parameters associated with the movement of an object and are not limited to the descriptions provided.

In some examples, processing and display unit **250** may be a display mat for use on a horizontal and flat surface, which display mat may be various sizes, shapes or dimensions. A display mat (e.g., display mat **104** (FIG. **1**A)) may be configured such that the user stands on the mat while moving the object, or stands adjacent to the mat while moving the object. A display mat may also be made of a material that is durable, impact resistant and able to sustain the weight of a person. In some examples, a display mat may be made of a material that is easily rolled up and lightweight for easy portability. As an example, a display mat may be made of an array of surface mounted light emitting devices (LEDs). The display mat may be configured to present or display any or all of the visual, graphic or numerical parameters discussed above. In other examples, processing and display unit **250** may be implemented differently and is not limited to the descriptions provided.

In other examples, processing and display unit **250** may be a portable display device for handheld use. In some examples, a portable display device may be small, lightweight and easily transported by the user. In other examples, a portable display device may be various sizes, shapes or dimensions. A portable display device may also be configured to present or display any or all of the visual, graphic or numerical parameters discussed above. In other examples, processing and display unit **250** as a portable display device may be implemented differently and is not limited to the descriptions provided.

In some examples, a power supply (not shown) such as a battery or external AC/DC converter may be coupled to processing and display unit **250**. Power supplies may be implemented as rechargeable, non-rechargeable, portable, or disposable batteries. In other examples, a battery (not shown) may be implemented as part of processing and display unit **250**, supplying power to processing and display unit **250** and its associated components. In still other examples, a power source may be implemented as another attachment to processing and display unit **250**.

Here, wireless modem **254** is coupled to wireless transceiver **252** for sending and receiving signals (e.g., RF) between processing and display unit **250** and motion sensor unit **200** (described above in connection with FIG. **2**A). In some examples, wireless transceiver **252** may be configured to send and receive communication signals using various wireless formats (e.g., ZigBee, RF waves, IEEE 802.11, Bluetooth, UHF, or others).

Here, wireless modem **254** communicates the data signal to micro-controller **256**. In some examples, micro-controller **256** is configured to process the measured data captured by motion sensor unit **200** (described above in connection with FIG. **2**A). Micro-controller **256** may calculate values associated with movement of an object (e.g., three dimensional velocity, three dimensional rotational velocity, location coordinates, maximum velocity, impact velocity, relative angle of object at point of impact, or others) using the movement data captured by motion sensor unit **200** (described above in connection with FIG. **2**A).

Here, micro-controller **256** communicates a position data signal to display driver **258** and swing position data to info driver **262**. Here further, display driver **258** communicates the position data to path driver **260**. Finally, path driver **260** and info driver **262** communicate the position and swing position data to and from user interface **264**.

In some examples, user interface **264** may be configured to include user controls which allow user configuration of the system. User interface **264** controls may include various input mechanism and allow the user to save a selected reference point (i.e., "best swing") or select the desired display parameters. In some examples, user interface **264** may be configured to include an acoustic signal to provide an auditory indication. In other examples, user interface **264** may be configured differently and is not limited to the descriptions provided. Still further, processing and display unit **250** and the above-described elements may be implemented differently and is not limited to the descriptions or examples provided above.

FIG. **3**A illustrates an exemplary motion sensor unit. Here, a top view of an exemplary user of the motion sensor unit is shown. In this example, motion sensor unit **300**, impact object **302**, movement object **304**, axial rotation **306**, planar rotation **308**, x-axis **320** and y axis **322** are shown. Motion sensor unit **300** may be configured and implemented as described above as motion sensor unit **200** (described above in connection with FIG. **2**A). As shown here, motion sensor unit **300** may be used to measure and capture axial rotation **306**, planar rotation **308**, x-axis acceleration along x-axis **320** and y-axis acceleration along y-axis **322**. In other examples, motion sensor unit **300** may be configured to measure and capture other parameters associated with movement of an object and is not limited by the descriptions provided.

As shown here, motion sensor **300** is coupled to movement object **304**, as shown here as a golf club. In other examples, movement object **304** may be a tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or other moveable object. As shown here, movement object **304** is intended to make dynamic contact with impact object **302**, as shown here as a golf ball. In other examples, impact object **302** may be a baseball, softball, hockey puck, or other moving object. In other examples, movement object **304** and impact object **302** may be different and are not limited to the descriptions provided.

FIG. **3**B illustrates a further exemplary motion sensor unit. Here, a side view of an exemplary user of the motion sensor unit is shown. In this example, motion sensor unit **300**, movement object **304**, orthogonal rotation **310**, x-axis **320** and

z-axis **324** are shown. Motion sensor unit **300** may be configured and implemented as described above as motion sensor unit **200** (described above in connection with FIG. **2**A). As shown here, motion sensor unit **300** may be used to measure and capture orthogonal rotation **310**, x-axis acceleration along x-axis **320** and z-axis acceleration along z-axis **324**. In other examples, motion sensor unit **300** may be configured to measure and capture other parameters associated with movement of an object and is not limited by the descriptions provided.

As shown here, motion sensor **300** is coupled to movement object **304**, as shown here as a golf club. In other examples, movement object **304** may be a tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or other moveable object. As shown here, movement object **304** is intended to make dynamic contact with impact object (not shown). In other examples, movement object **304** may be different and is not limited to the descriptions provided.

FIG. **4**A illustrates an exemplary process for motion capture and analysis. In some examples, data associated with movement of an object may be captured (**402**). The data may be processed to determine values associated with movement of the object (**404**). The data and the values may be stored (**406**). The data and values may be converted from analog to digital for a wireless transmission (**408**). The data and the values may be transmitted using a wireless connection (**410**). Once transmitted, data and values may be received using, for example, a wireless modem (FIG. **2**B) configured to modulate or demodulate transmitted data for processing and presentation on a display (e.g., display **108** (FIGS. **1**A-**1**C) (**412**). The data and values may be presented graphically (**414**). The above-described process may be varied in function, processes and performed in any arbitrary order and is not limited to the examples shown and described.

FIG. **4**B and FIG. **4**C illustrate an alternative exemplary process for motion capture and analysis. In some examples, binary data may be read (**420**). The frame may be split into 6 sensor channels (**422**). The binary data may be converted into integer values (**424**). The data and integer values may be filtered (**426**). Optionally, a "swing started" calculation may be performed (not shown) to determine when a swinging motion begins. A "swing started" calculation or determination may be performed, in some examples, after filtering data and integer values. Further, an optional operation for creating a lapsed time index may also be created (not shown). The data may be averaged to create initial offset values (**432**). Relative rotation may be converted to absolute data (**434**). The sensor data may be integrated (**436**). The adjusted calibration data may be calculated (**438**). Relative data may be converted to absolute data (**440**). A velocity calculation may be performed (**442**). A velocity clamping calculation may be performed (**444**). Optionally, a "swing end" calculation may be performed to determine when a swing motion ends or terminates (**446**). Velocity data may be integrated to determine location (**448**). Location data may be translated to object head (**450**). The above-described process may be varied in function, processes and performed in any arbitrary order and is not limited to the examples shown and described.

FIG. **5** illustrates an exemplary computer system suitable to implement motion capture and analysis. In some examples, computer system **500** may be used to implement computer programs, applications, methods, processes, or other software to perform the above-described techniques. Computer system **500** includes a bus **502** or other communication mechanism for communicating information, which interconnects subsystems and devices, such as processor **504**, system memory **506** (e.g., RAM), storage device **508** (e.g., ROM), disk drive **510** (e.g., magnetic or optical), communication interface **512** (e.g., modem or Ethernet card), display **514** (e.g., CRT or LCD), input device **516** (e.g., keyboard), and output control **518**.

According to some examples, computer system **500** performs specific operations by processor **504** executing one or more sequences of one or more instructions stored in system memory **506**. Such instructions may be read into system memory **506** from another computer readable medium, such as static storage device **508** or disk drive **510**. In some examples, hard-wired circuitry may be used in place of or in combination with software instructions for implementation.

The term "computer readable medium" refers to any tangible medium that participates in providing instructions to processor **504** for execution. Such a medium may take many forms, including but not limited to, non-volatile media and volatile media. Non-volatile media includes, for example, optical or magnetic disks, such as disk drive **510**. Volatile media includes dynamic memory, such as system memory **506**.

Common forms of computer readable media includes, for example, floppy disk, flexible disk, hard disk, magnetic tape, any other magnetic medium, CD-ROM, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, RAM, PROM, EPROM, FLASH-EPROM, any other memory chip or cartridge, or any other medium from which a computer can read.

Instructions may further be transmitted or received using a transmission medium. The term "transmission medium" may include any tangible or intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine, and includes digital or analog communications signals or other intangible medium to facilitate communication of such instructions. Transmission media includes coaxial cables, copper wire, and fiber optics, including wires that comprise bus **502** for transmitting a computer data signal.

In some examples, execution of the sequences of instructions may be performed by a single computer system **500**. According to some examples, two or more computer systems **500** coupled by communication link **520** (e.g., LAN, PSTN, or wireless network) may perform the sequence of instructions in coordination with one another. Computer system **500** may transmit and receive messages, data, and instructions, including program, i.e., application code, through communication link **520** and communication interface **512**. Received program code may be executed by processor **504** as it is received, and/or stored in disk drive **510**, or other non-volatile storage for later execution.

Although the foregoing examples have been described in some detail for purposes of clarity of understanding, the invention is not limited to the details provided. There are many alternative ways of implementing the invention. The disclosed examples are illustrative and not restrictive.

What is claimed is:

1. A system, comprising:

a motion sensor unit configured to be adjustably and detachably coupled to, but not mechanically integrated with, an outer surface at a first location on an object, the object being used in a physical sport or leisure activity, the motion sensor unit being further configured to capture data associated with movement of the object, to process the data to determine one or more values associated with movement of the object, and to translate the data or values to correspond to a second location on the object located away from the first location; and

a display unit configured to receive the data and values from the motion sensor unit, the data and values being

transmitted using wireless transmission, to store the data and values, and to graphically present the data and values.

2. The system of claim **1**, wherein the data comprises acceleration data associated with the object.

3. The system of claim **1**, wherein the data comprises angular momentum data associated with the object.

4. The system of claim **1**, wherein the one or more values indicate a maximum velocity associated with the object.

5. The system of claim **1**, wherein the one or more values indicate a graphical path associated with the object.

6. The system of claim **1**, wherein the one or more values indicate a velocity associated with the object at a time when the object impacts another object.

7. The system of claim **1**, wherein the one or more values indicate an angle associated with the object at a time when the object impacts another object.

8. The system of claim **1**, wherein the one or more values indicate a trajectory associated with the object adheres to a fixed plane.

9. The system of claim **1**, further comprising a control unit coupled to the motion sensor unit, the control unit being configured to receive input.

10. The system of claim **1**, further comprising a graphic indicator unit coupled to the motion sensor unit, the graphic indicator unit being configured to present the data and the one or more values.

11. The system of claim **1**, wherein the display unit is configured to graphically present the data and the one or more values as an image.

12. The system of claim **1**, wherein the display unit is configured to graphically present an image comprising the data and the one or more values.

13. The system of claim **1**, wherein the display unit is a display mat.

14. The system of claim **1**, wherein the object is selected from the group consisting of a golf club, a baseball bat, a tennis racket, a hockey stick, a fishing pole, a racquetball racquet and a squash racquet.

15. The system of claim **1**, wherein the motion sensor includes an accelerometer and a gyroscope.

16. A system, comprising:

a motion sensor unit configured to be adjustably coupled to, but not mechanically integrated with, an outer surface at a first location on an object using an adjustable attachment mechanism and to capture data associated with movement of the object, the object being used in a physical sports or leisure activity;

a processor configured to process the data to determine one or more values associated with movement of the object, and to translate the values and data to correspond to a second location on the object located away from the first location;

a wireless transmitter being coupled to the motion sensor unit, the wireless transmitter being configured to transmit the data; and

a display unit configured to generate one or more images based on the data and values, the display unit comprising a display and a wireless transceiver configured to send and receive the data from the motion sensor unit.

17. The system of claim **16**, wherein the motion sensor includes an accelerometer and a gyroscope.

18. A method, comprising:

capturing data associated with movement of an object, the data corresponding to a first location on the object and being captured by a motion sensor unit adjustably coupled to, but not mechanically integrated with, an outer surface of the object at the first location using an adjustable attachment mechanism, the object being used in a physical sports or leisure activity;

processing the data to determine one or more values associated with the movement of the object;

translating the values to correspond to a second location on the object located away from the first location;

storing the data and the one or more values;

transmitting the data and values using a wireless connection established between a wireless transmitter and a wireless receiver; and

presenting the data and the one or more values graphically.

19. The method of claim **18**, further comprising: generating one or more images based on the transmitted data and values; and displaying the images on a display.

20. The method of claim **18**, wherein capturing data includes capturing the outputs of an accelerometer and a gyroscope.

* * * * *

EXHIBIT C

US008589114B2

(12) **United States Patent**
Papadourakis

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(45) **Date of Patent: Nov. 19, 2013**

(54) **MOTION CAPTURE AND ANALYSIS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 904 days.

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A63B 57/00 (2006.01)

(52) **U.S. Cl.**
USPC **702/145**; 473/223

(58) **Field of Classification Search**
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See application file for complete search history.

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Primary Examiner — Toan Le
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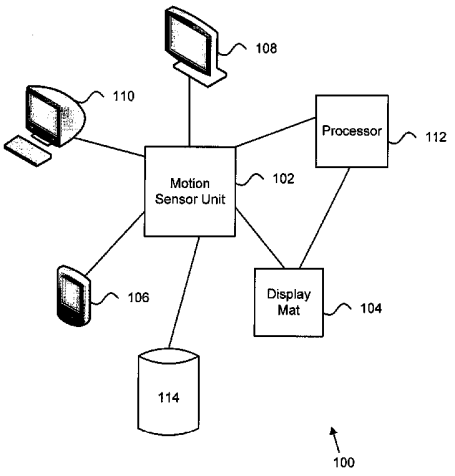
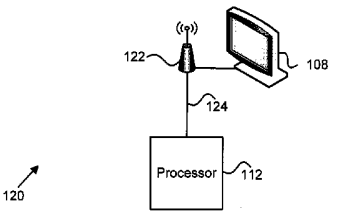
(57) **ABSTRACT**

Motion capture and analysis is described, including a motion sensor unit configured to capture data associated with movement of an object, to process the data to determine one or more values, to store the data and the one or more values, and to convert the data and the one or more values from an analog signal to a digital signal associated with a wireless transmission, and a display unit configured to receive the data from the motion sensor unit, the data being transmitted using through the wireless transmission, to process the data to determine one or more values, to store the data, and to graphically present the data and the one or more values.

24 Claims, 9 Drawing Sheets





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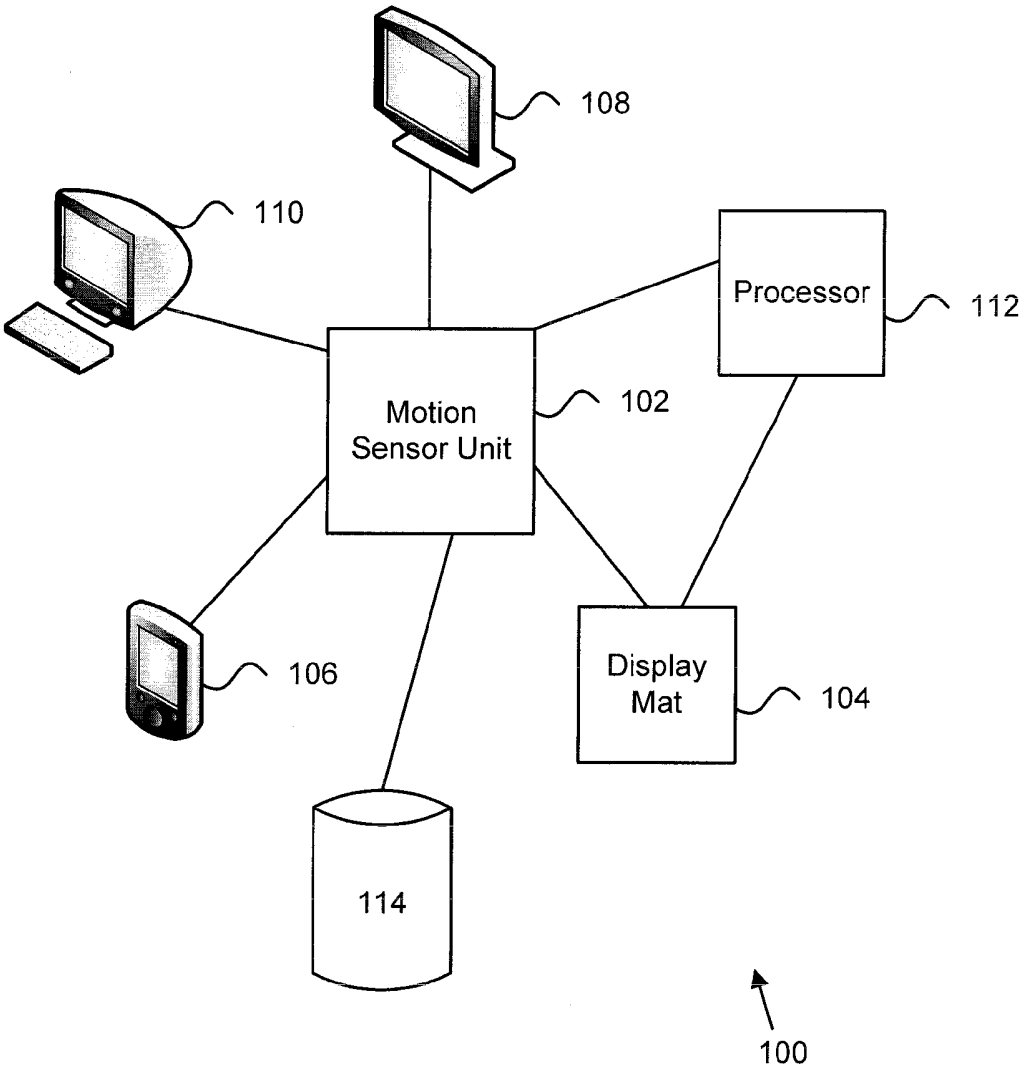
108
110
Processor
112
Motion
Sensor Unit
102
106
Display
Mat
104
114
100

FIG. 1A

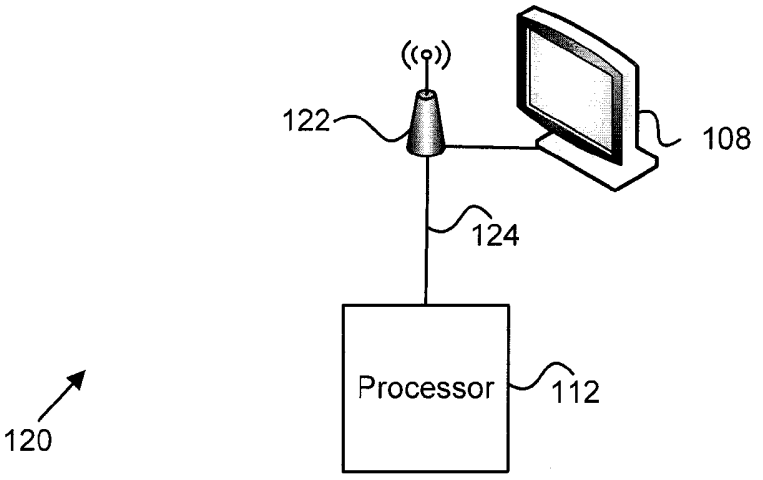
122
108
124
Processor
112
120

FIG. 1B

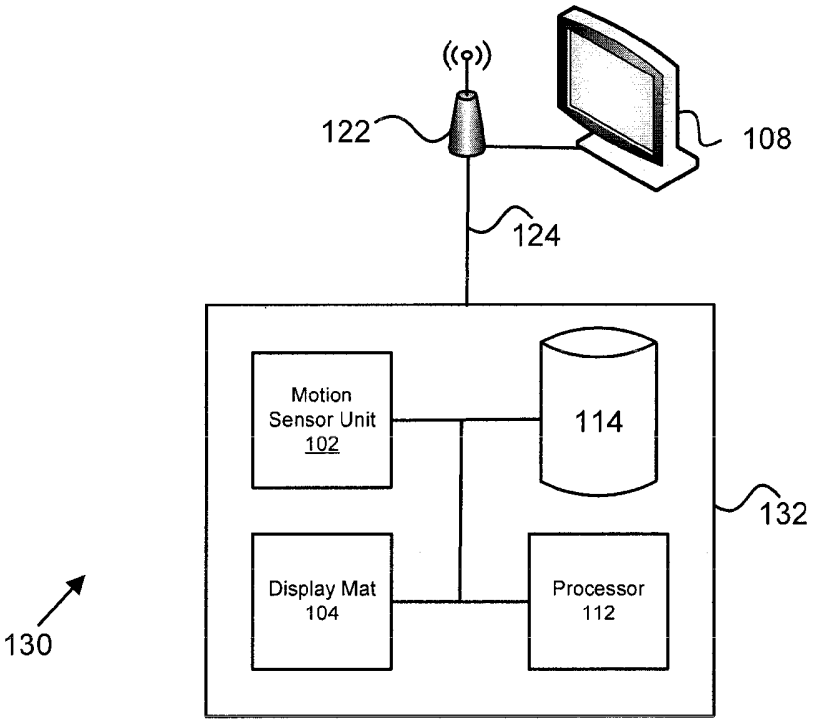
122
108
124
Motion Sensor Unit 102
114
132
Display Mat 104
Processor 112
130

FIG. 1C

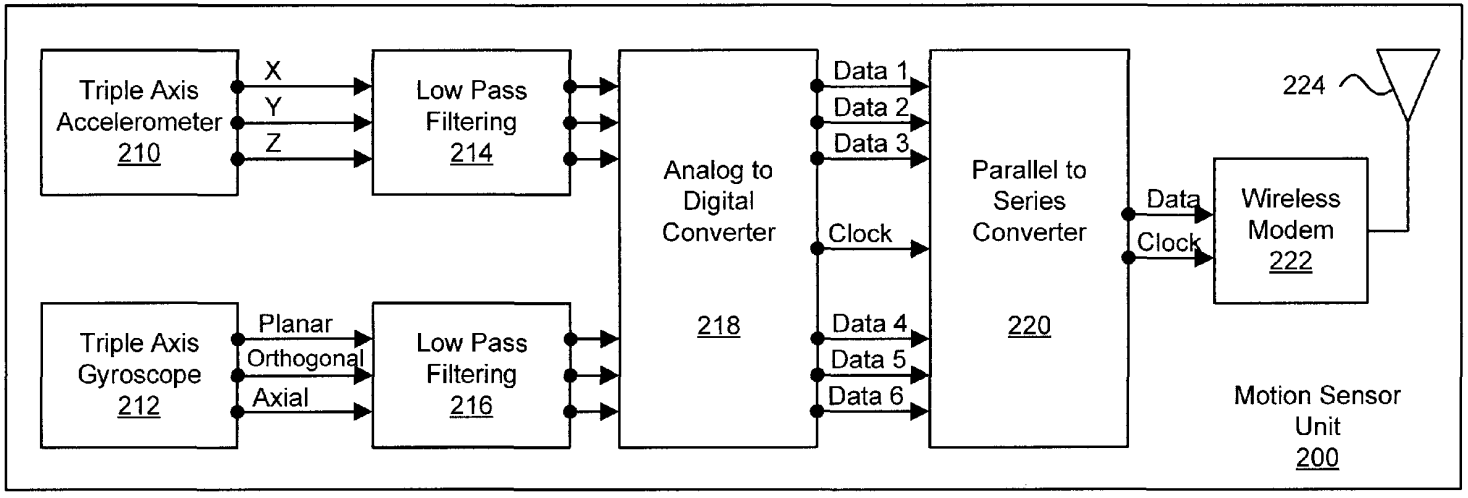
Triple Axis Accelerometer 210
X
Y
Z
Low Pass Filtering 214
Analog to Digital Converter 218
Data 1
Data 2
Data 3
Clock
Data 4
Data 5
Data 6
Parallel to Series Converter 220
Data
Clock
Wireless Modem 222
224
Triple Axis Gyroscope 212
Planar
Orthogonal
Axial
Low Pass Filtering 216
Motion Sensor Unit 200

FIG. 2A

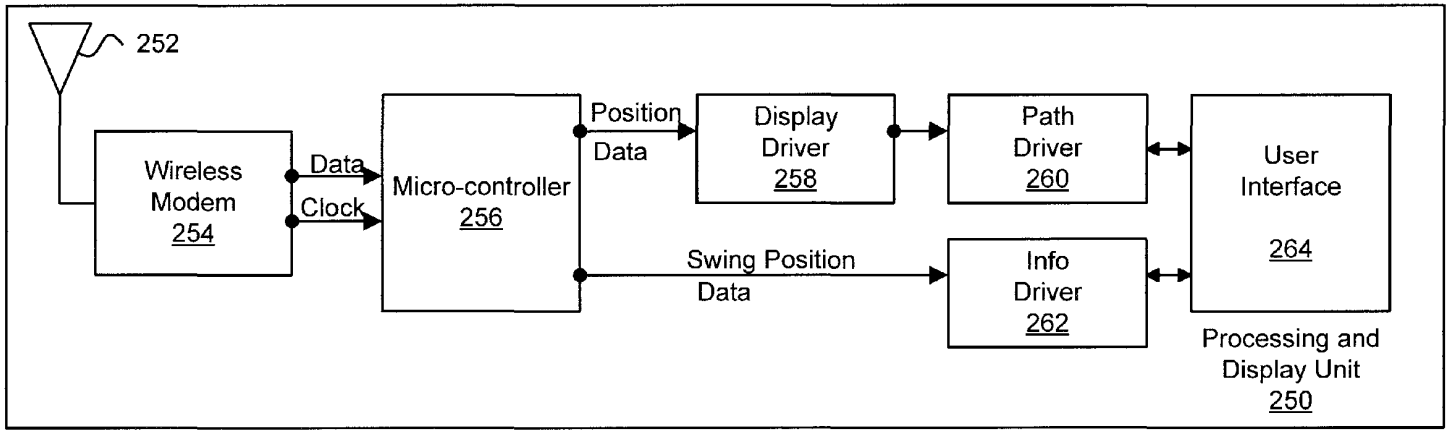
252
Wireless Modem 254
Data
Clock
Micro-controller 256
Position Data
Display Driver 258
Path Driver 260
User Interface 264
Swing Position Data
Info Driver 262
Processing and Display Unit 250

FIG. 2B

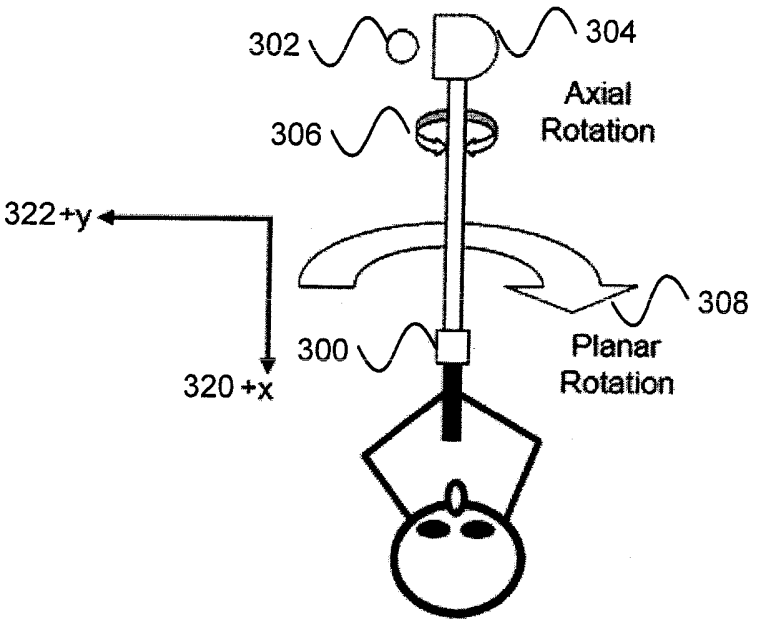
302
304
Axial
Rotation
306
322 +y
308
300
Planar
Rotation
320 +x

FIG. 3A

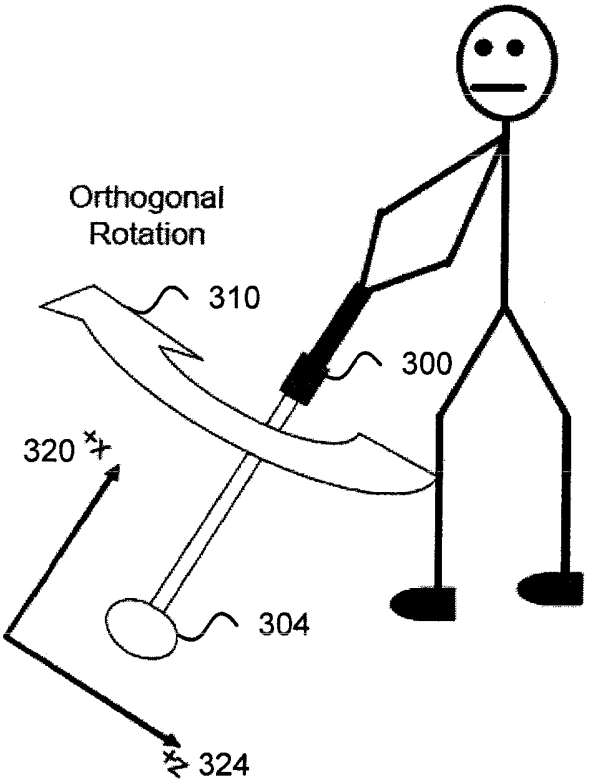

FIG. 3B

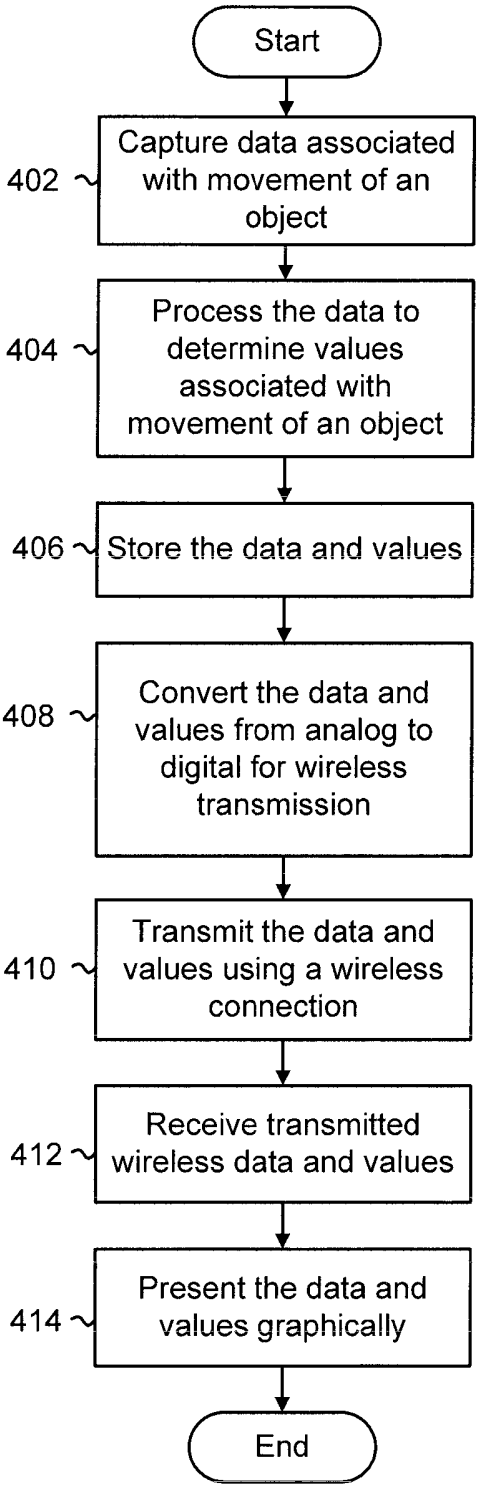
Start
402
Capture data associated with movement of an object
404
Process the data to determine values associated with movement of an object
406
Store the data and values
408
Convert the data and values from analog to digital for wireless transmission
410
Transmit the data and values using a wireless connection
412
Receive transmitted wireless data and values
414
Present the data and values graphically
End

FIG. 4A

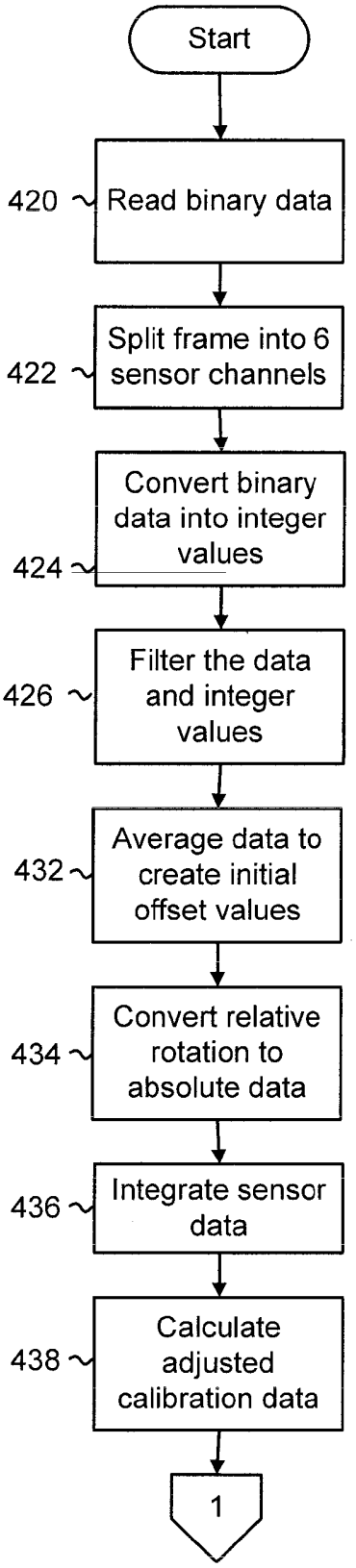
Start
420
Read binary data
422
Split frame into 6 sensor channels
424
Convert binary data into integer values
426
Filter the data and integer values
432
Average data to create initial offset values
434
Convert relative rotation to absolute data
436
Integrate sensor data
438
Calculate adjusted calibration data
1

FIG. 4B

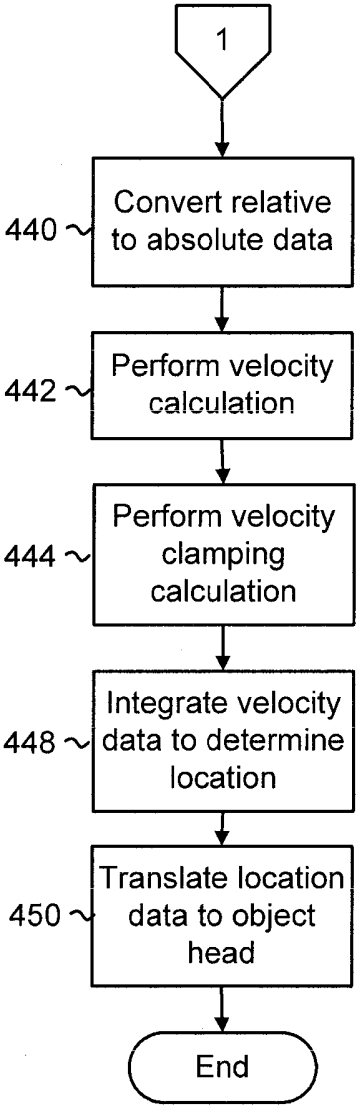
1
440
Convert relative to absolute data
442
Perform velocity calculation
444
Perform velocity clamping calculation
448
Integrate velocity data to determine location
450
Translate location data to object head
End

FIG. 4C

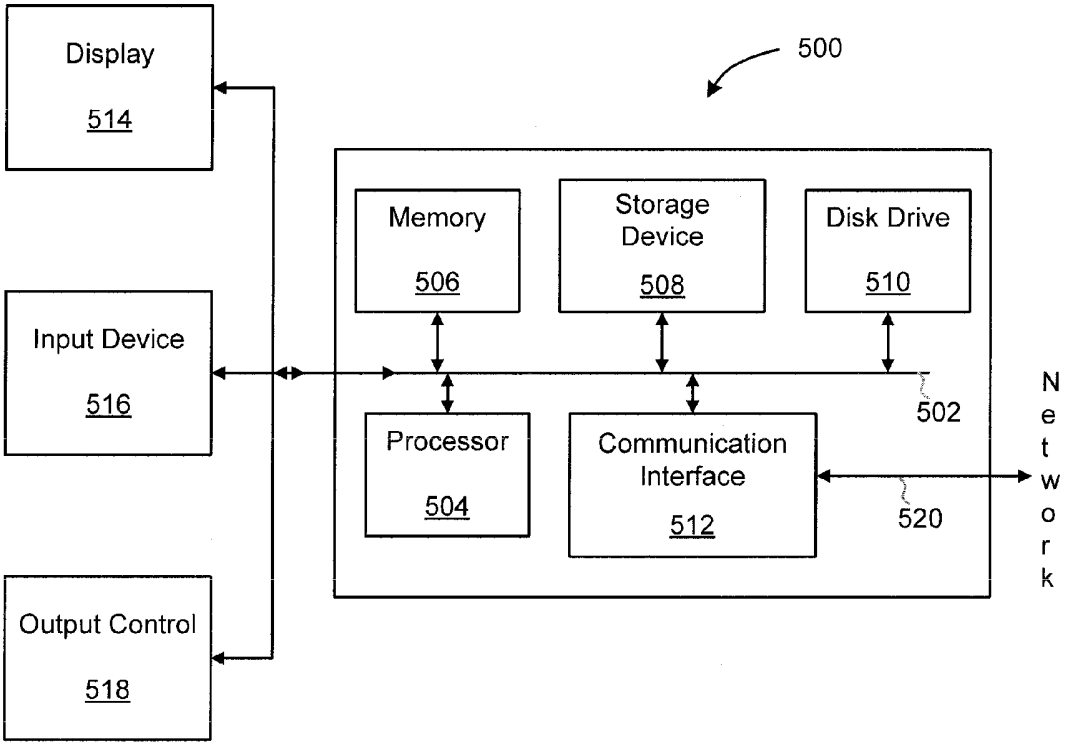
Display
514
500
Memory
506
Storage Device
508
Disk Drive
510
Input Device
516
502
Processor
504
Communication Interface
512
520
Network
Output Control
518

FIG. 5

MOTION CAPTURE AND ANALYSIS

FIELD

The present invention relates generally to computer software architecture and micro electromechanical devices and, more specifically, motion capture and analysis is described.

BACKGROUND

The evaluation of motion in various contexts and activities is a difficult and often problematic task using conventional solutions. Conventional solutions often have bulky, cumbersome, and inaccurate implementations that can affect the actual motion being evaluated. Further, many activities in which motion of, for example, a human body is evaluated require the use of specialized equipment that is often bulky and impractical. For example, motion evaluation of a combatant soldier wearing various types of gear and weapons may require, in conventional solutions, the use of bulky or heavy motion sensors. Conventional sensors and sensory systems may be coupled to processing units using either cumbersome wiring or heavy transmission equipment that requires a fixed and not portable system, minimizing both utility and effectiveness. As another convention example, a baseball bat may have a motion sensor that is heavy and attached to the bat, which could affect the detection and evaluation of certain motions. In other activities such as golf, motion (e.g., velocity, angle of impact of a club face against a ball, trajectory, and others) is typically not measured accurately nor easily measured using conventional solutions. As many golfers are aware, the trajectory of a golf ball depends upon the forward velocity, path, and relative club face angle of a golf club at the time of impact with the golf ball. Additionally, the ability to track and display the position and the forward velocity of the golf club through a full range of swing motion is vital to developing a successful and repeatable golf swing. While conventional techniques exist to capture motion of an object, there are various problems and limitations associated with conventional motion capture and analysis apparatus and techniques.

Limitations inherent to the conventional motion capture and analysis systems generally tend to preclude the everyday golfer from utilizing or benefitting from the training benefits imparted by such a system. For example, conventional motion capture and analysis systems tend to be complex, difficult to utilize and are not user friendly. Additionally, the conventional equipment is expensive, cumbersome and is limited in usability. Conventional equipment is not readily portable and must be used at a driving range or other training facility. Conventional equipment cannot be easily transported around a golf course, often becoming cumbersome for use throughout a round of golf. Conventional equipment lacks subjectivity and relies upon a universal standard in which to compare the user's particular swing motion. Conventional equipment does not account for variation in user's physiological characteristics.

Thus, what is needed is a solution for capturing and evaluating the swing motion of a golfer without the limitations of conventional techniques and equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, and like reference numerals designate like structural elements.

FIG. **1**A illustrates an exemplary system configured to implement motion capture and analysis;

FIG. **1**B illustrates an alternative exemplary system;

FIG. **1**C illustrates another alternative exemplary system;

FIG. **2**A illustrates an exemplary application architecture configured to implement motion capture and analysis;

FIG. **2**B further illustrates an exemplary application architecture configured to implement motion capture and analysis;

FIG. **3**A illustrates an exemplary motion sensor unit;

FIG. **3**B illustrates a further exemplary motion sensor unit;

FIG. **4**A illustrates an exemplary process for motion capture and analysis;

FIG. **4**B and FIG. **4**C illustrate an alternative exemplary process for motion capture and analysis; and

FIG. **5** illustrates an exemplary computer system suitable to implement motion capture and analysis.

DETAILED DESCRIPTION

Various embodiments or examples may be implemented in numerous ways, including as a system, a process, an apparatus, a user interface, or a series of program instructions on a computer readable medium such as a computer readable storage medium or a computer network where the program instructions are sent over optical, electronic, or wireless communication links. In general, operations of disclosed processes may be performed in an arbitrary order, unless otherwise provided in the claims.

A detailed description of one or more examples is provided below along with accompanying figures. The detailed description is provided in connection with such examples, but is not limited to any particular example. The scope is limited only by the claims and numerous alternatives, modifications and equivalents are encompassed. Numerous specific details are set forth in the following description in order to provide a thorough understanding. These details are provided for the purpose of example and the described techniques may be practiced according to the claims without some or all of these specific details. For clarity, technical material that is known in the technical fields related to the examples has not been described in detail to avoid unnecessarily obscuring the description.

In some examples, the described techniques may be implemented as a computer program or application ("application") or as a plug-in, module, or sub-component of another application. The described techniques may be implemented as software, hardware, firmware, circuitry, or a combination thereof. If implemented as software, the described techniques may be implemented using various types of programming, development, scripting, or formatting languages, frameworks, syntax, applications, protocols, objects, or techniques, including C, Objective C, C++, C#, Adobe® Integrated Runtime™ (Adobe® AIR™), ActionScript™, Flex™, Lingo™, Java™, Javascript™, Ajax, Perl, Python, COBOL, Fortran, ADA, XML, MXML, HTML, DHTML, XHTML, HTTP, XMPP, and others. Design, publishing, and other types of applications such as Dreamweaver®, Shockwave®, Flash®, and Fireworks® may also be used to implement the described techniques. The described techniques may be varied and are not limited to the examples or descriptions provided.

An apparatus and techniques for motion capture and analysis are described herein. By using this motion capture and analysis apparatus, a golfer may be provided a visual tool to aid in analysis and development of their golf swing. This motion capture apparatus allows a user to save their personalized best swing as a reference for future comparison. The designation of a best swing is made by the user, and is not

based upon an arbitrary universal conception of what constitutes a successful or productive swing motion. In other words, a motion capture and analysis apparatus may be used to assist the practice and perfection of a repeated dynamic motion, such as a golf swing. Various alternative implementations and modifications to the examples provided may be used and are not limited to the descriptions, dimensions, or other exemplary details provided herein.

FIG. **1**A illustrates an exemplary system configured to implement motion capture and analysis. Here, system **100** includes motion sensor unit **102**, display mat **104**, portable display **106**, display **108**, terminal **110**, processor **112**, and database **114**. In some examples, motion sensor unit **102** may be coupled, directly or indirectly, to a golf club, bat, racket, or other implement that may be used in a physical activity such as golf, baseball, tennis, or the like. Motion sensor unit **102** may include various types of devices or units (e.g., software, hardware, circuitry, or a combination thereof) for motion measurement (e.g., accelerometer, gyroscope, and others) may be used to gather data associated with the motion of a given implement that is processed using system **100**. Further, using processors and wireless data communication protocols and techniques, data may be transmitted from motion sensor unit **102** to display units (e.g., portable display **106**, display **108**, terminal **110**, or others), processor **112**, or devices that may be configured to use, analyze, evaluate, transform, or perform other operations on data from motion sensor unit **102**. Display **108**, in some examples, may be implemented using a liquid crystal display (LCD), projection tube television, digital television, or any type of analog or digital display. As an example, display **108** may receive data for display using various types of wireless, wired, optical, acoustic, or other video data transmission protocols (e.g., S-video, high definition multimedia interface (HDMI), or others). In other examples, a wireless receiving unit (not shown) may be coupled to display **108** and used to receive data from motion sensor unit **102**, processor **112**, display mat **104**, or other elements. In still other examples, processor **112** may be implemented as an element of a wireless receiving unit (not shown) coupled to display **108** in order to process data for generating and rendering an image or video on display **108**. In further examples, a wireless receiving unit (not shown) may be referred to as a sensor pod or dongle ("dongle") and, when coupled to display **108**, process data received from motion sensor unit **102** in order to generate and render an image for display. Further, the above-described techniques may be used to provide data processing capabilities of data received from motion sensor unit **102** and rendered on display **108**, terminal **110**, or other types of displays not shown. Still further, data may be transmitted from motion sensor unit **102**, received by a dongle (not shown), and processed, rendered, and displayed in real-time or substantially real-time on display **108**. In other examples, system **100** and the above-described elements may be varied in design, function, structure, configuration, implementation, or other aspects and are not limited to the examples described.

Here, processor **112** may be used to process data provided by motion sensor unit **102** in order to generate a display on, for example, portable display unit **106** or display mat **104**. As another example, processor **112** may be implemented in a separate device or in connection with motion sensor unit **102**, display mat **104**, portable display **106**, display **108**, terminal **110**, or any other type of device including, for example, a television (TV), monitor, display, or other type of device. For example, motion sensor unit **102** may be coupled to a golf club (not shown) and, when the golf club is swung, data may be captured by motion sensor unit **102** and transmitted to processor **112** using, for example, a wireless transmitter, transceiver, or the like (not shown). As another example, processor **112** may be implemented within a dongle or other type of wireless receiver coupled to display **108**. When data is received by a dongle, images or video of motion captured by motion sensor unit **102** may be recorded and/or processed to display an image or video on display **108**. In other examples, processor **112** may be implemented as part of display **108** without the use of a dongle or other wireless sensor pod coupled externally to display **108**. In some examples, database **114** may be implemented to store and retrieve data associated with motion (e.g., swinging motion of a golf club, bat, racket, or the like) captured by motion sensor unit **102**. For example, a golfer may wish to configure processor **112** to record and store data associated with a series of swings in database **114**, which may be implemented using a standalone or distributed database, repository, data warehouse, storage area network (SAN), network attached storage, or other type of data storage facility using hardware and/or software. Further, once stored, data may be retrieved from database **114**, which may be implemented with one, some, or none of the other elements shown in system **100**. In other words, database **114** may be implemented with processor **112** with display **108**. Database **114** may also be implemented with one or more of motion sensor unit **102**, display mat **104**, portable display unit **106**, display **108**, terminal **110**, processor **112**, or other elements (not shown). In some examples, data from motion sensor unit **102** may be transmitted to display mat **104**, portable display unit **106**, display **108**, or terminal **110** using one or more wireless, wired, optical, acoustic, or other types of data communication links or protocols.

Once transmitted, data may be interpreted and processed by, for example, processor **112**. Likewise, processor **112** may communicate data from motion sensor unit **102** to display mat **104** or other elements provided in system **100**. In some examples, display mat **104** may be configured to generate, render, and display an image on its surface. Display mat **104**, in some examples, may be configured for display on a horizontal, vertical, angled, or other type of surface. For example, display mat **104** be mounted on a vertical surface and used to display an image associated with a golf club, baseball bat, cricket bat, polo mallet, or others. Display mat **104** may also be configured to lie or be mounted to a horizontal surface (e.g., floor, ground, or the like) and used to present an image associated with motion under evaluation. Data for various types of motion may be evaluated and presented using the techniques described herein.

For example, motion associated with a portion of a body (e.g., human or otherwise) may be evaluated by system **100**, including detecting motion using motion sensor unit **102**, which is processed by processor **112** and stored in database **114** and/or presented on display mat **104**, the latter of which may be implemented using various types of displays (e.g., mats, screens, upright displays, liquid crystal displays, and others without limitation). Types of motion that may be evaluated include movement by a boxer's punching motion, a pitcher's baseball-throwing motion, a football player's kicking motion (e.g., a punt), running motion, combat or martial arts-related hand and foot motion, a dancer's foot, arm, or other body motion, and others.

As another example, when data is transmitted from motion sensor unit **102**, an image of a golf club head being swung may be generated on display mat **104**. Further, display mat **104** may use various types of display resolution techniques and is not limited to any particular implementation. Further, display mat **104** may be implemented using a flexible LCD, active matrix, thin film transistor (TFT), or other types of

display technologies. In other example, portable display **106**, display **108**, and terminal **110** may be used to display data generated by motion sensor unit **102**, stored and retrieved from database **114**, or processed by processor **112**. Links provided by and between elements **102-112** may be implemented as unidirectional, bidirectional, or other types of data communication links. In other examples, the number, type, configuration, and topology of system **100**, motion sensor unit **102**, display mat **104**, portable display **106**, display **108**, terminal **110**, and processor **112** may be varied and are not limited to the descriptions provided.

FIG. **1**B illustrates an alternative exemplary system. Here, system **120** includes display **108**, processor **112**, dongle **122**, and data connection **124**. In some examples, dongle **122** may be implemented as a wireless transceiver to receive and/or send data from processor **112** over data connection **124**, which may be implemented using wired, wireless, optical, acoustic, or other types of data communication protocols. In other examples, dongle **122** may be implemented using a wired data connection (not shown) in order to receive data for generating, rendering, and displaying an image on display **108**. In still other examples, processor **112** may be implemented as part of dongle **122**. Further, other elements (e.g., one or more of motion sensor unit **102**, processor **112**, database **114**, or others) may be implemented or integrated with dongle **122**. Still further, system **120** and the above-described elements may be varied in implementation, function, structure, or other aspects and are not limited to the examples provided above.

FIG. **1**C illustrates another alternative exemplary system. Here, system **130** includes motion sensor unit **102**, display mat **104**, display **108**, processor **112**, database **114**, dongle **122**, and data connection **124**, which may be implemented as described above or differently. Further, application **132** may include motion sensor unit **102**, display mat **104**, processor **112**, and database **114**, which may be implemented as described above or differently. Further, application **132** may be implemented using a standalone, distributed, or other type of application architecture or topology. Alternatively one or more elements (e.g., motion sensor unit **102**, display mat **104**, processor **112**, database **114**, or others) of application **132** may be implemented apart from or as part of dongle **122** or display **108**. In other examples, system **130** and the above-described elements may be varied in implementation, function, or structure and are not limited to the descriptions provided.

FIG. **2**A illustrates an exemplary application architecture configured to implement motion capture and analysis. Here, motion sensor unit **200** includes triple axis accelerometer **210**, triple axis gyroscope **212**, low pass filtering **214**, low pass filtering **216**, analog to digital converter **218**, parallel to series converter **220**, wireless modem **222** and wireless transceiver **224**. In some examples, motion sensor unit **200** may include a micro-controller (not shown) similar to micro-controller **256** (described below in connection with FIG. **2**B).

In some examples, motion sensor unit **200** may be detachably coupled to an object (e.g., golf club, tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or others). Motion sensor unit **200** may be various sizes and shapes to accommodate a static and secure attachment to the various shapes and sizes of the detachably coupled object. Motion sensor unit **200** may have an adjustable attachment mechanism to enable one unit to accommodate various shapes and sizes of attached objects. Motion sensor unit **200** may be lightweight and easily portable. Motion sensor unit **200** may be easily attached or detached from the object by the user, without the need for specialized tools or accessories. In other examples, motion sensor unit **200** and the above-described elements may be implemented differently and are not limited to the descriptions provided.

In some examples, a power supply (not shown) such as a battery or external AC/DC converter may be coupled to motion sensor unit **200**. Power supplies may be implemented as rechargeable, non-rechargeable, portable, or disposable batteries. In other examples, a battery (not shown) may be implemented as part of motion sensor unit **200**, supplying power to motion sensor unit **200** and its associated components. In still other examples, a power source may be implemented as another attachment to motion sensor unit **200**.

In some examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be configured to measure movement of an object (e.g., golf club, tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or others). In some examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be a micro electromechanical system (MEMS) device. In other examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be an analog or digital device. In some examples, triple axis accelerometer **210** may be configured to measure the acceleration of the object along the x-axis, y-axis and z-axis and triple axis gyroscope **212** may be configured to measure the rotational movement of the object along the planar, orthogonal and axial directions. In other examples, triple axis accelerometer **210** and triple axis gyroscope **212** may be configured differently and are not limited to the descriptions provided.

Here, triple axis accelerometer **210** communicates the data signal to low pass filtering **214** and triple axis gyroscope **212** communicates the data signal to low pass filtering **216**. Further, low pass filtering **214** and low pass filtering **216** communicate the data signal to analog to digital converter **218**. In some examples, analog to digital converter **218** may be configured to convert the data from an analog signal to a digital signal. Here, analog to digital converter **218** communicates the data signal to parallel to series converter **220**. In some examples, parallel to series converter **220** is configured to convert the data signal from a parallel electrical signal to a series electrical signal.

Here, parallel to series converter **220** communicates the data signal to wireless modem **222**. Wireless modem **222** is coupled to wireless transceiver **224** for sending and receiving signals (e.g., RF) between motion sensor unit **200** and display unit (described below in connection with FIG. **2**B). In some examples, wireless transceiver **224** may be configured to send and receive communication signals using various wireless formats (e.g., ZigBee (i.e., IEEE 802.15.4 data communication protocol/standard/specification), radio frequency (RF) waves, IEEE 802.11, Bluetooth, UHF, or others).

FIG. **2**B further illustrates an exemplary application architecture configured to implement motion capture and analysis. Here, processing and display unit **250** includes wireless modem **254**, wireless transceiver **252**, micro-controller **256**, display driver **258**, path driver **260**, info driver **262** and user interface **264**. In some examples, processing and display unit **250** may be a remote device or system (e.g., display mat, portable display device, television monitor, computer, server, video recorder, or others) configured to present or display visual, graphical or numerical data measured by the motion sensor unit (described above in connection with FIG. **2**A) and values associated with object movement, which are calculated using the measured data. In some examples, processing and display unit **250** may be configured to save the graphic and numerical data and values associated with a user selected reference point (i.e., "best swing") for comparison with subsequent iterations of the object movement. In some examples,

processing and display unit **250** may be configured to provide an acoustic indication or response. Processing and display unit **250** may be configured with a memory device (not shown here). The memory device may be a permanent or removable memory card or hard drive.

In some examples, processing and display unit **250** presents various parameters associated with the motion of an object such as measured data (e.g., three dimensional acceleration, three dimensional rotational acceleration, maximum acceleration, or others) or calculated values (e.g., three dimensional velocity, three dimensional rotational velocity, location coordinates, maximum velocity, impact velocity, relative angle of object at point of impact, or others). Still further, processing and display unit **250** may be configured to graphically present a directional path representing the actual movement of an object and graphically indicate various significant points of reference (e.g., point of maximum velocity, or others) along the object's path of movement. In other examples, processing and display unit **250** may be configured to present or display any number of different visual, graphical or numerical parameters associated with the movement of an object and are not limited to the descriptions provided.

In some examples, processing and display unit **250** may be a display mat for use on a horizontal and flat surface, which display mat may be various sizes, shapes or dimensions. A display mat (e.g., display mat **104** (FIG. **1**A)) may be configured such that the user stands on the mat while moving the object, or stands adjacent to the mat while moving the object. A display mat may also be made of a material that is durable, impact resistant and able to sustain the weight of a person. In some examples, a display mat may be made of a material that is easily rolled up and lightweight for easy portability. As an example, a display mat may be made of an array of surface mounted light emitting devices (LEDs). The display mat may be configured to present or display any or all of the visual, graphic or numerical parameters discussed above. In other examples, processing and display unit **250** may be implemented differently and is not limited to the descriptions provided.

In other examples, processing and display unit **250** may be a portable display device for handheld use. In some examples, a portable display device may be small, lightweight and easily transported by the user. In other examples, a portable display device may be various sizes, shapes or dimensions. A portable display device may also be configured to present or display any or all of the visual, graphic or numerical parameters discussed above. In other examples, processing and display unit **250** as a portable display device may be implemented differently and is not limited to the descriptions provided.

In some examples, a power supply (not shown) such as a battery or external AC/DC converter may be coupled to processing and display unit **250**. Power supplies may be implemented as rechargeable, non-rechargeable, portable, or disposable batteries. In other examples, a battery (not shown) may be implemented as part of processing and display unit **250**, supplying power to processing and display unit **250** and its associated components. In still other examples, a power source may be implemented as another attachment to processing and display unit **250**.

Here, wireless modem **254** is coupled to wireless transceiver **252** for sending and receiving signals (e.g., RF) between processing and display unit **250** and motion sensor unit **200** (described above in connection with FIG. **2**A). In some examples, wireless transceiver **252** may be configured to send and receive communication signals using various wireless formats (e.g., ZigBee, RF waves, IEEE 802.11, Bluetooth, UHF, or others).

Here, wireless modem **254** communicates the data signal to micro-controller **256**. In some examples, micro-controller **256** is configured to process the measured data captured by motion sensor unit **200** (described above in connection with FIG. **2**A). Micro-controller **256** may calculate values associated with movement of an object (e.g., three dimensional velocity, three dimensional rotational velocity, location coordinates, maximum velocity, impact velocity, relative angle of object at point of impact, or others) using the movement data captured by motion sensor unit **200** (described above in connection with FIG. **2**A).

Here, micro-controller **256** communicates a position data signal to display driver **258** and swing position data to info driver **262**. Here further, display driver **258** communicates the position data to path driver **260**. Finally, path driver **260** and info driver **262** communicate the position and swing position data to and from user interface **264**.

In some examples, user interface **264** may be configured to include user controls which allow user configuration of the system. User interface **264** controls may include various input mechanism and allow the user to save a selected reference point (i.e., "best swing") or select the desired display parameters. In some examples, user interface **264** may be configured to include an acoustic signal to provide an auditory indication. In other examples, user interface **264** may be configured differently and is not limited to the descriptions provided. Still further, processing and display unit **250** and the above-described elements may be implemented differently and is not limited to the descriptions or examples provided above.

FIG. **3**A illustrates an exemplary motion sensor unit. Here, a top view of an exemplary user of the motion sensor unit is shown. In this example, motion sensor unit **300**, impact object **302**, movement object **304**, axial rotation **306**, planar rotation **308**, x-axis **320** and y axis **322** are shown. Motion sensor unit **300** may be configured and implemented as described above as motion sensor unit **200** (described above in connection with FIG. **2**A). As shown here, motion sensor unit **300** may be used to measure and capture axial rotation **306**, planar rotation **308**, x-axis acceleration along x-axis **320** and y-axis acceleration along y-axis **322**. In other examples, motion sensor unit **300** may be configured to measure and capture other parameters associated with movement of an object and is not limited by the descriptions provided.

As shown here, motion sensor **300** is coupled to movement object **304**, as shown here as a golf club. In other examples, movement object **304** may be a tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or other moveable object. As shown here, movement object **304** is intended to make dynamic contact with impact object **302**, as shown here as a golf ball. In other examples, impact object **302** may be a baseball, softball, hockey puck, or other moving object. In other examples, movement object **304** and impact object **302** may be different and are not limited to the descriptions provided.

FIG. **3**B illustrates a further exemplary motion sensor unit. Here, a side view of an exemplary user of the motion sensor unit is shown. In this example, motion sensor unit **300**, movement object **304**, orthogonal rotation **310**, x-axis **320** and z-axis **324** are shown. Motion sensor unit **300** may be configured and implemented as described above as motion sensor unit **200** (described above in connection with FIG. **2**A). As shown here, motion sensor unit **300** may be used to measure and capture orthogonal rotation **310**, x-axis acceleration along x-axis **320** and z-axis acceleration along z-axis **324**. In other examples, motion sensor unit **300** may be configured to

measure and capture other parameters associated with movement of an object and is not limited by the descriptions provided.

As shown here, motion sensor **300** is coupled to movement object **304**, as shown here as a golf club. In other examples, movement object **304** may be a tennis racket, baseball bat, softball bat, hockey stick, other sporting equipment, or other moveable object. As shown here, movement object **304** is intended to make dynamic contact with impact object (not shown). In other examples, movement object **304** may be different and is not limited to the descriptions provided.

FIG. **4**A illustrates an exemplary process for motion capture and analysis. In some examples, data associated with movement of an object may be captured (**402**). The data may be processed to determine values associated with movement of the object (**404**). The data and the values may be stored (**406**). The data and values may be converted from analog to digital for a wireless transmission (**408**). The data and the values may be transmitted using a wireless connection (**410**). Once transmitted, data and values may be received using, for example, a wireless modem (FIG. **2**B) configured to modulate or demodulate transmitted data for processing and presentation on a display (e.g., display **108** (FIGS. **1**A-**1**C) (**412**). The data and values may be presented graphically (**414**). The above-described process may be varied in function, processes and performed in any arbitrary order and is not limited to the examples shown and described.

FIG. **4**B and FIG. **4**C illustrate an alternative exemplary process for motion capture and analysis. In some examples, binary data may be read (**420**). The frame may be split into **6** sensor channels (**422**). The binary data may be converted into integer values (**424**). The data and integer values may be filtered (**426**). Optionally, a "swing started" calculation may be performed (not shown) to determine when a swinging motion begins. A "swing started" calculation or determination may be performed, in some examples, after filtering data and integer values. Further, an optional operation for creating a lapsed time index may also be created (not shown). The data may be averaged to create initial offset values (**432**). Relative rotation may be converted to absolute data (**434**). The sensor data may be integrated (**436**). The adjusted calibration data may be calculated (**438**). Relative data may be converted to absolute data (**440**). A velocity calculation may be performed (**442**). A velocity clamping calculation may be performed (**444**). Optionally, a "swing end" calculation may be performed to determine when a swing motion ends or terminates (**446**). Velocity data may be integrated to determine location (**448**). Location data may be translated to object head (**450**). The above-described process may be varied in function, processes and performed in any arbitrary order and is not limited to the examples shown and described.

FIG. **5** illustrates an exemplary computer system suitable to implement motion capture and analysis. In some examples, computer system **500** may be used to implement computer programs, applications, methods, processes, or other software to perform the above-described techniques. Computer system **500** includes a bus **502** or other communication mechanism for communicating information, which interconnects subsystems and devices, such as processor **504**, system memory **506** (e.g., RAM), storage device **508** (e.g., ROM), disk drive **510** (e.g., magnetic or optical), communication interface **512** (e.g., modem or Ethernet card), display **514** (e.g., CRT or LCD), input device **516** (e.g., keyboard), and output control **518**.

According to some examples, computer system **500** performs specific operations by processor **504** executing one or more sequences of one or more instructions stored in system memory **506**. Such instructions may be read into system memory **506** from another computer readable medium, such as static storage device **508** or disk drive **510**. In some examples, hard-wired circuitry may be used in place of or in combination with software instructions for implementation.

The term "computer readable medium" refers to any tangible medium that participates in providing instructions to processor **504** for execution. Such a medium may take many forms, including but not limited to, non-volatile media and volatile media. Non-volatile media includes, for example, optical or magnetic disks, such as disk drive **510**. Volatile media includes dynamic memory, such as system memory **506**.

Common forms of computer readable media includes, for example, floppy disk, flexible disk, hard disk, magnetic tape, any other magnetic medium, CD-ROM, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, RAM, PROM, EPROM, FLASH-EPROM, any other memory chip or cartridge, or any other medium from which a computer can read.

Instructions may further be transmitted or received using a transmission medium. The term "transmission medium" may include any tangible or intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine, and includes digital or analog communications signals or other intangible medium to facilitate communication of such instructions. Transmission media includes coaxial cables, copper wire, and fiber optics, including wires that comprise bus **502** for transmitting a computer data signal.

In some examples, execution of the sequences of instructions may be performed by a single computer system **500**. According to some examples, two or more computer systems **500** coupled by communication link **520** (e.g., LAN, PSTN, or wireless network) may perform the sequence of instructions in coordination with one another. Computer system **500** may transmit and receive messages, data, and instructions, including program, i.e., application code, through communication link **520** and communication interface **512**. Received program code may be executed by processor **504** as it is received, and/or stored in disk drive **510**, or other non-volatile storage for later execution.

Although the foregoing examples have been described in some detail for purposes of clarity of understanding, the invention is not limited to the details provided. There are many alternative ways of implementing the invention. The disclosed examples are illustrative and not restrictive.

What is claimed:

1. A system, comprising:

a non-wearable motion sensor unit configured to be adjustably coupled to, but not mechanically integrated with, an outer surface at a first location on an object using an adjustable attachment mechanism, the object being used in a physical activity, the non-wearable motion sensor unit being further configured to be removed from the object and adjustably coupled to, but not mechanically integrated with, another outer surface of another object using the adjustable attachment mechanism and to capture data associated with movement of the object, to process the data to determine one or more values, to store the data and the one or more values, to translate the values to correspond to a second location on the object located away from the first location, and to convert an analog signal to a digital signal comprising the data and the one or more values; and

a display unit configured to receive the data from the non-wearable motion sensor unit, the data being transmitted using through the wireless transmission, to process the

data to determine one or more values, to store the data, and to graphically present the data and the one or more values.

2. The system of claim **1**, wherein the data comprises acceleration data associated with the object.

3. The system of claim **1**, wherein the data comprises angular momentum data associated with the object.

4. The system of claim **1**, wherein the one or more values indicate a maximum velocity associated with the object.

5. The system of claim **1**, wherein the one or more values indicate a graphical path associated with the object.

6. The system of claim **1**, wherein the one or more values indicate a velocity associated with the object at a time when the object impacts another object.

7. The system of claim **1**, wherein the one or more values indicate an angle associated with the object at a time when the object impacts another object.

8. The system of claim **1**, wherein the one or more values indicate a trajectory associated with the object adheres to a fixed plane.

9. The system of claim **1**, further comprising a control unit coupled to the non-wearable motion sensor unit, the control unit being configured to receive input.

10. The system of claim **1**, further comprising a graphic indicator unit coupled to the non-wearable motion sensor unit, the graphic indicator unit being configured to present the data and the one or more values.

11. The system of claim **1**, wherein the display unit is configured to graphically present the data and the one or more values as an image.

12. The system of claim **1**, wherein the display unit is configured to graphically present an image comprising the data and the one or more values.

13. The system of claim **1**, wherein the non-wearable motion sensor unit is detachably and adjustably coupled to the object.

14. The system of claim **1**, wherein the display unit is a display mat.

15. The system of claim **1**, wherein the object is a golf club.

16. The system of claim **1**, wherein the object is a baseball bat.

17. The system of claim **1**, wherein the object is a tennis racket.

18. The system of claim **1**, wherein the object is a hockey stick.

19. The system of claim **1**, wherein the object is a fishing pole.

20. The system of claim **1**, wherein the object is a racquetball racquet.

21. The system of claim **1**, wherein the object is a squash racquet.

22. A system, comprising:

a non-wearable motion sensor unit configured to be adjustably coupled to, but not mechanically integrated with, an outer surface at a first location on an object using an adjustable attachment mechanism, the object being used in a physical activity, the non-wearable motion sensor unit being further configured to be removed from the object and adjustably coupled to, but not mechanically integrated with, another outer surface of another object using the adjustable attachment mechanism and comprising a motion measurement unit configured to capture data associated with movement of the object;

a processor configured to process the data to determine one or more values associated with movement of the object, and to translate the values to correspond to a second location on the object located away from the first location;

a wireless transmitter being coupled to the non-wearable motion sensor unit, the wireless transmitter being configured to transmit the data; and

a display unit comprising a display and a wireless transceiver, the wireless transceiver being coupled to the display unit and configured to send and receive the data from the non-wearable motion sensor unit and another processor configured to process the data and generate an image based on the data.

23. A system, comprising:

a non-wearable motion sensor unit configured to be adjustably coupled to, but not mechanically integrated with, an outer surface at a first location on an object using an adjustable attachment mechanism, the object being used in a physical activity, the non-wearable motion sensor unit being further configured to be removed from the object and adjustably coupled to, but not mechanically integrated with, another outer surface of another object using the adjustable attachment mechanism, the motion sensor unit comprising a three-dimensional accelerometer and a gyroscope configured to capture data associated with movement of the object, a processor configured to process the data to determine one or more values associated with movement of the first location on the object and to translate the values to correspond to a second location on the object located away from the first location, and a wireless transmitter coupled to the non-wearable motion sensor unit, the wireless transmitter being configured to transmit and receive the data;

a display unit comprising a graphic display, a wireless transceiver coupled to the display unit, the wireless transceiver being configured to send and receive the data from the non-wearable motion sensor unit, and another processor configured to process the data and generate an image to be presented on the graphic display;

a portable handheld display unit comprising another graphic display, another wireless transceiver being coupled to the portable display unit, the another wireless transceiver being configured to send and receive the data from the non-wearable motion sensor unit; and

a further processor configured to process the data and generate another image to be presented on the another graphic display.

24. A method, comprising:

capturing data associated with movement of an object, the data corresponding to a first location on the object and being captured by a non-wearable motion sensor unit adjustably coupled to, but not mechanically integrated with, an outer surface of the object at the first location using an adjustable attachment mechanism the object being used in a physical activity, the non-wearable motion sensor unit being further configured to be removed from the object and adjustably coupled to, but not mechanically integrated with, another outer surface of another object using the adjustable attachment mechanism;

processing the data to determine one or more values associated with the movement of the object;

translating the values to correspond to a second location on the object located away from the first location;

storing the data and the one or more values;

converting an analog signal to a digital signal, the digital signal comprising the data and the one or more values;

transmitting the digital signal using a wireless connection established between a wireless transmitter and a wireless transceiver; and

presenting the data and the one or more values graphically.

* * * * *

JS 44 (Rev. 06/17)

CIVIL COVER SHEET

The JS 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. *(SEE INSTRUCTIONS ON NEXT PAGE OF THIS FORM.)*

I. (a) PLAINTIFFS

NewSpin Sports, LLC

(b) County of Residence of First Listed Plaintiff _____
(EXCEPT IN U.S. PLAINTIFF CASES)

(c) Attorneys *(Firm Name, Address, and Telephone Number)*
Frederick W. Kosmo, Jr. (138036), Hubert Kim (204957) and Morgan P. Suder (292499), Wilson Turner Kosmo LLP, 550 W. C Street, Suite 1050, San Diego, CA 92101; 619-236-9600

DEFENDANTS

Blast Motion, Inc. and TaylorMade Golf Company, Inc.

County of Residence of First Listed Defendant San Diego County
(IN U.S. PLAINTIFF CASES ONLY)

NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE TRACT OF LAND INVOLVED.

Attorneys *(If Known)*

'18CV2273 BAS JLB

II. BASIS OF JURISDICTION *(Place an "X" in One Box Only)*

- ☐ 1 U.S. Government Plaintiff
- ☒ 3 Federal Question *(U.S. Government Not a Party)*
- ☐ 2 U.S. Government Defendant
- ☐ 4 Diversity *(Indicate Citizenship of Parties in Item III)*

III. CITIZENSHIP OF PRINCIPAL PARTIES *(Place an "X" in One Box for Plaintiff and One Box for Defendant)*
(For Diversity Cases Only)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated *or* Principal Place of Business In This State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated *and* Principal Place of Business In Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. NATURE OF SUIT *(Place an "X" in One Box Only)*

Click here for: Nature of Suit Code Descriptions.

CONTRACT
- ☐ 110 Insurance
- ☐ 120 Marine
- ☐ 130 Miller Act
- ☐ 140 Negotiable Instrument
- ☐ 150 Recovery of Overpayment & Enforcement of Judgment
- ☐ 151 Medicare Act
- ☐ 152 Recovery of Defaulted Student Loans (Excludes Veterans)
- ☐ 153 Recovery of Overpayment of Veteran's Benefits
- ☐ 160 Stockholders' Suits
- ☐ 190 Other Contract
- ☐ 195 Contract Product Liability
- ☐ 196 Franchise

REAL PROPERTY
- ☐ 210 Land Condemnation
- ☐ 220 Foreclosure
- ☐ 230 Rent Lease & Ejectment
- ☐ 240 Torts to Land
- ☐ 245 Tort Product Liability
- ☐ 290 All Other Real Property

TORTS

PERSONAL INJURY
- ☐ 310 Airplane
- ☐ 315 Airplane Product Liability
- ☐ 320 Assault, Libel & Slander
- ☐ 330 Federal Employers' Liability
- ☐ 340 Marine
- ☐ 345 Marine Product Liability
- ☐ 350 Motor Vehicle
- ☐ 355 Motor Vehicle Product Liability
- ☐ 360 Other Personal Injury
- ☐ 362 Personal Injury - Medical Malpractice

PERSONAL INJURY
- ☐ 365 Personal Injury - Product Liability
- ☐ 367 Health Care/ Pharmaceutical Personal Injury Product Liability
- ☐ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
- ☐ 370 Other Fraud
- ☐ 371 Truth in Lending
- ☐ 380 Other Personal Property Damage
- ☐ 385 Property Damage Product Liability

CIVIL RIGHTS
- ☐ 440 Other Civil Rights
- ☐ 441 Voting
- ☐ 442 Employment
- ☐ 443 Housing/ Accommodations
- ☐ 445 Amer. w/Disabilities - Employment
- ☐ 446 Amer. w/Disabilities - Other
- ☐ 448 Education

PRISONER PETITIONS

Habeas Corpus:
- ☐ 463 Alien Detainee
- ☐ 510 Motions to Vacate Sentence
- ☐ 530 General
- ☐ 535 Death Penalty

Other:
- ☐ 540 Mandamus & Other
- ☐ 550 Civil Rights
- ☐ 555 Prison Condition
- ☐ 560 Civil Detainee - Conditions of Confinement

FORFEITURE/PENALTY
- ☐ 625 Drug Related Seizure of Property 21 USC 881
- ☐ 690 Other

LABOR
- ☐ 710 Fair Labor Standards Act
- ☐ 720 Labor/Management Relations
- ☐ 740 Railway Labor Act
- ☐ 751 Family and Medical Leave Act
- ☐ 790 Other Labor Litigation
- ☐ 791 Employee Retirement Income Security Act

IMMIGRATION
- ☐ 462 Naturalization Application
- ☐ 465 Other Immigration Actions

BANKRUPTCY
- ☐ 422 Appeal 28 USC 158
- ☐ 423 Withdrawal 28 USC 157

PROPERTY RIGHTS
- ☐ 820 Copyrights
- ☒ 830 Patent
- ☐ 835 Patent - Abbreviated New Drug Application
- ☐ 840 Trademark

SOCIAL SECURITY
- ☐ 861 HIA (1395ff)
- ☐ 862 Black Lung (923)
- ☐ 863 DIWC/DIWW (405(g))
- ☐ 864 SSID Title XVI
- ☐ 865 RSI (405(g))

FEDERAL TAX SUITS
- ☐ 870 Taxes (U.S. Plaintiff or Defendant)
- ☐ 871 IRS—Third Party 26 USC 7609

OTHER STATUTES
- ☐ 375 False Claims Act
- ☐ 376 Qui Tam (31 USC 3729(a))
- ☐ 400 State Reapportionment
- ☐ 410 Antitrust
- ☐ 430 Banks and Banking
- ☐ 450 Commerce
- ☐ 460 Deportation
- ☐ 470 Racketeer Influenced and Corrupt Organizations
- ☐ 480 Consumer Credit
- ☐ 490 Cable/Sat TV
- ☐ 850 Securities/Commodities/ Exchange
- ☐ 890 Other Statutory Actions
- ☐ 891 Agricultural Acts
- ☐ 893 Environmental Matters
- ☐ 895 Freedom of Information Act
- ☐ 896 Arbitration
- ☐ 899 Administrative Procedure Act/Review or Appeal of Agency Decision
- ☐ 950 Constitutionality of State Statutes

V. ORIGIN *(Place an "X" in One Box Only)*

☒ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from Another District *(specify)* ☐ 6 Multidistrict Litigation - Transfer ☐ 8 Multidistrict Litigation - Direct File

VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing ***(Do not cite jurisdictional statutes unless diversity)***:
35 USC Sec. 271 and 281

Brief description of cause:
Patent Infringement

VII. REQUESTED IN COMPLAINT:

☐ CHECK IF THIS IS A **CLASS ACTION** UNDER RULE 23, F.R.Cv.P.

DEMAND $

CHECK YES only if demanded in complaint:
JURY DEMAND: ☒ Yes ☐ No

VIII. RELATED CASE(S) IF ANY

(See instructions): JUDGE _____ DOCKET NUMBER _____

DATE
09/28/2018

SIGNATURE OF ATTORNEY OF RECORD
s/Frederick W. Kosmo, Jr.

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RECEIPT # _____ AMOUNT _____ APPLYING IFP _____ JUDGE _____ MAG. JUDGE _____