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(12) **United States Patent**
Hayashida

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(45) **Date of Patent: May 5, 2020**

(54) **ACTION CONTROL METHOD AND DEVICE**

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(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

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

(21) Appl. No.: **15/788,890**

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(30) **Foreign Application Priority Data**

Oct. 31, 2016 (JP) 2016-213625

(51) **Int. Cl.**
G06F 3/01 (2006.01)
G06T 13/40 (2011.01)

(52) **U.S. Cl.**
CPC ***G06F 3/011*** (2013.01); ***G06T 13/40*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/011; G06T 13/40; G06T 19/006; G06T 11/00; G06T 13/00; G06T 13/20; G06T 15/00; G06T 19/00; G06T 19/003; G02B 27/017; A63F 13/00; G06Q 30/00
USPC 345/619
See application file for complete search history.

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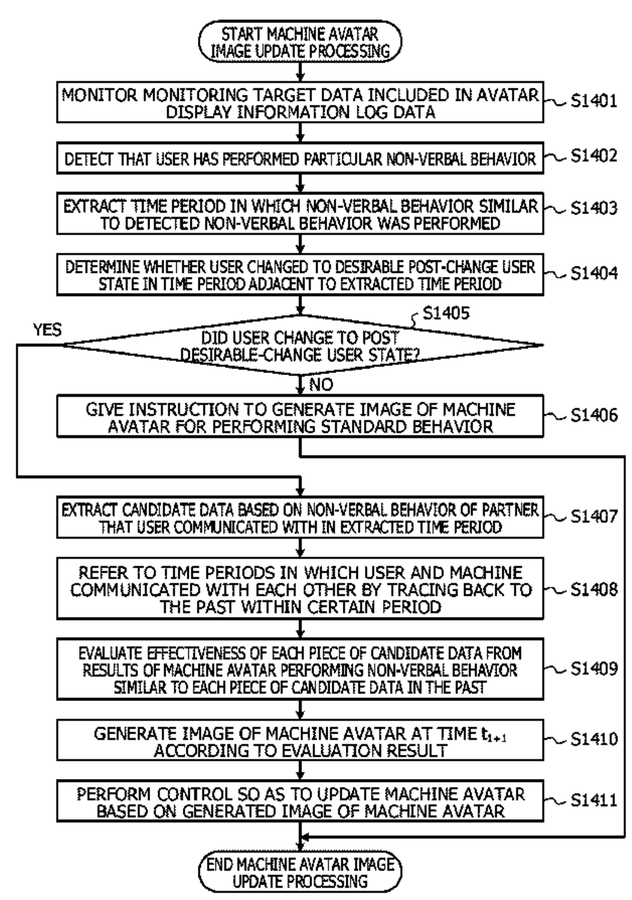
(74) *Attorney, Agent, or Firm* — Fujitsu Patent Center

(57) **ABSTRACT**

An action control method includes when a first state of a first user in communication with a first machine avatar is detected, specifying a first action of the first machine avatar for changing a state of the first user from the first state to a second state that is more desirable than the first state based on history information indicating changes in states of users in response to actions of machine avatars or different users in communication with the users, and causing the first machine avatar to perform the first action.

18 Claims, 37 Drawing Sheets



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2018/0143025	A1*	5/2018	Kurata	G01C 21/26

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FIG. 1

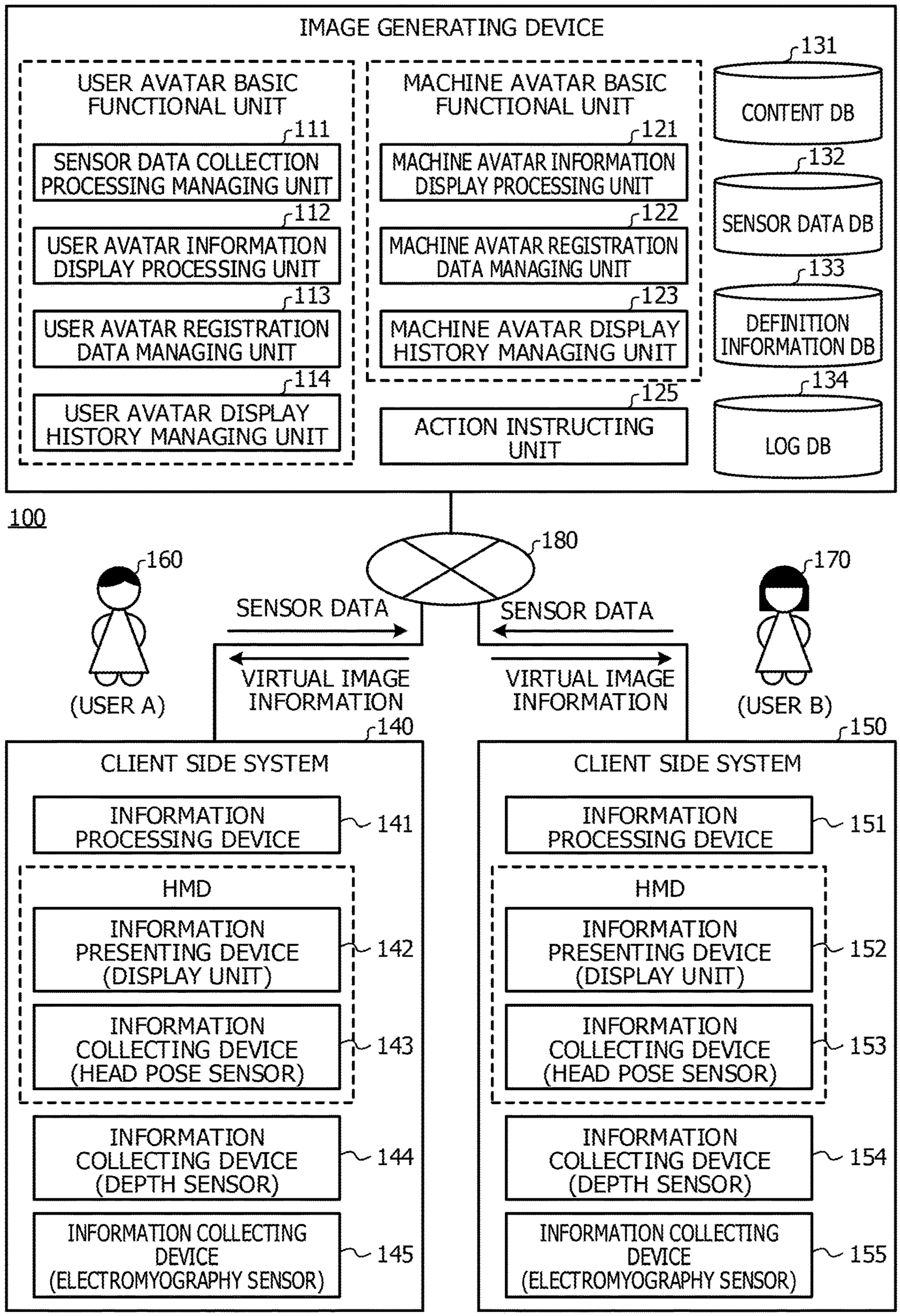


IMAGE GENERATING DEVICE
USER AVATAR BASIC FUNCTIONAL UNIT
111
SENSOR DATA COLLECTION PROCESSING MANAGING UNIT
112
USER AVATAR INFORMATION DISPLAY PROCESSING UNIT
113
USER AVATAR REGISTRATION DATA MANAGING UNIT
114
USER AVATAR DISPLAY HISTORY MANAGING UNIT
MACHINE AVATAR BASIC FUNCTIONAL UNIT
121
MACHINE AVATAR INFORMATION DISPLAY PROCESSING UNIT
122
MACHINE AVATAR REGISTRATION DATA MANAGING UNIT
123
MACHINE AVATAR DISPLAY HISTORY MANAGING UNIT
125
ACTION INSTRUCTING UNIT
131
CONTENT DB
132
SENSOR DATA DB
133
DEFINITION INFORMATION DB
134
LOG DB
100
180
160
(USER A)
170
(USER B)
SENSOR DATA
SENSOR DATA
VIRTUAL IMAGE INFORMATION
VIRTUAL IMAGE INFORMATION
140
CLIENT SIDE SYSTEM
INFORMATION PROCESSING DEVICE
141
HMD
INFORMATION PRESENTING DEVICE (DISPLAY UNIT)
142
INFORMATION COLLECTING DEVICE (HEAD POSE SENSOR)
143
INFORMATION COLLECTING DEVICE (DEPTH SENSOR)
144
INFORMATION COLLECTING DEVICE (ELECTROMYOGRAPHY SENSOR)
145
150
CLIENT SIDE SYSTEM
INFORMATION PROCESSING DEVICE
151
HMD
INFORMATION PRESENTING DEVICE (DISPLAY UNIT)
152
INFORMATION COLLECTING DEVICE (HEAD POSE SENSOR)
153
INFORMATION COLLECTING DEVICE (DEPTH SENSOR)
154
INFORMATION COLLECTING DEVICE (ELECTROMYOGRAPHY SENSOR)
155

FIG. 2

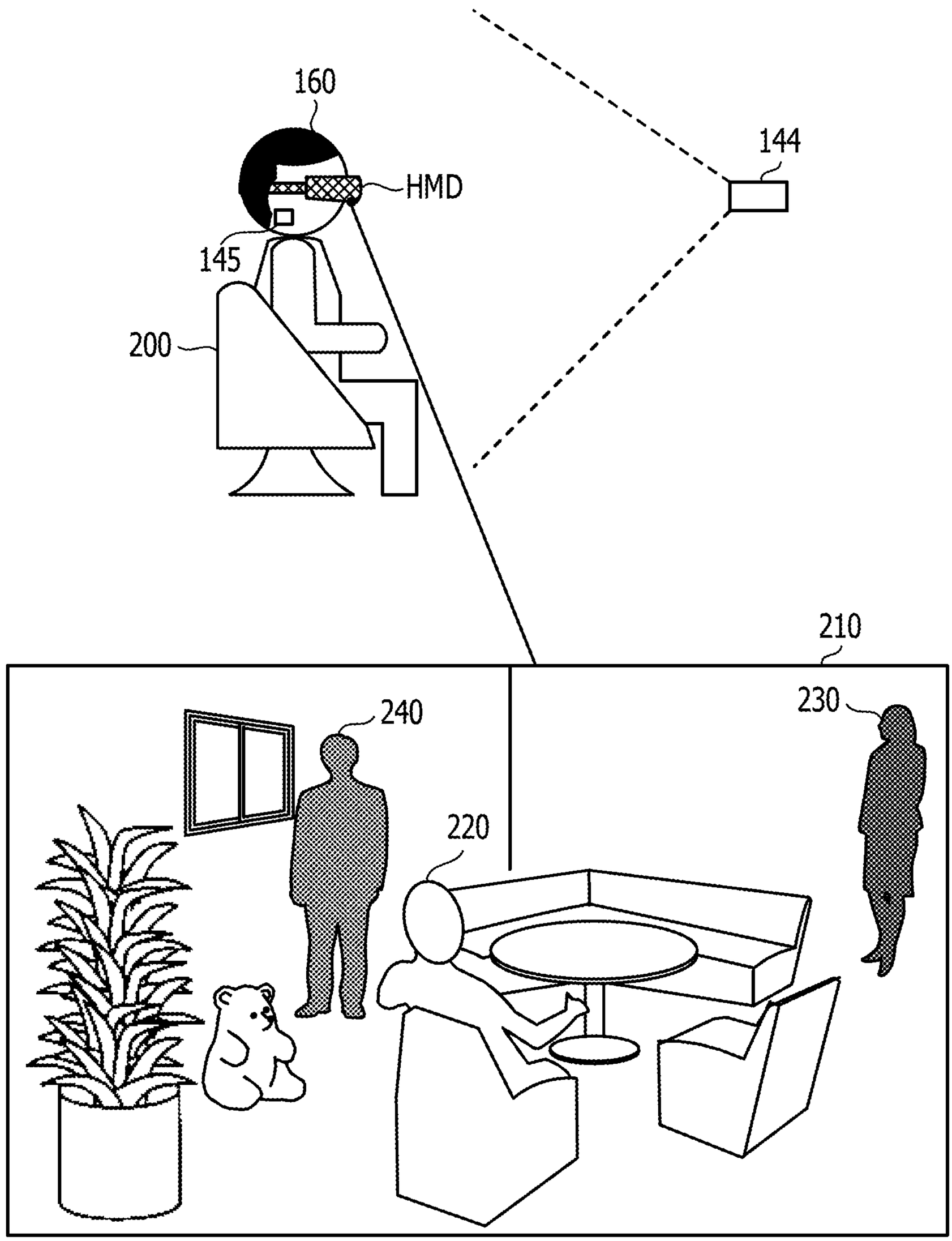


FIG. 3

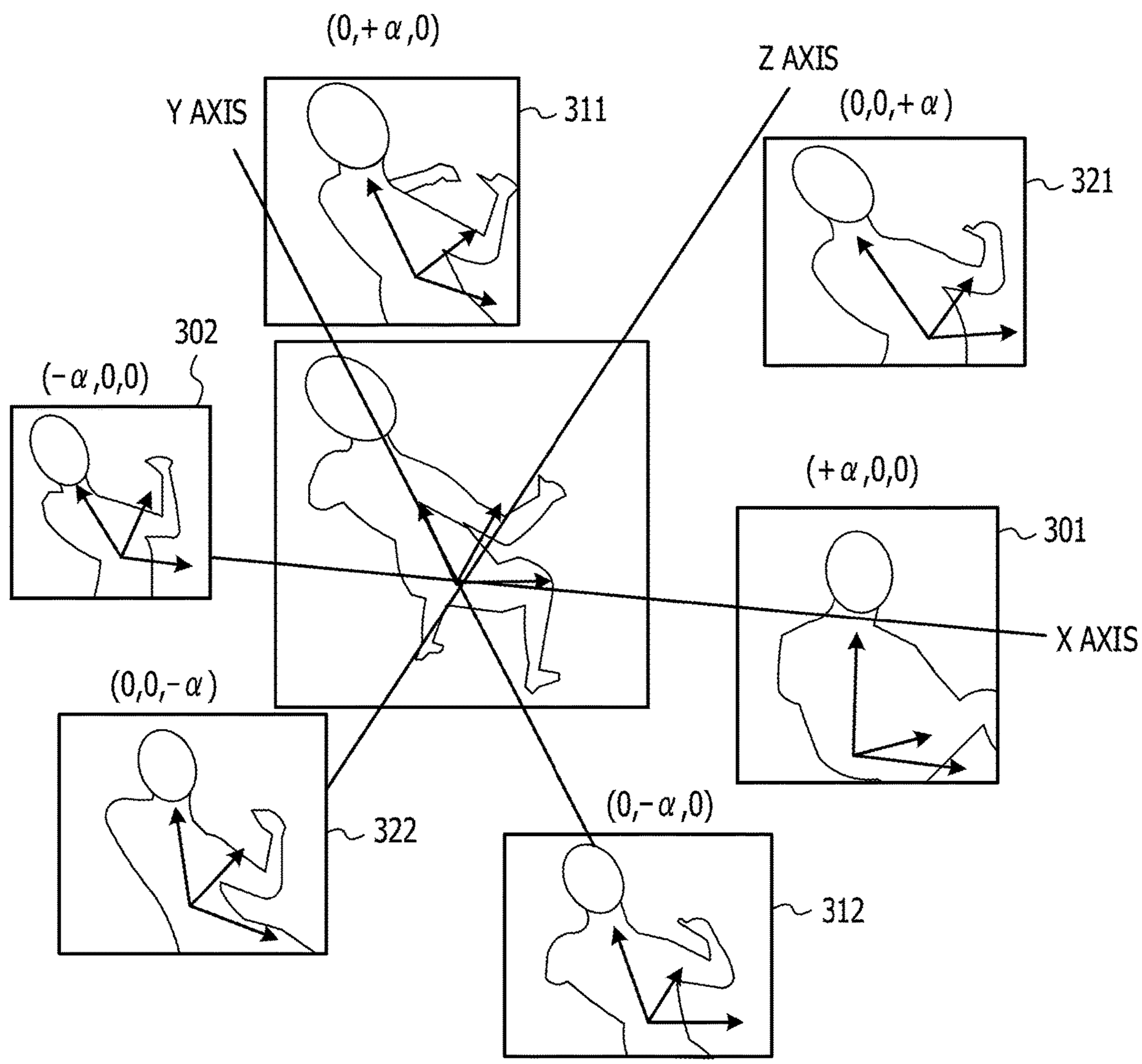
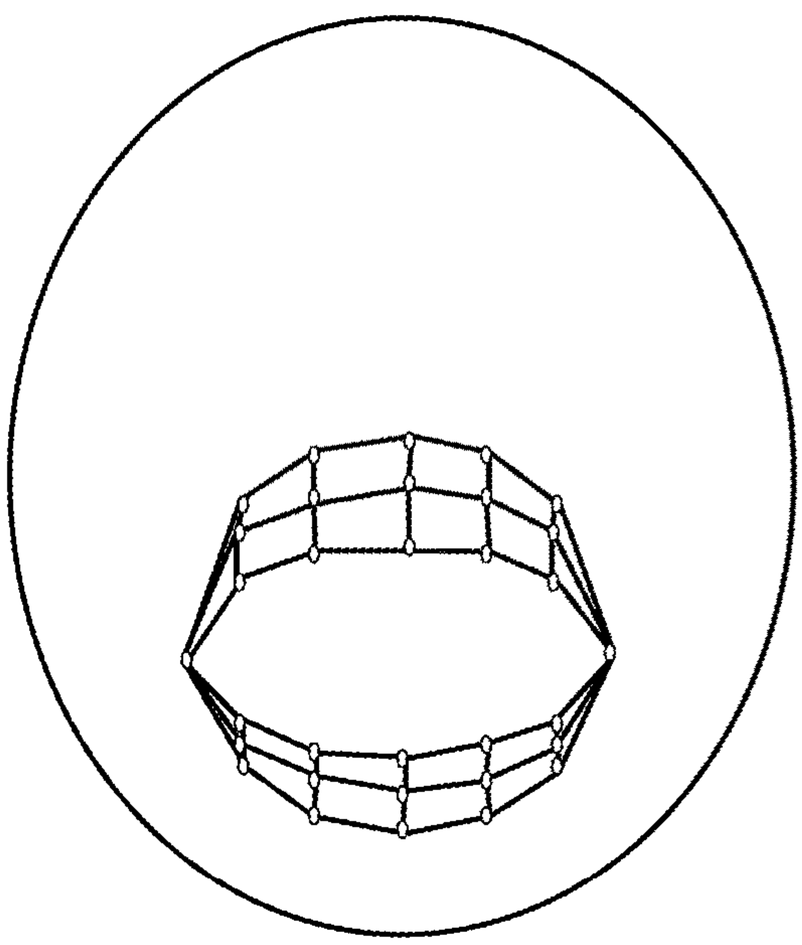
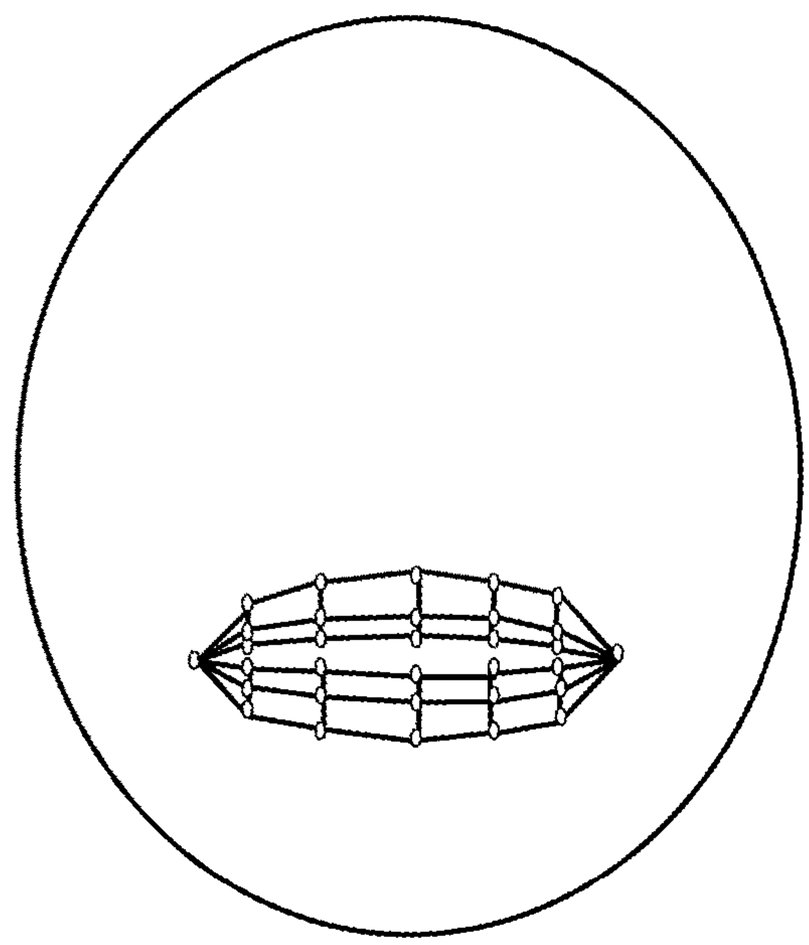

(0,+α,0)
Y AXIS
311
Z AXIS
(0,0,+α)
321
302
(−α,0,0)
(+α,0,0)
301
X AXIS
(0,0,−α)
322
(0,−α,0)
312

FIG. 4A



(a)

FIG. 4B



(b)

FIG. 5

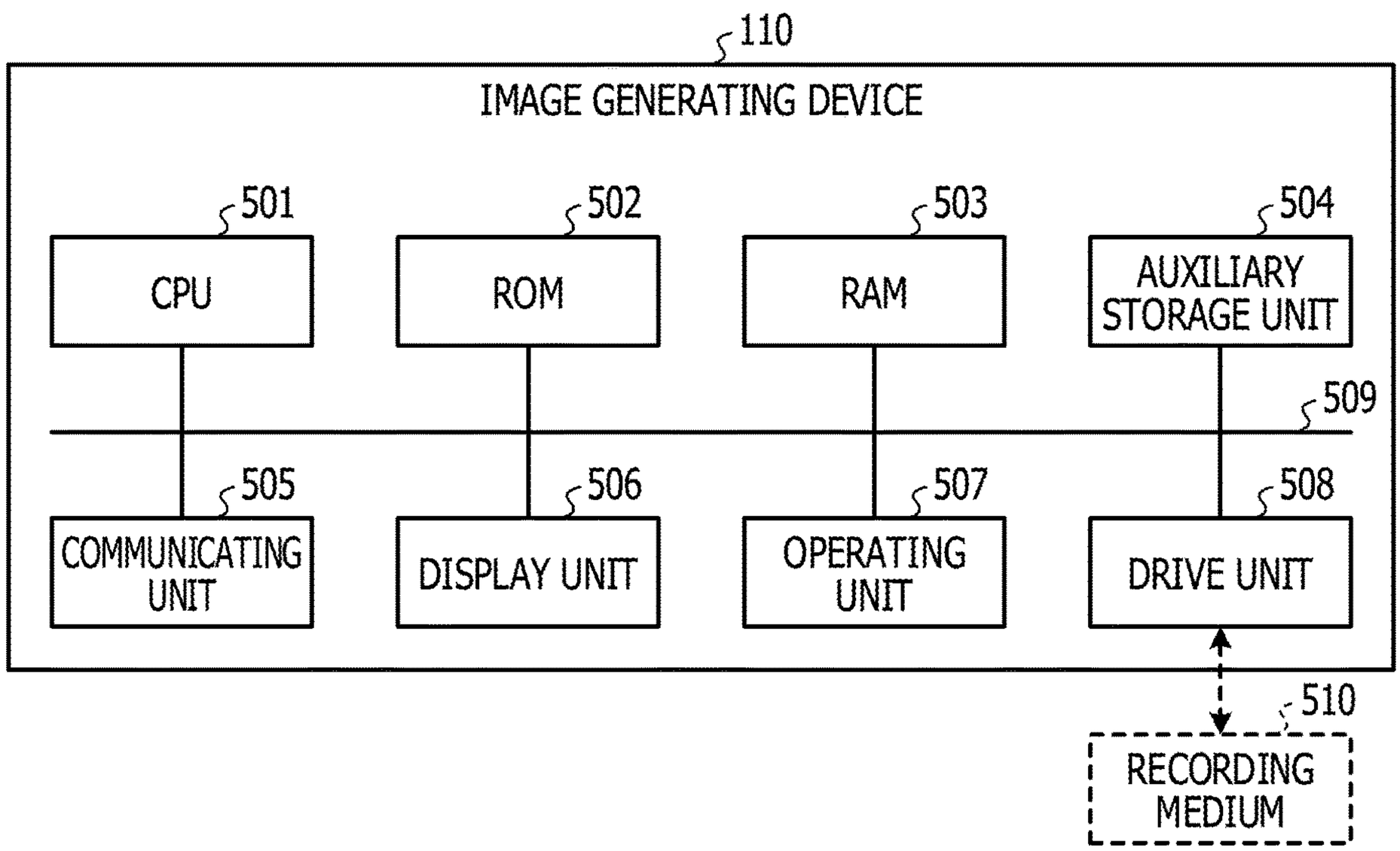

110
IMAGE GENERATING DEVICE
501
CPU
502
ROM
503
RAM
504
AUXILIARY STORAGE UNIT
509
505
COMMUNICATING UNIT
506
DISPLAY UNIT
507
OPERATING UNIT
508
DRIVE UNIT
510
RECORDING MEDIUM

FIG. 6

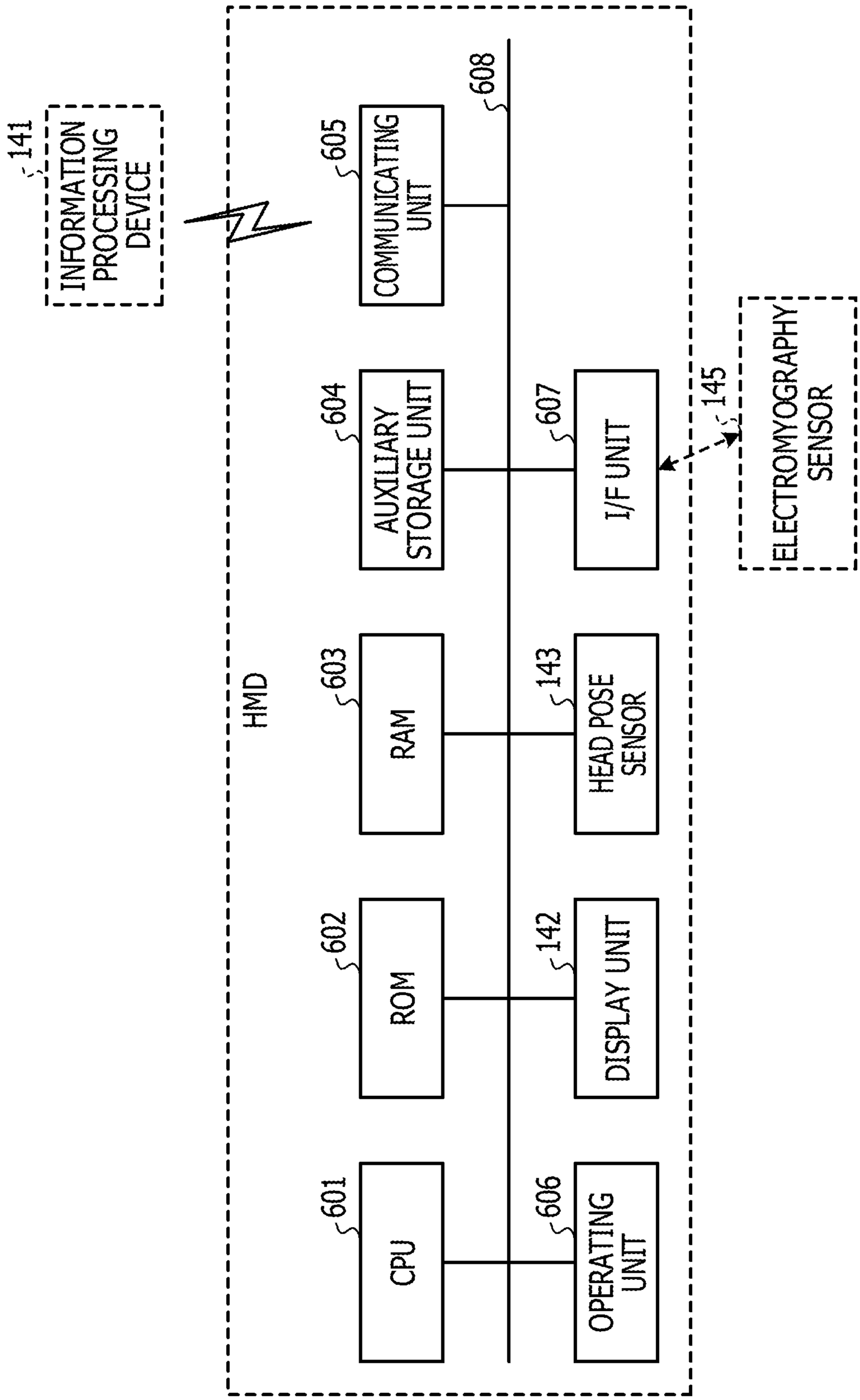

141
INFORMATION PROCESSING DEVICE
HMD
601
CPU
602
ROM
603
RAM
604
AUXILIARY STORAGE UNIT
605
COMMUNICATING UNIT
606
OPERATING UNIT
607
I/F UNIT
608
142
DISPLAY UNIT
143
HEAD POSE SENSOR
145
ELECTROMYOGRAPHY SENSOR

FIG. 7

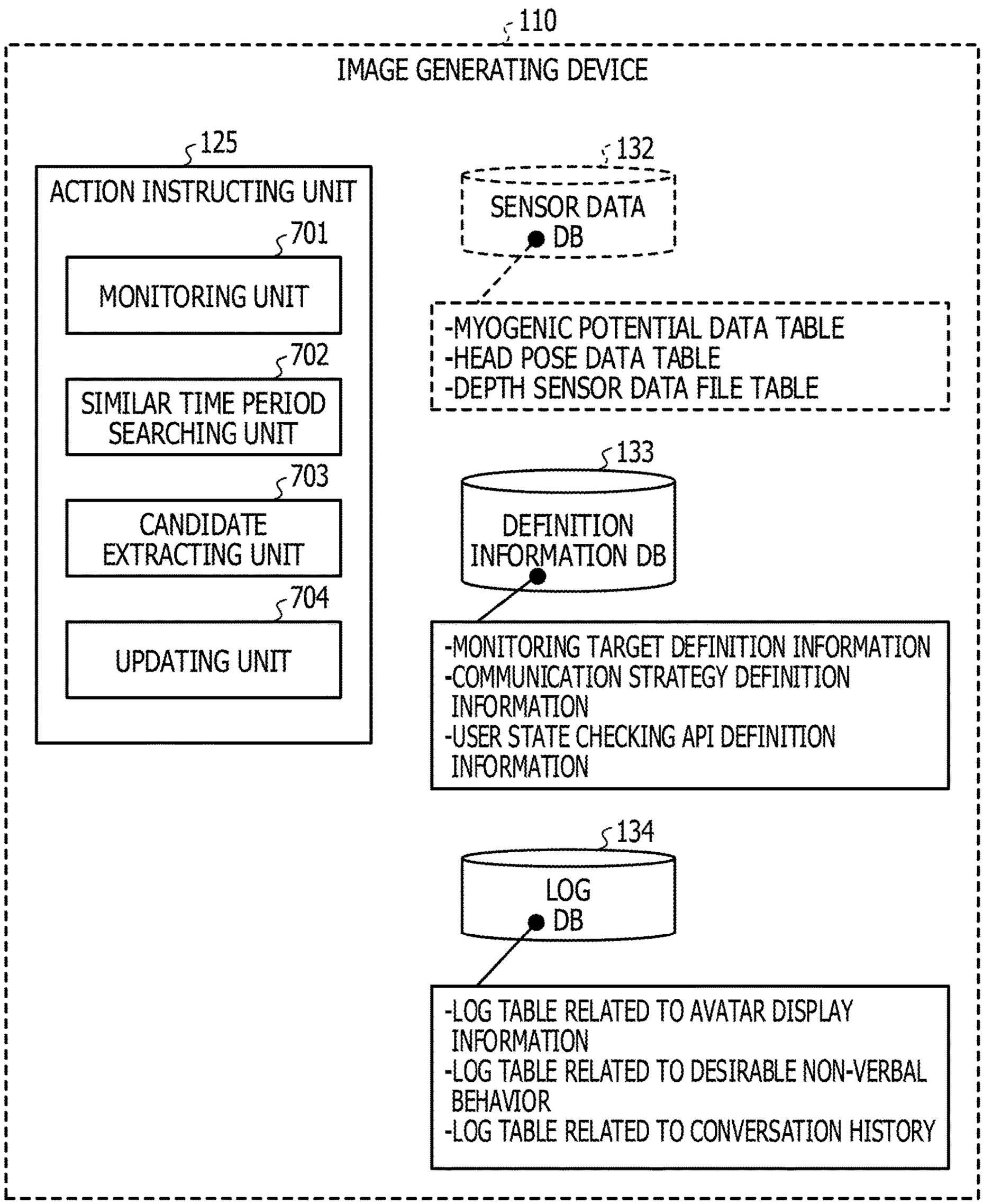

110
IMAGE GENERATING DEVICE
125
ACTION INSTRUCTING UNIT
701
MONITORING UNIT
702
SIMILAR TIME PERIOD SEARCHING UNIT
703
CANDIDATE EXTRACTING UNIT
704
UPDATING UNIT
132
SENSOR DATA DB
-MYOGENIC POTENTIAL DATA TABLE
-HEAD POSE DATA TABLE
-DEPTH SENSOR DATA FILE TABLE
133
DEFINITION INFORMATION DB
-MONITORING TARGET DEFINITION INFORMATION
-COMMUNICATION STRATEGY DEFINITION INFORMATION
-USER STATE CHECKING API DEFINITION INFORMATION
134
LOG DB
-LOG TABLE RELATED TO AVATAR DISPLAY INFORMATION
-LOG TABLE RELATED TO DESIRABLE NON-VERBAL BEHAVIOR
-LOG TABLE RELATED TO CONVERSATION HISTORY

FIG. 8A

810

MYOGENIC POTENTIAL DATA TABLE				
DB RECORDING TIME	SENSOR RECORDING TIME	USER NAME	INFORMATION COLLECTING DEVICE ID	MYOGENIC POTENTIAL ACTIVITY VALUE(EMG(μV))
⋮	⋮	⋮	⋮	⋮
2015/7/27 11:00:01.035	2015/7/27 11:00:01.000	userA	TcA_c3_zygomaticus(cheek)	33.9
2015/7/27 11:00:01.040	2015/7/27 11:00:01.010	userA	TcA_c3_orbicularis(under eye)	520.
2015/7/27 11:00:05.069	2015/7/27 11:00:04.000	userA	TcA_c3_corrugator(brow)	20.2
⋮	⋮	⋮	⋮	⋮

FIG. 8B

820

MYOGENIC POTENTIAL DATA TABLE				
DB RECORDING TIME	SENSOR RECORDING TIME	USER NAME	INFORMATION COLLECTING DEVICE ID	HEAD ATTITUDE DATA (POSITION, ANGLE)
⋮	⋮	⋮	⋮	⋮
2015/7/27 11:00:01.030	2015/7/27 11:00:00.000	userA	TcA_c1	(0,18,-10),(0,0,0)
2015/7/27 11:00:03.0.25	2015/7/27 11:00:02.000	userA	TcA_c1	(0,18,-10),(0,0,1)
2015/7/27 11:01:05.069	2015/7/27 11:00:04.000	userA	TcA_c1	(0,18,-10),(0,02.5)
⋮	⋮	⋮	⋮	⋮

FIG. 8C

830

DEPTH SENSOR DATA FILE TABLE					
DB RECORDING TIME	SENSOR RECORDING START TIME	SENSOR RECORDING END TIME	USER NAME	INFORMATION COLLECTING DEVICE ID	DEPTH SENSOR DATA RECORDING FILE URI
⋮	⋮	⋮	⋮	⋮	⋮
2015/7/27 11:00:01.030	2015/7/27 11:00:00.000	2015/7/27 11:00:01.000	userA	TcA_c2	20150712_0011100_00.exf
2015/7/27 11:00:03.0.25	2015/7/27 11:00:02.000	2015/7/27 11:00:03.000	userA	TcA_c2	20150712_0011102_00.exf
2015/7/27 11:01:05.069	2015/7/27 11:00:04.000	2015/7/27 11:01:05.000	userA	TcA_c2	20150712_0011104_00.exf
⋮	⋮	⋮	⋮	⋮	⋮

FIG. 9

900

LOG TABLE RELATED TO AVATAR DISPLAY INFORMATION					
DB RECORDING TIME	USER PRESENT TIME	USER NAME	INFORMATION PROCESSING DEVICE ID	LOG TYPE LABEL	AVATAR DISPLAY INFORMATION LOG DATA
:	:	:	:	:	:
2015/7/27 11:00:00.020	2015/7/27 11:00:00.000	userA	TCA	BONE	<Human><Head><Bone>((0,18,-10),(0,1,0))</Bone> <RightEye>… </Head> <Neck><Bone>… <RightShoulder>… </Neck> <Spine>…</Spine> <Chest>…</Chest> <Hip><RightUppLeg>..</RightUppLeg> <LeftUppLeg>..</LeftUppLeg> … </Hip><Human>
2015/7/27 11:00:00.020	2015/7/27 11:00:00.000	userA	TCA	Mesh	<Human><Head><Mesh>HeadMeshesMatrix □ </Mesh> <RightEye>… <>Mouse>… </Head> <Neck><Bone>… <RightShoulder>… </Neck> <Spine>…</Spine> <Chest>…</Chest> <Hip><RightUppLeg>..</RightUppLeg> <LeftUppLeg>..</LeftUppLeg> … </Hip><Human>

FIG. 10A

1010

LOG TABLE RELATED TO DESIRABLE NON-VERBAL BEHAVIOR					
DB RECORDING TIME	USER PRESENT TIME	USER NAME	INFORMATION PROCESSING DEVICE ID	DESIRABLE NON-VERBAL BEHAVIOR	CHECKING RESULT
:	:	:	:	:	:
2015/7/27 11:00:01.030	2015/7/27 11:00:00.000	userA	TcA_c2	Flow	falce
:	:	:	:	:	:

FIG. 10B

1020

LOG TABLE RELATED TO CONVERSATION HISTORY			
DIALOG START TIME	DIALOG END TIME	USER NAME 1	USER NAME 2
:	:	:	:
2015/7/27 9:00:00.000	2015/7/27 9:30:00.000	userA	userB
2015/7/27 9:10:00.000	2015/7/27 9:32:00.000	userA	userC
:	:	:	:

FIG. 11

1100

MONITORING TARGET DEFINITION INFORMATION		
COMMUNICATION PARTNER USER NAME	MONITORING TARGET	TRIGGER CHECKING API
:	:	:
userA	Bone_Chest	isSigh
userA	Bone_Head, Bone_LeftShoulder, Bone_Rightshoulder	isNap
userC	Bone_Head	isNap
N/D	Bone_Head, Bone_Chest	isRestles
:	:	:

FIG. 12A

1100

COMMUNICATION STRATEGY DEFINITION INFORMATION		
COMMUNICATION PARTNER USER NAME	TRIGGERING NON-VERBAL BEHAVIOR	DESIRABLE NON-VERBAL BEHAVIOR
userA	isSigh, return true	Flow
N/D	isRestles, return true	Flow
N/D	N/D	Smile
:	:	:

FIG. 12B

1220

USER STATE CHECKING API DEFINITION INFORMATION		
USER STATE	INPUT TARGET DATA	USER STATE CHECKING API
:	:	:
Flow	Bone_Head, Bone_Spine	checkFlow
Flow	shape_Mouth	checkSmile
:	:	:

FIG. 13

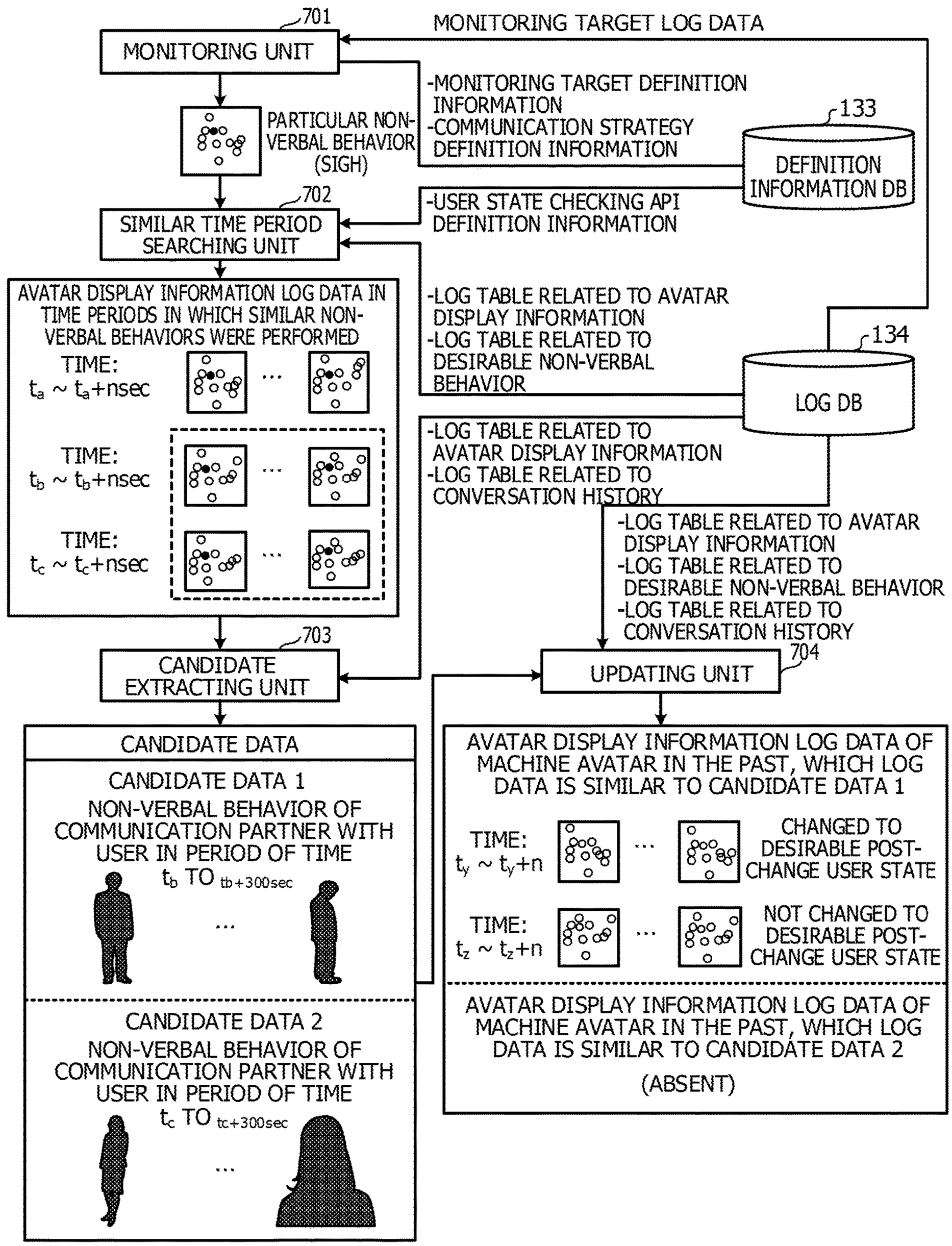

701
MONITORING UNIT
MONITORING TARGET LOG DATA
-MONITORING TARGET DEFINITION INFORMATION
-COMMUNICATION STRATEGY DEFINITION INFORMATION
PARTICULAR NON-VERBAL BEHAVIOR (SIGH)
133
DEFINITION INFORMATION DB
702
SIMILAR TIME PERIOD SEARCHING UNIT
-USER STATE CHECKING API DEFINITION INFORMATION
AVATAR DISPLAY INFORMATION LOG DATA IN TIME PERIODS IN WHICH SIMILAR NON-VERBAL BEHAVIORS WERE PERFORMED
TIME: $t_a \sim t_a$+nsec
TIME: $t_b \sim t_b$+nsec
TIME: $t_c \sim t_c$+nsec
-LOG TABLE RELATED TO AVATAR DISPLAY INFORMATION
-LOG TABLE RELATED TO DESIRABLE NON-VERBAL BEHAVIOR
134
LOG DB
-LOG TABLE RELATED TO AVATAR DISPLAY INFORMATION
-LOG TABLE RELATED TO CONVERSATION HISTORY
-LOG TABLE RELATED TO AVATAR DISPLAY INFORMATION
-LOG TABLE RELATED TO DESIRABLE NON-VERBAL BEHAVIOR
-LOG TABLE RELATED TO CONVERSATION HISTORY
703
CANDIDATE EXTRACTING UNIT
704
UPDATING UNIT
CANDIDATE DATA
CANDIDATE DATA 1
NON-VERBAL BEHAVIOR OF COMMUNICATION PARTNER WITH USER IN PERIOD OF TIME t_b TO $_{tb+300sec}$
CANDIDATE DATA 2
NON-VERBAL BEHAVIOR OF COMMUNICATION PARTNER WITH USER IN PERIOD OF TIME t_c TO $_{tc+300sec}$
AVATAR DISPLAY INFORMATION LOG DATA OF MACHINE AVATAR IN THE PAST, WHICH LOG DATA IS SIMILAR TO CANDIDATE DATA 1
TIME: $t_y \sim t_y$+n
CHANGED TO DESIRABLE POST-CHANGE USER STATE
TIME: $t_z \sim t_z$+n
NOT CHANGED TO DESIRABLE POST-CHANGE USER STATE
AVATAR DISPLAY INFORMATION LOG DATA OF MACHINE AVATAR IN THE PAST, WHICH LOG DATA IS SIMILAR TO CANDIDATE DATA 2
(ABSENT)

FIG. 14

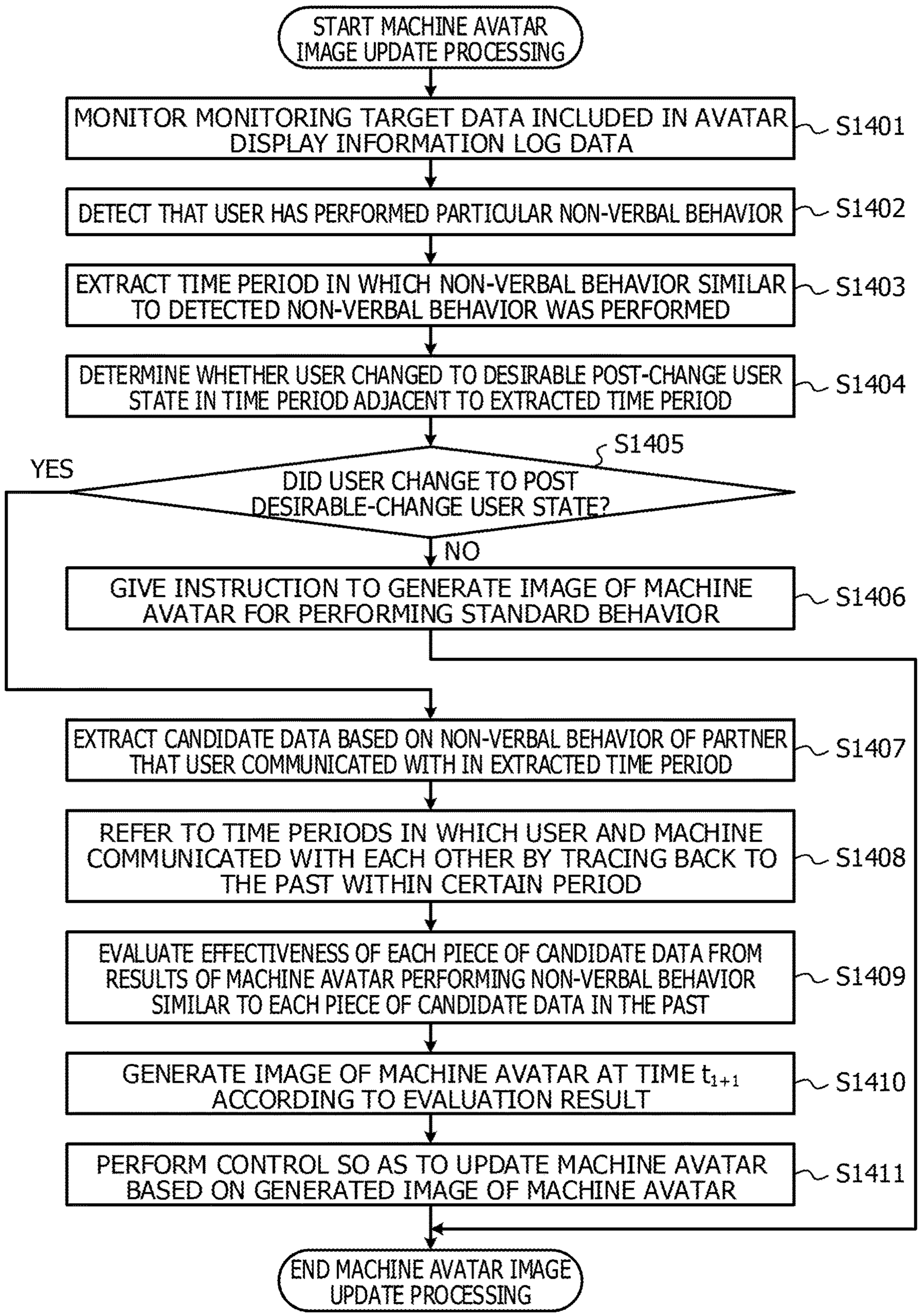

START MACHINE AVATAR IMAGE UPDATE PROCESSING
MONITOR MONITORING TARGET DATA INCLUDED IN AVATAR DISPLAY INFORMATION LOG DATA
S1401
DETECT THAT USER HAS PERFORMED PARTICULAR NON-VERBAL BEHAVIOR
S1402
EXTRACT TIME PERIOD IN WHICH NON-VERBAL BEHAVIOR SIMILAR TO DETECTED NON-VERBAL BEHAVIOR WAS PERFORMED
S1403
DETERMINE WHETHER USER CHANGED TO DESIRABLE POST-CHANGE USER STATE IN TIME PERIOD ADJACENT TO EXTRACTED TIME PERIOD
S1404
S1405
YES
DID USER CHANGE TO POST DESIRABLE-CHANGE USER STATE?
NO
GIVE INSTRUCTION TO GENERATE IMAGE OF MACHINE AVATAR FOR PERFORMING STANDARD BEHAVIOR
S1406
EXTRACT CANDIDATE DATA BASED ON NON-VERBAL BEHAVIOR OF PARTNER THAT USER COMMUNICATED WITH IN EXTRACTED TIME PERIOD
S1407
REFER TO TIME PERIODS IN WHICH USER AND MACHINE COMMUNICATED WITH EACH OTHER BY TRACING BACK TO THE PAST WITHIN CERTAIN PERIOD
S1408
EVALUATE EFFECTIVENESS OF EACH PIECE OF CANDIDATE DATA FROM RESULTS OF MACHINE AVATAR PERFORMING NON-VERBAL BEHAVIOR SIMILAR TO EACH PIECE OF CANDIDATE DATA IN THE PAST
S1409
GENERATE IMAGE OF MACHINE AVATAR AT TIME t_{1+1} ACCORDING TO EVALUATION RESULT
S1410
PERFORM CONTROL SO AS TO UPDATE MACHINE AVATAR BASED ON GENERATED IMAGE OF MACHINE AVATAR
S1411
END MACHINE AVATAR IMAGE UPDATE PROCESSING

FIG. 15

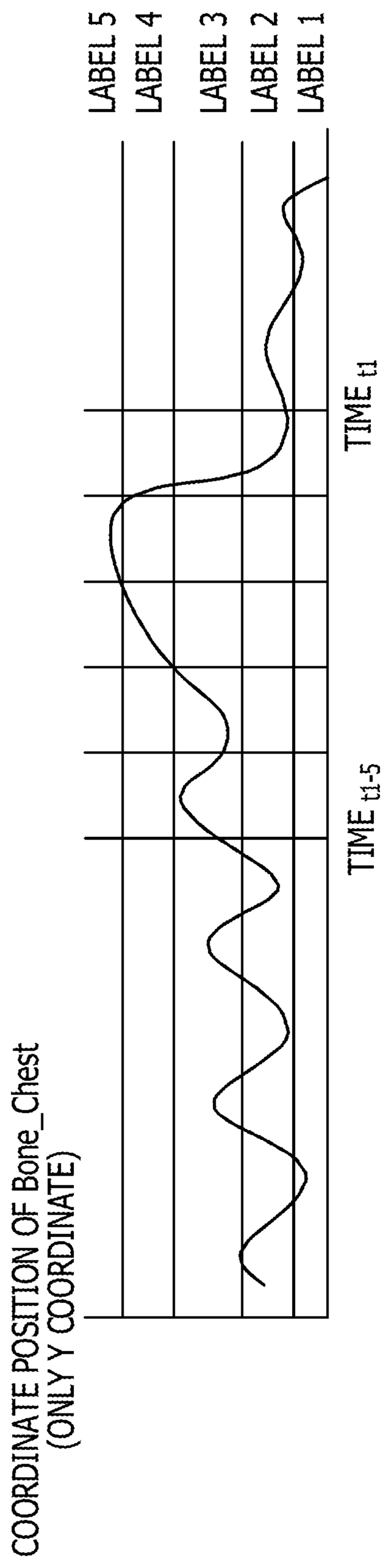

COORDINATE POSITION OF Bone_Chest
(ONLY Y COORDINATE)
TIME t1-5
TIME t1
LABEL 5
LABEL 4
LABEL 3
LABEL 2
LABEL 1

FIG. 16

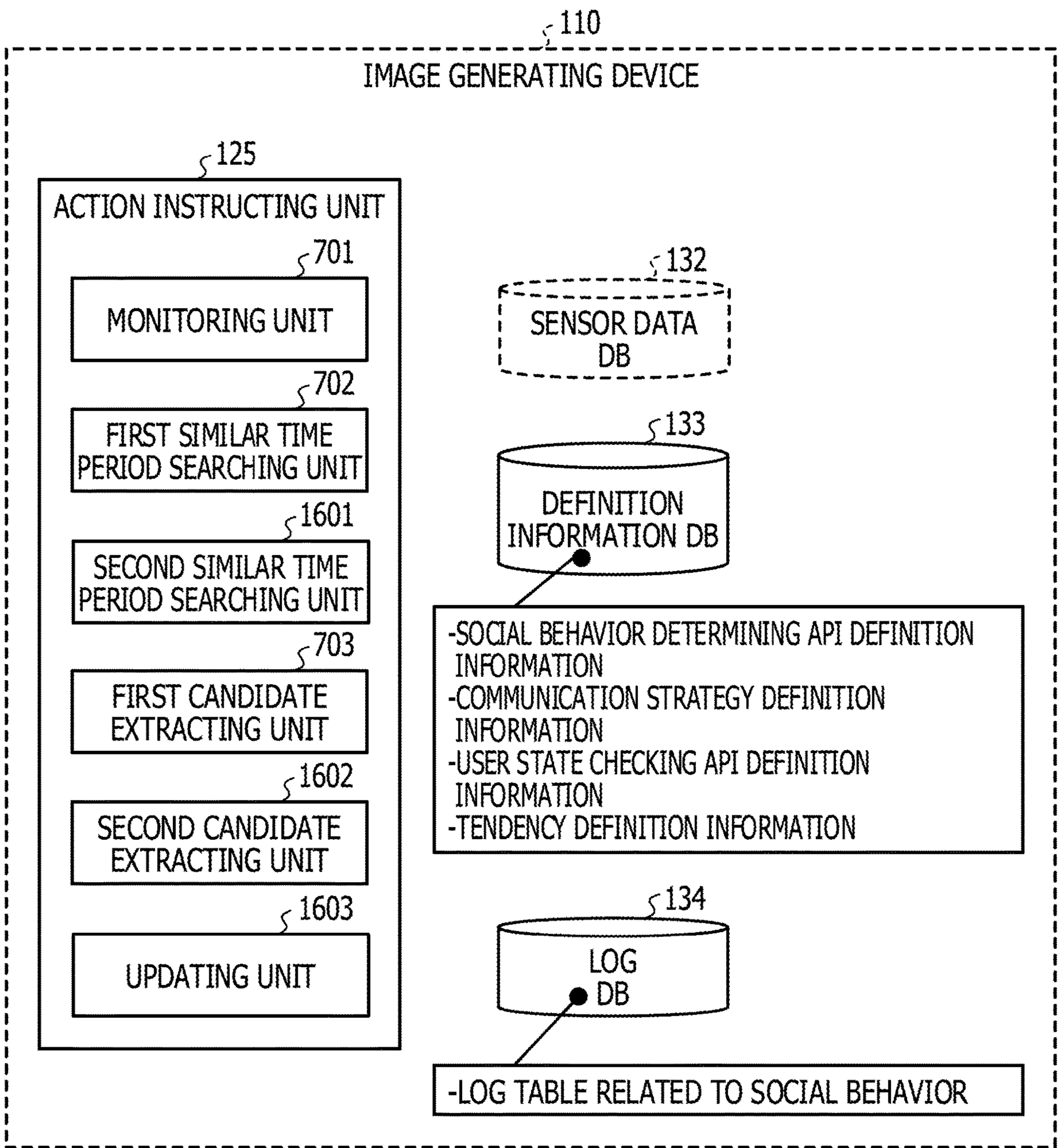

110
IMAGE GENERATING DEVICE
125
ACTION INSTRUCTING UNIT
701
MONITORING UNIT
702
FIRST SIMILAR TIME PERIOD SEARCHING UNIT
1601
SECOND SIMILAR TIME PERIOD SEARCHING UNIT
703
FIRST CANDIDATE EXTRACTING UNIT
1602
SECOND CANDIDATE EXTRACTING UNIT
1603
UPDATING UNIT
132
SENSOR DATA DB
133
DEFINITION INFORMATION DB
-SOCIAL BEHAVIOR DETERMINING API DEFINITION INFORMATION
-COMMUNICATION STRATEGY DEFINITION INFORMATION
-USER STATE CHECKING API DEFINITION INFORMATION
-TENDENCY DEFINITION INFORMATION
134
LOG DB
-LOG TABLE RELATED TO SOCIAL BEHAVIOR

FIG. 17

1700

LOG TABLE RELATED TO SOCIAL BEHAVIOR								
DB RECORDING TIME	SOCIAL BEHAVIOR DETERMINATION TIME (START)	SOCIAL BEHAVIOR DETERMINATION TIME (END)	USER NAME	INFORMATION PROCESSING DEVICE ID	SOCIAL BEHAVIOR			
					TYPE LABEL	TARGET	STAGE LABEL	LOG DATA
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
2015/7/27 11:02:03.020	2015/7/27 11:00:04.000	2015/7/27 11:01:05.000	userA	TcA	body -close-to	userB	S	Bone_Chest From ((0,8,-10),(4,0,0)) To ((0,8,-10),(12,0,0))
2015/7/27 11:02:05.050	2015/7/27 11:00:00.000	2015/7/27 11:00:04.000	userA	TcA	bodyparts -close-to	userB	S	Bone_LeftHand From ((0,25,-12),(0,0,0)) To ((0,25,-12),(90,0,0))
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

FIG. 18

1800

SOCIAL BEHAVIOR DETERMINING API DEFINITION INFORMATION				
INFORMATION PROCESSING DEVICE ID	SOCIAL BEHAVIOR DETERMINING API	SENSOR DATA	SOCIAL BEHAVIOR TYPE LABEL	BONE DESIRED AS API INPUT
⋮	⋮	⋮	⋮	⋮
c2	POSE ANALYZING API	DEPTH SENSOR DATA RECORDING	body-close-to	Bone_Chest
c2	POSE ANALYZING API	DEPTH SENSOR DATA RECORDING	body-far-to	Bone_Chest
c1	FACE ORIENTATION ANALYZING API	HEAD POSE DATA RECORDING	face-close-to	Bone_Chest
c1	POSE ANALYZING API	DEPTH SENSOR DATA RECORDING	boduparts-close-to	Bone_LeftHand, Bone_RightHand
⋮	⋮	⋮	⋮	⋮

FIG. 19A

1910

COMMUNICATION STRATEGY DEFINITION INFORMATION		
COMMUNICATION PARTNER USER NAME	TRIGGERING NON-VERBAL BEHAVIOR	DESIRABLE SOCIAL BEHAVIOR
userA	isSigh, return true	SocialFlow
N/D	N/D	SocialSmile
:	:	:

FIG. 19B

1920

USER STATE CHECKING API DEFINITION INFORMATION		
USER STATE	INPUT TARGET DATA	USER STATE CHECKING API
:	:	:
SocialFlow	jointattention-to, upperbody-leanforward-to	checkSocialFlow
SocialSmile	mutualattention-to, face-indirect-to, smile-to	checksocialSmile
:	:	:

FIG. 20

2000

TENDENCY DEFINITION INFORMATION	
SOCIAL BEHAVIOR TYPE LABEL	APPROACHING TENDENCY/AVOIDING TENDENCY
body-close-to	APPROACHING TENDENCY
body-far-to	AVOIDING TENDENCY
bodyparts-close-to	APPROACHING TENDENCY
bodyparts-far-to	AVOIDING TENDENCY
mutualattention-to	APPROACHING TENDENCY
avertedattention-to	AVOIDING TENDENCY
jointattention-to	APPROACHING TENDENCY
followingattention-to	APPROACHING TENDENCY
sharedattention-to	APPROACHING TENDENCY
face-close-to	APPROACHING TENDENCY
face-far-to	AVOIDING TENDENCY
uperbody-leanforward-to	APPROACHING TENDENCY
upperbodu-leanbackward-to	AVOIDING TENDENCY
:	:
smile-to	APPROACHING TENDENCY
nosmile-to	AVOIDING TENDENCY

FIG. 21

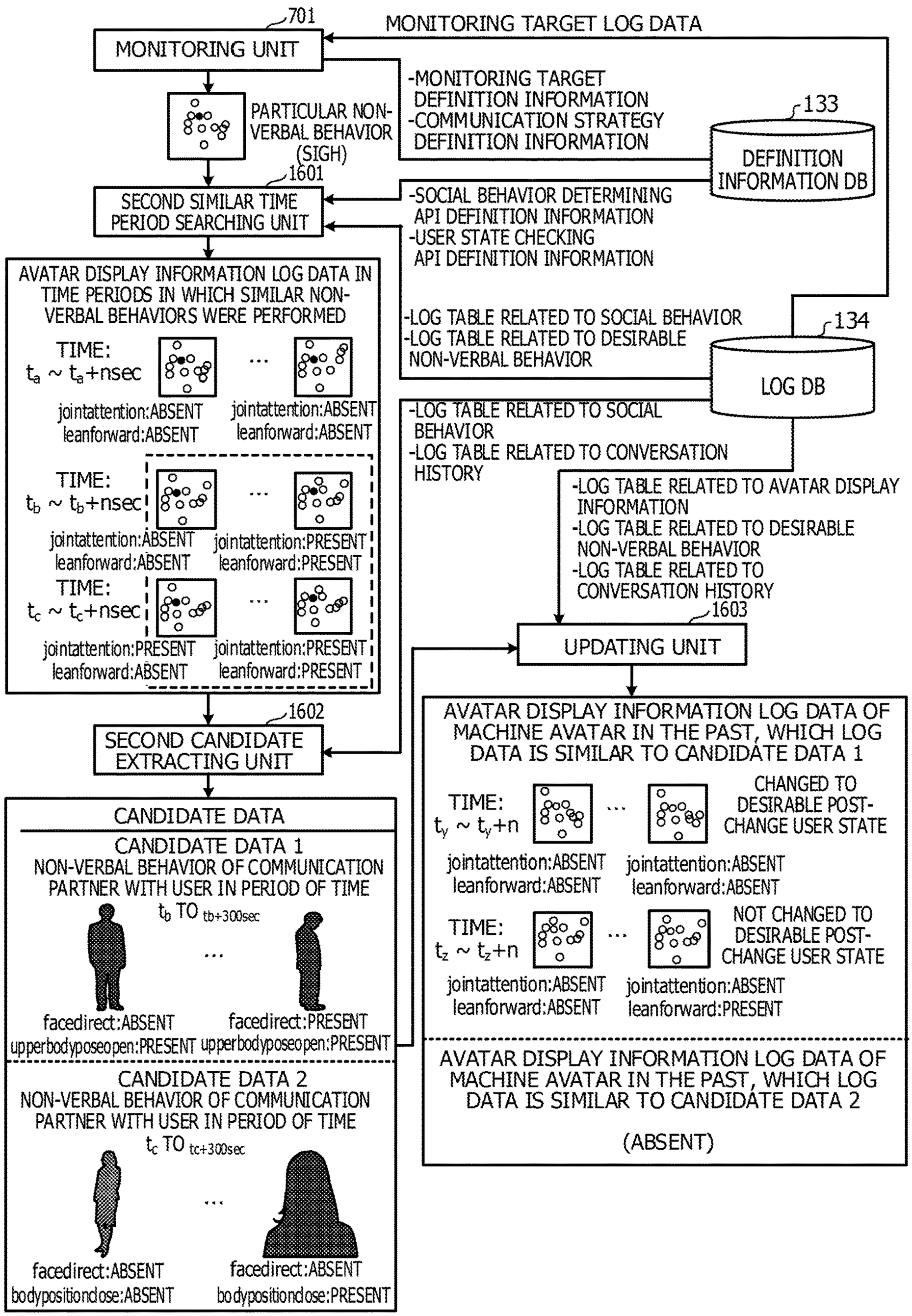

701
MONITORING UNIT
MONITORING TARGET LOG DATA
PARTICULAR NON-VERBAL BEHAVIOR (SIGH)
-MONITORING TARGET DEFINITION INFORMATION
-COMMUNICATION STRATEGY DEFINITION INFORMATION
133
DEFINITION INFORMATION DB
1601
SECOND SIMILAR TIME PERIOD SEARCHING UNIT
-SOCIAL BEHAVIOR DETERMINING API DEFINITION INFORMATION
-USER STATE CHECKING API DEFINITION INFORMATION
AVATAR DISPLAY INFORMATION LOG DATA IN TIME PERIODS IN WHICH SIMILAR NON-VERBAL BEHAVIORS WERE PERFORMED
TIME: $t_a \sim t_a$+nsec
jointattention:ABSENT leanforward:ABSENT
jointattention:ABSENT leanforward:ABSENT
TIME: $t_b \sim t_b$+nsec
jointattention:ABSENT leanforward:ABSENT
jointattention:PRESENT leanforward:PRESENT
TIME: $t_c \sim t_c$+nsec
jointattention:PRESENT leanforward:ABSENT
jointattention:PRESENT leanforward:PRESENT
-LOG TABLE RELATED TO SOCIAL BEHAVIOR
-LOG TABLE RELATED TO DESIRABLE NON-VERBAL BEHAVIOR
134
LOG DB
-LOG TABLE RELATED TO SOCIAL BEHAVIOR
-LOG TABLE RELATED TO CONVERSATION HISTORY
-LOG TABLE RELATED TO AVATAR DISPLAY INFORMATION
-LOG TABLE RELATED TO DESIRABLE NON-VERBAL BEHAVIOR
-LOG TABLE RELATED TO CONVERSATION HISTORY
1603
UPDATING UNIT
1602
SECOND CANDIDATE EXTRACTING UNIT
CANDIDATE DATA
CANDIDATE DATA 1
NON-VERBAL BEHAVIOR OF COMMUNICATION PARTNER WITH USER IN PERIOD OF TIME t_b TO $_{tb+300sec}$
facedirect:ABSENT upperbodyposeopen:PRESENT
facedirect:PRESENT upperbodyposeopen:PRESENT
CANDIDATE DATA 2
NON-VERBAL BEHAVIOR OF COMMUNICATION PARTNER WITH USER IN PERIOD OF TIME t_c TO $_{tc+300sec}$
facedirect:ABSENT bodypositionclose:ABSENT
facedirect:ABSENT bodypositionclose:PRESENT
AVATAR DISPLAY INFORMATION LOG DATA OF MACHINE AVATAR IN THE PAST, WHICH LOG DATA IS SIMILAR TO CANDIDATE DATA 1
TIME: $t_y \sim t_y$+n
jointattention:ABSENT leanforward:ABSENT
jointattention:ABSENT leanforward:ABSENT
CHANGED TO DESIRABLE POST-CHANGE USER STATE
TIME: $t_z \sim t_z$+n
jointattention:ABSENT leanforward:ABSENT
jointattention:ABSENT leanforward:PRESENT
NOT CHANGED TO DESIRABLE POST-CHANGE USER STATE
AVATAR DISPLAY INFORMATION LOG DATA OF MACHINE AVATAR IN THE PAST, WHICH LOG DATA IS SIMILAR TO CANDIDATE DATA 2
(ABSENT)

FIG. 22

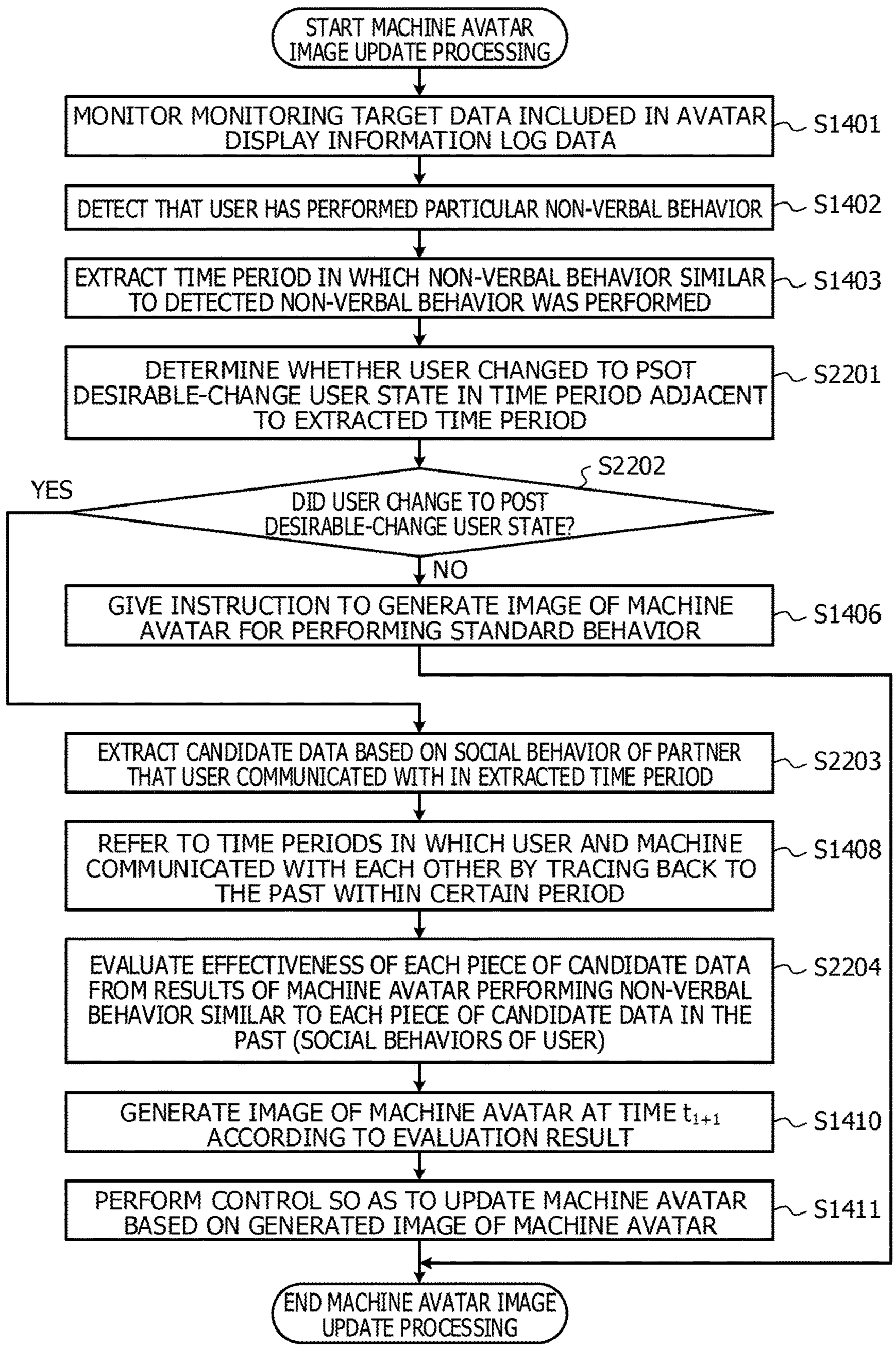

START MACHINE AVATAR IMAGE UPDATE PROCESSING
MONITOR MONITORING TARGET DATA INCLUDED IN AVATAR DISPLAY INFORMATION LOG DATA
S1401
DETECT THAT USER HAS PERFORMED PARTICULAR NON-VERBAL BEHAVIOR
S1402
EXTRACT TIME PERIOD IN WHICH NON-VERBAL BEHAVIOR SIMILAR TO DETECTED NON-VERBAL BEHAVIOR WAS PERFORMED
S1403
DETERMINE WHETHER USER CHANGED TO PSOT DESIRABLE-CHANGE USER STATE IN TIME PERIOD ADJACENT TO EXTRACTED TIME PERIOD
S2201
S2202
YES
DID USER CHANGE TO POST DESIRABLE-CHANGE USER STATE?
NO
GIVE INSTRUCTION TO GENERATE IMAGE OF MACHINE AVATAR FOR PERFORMING STANDARD BEHAVIOR
S1406
EXTRACT CANDIDATE DATA BASED ON SOCIAL BEHAVIOR OF PARTNER THAT USER COMMUNICATED WITH IN EXTRACTED TIME PERIOD
S2203
REFER TO TIME PERIODS IN WHICH USER AND MACHINE COMMUNICATED WITH EACH OTHER BY TRACING BACK TO THE PAST WITHIN CERTAIN PERIOD
S1408
EVALUATE EFFECTIVENESS OF EACH PIECE OF CANDIDATE DATA FROM RESULTS OF MACHINE AVATAR PERFORMING NON-VERBAL BEHAVIOR SIMILAR TO EACH PIECE OF CANDIDATE DATA IN THE PAST (SOCIAL BEHAVIORS OF USER)
S2204
GENERATE IMAGE OF MACHINE AVATAR AT TIME t_{1+1} ACCORDING TO EVALUATION RESULT
S1410
PERFORM CONTROL SO AS TO UPDATE MACHINE AVATAR BASED ON GENERATED IMAGE OF MACHINE AVATAR
S1411
END MACHINE AVATAR IMAGE UPDATE PROCESSING

FIG. 23

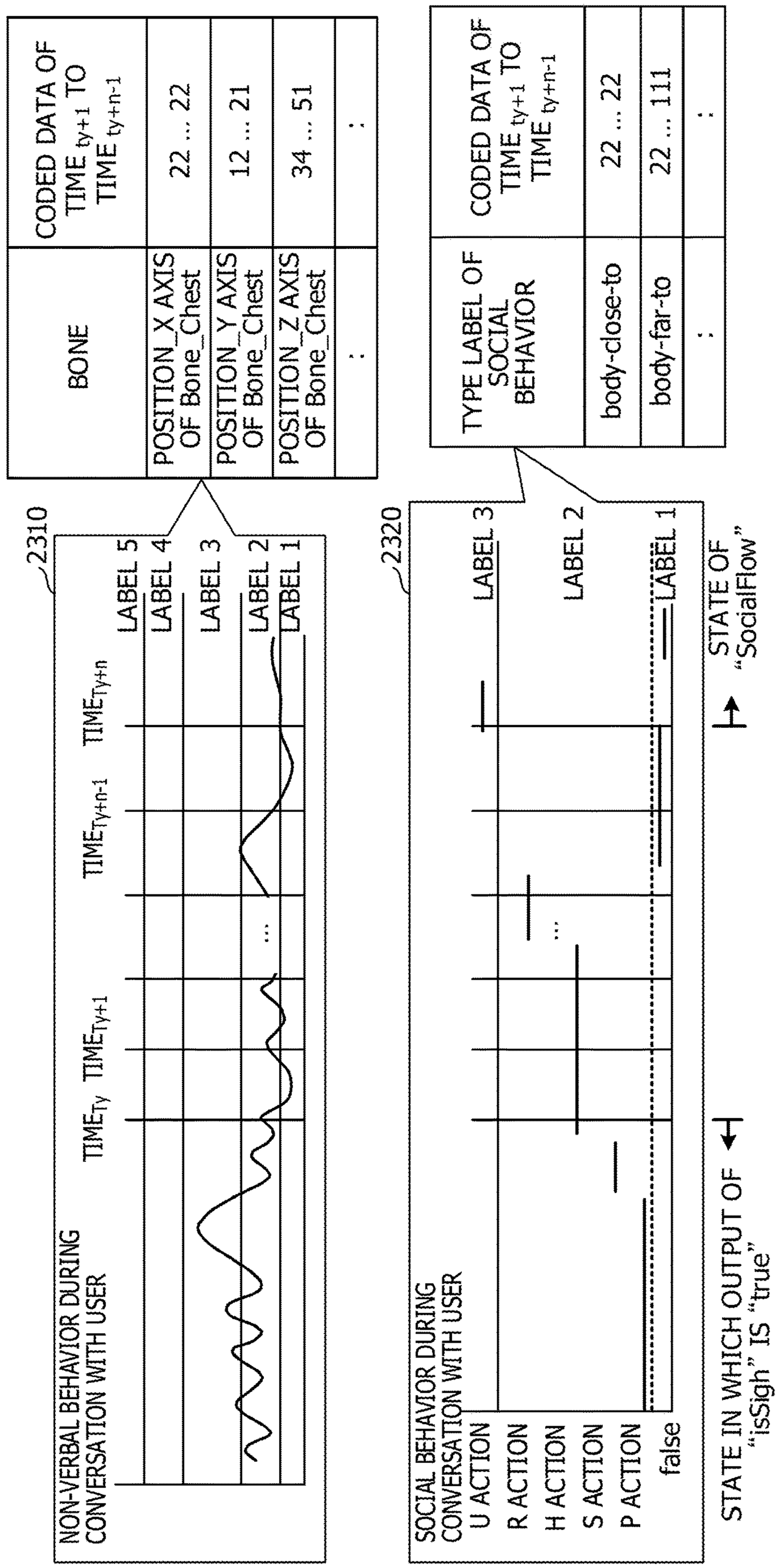

BONE
CODED DATA OF TIME ty+1 TO TIME ty+n-1
POSITION_X AXIS OF Bone_Chest
22 ... 22
POSITION_Y AXIS OF Bone_Chest
12 ... 21
POSITION_Z AXIS OF Bone_Chest
34 ... 51
TYPE LABEL OF SOCIAL BEHAVIOR
CODED DATA OF TIME ty+1 TO TIME ty+n-1
body-close-to
22 ... 22
body-far-to
22 ... 111
2310
2320
NON-VERBAL BEHAVIOR DURING CONVERSATION WITH USER
LABEL 5
LABEL 4
LABEL 3
LABEL 2
LABEL 1
TIMETy+n
TIMETy+n-1
TIMETy+1
TIMETy
SOCIAL BEHAVIOR DURING CONVERSATION WITH USER
U ACTION
R ACTION
H ACTION
S ACTION
P ACTION
false
STATE OF "SocialFlow"
STATE IN WHICH OUTPUT OF "isSigh" IS "true"

FIG. 24

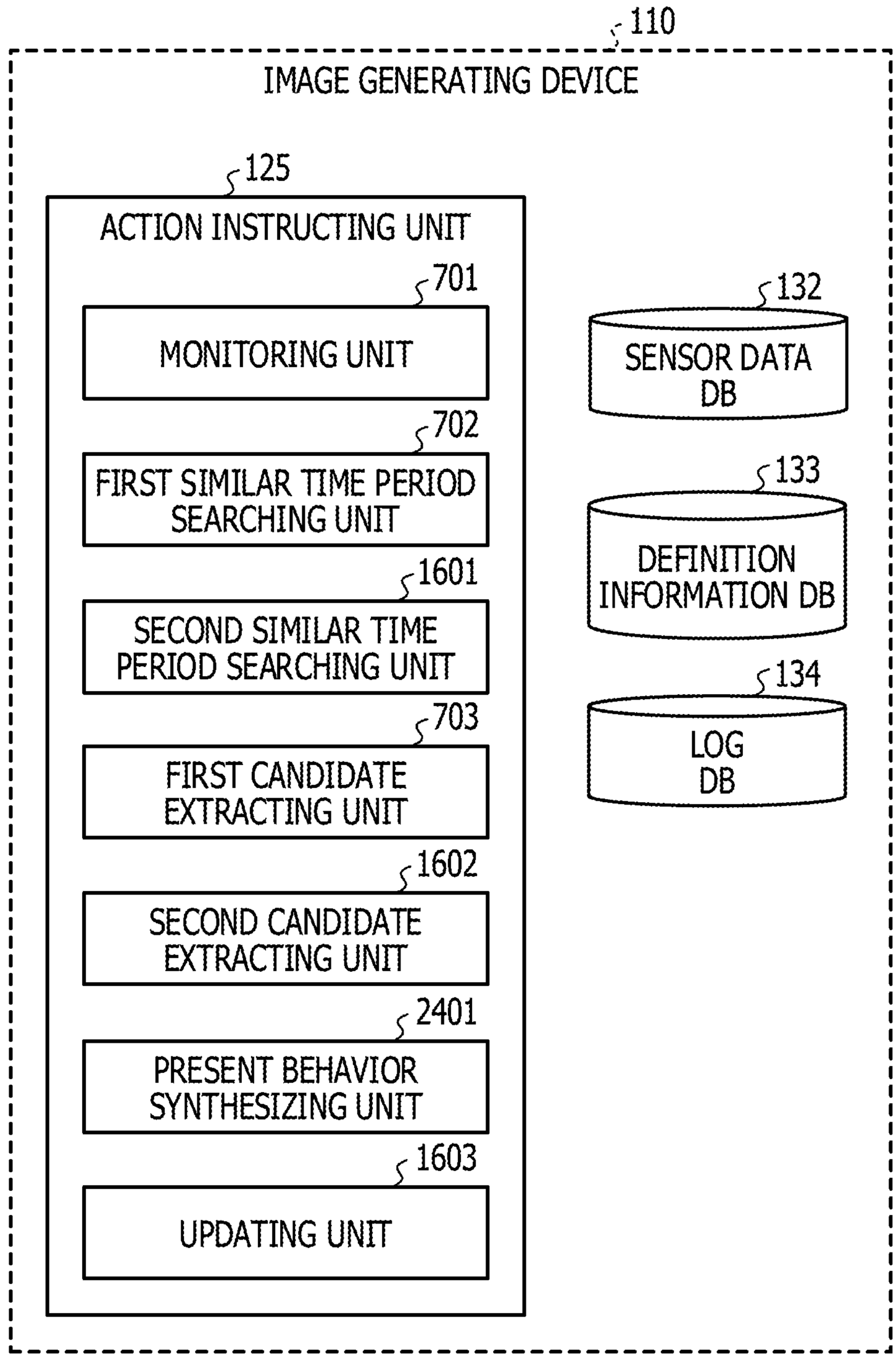

110
IMAGE GENERATING DEVICE
125
ACTION INSTRUCTING UNIT
701
MONITORING UNIT
702
FIRST SIMILAR TIME PERIOD SEARCHING UNIT
1601
SECOND SIMILAR TIME PERIOD SEARCHING UNIT
703
FIRST CANDIDATE EXTRACTING UNIT
1602
SECOND CANDIDATE EXTRACTING UNIT
2401
PRESENT BEHAVIOR SYNTHESIZING UNIT
1603
UPDATING UNIT
132
SENSOR DATA DB
133
DEFINITION INFORMATION DB
134
LOG DB

FIG. 25

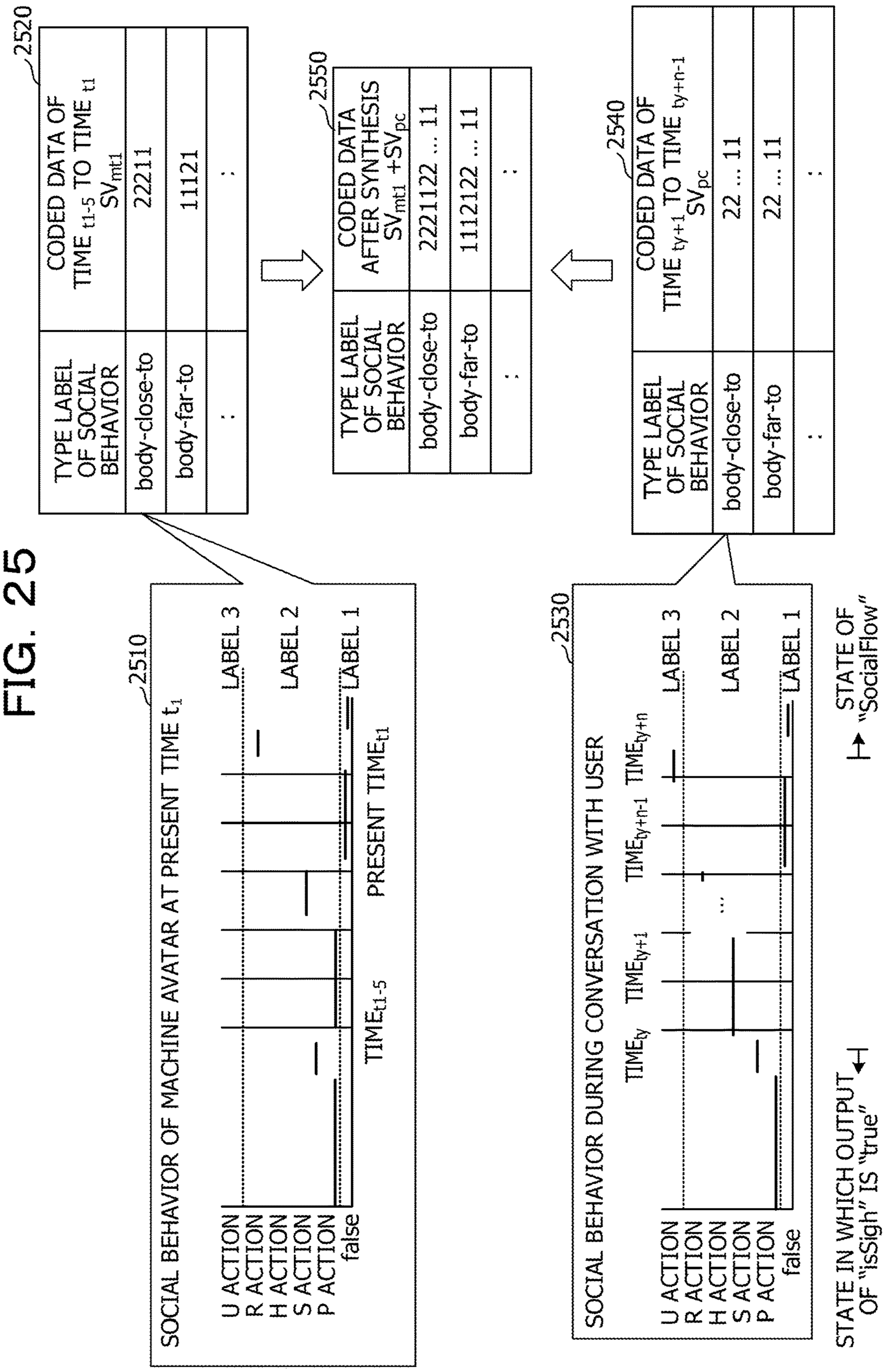

2520
CODED DATA OF TIME t1-5 TO TIME t1 SVmt1
TYPE LABEL OF SOCIAL BEHAVIOR
body-close-to
body-far-to
22211
11121
2550
CODED DATA AFTER SYNTHESIS SVmt1 +SVpc
2221122 ... 11
1112122 ... 11
2540
CODED DATA OF TIME ty+1 TO TIME ty+n-1 SVpc
22 ... 11
2510
SOCIAL BEHAVIOR OF MACHINE AVATAR AT PRESENT TIME t1
LABEL 3
LABEL 2
LABEL 1
U ACTION
R ACTION
H ACTION
S ACTION
P ACTION
false
PRESENT TIMEt1
TIMEt1-5
2530
SOCIAL BEHAVIOR DURING CONVERSATION WITH USER
TIMEty
TIMEty+1
TIMEty+n-1
TIMEty+n
STATE OF "SocialFlow"
STATE IN WHICH OUTPUT OF "isSigh" IS "true"

FIG. 26

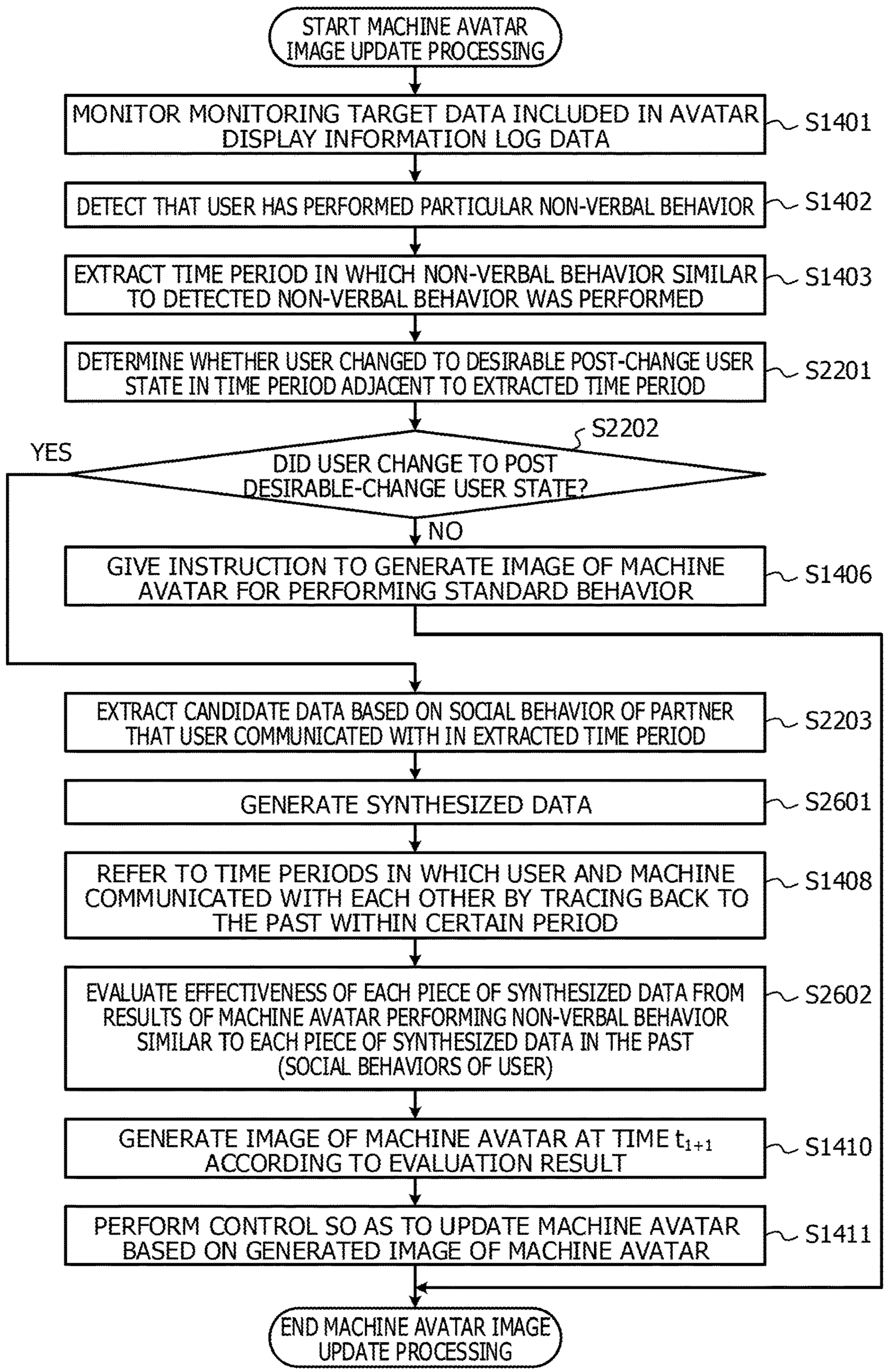

START MACHINE AVATAR IMAGE UPDATE PROCESSING
MONITOR MONITORING TARGET DATA INCLUDED IN AVATAR DISPLAY INFORMATION LOG DATA
S1401
DETECT THAT USER HAS PERFORMED PARTICULAR NON-VERBAL BEHAVIOR
S1402
EXTRACT TIME PERIOD IN WHICH NON-VERBAL BEHAVIOR SIMILAR TO DETECTED NON-VERBAL BEHAVIOR WAS PERFORMED
S1403
DETERMINE WHETHER USER CHANGED TO DESIRABLE POST-CHANGE USER STATE IN TIME PERIOD ADJACENT TO EXTRACTED TIME PERIOD
S2201
S2202
YES
DID USER CHANGE TO POST DESIRABLE-CHANGE USER STATE?
NO
GIVE INSTRUCTION TO GENERATE IMAGE OF MACHINE AVATAR FOR PERFORMING STANDARD BEHAVIOR
S1406
EXTRACT CANDIDATE DATA BASED ON SOCIAL BEHAVIOR OF PARTNER THAT USER COMMUNICATED WITH IN EXTRACTED TIME PERIOD
S2203
GENERATE SYNTHESIZED DATA
S2601
REFER TO TIME PERIODS IN WHICH USER AND MACHINE COMMUNICATED WITH EACH OTHER BY TRACING BACK TO THE PAST WITHIN CERTAIN PERIOD
S1408
EVALUATE EFFECTIVENESS OF EACH PIECE OF SYNTHESIZED DATA FROM RESULTS OF MACHINE AVATAR PERFORMING NON-VERBAL BEHAVIOR SIMILAR TO EACH PIECE OF SYNTHESIZED DATA IN THE PAST (SOCIAL BEHAVIORS OF USER)
S2602
GENERATE IMAGE OF MACHINE AVATAR AT TIME t_{1+1} ACCORDING TO EVALUATION RESULT
S1410
PERFORM CONTROL SO AS TO UPDATE MACHINE AVATAR BASED ON GENERATED IMAGE OF MACHINE AVATAR
S1411
END MACHINE AVATAR IMAGE UPDATE PROCESSING

FIG. 27

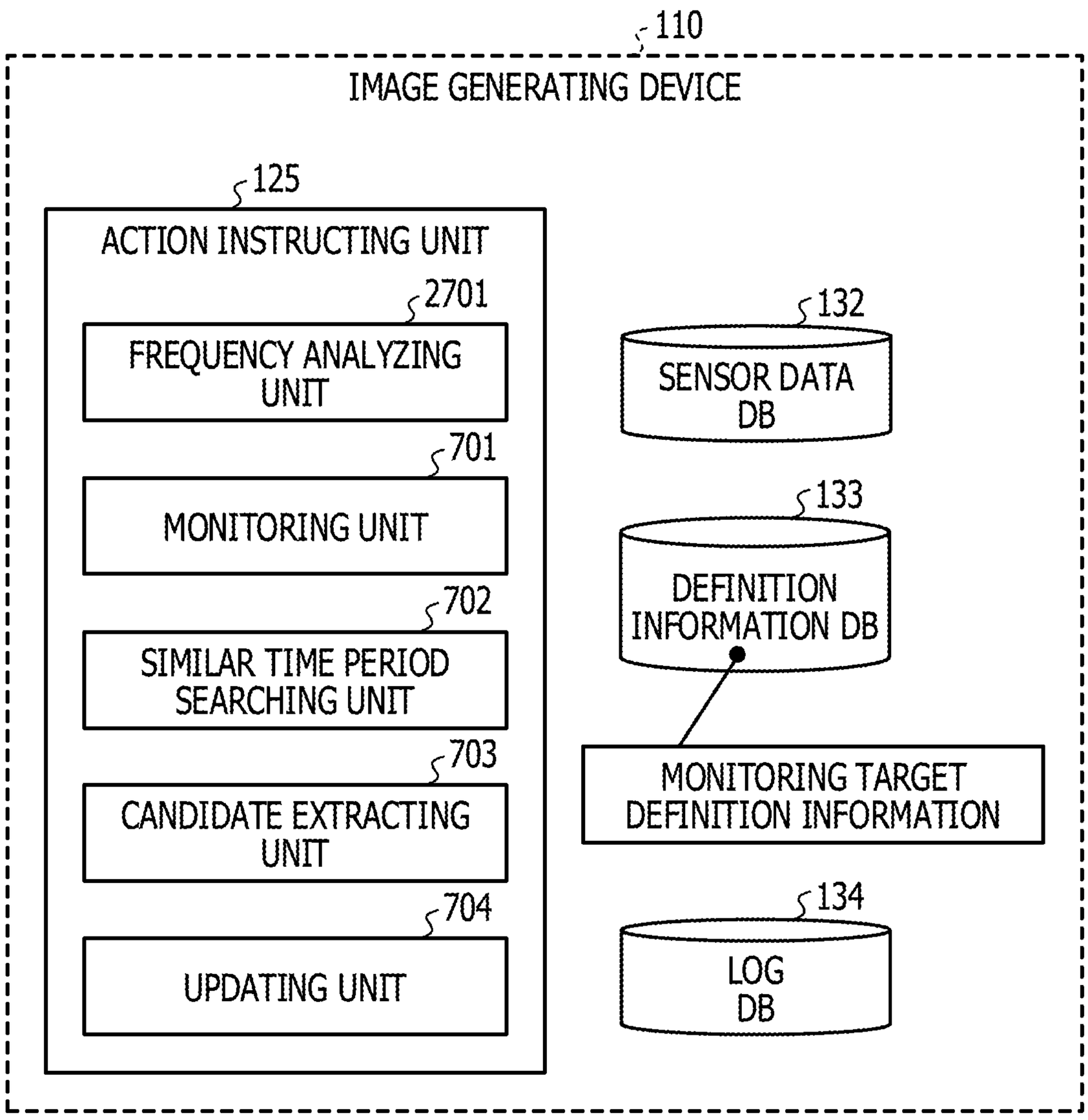

110
IMAGE GENERATING DEVICE
125
ACTION INSTRUCTING UNIT
2701
FREQUENCY ANALYZING UNIT
701
MONITORING UNIT
702
SIMILAR TIME PERIOD SEARCHING UNIT
703
CANDIDATE EXTRACTING UNIT
704
UPDATING UNIT
132
SENSOR DATA DB
133
DEFINITION INFORMATION DB
MONITORING TARGET DEFINITION INFORMATION
134
LOG DB

FIG. 28

2800

MONITORING TARGET DEFINITION INFORMATION			
COMMUNICATION PARTNER USER NAME	MONITORING TARGET	SUBTLE BEHAVIOR CHECK	TRIGGER CHECKING API
:	:	:	:
userA	Bone_Chest	false	isSigh
userA	Bone_Head, Bone_LeftShoulder, Bone_Rightshoulder	false	isNap
userC	Bone_Head	false	isNap
N/D	Bone_Head, Bone_Chest	true	isRestles
:	:	:	:

FIG. 29

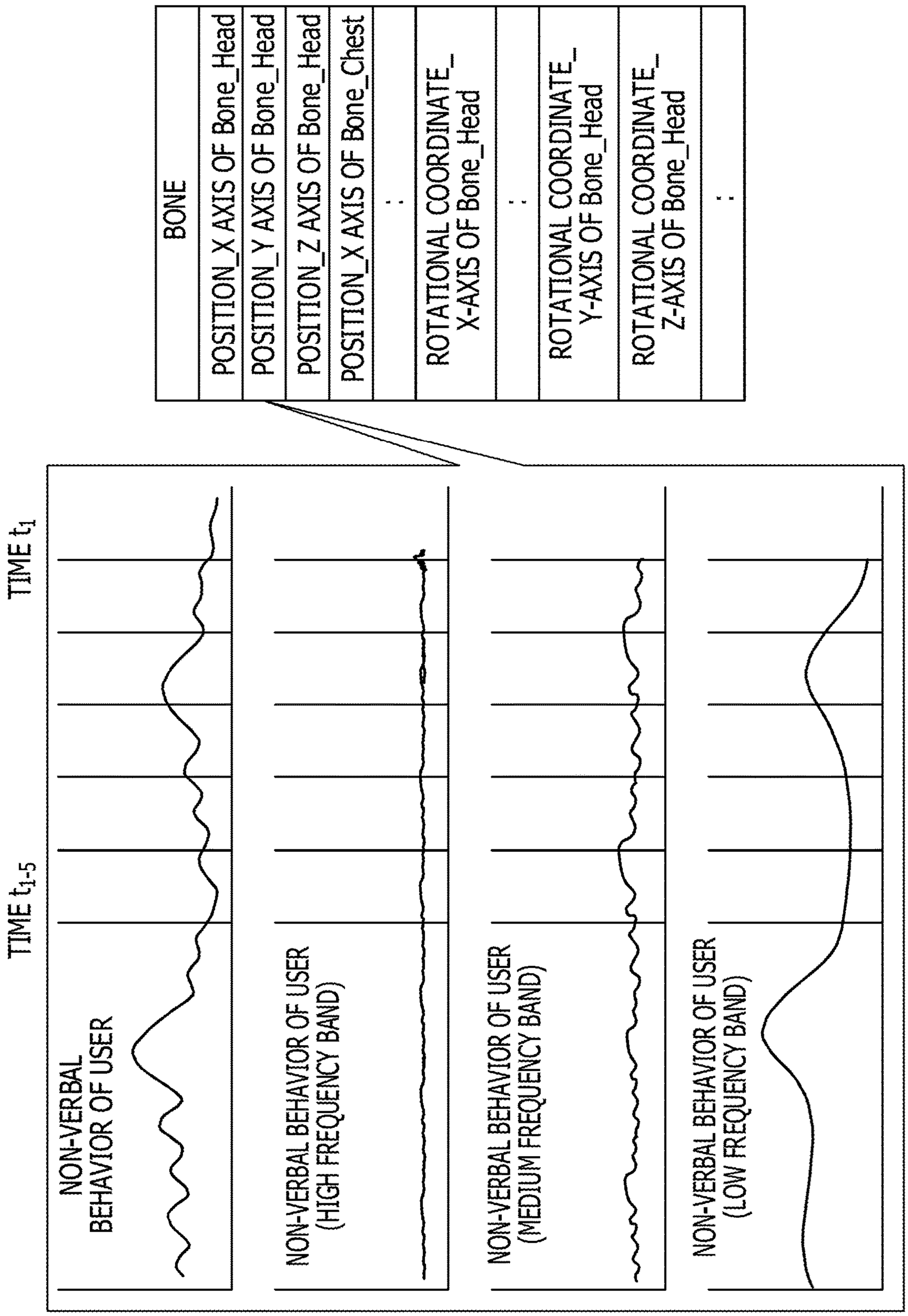

BONE
POSITION_X AXIS OF Bone_Head
POSITION_Y AXIS OF Bone_Head
POSITION_Z AXIS OF Bone_Head
POSITION_X AXIS OF Bone_Chest
ROTATIONAL COORDINATE_ X-AXIS OF Bone_Head
ROTATIONAL COORDINATE_ Y-AXIS OF Bone_Head
ROTATIONAL COORDINATE_ Z-AXIS OF Bone_Head
TIME t_{1-5}
TIME t_1
NON-VERBAL BEHAVIOR OF USER
NON-VERBAL BEHAVIOR OF USER (HIGH FREQUENCY BAND)
NON-VERBAL BEHAVIOR OF USER (MEDIUM FREQUENCY BAND)
NON-VERBAL BEHAVIOR OF USER (LOW FREQUENCY BAND)

FIG. 30

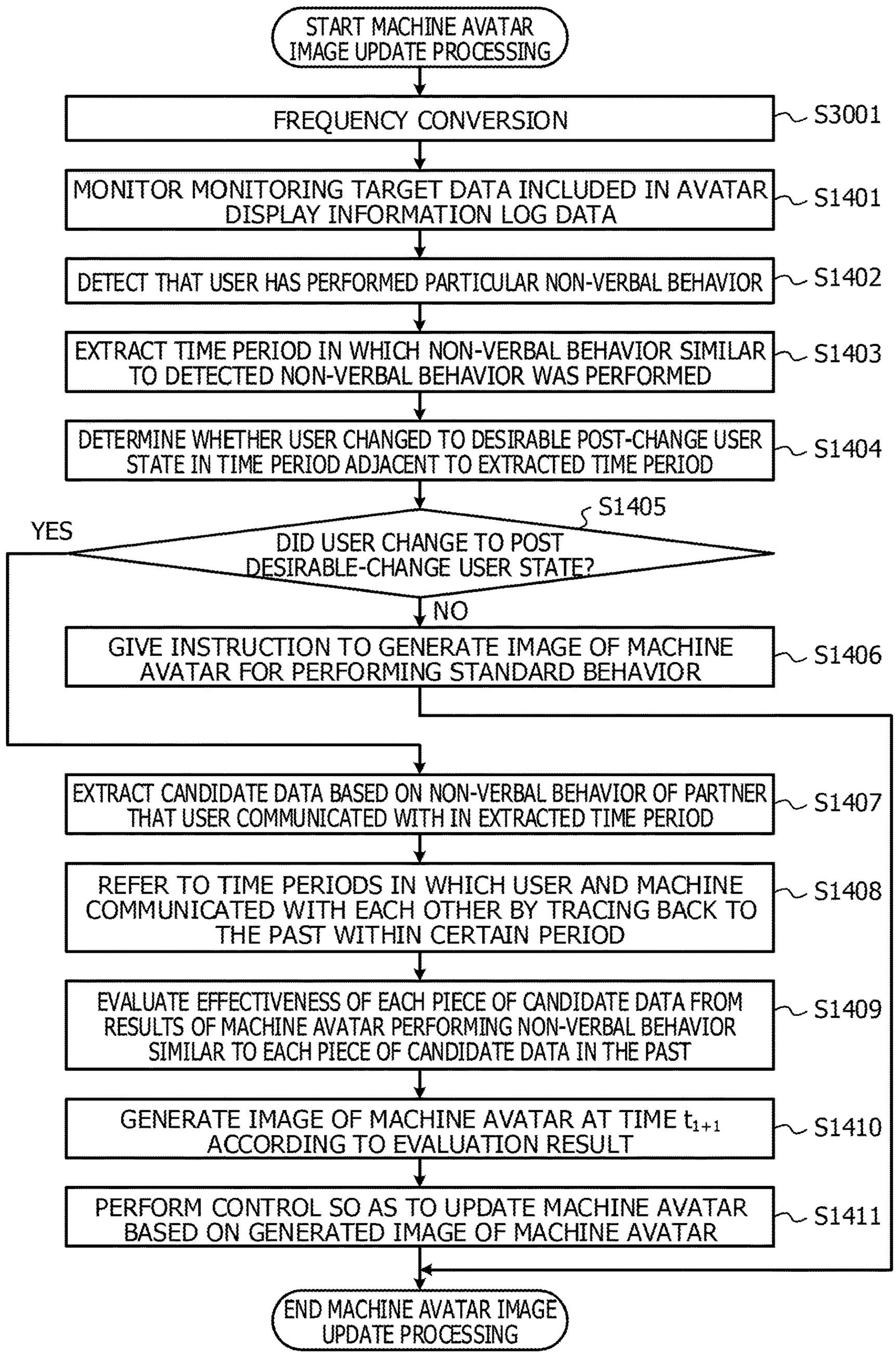

START MACHINE AVATAR IMAGE UPDATE PROCESSING
FREQUENCY CONVERSION
S3001
MONITOR MONITORING TARGET DATA INCLUDED IN AVATAR DISPLAY INFORMATION LOG DATA
S1401
DETECT THAT USER HAS PERFORMED PARTICULAR NON-VERBAL BEHAVIOR
S1402
EXTRACT TIME PERIOD IN WHICH NON-VERBAL BEHAVIOR SIMILAR TO DETECTED NON-VERBAL BEHAVIOR WAS PERFORMED
S1403
DETERMINE WHETHER USER CHANGED TO DESIRABLE POST-CHANGE USER STATE IN TIME PERIOD ADJACENT TO EXTRACTED TIME PERIOD
S1404
S1405
DID USER CHANGE TO POST DESIRABLE-CHANGE USER STATE?
YES
NO
GIVE INSTRUCTION TO GENERATE IMAGE OF MACHINE AVATAR FOR PERFORMING STANDARD BEHAVIOR
S1406
EXTRACT CANDIDATE DATA BASED ON NON-VERBAL BEHAVIOR OF PARTNER THAT USER COMMUNICATED WITH IN EXTRACTED TIME PERIOD
S1407
REFER TO TIME PERIODS IN WHICH USER AND MACHINE COMMUNICATED WITH EACH OTHER BY TRACING BACK TO THE PAST WITHIN CERTAIN PERIOD
S1408
EVALUATE EFFECTIVENESS OF EACH PIECE OF CANDIDATE DATA FROM RESULTS OF MACHINE AVATAR PERFORMING NON-VERBAL BEHAVIOR SIMILAR TO EACH PIECE OF CANDIDATE DATA IN THE PAST
S1409
GENERATE IMAGE OF MACHINE AVATAR AT TIME t_{1+1} ACCORDING TO EVALUATION RESULT
S1410
PERFORM CONTROL SO AS TO UPDATE MACHINE AVATAR BASED ON GENERATED IMAGE OF MACHINE AVATAR
S1411
END MACHINE AVATAR IMAGE UPDATE PROCESSING

FIG. 31

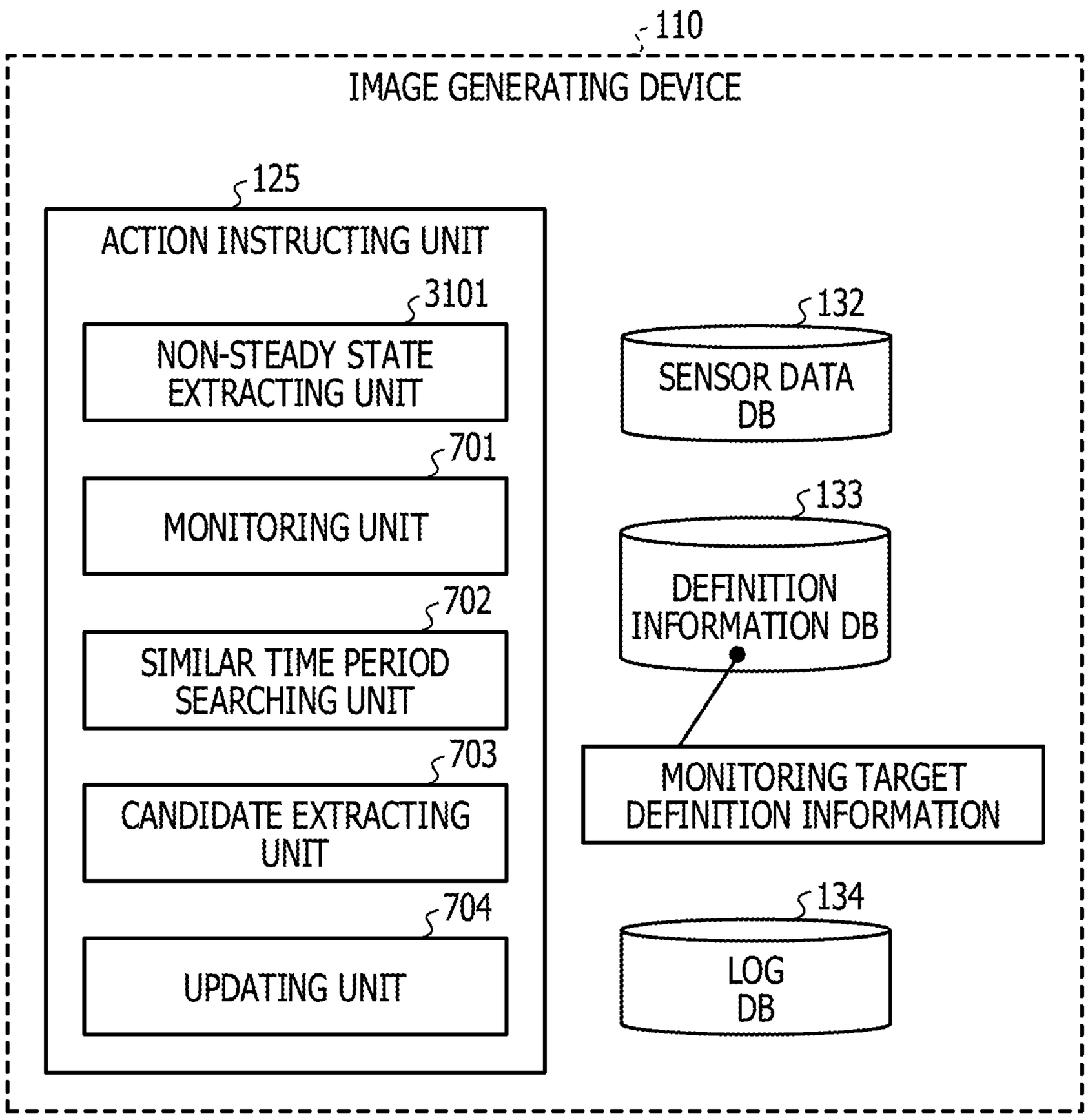

110
IMAGE GENERATING DEVICE
125
ACTION INSTRUCTING UNIT
3101
NON-STEADY STATE EXTRACTING UNIT
701
MONITORING UNIT
702
SIMILAR TIME PERIOD SEARCHING UNIT
703
CANDIDATE EXTRACTING UNIT
704
UPDATING UNIT
132
SENSOR DATA DB
133
DEFINITION INFORMATION DB
MONITORING TARGET DEFINITION INFORMATION
134
LOG DB

FIG. 32

3200

MONITORING TARGET DEFINITION INFORMATION				
COMMUNICATION PARTNER USER NAME	MONITORING TARGET	STEADY NON-VERBAL BEHAVIOR FILTERING	STEADY NON-VERBAL BEHAVIOR FREQUENCY BAND	TRIGGER CHECKING API
:	:	:	:	:
userA	Bone_Chest	false	isSigh	isSigh
userA	Bone_Head, Bone_LeftShoulder, Bone_Rightshoulder	true	Bone_LeftShoulder=LOW, Bone_RightShoulder=LOW	isNap
userC	Bone_Head	false	isNap	isNap
N/D	Bone_Head, Bone_Chest	true	isRestles	isRestles
:	:	:	:	:

FIG. 33

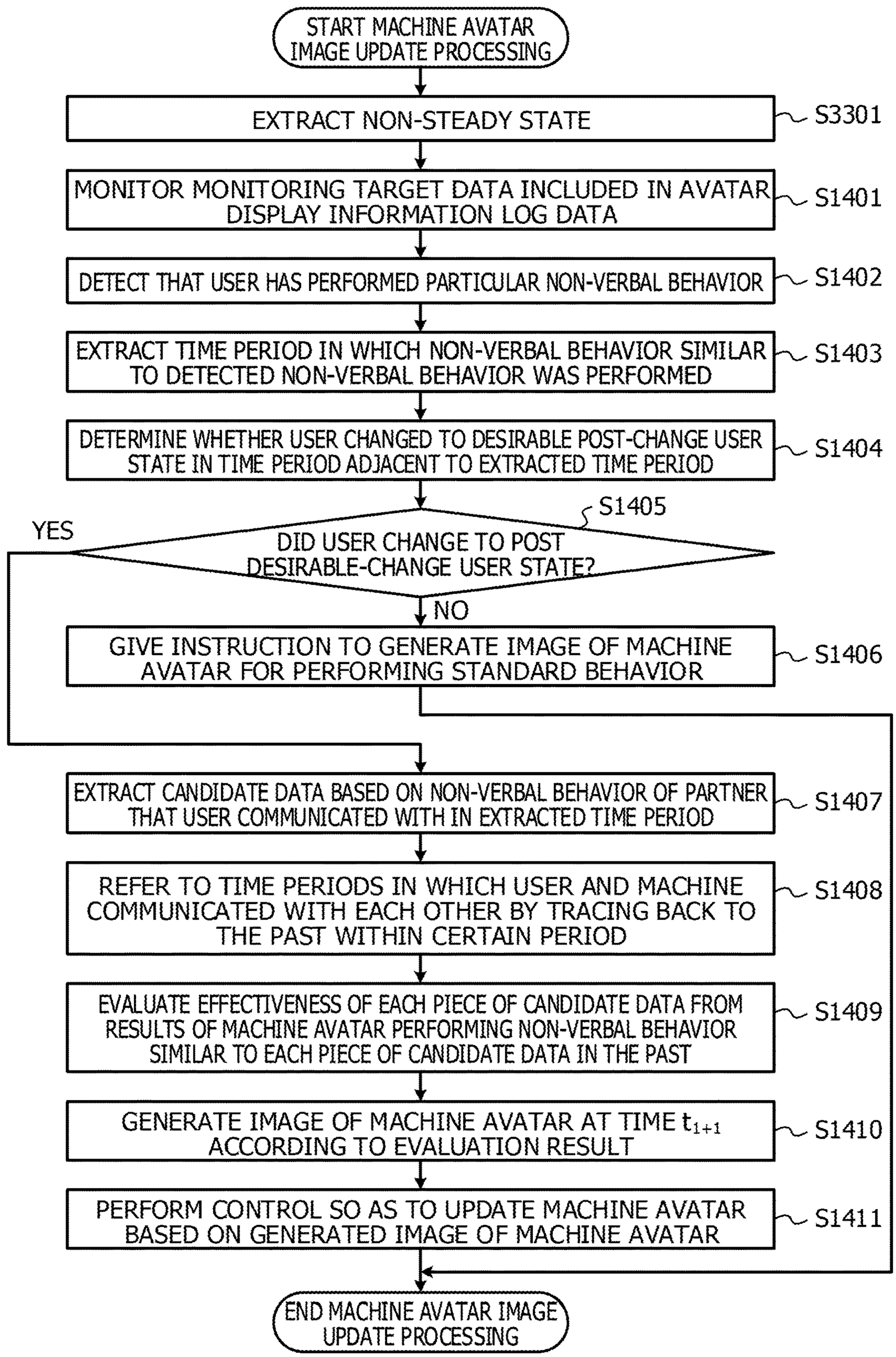

START MACHINE AVATAR IMAGE UPDATE PROCESSING
EXTRACT NON-STEADY STATE
S3301
MONITOR MONITORING TARGET DATA INCLUDED IN AVATAR DISPLAY INFORMATION LOG DATA
S1401
DETECT THAT USER HAS PERFORMED PARTICULAR NON-VERBAL BEHAVIOR
S1402
EXTRACT TIME PERIOD IN WHICH NON-VERBAL BEHAVIOR SIMILAR TO DETECTED NON-VERBAL BEHAVIOR WAS PERFORMED
S1403
DETERMINE WHETHER USER CHANGED TO DESIRABLE POST-CHANGE USER STATE IN TIME PERIOD ADJACENT TO EXTRACTED TIME PERIOD
S1404
S1405
YES
DID USER CHANGE TO POST DESIRABLE-CHANGE USER STATE?
NO
GIVE INSTRUCTION TO GENERATE IMAGE OF MACHINE AVATAR FOR PERFORMING STANDARD BEHAVIOR
S1406
EXTRACT CANDIDATE DATA BASED ON NON-VERBAL BEHAVIOR OF PARTNER THAT USER COMMUNICATED WITH IN EXTRACTED TIME PERIOD
S1407
REFER TO TIME PERIODS IN WHICH USER AND MACHINE COMMUNICATED WITH EACH OTHER BY TRACING BACK TO THE PAST WITHIN CERTAIN PERIOD
S1408
EVALUATE EFFECTIVENESS OF EACH PIECE OF CANDIDATE DATA FROM RESULTS OF MACHINE AVATAR PERFORMING NON-VERBAL BEHAVIOR SIMILAR TO EACH PIECE OF CANDIDATE DATA IN THE PAST
S1409
GENERATE IMAGE OF MACHINE AVATAR AT TIME t_{1+1} ACCORDING TO EVALUATION RESULT
S1410
PERFORM CONTROL SO AS TO UPDATE MACHINE AVATAR BASED ON GENERATED IMAGE OF MACHINE AVATAR
S1411
END MACHINE AVATAR IMAGE UPDATE PROCESSING

FIG. 34

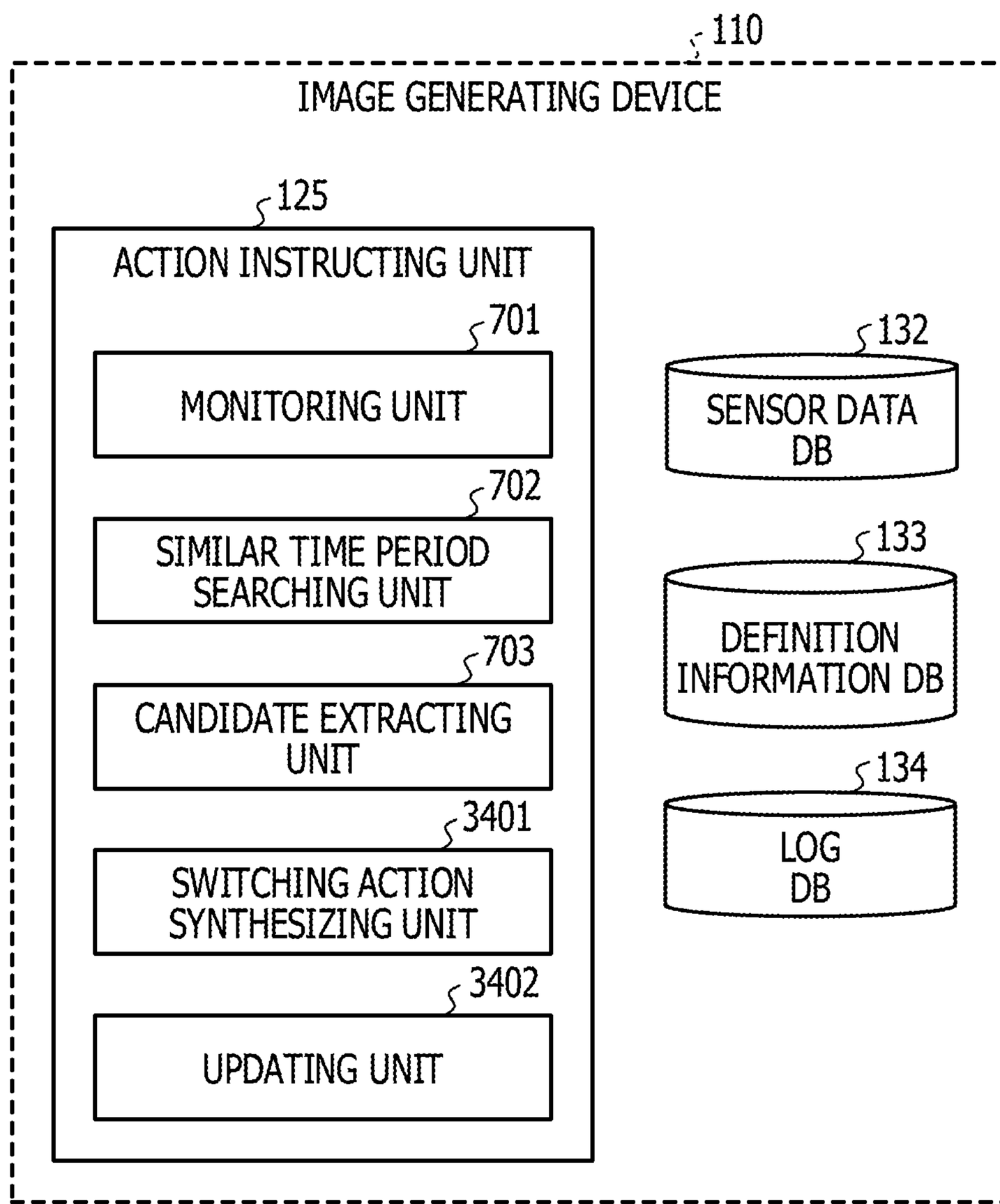

110
IMAGE GENERATING DEVICE
125
ACTION INSTRUCTING UNIT
701
MONITORING UNIT
702
SIMILAR TIME PERIOD SEARCHING UNIT
703
CANDIDATE EXTRACTING UNIT
3401
SWITCHING ACTION SYNTHESIZING UNIT
3402
UPDATING UNIT
132
SENSOR DATA DB
133
DEFINITION INFORMATION DB
134
LOG DB

FIG. 35

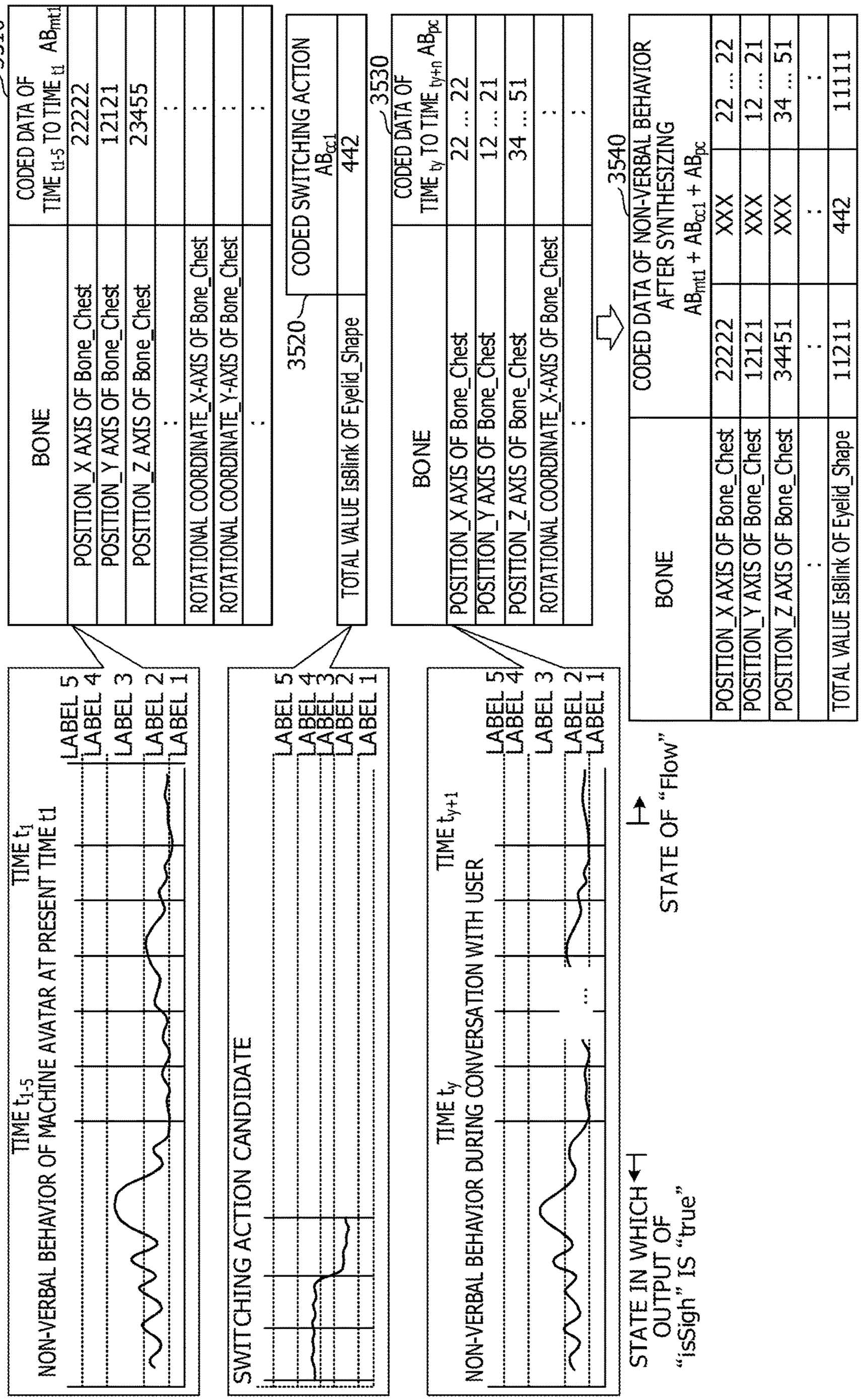
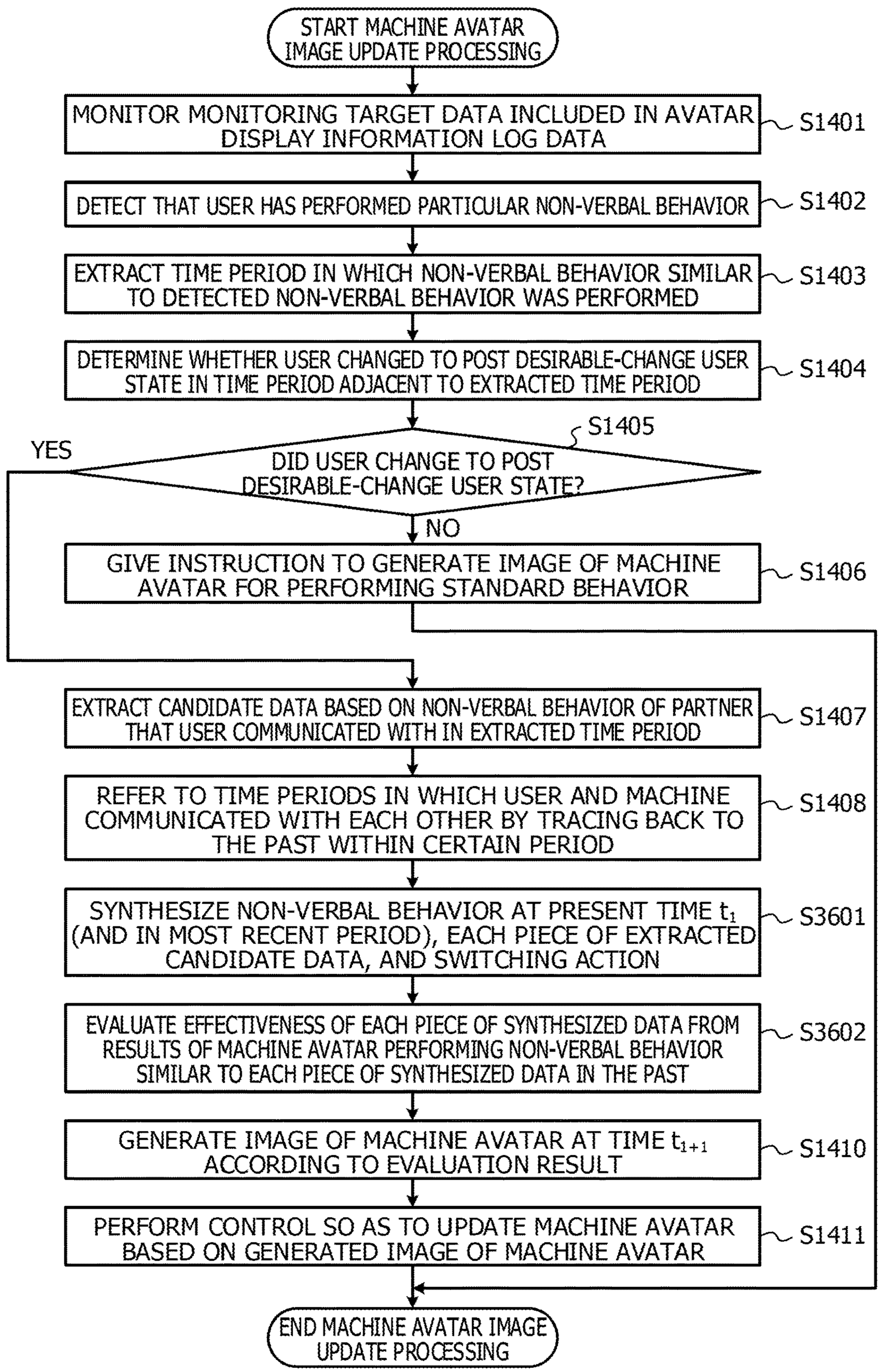

3510
BONE
CODED DATA OF TIME t_{t-5} TO TIME t_t AB_{mt1}
POSITION_X AXIS OF Bone_Chest 22222
POSITION_Y AXIS OF Bone_Chest 12121
POSITION_Z AXIS OF Bone_Chest 23455
ROTATIONAL COORDINATE_X-AXIS OF Bone_Chest
ROTATIONAL COORDINATE_Y-AXIS OF Bone_Chest
3520
TOTAL VALUE IsBlink OF Eyelid_Shape
CODED SWITCHING ACTION AB_{cc1} 442
3530
BONE
CODED DATA OF TIME t_y TO TIME t_{y+n} AB_{pc}
POSITION_X AXIS OF Bone_Chest 22 ... 22
POSITION_Y AXIS OF Bone_Chest 12 ... 21
POSITION_Z AXIS OF Bone_Chest 34 ... 51
ROTATIONAL COORDINATE_X-AXIS OF Bone_Chest
3540
BONE
CODED DATA OF NON-VERBAL BEHAVIOR AFTER SYNTHESIZING $AB_{mt1} + AB_{cc1} + AB_{pc}$
POSITION_X AXIS OF Bone_Chest 22222 XXX 22 ... 22
POSITION_Y AXIS OF Bone_Chest 12121 XXX 12 ... 21
POSITION_Z AXIS OF Bone_Chest 34451 XXX 34 ... 51
TOTAL VALUE IsBlink OF Eyelid_Shape 11211 442 11111
NON-VERBAL BEHAVIOR OF MACHINE AVATAR AT PRESENT TIME t1
TIME t_{t-5}
TIME t_t
LABEL 5
LABEL 4
LABEL 3
LABEL 2
LABEL 1
SWITCHING ACTION CANDIDATE
NON-VERBAL BEHAVIOR DURING CONVERSATION WITH USER
TIME t_y
TIME t_{y+1}
STATE IN WHICH OUTPUT OF "isSigh" IS "true"
STATE OF "Flow"

FIG. 36


START MACHINE AVATAR IMAGE UPDATE PROCESSING
MONITOR MONITORING TARGET DATA INCLUDED IN AVATAR DISPLAY INFORMATION LOG DATA
S1401
DETECT THAT USER HAS PERFORMED PARTICULAR NON-VERBAL BEHAVIOR
S1402
EXTRACT TIME PERIOD IN WHICH NON-VERBAL BEHAVIOR SIMILAR TO DETECTED NON-VERBAL BEHAVIOR WAS PERFORMED
S1403
DETERMINE WHETHER USER CHANGED TO POST DESIRABLE-CHANGE USER STATE IN TIME PERIOD ADJACENT TO EXTRACTED TIME PERIOD
S1404
S1405
YES
DID USER CHANGE TO POST DESIRABLE-CHANGE USER STATE?
NO
GIVE INSTRUCTION TO GENERATE IMAGE OF MACHINE AVATAR FOR PERFORMING STANDARD BEHAVIOR
S1406
EXTRACT CANDIDATE DATA BASED ON NON-VERBAL BEHAVIOR OF PARTNER THAT USER COMMUNICATED WITH IN EXTRACTED TIME PERIOD
S1407
REFER TO TIME PERIODS IN WHICH USER AND MACHINE COMMUNICATED WITH EACH OTHER BY TRACING BACK TO THE PAST WITHIN CERTAIN PERIOD
S1408
SYNTHESIZE NON-VERBAL BEHAVIOR AT PRESENT TIME t_1 (AND IN MOST RECENT PERIOD), EACH PIECE OF EXTRACTED CANDIDATE DATA, AND SWITCHING ACTION
S3601
EVALUATE EFFECTIVENESS OF EACH PIECE OF SYNTHESIZED DATA FROM RESULTS OF MACHINE AVATAR PERFORMING NON-VERBAL BEHAVIOR SIMILAR TO EACH PIECE OF SYNTHESIZED DATA IN THE PAST
S3602
GENERATE IMAGE OF MACHINE AVATAR AT TIME t_{1+1} ACCORDING TO EVALUATION RESULT
S1410
PERFORM CONTROL SO AS TO UPDATE MACHINE AVATAR BASED ON GENERATED IMAGE OF MACHINE AVATAR
S1411
END MACHINE AVATAR IMAGE UPDATE PROCESSING

ACTION CONTROL METHOD AND DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2016-213625, filed on Oct. 31, 2016, the entire contents of which are incorporated herein by reference.

FIELD

The embodiments discussed herein are related to an action instruction program, an action instruction method, and an image generating device.

BACKGROUND

In a communication service, communication is performed between users or a user and a machine via avatars in a virtual reality space.

In order to make communication proceed smoothly and construct interpersonal relationship appropriately via avatars in a virtual reality space, it may be important to maintain a balance of mutual intimacy as in a real space. Examples of the related art include Japanese National Publication of International Patent Application No. 2014-510336, Japanese Laid-open Patent Publication No. 2005-100382, Japanese Laid-open Patent Publication No. 2008-233946, and International Publication Pamphlet No. WO 2010/138582.

SUMMARY

According to an aspect of the embodiment, an action control method includes when a first state of a first user in communication with a first machine avatar is detected, specifying a first action of the first machine avatar for changing a state of the first user from the first state to a second state that is more desirable than the first state based on history information indicating changes in states of users in response to actions of machine avatars or different users in communication with the users, and causing the first machine avatar to perform the first action.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram illustrating an example of an entire configuration of an image generating system;

FIG. **2** is a diagram illustrating an example of an image of a virtual reality space;

FIG. **3** is a first diagram of assistance in explaining an avatar image representing method;

FIGS. **4**A and **4**B are second diagrams of assistance in explaining an avatar image representing method;

FIG. **5** is a diagram illustrating an example of a hardware configuration of an image generating device;

FIG. **6** is a diagram illustrating an example of a hardware configuration of a head-mounted display (HMD);

FIG. **7** is a first diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device;

FIGS. **8**A, **8**B, and **8**C are diagrams illustrating an example of data tables stored in a sensor data DB;

FIG. **9** is a first diagram illustrating an example of a log table stored in a log DB;

FIGS. **10**A and **10**B are second diagrams illustrating an example of log tables stored in a log DB;

FIG. **11** is a first diagram illustrating an example of definition information stored in a definition information DB;

FIGS. **12**A and **12**B are second diagrams illustrating an example of definition information stored in a definition information DB;

FIG. **13** is a first diagram of assistance in explaining functions of an action instructing unit;

FIG. **14** is a first flowchart of machine avatar image update processing;

FIG. **15** is a diagram illustrating an example of a method of encoding avatar display information log data;

FIG. **16** is a second diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device;

FIG. **17** is a third diagram illustrating an example of log tables stored in a log DB;

FIG. **18** is a third diagram illustrating an example of definition information stored in a definition information DB;

FIGS. **19**A and **19**B are fourth diagrams illustrating an example of definition information stored in a definition information DB;

FIG. **20** is a fifth diagram illustrating an example of definition information stored in a definition information DB;

FIG. **21** is a second diagram of assistance in explaining functions of an action instructing unit;

FIG. **22** is a second flowchart of machine avatar image update processing;

FIG. **23** is a diagram illustrating an example of a method of encoding avatar display information log data and social behavior log data;

FIG. **24** is a third diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device;

FIG. **25** is a diagram illustrating details of synthesis processing by a present behavior synthesizing unit;

FIG. **26** is a third flowchart of machine avatar image update processing;

FIG. **27** is a fourth diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device;

FIG. **28** is a sixth diagram illustrating an example of definition information stored in a definition information DB;

FIG. **29** is a diagram illustrating an example of frequency analysis by a frequency analyzing unit;

FIG. **30** is a fourth flowchart of machine avatar image update processing;

FIG. **31** is a fifth diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device;

FIG. **32** is a seventh diagram illustrating an example of definition information stored in a definition information DB;

FIG. **33** is a fifth flowchart of machine avatar image update processing;

FIG. **34** is a sixth diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device;

FIG. **35** is a diagram illustrating details of synthesis processing by a switching action synthesizing unit; and

FIG. **36** is a sixth flowchart of machine avatar image update processing.

DESCRIPTION OF EMBODIMENTS

In order to maintain a balance of mutual intimacy, it is desired that in communication between a user and a machine, for example, the non-verbal behavior of the user be analyzed and a result of the analysis be reflected in the behavior of an avatar of the machine. The non-verbal behavior is, for example, an action such as making eye contact, achieving physical closeness, a body gesture, a hand gesture, or a smile.

For example, it is desired that when the user performs such a non-verbal behavior as to disturb the balance of mutual intimacy, the avatar of the machine be operated so as to perform a non-verbal behavior such that the user maintains the balance of mutual intimacy.

Brief description will first be made of definitions of terms used in explaining an image generating system in each embodiment. The image generating system to be described in each of the following embodiments is a system that provides a virtual reality space for communication performed between users present at places separated from each other or between a user and a machine.

The "virtual reality space" in this case refers to a space in which the body of an avatar may be expressed by the positions and rotation angles of bones. Therefore, suppose that the virtual reality space includes a space in which the avatar of another user is projected in a real space in which a certain user is present, and it is difficult for the user himself/herself present in the real space to see the avatar of the user himself/herself.

In addition, of avatars having the positions and rotation angles of bodies expressed by bones in the virtual reality space, an avatar whose image is generated so as to be in synchronism with the non-verbal behavior (action) of the user in the real space will be referred to as a "user avatar." In addition, of the avatars having the positions and rotation angles of the bodies expressed by bones in the virtual reality space, the avatar of a machine operating autonomously according to instructions of a computer program will be referred to as a "machine avatar" (in the following, however, the avatar of the machine, including the machine itself that operates autonomously, will be referred to as a machine avatar). Incidentally, "bones" are objects indicating respective body parts of the body of an avatar in the virtual reality space, and include information such as positions and rotation angles.

In addition, of non-verbal behaviors of the user in the real space, non-verbal behaviors directed to a communication partner (communication target) will be referred to as "social behaviors." The social behaviors include various kinds of non-verbal behaviors such as making eye contact, looking at a same thing, turning the body toward the partner, approaching the partner, and smiling at the partner.

Description will next be made of an outline of processing of the image generating system in each embodiment. The image generating system in each of the following embodiments monitors non-verbal behaviors of the user as a communication partner for the machine avatar in the virtual reality space, and determines whether or not the user has performed a "particular non-verbal behavior." Then, when it is determined that the user has performed the particular non-verbal behavior, reference is made to the behavior of a communication partner that the user was communicating with when performing the particular non-verbal behavior in the past. Then, a next behavior of the machine avatar is determined based on the behavior of the communication partner such that the user performs a desirable non-verbal behavior and a behavior series including the desirable non-verbal behavior or such that the user is in a state (desirable user state) after performing the behavior series including the desirable non-verbal behavior. Incidentally, in each of the following embodiments, having performed the behavior series including the desirable non-verbal behavior and being in the desirable user state will be referred to collectively as a "post desirable-change user state." For example, the image generating system determines, while referring to the behavior of the communication partner in the past with the user, what behavior is appropriate as the behavior of the machine avatar for bringing the user into the "post desirable-change user state," and reflects a result of the determination in a next behavior of the machine avatar.

Thus, the machine avatar may perform an own behavior determined to be most appropriate to change the state of the user to a state desirable for the machine avatar. The behavior of the machine avatar is determined after appropriateness is determined from both aspects of appropriateness for the user as a conversation partner and appropriateness when the machine avatar itself performs the behavior. It is consequently possible to make communication between the user and the machine avatar proceed smoothly, and construct interpersonal relationship therebetween appropriately.

Each embodiment will be described in the following with reference to the accompanying drawings. It is to be noted that in the present specification and the drawings, constituent elements having substantially same functional configurations are identified by the same reference symbols, and thereby repeated description thereof will be omitted.

[First Embodiment]

<Entire Configuration of Image Generating System>

An image generating system will first be described. FIG. **1** is a diagram illustrating an example of an entire configuration of an image generating system. As illustrated in FIG. **1**, an image generating system **100** includes: an image generating device **110** in which server software is arranged; and client side systems **140** and **150** including information processing devices **141** and **151** in which client application software is arranged. The image generating device **110** and the client side systems **140** and **150** are coupled to each other via a network **180** typified by the Internet, a local area network (LAN), or the like.

In the image generating system **100**, the image generating device **110** and the client side systems **140** and **150** perform whole processing in a divided manner. The image generating system **100** thereby provides communication service. A user **160** (user identifier (ID)="userA") and a user **170** (user ID="userB") use the communication service provided by the image generating system **100** at places separated from each other. Thus, the user **160** and the user **170** may communicate with each other in the same virtual reality space via user avatars (images in states associated with the users).

The image generating device **110** is a server device that collects sensor data obtained as a result of sensing the users **160** and **170** and which performs various kinds of processing.

Installed on the image generating device **110** are a user avatar basic function program, a machine avatar basic function program, and an action instructing program as the server software. When these programs are executed, the image generating device **110** functions as a user avatar basic functional unit, a machine avatar basic functional unit, and an action instructing unit **125**.

The user avatar basic functional unit includes a sensor data collection processing managing unit **111**, a user avatar information display processing unit **112**, a user avatar registration data managing unit **113**, and a user avatar display history managing unit **114**. The user avatar basic functional unit implements basic functions related to the user avatars when the communication service is provided.

The sensor data collection processing managing unit **111** collects sensor data obtained as a result of sensing the users **160** and **170**, and stores the sensor data in data tables of a sensor data database (database will hereinafter be abbreviated to a DB) **132**.

The user avatar information display processing unit **112** generates an image of a user avatar in the virtual reality space based on the sensor data stored in the sensor data DB **132**. The user avatar information display processing unit **112** generates the image of the user avatar using an avatar skeleton model stored in a content DB **131**, for example. The avatar skeleton model is an image of a human model, and is an image expressing the movement of body parts, which movement accompanies a non-verbal behavior of the user, using a plurality of bones. The user avatar information display processing unit **112** generates the image of the user avatar by calculating the position and rotation angles of each bone in the virtual reality space, and reflects the calculated position and the calculated rotation angles in the avatar skeleton model.

In addition, the user avatar information display processing unit **112** generates (or updates) virtual reality space information by embedding the image of the user avatar and an image of a machine avatar to be described later in an image of the virtual reality space (background image), the background image being stored in the content DB **131**. The user avatar information display processing unit **112** further transmits the generated or updated virtual reality space information to the client side systems **140** and **150**.

The user avatar registration data managing unit **113** registers, in the content DB **131** and a definition information DB **133**, various kinds of definition information used when the user avatar information display processing unit **112** generates and transmits the virtual reality space information.

The user avatar display history managing unit **114** records log data used in generating the image of the user avatar in a log table of a log DB **134**.

The machine avatar basic functional unit includes a machine avatar information display processing unit **121**, a machine avatar registration data managing unit **122**, and a machine avatar display history managing unit **123**. The machine avatar basic functional unit implements basic functions related to the machine avatar when the communication service is provided.

The machine avatar information display processing unit **121** refers to the log data used in generating the image of the user avatar, the log data being stored into the log DB **134** by the user avatar display history managing unit **114**, and generates an image of the machine avatar in the virtual reality space. The machine avatar information display processing unit **121** generates the image of the machine avatar such that the machine avatar performs a standard behavior according to the non-verbal behavior of the communication partner user and a communication strategy possessed by the machine avatar.

In addition, the machine avatar information display processing unit **121** notifies the generated image of the machine avatar to the user avatar information display processing unit **112**. The image of the machine avatar is consequently embedded in the virtual reality space information generated by the user avatar information display processing unit **112**.

Incidentally, the machine avatar information display processing unit **121** changes the image of the machine avatar, which image is to be notified to the user avatar information display processing unit **112**, based on an instruction from the action instructing unit **125**.

For example, when an instruction is given from the action instructing unit **125** to display an image of the machine avatar, which image is generated in the action instructing unit **125**, at a next time, the machine avatar information display processing unit **121** notifies the image of the machine avatar which image is generated in the action instructing unit **125** to the user avatar information display processing unit **112**.

When an instruction is given from the action instructing unit **125** to display an image of the machine avatar for performing a standard behavior at the next time, on the other hand, the machine avatar information display processing unit **121** notifies the image of the machine avatar which image is generated in the machine avatar information display processing unit **121** to the user avatar information display processing unit **112**.

Incidentally, the action instructing unit **125** instructs the machine avatar information display processing unit **121** to display the image of the machine avatar for performing the standard behavior at the next time when it is difficult for the action instructing unit **125** to determine an appropriate image for the machine avatar.

The machine avatar registration data managing unit **122** registers, in the content DB **131**, various kinds of information used in generating the image of the machine avatar.

The machine avatar display history managing unit **123** records log data used in generating the image of the machine avatar in a log table of the log DB **134**.

The action instructing unit **125** monitors the non-verbal behavior of the communication partner user using the log data used in generating the image of the user avatar. In addition, the action instructing unit **125** determines whether or not the communication partner user has performed a particular non-verbal behavior based on a result of the monitoring. Further, when the action instructing unit **125** determines that the communication partner user has performed a particular non-verbal behavior, the action instructing unit **125** determines an appropriate image of the machine avatar for bringing the user into a post desirable-change user state, and gives an instruction to the machine avatar information display processing unit **121**.

When it is difficult for the action instructing unit **125** to determine an appropriate image of the machine avatar for bringing the user into a post desirable-change user state, on the other hand, the action instructing unit **125** instructs the machine avatar information display processing unit **121** to display an image of the machine avatar for performing a standard behavior.

Thus, in the image generating device **110** in the first embodiment, when it is determined that the communication partner user has performed a particular non-verbal behavior, a next image of the machine avatar is determined so that the user changes to a post desirable-change user state. For example, it is possible to determine what behavior is appropriate for bringing the user into a post desirable-change user state, and reflect a result of the determination in a next behavior of the machine avatar.

The client side systems will next be described. Incidentally, because the client side system **140** and the client side

system **150** include a similar configuration, the following description will be made of the client side system **140**.

The client side system **140** includes the information processing device **141**, an information presenting device **142**, and information collecting devices **143** to **145**.

An information processing program as a client application is installed in the information processing device **141**. The information processing device **141** transmits sensor data output from the information collecting devices **143** to **145** to the image generating device **110**, and receives the virtual reality space information transmitted from the image generating device **110** and outputs the virtual reality space information to the information presenting device **142**.

Incidentally, in the first embodiment, description will be made supposing that the information processing device **141** is included in an environment embedded terminal surrounding the user **160**. However, the information processing device **141** does not have to be included in an environment embedded terminal. For example, the information processing device **141** may be included in an HMD. Alternatively, the information processing device **141** may be included in a wearable mobile terminal such as a contact lens or an eyeglass, in a stationary server device, or the like.

The information presenting device **142** displays the virtual reality space information transmitted from the image generating device **110** to the user **160**. Incidentally, in the first embodiment, the information presenting device **142** is implemented by a display unit of an HMD.

The information collecting devices **143** to **145** sense the non-verbal behavior of the user **160** in the real space, and output sensor data.

In the first embodiment, the information collecting device **143** is a head pose sensor, and is included in the HMD. The head pose sensor **143** senses a "head orientation" included in the non-verbal behavior of the user **160** in the real space, and outputs head pose data.

In addition, in the first embodiment, the information collecting device **144** is a depth sensor. The depth sensor **144** is installed in front of the user **160**. The depth sensor **144** outputs a two-dimensional depth image or the like that changes according to the non-verbal behavior of the user **160** in the real space by sensing a three-dimensional distance from the installation position of the depth sensor **144** to the user **160**. Data (for example, 3 cm) indicating the depth of an object which depth is measured by the depth sensor **144** will be referred to herein as depth data. In addition, the two-dimensional depth image refers to an image obtained by plotting the depth data obtained from the depth sensor **144** in an XY plane. Each pixel on the two-dimensional depth image stores the value of a distance to an object (nearest object as viewed from the depth sensor **144**) at a corresponding XY coordinate position, the distance being obtained from the depth sensor **144**. Incidentally, data obtained from the depth sensor **144** (which data includes a color image as well as the depth data and the two-dimensional depth image, and the like) will be referred to collectively as depth sensor data.

In addition, in the first embodiment, the information collecting device **145** is a electromyography sensor. The electromyography sensor **145** senses a "change in expression" which change is included in the non-verbal behavior of the user **160** in the real space, and outputs myogenic potential data.

Incidentally, while the following description will be made supposing that one user is assigned onto one device (information processing device) in which client application software is arranged, a plurality of users may be assigned onto one device.

In addition, while the following description will be made supposing that server software and client application software are each arranged on one device (one image generating device or one information processing device), a plurality of pieces of software may be arranged on one device. Alternatively, the server software and the client application software may be arranged on one device. Alternatively, functions implemented in each software including the server software and the client application software may be distributed and arranged in a plurality of devices.

In addition, suppose in the following that the client application software identifies the user **160**, and converts the virtual reality space information transmitted from the image generating device **110** into virtual reality space information corresponding to the identified user **160** and displays the virtual reality space information corresponding to the identified user **160**.

In addition, the following description will be made supposing that sensor data obtained as a result of sensing the non-verbal behavior of the user **160** is transmitted to the image generating device **110** in association with the user **160**. Incidentally, suppose that the information processing device **141** in which the client application software is arranged is access-controlled by the client application software or the server software. For example, suppose in the following that the client application software performs personal identification (user authentication) in advance in the information processing device **141** in which the client application software is arranged.

In addition, suppose in the following that the client application software checks specifications of the information presenting device **142**, and converts the virtual reality space information transmitted from the image generating device **110** into virtual reality space information corresponding to the checked specifications and displays the virtual reality space information corresponding to the checked specifications.

In addition, suppose in the following that the client application software identifies the information processing device **141**, and transmits the sensor data obtained as a result of sensing the non-verbal behavior of the user **160** to the image generating device **110** in association with the information processing device **141**.

In addition, the following description will be made supposing that the user **160** has one kind of identifier identifying the user **160**. However, in a case where the image generating system **100** provides a plurality of services, the user **160** may have different identifiers for the respective services. In that case, however, suppose that the image generating system **100** manages association between the plurality of identifiers possessed by the user **160**.

In addition, while the following description will be made supposing that the head pose sensor, the depth sensor, and the electromyography sensor as the information collecting devices **143** to **145** sense the non-verbal behavior of the user **160**, another sensor may sense the non-verbal behavior of the user **160**. The other sensor includes, for example, a moving image imaging device, a 1 timeframe image (color image) imaging device, an audio obtaining device, and a biosensor.

Incidentally, there may be a case where data on the user **160** is not included in the sensor data of a contactless type sensor as in a case where the user **160** does not appear in a 1 timeframe image in which the user **160** is to be detected,

for example. In addition, there may be, for example, a case where a plurality of users are detected in the 1 timeframe image in which the user **160** is to be detected and it is difficult to distinguish which users are sensed. The present embodiment assumes that separate measures are taken for such events, and that the sensor data is correctly associated with the user **160** in the image generating device **110**.

In addition, while the following description will be made supposing that the sensor data itself sensed by the information collecting devices **143** to **145** is transmitted to the image generating device **110**, intermediate information that may be derived from the sensed sensor data may be transmitted to the image generating device **110**. For example, in a case where face image data of the user **160** is sensed, information indicating the magnitude of a change in a smiling face, the information being derived by directing attention to face parts of the user **160**, may be transmitted to the image generating device **110**. Alternatively, information indicating a change in body posture, the information being derived by directing attention to the size of the face of the user **160**, may be transmitted to the image generating device **110**.

Further, suppose in the following that time stamps are added to the sensor data transmitted from the information processing devices **141** and **151**. In addition, suppose that time adjustment between the client side system **140** and the client side system **150** is completed for the time stamps added in this case.

<Image of Virtual Reality Space>

Description will next be made of an image of the virtual reality space which image includes images of the user avatars of the user **160** and the user **170** and an image of the machine avatar. FIG. **2** is a diagram illustrating an example of an image of a virtual reality space.

As illustrated in FIG. **2**, a user (the user **160** in this case) using the communication service is seated in a chair **200**, for example, wearing the HMD (HMD including the head pose sensor **143** and the display unit **142**) and the electromyography sensor **145** in the real space. In addition, the depth sensor **144** is installed in front of the user **160** to sense the user **160**.

Head pose data, depth sensor data, and myogenic potential data obtained by sensing by the head pose sensor **143**, the depth sensor **144**, and the electromyography sensor **145** are transmitted to the image generating device **110** to generate an image **220** of the user avatar of the user **160**. Similar processing is also performed for the user **170** to generate an image **230** of the user avatar of the user **170**.

In addition, the image generating device **110** generates an image **240** of the machine avatar that communicates with the user **160** and the user **170**. Further, the images of the user avatars and the machine avatar which images are generated in the image generating device **110** are incorporated into an image of the virtual reality space, and the image of the virtual reality space is transmitted as virtual reality space information to each of the information processing devices **141** and **151**.

An image **210** illustrated in FIG. **2** is an example of the image of the virtual reality space, the image of the virtual reality space being included in the virtual reality space information transmitted to the information processing device **141**. The image **210** incorporates the image **220** of the user avatar of the user **160** and the image **230** of the user avatar of the user **170** as well as the image **240** of the machine avatar. As illustrated in FIG. **2**, the image **210** is displayed such that the user **160** sees the image **220** of the user avatar of the user **160** himself/herself from behind. When the user **160** performs a non-verbal behavior in this state, the image **220** of the user avatar within the image **210** also changes in synchronism. According to the image **210**, the user **160** checks the image **220** of the user avatar, which image changes within the virtual reality space according to the non-verbal behavior of the user **160** himself/herself, from the rear side of the image **220** of the user avatar.

<Method of Representing Image of Avatar>

Description will next be made of a method of representing an image of an avatar (the user avatars and the machine avatar) in the virtual reality space. The image generating device **110** in the first embodiment represents the position and rotation angles of each bone in the virtual reality space using the avatar skeleton model. In addition, the image generating device **110** in the first embodiment generates an image of the avatar by representing the states of surfaces of the avatar (clothes of the avatar, the color of the body, expression, and the like) using a point group referred to as a mesh.

The avatar skeleton model will first be described. As described above, a plurality of bones are included in the avatar skeleton model. For example, the bone of a head is included in the head of the avatar skeleton model. The position and rotation angles of the bone of the head are calculated based on head pose data. In addition, the bones of a body and limbs other than the head are included in the body and limbs other than the head of the avatar skeleton model. The positions and rotation angles of these bones are calculated based on depth sensor data.

The following description will be made of, as an example, a representing method that represents an image of an upper part of the body of the avatar using the avatar skeleton model. FIG. **3** is a first diagram illustrating an example of an avatar image representing method. FIG. **3** represents, as an image of the avatar, a non-verbal behavior in which the upper part of the body of the user leans forward or backward, a non-verbal behavior in which the user changes the orientation of the upper part of the body so as to look around left or right, and a non-verbal behavior in which the whole of the upper part of the body sways to a left side or a right side. In the case of the representing method using the avatar skeleton model, a bone ("Bone_Chest") located in the vicinity of the waist of the avatar being set as an origin, these non-verbal behaviors may be represented as changes in rotation angles of the bone with respect to three axial directions.

Incidentally, in FIG. **3**, an X-axis, a Y-axis, and a Z-axis of a coordinate system uniquely defined in the virtual reality space are respectively set as a left-right direction, an upward-downward direction, and a front-rear direction of the avatar.

An image **301** represents an image of the avatar in a case where the bone is rotated by $+\alpha$ [degrees] with respect to the X-axis. An image **302** represents an image of the avatar in a case where the bone is rotated by $-\alpha$ [degrees] with respect to the X-axis. In addition, an image **311** represents an image of the avatar in a case where the bone is rotated by $+\alpha$ [degrees] with respect to the Y-axis. An image **312** represents an image of the avatar in a case where the bone is rotated by $-\alpha$ [degrees] with respect to the Y-axis.

Further, an image **321** represents an image of the avatar in a case where the bone is rotated by $+\alpha$ [degrees] with respect to the Z-axis. An image **322** represents an image of the avatar in a case where the bone is rotated by $-\alpha$ [degrees] with respect to the Z-axis.

Description will next be made of a mesh representing the state of a surface of the avatar. FIGS. **4**A and **4**B are second diagrams illustrating an example of an avatar image repre-

senting method. In FIGS. **4**A and **4**B, a mesh is used to represent an oral expression of the user as an image of the avatar.

As illustrated in FIGS. **4**A and **4**B, the oral expression of the user may be represented as matrix data of a point group around a mouth. Examples of FIGS. **4**A and **4**B illustrate a group of 32 points around the mouth. Of the figures, FIG. **4**A represents a case where the user is in a smiling state. FIG. **4**B represents a case where the user is not in a smiling state.

<Hardware Configuration of Image Generating Device>

Description will next be made of a hardware configuration of the image generating device **110** included in the image generating system **100**. FIG. **5** is a diagram illustrating an example of a hardware configuration of an image generating device. As illustrated in FIG. **5**, the image generating device **110** includes a central processing unit (CPU) **501**, a read only memory (ROM) **502**, and a random access memory (RAM) **503**. The image generating device **110** also includes an auxiliary storage unit **504**, a communicating unit **505**, a display unit **506**, an operating unit **507**, and a drive unit **508**. Incidentally, the parts of the image generating device **110** are mutually coupled via a bus **509**.

The CPU **501** executes various kinds of programs (for example, the server software) installed in the auxiliary storage unit **504**. The ROM **502** is a nonvolatile memory. The ROM **502** is a main storage unit storing various kinds of programs, data, and the like needed for the CPU **501** to execute the various kinds of programs stored in the auxiliary storage unit **504**. For example, the ROM **502** stores a boot program such as a basic input/output system (BIOS) or an extensible firmware interface (EFI).

The RAM **503** is a volatile memory such as a dynamic random access memory (DRAM) or a static random access memory (SRAM). The RAM **503** functions as a main storage unit. The RAM **503** provides a work area in which the various kinds of programs stored in the auxiliary storage unit **504** are expanded when executed by the CPU **501**.

The auxiliary storage unit **504** stores the various kinds of programs installed in the image generating device **110** and information (various kinds of content, various kinds of definition information, and the like) used when the various kinds of programs are executed. In addition, the auxiliary storage unit **504** stores information (sensor data, log data, and the like) obtained by executing the various kinds of programs.

The communicating unit **505** is a device for communicating with the information processing devices **141** and **151** of the client side systems **140** and **150** coupled to the image generating device **110**. The display unit **506** is a device that displays a processing result and a processing state of the image generating device **110**. The operating unit **507** is a device used when various kinds of instructions are input to the image generating device **110**.

The drive unit **508** is a device for setting a recording medium **510**. The recording medium **510** in this case includes media on which information is recorded optically, electrically, or magnetically, such as a compact disk (CD)-ROM, a flexible disk, and a magneto-optical disk. The recording medium **510** also includes a semiconductor memory or the like in which information is recorded electrically, such as a ROM or a flash memory.

Incidentally, the various kinds of programs installed in the auxiliary storage unit **504** are installed by, for example, setting a distributed recording medium **510** in the drive unit **508** and reading the various kinds of programs recorded on the recording medium **510** by the drive unit **508**. Alternatively, the various kinds of programs installed in the auxiliary storage unit **504** may be installed by receiving the various kinds of programs from the network **180** via the communicating unit **505**.

Incidentally, while FIG. **5** has been described as a hardware configuration of the image generating device **110**, the information processing device **141** disposed in the client side system **140** and the information processing device **151** disposed in the client side system **150** also have a substantially similar hardware configuration.

<Hardware Configuration of HMD>

A hardware configuration of the HMD will next be described. FIG. **6** is a diagram illustrating an example of a hardware configuration of an HMD. As illustrated in FIG. **6**, the HMD includes a CPU **601**, a ROM **602**, and a RAM **603**. The HMD also includes an auxiliary storage unit **604** and a communicating unit **605**. The HMD further includes an operating unit **606**, a display unit **142**, a head pose sensor **143**, and an interface (I/F) unit **607**. These parts are mutually coupled via a bus **608**. Incidentally, the HMD is further provided with an audio output device (speaker or the like) and an audio obtaining device (microphone or the like). However, description of transmission and reception of audio data will be omitted in the first embodiment, and therefore description of the devices related to audio will also be omitted here.

The CPU **601** is a computer that executes various kinds of programs installed in the auxiliary storage unit **604**. The ROM **602** is a nonvolatile memory. The ROM **602** is a main storage unit storing various kinds of programs, data, and the like needed for the CPU **601** to execute the various kinds of programs stored in the auxiliary storage unit **604**. For example, the ROM **602** stores a boot program such as a BIOS or an EFI.

The RAM **603** is a volatile memory such as a DRAM or an SRAM. The RAM **603** functions as a main storage unit. The RAM **603** provides a work area in which the various kinds of programs stored in the auxiliary storage unit **604** are expanded when executed by the CPU **601**.

The auxiliary storage unit **604** stores the various kinds of installed programs and information used when the various kinds of programs are executed. The communicating unit **605** is a device for communicating with the information processing device **141**.

The operating unit **606** is a device used when various kinds of instructions are input to the HMD. The display unit **142** is a device that displays an image of the virtual reality space, the image of the virtual reality space being included in the virtual reality space information transmitted from the image generating device **110** via the information processing device **141**.

The head pose sensor **143** senses "head orientation" included in the non-verbal behavior of the user **160** in the real space, and outputs head pose data.

The I/F unit **607** is coupled to the electromyography sensor **145** to obtain myogenic potential data output from the electromyography sensor **145**.

Obtained sensor data such as the head pose data and the myogenic potential data is transmitted to the information processing device **141** by the communicating unit **605**.

Incidentally, while the example of FIG. **6** represents a case where the HMD is formed as an integral device, the HMD may be formed integrally, or may be formed by a plurality of separate devices.

<Description of Functional Configuration of Action Instructing Unit and Respective DBs in Image Generating Device>

A functional configuration of the action instructing unit **125** and respective DBs in the image generating device **110** will next be described with reference to FIG. **7**. FIG. **7** is a first diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device. As illustrated in FIG. **7**, the action instructing unit **125** includes a monitoring unit **701**, a similar time period searching unit **702**, a candidate extracting unit **703**, and an updating unit **704**.

In addition, the sensor data DB **132** stores, as data tables, a "myogenic potential data table," a "head pose data table," and a "depth sensor data file table." The definition information DB **133** stores, as definition information, "monitoring target definition information," "communication strategy definition information," and "user state checking application programming interface (API) definition information."

Further, the log DB **134** includes, as log tables, a "log table related to avatar display information," a "log table related to desirable non-verbal behavior," and a "log table related to a conversation history." The following description will be made of details of the tables stored in the respective DBs and details of functions of the respective parts possessed by the action instructing unit **125**.

<Description of Tables Stored in Respective DBs>

Description will be made of the respective tables stored in the respective DBs (the sensor data DB **132**, the log DB **134**, and the definition information DB **133**).

(1) Data Tables

The data tables stored in the sensor data DB **132** will first be described. The data tables illustrated in FIGS. **8**A to **8**C are stored into the sensor data DB **132** by the sensor data collection processing managing unit **111**.

FIGS. **8**A to **8**C are diagrams illustrating an example of data tables stored in a sensor data DB. Of the figures, FIG. **8**A illustrates a myogenic potential data table **810** storing myogenic potential data. As illustrated in FIG. **8**A, the myogenic potential data table **810** storing the myogenic potential data includes, as information items, a "DB recording time," a "sensor recording time," a "user name," an "information collecting device ID," and a "myogenic potential activity value."

Recorded as the "DB recording time" is a time stamp added at a point in time of storing myogenic potential data transmitted from the client side system **140** or **150** into the sensor data DB **132**.

Recorded as the "sensor recording time" is a time stamp added at a point in time of sensing the user **160** or **170** by the electromyography sensor **145** or **155**.

Recorded as the "user name" is an identifier identifying the user **160** or **170** sensed by the electromyography sensor **145** or **155**.

Recorded as the "information collecting device ID" is an identifier identifying an electromyography sensor. Electromyography sensors have different identifiers according to parts to be sensed. "TcA_c**3**_zygomaticus(cheek)" in a first row of data rows of FIG. **8**A is an identifier of an electromyography sensor sensing a cheek. In addition, "TcA_c**3**_orbicularis(under eye)" in a second row of the data rows of FIG. **8**A is an identifier of an electromyography sensor sensing a part under an eye. Further, "TcA_c**3**_corrugator(brow)" in a third row of the data rows of FIG. **8**A is an identifier of an electromyography sensor sensing an eyebrow.

Recorded as the "myogenic potential activity value" is the value of myogenic potential data sensed by a corresponding electromyography sensor.

FIG. **8**B illustrates a head pose data table **820** storing head pose data. As illustrated in FIG. **8**B, information items included in the head pose data table **820** are substantially same as the information items included in the myogenic potential data table **810**.

Incidentally, in the "information collecting device ID" of the head pose data table **820**, "TcA_c**1**" indicates that an information collecting device having "c**1**" as a kind of the information collecting device is associated with an information processing device having "TcA" as an information processing device ID. For example, "TcA_c**1**" is the head pose sensor **143** associated with the information processing device **141**.

In addition, recorded as the "head pose data" is data indicating the position of the head and data indicating the rotation angles of the head.

FIG. **8**C illustrates a depth sensor data file table **830** storing depth sensor data. As illustrated in FIG. **8**C, information items included in the depth sensor data file table **830** include a "sensor recording start time" as well as a "DB recording time," a "user name," and an "information collecting device ID." The information items included in the depth sensor data file table **830** further include a "sensor recording end time" and a "depth sensor data recording file uniform resource identifier (URI)."

Recorded as the "sensor recording start time" is a time of starting sensing by the depth sensor **144** or **154**. The depth sensors **144** and **154** output depth sensor data as a file having a given recording length. Recorded as the "sensor recording start time" is a time stamp added at a point in time of sensing first depth sensor data included in a corresponding file.

Recorded as the "sensor recording end time" is a time of ending the sensing by the depth sensor **144** or **154**. For example, a time stamp is recorded which is added at a point in time of sensing last depth sensor data included in the file having the given recording length.

Recorded as the "depth sensor data recording file URI" is a URI indicating the storage location of the file having the given recording length.

Incidentally, in the "information collecting device ID" of the depth sensor data file table **830**, "TcA_c**2**" indicates that an information collecting device having "c**2**" as a kind of the information collecting device is associated with an information processing device having "TcA" as an information processing device ID. For example, "TcA_c**2**" is the depth sensor **144** associated with the information processing device **141**.

(2) Log Tables

The log tables stored in the log DB **134** will next be described. The various kinds of log tables illustrated in FIG. **9** and FIGS. **10**A and **10**B are stored into the log DB **134** by the user avatar display history managing unit **114** and the machine avatar display history managing unit **123**.

FIG. **9** is a first diagram illustrating an example of a log table stored in a log DB, and is a diagram illustrating a log table related to avatar display information. A log table **900** related to the avatar display information stores data used in generating images of avatars.

As illustrated in FIG. **9**, the log table **900** related to the avatar display information includes, as information items, a "DB recording time," a "user present time," a "user name," an "information processing device ID," a "log type label," and "avatar display information log data."

Recorded as the "DB recording time" is a time of storing data used in generating an image of an avatar in the log table **900** related to the avatar display information.

Recorded as the "user present time" is a time at which the user performs a non-verbal behavior. Recorded as the "user name" is an identifier identifying the user performing the non-verbal behavior.

Recorded as the "information processing device ID" is an identifier identifying an information processing device that manages the user performing the non-verbal behavior.

Recorded as the "log type label" is information indicating a representing method in generating the image of the avatar. Recorded in the example of FIG. **9** are "bone," which indicates that a non-verbal behavior is represented by using the avatar skeleton model, and "mesh," which indicates that a non-verbal behavior is represented by using a mesh.

Recorded as the "avatar display information log data" is data used in generating the image of the avatar, the data being recorded as a structured list.

An example in a first row of data rows of FIG. **9** indicates that the user **160** having a user name="userA" performed a non-verbal behavior at 11:00:00.000 on Jul. 27, 2015" and that the position coordinates of the bone of the head in an image of the user avatar became (0, 18, −10). The example in the first row also indicates that the rotation angles of the bone of the head in the image of the user avatar became (0, 1, 0). The example in the first row also indicates that avatar display information log data including the position coordinates and the rotation angles was recorded in the log DB **134** at 11:00:00.020 on Jul. 27, 2015.

FIGS. **10**A and **10**B are second diagrams illustrating an example of log tables stored in a log DB. Of the figures, FIG. **10**A is a diagram illustrating a log table **1010** related to desirable non-verbal behaviors. The log table **1010** related to the desirable non-verbal behaviors stores information indicating whether or not desirable non-verbal behaviors defined in communication strategy definition information are performed by corresponding users. Incidentally, there may be a mode in which processing of log recording into the log table **1010** related to the desirable non-verbal behaviors, the log table **1010** being illustrated in FIG. **10**A, is performed only in certain periods that users perform the particular non-verbal behaviors.

As illustrated in FIG. **10**A, the log table **1010** related to the desirable non-verbal behaviors includes, as information items, a "DB recording time," a "user present time," a "user name," an "information processing device ID," a "desirable non-verbal behavior," and a "checking result."

Recorded as the "DB recording time" is a time of storing a checking result indicating whether or not a user is changed to a post desirable-change user state in the log table **1010** related to the desirable non-verbal behaviors.

Recorded as the "user present time" is a time at which the user is changed to the post desirable-change user state. Recorded as the "user name" is an identifier identifying the user changed to the post desirable-change user state.

Recorded as the "information processing device ID" is an identifier identifying an information processing device that manages the user changed to the post desirable-change user state.

Recorded as the "desirable non-verbal behavior" is the post desirable-change user state. The example of FIG. **10**A indicates that whether or not the user is changed to a concentrating state as a post desirable-change user state is checked.

Recorded as the "checking result" is a checking result when whether or not the user is changed to the post desirable-change user state is checked. The example of FIG. **10**A indicates that it is not determined that the user is changed to the post desirable-change user state ("false") as a result of checking whether or not the user is changed to the post desirable-change user state.

FIG. **10**B is a diagram illustrating a log table **1020** related to a conversation history. The log table **1020** related to the conversation history stores information about conversations performed in the virtual reality space.

As illustrated in FIG. **10**B, the log table **1020** related to the conversation history includes, as information items, a "conversation start time," a "conversation end time," a "user name **1**," and a "user name **2**."

Recorded as the "conversation start time" is a time at which a conversation is started. Recorded as the "conversation end time" is a time at which the conversation is ended.

Recorded as the "user name **1**" and the "user name **2**" are identifiers identifying users participating in the conversation performed via user avatars in the virtual reality space.

(3) Definition Information

The definition information stored in the definition information DB **133** will next be described. FIG. **11** is a first diagram illustrating an example of definition information stored in a definition information DB, and is a diagram illustrating monitoring target definition information. Monitoring target definition information **1100** defines the bones to be monitored of user avatars and APIs used for monitoring, to detect that particular non-verbal behaviors are performed by users.

The monitoring target definition information **1100** includes, as information items, a "communication partner user name," a "monitoring target," and a "trigger checking API."

Defined as the "communication partner user name" is an identifier for identifying a communication partner user that the machine avatar communicates with.

Defined as the "monitoring target" is a bone (bones) of a user avatar, the bone (bones) being to be monitored to detect that a particular non-verbal behavior is performed by the user.

Defined as the "trigger checking API" is an API used for monitoring.

An example in a first row of data rows of the monitoring target definition information **1100** illustrated in FIG. **11** indicates that monitoring is performed by inputting the position coordinates and rotation angles of "Bone_Chest" of the user avatar having a user name="userA" to an API="isSigh." According to the example in the first row of the data rows, the monitoring unit **701** monitors whether the corresponding user sighs.

In addition, an example in a second row of the data rows indicates that monitoring is performed by inputting the position coordinates and rotation angles of "Bone_Head" and the like of the user avatar having the user name="userA" to an API="isNap." According to the example in the second row of the data rows, the monitoring unit **701** monitors whether the corresponding user is dozing.

In addition, an example in a third row of the data rows indicates that monitoring is performed by inputting the position coordinates and rotation angles of "Bone_Head" of a user avatar having a user name="userC" to the API="isNap." According to the example in the third row of the data rows, the monitoring unit **701** monitors whether the corresponding user is dozing.

Further, an example in a fourth row of the data rows indicates that monitoring is performed by inputting the position coordinates and rotation angles of "Bone_Head"

and "Bone_Chest" of a user avatar of some user to an API="isRestles." According to the example in the fourth row of the data rows, the monitoring unit **701** monitors whether some user is in a restless state.

FIGS. **12**A and **12**B are second diagrams illustrating an example of definition information stored in a definition information DB. Of the figures, FIG. **12**A illustrates communication strategy definition information **1210**. FIG. **12**B illustrates user state checking API definition information **1220**.

As illustrated in FIG. **12**A, the communication strategy definition information **1210** defines the post desirable-change user states of communication partner users, the post desirable-change user states being desirable for the machine avatar, in cases where the users perform particular non-verbal behaviors. The communication strategy definition information **1210** includes, as information items, a "communication partner user name," a "triggering non-verbal behavior," and a "desirable non-verbal behavior."

Defined as the "communication partner user name" is an identifier for identifying a communication partner user that the machine avatar communicates with.

Defined as the "triggering non-verbal behavior" is a detecting condition for detecting that a particular non-verbal behavior is performed by the user. Defined as the "desirable non-verbal behavior" is a post desirable-change user state when it is detected that the particular non-verbal behavior is performed by the user.

An example in a first row of data rows of the communication strategy definition information **1210** in FIG. **12**A indicates that when the output of the API="isSigh" for the user name="userA" is "true," it is determined that a particular non-verbal behavior is performed by the user. In addition, the example in the first row indicates that a post desirable-change user state when it is determined that the particular non-verbal behavior is performed by the user is "Flow."

In addition, an example in a second row of the data rows indicates that when the output of the API="isRestles" for some user is "true," it is determined that a particular non-verbal behavior is performed by the user. In addition, the example in the second row indicates that a post desirable-change user state when it is determined that the particular non-verbal behavior is performed by the user is "Flow."

On the other hand, as illustrated in FIG. **12**B, the user state checking API definition information **1220** defines checking methods for checking the user states of communication partner users by a calling function (API) within the system, input data for the API, and output data from the API. The user state checking API definition information **1220** includes, as information items, a "user state," "input target data," and a "user state checking API."

Defined as the "user state" is output data from an API. A post desirable-change user state is defined as the "user state" when the API is used to check the post desirable-change user state. Defined as the "input target data" is input data for the API. When the API is used to check the post desirable-change user state, a bone (bones) used to check the post desirable-change user state is (are) defined as the "input target data." Defined as the "user state checking API" is the calling function name of the API. When the API is used to check the post desirable-change user state, the name of the API called at the time of the checking is defined as the "user state checking API."

An example in a first row of data rows of the user state checking API definition information **1220** in FIG. **12**B indicates that whether or not a user state is "Flow" may be checked by using an API referred to as checkFlow. In addition, the example in the first row indicates that the checking is performed by inputting the position coordinates and rotation angles of "Bone_Head" and "Bone_Spine" of the user to the API="checkFlow."

An example in a second row of the data rows indicates that whether a user state is "Smile" may be checked by using an API referred to as checkSmile. In addition, the example in the second row indicates that the checking is performed by inputting the matrix data of "Shape_Mouse" of the user to the API="checkSmile."

<Description of Functions of Action Instructing Unit>

Description will next be made of details of functions of the parts of the action instructing unit **125** in the image generating device **110**. FIG. **13** is a first diagram of assistance in explaining functions of an action instructing unit.

As illustrated in FIG. **13**, the monitoring unit **701** monitors monitoring target log data in data (avatar display information log data) used in generating an image of the user avatar of a communication partner user (following description will be made supposing that the communication partner user is the user **160**). Which data is set as a monitoring target is determined based on the monitoring target definition information **1100** stored in the definition information DB **133**.

The monitoring unit **701** determines whether or not the user **160** has performed a particular non-verbal behavior based on a result of monitoring the monitoring target log data. In addition, when determining that the user **160** has performed the particular non-verbal behavior, the monitoring unit **701** notifies the similar time period searching unit **702** of a time period in which the user **160** performed the particular non-verbal behavior. Further, the monitoring unit **701** refers to the communication strategy definition information **1210**, and identifies a post desirable-change user state when the user **160** has performed the particular non-verbal behavior. The monitoring unit **701** notifies the identified post desirable-change user state to the similar time period searching unit **702**.

Description will be made by citing a concrete example. The monitoring unit **701** obtains the log data of Bone_Chest used in generating the image **220** of the user avatar of the user **160** from time t_{1-m} to time t_1 from the log table **900** related to the avatar display information, and inputs the log data of Bone_Chest to the API="isSigh."

Here, suppose that time t_1 denotes an update time at which virtual reality space information is generated (updated). In addition, suppose that time t_{1-1} denotes a first virtual reality space information update time before time t_1, and that time t_{1+1} denotes a next virtual reality space information update time after time t_1. Hence, time t_{1-m} denotes an mth virtual reality space information update time before time t_1. Incidentally, there may be a mode in which DB recording times in FIG. **9** are used as the update times referred to here.

When "true" is output as a result of the input, the monitoring unit **701** determines that the user **160** has performed a particular non-verbal behavior (has sighed). When determining that the user **160** has sighed, the monitoring unit **701** notifies a time period from time t_{1-m} to time t_1 to the similar time period searching unit **702**. In addition, the monitoring unit **701** refers to the communication strategy definition information **1210**, and identifies "Flow" as a post desirable-change user state in a case where the user **160** has sighed. The monitoring unit **701** notifies "Flow" as the identified post desirable-change user state to the similar time period searching unit **702**.

The similar time period searching unit **702** refers to the log table **900** related to the avatar display information, and reads avatar display information log data in the time period notified from the monitoring unit **701**. In addition, the similar time period searching unit **702** retrieves log data (action group) similar to the read avatar display information log data from the log table **900** related to the avatar display information. For example, log data similar to the non-verbal behavior determined to have sighed is retrieved.

In addition, the similar time period searching unit **702** refers to the log table **1010** related to the desirable non-verbal behaviors for an adjacent time period subsequent to a time period corresponding to the retrieved log data. As a result of the reference, the similar time period searching unit **702** determines whether or not the user **160** changed to the post desirable-change user state. For example, whether a user state changed to Flow is determined.

Further, when determining that the user **160** changed to the post desirable-change user state in the adjacent time period, the similar time period searching unit **702** extracts the retrieved time period, and notifies the time period to the candidate extracting unit **703**. Incidentally, when determining that the user **160** did not change to the post desirable-change user state in any adjacent time period, the similar time period searching unit **702** decides to generate an image of the machine avatar for performing a standard behavior. Incidentally, there may be a mode in which past log data of the user **160** himself/herself, the past log data preceding a certain period, is included in retrieval targets in the retrieval by the similar time period searching unit **702** or log data of all users within the system or users similar to the user **160** is included in the retrieval targets.

Description will be made by citing a concrete example. The similar time period searching unit **702** refers to the log table **900** related to the avatar display information. In addition, the similar time period searching unit **702** reads the avatar display information log data (time series data of position coordinates and rotation angles of all bones) of the user **160** in the period from time t_{1-m} to time t_1. Incidentally, the time series data of the position coordinates and rotation angles of all of the bones from time t_{1-m} to time t_1 will hereinafter be referred to as "time series data at a search start position."

Next, the similar time period searching unit **702** refers to avatar display information log data in a certain period (for example, the past one day) in the log table **900** related to the avatar display information, and searches for a time period of time series data similar to the time series data at the search start position. For example, supposing that the time series data at the search start position is time series data for five seconds, the similar time period searching unit **702** makes a search using the values of the time series data as it is as a multidimensional vector. Supposing that the number of bones is 80, the similar time period searching unit **702** makes a search using values of the time series data as an 80-dimensional vector of the position coordinates of the bones. In addition, the similar time period searching unit **702** makes a search using values of the time series data as an 80-dimensional vector of the rotation angles of the bones.

Suppose that as a result of the search, time periods from time t_a to time t_{a+nsec}, from time t_b to time t_{b+nsec}, and from time t_c to time t_{c+nsec} are extracted, as illustrated in FIG. **13**. Incidentally, time t_{a+nsec} refers to a virtual reality space information update time n seconds after time t_a.

The similar time period searching unit **702** refers to the log table **1010** related to the desirable non-verbal behaviors for a time period adjacent to each of the extracted time periods. In this case, the similar time period searching unit **702** sets a time period within 300 [seconds] of the start time of each of the extracted time periods as an adjacent time period, and refers to the log table **1010** related to the desirable non-verbal behaviors.

For example, in the log table **1010** related to the desirable non-verbal behaviors, the similar time period searching unit **702** refers to a "checking result" for "Flow," where a "user present time" is included in the time period of time t_a to time $t_{a+300\ sec}$ and a "user name" corresponds to UserA. When a result of the reference indicates that the "checking result" for "Flow" is "false," the similar time period searching unit **702** determines that the user **160** did not change to the post desirable-change user state in the time period of time t_a to time $t_{a+300\ sec}$.

Similarly, in the log table **1010** related to the desirable non-verbal behaviors, the similar time period searching unit **702** refers to a "checking result" for "Flow," where a "user present time" is included in the time period of time t_b to time $t_{b+300\ sec}$ and a "user name" corresponds to UserA. When a result of the reference indicates that the "checking result" for "Flow" is "true," the similar time period searching unit **702** determines that the user **160** changed to the post desirable-change user state in the time period of time t_b to time $t_{b+300\ sec}$. In this case, the similar time period searching unit **702** notifies the time period of time t_b to time $t_{b+300\ sec}$ to the candidate extracting unit **703**. The time period of time t_b to time $t_{b+300\ sec}$ may be said to be a time period during the past one day in which time period the user **160** changed from a sighing state (output of "isSigh" is "true") to a concentrating state ("IsFlow" is "true").

Similarly, in the log table **1010** related to the desirable non-verbal behaviors, the similar time period searching unit **702** refers to a "checking result" for "Flow," where a "user present time" is included in the time period of time t_c to time $t_{c+300\ sec}$ and a "user name" corresponds to UserA. When a result of the reference indicates that the "checking result" for "Flow" is "true," the similar time period searching unit **702** determines that the user **160** changed to the post desirable-change user state in the time period of time t_c to time $t_{c+300\ sec}$. In this case, the similar time period searching unit **702** notifies the time period of time t_c to time $t_{c+300\ sec}$ to the candidate extracting unit **703**. The time period of time t_c to time $t_{c+300\ sec}$ may be said to be a time period during the past one day in which time period the user **160** changed from a sighing state (output of "isSigh" is "true") to a concentrating state ("IsFlow" is "true").

Incidentally, in the present embodiment, an expression beginning with a lowercase letter as in "isSigh" denotes a function determining a user state. On the other hand, an expression beginning with a capital letter as in "IsFlow" denotes a variable (user state). Hence, when the variable "IsFlow" includes "true," it is indicated that the user state is Flow. When the variable "IsFlow" includes "false," it is indicated that the user state is not Flow.

The candidate extracting unit **703** refers to the log table **900** related to the avatar display information, and extracts avatar display information log data included in the time periods notified from the similar time period searching unit **702**, the avatar display information log data being log data of a user as a communication partner with the user **160** or the machine avatar. The time series data of position coordinates and rotation angles of each bone included in the log data extracted by the candidate extracting unit **703** will hereinafter be referred to as "candidate data." The candidate extracting unit **703** notifies the extracted candidate data to the updating unit **704**.

Description will be made by citing a concrete example. The candidate extracting unit **703** refers to the log table **900** related to the avatar display information for the time period of time t_b to time $t_{b+300\ sec}$ and the time period of time t_c to time $t_{c+300\ sec}$, the time periods being notified from the similar time period searching unit **702**. In addition, the candidate extracting unit **703** extracts log data in the time period of time t_b to time $t_{b+300\ sec}$ and the time period of time t_c to time $t_{c+300\ sec}$, the log data being log data of the user as the communication partner with the user **160** or the machine avatar.

Incidentally, in extracting the log data, the candidate extracting unit **703** refers to the log table **1020** related to the conversation history. By referring to the log table **1020** related to the conversation history, the candidate extracting unit **703** may identify the user or the machine avatar that communicated with the user **160** in the time period of time t_b to time $t_{b+300\ sec}$. Similarly, by referring to the log table **1020** related to the conversation history, the candidate extracting unit **703** may identify the user or the machine avatar that communicated with the user **160** in the time period of time t_c to time $t_{c+300\ sec}$.

Here, suppose that the user **160** was communicating with a machine avatar M (for example, the machine avatar represented as the image **240**) in the time period of time t_b to time $t_{b+300\ sec}$. In this case, the candidate extracting unit **703** extracts the log data of the machine avatar M in the time period of time t_b to time $t_{b+300\ sec}$ from the log table **900** related to the avatar display information.

Incidentally, the log data in the time period of time t_b to time $t_{b+300\ sec}$ in the log table **900** related to the avatar display information includes a time period of time series data similar to the time series data at the search start position (which time period will be referred to as a "first time period"). Further, the log data in the time period of time t_b to time $t_{b+300\ sec}$ includes a time period in which the user **160** changed to the post desirable-change user state (which time period will be referred to as a "third time period"). Hence, the log data of the machine avatar M in the time period of time t_b to time $t_{b+300\ sec}$, the log data being extracted by the candidate extracting unit **703** from the log table **900** related to the avatar display information, is log data in a "second time period" between the first time period and the third time period. For example, the candidate extracting unit **703** notifies the updating unit **704** of, as candidate data **1**, the time series data of the position coordinates and rotation angles of each bone included in the log data in the second time period.

In addition, suppose that the user **160** was communicating with the user **170** in the time period of time t_c to time $t_{c+300\ sec}$. In this case, the candidate extracting unit **703** extracts the log data of the user **170** in the time period of time t_c to time $t_{c+300\ sec}$ from the log table **900** related to the avatar display information.

Incidentally, the log data in the time period of time t_c to time $t_{c+300\ sec}$ in the log table **900** related to the avatar display information includes a time period (first time period) of time series data similar to the time series data at the search start position. Further, the log data in the time period of time t_c to time $t_{c+300\ sec}$ includes a time period (third time period) in which the user **160** changed to the post desirable-change user state. Hence, the log data of the user avatar of the user **170** in the time period of time t_c to time $t_{c+300\ sec}$ the log data being extracted by the candidate extracting unit **703** from the log table **900** related to the avatar display information, is log data in a second time period between the first time period and the third time period. For example, the candidate extracting unit **703** notifies the updating unit **704** of, as candidate data **2**, the time series data of the position coordinates and rotation angles of each bone included in the log data in the second time period.

The updating unit **704** evaluates the effectiveness of the candidate data notified from the candidate extracting unit **703**, and generates an image of the machine avatar at time t_{1+1} based on candidate data evaluated as effective. In addition, the updating unit **704** notifies the machine avatar information display processing unit **121** of the generated image of the machine avatar at time t_{1+1}.

Incidentally, in evaluating the effectiveness of the candidate data, the updating unit **704** checks whether or not an image of the machine avatar, the image being generated based on data similar to the candidate data, has been displayed in the past. When determining that an image of the machine avatar, the image being generated based on data similar to the candidate data, has been displayed in the past, the updating unit **704** checks whether or not the display of the image resulted in the user **160** changing to the post desirable-change user state. The updating unit **704** evaluates the effectiveness of the candidate data based on a result of the checking, and notifies the machine avatar information display processing unit **121** of an image of the machine avatar at time t_{1+1}, which image is generated based on the candidate data evaluated as effective.

Incidentally, when the similar time period searching unit **702** determines that an image of the machine avatar for performing a standard behavior is to be generated, the updating unit **704** instructs the machine avatar information display processing unit **121** to generate the image of the machine avatar for performing the standard behavior.

Functions of the updating unit **704** will be described by citing a concrete example. The updating unit **704** refers to the log table **1020** related to the conversation history for the past one week, and extracts time periods in which the user **160** and the machine avatar communicated with each other. In addition, the updating unit **704** refers to the log table **900** related to the avatar display information for the past one week, and retrieves time series data identical or similar to the candidate data **1** and the candidate data **2** from time series data derived from avatar display information log data in the extracted time periods.

For example, suppose that the updating unit **704** extracts two pieces of time series data identical or similar to the candidate data **1** in the past one week (from time t_y to time t_{y+n} and from time t_z to time t_{z+n}). In this case, the updating unit **704** refers to the log table **1010** related to the desirable non-verbal behaviors, and determines whether or not the user **160** changed to the post desirable-change user state in time periods subsequent to the two respective extracted pieces of time series data.

Here, suppose that the user **160** changed to the post desirable-change user state in one of the time periods subsequent to the two respective extracted pieces of time series data. In this case, the updating unit **704** calculates, as an evaluation value of the candidate data **1**, the ratio (1/2) of the number of times that the user **160** changed to the post desirable-change user state.

On the other hand, suppose that the updating unit **704** does not extract any time series data identical or similar to the candidate data **2** in the past one week. In this case, the updating unit **704** calculates, as an evaluation value of the candidate data **2**, the ratio (0/0) of the number of times that the user **160** changed to the post desirable-change user state.

The updating unit **704** compares the evaluation value of the candidate data **1** and the evaluation value of the candi-

date data **2** with each other. When the updating unit **704** determines that the evaluation value of the candidate data **1** is larger, the updating unit **704** generates an image of the machine avatar at time t_{1+1} based on the candidate data **1**, and notifies the machine avatar information display processing unit **121** of the image of the machine avatar at time t_{1+1}.

Incidentally, in the above-described concrete example, the time periods in which the user **160** and the machine avatar communicated with each other are set as a target to evaluate the candidate data **1** and the candidate data **2**. However, there may be an embodiment in which an evaluation value of zero (case where a change to the post desirable-change user state is not made even once) is set as a maximum evaluation value at a time of evaluation. In addition, time periods in which another user and the machine avatar communicated with each other may be set as a target to evaluate the candidate data **1** and the candidate data **2**. Alternatively, time periods in which a user having an attribute similar to that of the user **160** and the machine avatar communicated with each other may be set as a target to evaluate the candidate data **1** and the candidate data **2**.

<Machine Avatar Image Update Processing>

A flow of machine avatar image update processing will next be described. FIG. **14** is a first flowchart of machine avatar image update processing.

In step S**1401**, the monitoring unit **701** refers to the log table **900** of the avatar display information, and monitors monitoring target log data in data used in generating an image of the user avatar of the user **160**.

In step S**1402**, the monitoring unit **701** determines whether or not the user **160** has performed a particular non-verbal behavior based on a result of monitoring the monitoring target log data. In addition, when determining that the user **160** has performed the particular non-verbal behavior, the monitoring unit **701** notifies the similar time period searching unit **702** of a time period (from time t_{1-m} to time t_1) in which the user **160** performed the particular non-verbal behavior. Further, when determining that the user **160** has performed the particular non-verbal behavior, the monitoring unit **701** identifies a post desirable-change user state of the user **160** by referring to the communication strategy definition information **1210**. The monitoring unit **701** notifies the similar time period searching unit **702** of the identified post desirable-change user state.

In step S**1403**, the similar time period searching unit **702** refers to the log table **900** related to the avatar display information, and extracts a time period including log data similar to avatar display information log data in the notified time period. Thus, a time period in which a non-verbal behavior similar to the particular non-verbal behavior was performed is extracted.

In step S**1404**, the similar time period searching unit **702** determines whether or not the user **160** changed to the post desirable-change user state in a time period adjacent to the extracted time period.

When determining that the user **160** did not change to the post desirable-change user state in the adjacent time period (No in step S**1405**), the similar time period searching unit **702** proceeds to step S**1406**.

In step S**1406**, the updating unit **704** instructs the machine avatar information display processing unit **121** to generate an image of the machine avatar for performing a standard behavior.

When determining that the user **160** changed to the post desirable-change user state in the adjacent time period (Yes in step S**1405**), on the other hand, the similar time period searching unit **702** proceeds to step S**1407**.

In step S**1407**, the candidate extracting unit **703** extracts candidate data based on avatar display information log data of a communication partner with the user **160** in the extracted time period.

In step S**1408**, the updating unit **704** refers to time periods in which the user **160** and the machine avatar communicated with each other by tracing back to the past within a certain period.

In step S**1409**, the updating unit **704** retrieves time series data similar to the candidate data in the referred-to time periods, and determines whether or not the user **160** changed to the post desirable-change user state in time periods subsequent to the retrieved time series data. In addition, the updating unit **704** evaluates the effectiveness of the candidate data based on a result of the determination. Thus, the effectiveness of the candidate data may be evaluated based on the non-verbal behaviors of the user in response to non-verbal behaviors performed by the machine avatar in the past.

In step S**1410**, the updating unit **704** generates an image of the machine avatar at time t_{1+1} based on effective candidate data.

In step S**1411**, the updating unit **704** instructs the machine avatar information display processing unit **121** to update display using the generated image of the machine avatar.

As is clear from the above description, when a communication partner user performs a particular non-verbal behavior, the image generating system according to the first embodiment refers to the log data of a user or the machine avatar that the user in question communicated with in the past. Then, the image generating system according to the first embodiment generates a next image of the machine avatar, which image is effective in bringing the user into a post desirable-change user state, based on the referred-to log data.

Thus, according to the image generating system in accordance with the first embodiment, the machine avatar may be made to behave appropriately when the communication partner user performs a particular non-verbal behavior.

The behavior to be performed by the machine avatar is determined after appropriateness is determined from both aspects of appropriateness for the user as a conversation partner and appropriateness when the machine avatar itself performs the behavior.

Thus, according to the image generating system in accordance with the first embodiment, it is possible to make communication between the user and the machine avatar proceed smoothly, and construct interpersonal relationship therebetween appropriately.

For example, the image generating system in accordance with the first embodiment has, as a communication strategy, a post desirable-change user state in response to a non-verbal behavior performed by the conversation partner user, the post desirable-change user state being desirable for the machine avatar, and determines a non-verbal behavior of the machine avatar so as to guide the conversation partner user to the desirable post-change state. Thus, according to the image generating system in accordance with the first embodiment, it is possible to make communication between the user and the machine avatar proceed smoothly, and construct interpersonal relationship therebetween appropriately.

[Second Embodiment]

In the foregoing first embodiment, the similar time period searching unit **702** refers to avatar display information log data in the log table **900** related to the avatar display information, and searches for time periods of time series

data similar to the time series data at the search start position. On the other hand, the second embodiment encodes time series data by dividing the time series data into labels of five levels, and searches for time periods in which label changes similar to label changes at a search start position occur.

FIG. **15** is a diagram illustrating an example of a method of encoding avatar display information log data. The example of FIG. **15** illustrates time series data on the Y-coordinate position of a bone="Bone_Chest" in avatar display information log data.

As illustrated in FIG. **15**, when encoding is performed at intervals of one second, the time series data of the Y-coordinate position of the bone="Bone_Chest" makes a transition from label **3** to label **2** via label **3**, label **4** and label **5** in a period of past five seconds from time t_1. The similar time period searching unit **702** may therefore encode the time series data at the search start position as (3, 3, 4, 5, 2).

By encoding time series data derived based on avatar display information log data recorded in the log table **900** related to the avatar display information by a similar encoding method, the similar time period searching unit **702** may search for similar time periods using the coded data.

Incidentally, in searching for similar time periods using the coded data, the similar time period searching unit **702** may regard a time period in which coded data matches 100% as a similar time period, or may regard a time period in which coded data matches 80% as a similar time period. For example, suppose that a determining condition for determining whether or not coded data matches may be set arbitrarily.

In addition, in searching for similar time periods, the similar time period searching unit **702** generates coded data on all of the bones included in avatar display information log data, and extracts a time period in which coded data on all of the bones matches as a similar time period. However, the similar time period searching unit **702** may generate coded data on a part of the bones (for example, a monitoring target bone), and extract a time period in which coded data on the part of the bones matches as a similar time period. In addition, the similar time period searching unit **702** may generate coded data on a part of the position coordinates or rotation angles of a part of the bones, and extract a time period in which coded data on the part of the position coordinates or rotation angles of the part of the bones matches as a similar time period.

Alternatively, the similar time period searching unit **702** may generate coded data on all of the bones, calculate a degree of matching for each bone, and extract a similar time period based on a statistical value (for example, an average value) of the calculated degrees of matching.

[Third Embodiment]

In the foregoing first embodiment, the similar time period searching unit **702** refers to the log table **900** related to the avatar display information, and searches for time periods of time series data similar to the time series data at the search start position. On the other hand, a third embodiment further refers to a log table related to social behaviors, and searches for time periods of log data similar to social behavior log data at a search start position. Thus, according to the third embodiment, candidate data based on social behaviors may be extracted. The following description will be made of the third embodiment, centering on differences from the first embodiment.

<Description of Functional Configuration of Action Instructing Unit and Respective DBs in Image Generating Device>

A functional configuration of an action instructing unit **125** and respective DBs in an image generating device **110** will first be described with reference to FIG. **16**. FIG. **16** is a second diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device. As illustrated in FIG. **16**, the action instructing unit **125** includes a monitoring unit **701**, a first similar time period searching unit **702**, a second similar time period searching unit **1601**, a first candidate extracting unit **703**, a second candidate extracting unit **1602**, and an updating unit **1603**.

Incidentally, the first similar time period searching unit **702** has the substantially same functions as the similar time period searching unit **702** in FIG. **7**. In addition, the first candidate extracting unit **703** has the substantially same functions as the candidate extracting unit **703** in FIG. **7**.

In addition, a sensor data DB **132** stores the various kinds of data table illustrated in FIG. **7**. A definition information DB **133** stores "social behavior determining API definition information," "communication strategy definition information," "user state checking API definition information," and "tendency definition information" in addition to the various kinds of definition information illustrated in FIG. **7**.

Further, a log DB **134** includes a "log table related to social behaviors" in addition to the various kinds of log tables illustrated in FIG. **7**.

<Description of Tables Stored in Respective DBs>

Description will next be made of tables other than the tables already described in the foregoing first embodiment among the respective tables stored in the respective DBs (the sensor data DB **132**, the log DB **134**, and the definition information DB **133**).

(1) Log Table

FIG. **17** is a third diagram illustrating an example of a log table stored in a log DB, and is a diagram illustrating the log table related to the social behaviors. A log table **1700** related to the social behaviors is a table in which the sensor data collection processing managing unit **111** records information related to social behaviors, the information being calculated by inputting sensor data to a social behavior determining API. The log table **1700** related to the social behaviors is stored into the log DB **134** by the sensor data collection processing managing unit **111**.

As illustrated in FIG. **17**, the log table **1700** related to the social behaviors includes, as information items, a "DB recording time," a "social behavior determination time (start)," and a "social behavior determination time (end)." The log table **1700** related to the social behaviors further includes, as information items, a "user name," an "information processing device ID," and a "social behavior."

Recorded as the "DB recording time" is a time stamp added at a point in time of recording social behavior log data in the log table **1700** related to the social behaviors.

Recorded as the "social behavior determination time (start)" and the "social behavior determination time (end)" are a time at which a user started a social behavior and a time at which the user ended the social behavior. For example, time stamps each added to first and last sensor data of sensor data in a given time range are recorded, the sensor data being used in determining that the social behavior is performed. In a case of depth sensor data, time stamps are recorded which are added to first and last depth sensor data included in a depth sensor data file used in determining that the social behavior is performed. However, in a case of a long depth sensor data file, the time of starting the social behavior and the time of ending the social behavior may be accurately

identified and recorded based on time stamps of depth sensor data actually used in generating the social behavior log data.

Incidentally, the sensor data collection processing managing unit **111** generates social behavior log data at time t_{1+1} using sensor data in a time range to time t_{1+1-k} tracing back by a certain time k from sensor data sensed at time t_{1+1}. For example, the sensor data collection processing managing unit **111** generates social behavior log data at time t_{1+1} using sensor data in a time range=time t_{1+1-k} to time t_{1+1}. Therefore, for example, the sensor data collection processing managing unit **111** extracts depth sensor data tracing back by the certain time k from a sensor recording end time="2015/7/27/11:01:05.000" (see FIG. **8**C). The sensor data collection processing managing unit **111** then determines a social behavior at the time t_{1+1} based on the extracted depth sensor data.

Recorded as the "user name" is an identifier identifying the user. Recorded as the "information processing device ID" is an identifier of an information processing device managing the user.

The "social behavior" further includes a "type label," a "target," a "stage label," and "log data."

Recorded as the "type label" is information indicating a kind of the social behavior. Recorded as the "target" is an identifier identifying a user as a target of the social behavior. Recorded as the "stage label" is a stage label of the social behavior. The stage label of the social behavior is output by the social behavior determining API, and is recorded. For example, when the social behavior is an action of starting a motion, "S (stroke)" is recorded as a stage label. When the social behavior is a state of staying after starting a motion, "H (Hold)" is recorded as a stage label. When the social behavior is an action of returning to an original position, "R (Return)" is recorded as a stage label. When the social behavior is a preparing action, "P (Preparation)" is recorded as a stage label. In a case of an action unclear as to whether the action is a social behavior or an action unclear as to the kind of the social behavior, a partner in the social behavior, the length of the social behavior, or the like, "U (Unclear)" is recorded as a stage label.

Recorded as the "log data" is log data on a bone used in the social behavior performed by the user.

An example in a first row of data rows of FIG. **17** indicates that it is determined that the user **160** (user name="userA") performed a social behavior with a type label of "body-close-to" toward the user **170** (target="userB"). In addition, the example in the first row of the data rows of FIG. **17** indicates that a bone (Bone_Chest) of the user avatar rotated by +8 [degrees] from 4 [degrees] to 12 [degrees] with respect to the X-axis without changing in position as a result of the social behavior performed by the user **160**.

(2) Definition Information

FIG. **18** is a third diagram illustrating an example of definition information stored in a definition information DB, and is a diagram illustrating social behavior determining API definition information. Social behavior determining API definition information **1800** defines APIs used when the sensor data collection processing managing unit **111** determines the social behaviors of users based on sensor data.

As illustrated in FIG. **18**, the social behavior determining API definition information **1800** includes, as information items, an "information collecting device ID," a "social behavior determining API," "sensor data," a "social behavior type label," and a "bone desired as API input."

Defined as the "information collecting device ID" is an identifier indicating a kind of information collecting device. Defined as the "social behavior determining API" is an API used in determining a social behavior.

Defined as the "sensor data" is a kind of sensor data input to the social behavior determining API.

Defined as the "social behavior type label" is a kind of social behavior determined by the social behavior determining API. Defined as the "bone desired as API input" is a kind of bone (kinds of bones) to be input to the API in determining the social behavior using the social behavior determining API.

An example in a first row of data rows of FIG. **18** indicates that depth sensor data sensed by the depth sensor **144** identified by an information collecting device ID="c**2**" is input to a "pose analyzing API." In addition, the example in the first row of the data rows of FIG. **18** indicates that whether or not the social behavior of a user corresponds to "body-close-to" is determined. Further, the example in the first row of the data rows of FIG. **18** indicates that whether or not the social behavior of the user corresponds to "body-close-to" is determined based on the motion of a bone="Bone-Chest."

In addition, an example in a second row of the data rows of FIG. **18** indicates that depth sensor data sensed by the depth sensor **144** identified by the information collecting device ID="c**2**" is input to the "pose analyzing API." The example in the second row of the data rows of FIG. **18** also indicates that whether or not the social behavior of the user **160** corresponds to "body-far-to" is determined. Further, the example in the second row of the data rows of FIG. **18** indicates that whether or not the social behavior of the user **160** corresponds to "body-far-to" is determined based on the motion of a bone="Bone_Chest."

In addition, an example in a third row of the data rows of FIG. **18** indicates that head pose data sensed by the head pose sensor **143** identified by an information collecting device ID="c**1**" is input to a "face orientation analyzing API." In addition, the example in the third row of the data rows of FIG. **18** indicates that whether or not the social behavior of the user **160** corresponds to "face-close-to" is determined. Further, the example in the third row of the data rows of FIG. **18** indicates that whether or not the social behavior of the user **160** corresponds to "face-close-to" is determined based on the motion of a bone="Bone_Head."

Further, an example in a fourth row of the data rows of FIG. **18** indicates that depth sensor data sensed by the depth sensor **144** identified by the information collecting device ID="c**2**" is input to the "pose analyzing API." In addition, the example in the fourth row of the data rows of FIG. **18** indicates that whether or not the social behavior of the user **160** corresponds to "bodyparts-close-to" is determined. Further, the example in the fourth row of the data rows of FIG. **18** indicates that whether or not the social behavior of the user **160** corresponds to "bodyparts-close-to" is determined based on the motion of bones="Bone_LeftHand" and "Bone_RightHand."

FIGS. **19**A and **19**B are fourth diagrams illustrating an example of definition information stored in a definition information DB. Of the figures, FIG. **19**A illustrates communication strategy definition information **1910**. FIG. **19**B illustrates user state checking API definition information **1920**.

As illustrated in FIG. **19**A, the communication strategy definition information **1910** defines the post desirable-change user states of communication partner users when the users perform a particular non-verbal behavior, the post desirable-change user states being desirable for the machine avatar. The communication strategy definition information

1910 includes, as information items, a "communication partner user name," a "triggering non-verbal behavior," and a "desirable social behavior."

Defined as the "communication partner user name" is an identifier for identifying a communication partner user that the machine avatar communicates with.

Defined as the "triggering non-verbal behavior" is a detecting condition for detecting that a particular non-verbal behavior is performed by the user. Defined as the "desirable social behavior" is a post desirable-change user state (a desirable social behavior is performed and a state after the desirable social behavior is performed is brought about) when it is detected that the particular non-verbal behavior is performed by the user.

An example in a first row of data rows of the communication strategy definition information **1910** of FIG. **19**A indicates that when the output of the API="isSigh" is "true" for the user name="userA," it is determined that the particular non-verbal behavior has been performed by the user. In addition, it is indicated that a post desirable-change user state when it is determined that the particular non-verbal behavior has been performed by the user is "SocialFlow."

On the other hand, as illustrated in FIG. **19**B, the user state checking API definition information **1920** defines checking methods for checking the user states of communication partner users by a calling function (API) within the system, input data for the API, and output data from the API. The user state checking API definition information **1920** includes, as information items, a "user state," "input target data," and a "user state checking API."

Defined as the "user state" is output data from an API. A post desirable-change user state is defined as the "user state" when the API is used to check the post desirable-change user state. Defined as the "input target data" is input data for the API. When the API is used to check the post desirable-change user state, social behavior type labels used to check the post desirable-change user state are defined as the "input target data." Defined as the "user state checking API" is a calling function name of the API. When the API is used to check the post desirable-change user state, the name of the API called at the time of the checking is defined as the "user state checking API."

An example in a first row of data rows of FIG. **19**B indicates that whether or not a user state is "SocialFlow" may be checked by using an API referred to as checkSocialFlow. In addition, the example in the first row indicates that the checking is performed by inputting, as input target data, "jointattention-to" and "upperbody-leanforward-to," which are social behavior type labels of a corresponding user, to the API.

For example, when the input target data is input to the API, either "true" or "false" is output from the API with regard to "SocialFlow." For example, when the user fixes attention to a substantially same thing that the machine avatar is directing attention to and the upper part of the body of the user is leaned forward, "true" is output from the API with regard to "SocialFlow."

An example in a second row of the data rows indicates that whether or not a user state is "SocialSmile" may be checked by using an API referred to as checkSocialSmile. In addition, the example in the second row indicates that the checking is performed by inputting, as input target data, "mutualattention-to," "face-indirect-to," and "Shape-Mouse," which are social behavior type labels of a corresponding user, to the API.

For example, when the input target data in a time period in which the user is dialoging with the machine avatar is input to the API, either "true" or "false" is output from the API with regard to "SocialSmile." For example, "true" is output from the API when three states are established at the substantially same time, the three states being a state in which the user and the machine avatar are directing attention to each other, a state in which the face of the user is not oriented toward the machine avatar, and a state in which the user is smiling.

Incidentally, also in the present embodiment, the input target data may be not only social behavior type labels, but Shape_Mouse, bones, or the like as in the first embodiment may be specified and used together with social behavior type labels as illustrated in the present example.

FIG. **20** is a fifth diagram illustrating an example of definition information stored in a definition information DB. As illustrated in FIG. **20**, tendency definition information **2000** includes, as information items, a "social behavior type label" and an "approaching tendency/avoiding tendency."

Defined as the "social behavior type label" is a kind of social behavior. Defined as the "approaching tendency/avoiding tendency" is either an approaching tendency or an avoiding tendency for each kind of social behavior. Incidentally, records defined as "social behavior type labels" in the tendency definition information **2000** denote the following actions.

For example, "body-close-to" denotes an action of bringing a body close to a partner. "body-far-to" denotes an action of moving the body away from the partner. "bodyparts-close-to" denotes an action of bringing parts of the body close to the partner. "bodyparts-far-to" denotes an action of moving parts of the body away from the partner.

In addition, "mutualattention-to" denotes an action of looking at each other. However, the action of looking at each other in this case includes an action in a case where one looks at a hand of another and the other looks at the face of the one as well as looking at each other's faces, for example. "avertedattention-to" denotes an action of looking away from the partner. "jointattention-to" denotes an action of looking at a substantially same thing as the partner. "followingattention-to" denotes an action of following and looking at a thing at which the partner is looking. "sharedattention-to" denotes an action of looking at a substantially same thing as the partner while knowing that both look at the substantially same thing.

In addition, "face-close-to" denotes an action of bringing the face close to the partner. "face-far-to" denotes an action of moving the face away from the partner. "upperbody-leanforward-to" denotes an action of leaning forward the upper part of the body. "upperbody-leanbackward-to" denotes an action of leaning the body rearward.

Further, "smile-to" denotes an action of smiling at the partner. "nosmile-to" denotes an action of not smiling at the partner.

Actions other than the actions illustrated in the tendency definition information **2000** of FIG. **20** may also be defined as approaching tendency behaviors or avoiding tendency behaviors in the tendency definition information **2000**. For example, approaching tendency behaviors include an action of turning the face to the partner side and an action of turning the body to the partner side. In addition, avoiding tendency behaviors include an action of turning the face away from the partner and an action of turning the body away from the partner.

<Description of Functions of Action Instructing Unit>

Description will next be made of details of functions of the respective parts of the action instructing unit **125** in the image generating device **110**. FIG. **21** is a second diagram of

assistance in explaining functions of an action instructing unit. Incidentally, functions already described with reference to FIG. **7** are omitted in FIG. **21**. The following description will be made of functions of the second similar time period searching unit **1601**, the second candidate extracting unit **1602**, and the updating unit **1603**, for example, among the respective parts illustrated in FIG. **16**.

The second similar time period searching unit **1601** refers to the log table **1010** related to the desirable non-verbal behaviors, and determines whether or not the user **160** changed to a post desirable-change user state in a time period adjacent to a time period extracted by the first similar time period searching unit **702**.

Description will be made by citing a concrete example. Suppose that the first similar time period searching unit **702** extracts time periods of time t_a to time t_{a+nsec}, time t_b to time t_{b+nsec}, and time t_c to time t_{c+nsec}. The second similar time period searching unit **1601** refers to the log table **1010** related to the desirable non-verbal behaviors for a time period adjacent to each of the extracted time periods.

For example, the second similar time period searching unit **1601** refers to a "checking result" satisfying the following conditions in the log table **1010** related to the desirable non-verbal behaviors. •A "user present time" is included in the time period of time t_a to time $t_{a+300\ sec}$. •A "user name" corresponds to UserA. •A "desirable non-verbal behavior" is SocialFlow.

When the "checking result" is "false" as a result of the reference, the second similar time period searching unit **1601** determines that the user **160** did not change to the post desirable-change user state.

Similarly, the second similar time period searching unit **1601** refers to a "checking result" satisfying the following conditions in the log table **1010** related to the desirable non-verbal behaviors. •A "user present time" is included in the time period of time t_b to time $t_{b+300\ sec}$. •A "user name" corresponds to UserA. •A "desirable non-verbal behavior" is SocialFlow.

When the "checking result" is "true" as a result of the reference, the second similar time period searching unit **1601** determines that the user **160** changed to the post desirable-change user state. In this case, the second similar time period searching unit **1601** notifies the time period of time t_b to time $t_{b+300\ sec}$ to the second candidate extracting unit **1602**. The time period of time t_b to time $t_{b+300\ sec}$ is a time period in which the state of the user **160** changed from a state of sighing to a state of concentrating in cooperation during the past one day. Incidentally, the state of sighing is a state in which the output of "isSigh" is "true." In addition, the state of concentrating in cooperation as used in the description is a state of "SocialFlow."

Similarly, the second similar time period searching unit **1601** refers to a "checking result" satisfying the following conditions in the log table **1010** related to the desirable non-verbal behaviors. •A "user present time" is included in the time period of time t_c to time $t_{c+300\ sec}$. •A "user name" corresponds to userA. •A "desirable non-verbal behavior" is SocialFlow.

When the "checking result" is "true" as a result of the reference, the second similar time period searching unit **1601** determines that the user **160** changed to the post desirable-change user state. In this case, the second similar time period searching unit **1601** notifies the time period of time t_c to time $t_{c+300\ sec}$ to the second candidate extracting unit **1602**. The time period of time t_c to time $t_{c+300\ sec}$ is a time period in which the state of the user **160** changed from a state of sighing to a state of concentrating in cooperation during the past one day.

The second candidate extracting unit **1602** identifies second time periods based on the time periods notified from the second similar time period searching unit **1601**.

The second candidate extracting unit **1602** refers to the log table **1700** related to the social behaviors based on the identified second time periods, and extracts the log data of a user as a communication partner with the user **160** or the machine avatar. The second candidate extracting unit **1602** notifies the updating unit **1603** of, as candidate data, the time series data of position coordinates and rotation angles of each bone included in the extracted social behavior log data.

Incidentally, the example of FIG. **21** illustrates that the log data of the machine avatar M is extracted in the second time period of the time period of time t_b to time $t_{b+300\ sec}$ (candidate data **1**). For example, it is illustrated that social behavior log data is extracted in which a type label="face-direct" makes a transition from "absent" to "present" and a type label="upper-bodypose-open" continues to remain "present."

In addition, the example of FIG. **21** illustrates that the log data of the user **170** is extracted in the second time period of the time period of time t_c to time $t_{c+300\ sec}$ (candidate data **2**). For example, it is illustrated that social behavior log data is extracted in which a type label="face-direct" continues to remain "absent" and a type label="bodyposition-close" makes a transition from "absent" to "present."

The updating unit **1603** evaluates the effectiveness of the candidate data notified from the second candidate extracting unit **1602**, and generates an image of the machine avatar M at time t_{1+1} based on candidate data evaluated as effective. In addition, the updating unit **1603** notifies the generated image of the machine avatar M at time t_{1+1} to the machine avatar information display processing unit **121**.

Incidentally, in order to determine the effectiveness of the candidate data for the user, the updating unit **1603** checks whether the machine avatar has performed a social behavior similar to that of the candidate data toward the user **160** in the past. In a case where the machine avatar has performed a social behavior similar to that of the candidate data toward the user **160** in the past, the updating unit **1603** checks whether the user **160** changed to a post desirable-change user state. The effectiveness in this case indicates a degree of possibility that the user **160** changes to the post desirable-change user state when the machine avatar performs a social behavior similar to that of the candidate data toward the user **160**. When it is determined that the machine avatar has performed a social behavior similar to that of the candidate data toward the user **160** in the past, the updating unit **1603** checks whether or not the user **160** changed to the post desirable-change user state as a result of the social behavior performed toward the user **160**. The updating unit **1603** evaluates the effectiveness of the candidate data based on a result of the checking, and notifies the machine avatar information display processing unit **121** of an image of the machine avatar at time t_{1+1}, the image being generated based on candidate data evaluated as effective.

Functions of the updating unit **1603** will be described by citing a concrete example. The following description will be made of a case where the effectiveness of the candidate data notified from the second candidate extracting unit **1602** is evaluated.

The updating unit **1603** refers to the log table **1020** related to the conversation history for the past one week, and

extracts time periods in which the user **160** and the machine avatar communicated with each other.

The updating unit **1603** also refers to the log table **1700** related to the social behaviors for the past one week. Then, the updating unit **1603** extracts time series data identical or similar to the candidate data **1** and the candidate data **2**, the time series data being derived from social behavior log data in the extracted time periods.

For example, suppose that the updating unit **1603** extracts two pieces of time series data identical or similar to the candidate data **1** in the past one week (from time t_y to time t_{y+n} and from time t_z to time t_{z+n}). In this case, the updating unit **1603** refers to the log table **1010** related to the desirable non-verbal behaviors, and determines whether or not the user **160** changed to the post desirable-change user state in time periods subsequent to the two respective extracted pieces of time series data.

The example of FIG. **21** illustrates that the user **160** did not change to the post desirable-change user state in the time period subsequent to the time period of time t_y to time t_{y+n} among the time periods subsequent to the two respective extracted pieces of time series data. For example, in the social behavior of the user **160** in the time period subsequent to the time period of time t_y to time t_{y+n}, both "jointattention-to" and "lean-forward-to" continue to remain "absent."

The example of FIG. **21** also illustrates that the user **160** changed to the post desirable-change user state in the time period subsequent to the time period of time t_z to time t_{z+n} among the time periods subsequent to the two respective extracted pieces of time series data. For example, in the social behavior of the user **160** in the time period subsequent to the time period of time t_z to time t_{z+n}, "jointattention-to" continues to remain "absent," while "lean-forward-to" makes a transition from "absent" to "present." Consequently, the updating unit **1603** calculates, as an evaluation value of the candidate data **1**, the ratio (1/2) of the number of times that the user **160** changed to the post desirable-change user state.

On the other hand, suppose that the updating unit **1603** does not extract any time series data identical or similar to the candidate data **2** in the past one week. In this case, the updating unit **1603** calculates, as an evaluation value of the candidate data **2**, the ratio (0/0) of the number of times that the user **160** changed to the post desirable-change user state.

The updating unit **1603** compares the evaluation value of the candidate data **1** and the evaluation value of the candidate data **2** with each other. When the updating unit **1603** determines that the evaluation value of the candidate data **1** is larger, the updating unit **1603** generates an image of the machine avatar at time t_{1+1} based on the candidate data **1**, and notifies the machine avatar information display processing unit **121** of the image of the machine avatar at time t_{1+1}. Incidentally, as for the evaluation value, a case where the number of times of performing the social behavior is zero may be evaluated highly in some cases.

<Image Update Processing of Machine Avatar>

A flow of machine avatar image update processing will next be described. FIG. **22** is a second flowchart of machine avatar image update processing. The machine avatar image update processing of FIG. **22** is performed in parallel with the first flowchart illustrated in FIG. **14**. Incidentally, of respective processes illustrated in FIG. **22**, steps S**1401** to S**1403**, step S**1406**, step S**1408**, and steps S**1410** to S**1411** are substantially the same as the respective corresponding processes in FIG. **14**. Description will therefore be omitted in the following.

In step S**2201**, the second similar time period searching unit **1601** determines whether or not the user **160** changed to the post desirable-change user state in a time period adjacent to a time period extracted by the first similar time period searching unit **702**.

When determining that the user **160** did not change to the post desirable-change user state in the adjacent time period (No in step S**2202**), the second similar time period searching unit **1601** proceeds to step S**1406**.

When determining that the user **160** changed to the post desirable-change user state in the adjacent time period (Yes in step S**2202**), on the other hand, the second similar time period searching unit **1601** proceeds to step S**2203**.

In step S**2203**, the second candidate extracting unit **1602** extracts candidate data based on social behavior log data of a communication partner with the user **160** in the extracted time period.

In step S**2204**, the updating unit **1603** retrieves time series data similar to the candidate data in the time periods referred to in step S**1408**, and identifies the social behaviors of the user **160** in time periods subsequent to the retrieved time series data. In addition, the updating unit **1603** determines whether or not the user **160** changed to the post desirable-change user state based on the identified social behaviors, and evaluates the effectiveness of the candidate data based on a result of the determination.

As is clear from the above description, when a communication partner user performs a particular non-verbal behavior, the image generating system according to the third embodiment refers to the social behavior of a user or the machine avatar that the user in question communicated with in the past. Then, the image generating system according to the third embodiment generates a next image of the machine avatar, the next image being effective in bringing about a post desirable-change user state, based on the referred-to social behavior.

By thus referring to social behaviors, it is possible to extract more candidate data. For example, even in non-verbal behaviors of raising a hand, the position coordinates and rotation angles of the bone in the avatar skeleton model differ depending on a raising speed and a raising angle. For example, even in a case of identical non-verbal behaviors as viewed from the eyes of a user, the avatar display information log data is not necessarily completely the same. On the other hand, because social behavior log data indicates a non-verbal behavior toward a communication partner, a similar non-verbal behavior of raising a hand in a direction of the partner may be regarded as the same social behavior. Consequently, by referring to social behaviors in the machine avatar image update processing, it is possible to extract, as candidate data, non-verbal behaviors that it is difficult to extract in the first embodiment.

[Fourth Embodiment]

In the foregoing third embodiment, the updating unit **1603** refers to the log table **900** related to the avatar display information or the log table **1700** related to the social behaviors, and searches for time series data identical or similar to candidate data.

On the other hand, a fourth embodiment encodes candidate data and encodes avatar display information log data and social behavior log data, and searches for identical or similar coded data.

FIG. **23** is a diagram illustrating an example of a method of encoding avatar display information log data and social behavior log data. In FIG. **23**, a graph **2310** illustrates time series data on the Y-coordinate position of "Bone_Chest" among the respective bones of the machine avatar.

Incidentally, a method of encoding avatar display information log data (method of performing encoding by division into labels of five levels) is already described in the foregoing second embodiment, and therefore description will be omitted in the following.

On the other hand, a graph **2320** illustrates changes in the stage label of "body-close-to" among social behaviors of the machine avatar toward the user **160** (user ID="userA").

As illustrated in the graph **2320**, the fourth embodiment encodes the stage label into one of labels of three levels in each update cycle. For example, in a case of the stage label="false," the stage label is encoded into a label **1**, and in a case of the stage label="P," "S," "H," or "R," the stage label is encoded into a label **2**. In addition, in a case of the stage label="U," the stage label is encoded into a label **3**.

Thus, the social behavior log data of the machine avatar M in a period of time t_{y+1} to time t_{y+n-1} may be encoded into (2, 2, . . . , 1, 1). Incidentally, the user **160** is in a sighing state (output of "isSigh" is "true") before time t_y, and the user **160** is in a concentrating state (state of "SocialFlow") after time t_{y+n}.

An example of coded data obtained by encoding avatar display information log data and social behavior log data in the period of time t_{y+1} to time t_{y+n-1} is illustrated on the right side of the graph **2310** and the graph **2320** of FIG. **23**.

When avatar display information log data and social behavior log data are thus encoded, the updating unit **1603** may make a search using the coded data in searching for data identical or similar to candidate data.

Incidentally, while the stage label is encoded into labels of three levels when the social behavior log data is encoded in the above description, the encoding method is not limited to this. The stage label may be encoded into labels of five levels, which are the same as those of the stage label.

[Fifth Embodiment]

The updating unit **1603** in the foregoing third embodiment evaluates the effectiveness of candidate data based on an evaluation value calculated according to whether or not the user **160** changed to a post desirable-change user state. On the other hand, a fifth embodiment calculates distances (degrees of similarity) between candidate data and time series data similar to the candidate data, and calculates weighted evaluation values by weighting evaluation values using average values of the calculated distances.

Incidentally, in describing the calculation of the weighted evaluation values using a concrete example, description will be made of a case where there are following two pieces of candidate data as time series data similar to the candidate data **1** in the fifth embodiment.

One piece of candidate data is extracted based on the log data of a user P. Another piece of candidate data is extracted based on the log data of a user Q. Incidentally, the pieces of candidate data of respective non-verbal behavior groups will be denoted as SV_{pc} and SV_{qc}. In addition, suppose, for example, that there are six cases of the machine avatar M performing a non-verbal behavior similar to the candidate data SV_{pc} toward the user **160** during the past one week, and that there are two cases of the machine avatar M performing a non-verbal behavior similar to the candidate data SV_{qc} toward the user **160** during the past one week. Suppose that social behavior groups of the machine avatar M in the six time periods similar to SV_{pc} are SV_{mp1}, SV_{mp2}, . . . , and SV_{mp6}. Similarly, suppose that social behavior groups of the machine avatar M in the two time periods similar to SV_{qc} are SV_{mq1} and SV_{mq2}.

In the fifth embodiment, the updating unit **1603** analyzes the breakdown of "SV_{pc}," which is the candidate data of the non-verbal behavior group of the user P. For example, when SV_{pc} is social behavior log data for 100 seconds, and a time occupied by an approaching tendency behavior is 50 seconds, the updating unit **1603** calculates that a ratio of the approaching tendency behavior is 0.5. In addition, when a time occupied by an avoiding tendency behavior is 30 seconds, the updating unit **1603** calculates that a ratio of the avoiding tendency behavior is 0.3. The ratio of the approaching tendency behavior and the ratio of the avoiding tendency behavior are calculated because a plurality of non-verbal behaviors are performed in one time period in the present embodiment, in which it is desired to calculate similarity between a non-verbal behavior group performed in one time period and non-verbal behavior groups performed in a plurality of time periods. For example, by calculating the above-described ratios, it is possible to numerically evaluate the tendency of social behaviors included in the non-verbal behavior group performed in one time period.

For example, when both of the ratios of approaching tendency behaviors and the ratios of avoiding tendency behaviors, the approaching tendency behaviors and the avoiding tendency behaviors being included in non-verbal behaviors performed in two respective time periods, are close to each other, the tendencies of the social behaviors included in the two non-verbal behavior groups are close to each other, and therefore it may be determined that the non-verbal behaviors in the two time periods are similar.

Accordingly, the updating unit **1603** first calculates the ratio of an approaching tendency behavior and the ratio of an avoiding tendency behavior in each of the social behavior log data groups SV_{mp1} to SV_{mp6} of the machine avatar in the six time periods similar to the candidate data SV_{pc} of the non-verbal behavior group of the user P. The updating unit **1603** similarly calculates the ratio of an approaching tendency behavior and the ratio of an avoiding tendency behavior in each of the social behavior log data groups SV_{mq1} and SV_{mq2} of the machine avatar in the two time periods similar to the candidate data SV_{qc} of the non-verbal behavior group of the user Q.

Next, the updating unit **1603** calculates distances between the ratio of the approaching tendency of SV_{pc} and each of the ratios of the approaching tendencies of SV_{mp1}, SV_{mp2}, SV_{mp3}, SV_{mp4}, SV_{mp5}, and SV_{mp6}. In addition, the updating unit **1603** calculates distances between the ratio of the avoiding tendency of SV_{pc} and each of the ratios of the avoiding tendencies of SV_{mp1}, SV_{mp2}, SV_{mp3}, SV_{mp4}, SV_{mp5}, and SV_{mp6}.

Similarly, the updating unit **1603** calculates distances between the ratio of the approaching tendency of SV_{qc} and each of the ratios of the approaching tendencies of SV_{mq1} and SV_{mq2}. The updating unit **1603** also calculates distances between the ratio of the avoiding tendency of SV_{qc} and each of the ratios of the avoiding tendencies of SV_{mq1} and SV_{mq2}.

In addition, the updating unit **1603** calculates average values of the distances calculated for the ratios of the approaching tendencies, and calculates average values of the distances calculated for the ratios of the avoiding tendencies.

Further, the updating unit **1603** calculates weighted evaluation values by weighting the evaluation value of the candidate data **1** and the evaluation value of the candidate data **2** using the respective calculated average values.

The above functions of the updating unit **1603** will be described by citing a concrete example. Suppose that the ratio of the approaching tendency of SV_{pc} is 0.5, and that the ratios of the approaching tendencies of SV_{mp1}, SV_{mp2}, SV_{mp3}, SV_{mp4}, SV_{mp5}, and SV_{mp6}, respectively, are (0.7, 0.3, 0.9, 0, 0, 0.1). In this case, approaching tendency

distances from SV_{pc} are (0.2, −0.2, 0.4, −0.5, −0.5, −0.4). As a result, an average value of the distances between the ratio of the approaching tendency of SV_{pc} and the ratios of the approaching tendencies of SV_{mp1} to SV_{mp6} is −0.16.

In addition, suppose that the ratio of the avoiding tendency of SV_{pc} is 0.3, and the ratios of the avoiding tendencies of SV_{mp1}, SV_{mp2}, SV_{mp3}, SV_{mp4}, SV_{mp5}, and SV_{mp6}, respectively, are (0.4, 0.2, 0.1, 0.5, 0.9, 0.7). In this case, avoiding tendency distances from SV_{pc} are (0.1, −0.1, −0.2, 0.2, 0.6, 0.4). As a result, an average value of the distances between the ratio of the avoiding tendency of SV_{pc} and the ratios of the avoiding tendencies of SV_{mp1} to SV_{mp6} is 0.16.

Similarly, suppose that an average value of distances between the ratio of the approaching tendency of SV_{qc} and the ratios of the approaching tendencies of SV_{mq1} to SV_{mq2} is calculated to be 0.3.

In addition, suppose that an average value of distances between the ratio of the avoiding tendency of SV_{qc} and the ratios of the avoiding tendencies of SV_{mq1} to SV_{mq2} is calculated to be 0.16.

Consequently, the updating unit **1603** calculates a weighted evaluation value=(3/6)×(1−|−0.16×10.16|) by weighting the evaluation value of the candidate data **1** (the evaluation value being assumed to be "3/6" in this case). Similarly, the updating unit **1603** calculates a weighted evaluation value=(1/2)×(1−|−0.3|×|0.16|) by weighting the evaluation value of the candidate data **2** (the evaluation value being assumed to be "1/2" in this case).

When evaluation values are thus weighted using social behavior log data, the more similar the ratios of the approaching tendency and the avoiding tendency of candidate data are (for example, the more similar the social behaviors of the candidate data are), the more the evaluation value of the candidate data may be increased.

[Sixth Embodiment]

The foregoing fifth embodiment evaluates the effectiveness of each piece of extracted candidate data, and generates an image of the machine avatar at time t_{1+1} using candidate data evaluated as effective. On the other hand, a sixth embodiment synthesizes most recent social behavior log data of the machine avatar and social behavior log data corresponding to candidate data, and evaluates the effectiveness of the synthesized data. Then, an image of the machine avatar at time t_{1+1} is generated using the candidate data corresponding to synthesized data evaluated as effective. The following description will be made of the sixth embodiment, centering on differences from the foregoing fifth embodiment.

<Description of Functional Configuration of Action Instructing Unit and respective DBs in Image Generating Device>

FIG. **24** is a third diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device. A difference from FIG. **16** is that a present behavior synthesizing unit **2401** is provided.

The present behavior synthesizing unit **2401** synthesizes the social behavior log data of the machine avatar at a present time and in a most recent period and social behavior log data corresponding to candidate data extracted in the second candidate extracting unit **1602**.

Suppose that coded data obtained by encoding the social behavior log data of the machine avatar at a present time and in a most recent period (time t_{1-5} to time t_1) is "SV_{mt1}." In addition, description will be made of a case where there are following two pieces of candidate data as non-verbal behaviors to be performed by the machine avatar. In the present example, one piece of candidate data is extracted based on the log data of the user P. Another piece of candidate data is extracted based on the log data of the user Q. Suppose that coded data obtained by encoding social behavior log data corresponding to the candidate data **1** is "SV_{pc}," and that coded data obtained by encoding social behavior log data corresponding to the candidate data **2** is "SV_{qc}."

The present behavior synthesizing unit **2401** synthesizes SV_{mt1} and SV_{pc}. In addition, the present behavior synthesizing unit **2401** synthesizes SV_{mt1} and SV_{qc}. A concrete example of synthesis processing of the present behavior synthesizing unit **2401** will be described with reference to FIG. **25**.

FIG. **25** is a diagram illustrating details of synthesis processing by a present behavior synthesizing unit. In FIG. **25**, a graph **2510** illustrates changes in the stage label of "body-close-to" in the social behavior log data of the machine avatar in the period of time t_{1-5} to time t_1. In addition, a table **2520** illustrates coded data (SV_{mt1}) obtained by encoding the stage label of each type label of the social behavior log data of the machine avatar in the period of time t_{1-5} to time t_1.

A graph **2530** illustrates changes in the stage label of "body-close-to" in the social behavior log data corresponding to the candidate data **1**. In addition, a table **2540** illustrates coded data (SV_{pc}) obtained by encoding the social behavior log data corresponding to the candidate data **1**.

Further, a table **2550** illustrates coded data after the synthesis processing by the present behavior synthesizing unit. As illustrated in the table **2550**, the present behavior synthesizing unit **2401** generates synthesized data by synthesizing the coded data for each corresponding type label.

For example, the present behavior synthesizing unit **2401** synthesizes coded data (2, 2, 2, 1, 1) of "body-close-to" which coded data is included in SV_{mt1} and coded data (2, 2, . . . , 1, 1) of "body-close-to" which coded data is included in SV_{pc}. Synthesized data (2, 2, 2, 1, 1, 2, 2, . . . , 1, 1) is thereby generated.

Similarly, the present behavior synthesizing unit **2401** synthesizes coded data (1, 1, 1, 2, 1) of "body-far-to" which coded data is included in SV_{mt1} and coded data (2, 2, . . . , 1, 1) of "body-far-to" which coded data is included in SV_{pc}. Synthesized data (1, 1, 1, 2, 1, 2, 2, . . . , 1, 1) is thereby generated.

<Machine Avatar Image Update Processing>

A flow of machine avatar image update processing will next be described. FIG. **26** is a third flowchart of machine avatar image update processing. Incidentally, of respective processes illustrated in FIG. **26**, steps S**1401** to S**2203**, step S**1408**, and step S**1410** and step S**1411** are substantially the same as the respective corresponding processes in FIG. **22**. Description will therefore be omitted in the following.

In step S**2601**, the present behavior synthesizing unit **2401** synthesizes the social behavior log data of the machine avatar at a present time and in a most recent period and social behavior log data corresponding to candidate data extracted in the second candidate extracting unit **1602**. The present behavior synthesizing unit **2401** thereby generates synthesized data.

In step S**2602**, the updating unit **1603** retrieves coded data similar to the synthesized data in time periods referred to in step S**1408**. In addition, the updating unit **1603** determines whether or not the user **160** changed to a post desirable-change user state in time periods subsequent to the retrieved coded data. In addition, the updating unit **1603** evaluates the effectiveness of the synthesized data based on a result of the determination.

By thus evaluating the synthesized data, the sixth embodiment may increase a possibility of the communication partner user changing to the post desirable-change user state.

[Seventh Embodiment]

In the foregoing first to sixth embodiments, the monitoring unit **701** determines whether or not the user **160** has performed a particular non-verbal behavior by using a trigger checking API for monitoring target log data. On the other hand, a seventh embodiment separates monitoring target log data into a plurality of frequency bands by performing frequency analysis of the monitoring target log data, and determines whether or not a particular non-verbal behavior has been performed by using a trigger checking API for data in each of the frequency bands. The following description will be made of the seventh embodiment, centering mainly on differences from the first embodiment.

<Description of Functional Configuration of Action Instructing Unit and Respective DBs in Image Generating Device>

FIG. **27** is a fourth diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device. As illustrated in FIG. **27**, the action instructing unit **125** includes a frequency analyzing unit **2701** in addition to the respective parts illustrated in FIG. **7**. In addition, the definition information DB **133** has monitoring target definition information different from the monitoring target definition information **1100** illustrated in FIG. **11**.

The frequency analyzing unit **2701** performs frequency analysis of monitoring target log data, and separates the monitoring target log data into data in a high frequency band, data in a medium frequency band, and data in a low frequency band, for example. The frequency analyzing unit **2701** performs the frequency analysis by, for example, a method such as empirical mode decomposition (EMD). In addition, the frequency analyzing unit **2701** notifies the monitoring unit **701** of data in a frequency band suitable for detecting a particular non-verbal behavior of the user **160** in the separated monitoring target log data.

<Description of Monitoring Target Definition Information Stored in Definition Information DB>

FIG. **28** is a fourth diagram illustrating an example of definition information stored in a definition information DB, and is a diagram illustrating monitoring target definition information. Monitoring target definition information **2800** includes a "subtle behavior check" in addition to the information items included in the monitoring target definition information **1100**.

Defined as the "subtle behavior check" is information indicating whether or not to perform determination using data in a given frequency band in the monitoring target log data. "true" indicates that determination is performed using data in a given frequency band in the monitoring target log data. "false" indicates that determination is performed using the monitoring target log data (data before being separated into given frequency bands).

For example, in a fifth row of data rows of the monitoring target definition information **2800** in FIG. **28**, "Bone_Head" and "Bone_Chest" are defined as monitoring target log data, and "true" is defined for the "subtle behavior check."

Therefore, the monitoring unit **701** inputs data in each frequency band or a particular frequency band determined in advance with regard to "Bone_Head" and "Bone_Chest" to the trigger checking API="isRestles."

<Example of Frequency Analysis>

An example of the frequency analysis by the frequency analyzing unit **2701** will next be described. FIG. **29** is a diagram illustrating an example of frequency analysis by a frequency analyzing unit.

As illustrated in FIG. **29**, the frequency analyzing unit **2701**, for example, performs frequency analysis of time series data on the Y-coordinate position of "Bone_Chest" at a present time and in a most recent period (from time t_{1-5} to time t_1), and separates the time series data into data in a high frequency band, data in a medium frequency band, and data in a low frequency band.

Whether or not the output of "isRestles" is "true" for the user **160** (restless or uneasy state) depends on the data in the high frequency band. The monitoring unit **701** therefore performs a non-verbal behavior trigger check for the user **160** using the time series data in the high frequency band in the time series data of the Y-coordinate position of "Bone_Chest." For example, whether or not the output of "isRestles" is "true" is determined.

<Machine Avatar Image Update Processing>

A flow of machine avatar image update processing will next be described. FIG. **30** is a fourth flowchart of machine avatar image update processing. Incidentally, of respective processes illustrated in FIG. **30**, steps S**1401** to S**1411** are substantially the same as the respective corresponding processes in FIG. **14**. Description will therefore be omitted in the following.

In step S**3001**, the frequency analyzing unit **2701** performs frequency analysis of monitoring target log data, and separates the monitoring target log data into data in a high frequency band, data in a medium frequency band, and data in a low frequency band, for example. In addition, the frequency analyzing unit **2701** notifies the monitoring unit **701** of data in a frequency band (for example, the high frequency band) suitable for extracting a particular non-verbal behavior of the user **160** in the separated monitoring target log data.

Thus, the seventh embodiment judges the monitoring target log data using the data in the frequency band suitable for determining whether or not the user **160** has performed a particular non-verbal behavior. It is therefore possible to avoid a situation in which even though the user **160** performs a particular non-verbal behavior, the monitoring unit **701** overlooks the particular non-verbal behavior. For example, even in a case where another slow motion and a jittering motion occur simultaneously, it is possible to avoid a situation in which the monitoring unit **701** overlooks the jittering motion desired to be detected as a non-verbal behavior.

[Eighth Embodiment]

In the foregoing first to sixth embodiments, the monitoring unit **701** determines whether or not the user **160** has performed a particular non-verbal behavior using a trigger checking API for monitoring target log data. On the other hand, an eighth embodiment performs frequency analysis of monitoring target log data, and determines whether or not the user **160** has performed a particular non-verbal behavior by inputting the monitoring target log data to a trigger checking API after removing a steady non-verbal behavior. Incidentally, a steady non-verbal behavior refers to a motion caused by the pulsation of a heart or respiration. The following description will be made of the eighth embodiment, centering mainly on differences from the first embodiment.

<Description of Functional Configuration of Action Instructing Unit and Respective DBs in Image Generating Device>

FIG. **31** is a fifth diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device. As illustrated in FIG. **31**, the action instructing unit **125** includes a non-steady state extracting unit **3101** in addition to the respective parts illustrated in FIG. **7**. In addition, the definition information DB **133** has monitoring target definition information **3200** different from the monitoring target definition information **1100** illustrated in FIG. **11** and FIG. **27**.

The non-steady state extracting unit **3101** performs frequency analysis of monitoring target log data, and separates the monitoring target log data into data in a high frequency band, data in a medium frequency band, and data in a low frequency band, for example. The non-steady state extracting unit **3101** performs the frequency analysis by, for example, a method such as EMD. In addition, the non-steady state extracting unit **3101** removes data in a frequency band in which a steady non-verbal behavior tends to appear, the data having a type label in which a steady non-verbal behavior tends to appear, from the separated monitoring target log data, and then notifies resulting data to the monitoring unit **701**. For example, the non-steady state extracting unit **3101** extracts data including a non-steady non-verbal behavior from the monitoring target data, and notifies the data including the non-steady non-verbal behavior to the monitoring unit **701**.

Description will be made by citing a concrete example. The pulsation of a heart, for example, is between 60 beats to 80 beats per minute, and is included in a low frequency band around 1 [Hz]. On the other hand, of respective bones, "Bone_Chest" is a bone close to the position of the heart, and therefore the position coordinates of "Bone_Chest" tend to be affected by the pulsation of the heart. For example, time series data on the position coordinates of "Bone_Chest" may be said to be data having a type label in which a steady non-verbal behavior tends to appear.

Accordingly, the non-steady state extracting unit **3101** separates time series data on the position coordinates of "Bone_Chest" of a particular user into data in a high frequency band (IMF_{high}), data in a medium frequency band (IMF_{mid}), and data in a low frequency band (IMF_{low}). A steady non-verbal behavior is included in IMF_{low}. Thus, the non-steady state extracting unit **3101** removes IMF_{low}, and notifies IMF_{mid} and IMF_{high} to the monitoring unit **701**.

<Description of Monitoring Target Definition Information Stored in Definition Information DB>

FIG. **32** is a fifth diagram illustrating an example of definition information stored in a definition information DB, and is a diagram illustrating monitoring target definition information. The monitoring target definition information may be the monitoring target definition information **3200** in FIG. **31**. The monitoring target definition information **3200** includes "steady non-verbal behavior filtering" and a "steady non-verbal behavior frequency band" in addition to the information items included in the monitoring target definition information **1100**.

Defined as the "steady non-verbal behavior filtering" is whether or not to remove a given frequency band.

Defined as the "steady non-verbal behavior frequency band" is a frequency band to be removed. In a second row of data rows of the monitoring target definition information **3200** in FIG. **32**, "Bone_Head," "Bone_LeftShoulder," and "Bone_RightShoulder" are defined as monitoring target data. With regard to "Bone_Head" in the monitoring target data, the monitoring unit **701** inputs data before being separated into the given frequency bands to a trigger checking API="isNap." On the other hand, with regard to "Bone_LeftShoulder" and "Bone_RightShoulder," the monitoring unit **701** inputs data in the high frequency band and the medium frequency band to the trigger checking API="isNap." This is because a steady non-verbal behavior is included in data in the low frequency band.

In a fourth row of the data rows, "Bone_Head" and "Bone_Chest" are defined as monitoring target data. With regard to "Bone_Head" in the monitoring target data, the monitoring unit **701** inputs data before being separated into the given frequency bands to the trigger checking API="isRestles." On the other hand, with regard to "Bone_Chest," the monitoring unit **701** inputs data in the high frequency band and the medium frequency band to the trigger checking API="isNap." This is because a steady non-verbal behavior is included in the data in the low frequency band.

<Machine Avatar Image Update Processing>

A flow of machine avatar image update processing will next be described. FIG. **33** is a fifth flowchart of machine avatar image update processing. Incidentally, of respective processes illustrated in FIG. **33**, steps S**1401** to S**1411** are substantially the same as the respective corresponding processes in FIG. **14**. Description thereof will therefore be omitted in the following.

In step S**3301**, the non-steady state extracting unit **3101** performs frequency analysis of monitoring target log data, and separates the monitoring target log data into data in a high frequency band, data in a medium frequency band, and data in a low frequency band, for example. In addition, the non-steady state extracting unit **3101** removes data in a frequency band in which a steady non-verbal behavior tends to appear, the data having a type label in which a steady non-verbal behavior tends to appear, from the separated monitoring target log data, and then notifies resulting data to the monitoring unit **701**.

Thus, the eighth embodiment removes data in a frequency band in which a steady non-verbal behavior is included, and judges the monitoring target log data. It is therefore possible to avoid a situation in which a steady non-verbal behavior of the user **160** is erroneously determined to be a particular non-verbal behavior. In addition, as far as an objective of judging a non-verbal behavior is concerned, the presence or absence of a non-verbal behavior may be determined using input data from which a steady non-verbal behavior, which may be noise data, is removed. It is thus possible to improve determination accuracy.

[Ninth Embodiment]

The foregoing sixth embodiment generates synthesized data by synthesizing social behavior log data of the machine avatar at a present time and in a most recent period and social behavior log data corresponding to candidate data. On the other hand, in generating synthesized data, a ninth embodiment includes data on a switching action between most recent avatar display information log data of the machine avatar and candidate data. A switching action refers to a given action synthesized to provide a natural action when the most recent avatar display information log data of the machine avatar and the candidate data are synthesized. Switching actions include, for example, a blink, an action of long closing eyes, a sigh, a nod, an action of being reseated, and an action of touching the body with a hand.

It is thereby possible to reduce a feeling of strangeness between an image of the machine avatar at time t_{1+1} and an image of the machine avatar at time t_1 when the image of the

machine avatar at time t_{1+1} is displayed. The following description will be made of the ninth embodiment.

<Description of Functional Configuration of Action Instructing Unit and Respective DBs in Image Generating Device>

FIG. **34** is a sixth diagram illustrating a functional configuration of an action instructing unit and respective DBs in an image generating device. Differences from FIG. **7** lie in that a switching action synthesizing unit **3401** is provided and in that functions of an updating unit **3402** are different from functions of the updating unit **704**.

The switching action synthesizing unit **3401** synthesizes avatar display information log data of the machine avatar at a present time and in a most recent period, switching action data, and candidate data.

Here, suppose that coded data obtained by encoding the avatar display information log data of the machine avatar at the present time and in the most recent period (time t_{1-5} to time t_1) is "AB_{mt1}." In addition, suppose that coded data obtained by encoding the switching action data is "AB_{cc1}," and that coded data obtained by encoding the candidate data **1** (see FIG. **7**) is "AB_{pc}." The switching action synthesizing unit **3401** synthesizes "AB_{mt1}," "AB_{cc1}," and "AB_{pc}."

Description will be made by citing a concrete example with reference to FIG. **35**. FIG. **35** is a diagram illustrating details of synthesis processing by a switching action synthesizing unit. Suppose, for example, that coded data on the X-coordinate position of "Bone_Chest" in AB_{mt1}, AB_{cc1}, and AB_{pc} is 22222, no definition (XXX), and 22, . . . , 22, respectively (see tables **3510** and **3530**). In this case, synthesized data generated by the switching action synthesizing unit **3401** is 22222XX22, . . . , 22 (see a table **3540**).

Here, suppose that a total value "isBlink" of "Eyelid_Shape" is defined as a switching action (see a table **3520**). The total value "isBlink" of "Eyelid_Shape" refers to a value expressing a blinking state in a range of zero to one from a positional state of a mesh on the periphery of eyes, with a closed state of eyelids as zero and an opened state of eyelids as one.

In this case, no definition for the position coordinates of Bone_Chest is provided as a switching action. Therefore, coded data indicating that no action is to be performed is automatically inserted in the part of "XXX."

However, when no definition for the position coordinates of Bone_Chest is provided as a switching action, coded data indicating that some action is to be performed may be automatically inserted in the part of "XXX." For example, last coded data ("2") of AB_{mt1} and first coded data ("2") of AB_{pc} may be duplicated as respective halves, and automatically inserted. Alternatively, an average value ("2") of last coded data ("1") of AB_{mt1} and first coded data ("3") of AB_{pc} may be duplicated and automatically inserted.

The updating unit **3402** evaluates the effectiveness of the synthesized data generated by the switching action synthesizing unit **3401**, and generates an image of the machine avatar at time t_{1+1} based on switching action data and candidate data corresponding to synthesized data evaluated as effective.

Here, suppose that coded data indicating that no action is to be performed is automatically inserted in the part of the switching action ("XXX") when the switching action synthesizing unit **3401** generates synthesized data. In this case, the updating unit **3402** inserts data indicating a standard action of the machine avatar. A standard action of the machine avatar refers to, for example, an action of lowering both arms and swaying while relaxed.

The updating unit **3402** replaces all of the switching action ("XXX") by the standard action. Alternatively, the updating unit **3402** may replace a first half part of the switching action by an action for realizing natural switching between the non-verbal behavior at the present time and in the most recent period and the first half part of the switching action. In addition, the updating unit **3402** may replace a second half part of the switching action by an action for realizing natural switching between the second half part of the switching action and the non-verbal behavior at time t_{1+1}.

In addition, suppose that when the switching action synthesizing unit **3401** generates synthesized data, the switching action synthesizing unit **3401** duplicates and automatically inserts the last coded data ("2") of AB_{mt1} and the first coded data ("2") of AB_{pc} as respective halves in the part of the switching action ("XXX"). In this case, the updating unit **3402** duplicates avatar display information log data corresponding to the duplicated coded data, and inserts the avatar display information log data as switching action data.

In addition, the updating unit **3402** selects an appropriate switching action from among a plurality of switching actions. For example, the updating unit **3402** calculates degrees of similarity between synthesized data including the switching actions and synthesized data not including the switching actions, and selects a switching action corresponding to a higher degree of similarity. Further, the updating unit **3402** uses the switching action and candidate data corresponding to the synthesized data including the selected switching action when generating an image of the machine avatar at time t_{1+1}. Thus, the image of the machine avatar at time t_{1+1} may be generated based on the synthesized data in which the inclusion of the switching action produces a smaller effect.

For example, suppose that the synthesized data including the switching actions is $AB_{mt1}+AB_{cc1}+AB_{pc}$ and $AB_{mt1}+AB_{cc2}+AB_{pc}$. In addition, suppose that the synthesized data not including the switching actions is $AB_{mt1}+AB_{pc}$. In this case, the updating unit **3402** calculates both a degree of similarity between $AB_{mt1}+AB_{cc1}+AB_{pc}$ and $AB_{mt1}+AB_{pc}$ and a degree of similarity between $AB_{mt1}+AB_{cc2}+AB_{pc}$ and $AB_{mt1}+AB_{pc}$.

Here, the updating unit **3402** calculates the degrees of similarity using coded data obtained by encoding social behavior log data. Incidentally, there may be a mode in which the degrees of similarity of the non-verbal behaviors are calculated for each bone or each social behavior by comparison of time series data of avatar bones. The following description will be made of a case where the degree of similarity between $AB_{mt1}+AB_{cc1}+AB_{pc}$ and $AB_{mt1}+AB_{pc}$ and the degree of similarity between $AB_{mt1}+AB_{cc2}+AB_{pc}$ and $AB_{mt1}+AB_{pc}$ are calculated using coded data obtained by encoding social behavior log data as illustrated in the fifth embodiment. Incidentally, because AB_{mt1} and AB_{pc} are common coded data, the updating unit **3402** calculates a degree of similarity between $AB_{mt1}+AB_{pc}$ and AB_{cc1} and a degree of similarity between $AB_{mt1}+AB_{pc}$ and AB_{cc2}. In addition, suppose that AB_{cc1} and AB_{cc2} are generated based on last coded data included in AB_{mt1} and first coded data included in AB_{pc}, and AB_{cc1} and AB_{cc2} will be described as AB_{cc1}' and AB_{cc2}' in the following.

The updating unit **3402** calculates a distance between the ratio of an approaching tendency of $AB_{mt1}+AB_{pc}$ and the ratio of an approaching tendency of AB_{cc1}'. Here, suppose that −0.2 is calculated as the distance between the ratio of the approaching tendency of $AB_{mt1}+AB_{pc}$ and the ratio of the approaching tendency of AB_{cc1}'. In addition, the updating

unit **3402** calculates a distance between the ratio of an avoiding tendency of $AB_{mt1}+AB_{pc}$ and the ratio of an avoiding tendency of AB_{cc1}'. Here, suppose that 0.15 is calculated as the distance between the ratio of the avoiding tendency of $AB_{mt1}+AB_{pc}$ and the ratio of the avoiding tendency of AB_{cc1}'.

Next, the updating unit **3402** calculates a distance between the ratio of the approaching tendency of $AB_{mt1}+AB_{pc}$ and the ratio of an approaching tendency of AB_{cc2}'. Here, suppose that −0.3 is calculated as the distance between the ratio of the approaching tendency of $AB_{mt1}+AB_{pc}$ and the ratio of the approaching tendency of AB_{cc2}'. In addition, the updating unit **3402** calculates a distance between the ratio of the avoiding tendency of $AB_{mt1}+AB_{pc}$ and the ratio of an avoiding tendency of AB_{cc2}'. Here, suppose that 0.10 is calculated as the distance between the ratio of the avoiding tendency of $AB_{mt1}+AB_{pc}$ and the ratio of the avoiding tendency of AB_{cc2}'.

Supposing that Degree of Similarity=1−((|Approaching Tendency Distance|+|Avoiding Tendency Distance|)/2), the degree of similarity between $AB_{mt1}+AB_{cc1}'+AB_{pc}$ and $AB_{mt1}+AB_{pc}$ is 1−((|−0.2|+|0.15|)/2)=0.825. In addition, the degree of similarity between $AB_{mt1}+AB_{cc2}'+AB_{pc}$ and $AB_{mt1}+AB_{pc}$ is 1−((|−0.3|+|0.10|)/2)=0.8.

Consequently, the updating unit **3402** selects AB_{cc1}' as an appropriate switching action. Further, the updating unit **3402** generates an image of the machine avatar at time t_{1+1} based on $AB_{cc1}f+AB_{pc}$ including AB_{cc1}' as the appropriate switching action data and the candidate data AB_{pc}.

<Machine Avatar Image Update Processing>

A flow of machine avatar image update processing will next be described. FIG. **36** is a sixth flowchart of machine avatar image update processing. Incidentally, of respective processes illustrated in FIG. **36**, steps S**1401** to S**1408** and steps S**1410** and S**1411** are substantially the same as the respective corresponding processes in FIG. **14**. Description will therefore be omitted in the following.

In step S**3601**, the switching action synthesizing unit **3401** generates synthesized data by synthesizing the avatar display information log data of the machine avatar at the present time and in the most recent period, switching action data, and candidate data.

In step S**3602**, the updating unit **3402** evaluates the effectiveness of the synthesized data.

By thus including appropriate switching action data to generate an image of the machine avatar, the ninth embodiment may reduce a feeling of strangeness between the image of the machine avatar at time t_{1+1} and the image of the machine avatar at time t_1 when displaying the image of the machine avatar at time t_{1+1}.

It is to be noted that the present technology is not limited to the configurations illustrated herein. For example, the configurations cited in the foregoing embodiments may be combined with other elements. In these respects, the present technology may be changed without departing from the spirit of the present technology, and may be defined appropriately according to modes of application thereof.

All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. An action control method executed by a computer, the method comprising:

detecting, on the basis of data obtained by a sensor, a first state of a first user in communication with a first machine avatar;

extracting candidate data, from action history data, in which any user was in the first state;

selecting a time period from a start time to a detection time that the detecting detects the first state of the first user;

excluding one or more actions from the candidate data, the excluded one or more actions having taken place before the selected time period;

identifying an action from the candidate data in which the one or more actions are excluded, the identified action being an action resulting in the any user changing from the first state to a second state; and

causing the first machine avatar to take an action corresponding to the identified action.

2. The action control method according to claim **1**, wherein the first state is non-verbal behavior.

3. The action control method according to claim **1**, wherein the second state is a desirable non-verbal behavior for responding to the identified action.

4. The action control method according to claim **1**, wherein the second state is a desirable social behavior for responding to the identified action.

5. The action control method according to claim **1**, wherein

the first state is detected by monitoring a particular action in a given frequency band among actions performed by the first user.

6. The action control method according to claim **1**, wherein

the first state is detected by monitoring a particular action not in a given frequency band among actions performed by the first user.

7. The action control method according to claim **1**, wherein the one or more excluded actions are actions in which the any user is not in a desirable state for responding to the identified action.

8. The action control method according to claim **1**, wherein the time period is a time period before the detection time.

9. The action control method according to claim **1**, wherein the excluding includes calculating ratios for the candidate data relating to the any user changing from the first state to the second state, and the identifying being based on the calculated ratios.

10. The action control method according to claim **1**, wherein the identifying includes synthesizing a candidate action and a switching action, the candidate action being specified based on the excluding.

11. An action control device comprising:

a memory; and

a processor coupled to the memory and the processor configured to:

detect, on the basis of data obtained by a sensor, a first state of a first user in communication with a first machine avatar;

extract candidate data, from action history data, in which any user was in the first state;

select a time period from a start time to a detection time that the detecting detects the first state of the first user;

exclude one or more actions from the candidate data, the excluded one or more actions having taken place before the selected time period;

identify an action from the candidate data in which the one or more actions are excluded, the identified action being an action resulting in the any user changing from the first state to a second state; and

cause the first machine avatar to take an action corresponding to the identified action.

12. The action control device according to claim **11**, wherein the first state is non-verbal behavior.

13. The action control device according to claim **11**, wherein the second state is a desirable non-verbal behavior for responding to the identified action.

14. The action control device according to claim **11**, wherein the second state is a desirable social behavior for responding to the identified action.

15. The action control device according to claim **11**, wherein

the first state is detected by monitoring a particular action in a given frequency band among actions performed by the first user.

16. The action control device according to claim **11**, wherein

the first state is detected by monitoring a particular action not in a given frequency band among actions performed by the first user.

17. The action control device according to claim **11**, wherein the one or more excluded actions include actions in which the any user is not in a desirable state for responding to the identified action.

18. A non-transitory computer-readable storage medium storing an action control program that causes a computer to execute a process comprising:

detecting, on the basis of data obtained by a sensor, a first state of a first user in communication with a first machine avatar;

extracting candidate data, from action history data, in which any user was in the first state;

selecting a time period from a start time to a detection time that the detecting detects the first state of the first user;

excluding one or more actions from the candidate data, the excluded one or more actions having taken place before the selected time period;

identifying an action from the candidate data in which the one or more actions are excluded, the identified action being an action resulting in the any user changing from the first state to a second state; and

causing the first machine avatar to take an action corresponding to the identified action.

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