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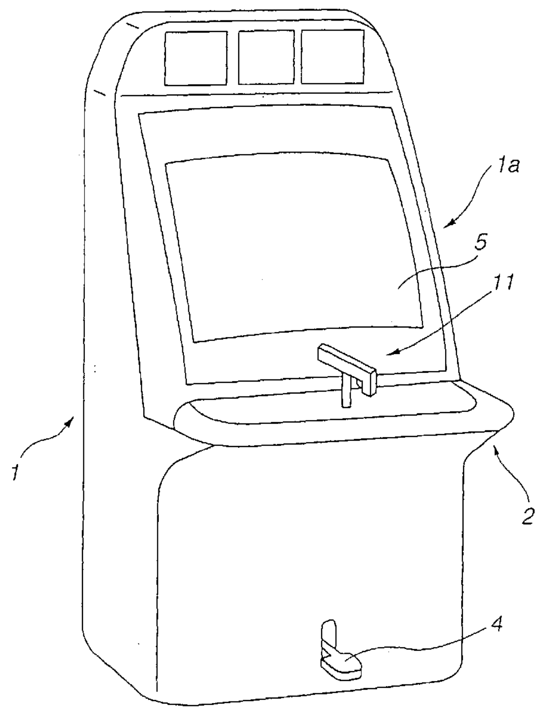
(54) **Image generating device for an Ego Shooter game**

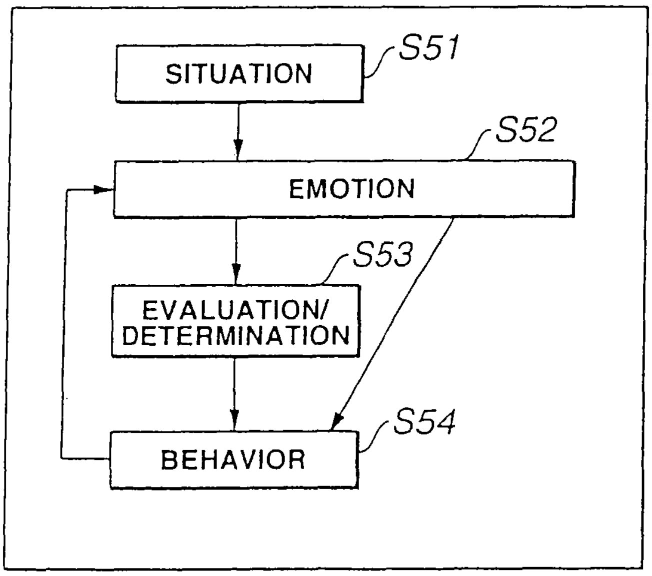
(57) An image generating device for displaying on a display (1a) images for a player to play a gun shooting game with an enemy character existing in a virtual game space. The image generating device comprises: AI (artificial intelligence) processing means (101) for executing AI processing (steps S8/S9) incorporating emotions of said character influenced between circumstances, evaluation/determination, and factors of behaviors in said game.

FIG.1



EP 1 829 590 A2

FIG.13


SITUATION
S51
S52
EMOTION
S53
EVALUATION/
DETERMINATION
S54
BEHAVIOR

Description

Technical Field

[0001] The present invention relates to an image generating device. Particularly, this invention relates to an image generating device suitable for gun shooting games and the like, wherein essential is the movement control of a movable object to be moved within a virtual three-dimensional space and a camera viewpoint (i.e., monitor image) within such space for making the image follow this movable object.

Background Art

[0002] Pursuant to the development of computer graphics technology in recent years, simulation devices and game devices have become widely popular for both business and domestic use. As one type of game device, there is a gun shooting game (gun game) for shooting down targets (enemies) moving in a virtual space, and has gained deep-rooted popularity.

[0003] This game device is usually equipped with a gun unit, CPU for graphics processing, monitor, and so on. When a player operates the trigger of the gun unit upon aiming at the enemy appearing on the monitor screen, the CPU detects the position on the monitor screen of the light signal fired from the gun unit and performs image processing inclusive of processing for defeating the enemy based on this position data.

[0004] As one representative gun shooting game heretofore, there is "Virtua Cop (trademark)" manufactured by SEGA ENTERPRISES, LTD. This is a gun game where players compete for scores by using a gun unit and shooting down the enemies appearing in the virtual three-dimensional space (game space) on the monitor screen. In this game, the enemies appear at predetermined positions in a predetermined timing on the monitor screen. When the player aims the gun unit at the enemy, the viewpoint on the monitor screen approaches the enemy and such enemy is enlarged and displayed on the monitor screen. Movements of the enemy are controlled by the CPU of the device pursuant to prescribed programs and, as necessary, are set to make an attack toward the player viewing the monitor screen.

[0005] Nevertheless, as a result of the various studies conducted by the present inventors regarding conventional gun shooting games, they have discovered that recent demands of extremely real and ambient games, which also heighten the interest thereof, have not been fulfilled heretofore in a sufficient manner.

(1) For example, in conventional gun shooting games, there is a problem when the enemy makes an attack toward the player. When an enemy fires a bullet pursuant to the CPU control, the player is in a "dangerous situation" (situation of being hunted by the enemy) in the game. Nevertheless, conventionally, as the front area of the enemy is smallest when such enemy is hunting the player, such player had difficulty recognizing that he/she is facing a "dangerous situation" merely by the image of the enemy. Therefore, the player would perceive the feeling of being suddenly defeated by the enemy, and unnaturalness in comparison to a game in the real world.
In order to avoid the above, there are conventional devices which employ a method of displaying a mark on the monitor screen to make the player recognize that he/she is in a "dangerous situation." This, however, is too artificial and is unable to provide a natural game feeling.

(2) Secondly, it was not possible to move the camera viewpoint (i.e., viewpoint of the monitor screen viewed by the player) properly so as to follow the enemy without losing sight of the enemy. For example, when the moving speed of the enemy is fast, or when there is a plurality of enemies, as the rotation of conventional camera viewpoints was too abrupt, there was a problem in that the player would lose sight of the enemy on the screen.

(3) Moreover, in conventional gun shooting games, it is necessary to have a rule base corresponding to all situations in order to control the behaviors of people. Therefore, for instance, in order not to make a character behave unnaturally such as "calmly counterattacking immediately after having been scared until then", it was necessary to prepare rules for the connection between such behavior (result) and cause and to priorly store the same as a database. Accordingly, time and labor were required for the development of such database, and there was a problem in that the development costs would rise. Further, as it is stored as a database, there was a problem in that it is difficult to discover errors in the stored information. In addition, the memory capacity for the database had to be increased.

(4) Moreover, structures other than the movable object, such as walls and obstacles, were not moved in conventional gun shooting games. Therefore, collision (contact) judgment between a bullet and such structures was made on the premise that the structure is always located at a fixed position on the game space. Although this will provide a precise image, this is insufficient in terms of producing powerfulness upon a collision or dynamic game developments from the perspective of improving the amusement of the game.

(5) Moreover, in conventional gun shooting games, there were various problems in that the movement of parts structuring the character or the movement between the motions of the characters lacking reality. For example, conventionally, upon being hit by a bullet, the mere motion of collapsing was made. But actually, desired is a presentation of reactions upon being hit by a bullet or expressions such as "I'm hit, but not dead yet!" and so on. Further, there was also dissatisfaction in terms of reducing the operational load of character movements between one motion and the next motion as well as making such movements smooth.

SUMMARY OF THE INVENTION

[0006] The present invention was devised in view of the aforementioned problems encountered by the conventional art, and the main object thereof is to provide an image generating device suitable for gun shooting games and the like, having abundant realism and ambience than conventionally, and which does not suffer the operational processing in comparison to conventional devices.

[0007] Further, another object of the present invention is to increase the ambience and considerably enhance the interest in the game feeling and game amusement by making the player recognize the "dangerous situation" with accuracy.

[0008] Moreover, still another object of the present invention is to provide a game device suitable for gun shooting games and the like and which substantially enhances the interest in the game feeling and game amusement by making the camera viewpoint move properly with the movement of the enemy without losing sight of such enemy.

[0009] Moreover, a further object of the present invention is to provide a game device suitable for gun shooting games and the like and which makes a character have elements of "behaviors" resulting from "emotions" upon controlling the action of the character, and which is abundant in realism and ambience without increasing the operational load than conventionally.

[0010] Still a further object of the present invention is to provide a game device capable of making the collision with structures other than the movable object, such as walls and obstacles, to be impressive, realizing dynamic game developments, increasing ambience, and considerably enhancing the game feeling and interest in the game.

[0011] Yet another object of the present invention is to provide a game device suitable for gun shooting games and the like, capable of improving the realism in the movement of parts structuring the character or the movement between the motions of the characters, increasing realism and ambience, and which does not suffer the operational processing in comparison to conventional devices.

[0012] In order to achieve the aforementioned objects, the image generating device according to the present invention is structured as follows.

[0013] The first structure is an image generating device for generating images capturing a movable object moving within a virtual three-dimensional space from a movable viewpoint in the virtual three-dimensional space, the image generating device comprising: movement means for controlling the movement of the camera viewpoint upon utilizing the position relationship between the observable point set in relation to the movable body and the line of sight from the current camera viewpoint. Preferably, the virtual three-dimensional space is a game space, and the movable body is an enemy in a gun shooting game enacting in the game space. More preferably, the image generating device further comprises: display means for displaying the game space on a screen; a gun unit capable of producing signals toward the screen by the player manipulating the trigger; a sensor for detecting the arrival position of the signals on the screen of the display means; and game implementing means for implementing a gun shooting game between the enemy and player based on the arrival position.

[0014] For example, the position of the observable point is at a different position than that of the movable body, and the image generating device further comprises: observable point moving means for moving this observable point toward the movable body for each display of one frame of the image. The observable point moving means is means for moving, for each display of one frame of the image and along the straight line distance connecting the observable point and the position of the movable object, the observable point toward the movable object in prescribed distances of the direct distance thereof. The observable point moving means comprises: means for operating the open angle between the current line of sight extending from the camera viewpoint and the line extending from the camera viewpoint through the observable point; means for operating a prescribed rotational angle from such open angle; and means for rotating, for each display of one frame of the image, the camera viewpoint toward the observable point side at the rotational angle.

[0015] Preferably, the moving means comprises: judging means for judging the occurrence of specific circumstances of the relative position relationship between the camera viewpoint, which changes in accordance with manipulations of the player, and the observable point; and viewpoint movement control means for controlling the position of the camera viewpoint so as to continuously capture the position of the observable point when it is judged as a specific circumstance by the judging means. For example, the viewpoint movement control means is means for performing position control pursuant to movement motion for moving the camera viewpoint, and rotational motion in accordance with the angle formed by the direction toward the observable point from the position of the camera viewpoint after the movement and the line-of-sight direction of the camera viewpoint before the movement. For instance, the viewpoint movement control means includes viewpoint rotation means for rotating the camera viewpoint toward the observable point side in accordance with the angle. As one example, the viewpoint rotation means is means for rotating the camera viewpoint toward the observable point side based on an angle in which the angle is increased/decreased a prescribed value. Thereby, the observable point may be moved slightly on the screen, and it is possible to actively provide to the player a sense of movement and circling around. Further provided is avoidance manipulation means for a player to manipulate the character, which is a simulation of such player on a screen, to avoid the bullet fired from the enemy; wherein the judging means is means for judging whether the avoidance manipulation means is in a manipulative state or not.

[0016] The second structure of the present invention is an image generating device for displaying on a display images for a player to play a gun shooting game with an enemy character existing in a virtual game space, the image generating device comprising: image processing means for performing image display suggesting in advance to the player an attack made by the enemy character to the player. Preferably, the image display is a display of a bullet fired from the enemy character and flying toward the player in the actual space. The display of the bullet is, for example, a display of the bullet flying in an arc.

[0017] The third structure of the present invention is an image generating device for displaying on a display images for a player to play a gun shooting game with an enemy character existing in a virtual game space, the image generating device comprising: AI processing means for executing AI processing incorporating emotions of the character influenced between circumstances, evaluation/determination, and factors of behaviors in the game. For example, the factors of emotions are represented by emotional elements of fear and anger in relation to the game. Preferably, the AI processing means includes means for performing processing to reflect the results of behavior based on the factors of behaviors to the factors of emotions.

[0018] The fourth structure of the present invention is an image generating device for generating images by representing a movable object simulating a person and moving inside a virtual three-dimensional space as a plurality of parts connected via connection points, the image generating device comprising: first specifying means for specifying a subpart on the terminal side and a main part on the central side with respect to two adjacent parts among the plurality of parts; first operating means for operating the impulse of the subpart motion communicated to the main part under the presumption that the connection point of the subpart to the main part is a fixed point; first repeating means for repeating, in a recurring manner, the movements of the first specifying means and the first operating means from the terminal side of the movable object to the central side thereof; second specifying means for specifying a main part on the central side and a subpart on the terminal side with respect to two adjacent parts among the plurality of parts; second operating means for operating the impulse of the main part motion communicated to the subpart; and second repeating means for repeating, in a recurring manner, the movements of the second specifying means and the second operating means from the central side of the movable object to the terminal side thereof.

[0019] In this fourth structure, at least one of the first and second operating means is means for executing seasoning-like operational processing upon simulating the person. For example, the seasoning-like operational processing includes at least one of, or a plurality of operations among: operation for applying a reverse moment, which is caused pursuant to restrictions of the movement of joints of the person, to the parts; operation for reflecting the external force inflicted on the person to the parts; operation for correcting the unnaturalness of the position of the parts caused pursuant to differences in calculations; operation for applying the internal force moment caused by physical characteristics of the person to the parts; and control operation of the rotation or movement speed of the parts for reflecting expressions caused by the mentality of the person to the parts.

[0020] The fifth structure of the present invention is an image generating device for generating image data which interpolates the motion between two types of motions of the movable object moving within a virtual three-dimensional space; comprising: operating means for discretely operating the function curve of the motion between the two types of motions pursuant to the current rotational angle, target rotational angle, and number of frames required to reach the target rotational angle; and interpolation means for performing motion interpolation based on the operational results of the operating means.

[0021] The sixth structure of the present invention is an image generating device for generating images requiring the collision judgment between a movable object moving within a virtual three-dimensional space and a structural object arranged in the space, comprising collision judgment means for judging the collision with the movable object while moving the structural object. Preferably, the collision judgment means is means for judging the collision while moving the structural object in either parallel movement or rotational movement.

[0022] The present invention is also a storage medium storing a program for executing the respective means of the image generating device. A storage medium is any medium having stored therein information (mainly digital data and programs) by some physical means, and is capable of making processing devices such as computers and dedicated processors execute prescribed functions. In other words, any means capable of downloading a program onto a computer and executing prescribed functions will suffice.

[0023] For example, this would include a flexible disk, hard disk, magnetic tape, magnetic disk, CD, CD-ROM, DVD-RAM, DVD-ROM, DVD-R, PD, NID, DCC, ROM cartridge, RAM memory card with battery backup, flash memory cartridge, non-volatile RAM cartridge, and so forth.

[0024] Cases of receiving data transfer from a host computer via wire- or radio-communication circuits (public circuits, data-dedicated circuits, satellite circuits, etc.) shall also be included in the above. The so-called Internet is also included in the storage medium described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Fig. 1 is an overall perspective view of the game device as the image generating device according to one embodiment of the present invention. Fig. 2 is an electrical block diagram of the game processing board. Fig. 3 is a conceptual diagram showing an example of the game space. Fig. 4 is a diagram showing a typical example of a game screen to be displayed on the display. Fig. 5 is a schematic flowchart of the main routine processing executed by the CPU. Fig. 6 is a schematic flowchart of the subroutine showing the camera viewpoint movement control processing. Fig. 7 is a diagram explaining the camera viewpoint movement control. Fig. 8 is a diagram explaining the camera viewpoint movement control. Fig. 9 is a diagram explaining the camera viewpoint movement control. Fig. 10 is a diagram explaining the camera viewpoint movement control. Fig. 11 is a schematic flowchart of the subroutine showing the attack suggestion processing. Fig. 12 is a diagram showing an example of a game screen according to the attack suggestion processing. Fig. 13 is a schematic flowchart of a subroutine showing the emotion/motion AI processing. Fig. 14 is a diagram explaining a two-dimensional representation of the emotion factor. Fig. 15 is a schematic flowchart of a subroutine showing the AI processing for comparative explanation. Fig. 16 is a schematic flowchart of a subroutine showing the real-time dynamics motion calculation processing. Fig. 17 is a diagram representing a person structured of a plurality of parts. Fig. 18 is a schematic flowchart of a subroutine showing the non-linear discrete motion interpolation processing. Fig. 19 is a diagram showing an example of a functional curve of linear interpolation, which is conventional motion interpolation. Fig. 20 is a diagram showing an example of a functional curve of three-dimensional curve interpolation, which is another conventional motion interpolation. Fig. 21 is a graph showing the steps of non-linear discrete motion interpolation processing. Fig. 22 is a schematic flowchart of a subroutine showing the collision movement control processing. Fig. 23 is a diagram explaining the collision judgment of a fixed collision plane. Fig. 24 is a diagram explaining the collision judgment of a parallel movement collision plane. Fig. 25 is a diagram explaining one step of the collision judgment of a rotational movement collision plane . Fig. 26 is a diagram explaining one step of the collision judgment of the rotational movement collision plane. Fig. 27 is a diagram explaining one step of the collision judgment of the rotational movement collision plane.

BEST MODE FOR CARRYING OUT THE INVENTION

[0026] One embodiment of the present invention is now explained with reference to the drawings.

[0027] Fig. 1 shows an example of the appearance of the game device as the image generating device of the present invention. This game device executes a gun shooting game for shooting down targets (enemies) moving in a virtual game space.

[0028] As shown in Fig. 1, the game device comprises a device main body 1 . The device main body 1 has an overall box-like shape and comprises a display 1a at the front face thereof. A speaker 14 described later is mounted on the side of the display 1a.

[0029] On the front face of the device main body 1 is provided a manipulation panel 2 positioned to be below the display 1a. A gun unit 11 comprising a trigger to be manipulated by a player is mounted on the manipulation panel 2. By the player pulling (manipulating) the trigger of the gun unit 11, light signals from the gun unit 11 are emitted toward the display 1a. Further, at the lower part of the device main body 1, provided is a pedal sensor 4 as avoidance manipulation means to be manipulated by the player. This pedal sensor 4 is used for moving the character on the display screen simulating the player himself/herself in order to avoid the bullet, and so on. The detection information of this pedal sensor 4 is sent to the game processing board explained later. A manual switch or manual lever may be used instead of this pedal sensor.

[0030] A position sensor 5 for detecting the entering position of the light signal from the gun unit 11 is provided on the display screen of the display 1a. The position sensor 5 forms a part of the gun unit 11. The detected information of this position sensor 5 is sent to the game processing board explained later.

[0031] A game processing board is internally provided to the device main body 1. Devices such as a display la, pedal sensor 4, position sensor 5, output devices 12 such as indicators, speaker 14, etc. are electrically connected to this game processing board. The player plays a gun shooting game by manipulating the gun unit 11 while viewing the game screen displayed on the display 1a.

[0032] Fig. 2 shows a block diagram of the game device according to the present embodiment. As shown in Fig. 2, the game processing board 10 comprises a counter 100, CPU (central processing unit) 101, ROM 102, RAM 103, sound device 104, I/O interface 106, scroll data operation device 107, coprocessor (auxiliary operational processing device) 108, diagram data ROM 109, geometrizer 110, shape data ROM 111, drawing device 112, texture data ROM 113, texture map RAM 114, frame buffer 115, image synthesizing device 116, and D/A converter 117.

[0033] Among the above, the CPU 101 is connected, via a bus line, to the ROM 102 storing prescribed programs or image processing programs, RAM 103 storing operational data, sound device 104, I/O interface 106, scroll data operation device 107, coprocessor 108, and geometrizer 110. The RAM 103 functions as a buffer, and is used to write various commands (display of objects, etc.) to the geometrizer and to write necessary data upon various operations.

[0034] The I/O interface 106 is connected to the pedal sensor 4 and position sensor 5, and detection signals of both sensors are written into the CPU 101 as digital values. The sound device 104 is connected to the speaker 14 via a power amplifier 105. Thereby, sound signals generated by the sound device 104 are power amplified and output as sounds from the speaker 14.

[0035] Based on the program built in the ROM 102, the CPU 101 reads manipulation signals from the gun unit 11 and landform data from the landform data ROM 109, and shape data (three dimensional data, e.g., "characters such as enemies" and "backgrounds such as landforms, sky, and various structural buildings") from the shape data ROM 111 , and performs operations including the behavior calculation (simulation) of characters and calculation of special effects.

[0036] Behavior calculation is for simulating the movement of enemies in the virtual three-dimensional space (game space). In order to implement the above, after the enemy polygon coordinate values in the virtual three-dimensional space are determined, a conversion matrix for converting these coordinate values into a two-dimensional visual field coordinate system and shape data (polygon data) are designated by the geometrizer 110. The landform data ROM 109 is connected to the coprocessor 10.8 and predetermined landform data is delivered to the coprocessor 108 and CPU 101. The coprocessor 108 mainly undertakes the operation of floating decimal points. Thus, as various judgments are executed with the coprocessor 108 and the judgment results are provided to the CPU 101, the operational load of the CPU is lightened.

[0037] The geometrizer 110 is connected to the shape data ROM 111 and drawing device 112. As mentioned above, priorly stored in the shape data ROM 111 is shape data formed of a plurality of polygons (three-dimensional data such as characters, landforms, backgrounds, etc. formed of the respective apexes). This shape data is delivered to the geometrizer 110. The geometrizer 110 conducts perspective conversion to the designated shape data with the conversion matrix sent from the CPU 101, and obtains data converted from the coordinate system in the three-dimensional space into a visual field coordinate system.

[0038] The drawing device 112 affixes texture to the shape data of the converted visual field coordinate system, and outputs this to the frame buffer 115. In order to affix this texture, the drawing device 112 is connected to the texture data ROM 113 and texture map RAM 114 as well as to the frame buffer 115.

[0039] Here, polygon data shall mean coordinate data groups relative to the respective apexes or of absolute coordinates of polygons (polygonal: mainly triangles and quadrilaterals) composed of a plurality of apexes. Stored in the landform data ROM 109 is polygon data set to be relatively rough but sufficient in implementing prescribed judgments (collision judgments, etc.) . Meanwhile, stored in the shape data ROM 111 is polygon data set to be more precise in relation to the shape structuring screens such as enemies and backgrounds.

[0040] The scroll data operation device 107 calculates data (stored in the ROM 102) of scroll screens such as characters. This operation device 107 and frame buffer 115 arrive at the display 1a via the image synthesizing device 116 and D/A converter 117. Thereby, polygon screens (simulation results) of enemies and landforms (backgrounds) temporarily stored in the frame buffer 115 and scroll screens such as character information and so on are synthesized in accordance with the designated priority, and a final frame image data is generated for each fixed timing. This frame image data is converted into analogue signals at the D/A converter 117 and sent to the display la, and displayed as a game screen in real time.

[0041] This game device conducts a gun shooting game by the operational processing described later mainly with the CPU 101 . Fig. 3 shows a conceptual diagram of a game space provided by this game device. Fig. 4 shows a typical example of a game screen of the display 1a.

[0042] In Fig. 3, the game space is formed of a virtual three-dimensional space, and includes an enemy (movable body) 3a, obstacle (structural object) 3b, camera viewpoint 3c, bullet (movable body) 3d, and so on. The enemy 3a is a target which the player hunts and, pursuant to the CPU control on the device side, autonomously moves while avoiding the bullet fired, via the gun unit 11, by the player simulated at the position of the camera viewpoint, and makes an attack (fires bullets) to the player simulated at the position of the camera viewpoint. The camera viewpoint 3a is the viewpoint of the player, and, for example, is provided on a flying object such as a helicopter. This viewpoint moves in the game space while following the movement of the enemy. Further, a plurality of enemies 3a exist in the game space. The obstacle 3b may be structures such as a container, building, or wall and is provided to give variation to the game. The enemy 3a and camera viewpoint 3c move in the game space while avoiding the collision with such obstacle 3b.

[0043] In Fig. 4, the game screen corresponds to the composition viewed from the camera viewpoint 3c of Fig. 3. A sight 3e is displayed on the game screen. This sight 3e moves pursuant to the player changing the direction of the gun unit 11. When the sight 3e overlaps with the enemy 3a and the player pulls the trigger of the gun unit 11, a bullet 3d is fired toward the enemy 3a.

(Working)

[Main Routine Processing]

[0044] Next, explained is the image generation processing of the gun shooting game of the game device according to the present embodiment. Fig. 5 shows the main routine of the image generation processing. This main routine, for example, is repeatedly executed with the CPU 101 for each one field (1/60 seconds) synchronized with the display interrupt.

[0045] Foremost, the CPU 101 reads information of the pedal sensor 4, trigger of the gun unit 11, in other words, the position sensor 5 (step S1).

[0046] Next, the CPU 101 judges whether the target enemy has been decided or not (step S2). If decided, the next enemy determination processing (step S3) is skipped, and an enemy to be the viewpoint target among the plurality of enemies is determined as a predetermined enemy by the system side since a target enemy is not decided in the initial state of the game (step S3). Thereby, at the initial stage of the game, a game space with the predetermined enemy in the center is displayed on the display 1a. The target enemy, however, will change in accordance with the game progress.

[0047] Then, the CPU 101 successively executes the processing from steps S4 to S12 . These processing steps are characteristic to the present invention.

[0048] First, performed is the processing for moving the camera viewpoint toward the decided or previously determined target enemy (steps S4, S5) . Thereby, when the target enemy deviates from the camera viewpoint, the camera viewpoint follows this enemy. The camera viewpoint is moved such that the composition of the enemy on the display is at an optimum position. The processing of moving the camera viewpoint is explained later.

[0049] Further, processing for suggesting to the player an attack from the enemy is executed (steps S6, S7). As the enemy controlled by the system side is hunting the player, this is to make the player priorly recognize that he/she is in a situation of a "dangerous state". This attack suggestion processing is also explained later.

[0050] Moreover, processing referred to as "emotion/motion AI (artificial intelligence) processing" is executed (steps S8, S9). This emotion/motion AI processing is processing for simulating the emotions of human beings in a more realistic manner by adding the factor of "emotion" to the AI, which controls the behavior of enemies, comrades, and other people in the game. This emotion/motion AI processing is also explained later.

[0051] In addition, processing for controlling the behavior and movement of enemies is executed (steps S10, S11). This processing includes "real-time dynamics motion processing" and "non-linear discrete motion interpolation processing" to enemies. Pursuant to both such processing steps, the display of the behavior and movement of enemies is expressed more realistically. This processing is also explained 1ater.

[0052] Furthermore, collision judgment processing (collision processing) between the bullet and enemy, obstacle is executed (step S12). This collision judgment processing includes processing referred to as "moving collision processing" which creates a dynamic sensation by moving the collision face. This processing is also explained later.

[0053] After the completion of these various characteristic processing steps, the CPU 101 then executes the game processing (step S13) . In other words, a conversion matrix is generated for perspectively converting the three-dimensional game space seen from the camera viewpoint confirmed at step S5 into the two-dimensional perspective screen and this is designated to the geometrizer 110, and further, parts (formed of a plurality of polygons) representing characters and obstacles such as enemies are designated to the geometrizer 110. The conversion matrix and polygon data designated above are reflected to the various factors of the behavior calculations processed in the aforementioned steps S5, S7, S9, S11, and S12.

[0054] When this game processing is completed, the processing returns once again to step S1, and the above series of processing steps are repeatedly executed for each fixed time frame. As a result thereof, image data of the respective frames simulated for each fixed time frame is successively displayed as the game screen in real time on the display la, and the game image is developed pursuant to the lapse in time.

[0055] Next, details of the various characteristic sub routines, which are executed during the aforementioned main routine, of the present invention are described below.

[Camera Viewpoint Movement Processing]

[0056] The camera viewpoint movement processing is now explained with reference to Figs. 6 to 8.

[0057] Fig. 6 shows a detailed example of the camera viewpoint movement processing to be executed by the CPU 101 at step S5 of the main routine. Here, as shown in Fig. 7, the observable point P is moved toward the observable enemy E, and the line of sight of the camera C (central line of the visual field when the viewpoint is placed on the camera) is made to follow the direction of such observable point P. That is, the observable point P is the target point of the line of sight of the camera C, and the observable enemy E is the moving target point of the observable point. The movement of the camera line-of-sight is processed by being divided into cases of the occurrence of "avoidance" where the player tries to avoid a bullet, and a normal state where no such avoidance has occurred.

[0058] Foremost, the current positions of the observable enemy E and observable point P are operated (step S21). Next, the direction and distance between the observable enemy E and observable point P are operated (step S22) Then, operation is performed so as to move the observable point P a prescribed distance toward the observable enemy E side. Fig. 8 shows a typical example of such movement. The observable point P is moved toward the observable enemy at 1/8 ~ 1/12 of the distance between the observable point P and observable enemy E for each frame (1/60 seconds). This distance may be suitably selected.

[0059] Based on the input signals of the pedal in step S1 of the main processing, judged is whether the "avoidance" motion, where the player tries to avoid the bullet, is being conducted (step S24) . When the judgment is NO at this step S24, it is normal, and steps S25 and S26 are successively executed. Foremost, operated is the open angle θ formed by the current camera line-of-sight and the line connecting the camera position and the observable point P (step S25: cf. Fig. 9) . Operation is conducted such that the current camera line-of-sight is rotated toward the observable point P side for minute angle d θ determined by d $\theta = \theta$ b/a per frame with respect to the open angle θ (step S26). Here, a and b are coefficients. Coefficient a is a value for determining the speed upon rotating the camera at θ degrees, and larger the value of coefficient a, the slower the speed. A suitable value may be preferably set as coefficient a. Coefficient b represents the change in speed during the rotation of the camera, and smaller the value of coefficient b, the steadier the speed. A value of 1 or 2 (preferably about 1.5) is set as coefficient b, and it is thereby possible to provide a sense of following similar to human motion.

[0060] Meanwhile, when YES is judged at step S24, the control processing of the camera position and direction (line of sight) upon avoidance is executed at steps S27 to S31 . These processing steps not only control the direction (line of sight) of the camera, they are characterized in also pertaining to the movement of the camera position.

[0061] First, the current direction from the camera C to the observable point P is determined (step S27) . Then, as shown in Fig. 10, the position of the camera C is moved a prescribed distance (step S28), and the direction from the camera position after movement to the observable point P is determined (step S29) . Further, operated is the angle α formed by the direction of the camera to the observable point before movement and after movement (step S30). Then, operation for rotating the direction of the camera (direction of line of sight) 0.8α ~ 1.2α is executed. Thereafter, the processing is returned to the main processing.

[0062] By rotating the direction of the camera C α degrees as above, the outward appearance of the observable point on the screen will not change, and the sight of the observable point will not be lost. When a player manipulates the pedal during the game and an avoidance occurs (including cases when the system side judges danger and makes an avoidance), the player may lose sight of the enemy on the screen with the aforementioned ordinary control of the camera line-of-sight since the movement is too sudden. With the present control of the camera position and direction upon an occurrence of avoidance, such circumstances can be avoided with certainty.

[0063] The actual rotational amount of 0.8 α ~ 1 . 2 α for rotating the camera direction is made to have versatility. Therefore, if the rotational amount is set slightly smaller than the open angle α (0.8α for example) (cf. virtual arrow (i) of Fig. 10), as the observable point P will move slightly toward the direction of camera movement, a sense of movement will be provided to the player. This will also increase the difficulty of the game. Contrarily, if set slightly larger than the open angle α (1.2 α for example; cf. virtual arrow (ii) of Fig. 10), as the observable point P will move slightly in the direction opposite to the camera movement, a sense of circling around will be provided to the player. This will also increase the difficulty of the game.

[Attack Suggestion Processing]

[0064] Fig. 11 shows one example of the attack suggestion processing executed at step S7 of the main routine processing. This processing is also executed with the CPU 101.

[0065] Foremost, judged is whether an attack from the enemy will begin, or has begun (step S41). When this judgment is NO; that is, when the enemy is not attacking (shooting) the character simulating the player, flags F1 and F2 showing the attack suggestion processing are set to zero and the processing is returned to the main routine (step S42).

[0066] When the judgment is YES at step S41, judged is whether the bullets fired from the enemy in a series have reached m number of bullets (step S43). The letter m representing the number of bullets fired in a series is set, for example, to m = 4. If this judgment is NO; in other words, that it has not yet reached the m number of bullets fired in a series, further judged is whether flag F1 = 1 (step S44) . If the judgment here is NO, a bullet path deviating a prescribed distance from the position in the game space (virtual three-dimensional space) of the character simulating the current player is operated and stored (step S45) . In order to suggest to the player of a dangerous situation of being hunted by an enemy, this path is operated, as shown in Fig. 12, to be of an arc.

[0067] Next, in order to complete this path calculation, flag F1 is set to F1 = 1 (step S46). When the judgment at step S44 is YES, the processing steps of S45 and S46 are skipped.

[0068] Then, based on the operated arc-shaped bullet path, the bullet position per display frame is operated (step

S47). Further, processing for leaving an afterimage on the path of the bullet of the operated position is performed (step S48). The afterimage processing at this step S48 may be omitted depending on the situation. Thereafter, the processing is returned to the main routine processing.

[0069] Meanwhile, when it is judged as YES at step S43, based on the processing of the system side, m number of bullets are made to come flying in an arc so as to graze the character simulating the player. As these m number of bullets are set such that they will not hit the character, the player is given some time upon recognizing that the enemy has begun the attack. Thus, seasoning is given to the game where a player will not suddenly be defeated simultaneously with the commencement of the enemy attack. While the m number of bullets come flying, the player is able to actually feel that he/she is being attacked (hunted)

[0070] Therefore, when it is judged as YES at step S43, confirmed is whether the other flag F2 = 1 (step S49). When flag F2 = 0, the bullet path to hit the character in relation to the position in the game space of the character simulating the current player is operated and stored (step S50) . Next, in order to complete this path calculation, flag F2 is set to 1 (step S51) . When the judgment at step S49 is YES, the processing steps of S50 and S51 are skipped.

[0071] Thereafter, operated is the position of the bullet per display frame based on the operated bullet path (step S52) . The processing is then returned to the main routine processing.

[0072] Since the attack suggestion processing is as described above, the player may perceive the dangerous state in light of several bullets that come flying in an arc while grazing the such player's character. Thereby, the player may proceed to actions of manipulating the pedal for avoidance (changing the position), and such player will not be suddenly defeated by the enemy attack. Accordingly, it is possible to add the seasoning of heightening the amusement in the game. By setting the number of bullets to an adequate number, the natural flow of the game can be secured, and such methods for making the player recognize the dangerous state by displaying unnatural marks become unnecessary.

[0073] Moreover, as a substitute for the afterimage processing at step S48, the recognition of the player may be heightened by employing a display processing of light such that the gun reflects light and shines.

[0074] Although explained above is the processing for suggesting the attack from an enemy character on the premise that a character simulating the player is displayed on the screen of the display, this processing may also be employed in gun shooting games which do not display a player character on the screen or similar game scenes. In such a case, image processing may be performed similar to the above such that the bullets representing the attack of the enemy character, for example, will come flying along a path "in the vicinity of a priorly set area where the player will be hit and within the area displayed on the screen." Thereby, the player in the actual space viewing the screen will have the feeling of himself/herself existing in the virtual space and being attacked by the enemy. Therefore, the similar working effect as above can be obtained.

[0075] Regarding the m number of warning shots described in step S43 in aforementioned Fig. 11, the following modification example may also be added thereto. That is, during the process the warning shots reaching m number of bullets, the distance between the landing point and hitting point of the warning shots (camera position of the player viewpoint or position of the character simulating the player) is gradually shortened in accordance with the increase in the number of warning shots. This produces a feeling of the aim of the enemy gradually becoming more accurate, and more powerfully suggested is the "dangerous" state in the game.

[Emotion/Motion AI Processing]

[0076] Fig. 13 shows one example of the emotion/motion AI processing executed at step S9 of the main routine processing. This emotion/motion AI processing aims at realizing a more human-like movement by controlling the person character appearing in the game pursuant to AI inclusive of the emotion factor.

[0077] As shown in Fig. 13, input to this emotion/motion AI processing are the situation factor (step S51), emotion factor (step S52), evaluation, determination factor (step S53), and behavior factor (step S54) in the aforementioned order of influence. The emotion factor, as shown in Fig. 14 in the present embodiment, is represented two-dimensionally with anger and fear. This emotion does not necessarily have to be two-dimensional, and adopted may bean adequate dimension. Moreover, the behavior factor is recurrently reflected on the emotion factor. The emotion factor may directly influence the behavior factor. This emotion/motion AI processing is characterized in that the emotion factor has been introduced, and this emotion factor mutually influences and is influenced by the evaluation, determination, and behavior factor, and the final action of the person is decided thereby. Fig. 15 shows the AI processing in comparison to the processing of Fig. 13.

[0078] A specific example of the emotion/motion AI processing of Fig. 13 is shown below.

a. The following are examples of the "situation" influencing the "emotion":

a-1: In the case of an enemy

* When the player' s bullet passes near, "fear" rises.
* When the player defeats one's comrade, "anger" rises.
* When an enemy that will not die with one hit sustains damage, "anger" rises.
* When the player character sustains damage, both "anger" and "fear" will lower.
* When shooting at the player but the bullets are avoided and miss, "anger" rises and "fear" lowers.
* Pursuant to the lapse in time, both "anger" and "fear" will lower.

a-2: In the case of a civilian:

* When a bullet passes near, "fear" rises.
* When another person dies, "fear" rises.
* Pursuant to the lapse in time, both "anger" and "fear" will lower.

b. The following are examples of the "behavior" influencing the "emotion":

* When one fires a bullet and becomes relieved, "anger" lowers.
* When one continuously fires bullets and becomes numb, "anger" lowers.

c. The following are examples of the "emotion" influencing the "evaluation/determination":

* When "fear" is strong, one does not shoot and hides.
* When "anger" is strong, one does not avoid danger and shoots continuously.
* When "fear" is so strong, one becomes petrified.

d. The following are examples of the "emotion" influencing the "behavior":

* When "fear" is weak, the hit rate is high.
* When "fear" is strong, the hit rate is low.
* When "anger" is strong, movement upon attacking becomes quick.

[0079] As a result of setting the emotion/motion AI as above, it is possible to alleviate or exclude representations of unnatural movements as a person (e.g., becoming suddenly calm although frightened up until then), and the game will be represented more realistically. For example, in the game of this embodiment, the first shot from the enemy will not hit the player, and a path is set such that the last bullet of a series of shots will hit the player. Thus, when the "hit rate of bullets" becomes high pursuant to the aforementioned emotion AI, for example, the setting of the fourth bullet hitting the player will be made such that the third bullet will hit the player. Contrarily, when "both fear and anger are high," it is, possible to accurately represent the panic as with human mentality wherein, although the player will shoot furiously without stopping, it is difficult to hit the target.
[0080] Further, if there are several persons in the game, each person will be able to move autonomously pursuant to the emotion/motion AI of such person. Thus, without having to control the overall group of people, it is possible to represent the picture of the group more realistically.
[0081] Moreover, as it is not necessary to hold a rule base for determining all actions as with conventional processing, there is also the advantage of lightening or restraining the data load and operational load.

[Real-time Dynamics Motion Processing]

[0082] Fig. 16 shows one example of the real-time dynamics motion processing executed with the CPU 101 at step 511 of the main routine processing.
[0083] This motion processing paid attention to the characteristics of the parts (the respective parts are formed of a plurality of polygons) structuring a person character. That is, among the parts structuring the body, as the main parts have more mass than the subparts, there is a characteristic that the connection points with the main parts may be deemed as the fixed points for the subparts.
[0084] The division of main parts and subparts adopted in this embodiment is for the sake of convenience, and the part at the end side of the body (far from the body) among the two adjacent parts is referred to as the subpart, and the part at the center side of the body (near the body) is referred to as the main part.
[0085] Fig. 17 shows an example representing a person using 16 parts. The black circles of Fig. 17 show the connection points between the parts.
[0086] Thereby, as shown in Fig. 16, the CPU 101 first selects the subparts at the very end of the body (step S61),

and then specifies the main parts thereof (step S62). Here, the connection points between the subparts and the main parts are deemed fixed points, the movement of the subparts is calculated (step S63), and, thereafter, the impulse (power X time) to be provided to the main parts is calculated (step S64). The movement of the subparts and the impulse to be provided to the main parts are calculated upon deeming the respective parts as a rigid body.

[0087] The series of processing steps are recurrently repeated for the respective parts structuring the body, from end parts to main parts, and to the main parts to be connected to such subparts, with such main parts being the subparts (step S65). This repetition is continued until the subpart becomes the most central part (a part where there is no other main part; the calculation would be simplified if waist parts requiring the central position of gravity as this center part are adopted).

[0088] Upon reaching the center part, contrarily, the main parts are specified (step S66) . The first main part is the center part. Next, subparts are specified (step S67) and the impulse to be inflicted on the subparts is calculated based on the movement of the main part (step S68). This reverse calculation is recurrently repeated in order with the subpart being the main part until the end (step S69).

[0089] By controlling the motion of characters as above, upon making one motion, a human's body will move from the end or end side, such movement is relayed to the central part side of the body while the movement or restriction from the central part side is mutually added to the end side, and a more natural and smooth motion is represented pursuant to such form.

[0090] Further, various seasoning-like processing may be added to this motion calculation. For example, as restrictions accompany the movement of joints, reverse moments are provided to parts trying to move exceeding such restrictions (steps S70 to S72). Thereby, human-like and accurate movements can be represented. Moreover, when force is inflicted on the parts upon contact with external objects such as walls, floors, or bullets, or when external force such as gravity exists, calculation with such force added thereto is conducted (steps S73, S74). Here, when phenomena such as the parts caving into the floor due to differences in the calculation occur, it is desirable that appropriate corrections are made and processing for making such phenomena inconspicuous is conducted. Further, as a human generates internal force pursuant to phenomena such as the contraction of muscles upon feeling pain, processing for adding internal force or moments can be implemented at the instant a person is hit by a bullet (steps S75, S76).. It is therefore possible to represent realistic movement. Moreover, humans have a function of autonomously amending their posture in order not to fall down. In order to express the situation of "I'm hit, but not dead yet", it is preferable to execute processing for decelerating the rotation speed of the parts (steps S77, S78). This will enable the representation of "endurance", and the realistic movement is further enhanced. The processing of these steps S70 to S78 may be suitably combined and executed for the selected additional items by being arranged appropriately in a position during the series of processing steps S61 to S69.

[0091] In the aforementioned real-time dynamics motion processing, the order of motion calculation may be conducted from the end side among the plurality of parts representing the body, or from the central part of the body, and there is no limitation in the order thereof. When an impact is inflicted, calculation may be conducted in the order of such inflicted part.

[Non-linear Discrete Motion Interpolation Processing]

[0092] Fig. 18 shows one example of the non-linear discrete motion interpolation processing executed with the CPU 101 at step S11 of the main routine processing.

[0093] Here, motion interpolation processing shall mean the interpolation processing for generating movements connecting two motions; for example, "turning back" after "running". As methods conventionally known for this type of interpolation processing, there are the liner interpolation processing shown in Fig. 19 and the three-dimensional curvilinear interpolation processing shown in Fig 20. Motion interpolation by linear interpolation processing represents the movements connecting the motions with linear functions, and, although there is an advantage of the calculation load being light, it lacks the smoothness of the connection between the motions. Meanwhile, motion interpolation by the three-dimensional curvilinear interpolation processing represents the movements connecting the motions with three-dimensional curvilinear functions, and, although the connection of the movements is smooth, the function curve cannot be calculated unless the current motion and the next motion are designated. There is a further disadvantage in that the calculation load will increase due to the calculation of the spline curve.

[0094] In order to overcome these problems, provided is non-linear discrete motion interpolation processing. This motion interpolation processing is a method of directly calculating the function curve of the motion as discrete data, and not as consecutive functions.

[0095] Specifically, as shown in Fig. 18, based on the current angle θ o, target angle θ a, and frame number f until reaching the target angle, the angle speed d θ a required for reaching the target is calculated (step S81) with the following formula:

$$d\theta a = (\bar{\theta} a - \theta a)/f$$

This means that the state shown in Fig. 21 (a) is differentiated by the number of frames; i.e., time t, and converted to the state shown in Fig. 21 (b).

[0096] Next, the previous angle speed d θ o is read from the memory (step S82), the point between the calculated angle speed d θ a and the read previous angle speed d θ o is assumed to be the current angle speed d θ, and angle speed d θ is calculated (step S83) with the following formula:

$$d\theta = (A \cdot d\theta o + B \cdot d\theta a) / (A + B)$$

A to B is the distance for determining the angle speed dθ by dividing the segments connecting angle speeds d θ a and dθ o at the upper part of Fig. 21 (b). According to this formula, the state of Fig. 21 (b) may be converted to the state shown in Fig. 21 (c) . Here, if A = B, the position of the current angle speed dθ will be set to be the middle point. The larger distance A is set than distance B, the larger the representable inertia.

[0097] The currently operated angle speed d θ is stored in the memory as the previous angle speed d θ o in the subsequent interrupt (step S84).

[0098] The time integrated function curve of the angle speed d θ calculated per interrupt as above is show in Fig. 21 (d).

[0099] As clear from Fig. 21 (d), inertia is given to the motion upon moving from the current motion to the subsequent motion and, without exactly stopping at the target angle, becomes a heavy-feeling motion. By suitably adjusting this inertia, such inertia may be positively utilized, and in comparison to three-dimensional curvilinear interpolation, represented is a realistic and heavy-feeling motion with a smooth connection. And even if abruptly switching during the motion, pursuant to the inertia, it is possible to proceed to the next motion smoothly. Meanwhile, as the processing is conducted with a discrete value and not a continuous function, even in comparison to linear interpolation, the processing load will not be that heavy. The advantage lies in the smooth motion interpolation with a lightened operational load.

[Moving Collision Processing]

[0100] Fig. 22 shows an example of moving collision processing executed by the CPU 101 at step S12 of the main routine processing.

[0101] In conventional games, collisions of stages were not moved. The present invention enables such movement, and endeavors to provide a more dynamic game progress. This moving collision processing, by fixing the coordinate system of the collision face, calculates the movement of the collision face by outwardly erasing such face.

[0102] Foremost explained is the existing processing of a non-moving fixed collision. As shown in Fig. 23, when not moving the collision plane (e.g., ground, walls, etc.), the collision point p may be easily obtained from this collision plane and the ordinary collision segment (e.g., bullet path) by calculating the intersecting point of the straight line and the plane.

[0103] The present invention moves the collision dynamically, and as shown in Fig. 22, the CPU 101 judges per interrupt whether to move the collision or whether it is moving (step S91). If the judgement is NO (not to move), the routine proceeds to step S92, and judges the aforementioned fixed collision. However, when moving the collision, the routine proceeds to step S93, and it is further judged whether the movement is parallel or a rotation.

[0104] When this judgment is parallel, the routine proceeds to step S94 and judged is the parallel movement collision. Specifically, as shown in Fig. 24 (a) and Fig. 24 (b), when moving the collision plane in parallel, the coordinate system is fixed to the collision plane, and the terminus p of the collision segment is moved in the distance of the reverse vector of the parallel movement vector of the collision. Thereupon, the intersecting point p' of the plane and segment is sought as the collision point, and thereafter, conversion for restoring the coordinate system of p' is conducted for obtaining the intersecting point p.

[0105] Meanwhile, when the judgment at step S23 is a rotation movement, judgment of the rotation movement collision is made at step S95. Particularly, as shown in Figs. 25 through 27, upon rotatively moving the collision plane, similar to the parallel movement, the terminus p1 of the collision segment is moved in a distance of .the reverse vector of the parallel movement vector of the collision plane, and made p1 (cf. Figs. 25 and 26) . Thereby, the influence pursuant to the parallel movement can be outwardly erased.

[0106] Next, the terminus pl' of the collision segment is rotated

- θ with the origin of the collision plane as the axis, and made p1" (cf. Fig. 27) . According to the aforementioned operation, the coordinate system of the collision plane is fixed, and the influence of the collision movement and rotation may be outwardly erased. Thereby, the intersecting point p" of the segment p0

- p1" and the collision plane is sought as the collision point, and by performing reverse operation to this point, the intersecting point p is obtained.

[0107] According to the above, by moving the collision face such as walls and the ground while performing collision judgment with the collision segment such as a bullet, a dynamic game screen is generated not possible heretofore.

[0108] Further, upon rotatively moving the collision plane, the rotational origin thereof does not necessarily have to be on the collision plane, and may be outside the collision plane. In an actual calculation, the collision segment is represented in the vector formula of "p = p0 + (pl - p0) t". When t is computed during the calculation of p' or p", immediately thereafter, by substituting this formula, it is possible to omit the trouble of reconverting the coordinates after calculating the coordinates of p' and p". In the aforementioned embodiment, although the collision face was described as a plane, the same method may be used to calculate the collision face even if it were a curved face. Moreover, it is preferable that the rotational angle θ of the collision face is a sufficiently small value. If this rotational angle θ is too large, differences in the calculated coordinates of the collision point may increase . Here, the calculation should be made upon dividing the rotation a certain number of times.

[0109] The enemy explained here shall mean a target, enemy, or a subject of attack to be operated by the computer of the game machine main body side.

INDUSTRIAL APPLICABILITY

[0110] As described above, the present invention provides an image generating device suitable for gun shooting games and the like, having abundant realism and ambience than conventionally, considerably heightens the game feeling and game amusement, and which does not suffer the operational processing in comparison to conventional devices.

[0111] Specifically, it is possible to increase the ambience and considerably enhance the interest in the game feeling and game amusement by making the player recognizing the "dangerous situation" with accuracy. Moreover, provided is a game device suitable for gun shooting games and the like and which substantially enhances the interest in the game feeling and game amusement by making the camera viewpoint move properly with the movement of the enemy without losing sight of such enemy.

[0112] Further, provided is an image generating device suitable for gun shooting games and the like wherein the element of "action" resulting from "emotions" is provided to the AI controlling the character, the trouble and time required for the development thereof is suppressed, and which is abundant in realism and ambience without increasing the operational load than conventionally. Moreover, provided a game device capable of making the collision with structures other than the movable object, such as walls and obstacles, to be impressive, realizing dynamic game developments, increasing ambience, and considerably enhancing the game feeling and interest in the game.

[0113] Further, provided is a game device suitable for gun shooting games and the like, capable of improving the realism in the movement of parts structuring the character or the movement between the motions of the characters, increasing realism and ambience, and which does not suffer the operational processing in comparison to conventional devices.

Claims

1. An image generating device for displaying on a display images for a player to play a gun shooting game with an enemy character existing in a virtual game space, said image generating device comprising: AI processing means for executing AI processing incorporating emotions of said character influenced between circumstances, evaluation/ determination, and factors of behaviors in said game.

2. An image generating device according to claim 1, wherein said factors of emotions are represented by emotional elements of fear and anger in relation to said game.

3. An image generating device according to claim 2, wherein said AI processing means includes means for performing processing to reflect the results of behavior based on said factors of behaviors to said factors of emotions.

4. An image generating device for displaying on a display images for a player to play a gun shooting game with an enemy character existing in a virtual game space, said image generating device comprising: image processing means for performing image display suggesting in advance to the player an attack made by said enemy character to said player.

5. An image generating device according to claim 4, wherein said image display is a display of a bullet fired from said enemy character and flying toward said player in the actual space.

6. An image generating device according to claim 5, wherein the display of said bullet is a display of the bullet flying in an arc.

7. An image generating device for generating images by representing a movable object simulating a person and moving inside a virtual three-dimensional space as a plurality of parts connected via connection points, said image generating device comprising: first specifying means for specifying a subpart on the terminal side and a main part on the central side with respect to two adjacent parts among said plurality of parts; first operating means for operating the impulse of the subpart motion communicated to the main part under the presumption that the connection point of said subpart to said main part is a fixed point; first repeating means for repeating, in a recurring manner, the movements of said first specifying means and said first operating means from the terminal side of said movable object to the central side thereof; second specifying means for specifying a main part on the central side and a subpart on the terminal side with respect to two adjacent parts among said plurality of parts; second operating means for operating the impulse of the main part motion communicated to the subpart; and second repeating means for repeating, in a recurring manner, the movements of said second specifying means and said second operating means from the central side of said movable object to the terminal side thereof.

8. An image generating device according to claim 7, wherein at least one of said first and second operating means is means for executing seasoning-like operational processing upon simulating said person.

9. An image generating device according to claim 8, wherein said seasoning-like operational processing includes at least one of, or a plurality of operations among: operation for applying a reverse moment, which is caused pursuant to restrictions of the movement of joints of said person, to said parts; operation for reflecting the external force inflicted on said person to said parts; operation for correcting the unnaturalness of the position of said parts caused pursuant to differences in calculations; operation for applying the internal force moment caused by physical characteristics of said person to said parts; and control operation of the rotation or movement speed of said parts for reflecting expressions caused by the mentality of said person to said parts.

10. An image generating device for generating image data which interpolates the motion between two types of motions of the movable object moving within a virtual three-dimensional space; comprising: operating means for discretely operating the function curve of the motion between said two types of motions pursuant to the current rotational angle, target rotational angle, and number of frames required to reach the target rotational angle; and interpolation means for performing motion interpolation based on the operational results of said operating means.

11. An image generating device for generating images requiring the collision judgment between a movable object moving within a virtual three-dimensional space and a structural object arranged in said space, comprising collision judgment means for judging the collision with said movable object while moving said structural object.

12. An image generating device according to claim 11, wherein said collision judgment means is means for judging the collision while moving said structural object in either parallel movement or rotational movement.

13. A computer program for executing the operations of the respective means of an image generating device according to any preceding claim, when said program is run on computer apparatus.

14. A computer program according to claim 13 embodied on a computer readable storage medium.

FIG.1

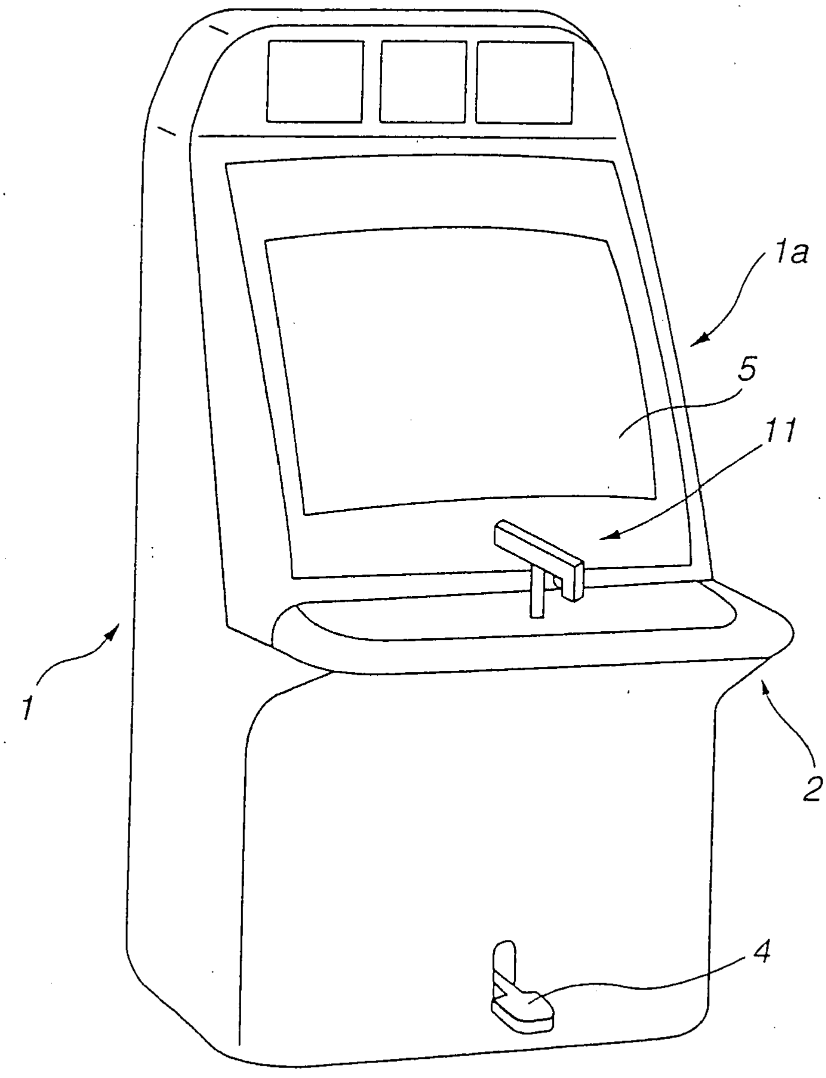


FIG.2

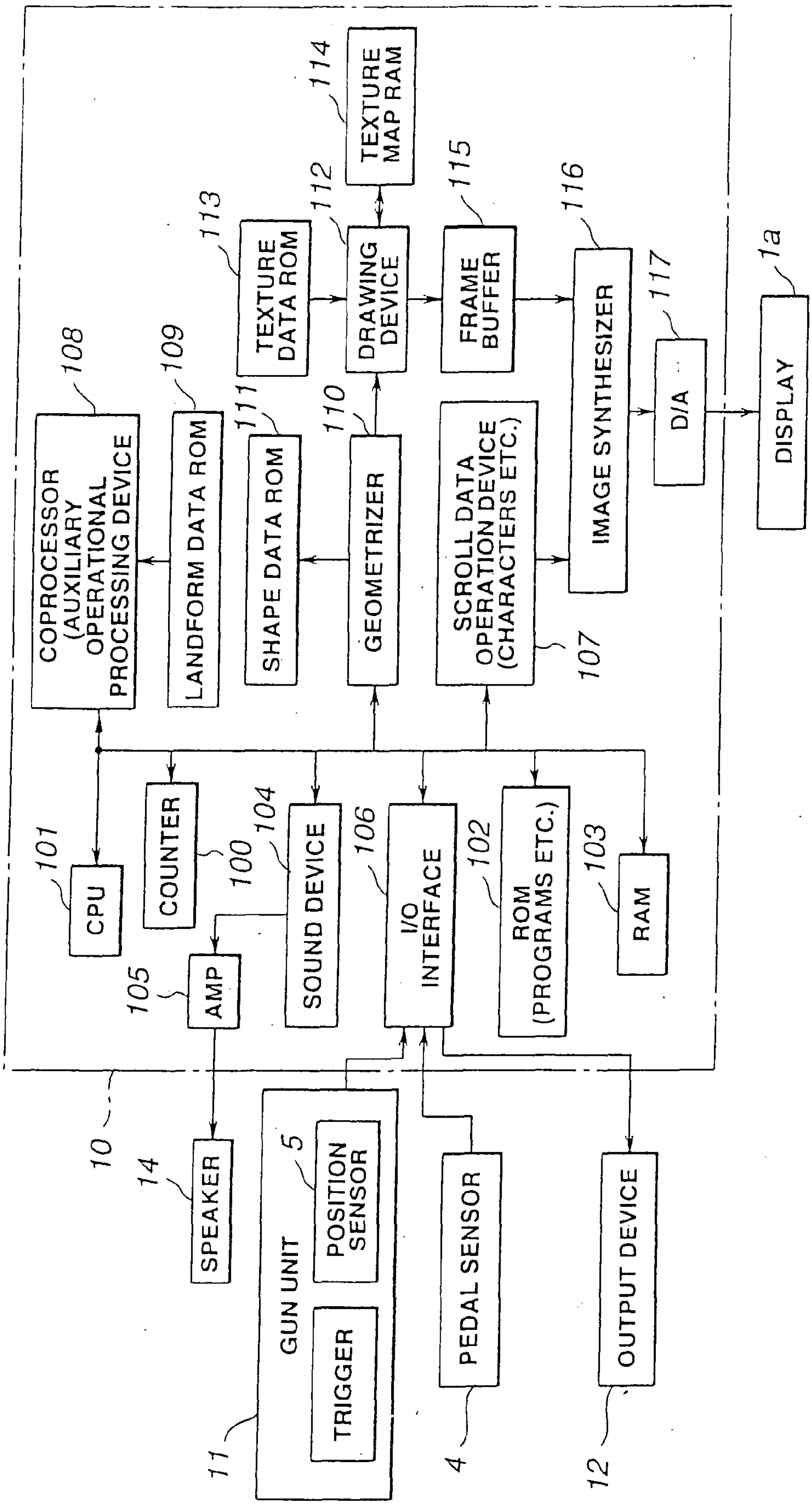

10
101
CPU
COUNTER
100
104
SOUND DEVICE
105
AMP
106
I/O INTERFACE
102
ROM (PROGRAMS ETC.)
103
RAM
108
COPROCESSOR (AUXILIARY OPERATIONAL PROCESSING DEVICE
109
LANDFORM DATA ROM
111
SHAPE DATA ROM
110
GEOMETRIZER
107
SCROLL DATA OPERATION DEVICE (CHARACTERS ETC.)
113
TEXTURE DATA ROM
112
DRAWING DEVICE
114
TEXTURE MAP RAM
115
FRAME BUFFER
116
IMAGE SYNTHESIZER
117
D/A
1a
DISPLAY
14
SPEAKER
11
GUN UNIT
5
POSITION SENSOR
TRIGGER
4
PEDAL SENSOR
12
OUTPUT DEVICE

FIG.3

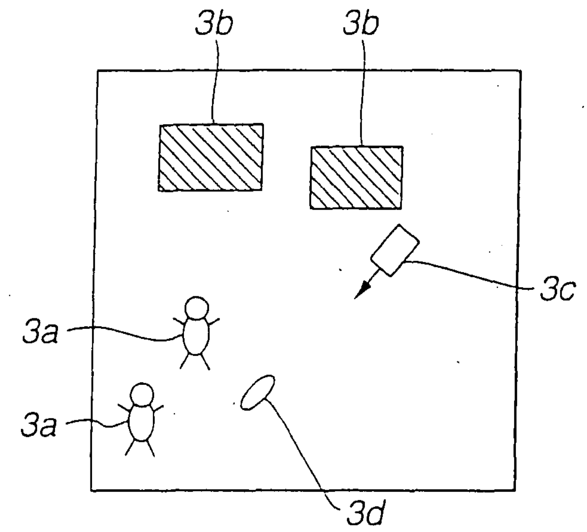


FIG.4

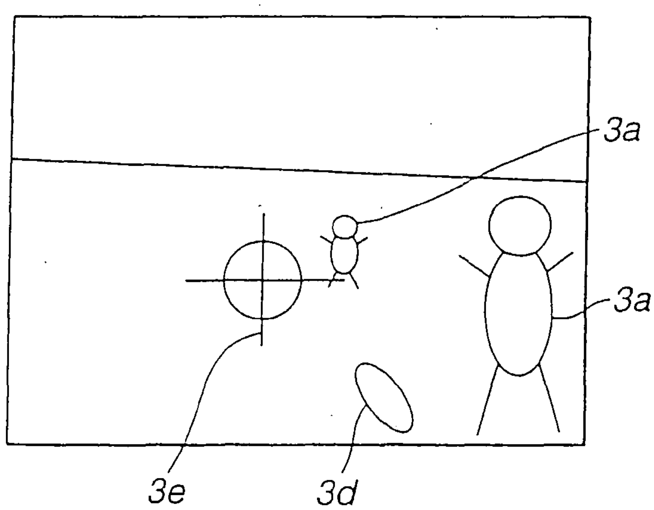


FIG.5

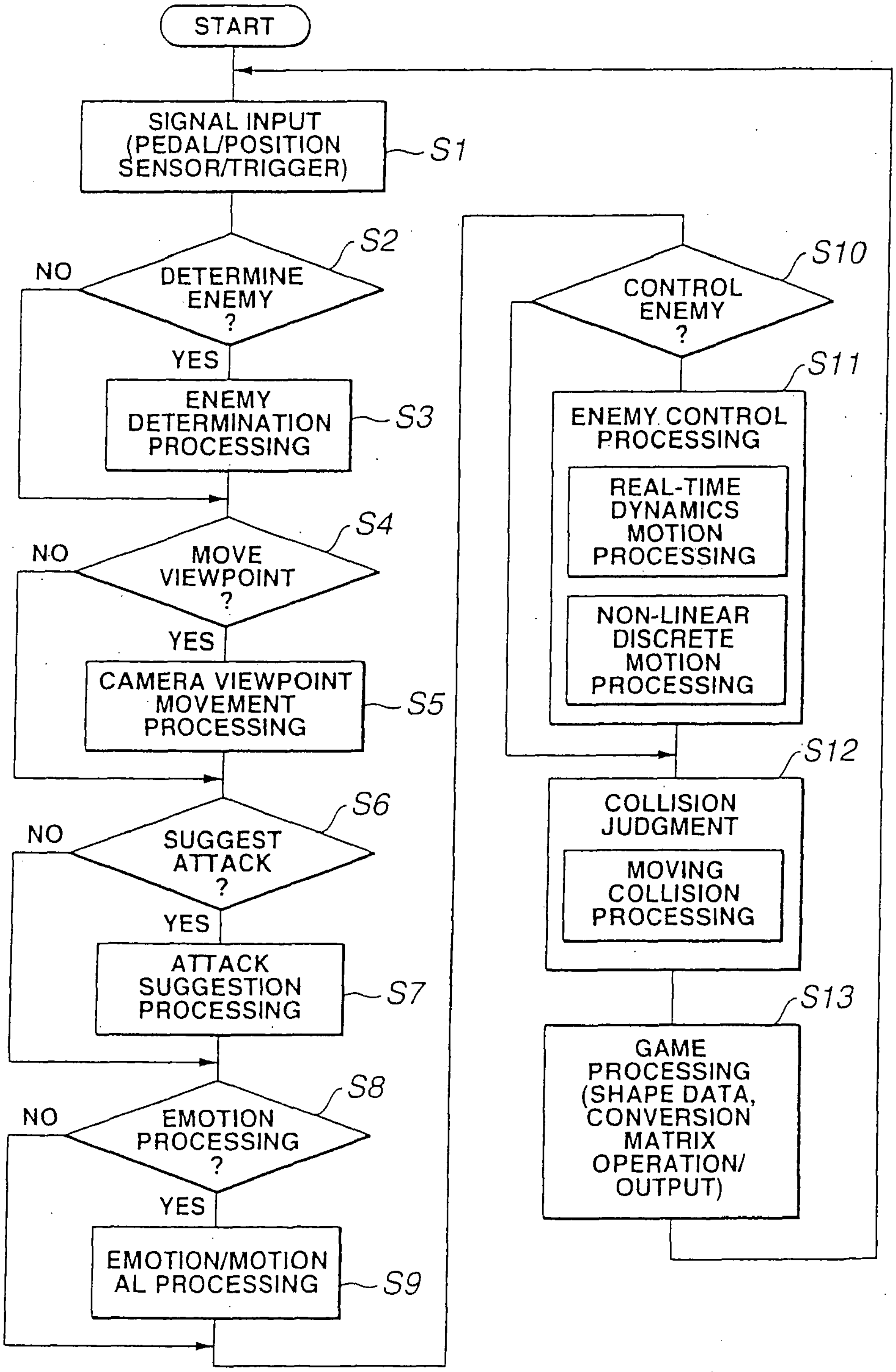

START
SIGNAL INPUT (PEDAL/POSITION SENSOR/TRIGGER)
S1
DETERMINE ENEMY ?
S2
NO
YES
ENEMY DETERMINATION PROCESSING
S3
MOVE VIEWPOINT ?
S4
NO
YES
CAMERA VIEWPOINT MOVEMENT PROCESSING
S5
SUGGEST ATTACK ?
S6
NO
YES
ATTACK SUGGESTION PROCESSING
S7
EMOTION PROCESSING ?
S8
NO
YES
EMOTION/MOTIONAL PROCESSING
S9
CONTROL ENEMY ?
S10
ENEMY CONTROL PROCESSING
S11
REAL-TIME DYNAMICS MOTION PROCESSING
NON-LINEAR DISCRETE MOTION PROCESSING
COLLISION JUDGMENT
S12
MOVING COLLISION PROCESSING
GAME PROCESSING (SHAPE DATA, CONVERSION MATRIX OPERATION/ OUTPUT)
S13

FIG.6

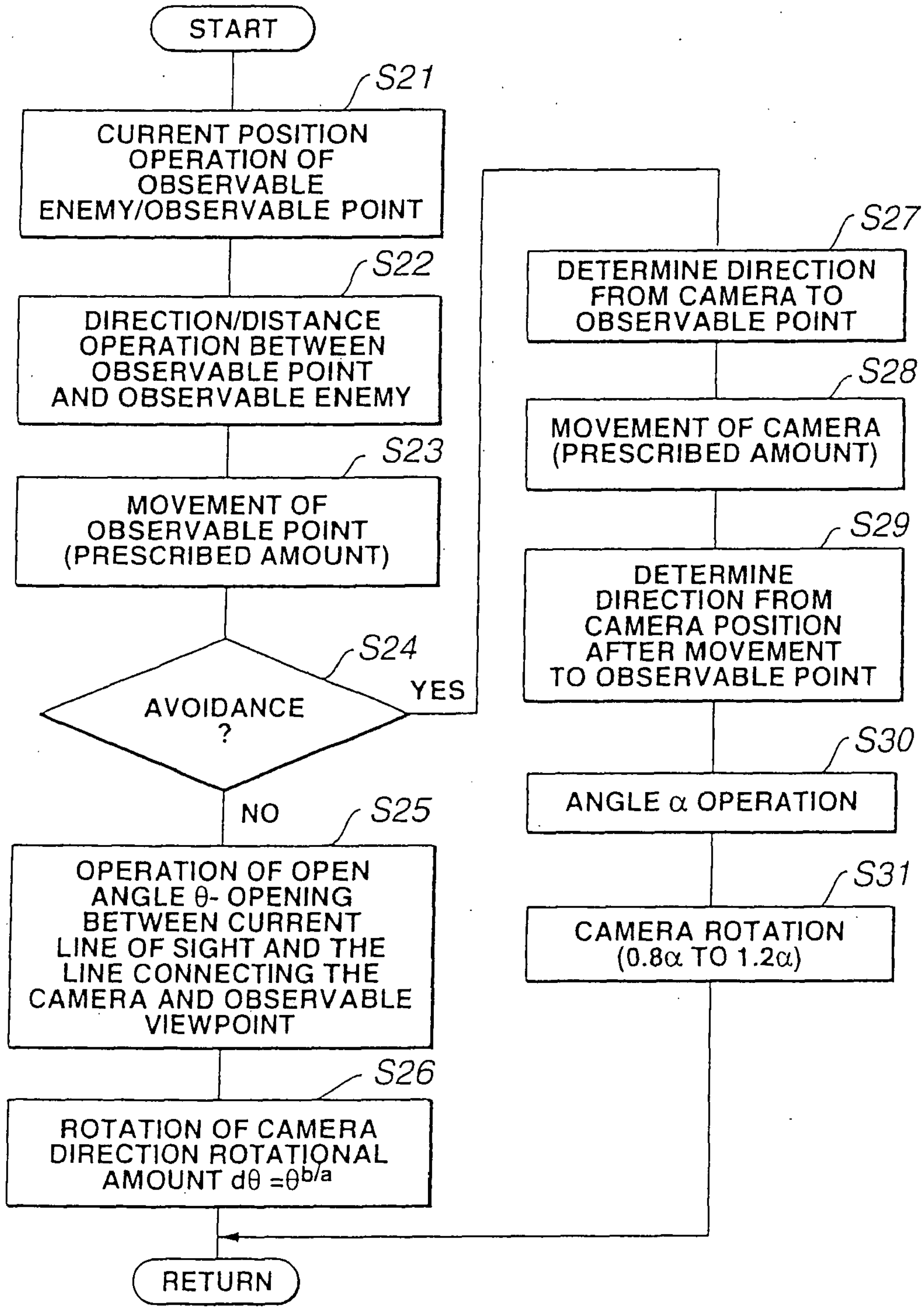

START
S21
CURRENT POSITION OPERATION OF OBSERVABLE ENEMY/OBSERVABLE POINT
S22
DIRECTION/DISTANCE OPERATION BETWEEN OBSERVABLE POINT AND OBSERVABLE ENEMY
S23
MOVEMENT OF OBSERVABLE POINT (PRESCRIBED AMOUNT)
S24
AVOIDANCE ?
YES
NO
S25
OPERATION OF OPEN ANGLE θ- OPENING BETWEEN CURRENT LINE OF SIGHT AND THE LINE CONNECTING THE CAMERA AND OBSERVABLE VIEWPOINT
S26
ROTATION OF CAMERA DIRECTION ROTATIONAL AMOUNT dθ =θ^b/a
S27
DETERMINE DIRECTION FROM CAMERA TO OBSERVABLE POINT
S28
MOVEMENT OF CAMERA (PRESCRIBED AMOUNT)
S29
DETERMINE DIRECTION FROM CAMERA POSITION AFTER MOVEMENT TO OBSERVABLE POINT
S30
ANGLE α OPERATION
S31
CAMERA ROTATION (0.8α TO 1.2α)
RETURN

FIG.7

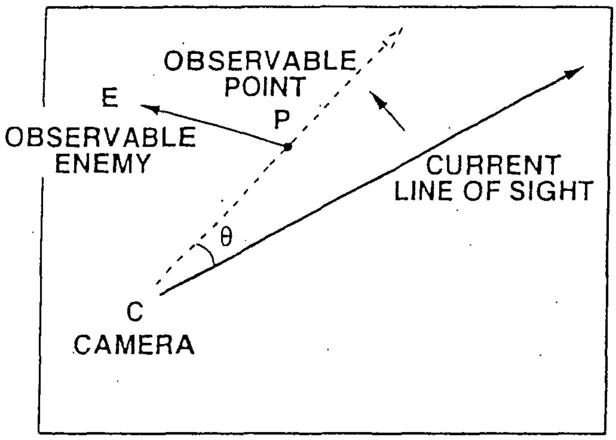

OBSERVABLE
POINT
E
P
OBSERVABLE
ENEMY
CURRENT
LINE OF SIGHT
θ
C
CAMERA

FIG.8

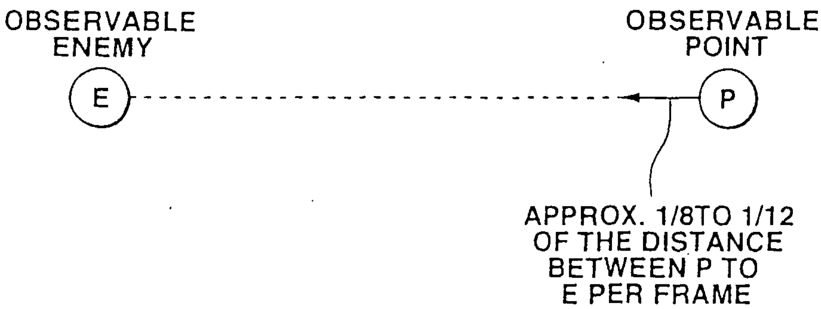

OBSERVABLE
ENEMY
OBSERVABLE
POINT
E
P
APPROX. 1/8TO 1/12
OF THE DISTANCE
BETWEEN P TO
E PER FRAME

FIG.9

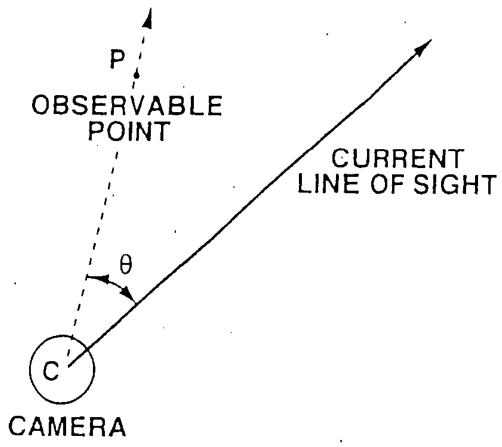

P
OBSERVABLE
POINT
CURRENT
LINE OF SIGHT
θ
C
CAMERA

FIG.10

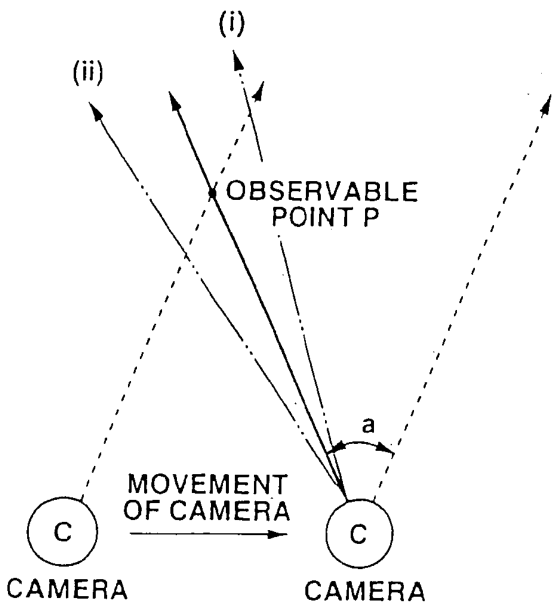

(i)
(ii)
OBSERVABLE
POINT P
a
MOVEMENT
OF CAMERA
C
CAMERA
C
CAMERA

FIG.11

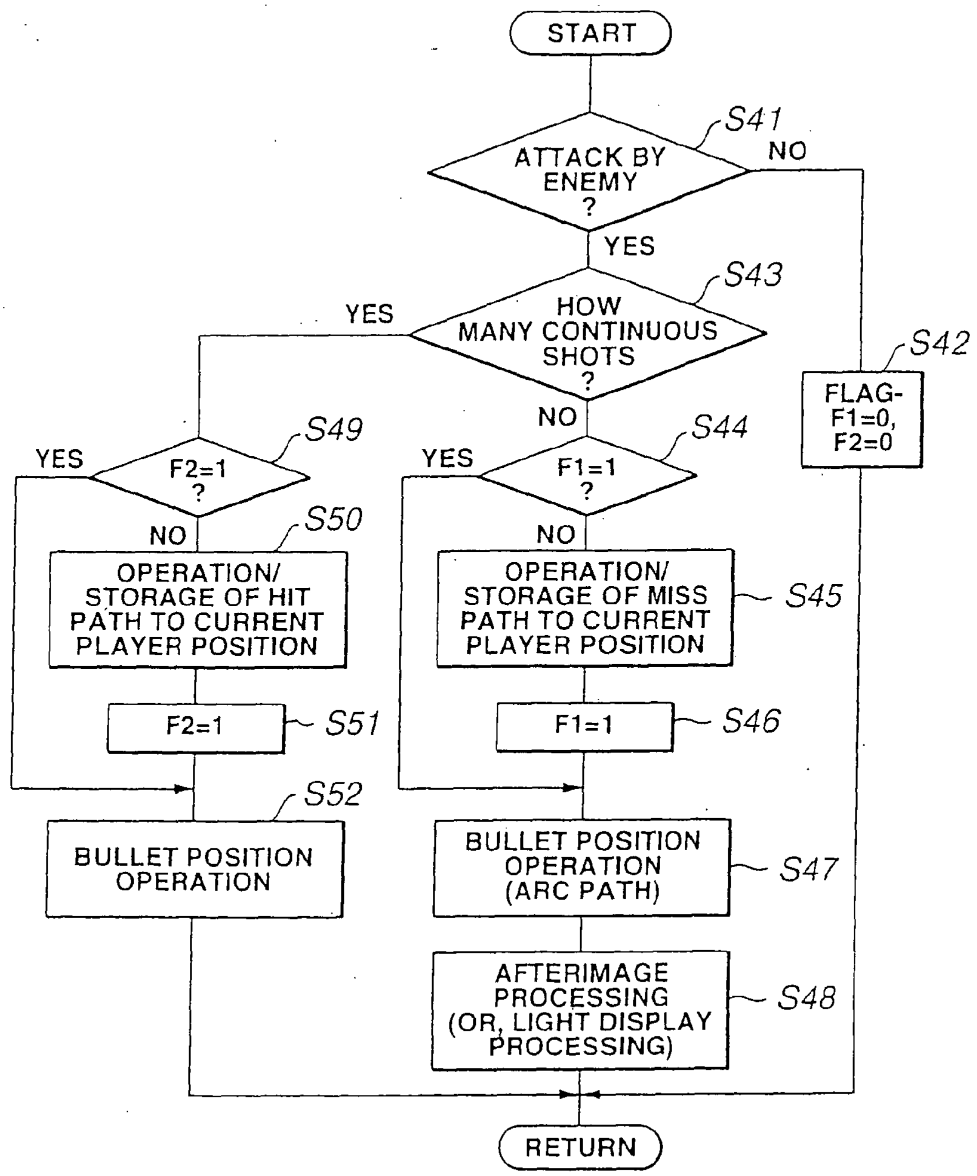

START
S41
ATTACK BY ENEMY ?
NO
YES
S43
HOW MANY CONTINUOUS SHOTS ?
YES
NO
S42
FLAG-F1=0, F2=0
S49
F2=1 ?
YES
NO
S44
F1=1 ?
YES
NO
S50
OPERATION/ STORAGE OF HIT PATH TO CURRENT PLAYER POSITION
OPERATION/ STORAGE OF MISS PATH TO CURRENT PLAYER POSITION
S45
F2=1
S51
F1=1
S46
S52
BULLET POSITION OPERATION
BULLET POSITION OPERATION (ARC PATH)
S47
AFTERIMAGE PROCESSING (OR, LIGHT DISPLAY PROCESSING)
S48
RETURN

FIG.12

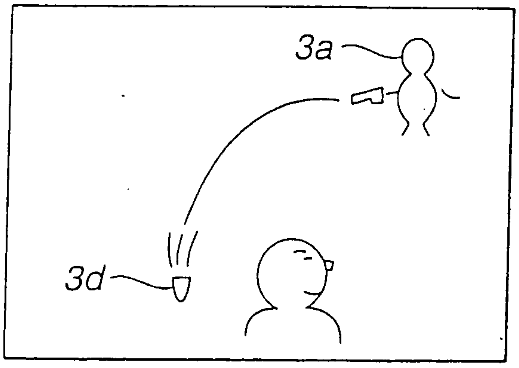

3a
3d

FIG.13

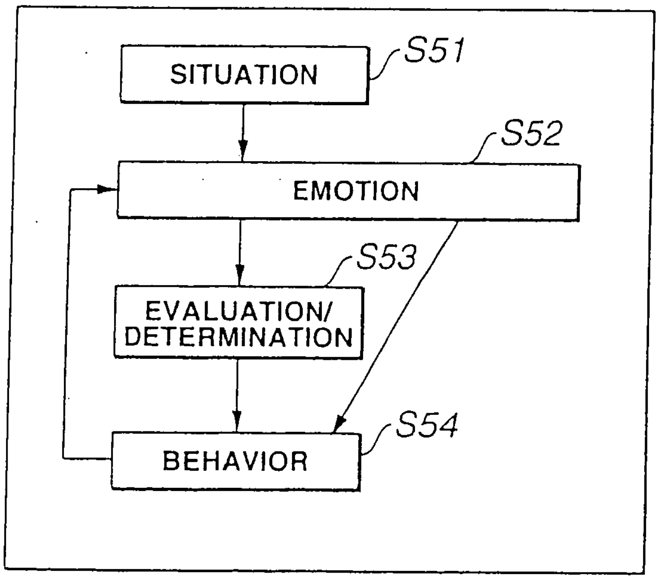

SITUATION
S51
S52
EMOTION
S53
EVALUATION/
DETERMINATION
S54
BEHAVIOR

FIG.14

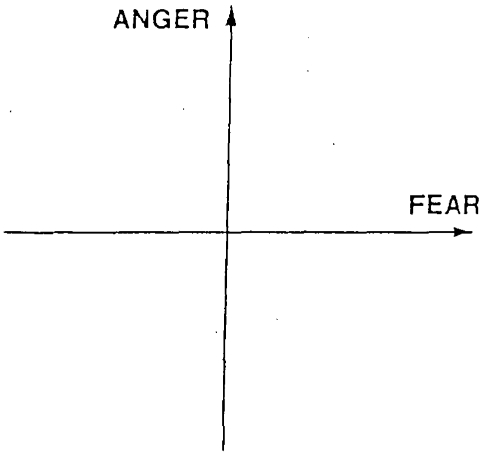

ANGER
FEAR

FIG.15

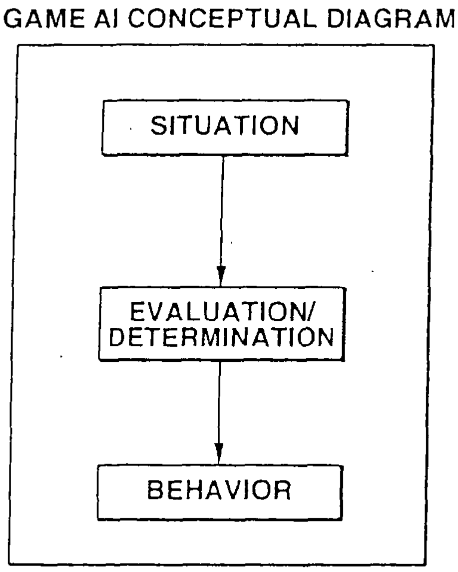

GAME AI CONCEPTUAL DIAGRAM
SITUATION
EVALUATION/
DETERMINATION
BEHAVIOR

FIG.16

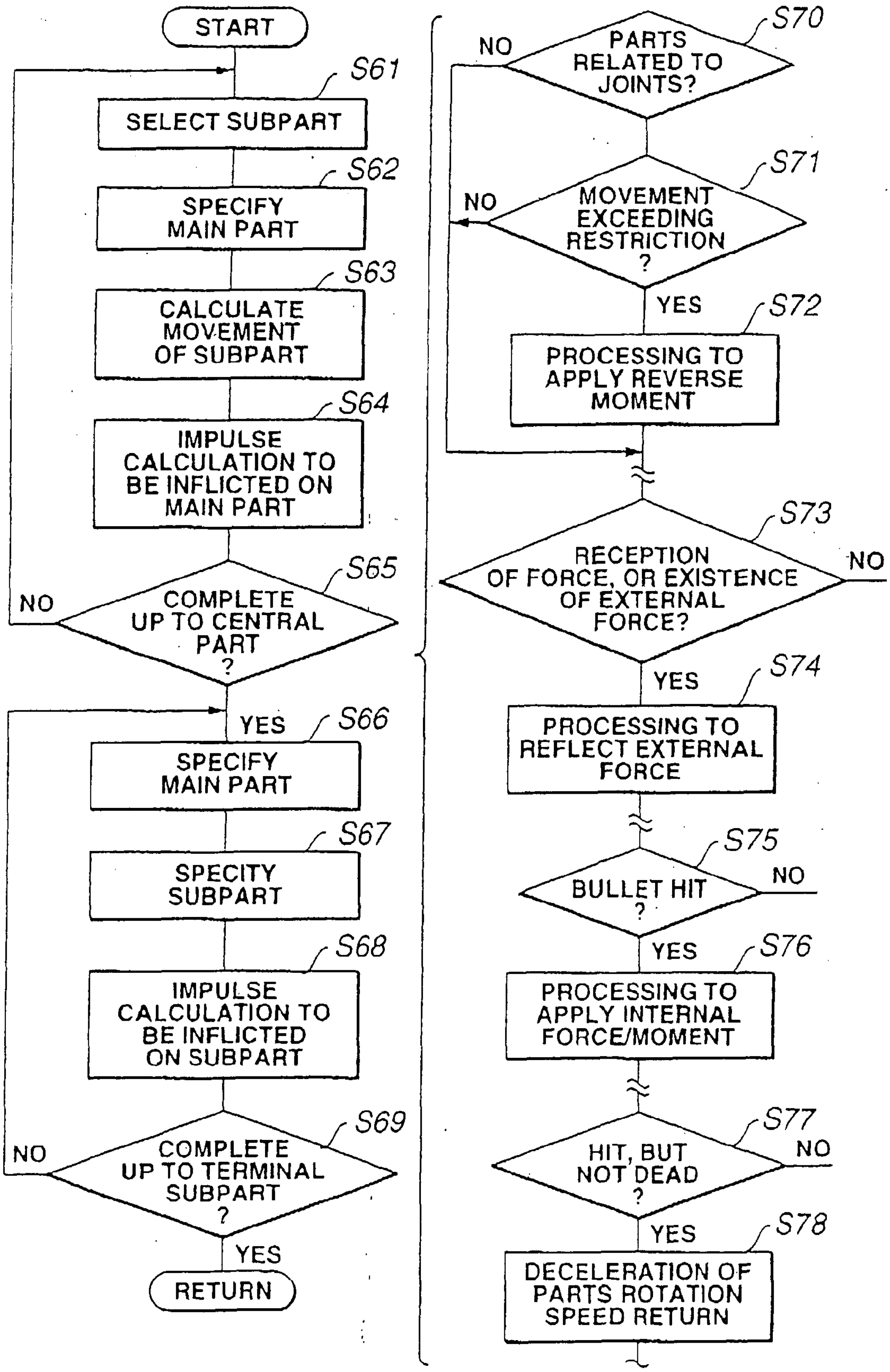

START
S61
SELECT SUBPART
S62
SPECIFY MAIN PART
S63
CALCULATE MOVEMENT OF SUBPART
S64
IMPULSE CALCULATION TO BE INFLICTED ON MAIN PART
S65
COMPLETE UP TO CENTRAL PART ?
NO
YES
S66
SPECIFY MAIN PART
S67
SPECITY SUBPART
S68
IMPULSE CALCULATION TO BE INFLICTED ON SUBPART
S69
COMPLETE UP TO TERMINAL SUBPART ?
NO
YES
RETURN
S70
PARTS RELATED TO JOINTS?
NO
S71
MOVEMENT EXCEEDING RESTRICTION ?
NO
YES
S72
PROCESSING TO APPLY REVERSE MOMENT
S73
RECEPTION OF FORCE, OR EXISTENCE OF EXTERNAL FORCE?
NO
YES
S74
PROCESSING TO REFLECT EXTERNAL FORCE
S75
BULLET HIT ?
NO
YES
S76
PROCESSING TO APPLY INTERNAL FORCE/MOMENT
S77
HIT, BUT NOT DEAD ?
NO
YES
S78
DECELERATION OF PARTS ROTATION SPEED RETURN

FIG.17

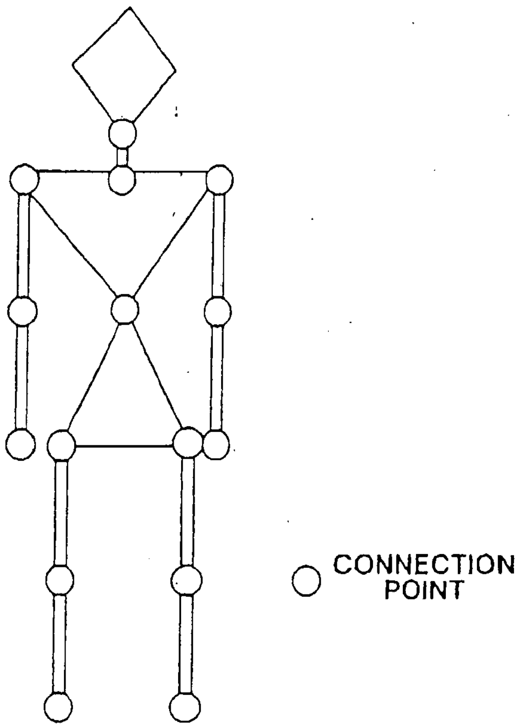


FIG.18

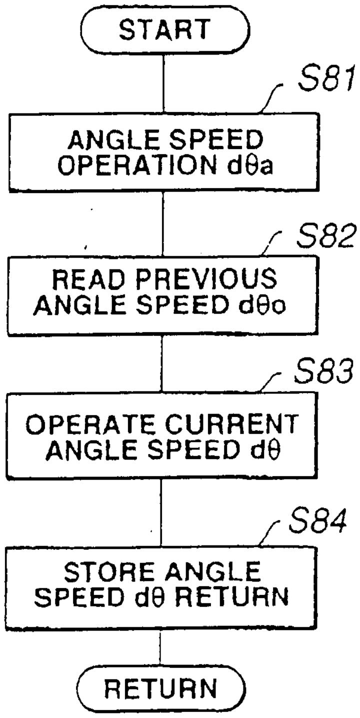
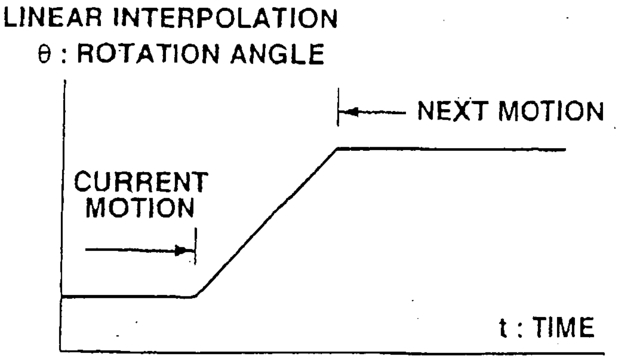
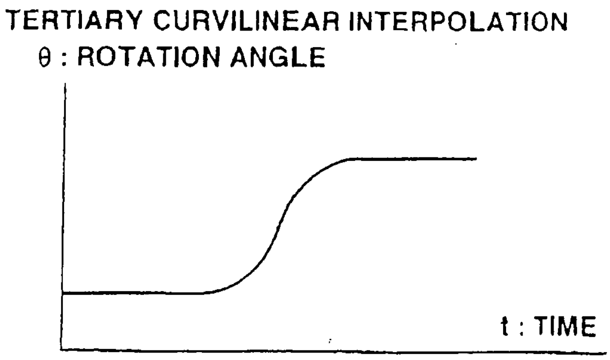

START
S81
ANGLE SPEED OPERATION dθa
S82
READ PREVIOUS ANGLE SPEED dθo
S83
OPERATE CURRENT ANGLE SPEED dθ
S84
STORE ANGLE SPEED dθ RETURN
RETURN

FIG.19



FUNCTION CURVE OF LINEAR INTERPOLATION

FIG.20



FUNCTION CURVE OF
TERTIARY FUNCTIONAL INTERPOLATION

FIG.21

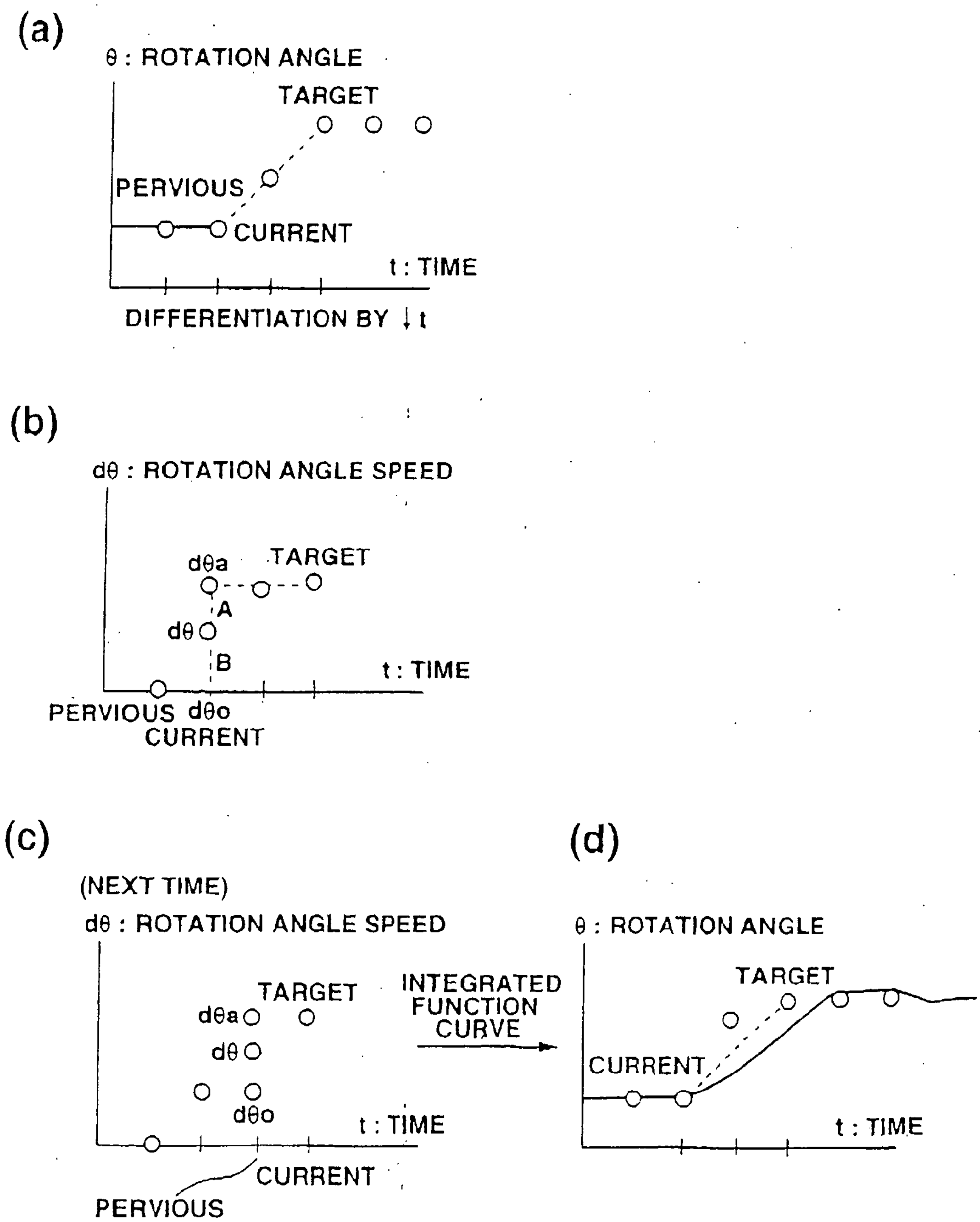

(a)
θ : ROTATION ANGLE
TARGET
PERVIOUS
CURRENT
t : TIME
DIFFERENTIATION BY ↓t
(b)
dθ : ROTATION ANGLE SPEED
dθa
TARGET
A
dθ
B
t : TIME
PERVIOUS
dθo
CURRENT
(c)
(NEXT TIME)
dθ : ROTATION ANGLE SPEED
TARGET
dθa
dθ
dθo
t : TIME
CURRENT
PERVIOUS
INTEGRATED
FUNCTION
CURVE
(d)
θ : ROTATION ANGLE
TARGET
CURRENT
t : TIME

FIG.22

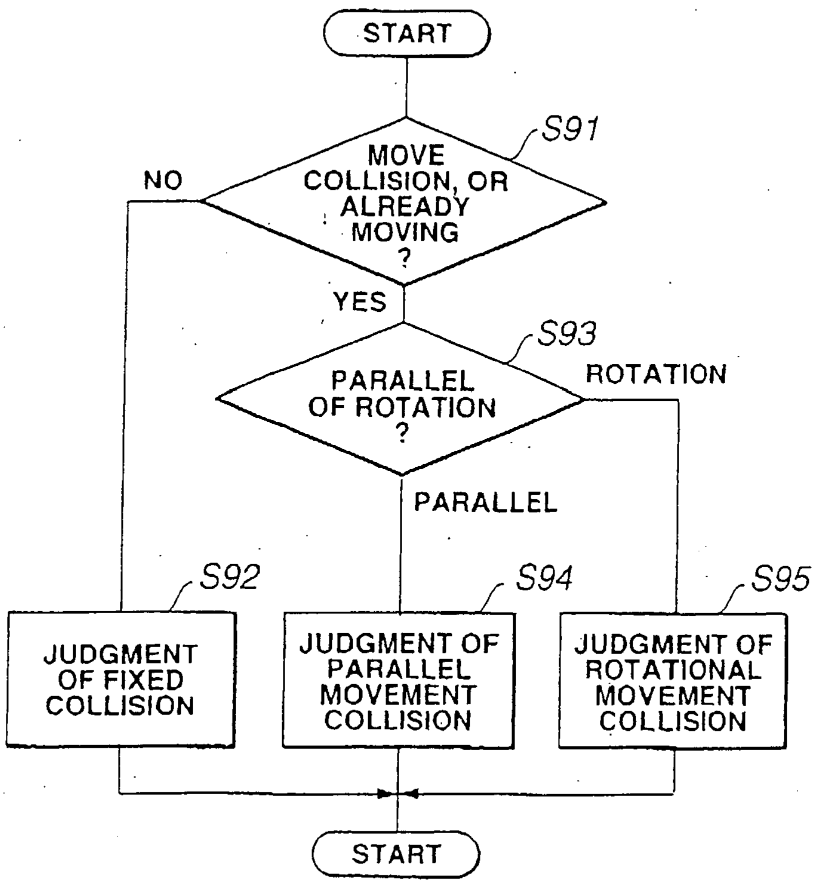

START
S91
MOVE COLLISION, OR ALREADY MOVING ?
NO
YES
S93
PARALLEL OF ROTATION ?
ROTATION
PARALLEL
S92
S94
S95
JUDGMENT OF FIXED COLLISION
JUDGMENT OF PARALLEL MOVEMENT COLLISION
JUDGMENT OF ROTATIONAL MOVEMENT COLLISION
START

FIG.23

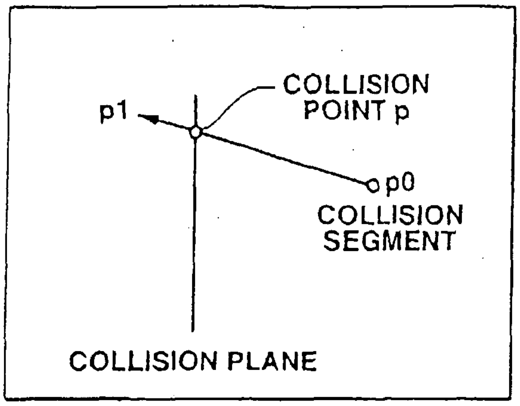

COLLISION POINT p
p1
p0
COLLISION SEGMENT
COLLISION PLANE

FIG.24

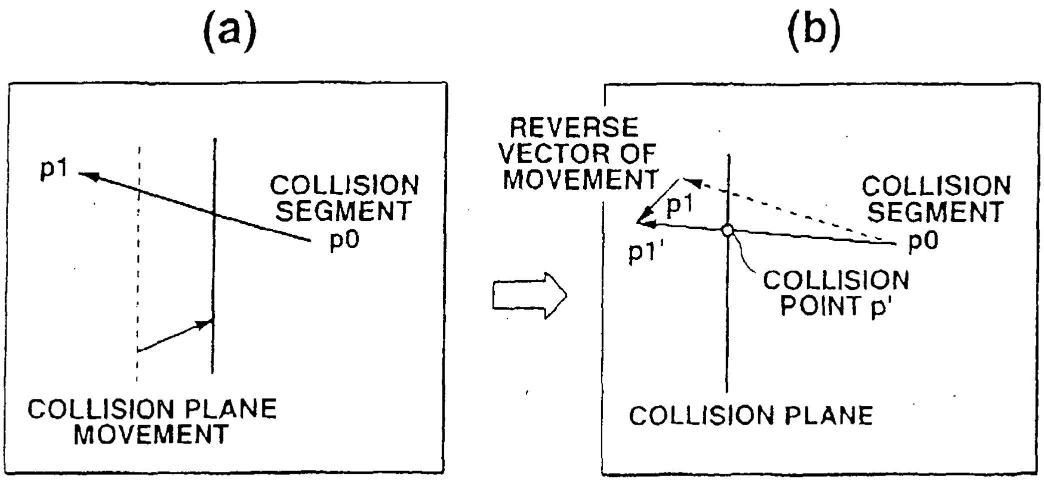

(a)
(b)
p1
COLLISION SEGMENT
p0
COLLISION PLANE MOVEMENT
REVERSE VECTOR OF MOVEMENT
p1
p1'
COLLISION SEGMENT
p0
COLLISION POINT p'
COLLISION PLANE

FIG.25

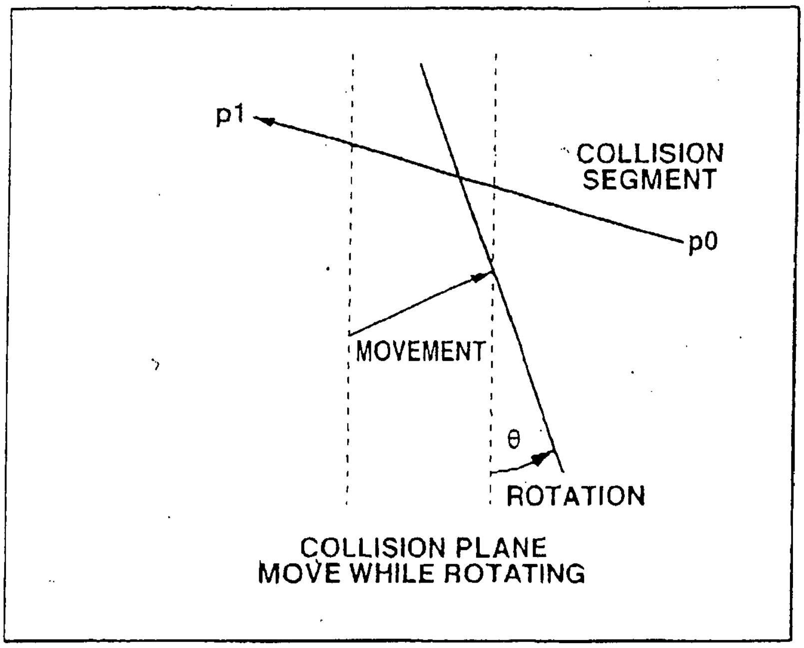

p1
COLLISION
SEGMENT
p0
MOVEMENT
θ
ROTATION
COLLISION PLANE
MOVE WHILE ROTATING

FIG.26

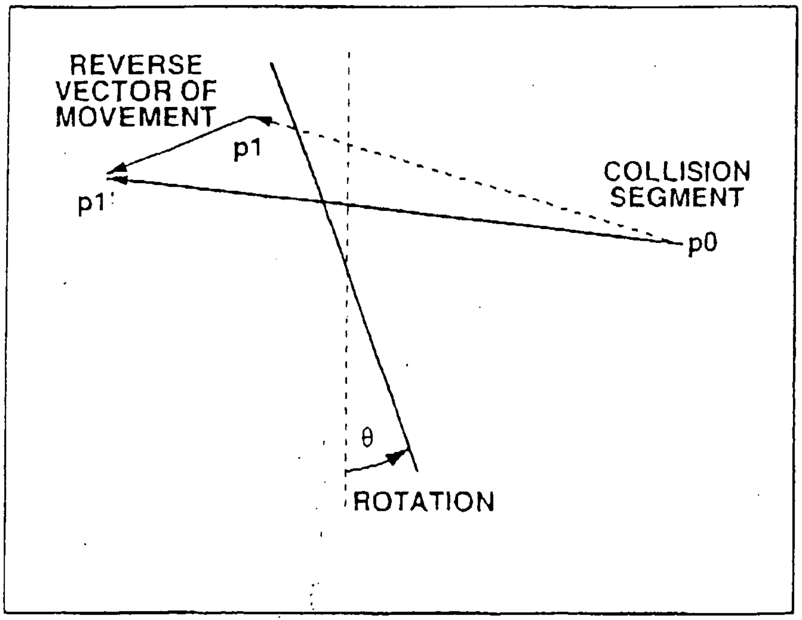

REVERSE
VECTOR OF
MOVEMENT
p1
p1'
COLLISION
SEGMENT
p0
θ
ROTATION

FIG.27