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Non-transitory computer-readable storage medium having game program stored therein, game processing system, game processing apparatus, and game processing method

Abstract

When a first speed indicating a speed difference between a first object and another object at a point of contact between both objects, or a ratio of the first speed to a second speed indicating a speed difference between centers of gravity of both objects, is within a first range including 0, a rolling sound is outputted. When the first speed or the ratio of the first speed to the second speed is within a second range not including 0, a sliding sound is outputted.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATION

(1) This application claims priority to Japanese Patent Application No. 2022-199094 filed on Dec. 14, 2022, the entire contents of which are incorporated herein by reference.

FIELD

(2) The present disclosure relates to information processing for a game or the like.

BACKGROUND AND SUMMARY

(3) Hitherto, game processing in which, on the basis of an operation input, an object in a virtual space is rolled and a rolling sound (sound effect) is also outputted has been known.

(4) The game processing described above does not handle sound effects for motions other than rolling, such as rubbing or sliding. In recent years, the behavior of objects is often controlled by physics calculation, but in such control, improvements are needed to identify the state of motion such as the case of rolling or the case of rubbing or sliding and to output sound effects appropriately.

(5) Therefore, it is an object of the exemplary embodiments to provide a non-transitory computer-readable storage medium having a game program stored therein, a game processing system, a game processing apparatus, and a game processing method that, when an object in a virtual space performs various motions in relation to another object, can appropriately perform processing corresponding to each case.

(6) In order to attain the object described above, for example, the following configuration examples are exemplified.

(7) A configuration example is directed to a non-transitory computer-readable storage medium having stored therein instructions that, when executed by a processor of an information processing apparatus, cause the information processing apparatus to: control motion of a first object in a virtual space; when the first object and another object are in contact with each other and are not stationary relative to each other, calculate a point of contact between the first object and the other object; compare a first speed indicating a speed difference between the first object and the other object at the point of contact and a second speed indicating a speed difference between a center of gravity or a predetermined reference point of the first object and a center of gravity or a predetermined reference point of the other object; and when the first speed or a ratio of the first speed to the second speed satisfies a first condition of being within a first range including 0, perform a first process for the first object, and when the first speed or the ratio of the first speed to

the second speed satisfies a second condition of being within a second range not including 0, perform a second process for the first object.
(8) According to the above configuration, different processes can be performed depending on the type of motion of the object.
(9) In another configuration example, the first process may be a process of outputting a first sound associated with the first object, and the second process may be a process of outputting a second sound associated with the first object and different from the first sound.
(10) According to the above configuration, different sound effects can be generated depending on the type of motion of the object.
(11) In another configuration example, the first process may be a process performed when the first object is rolling on the other object, and the second process may be a process performed when the first object is rubbing or sliding on the other object.
(12) According to the above configuration, a rolling sound and a rubbing (sliding) sound can be selectively used according to the behavior of the object.
(13) In another configuration example, the instructions further cause the information processing apparatus to: when the second condition is satisfied, determine a direction in which the first object rotates while rubbing or sliding on the other object, on the basis of whether a speed of the first object at the point of contact with respect to the center of gravity or the predetermined reference point of the first object is positive or negative.
(14) According to the above configuration, the direction of rotation of the object occurring while rubbing (or sliding) can be determined.
(15) In another configuration example, the second range may be a range where the first speed or the ratio of the first speed to the second speed falls outside the first range.
(16) According to the above configuration, a rolling sound and a rubbing (sliding) sound can be outputted continuously.
(17) In another configuration example, the instructions further cause the information processing apparatus to control the motion of the first object on the basis of physics calculation based on at least virtual power, virtual gravity, and collision.
(18) According to the above configuration, a rolling sound and a rubbing (sliding) sound can be outputted in accordance with the physics calculation.
(19) In another configuration example, the other object may be an object that does not move in the virtual space, the first speed may be a speed of the first object at the point of contact, and the second speed may be a speed of the center of gravity or the predetermined reference point of the first object.
(20) In another configuration example, the other object may be a terrain object in the virtual space.
(21) According to the above configuration, a rolling sound and a rubbing (sliding) sound can be outputted for the object performing motion on the terrain object.
(22) In another configuration example, the other object may be an object that moves in the virtual space, the first speed may be a relative speed between the first object and the other object at the point of contact, and the second speed may be a relative speed between the center of gravity or the predetermined reference point of the first object and the center of gravity or the predetermined reference point of the other object.
(23) According to the above configuration, a rolling sound and a rubbing (sliding) sound can be outputted for the object performing motion on the moving object.
(24) According to the exemplary embodiments, it is possible to provide a non-transitory computer-readable storage medium having a game program stored therein, a game processing system, a game processing apparatus, and a game processing method that, when an object in a virtual space performs various motions in relation to another object, can appropriately perform processing corresponding to each case.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** shows a non-limiting example of a state where a left controller **3** and a right controller **4** are attached to a main body apparatus **2**;

(2) FIG. **2** is a block diagram showing a non-limiting example of the internal configuration of the main body apparatus **2**;

(3) FIG. **3** is a block diagram showing a non-limiting example of the internal configurations of the main body apparatus **2**, the left controller **3**, and the right controller **4**;

(4) FIG. **4** is a non-limiting example diagram for describing rolling/sliding determination;

(5) FIG. **5** is a non-limiting example diagram for describing the rolling/sliding determination;

(6) FIG. **6** is a non-limiting example diagram for describing determination in the case of sliding while rotating forward;

(7) FIG. **7** is a non-limiting example diagram for describing determination in the case of sliding while rotating backward;

(8) FIG. **8** is a non-limiting example diagram for describing the rolling/sliding determination;

(9) FIG. **9** is a non-limiting example diagram for describing the rolling/sliding determination;

(10) FIG. **10** is a non-limiting example diagram for describing determination in the case of sliding while rotating forward;

(11) FIG. **11** is a non-limiting example diagram for describing determination in the case of sliding while rotating backward;

(12) FIG. **12** is a diagram for describing a non-limiting example of the case where it is determined as rolling and a rolling sound is outputted;

(13) FIG. **13** is a diagram for describing a non-limiting example of the case where it is determined as sliding and a sliding sound is outputted;

(14) FIG. **14** shows a non-limiting example of various types of data stored in a DRAM **85**;

(15) FIG. **15** is a non-limiting example of a flowchart of game processing;

(16) FIG. **16** is a non-limiting example of a flowchart of the game processing; and

(17) FIG. **17** is a non-limiting example of a flowchart of the game processing.

DETAILED DESCRIPTION OF NON-LIMITING EXAMPLE EMBODIMENTS

(18) Hereinafter, an exemplary embodiment will be described.

(19) [Hardware Configuration of Information Processing System]

(20) Hereinafter, an information processing system (game system) according to an example of the exemplary embodiment will be described below. An example of a game system **1** according to the exemplary embodiment includes a main body apparatus (an information processing apparatus, which functions as a game apparatus main body in the exemplary embodiment) **2**, a left controller **3**, and a right controller **4**. Each of the left controller **3** and the right controller **4** is attachable to and detachable from the main body apparatus **2**. That is, the game system **1** can be used as a unified apparatus obtained by attaching each of the left controller **3** and the right controller **4** to the main body apparatus **2**. Further, in the game system **1**, the main body apparatus **2**, the left controller **3**, and the right controller **4** can also be used as separate bodies. Hereinafter, first, the hardware configuration of the game system **1** according to the exemplary embodiment will be described, and then, the control of the game system **1** according to the exemplary embodiment will be described.

(21) FIG. **1** shows an example of the state where the left controller **3** and the right controller **4** are attached to the main body apparatus **2**. As shown in FIG. **1**, each of the left controller **3** and the right controller **4** is attached to and unified with the main body apparatus **2**. The main body apparatus **2** is an apparatus for performing various processes (e.g., game processing) in the game system **1**. The main body apparatus **2** includes a display **12**. Each of the left controller **3** and the right controller **4** is an apparatus including operation sections with which a user provides inputs.

(22) The main body apparatus **2** also includes speakers **88**, and sounds such as sound effects are outputted from the speakers **88**.
(23) The main body apparatus **2** also includes a left terminal **17** for the main body apparatus **2** to perform wired communication with the left controller **3**, and a right terminal **21** for the main body apparatus **2** to perform wired communication with the right controller **4**.
(24) The main body apparatus **2** also includes a slot **23**. The slot **23** is provided on an upper side surface of a housing of the main body apparatus **2**. The slot **23** is so shaped as to allow a predetermined type of storage medium to be attached to the slot **23**. The predetermined type of storage medium is, for example, a dedicated storage medium (e.g., a dedicated memory card) for the game system **1** and an information processing apparatus of the same type as the game system **1**. The predetermined type of storage medium is used to store, for example, data (e.g., saved data of an application or the like) used by the main body apparatus **2** and/or a program (e.g., a program for an application or the like) executed by the main body apparatus **2**. Further, the main body apparatus **2** includes a power button **28**.
(25) Each of the left controller **3** and the right controller **4** includes various operation buttons, etc. The various operation buttons, etc., are used to give instructions according to various programs (e.g., an OS program and an application program) executed by the main body apparatus **2**.
(26) Each of the left controller **3** and the right controller **4** also includes a terminal **42** or **64** for performing wired communication with the main body apparatus **2**.
(27) FIG. **2** is a block diagram showing an example of the internal configuration of the main body apparatus **2**. The main body apparatus **2** includes a processor **81**. The processor **81** is an information processing section for executing various types of information processing to be executed by the main body apparatus **2**. For example, the processor **81** may be composed only of a CPU (Central Processing Unit), or may be composed of a SoC (System-on-a-chip) having a plurality of functions such as a CPU function and a GPU (Graphics Processing Unit) function. The processor **81** executes an information processing program (e.g., a game program) stored in a storage section (specifically, an internal storage medium such as a flash memory **84**, an external storage medium attached to the slot **23**, or the like), thereby performing the various types of information processing.
(28) The main body apparatus **2** includes the flash memory **84** and a DRAM (Dynamic Random Access Memory) **85** as examples of internal storage media built into the main body apparatus **2**. The flash memory **84** and the DRAM **85** are connected to the processor **81**. The flash memory **84** is a memory mainly used to store various data (or programs) to be saved in the main body apparatus **2**. The DRAM **85** is a memory used to temporarily store various data used for information processing.
(29) The main body apparatus **2** includes a slot interface (hereinafter, abbreviated as “I/F”) **91**. The slot I/F **91** is connected to the processor **81**. The slot I/F **91** is connected to the slot **23**, and in accordance with an instruction from the processor **81**, reads and writes data from and to the predetermined type of storage medium (e.g., a dedicated memory card) attached to the slot **23**.
(30) The processor **81** appropriately reads and writes data from and to the flash memory **84**, the DRAM **85**, and each of the above storage media, thereby performing the above information processing.
(31) The main body apparatus **2** includes a network communication section **82**. The network communication section **82** is connected to the processor **81**. The network communication section **82** communicates (specifically, through wireless communication) with an external apparatus via a network. In the exemplary embodiment, the network communication section **82** connects to a wireless LAN by a method compliant with the Wi-Fi standard, for example, and performs Internet communication or the like with an external apparatus (another main body apparatus **2**). Further, the network communication section **82** can also perform short-range wireless communication (e.g., infrared light communication) with another main body apparatus **2**.

(32) The main body apparatus **2** includes a controller communication section **83**. The controller communication section **83** is connected to the processor **81**. The controller communication section **83** wirelessly communicates with the left controller **3** and/or the right controller **4**. The communication method between the main body apparatus **2** and the left controller **3** and the right controller **4** is discretionary. In the exemplary embodiment, the controller communication section **83** performs communication compliant with the Bluetooth (registered trademark) standard with the left controller **3** and with the right controller **4**.
(33) The processor **81** is connected to the above left terminal **17**, the above right terminal **21**, and a lower terminal **27**. When performing wired communication with the left controller **3**, the processor **81** transmits data to the left controller **3** via the left terminal **17** and also receives operation data from the left controller **3** via the left terminal **17**. Further, when performing wired communication with the right controller **4**, the processor **81** transmits data to the right controller **4** via the right terminal **21** and also receives operation data from the right controller **4** via the right terminal **21**. Further, when communicating with a cradle, the processor **81** transmits data to the cradle via the lower terminal **27**. As described above, in the exemplary embodiment, the main body apparatus **2** can perform both wired communication and wireless communication with each of the left controller **3** and the right controller **4**. Further, when the unified apparatus obtained by attaching the left controller **3** and the right controller **4** to the main body apparatus **2** or the main body apparatus **2** alone is attached to the cradle, the main body apparatus **2** can output data (e.g., image data or sound data) to the stationary monitor or the like via the cradle.
(34) The main body apparatus **2** includes a touch panel controller **86**, which is a circuit for controlling a touch panel **13**. The touch panel controller **86** is connected between the touch panel **13** and the processor **81**. On the basis of a signal from the touch panel **13**, the touch panel controller **86** generates data indicating the position at which a touch input has been performed, for example, and outputs the data to the processor **81**.
(35) Further, the display **12** is connected to the processor **81**. The processor **81** displays a generated image (e.g., an image generated by executing the above information processing) and/or an externally acquired image on the display **12**.
(36) The main body apparatus **2** includes a codec circuit **87** and the speakers (specifically, a left speaker and a right speaker) **88**. The codec circuit **87** is connected to the speakers **88** and a sound input/output terminal **25** and also connected to the processor **81**. The codec circuit **87** is a circuit for controlling the input and output of sound data to and from the speakers **88** and the sound input/output terminal **25**.
(37) The main body apparatus **2** includes a power control section **97** and a battery **98**. The power control section **97** is connected to the battery **98** and the processor **81**. Further, although not shown in FIG. **6**, the power control section **97** is connected to components of the main body apparatus **2** (specifically, components that receive power supplied from the battery **98**, the left terminal **17**, and the right terminal **21**). On the basis of a command from the processor **81**, the power control section **97** controls the supply of power from the battery **98** to the above components.
(38) Further, the battery **98** is connected to the lower terminal **27**. When an external charging device (e.g., the cradle) is connected to the lower terminal **27**, and power is supplied to the main body apparatus **2** via the lower terminal **27**, the battery **98** is charged with the supplied power.
(39) FIG. **3** is a block diagram showing examples of the internal configurations of the main body apparatus **2**, the left controller **3**, and the right controller **4**. It should be noted that the details of the internal configuration of the main body apparatus **2** are shown in FIG. **2** and therefore are omitted in FIG. **3**.
(40) The left controller **3** includes a communication control section **101**, which communicates with the main body apparatus **2**. As shown in FIG. **7**, the communication control section **101** is connected to components including the terminal **42**. In the exemplary embodiment, the communication control section **101** can communicate with the main body apparatus **2** through both

wired communication via the terminal **42** and wireless communication not via the terminal **42**. The communication control section **101** controls the method for communication performed by the left controller **3** with the main body apparatus **2**. That is, when the left controller **3** is attached to the main body apparatus **2**, the communication control section **101** communicates with the main body apparatus **2** via the terminal **42**. Further, when the left controller **3** is detached from the main body apparatus **2**, the communication control section **101** wirelessly communicates with the main body apparatus **2** (specifically, the controller communication section **83**). The wireless communication between the communication control section **101** and the controller communication section **83** is performed in accordance with the Bluetooth (registered trademark) standard, for example.

(41) The left controller **3** also includes a memory **102** such as a flash memory. The communication control section **101** includes, for example, a microcomputer (or a microprocessor) and executes firmware stored in the memory **102**, thereby performing various processes.

(42) The left controller **3** includes buttons **103** (specifically, buttons **33** to **39**, **43**, **44**, and **47**). The left controller **3** also includes a left stick **32**. Each of the buttons **103** and the left stick **32** outputs information regarding an operation performed on itself to the communication control section **101** repeatedly at appropriate timings.

(43) The left controller **3** includes inertial sensors. Specifically, the left controller **3** includes an acceleration sensor **104**. Further, the left controller **3** includes an angular velocity sensor **105**. In the exemplary embodiment, the acceleration sensor **104** detects the magnitudes of accelerations along predetermined three axial (e.g., xyz axes shown in FIG. **4**) directions. It should be noted that the acceleration sensor **104** may detect an acceleration along one axial direction or accelerations along two axial directions. In the exemplary embodiment, the angular velocity sensor **105** detects angular velocities about predetermined three axes (e.g., the xyz axes shown in FIG. **4**). It should be noted that the angular velocity sensor **105** may detect an angular velocity about one axis or angular velocities about two axes. Each of the acceleration sensor **104** and the angular velocity sensor **105** is connected to the communication control section **101**. Then, the detection results of the acceleration sensor **104** and the angular velocity sensor **105** are outputted to the communication control section **101** repeatedly at appropriate timings.

(44) The communication control section **101** acquires information regarding an input (specifically, information regarding an operation, or the detection result of the sensor) from each of input sections (specifically, the buttons **103**, the left stick **32**, and the sensors **104** and **105**). The communication control section **101** transmits operation data including the acquired information (or information obtained by performing predetermined processing on the acquired information) to the main body apparatus **2**. It should be noted that the operation data is transmitted repeatedly, once every predetermined time. It should be noted that the interval at which the information regarding an input is transmitted from each of the input sections to the main body apparatus **2** may or may not be the same.

(45) The above operation data is transmitted to the main body apparatus **2**, whereby the main body apparatus **2** can obtain inputs provided to the left controller **3**. That is, the main body apparatus **2** can determine operations on the buttons **103** and the left stick **32** on the basis of the operation data. Further, the main body apparatus **2** can calculate information regarding the motion and/or the orientation of the left controller **3** on the basis of the operation data (specifically, the detection results of the acceleration sensor **104** and the angular velocity sensor **105**).

(46) The left controller **3** includes a power supply section **108**. In the exemplary embodiment, the power supply section **108** includes a battery and a power control circuit. Although not shown in FIG. **7**, the power control circuit is connected to the battery and also connected to components of the left controller **3** (specifically, components that receive power supplied from the battery).

(47) As shown in FIG. **3**, the right controller **4** includes a communication control section **111**, which communicates with the main body apparatus **2**. The right controller **4** also includes a memory **112** which is connected to the communication control section **111**. The communication

control section **111** is connected to components including the terminal **64**. The communication control section **111** and the memory **112** have functions similar to those of the communication control section **101** and the memory **102**, respectively, of the left controller **3**. Thus, the communication control section **111** can communicate with the main body apparatus **2** through both wired communication via the terminal **64** and wireless communication not via the terminal **64** (specifically, communication compliant with the Bluetooth (registered trademark) standard). The communication control section **111** controls the method for communication performed by the right controller **4** with the main body apparatus **2**.

(48) The right controller **4** includes input sections similar to the input sections of the left controller **3**. Specifically, the right controller **4** includes buttons **113**, a right stick **52**, and inertial sensors (an acceleration sensor **114** and an angular velocity sensor **115**). These input sections have functions similar to those of the input sections of the left controller **3** and operate similarly to the input sections of the left controller **3**.

(49) The right controller **4** includes a power supply section **118**. The power supply section **118** has a function similar to that of the power supply section **108** of the left controller **3** and operates similarly to the power supply section **108**.

(50) [Game Assumed in Exemplary Embodiment]

(51) Next, an outline of game processing (an example of the information processing) executed in the game system **1** according to the exemplary embodiment will be described. A game assumed in the exemplary embodiment is, for example, a role-playing game in which a player object (sometimes referred to as "character") which performs actions in accordance with operations performed by a player moves and performs other actions in a virtual space (game space) in which various objects are placed, to achieve a predetermined objective. The game is not limited to the role-playing game, and may be other types of games (competitive game, etc.).

(52) [Outline of Game Processing of Exemplary Embodiment]

(53) In the game processing, actions, etc., of the character are controlled in accordance with operations performed by the player (user), and an image of the virtual space is taken by a virtual camera and displayed on the display **12**, thereby advancing the game. In the game processing, physics calculation is performed. That is, in the game processing, the motion of each object in the virtual space is controlled by physics calculation based on virtual power, gravity, collision, etc. Appropriate processing can then be performed in accordance with the motion of each object controlled by the physics calculation.

(54) Specifically, on the basis of the relationship between objects, it is determined whether one object is rolling or sliding on the other object. When the one object is rolling, a rolling sound is outputted from the speakers **88**, and when the one object is sliding (moving while rubbing), a sliding sound is outputted from the speakers **88**. Hereinafter, a specific description will be given with reference to the drawings. Instead of (or in addition to) outputting a rolling sound or a sliding sound from the speakers **88**, other processes (such as displaying a virtual effect corresponding to rolling or sliding) may be performed.

(55) [Case where Object Moves on Object that does not Move]

(56) First, the case where an object moves on an object (surface) that does not move will be described with reference to FIG. **4** to FIG. **7**. In this description, the case where a spherical object (sometimes referred to as "sphere object") **200** is moving on a ground object **300** is used as an example.

(57) FIG. **4** is a diagram for describing the case where the sphere object **200** moves on the ground object **300** by rolling (without sliding). In FIG. **4**, the sphere object **200** on the ground object **300** is moving in an X-axis direction by rolling (without sliding). In addition, in FIG. **4**, G**1** indicates the center of gravity of the sphere object **200**, C indicates the point of contact between the sphere object **200** and the ground object **300**, and A indicates a point on the surface of the sphere object **200**. In FIG. **4**, the position of the point A is moving as the sphere object **200** rolls.

(58) As shown in FIG. **4**, when the sphere object **200** moves in the X-axis direction by rolling without sliding, no sliding (rubbing) occurs at the point of contact C. From this, it can be said that a portion at the point of contact C of the sphere object **200** is not moving relative to a portion at the point of contact C of the ground object **300**. In other words, the speed of the sphere object **200** at the point of contact C is 0 (zero). Therefore, when the speed of the sphere object **200** at the point of contact C is 0, it can be determined that the sphere object **200** is rolling on the ground object **300** without sliding.
(59) FIG. **5** is a diagram for describing the case where the sphere object **200** moves on the ground object **300** while sliding (rubbing). In FIG. **5**, the sphere object **200** on the ground object **300** is moving in the X-axis direction while sliding. In addition, in FIG. **5**, G**1** indicates the center of gravity of the sphere object **200**, C indicates the point of contact between the sphere object **200** and the ground object **300**, and A indicates a point on the surface of the sphere object **200**. In FIG. **5**, since the sphere object **200** is moving while sliding without rotating at all, the point A remains at the same position as the point of contact C.
(60) As shown in FIG. **5**, when the sphere object **200** moves in the X-axis direction while sliding without rotating at all, sliding (rubbing) occurs at the point of contact C. From this, it can be said that the portion at the point of contact C of the sphere object **200** is moving relative to the portion at the point of contact C of the ground object **300** which does not move. In other words, the speed of the sphere object **200** at the point of contact C is not 0 (zero). Therefore, when the speed of the sphere object **200** at the point of contact C is not 0, it can be determined that the sphere object **200** is sliding on the ground object **300**.
(61) FIG. **6** is a diagram for describing the case where the sphere object **200** moves on the ground object **300** by sliding while rotating forward. In FIG. **6**, the sphere object **200** on the ground object **300** is moving in the X-axis direction by sliding while rotating forward. In addition, in FIG. **6**, G**1** indicates the center of gravity of the sphere object **200**, C indicates the point of contact between the sphere object **200** and the ground object **300**, and A indicates a point on the surface of the sphere object **200**. In FIG. **6**, the position of the point A is moving as the sphere object **200** rotates forward.
(62) As shown in FIG. **6**, when the sphere object **200** moves in the X-axis direction by sliding while rotating forward, sliding (rubbing) occurs at the point of contact C. From this, as in the case of FIG. **5**, the speed of the sphere object **200** at the point of contact C is not 0 (zero). In addition, as shown in FIG. **6**, the speed in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the sphere object **200** is a negative value. Therefore, when the speed of the sphere object **200** at the point of contact C is not 0 and the speed in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the sphere object **200** is negative, it can be determined that the sphere object **200** is sliding on the ground object **300** while rotating forward.
(63) FIG. **7** is a diagram for describing the case where the sphere object **200** moves on the ground object **300** by sliding while rotating backward. In FIG. **7**, the sphere object **200** on the ground object **300** is moving in the X-axis direction by sliding while rotating backward. In addition, in FIG. **7**, G**1** indicates the center of gravity of the sphere object **200**, C indicates the point of contact between the sphere object **200** and the ground object **300**, and A indicates a point on the surface of the sphere object **200**. In FIG. **7**, the position of the point A is moving as the sphere object **200** rotates backward.
(64) As shown in FIG. **7**, when the sphere object **200** moves in the X-axis direction by sliding while rotating backward, sliding (rubbing) occurs at the point of contact C. From this, as in the case of FIG. **5**, the speed of the sphere object **200** at the point of contact C is not 0 (zero). In addition, as shown in FIG. **7**, the speed in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the sphere object **200** (or the entire sphere object **200**) is a positive value. Therefore, when the speed of the sphere object **200** at the point of contact C is not 0 and the speed in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the

sphere object **200** is positive, it can be determined that the sphere object **200** is sliding on the ground object **300** while rotating backward.
(65) [Case where Object Moves on Moving Object]
(66) Next, the case where an object moves on a moving object (surface) will be described with reference o FIG. **8** to FIG. **11**. In this description, the case where the sphere object **200** is moving on a moving object (sometimes referred to as "movement object") **400** is used as an example. The moving object **400** is, for example, the deck of a moving ship. The case where the sphere object **200** is moving on the ground object **300** as described with reference to FIG. **4** to FIG. **7** can be considered as the case where the movement object **400** does not move (is stationary) in the following description.
(67) FIG. **8** is a diagram for describing the case where the sphere object **200** moves on the movement object **400** by rolling (without sliding). In FIG. **8**, the sphere object **200** is moving in the X-axis positive direction by rolling (without sliding) on the movement object **400** moving in the X-axis negative direction. In FIG. **8**, the movement object **400** is moving from a position shown by a broken line to a position shown by a solid line. In addition, in FIG. **8**, G**1** indicates the center of gravity of the sphere object **200**, G**2** indicates the center of gravity of the movement object **400**, C indicates the point of contact between the sphere object **200** and the movement object **400**, and A indicates a point on the surface of the sphere object **200**. In FIG. **8**, the position point A is moving as the sphere object **200** rolls on the movement object **400**.
(68) As shown in FIG. **8**, when the sphere object **200** moves in the X-axis direction by rolling on the movement object **400** without sliding, no sliding (rubbing) occurs at the point of contact C as in FIG. **4**. From this, it can be said that a portion at the point of contact C of the sphere object **200** is not moving relative to a portion at the point of contact C of the movement object **400**. In other words, the difference between the speed of the sphere object **200** and the speed of the movement object **400** at the point of contact C is 0 (zero). Therefore, when the difference between the speed of the sphere object **200** and the speed of the movement object **400** at the point of contact C is 0, it can be determined that the sphere object **200** is rolling on the movement object **400** without sliding.
(69) FIG. **9** is a diagram for describing the case where the sphere object **200** moves on the movement object **400** while sliding (while rubbing). In FIG. **9**, the sphere object **200** is moving in the X-axis positive direction while sliding on the movement object **400** moving in the X-axis negative direction. In addition, in FIG. **9**, G**1** indicates the center of gravity of the sphere object **200**, G**2** indicates the center of gravity of the movement object **400**, C indicates the point of contact between the sphere object **200** and the movement object **400**, and A indicates a point on the surface of the sphere object **200**. In FIG. **9**, since the sphere object **200** is moving while sliding without rotating at all, the point A remains at the same position as the point of contact C.
(70) As shown in FIG. **9**, when the sphere object **200** moves in the X-axis positive direction while sliding without rotating at all, sliding (rubbing) occurs at the point of contact C as in FIG. **5**. From this, it can be said that the portion at the point of contact C of the sphere object **200** is moving relative to the portion at the point of contact C of the movement object **400**. In other words, the difference between the speed of the sphere object **200** and the speed of the movement object **400** at the point of contact C is not 0 (zero). Therefore, when the difference between the speed of the sphere object **200** and the speed of the movement object **400** at the point of contact C is not 0, it can be determined that the sphere object **200** is sliding on the movement object **400**.
(71) FIG. **10** is a diagram for describing the case where the sphere object **200** moves by sliding on the movement object **400** while rotating forward. In FIG. **10**, the sphere object **200** is moving in the X-axis positive direction by sliding, while rotating forward, on the movement object **400** moving in the X-axis negative direction. In addition, in FIG. **10**, G**1** indicates the center of gravity of the sphere object **200**, G**2** indicates the center of gravity of the movement object **400**, C indicates the point of contact between the sphere object **200** and the movement object **400**, and A indicates a point on the surface of the sphere object **200**. In FIG. **10**, the position of the point A is moving as

the sphere object **200** rotates forward.

(72) As shown in FIG. **10**, when the sphere object **200** moves in the X-axis positive direction by sliding while rotating forward, sliding (rubbing) occurs at the point of contact C as in FIG. **9**. From this, as in the case of FIG. **9**, the difference between the speed of the sphere object **200** and the speed of the movement object **400** at the point of contact C is not 0 (zero). In addition, as shown in FIG. **10**, the speed in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the sphere object **200** is a negative value. Therefore, when the difference between the speed of the sphere object **200** and the speed of the movement object **400** at the point of contact C is not 0 and the speed in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the sphere object **200** is a negative value, it can be determined that the sphere object **200** is sliding on the movement object **400** while rotating forward.

(73) FIG. **11** is a diagram for describing the case where the sphere object **200** moves by sliding on the movement object **400** while rotating backward. In FIG. **11**, the sphere object **200** is moving in the X-axis positive direction by sliding, while rotating backward, on the movement object **400** moving in the X-axis negative direction. In addition, in FIG. **11**, G**1** indicates the center of gravity of the sphere object **200**, G**2** indicates the center of gravity of the movement object **400**, C indicates the point of contact between the sphere object **200** and the movement object **400**, and A indicates a point on the surface of the sphere object **200**. In FIG. **11**, the position of the point A is moving as the sphere object **200** rotates backward.

(74) As shown in FIG. **11**, when the sphere object **200** moves in the X-axis positive direction by sliding while rotating backward, sliding (rubbing) occurs at the point of contact C as in FIG. **9**. From this, as in the case of FIG. **9**, the difference between the speed of the sphere object **200** and the speed of the movement object **400** at the point of contact C is not 0 (zero). In addition, as shown in FIG. **11**, the speed in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the sphere object **200** is a positive value. Therefore, when the difference between the speed of the sphere object **200** and the speed of the movement object **400** at the point of contact C is not 0 and the speed in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the sphere object **200** is a positive value, it can be determined that the sphere object **200** is sliding on the movement object **400** while rotating backward.

(75) The above description can be summarized as follows. (1) When the difference between the speed (speed in the X-axis direction) of the sphere object **200** and the speed (speed in the X-axis direction) of the movement object **400** at the point of contact C (sometimes referred to as “first speed”) is 0, it can be determined that the sphere object **200** is rolling on the movement object **400** without sliding (see FIG. **8**). (2) When the first speed is not 0, it can be determined that the sphere object **200** is sliding on the movement object **400** (see FIG. **9**). (3) When it is determined that the sphere object **200** is sliding on the movement object **400**, if the speed in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the sphere object **200** (sometimes referred to as “third speed”) is a negative value, it can be determined that the sphere object **200** is sliding on the movement object **400** while rotating forward (see FIG. **10**). (4) When it is determined that the sphere object **200** is sliding on the movement object **400**, if the third speed is a positive value, it can be determined that the sphere object **200** is sliding on the movement object **400** while rotating backward (see FIG. **11**).

[Method of Considering Relative Speed Between Centers of Gravity of Objects]

(76) Next, a method of considering the relative speed between the centers of gravity of objects in the above-described determination of the state of the object (determination as to whether the object is rolling or sliding) will be described.

(77) Specifically (see FIG. **10**), when the absolute value (sometimes referred to as “ratio value”) of a value obtained by dividing the first speed by the speed difference in the X-axis direction between the center of gravity G**1** of the sphere object **200** and the center of gravity G**2** of the movement object **400** (relative speed in the X-axis direction between the center of gravity G**1** and the center of

gravity G**2**: sometimes referred to as "second speed") is equal to or lower than a predetermined value D (e.g., D=0.5), it is determined that the sphere object **200** is rolling on the movement object **400** without sliding. That is, when the following (Formula 1) is satisfied, it is determined that the sphere object **200** is rolling on the movement object **400** without sliding.

(78) $|\text{firstspeed} / \text{secondspeed}| \leq D$ (Formula1)

(79) On the other hand (see FIG. **11**), when the above-described absolute value is higher than the predetermined value D (e.g., D=0.5), it is determined that the sphere object **200** is sliding on the movement object **400**. That is, when the following (Formula 2) is satisfied, it is determined that the sphere object **200** is sliding on the movement object **400**.

(80) $|\text{firstspeed} / \text{secondspeed}| > D$ (Formula2)

(81) By considering the relative speed between the centers of gravity of the objects as described above, it becomes easier to determine that the object is rolling, as the second speed increases. This can avoid giving an uncomfortable feeling by determining that the object is rolling, and performing later-described control of outputting a rolling sound in a situation in which the relative speed between both objects is high and it is difficult for the player to recognize (see) whether or not the object is rolling.

(82) Here, the already described method of determining that the sphere object **200** is sliding on the movement object **400** while rotating forward can also be applied to the method of considering the relative speeds between the centers of gravity of the objects as described above (see FIG. **10**). Similarly, the method of determining that the sphere object **200** is sliding on the movement object **400** while rotating backward can also be applied to the method of considering the relative speeds between the centers of gravity of the objects as described above (see FIG. **11**).

(83) Either one of the above-described method of considering the relative speeds between the centers of gravity of the objects and the above-described method of not considering the relative speeds between the centers of gravity of the objects may be used, or both of these methods may be used.

(84) Next, an example of control using the results of the above-described rolling and sliding determination will be described. FIG. **12** is a diagram for describing an example of processing in the case where it is determined that an object is rolling. FIG. **13** is a diagram for describing an example of processing in the case where it is determined that an object is sliding. When a player character **202** is rolling the sphere object **200** on the ground object **300** as shown in FIG. **12**, if it is determined by the above-described method that the sphere object **200** is rolling (without sliding), a rolling sound is outputted from the speakers **88**. Meanwhile, when the player character **202** is pulling and sliding the sphere object **200** on the ground object **300** as shown in FIG. **13**, if it is determined by the above-described method that the sphere object **200** is sliding, a sliding sound is outputted from the speakers **88**. In addition, when it is determined that the sphere object **200** is sliding, if it is determined that the sphere object **200** is rotating forward, a sliding sound for forward rotation is outputted from the speakers **88**, and if it is determined that the sphere object **200** is rotating backward, a sliding sound for backward rotation is outputted from the speakers **88**. Instead of (or in addition to) the above-described rolling sound, for example, a predetermined virtual effect may be displayed for the sphere object **200**. In addition, instead of (or in addition to) the above-described sliding sound, for example, a virtual effect different from the above-described predetermined virtual effect may be displayed for the sphere object **200**.

(85) [Details of Information Processing of Exemplary Embodiment]

(86) Next, the information processing of the exemplary embodiment will be described in detail with reference to FIG. **14** to FIG. **17**.

(87) [Data to be Used]

(88) Various types of data used in the game processing will be described. FIG. **14** shows an example of data stored in the DRAM **85** of the game system **1**. As shown in FIG. **14**, the DRAM **85**

is provided with at least a program storage area **301** and a data storage area **302**. A game program **401** is stored in the program storage area **301**. In the data storage area **302**, game control data **402**, image data **408**, virtual camera control data **409**, operation data **410**, transmission data **411**, reception data **412**, etc., are stored. The game control data **402** includes object data **403**.
(89) The game program **401** is a game program for executing the game processing. The game program **401** includes a physics calculation program for performing physics calculation that reproduces the motion of each object in the virtual space (game space) as in the real world.
(90) The object data **403** is data of objects to be placed in the virtual space, such as the player character, other characters, items, ground, rocks, stones, trees, and buildings. The object data **403** is also data indicating the shape, position, orientation, movement state, action state, attribute, etc., of each object. In addition, the above-described physics calculation program performs physics calculation using the object data **403**.
(91) The image data **408** is image data of backgrounds, virtual effects, etc.
(92) The virtual camera control data **409** is data for controlling the motion of the virtual camera placed in the virtual space. Specifically, the virtual camera control data **409** is data that specifies the position/orientation, angle of view, imaging direction, etc., of the virtual camera.
(93) The operation data **410** is data indicating the contents of operations performed on the left controller **3** and the right controller **4**. The operation data **410** includes, for example, data indicating motions and orientation changes of the left controller **3** and the right controller **4** and input states regarding press states and the like of various buttons. The contents of the operation data **410** are updated at a predetermined cycle on the basis of signals from the left controller **3** and the right controller **4**.
(94) The transmission data **411** is data to be transmitted to other game systems **1**, and is data including at least information for identifying the transmission source, and the contents of the operation data **410**.
(95) The reception data **412** is data stored such that transmission data received from other game systems **1** (i.e., transmission sources) can be discerned for each of the other game systems **1**.
(96) In addition, various types of data to be used in game processing is stored as necessary in the DRAM **85**.
(97) [Details of Game Processing]
(98) Next, the game processing according to the exemplary embodiment will be described in detail with reference to flowcharts. FIG. **15** to FIG. **17** are each an example of a flowchart showing the details of the game processing according to the exemplary embodiment.
(99) First, upon start of the game processing, the processor **81** performs a game start process in step S**100** in FIG. **15**. For example, the processor **81** displays, on a display section (e.g., the display **12**), a representation showing the start of the game processing. Then, the processing proceeds to step S**200**.
(100) In step S**200**, the processor **81** performs a game control process. Specifically, the processor **81** performs a process of advancing the game by, for example, causing the player character to perform an action in the virtual space on the basis of an operation performed by the player. In addition, the processor **81** reproduces the motion of each object in the virtual space as in the real world by performing physics calculation on the basis of the object data **403**, etc. During the execution of the game control process, acquisition of operation data, control of each object in the virtual space, image display, etc., are performed every frame (i.e., at predetermined time intervals).
(101) In addition, in the game control process in step S**200**, the processor **81** executes a rolling/sliding sound process for objects on the basis of the results of the physics calculation. FIG. **16** is an example of a flowchart of the rolling/sliding sound process.
(102) In step S**501** in FIG. **16**, the processor **81** calculates the point of contact C (see FIG. **8**, etc.) between objects that are not stationary relative to each other, on the basis of the object data **403**, etc. Then, the processing proceeds to step S**502**. The calculation of the point of contact C between

the objects may also be performed during a period when both objects that are in contact with each other are stationary.

(103) In step S**502**, the processor **81** calculates the speed difference (first speed) between both objects (objects that are in contact with each other) at the point of contact C calculated in step S**501**, on the basis of the object data **403**, etc. Specifically, the processor **81** calculates the difference (first speed) between the speed (speed in the X-axis direction) of the sphere object **200** and the speed (speed in the X-axis direction) of the movement object **400** at the point of contact C as described with reference to FIG. **8**, etc. Then, the processing proceeds to step S**503**.

(104) In step S**503**, the processor **81** determines whether or not the first speed calculated in step S**502** is 0. When this determination is YES, the processing proceeds to step S**504**, and when this determination is NO, the processing proceeds to step S**505**.

(105) In step S**504**, the processor **81** determines that the object is rolling, and outputs a rolling sound from the speakers **88** as described with reference to FIG. **12**. Then, the processing returns to step S**501**.

(106) In step S**505**, the processor **81** calculates whether or not the object is rotating and the direction of rotation on the basis of the object data **403**, etc. Specifically, as described with reference to FIG. **10** and FIG. **11**, when the speed (third speed) in the X-axis direction of the point A with respect to the position of the center of gravity G**1** of the sphere object **200** is 0, the processor **81** determines that the object is sliding without rotating: when the third speed is negative, the processor **81** determines that the object is sliding while rotating forward; and when the third speed is positive, the processor **81** determines that the object is sliding while rotating backward. Then, the processing proceeds to step S**506**.

(107) In step S**506**, as described with reference to FIG. **13**, the processor **81** determines that the object is sliding, and outputs a sliding sound from the speakers **88**. In addition, the processor **81** changes the sliding sound to be outputted from the speakers **88**, on the basis of the determination in step S**505**. For example, a relatively high pitched sliding sound is outputted when the object is rotating forward, and a relatively low pitched sliding sound is outputted when the object is rotating backward. Then, the processing returns to step S**501**.

(108) In the game control process in step S**200**, the processor **81** can also execute another rolling/sliding sound process on the basis of the results of the physics calculation. FIG. **17** is an example of a flowchart of the other rolling/sliding sound process.

(109) In the flowchart in FIG. **17**, step S**503** in the flowchart in FIG. **16** is replaced with steps S**601** to S**603**. Therefore, steps S**601** to S**603** will be described below, and the description of the other steps is omitted.

(110) In step S**601**, the processor **81** calculates the speed difference (second speed) between the centers of gravity of both objects coming into contact with each other at the point of contact C calculated in step S**501** (objects that are in contact with each other), on the basis of the object data **403**, etc. Specifically, as already described, the processor **81** calculates the speed difference (second speed) in the X-axis direction between the center of gravity G**1** of the sphere object **200** and the center of gravity G**2** of the movement object **400** (see FIG. **8**, etc.). Then, the processing proceeds to step S**602**.

(111) In step S**602**, the processor **81** calculates a ratio value. Specifically, as already described, the processor **81** calculates the absolute value (ratio value) of the value obtained by dividing the first speed by the second speed. Then, the processing proceeds to step S**603**.

(112) In step S**603**, the processor **81** determines whether or not the ratio value calculated in step S**602** is equal to or lower than a predetermined value D (e.g., D=0.5). When this determination is YES, the processing proceeds to step S**504**, and when this determination is NO, the processing proceeds to step S**505**.

(113) This is the end of the description of the rolling/sliding sound process. Either one of the rolling/sliding sound process described with reference to FIG. **16** and the rolling/sliding sound

process described with reference to FIG. **17** may be executed, or both of these processes may be executed.
(114) Referring back to FIG. **15**, in step S**300**, the processor **81** determines whether or not a game processing ending condition has been satisfied. When this determination is YES, the processing proceeds to step S**400**, and when this determination is NO, the processing returns to step S**200** and the game is continued.
(115) In step S**400**, the processor **81** performs a game ending process of ending the game processing. Then, the game processing is ended.
(116) As described above, according to the exemplary embodiment, whether an object is rolling or sliding on another object is determined, and a rolling sound or a sliding sound can be outputted depending on this determination (see FIG. **16**, FIG. **17**, etc.). In addition, according to the exemplary embodiment, by considering the relative speed between the centers of gravity of the objects, it becomes easier to determine that the object is rolling, as the second speed increases (see FIG. **17**, etc.). This can avoid giving an uncomfortable feeling by determining that the object is rolling, and performing control of outputting a rolling sound in a situation in which the relative speed between both objects is high and it is difficult for the player to recognize (see) whether or not the object is rolling.
(117) [Modifications]
(118) In the above-described exemplary embodiment, the example in which the second speed, etc., are calculated using the centers of gravity (G**1**, G**2**) of the objects has been described. However, a predetermined reference point (point at which the speed of the object can be represented) may be used instead of the centers of gravity. For example, instead of the centers of gravity, the center point (graphical center point) of the object or a point calculated as the rotation center of the object in physics calculation may be used.
(119) In the above-described exemplary embodiment, as an example, the same value D (e.g., D=0.5) is used for the above-described (Formula 1): |first speed/second speed|≤D and (Formula 2): |first speed/second speed|>D when determining the state of the object (whether the object is rolling or sliding) in consideration of the relative speed between the centers of gravity of the objects (see FIG. **8** to FIG. **11** and FIG. **17**). However, different values of D may be used for (Formula 1) and (Formula 2). For example, as shown below, (Formula 2′) in which D′ different from D (D′>D or D′<D) is used instead of D (e.g., D=0.5) for (Formula 2) may be used.
(120) $$\left|\text{firstspeed}/\text{secondspeed}\right| > D' \quad (\text{Formula2}')$$
(121) When D′>D in the above (Formula 2′), a case (period) in which neither (Formula 1) nor (Formula 2) applies occurs. Then, in such a case (period), both the rolling sound and the sliding sound may not necessarily be outputted, and in addition, another sound different from the rolling sound and the sliding sound may be outputted. On the other hand, when D′<D in the above (Formula 2′), a case (period) in which both (Formula 1) and (Formula 2) apply occurs. Then, in such a case (period), both the rolling sound and the sliding sound may be outputted.
(122) In the above-described exemplary embodiment, when both the absolute value of the first speed and the absolute value of the second speed are equal to or lower than the predetermined threshold in the above-described (Formula 1) and (Formula 2), the sphere object **200** may be considered (determined) not to be moving relative to the movement object **400**, and neither the rolling sound nor the sliding sound may be outputted.
(123) In the exemplary embodiment, a case in which a series of processes regarding the game processing are executed in a single game apparatus (main body apparatus **2**) has been described. In another exemplary embodiment, the series of processes may be executed in an information processing system including a plurality of information processing apparatuses. For example, in an information processing system including a terminal-side apparatus and a server-side apparatus communicable with the terminal-side apparatus via a network, some of the series of processes

above may be executed by the server-side apparatus. Further, in an information processing system including a terminal-side apparatus and a server-side apparatus communicable with the terminal-side apparatus via a network, major processes among the series of processes above may be executed by the server-side apparatus, and some of the processes may be executed in the terminal-side apparatus. Further, in the above information processing system, the system on the server side may be implemented by a plurality of information processing apparatuses, and processes that should be executed on the server side may be shared and executed by a plurality of information processing apparatuses. Further, a configuration of a so-called cloud gaming may be adopted. For example, a configuration may be adopted in which: the game apparatus (main body apparatus **2**) sends operation data indicating operations performed by the user to a predetermined server, various game processes are executed in the server; and the execution result is streaming-distributed as a moving image/sound to the game apparatus (main body apparatus **2**).
(124) While the exemplary embodiment and the modifications have been described, the description thereof is in all aspects illustrative and not restrictive. It is to be understood that various other modifications and variations may be made to the exemplary embodiment and the modifications.

Claims

1. A non-transitory computer-readable storage medium having stored therein instructions that, when executed by a processor of an information processing apparatus, cause the information processing apparatus to: control motion of a first object in a virtual space; when the first object and another object are in contact with each other and are not stationary relative to each other, calculate a point of contact between the first object and the other object; compare a first speed indicating a speed difference between the first object and the other object at the point of contact and a second speed indicating a speed difference between a center of gravity or a predetermined reference point of the first object and a center of gravity or a predetermined reference point of the other object; and when the first speed or a ratio of the first speed to the second speed satisfies a first condition of being within a first range including 0, perform a first process for the first object, and when the first speed or the ratio of the first speed to the second speed satisfies a second condition of being within a second range not including 0, perform a second process for the first object.
2. The storage medium according to claim 1, wherein the first process is a process of outputting a first sound associated with the first object, and the second process is a process of outputting a second sound associated with the first object and different from the first sound.
3. The storage medium according to claim 2, wherein the first process is a process performed when the first object is rolling on the other object, and the second process is a process performed when the first object is rubbing or sliding on the other object.
4. The storage medium according to claim 3, wherein the instructions further cause the information processing apparatus to: when the second condition is satisfied, determine a direction in which the first object rotates while rubbing or sliding on the other object, on the basis of whether a speed of the first object at the point of contact with respect to the center of gravity or the predetermined reference point of the first object is positive or negative.
5. The storage medium according to claim 2, wherein the instructions further cause the information processing apparatus to control the motion of the first object on the basis of physics calculation based on at least virtual power, virtual gravity, and collision.
6. The storage medium according to claim 1, wherein the second range is a range where the first speed or the ratio of the first speed to the second speed falls outside the first range.
7. The storage medium according to claim 1, wherein the other object is an object that does not move in the virtual space, the first speed is a speed of the first object at the point of contact, and the second speed is a speed of the center of gravity or the predetermined reference point of the first object.

8. The storage medium according to claim 7, wherein the other object is a terrain object in the virtual space.
9. The storage medium according to claim 1, wherein the other object is an object that moves in the virtual space, the first speed is a relative speed between the first object and the other object at the point of contact, and the second speed is a relative speed between the center of gravity or the predetermined reference point of the first object and the center of gravity or the predetermined reference point of the other object.
10. A game processing system, comprising: a processor and a memory coupled thereto, the processor being configured to control the processing system to at least: control motion of a first object in a virtual space; when the first object and another object are in contact with each other and are not stationary relative to each other, calculate a point of contact between the first object and the other object; compare a first speed indicating a speed difference between the first object and the other object at the point of contact and a second speed indicating a speed difference between a center of gravity or a predetermined reference point of the first object and a center of gravity or a predetermined reference point of the other object; and when the first speed or a ratio of the first speed to the second speed satisfies a first condition of being within a first range including 0, perform a first process for the first object, and when the first speed or the ratio of the first speed to the second speed satisfies a second condition of being within a second range not including 0, perform a second process for the first object.
11. The game processing system according to claim 10, wherein the first process is a process of outputting a first sound associated with the first object, and the second process is a process of outputting a second sound associated with the first object and different from the first sound.
12. The game processing system according to claim 11, wherein the first process is a process performed when the first object is rolling on the other object, and the second process is a process performed when the first object is rubbing or sliding on the other object.
13. The game processing system according to claim 12, wherein the processor is further configured to: when the second condition is satisfied, determine a direction in which the first object rotates while rubbing or sliding on the other object, on the basis of whether a speed of the first object at the point of contact with respect to the center of gravity or the predetermined reference point of the first object is positive or negative.
14. The game processing system according to claim 11, wherein the processor is further configured to control the motion of the first object on the basis of physics calculation based on at least virtual power, virtual gravity, and collision.
15. The game processing system according to claim 10, wherein the second range is a range where the first speed or the ratio of the first speed to the second speed falls outside the first range.
16. The game processing system according to claim 10, wherein the other object is an object that does not move in the virtual space, the first speed is a speed of the first object at the point of contact, and the second speed is a speed of the center of gravity or the predetermined reference point of the first object.
17. The game processing system according to claim 16, wherein the other object is a terrain object in the virtual space.
18. The game processing system according to claim 10, wherein the other object is an object that moves in the virtual space, the first speed is a relative speed between the first object and the other object at the point of contact, and the second speed is a relative speed between the center of gravity or the predetermined reference point of the first object and the center of gravity or the predetermined reference point of the other object.
19. A game processing apparatus, comprising: a processor and a memory coupled thereto, the processor being configured to control the game processing apparatus to at least: control motion of a first object in a virtual space; when the first object and another object are in contact with each other and are not stationary relative to each other, calculate a point of contact between the first object and

the other object; compare a first speed indicating a speed difference between the first object and the other object at the point of contact and a second speed indicating a speed difference between a center of gravity or a predetermined reference point of the first object and a center of gravity or a predetermined reference point of the other object; and when the first speed or a ratio of the first speed to the second speed satisfies a first condition of being within a first range including 0, perform a first process for the first object, and when the first speed or the ratio of the first speed to the second speed satisfies a second condition of being within a second range not including 0, perform a second process for the first object.

20. The game processing apparatus according to claim 19, wherein the first process is a process of outputting a first sound associated with the first object, and the second process is a process of outputting a second sound associated with the first object and different from the first sound.

21. A game processing method executed by a computer configured to control a game processing system, the game processing method causing the game processing system to: control motion of a first object in a virtual space; when the first object and another object are in contact with each other and are not stationary relative to each other, calculate a point of contact between the first object and the other object; compare a first speed indicating a speed difference between the first object and the other object at the point of contact and a second speed indicating a speed difference between a center of gravity or a predetermined reference point of the first object and a center of gravity or a predetermined reference point of the other object; and when the first speed or a ratio of the first speed to the second speed satisfies a first condition of being within a first range including 0, perform a first process for the first object, and when the first speed or the ratio of the first speed to the second speed satisfies a second condition of being within a second range not including 0, perform a second process for the first object.

22. The game processing method according to claim 21, wherein the first process is a process of outputting a first sound associated with the first object, and the second process is a process of outputting a second sound associated with the first object and different from the first sound.