

[DESCRIPTION]

[Title of Invention]

INFORMATION PROCESSING APPARATUS, INFORMATION PROCESSING
METHOD, AND RECORDING MEDIUM

[Technical Field]

[0001]

The present disclosure relates to an information processing apparatus, an information processing method, and a recording medium.

[Background Art]

[0002]

In recent years, techniques for acquiring and using three-dimensional information of a three-dimensional space, which is a real space, by a laser scanner or light detection and ranging (LiDAR) have been commonly used at, for example, construction sites.

PTL 1 discloses a technique for generating three-dimensional reference data representing the inside of a structure based on three-dimensional model data indicating the arrangement of components inside the structure in which a moving object moves and three-dimensional sensing data indicating a result of sensing the inside of the structure by a sensor, and generating a movement route for the moving object based on the three-dimensional reference data.

[Citation List]

[Patent Literature]

[0003]

[PTL 1]

Japanese Unexamined Patent Application Publication No.2023-992

[Summary of Invention]

[Technical Problem]

[0004]

According to the related art, the arrangement of components inside the structure and the three-dimensional sensing data obtained by sensing the inside of the structure are used for generating a movement route. However, risks of the case that the moving object collides with the components are not considered. Taking this into account, more accurate route search has been desired.

In view of the above, an object of the present disclosure is to provide an information processing apparatus, an information processing method, and a recording medium to perform a route search for an object to move in a space with higher accuracy.

[Solution to Problem]

[0005]

The present disclosure described herein provides an information processing apparatus including a memory that stores object information and spatial information. The object

information is information on an object to move in a space. The spatial information is information on the space and includes at least three-dimensional information of the space. The information processing apparatus includes an input device that receives movement condition information indicating a condition for movement of the object. The movement condition information includes at least information on a start point and an end point of the movement of the object. The information processing apparatus includes an information processor that generates route-related information including information on the movement of the object in the space based on the object information, the spatial information, and the movement condition information.

The present disclosure described herein provides an information processing method including reading object information and spatial information from a memory. The object information is information on an object to move in a space. The spatial information is information on the space and includes at least three-dimensional information of the space. The information processing method includes receiving movement condition information indicating a condition for movement of the object. The movement condition information includes at least information on a start point and an end point of the movement of the object. The information processing method includes generating route-related information including information on the movement of the object in the space based on the object information, the spatial information, and the movement condition information.

The present disclosure described herein provides a recording medium storing computer-readable code for controlling a computer system to carry out a method. The method includes reading object information and spatial information from a memory. The object information is information on an object to move in a space. The spatial information is information on the space and includes at least three-dimensional information of the space. The information processing method includes receiving movement condition information indicating a condition for movement of the object. The movement condition information includes at least information on a start point and an end point of the movement of the object. The information processing method includes generating route-related information including information on the movement of the object in the space based on the object information, the spatial information, and the movement condition information.

[Advantageous Effects of Invention]

[0006]

According to one aspect of the present disclosure, a route search with higher accuracy for an object to move in a space is achieved.

[Brief Description of Drawings]

[0007]

A more complete appreciation of embodiments of the present disclosure and many of the attendant advantages and features thereof can be readily obtained and understood from the following detailed description with reference to the accompanying drawings.

[FIG. 1]

FIG. 1 is a block diagram illustrating a hardware configuration of an information processing apparatus according to a first embodiment.

[FIG. 2]

FIG. 2 is a block diagram illustrating a functional configuration for a process for generating route-related information according to the first embodiment.

[FIG. 3]

FIG. 3 is a flowchart of the process for generating route-related information according to the first embodiment.

[FIG. 4]

FIG. 4 is a flowchart of a process for generating risk level information according to the first embodiment.

[FIG. 5]

FIG. 5 is a diagram illustrating risk level information according to the first embodiment.

[FIG. 6]

FIG. 6 is a diagram illustrating an example of a screen displaying route information and risk level information according to the first embodiment.

[FIG. 7]

FIG. 7 is a diagram illustrating another example of a screen displaying route information and risk level information according to the first embodiment.

[FIG. 8]

FIG. 8 is a block diagram illustrating a functional configuration for a process for generating route-related information according to a second embodiment.

[FIG. 9]

FIG. 9 is a flowchart of the process for generating route-related information according to the second embodiment.

[FIG. 10]

FIG. 10 is a diagram illustrating risk level information according to the second embodiment.

[FIG. 11]

FIG. 11 is a diagram illustrating a screen displaying route information and risk level information according to the second embodiment.

[FIG. 12]

FIG. 12 is a block diagram illustrating a functional configuration for a process for generating route-related information according to a third embodiment.

[FIG. 13]

FIG. 13 is a flowchart of the process for generating route-related information according to the third embodiment.

[FIG. 14]

FIG. 14 is a block diagram illustrating a functional configuration for a process for generating route-related information and caution information according to a fourth embodiment.

[FIG. 15]

FIG. 15 is a flowchart of a process for generating route-related information and caution information according to the fourth embodiment.

[FIG. 16]

FIG. 16 is a flowchart of a process for generating caution information according to the fourth embodiment.

[FIG. 17]

FIG. 17 is a diagram illustrating caution information according to the fourth embodiment.

[FIG. 18]

FIG. 18 is a diagram illustrating an example of a screen displaying route information, risk level information, and caution information according to the fourth embodiment.

[FIG. 19]

FIG. 19 is a diagram illustrating another example of a screen displaying route information, risk level information, and caution information according to the fourth embodiment.

[FIG. 20]

FIG. 20 is a block diagram illustrating a functional configuration for a process for generating route-related information and caution information according to a fifth embodiment.

[FIG. 21]

FIG. 21 is a flowchart of a process for generating route-related information and caution information according to the fifth embodiment.

[FIG. 22]

FIG. 22 is a diagram illustrating a screen displaying route information, risk level information, and caution information according to the fifth embodiment.

[FIG. 23]

FIG. 23 is a block diagram illustrating a functional configuration for a process for generating route-related information and caution information according to a sixth embodiment.

[FIG. 24]

FIG. 24 is a flowchart of the process for generating route-related information and caution information according to the sixth embodiment.

The accompanying drawings are intended to depict embodiments of the present disclosure and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted. Also, identical or similar reference numerals designate identical or similar components throughout the several views.

[Description of Embodiments]

[0008]

In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this specification is not intended to be limited

to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that have a similar function, operate in a similar manner, and achieve a similar result.

Referring now to the drawings, embodiments of the present disclosure are described below. As used herein, the singular forms “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0009]

An information processing apparatus and an information processing method are described in detail with reference to the drawings.

[0010]

First Embodiment

FIG. 1 is a block diagram illustrating a hardware configuration of an information processing apparatus 1 according to a first embodiment. The information processing apparatus 1 is an apparatus to generate route information indicating a route along which an object is to move and information on a risk present along the route using, for example, object information and spatial information and present the generated information to a user. The object information and spatial information will be described later.

[0011]

As illustrated in FIG. 1, the information processing apparatus 1 includes a memory 10, a user interface (UI) device 11, and an information processor 12. The information processor 12 controls the memory 10 and the UI device 11.

[0012]

As illustrated in FIG. 1, the information processor 12 includes a central processing unit (CPU) 12A, a read-only memory (ROM) 12B, a random-access memory (RAM) 12C, and a network I/F 12D. The CPU 12A controls the entire operation of the information processing apparatus 1. The ROM 12B stores a program used for driving the CPU 12A. The RAM 12C is used as a working area of the CPU 12A. The network I/F 12D is an interface for data communication using communication networks, such as the Internet and gateways (repeaters)

[0013]

The information processor 12 reads object information and spatial information from the memory 10. The object information and the spatial information will be described later. Further, movement condition information is read from an input device 11B to the information processor 12. The movement condition information will be described later. The information processor 12 generates route-related information based on the object information, the spatial information, and the movement condition information.

[0014]

The memory 10 stores various information. The various information includes the object information indicating an object to move in a space and the spatial information regarding the space in which the object is to move. The movement of the object includes movement due to

loading work or similar tasks performed by humans, movement controlled by an operation of a remote controller, and autonomous movement using a sensor or a camera of the object.

[0015]

Such information may be pre-stored in the memory 10 or input and stored in the memory 10 via the UI device 11.

[0016]

The object information includes information on the object, such as the size, weight, shape, hardness, and material. The object information may be three-dimensional (3D) information (e.g., point cloud information, 3D model information) of the object, information estimated based on the three-dimensional information or a brightness image (e.g., an RGB image) of the object (an example of estimation information for the object), or information input by the user (an example of input information for the object). The input information may be input in association with the three-dimensional information of the object. The object information may include information indicating that the size of the object increases or decreases along the route. For example, the information can indicate that the size or weight of the object increases or decreases due to a predetermined process, such as assembly, folding, splitting, or combining with another object, on the object.

[0017]

The spatial information includes three-dimensional information (e.g., point cloud information, 3D model information) of the space. The spatial information may include information on a component of the space, such as the size, weight, shape, hardness, and material. The information on the component of the space may be information estimated based on three-dimensional information of the space or a brightness image (e.g., an RGB image) of the space (an example of estimation information for the space) or may be information input by the user (an example of input information for the space). The input information may be input in association with the three-dimensional information of the space.

[0018]

The information on size, weight, shape, hardness, or material may be information expressed by text such as “large, small,” “heavy, light,” “hard, soft,” “round, square,” or “metal, plastic, wood,” or may be information represented by a continuous scale such as volume, weight, shape feature values (such as the radius of a circle and the length of each side of a cube), or hardness. It is preferable that a limited numerical range is associated with a text indicating a qualitative state such as “large, small,” “heavy, light,” or “hard, soft” in a stepwise manner.

[0019]

The three-dimensional information includes information representing a three-dimensional space that is a real space (depth information and preferably brightness information), point cloud data, and a 3D model. The three-dimensional information may be acquired by, for example, a typical optical camera, a spherical camera, a time-of-flight (ToF) camera, a stereo camera, a laser scanner, a light detection and ranging (LiDAR), or a system using

photogrammetry. The ToF method is a method of irradiating an infrared ray to a measurement target and obtaining a distance from a time until reflected light returns. The stereo camera is a camera that obtains depth information as distance information using an interval between two cameras and parallax information of images obtained by the two cameras.

[0020]

The file format of the three-dimensional information is not limited. The three-dimensional information is represented by, for example, shape data representing a three-dimensional shape of a three-dimensional object included in the real space. The three-dimensional information is, for example, a file in a point cloud format in which the three-dimensional space is represented by discrete points, or a file in a polygon mesh format in which the three-dimensional space is represented by vertices and planes. The file in a point cloud format may be referred to as, for example, a depth map or a distance image.

[0021]

Examples of the file in a point cloud format include files represented by extensions such as “.xyz,” “.e57,” and “.ply”. The file in a polygon mesh format includes files represented by extensions such as “.obj,” “.fbx,” and “.stl.”

[0022]

The UI device 11 includes a display 11A and an input device 11B. The display 11A displays various information. The input device 11B receives an operation instruction from the user. The input device 11B includes a keyboard, a pointing device, and a mouse. The display 11A and the input device 11B may be integrated as a touch panel.

[0023]

The display 11A displays the route-related information generated by the information processor 12. The route-related information includes the route information indicating the route along which the object is to move in the space, and risk level information indicating a level of risk along the route. The display 11A may display caution information that includes explanatory text to inform the user of the level of risk.

[0024]

The route-related information may include the caution information. When the route-related information includes the caution information, the display 11A displays the caution information together with the route-related information. The caution information may be displayed in association with the route information or the risk level information, or may be displayed independently of the route information and the risk level information. For example, the caution information may be displayed in a display area different from an area in which the route information or the risk level information is displayed.

[0025]

The route indicated by the route information is defined as a connection between the start point and the end point of movement of an object in a space. For example, the route information

may indicate a three-dimensional shortest route that follows from the start point to the end point without colliding with a component of the space, or may indicate a three-dimensional route that is not the shortest but has a low risk of colliding by mistake. Further, the route information may indicate a three-dimensional route passing through a specified point (e.g., an elevator, a workspace), or may include multiple pieces of route information generated according to tasks along the route.

[0026]

The risk level information indicates the levels of risk corresponding to points along the route. The risk level information may include the coordinates and the level of risk of each point. The level of risk is a scale indicating the degree of danger based on the object information and the spatial information, and may be a scale represented by text such as “Danger” and “Safe” or may be represented by a continuous scale (such as numerical information ranging from 0 to 100, where 100 represents danger and 0 represents safety).

[0027]

The level of risk indicates the likelihood of issues, such as the falling of a component or damage or malfunction of the object, arising when the object comes into contact with the component along the route, or the degree of necessity to take action, such as implementing preventive measures by removing dirt or performing repairs. A scenario is assumed in which the object information indicates that the weight of the object is heavy and that the object is hard, while the spatial information indicates that a component along the route the object passes through is light and hard. Since the object is heavier than the component, it is predicted that the component is likely to fall if the object comes into contact with the component. In this case, the level of risk is expressed by a level such as “Danger” or a numerical value such as 80.

[0028]

The caution information is information for informing the user of a danger or an action to be taken at a point along the route. For example, the information includes text information (explanatory text) such as “There is a risk of hitting the wall,” “The side of the passage is easily damaged,” “It is recommended to reinforce with a sheet,” “Be careful not to trip over the low step,” “The floor is uneven,” “A forklift is required due to the high step,” and “A cart with a stopper is required the continuous slope.”

[0029]

The caution information is generated based on the risk level information, but may be generated by further using the object information or the spatial information. The caution information may be generated to be included in the route-related information, or may be generated not to be included in the route-related information.

[0030]

The movement condition information is input to the input device 11B. The movement condition information is information on the start point and the end point of the movement of

the object in the space, information on a point through which the object is to pass along the route (e.g., an elevator entrance on a different floor, a workspace in which a predetermined process, such as assembly, folding, splitting, or combining with another object, on the object is to be performed.

[0031]

The information on the start point, the end point, and the points to be passed may be coordinate data or information indicating a location in the space (e.g., “entrance to second floor,” “exit from first floor,” “elevator on third floor”).

[0032]

A process of generating route-related information in the information processor 12 will be described below.

[0033]

FIG. 2 is a block diagram illustrating a functional configuration for a process for generating route-related information. The information processor 12 includes a route information generation unit 20, a risk level information generation unit 21, a route-related information generation unit 22, and a control unit 23.

[0034]

The route information generation unit 20 generates route information based on object information and spatial information read from the memory 10 and movement condition information input to the input device 11B.

[0035]

The risk level information generation unit 21 generates risk level information based on the object information, the spatial information, and the route information generated by the route information generation unit 20.

[0036]

The route-related information generation unit 22 generates route-related information based on the route information and the risk level information.

[0037]

The control unit 23 controls the route information generation unit 20, the risk level information generation unit 21, and the route-related information generation unit 22, and performs, for example, the input and output of data, the generation of route information, risk level information, and route-related information.

[0038]

FIG. 3 is a flowchart of a process for generating route-related information.

[0039]

The control unit 23 receives movement condition information from the input device 11B and inputs the movement condition information to the information processor 12 (Step S31). The control unit 23 reads object information from the memory 10 (Step S32). The control unit 23 reads spatial information from the memory 10 (Step S33). The object information and the

spatial information may be input from the input device 11B instead of being read from the memory 10.

[0040]

Subsequently, the route information generation unit 20 generates route information based on the object information, the spatial information, and the movement condition information (Step S34).

[0041]

Subsequently, the risk level information generation unit 21 generates risk level information based on the object information, the spatial information, and the route information (Step S35).

[0042]

Subsequently, the route-related information generation unit 22 generates route-related information from the generated route information and the risk level information, and the control unit 23 cause the display 11A to display the route-related information (Step S36).

[0043]

A method of generating route information and risk level information will be described below.

[0044]

The route information is generated as a three-dimensional optimal route based on the object information, the spatial information, the start point information, and the end point information. The dimensional optimal route is obtained by searching for the shortest route in which the object does not collide with a component in the space. The route information may be generated based on the object information, the spatial information, the start point information, the end point information, and the risk level information. The risk level information will be described later. The risk level information can be used in route search (re-search) performed again when a high-risk waypoint is present along the route generated in the first route search. In the following description, re-search refers to search again. Even when a high-risk waypoint is not present along the route, the risk level information can be used for the re-search performed in response to, for example, an instruction from the user.

[0045]

The route search is performed using Artificial Intelligence (AI) for route search that three-dimensionally expands a deep learning version of an optimal route problem solution algorithm. The AI for route search is pre-trained using machine learning to take multiple sets each including the object information, the spatial information, the start information, and the end information as an input and output the optimal route information (correct data) corresponding to each set. When the route search is performed using the risk level information, the AI for route search is pre-trained using machine learning to take multiple sets each including the object information, the spatial information, the start point information, the end point information, and the risk level information as an input and output the optimum route information (correct data) corresponding to each set.

[0046]

For the route search, a rule-based method may be used instead of AI. Specifically, a point cloud included in the spatial information is voxelized to be a “barrier,” and a route search algorithm that three-dimensionally expands an optimal route problem solution algorithm such as the Dijkstra method, the A-star method, or the Bellman-Ford method, is applied.

[0047]

The risk level information is generated by calculating or inferring the levels of risk corresponding to the points along the route based on the object information, the spatial information, and the route information (information on the route search result).

[0048]

FIG. 4 is a flowchart of a process for generating risk level information.

[0049]

The risk level information generation unit 21 extracts points that are present along the route in the point cloud based on the route information and the coordinates of the points of the point cloud of the spatial information (Step S41).

[0050]

Subsequently, the level of risk at each point is derived based on the spatial information indicating the extracted point and the object information on the object that is to pass through the point. (S42).

[0051]

To derive the risk level, an AI for risk derivation including a deep learning version of an input-output problem solution algorithm is applied. The AI for deriving levels of risk is pre-trained using machine learning to take the object information and the spatial information at a point of the point cloud of the space as an input and output the risk level information (correct data) corresponding to the point. The point cloud of the space used for machine learning may be input at once, or may be serially input for each area obtained by dividing the space. When the input is made for each area, the correct data is, for example, data indicating a level of risk when the object comes into contact with a component in the corresponding area. The levels of risks may be derived as a continuous scale based on a predetermined calculation formula. A level of risk may be categorized as “Danger” corresponding to a predetermined range with a high risk on the derived continuous scale.

[0052]

Subsequently, the risk level information is generated by associating the coordinates of each extracted point with the corresponding level of risk (Step S43).

[0053]

FIG. 5 is a diagram illustrating risk level information that is generated according to the first embodiment. In FIG. 5, the route number is a number used to distinguish each route when multiple routes are generated. The coordinates are three-dimensional coordinates representing a point on the route, and are expressed by defining, for example, an x-axis and a y-axis on a horizontal plane and a z-axis perpendicular to the horizontal plane. In FIG. 5, the levels of

risk are represented using a continuous scale between 0 (indicating safety) and 100 (indicating danger). A case indicated by a dashed line in FIG. 5 (a case where the level of risk is 40 at the coordinates (1, 0, h)) will be described later with reference to FIG. 6.

[0054]

FIG. 6 is a diagram illustrating a screen of the display 11A displaying route information and risk level information generated by the information processor 12 according to the first embodiment. In FIG. 6, the route along which the object is to move on a plane (an x-y plane including an x-axis and a y-axis) from a start point to an end point of the first floor of a building is displayed as a route (1). The vertical axis (z-axis) is not illustrated, but is to be orthogonal to the x-y plane. On the first floor, there are components A to D such as a room and a shelf that are impassable by the object. Additionally, there are a workspace E and an elevator (EV) through which the object can pass on the first floor. The units of the scales on each axis are in meters.

[0055]

In FIG. 6, an arrow (route (1)) connecting the start point and the end point indicates route information. The text of "LEVEL OF RISK = numerical value" and the arrow extending therefrom represent risk level information.

[0056]

The route (1) indicates the shortest route that proceeds from the start point to the right, continues along the passage, then turns downward (by making a right turn) at the end, and reaches the end point. The first straight line of the route (1) has a passage width sufficiently wider than the object, and thus the level of risk is indicated as 20 (solid arrow).

[0057]

In Area A1 of the component A, the upper area of the wall surface (at a height of h from the floor) uses a material that is easily damaged. Accordingly, when the height of the object that is to move is higher than h and the upper portion of the object is harder than the material of the wall surface, information indicated by a dashed box in FIG. 5 (level of risk = 40 at the coordinates (1, 0, h)) is generated, and the level of risk at the corresponding portion in FIG. 6 is indicated as 40 (dashed arrow). On the other hand, when the height of the object is lower than h, the information indicated by the dashed box in FIG. 5 is not generated, and the level of risk of the corresponding portion is not displayed in FIG. 6.

[0058]

In the next straight line of the route (1), the width of the passage immediately after the right turn is narrow, and thus the level of risk is indicated as 80 (solid arrow).

[0059]

When the movement condition information can include a point through which the object is to pass along the route, a passing point such as "workspace" or "elevator" can be specified according to a user operation. In this case, the route information generation unit 20 generates route information so that the route includes the specified point as a waypoint. Even when a

waypoint is specified, the route information generation unit 20 may generate a route that passes through the waypoint and a route that does not pass through the waypoint. This is because a route that does not pass through a waypoint may have a lower level of risk or may have a space suitable for work along the route.

[0060]

When the object information includes information indicating that the size of the object increases or decreases, the information can be set to indicate, for example, that the size of the object can be decreased at a point where the passage is narrow according to a user operation. In this case, the risk level information generation unit 21 generates the risk level information by setting the level of risk of the second straight line of the route (1) to 20.

[0061]

FIG. 7 is a diagram illustrating another example of a screen of the display 11A displaying the route information and the risk level information. In FIG. 7, a part of the passage along the route is three-dimensionally displayed. Since there is a large step in the passage along the route and the object may fall and be damaged if the object continues to move forward as it is, the level of risk at the step portion is indicated as 80.

[0062]

As described above, the risk level information in the route for the movement is generated using the object information and the spatial information. Accordingly, safety along the route can be achieved before the object starts moving along the route, and a more accurate route search by examining another route can be performed.

[0063]

One or more of the units included in the information processing apparatus 1 is implemented by, for example, one or more processors and one or more memories. The above-described units may be implemented by causing a processor such as a CPU to execute a program while reading data from a memory, that is, by software. For example, the memory may be a ROM or a RAM.

One or more of the above-described units may be implemented by a processor such as a dedicated integrated circuit (IC) or a memory, that is, hardware. One or more of the above-described units may be implemented by using both software and hardware. When multiple processors are used, each processor may implement one of the units or two or more of the units. The software for implementing the above-described units may be stored in a terminal used by a user and the program may be executed on the terminal, or may be stored in a server connected to a network such as the Internet and the program may be executed on the server.

[0064]

Second Embodiment

FIG. 8 is a block diagram illustrating a functional configuration for a process for generating route-related information according to a second embodiment. The information processor 12 according to the second embodiment includes a route information generation unit 80, a risk

level information generation unit 81, a route-related information generation unit 82, and a control unit 83. The operation of each of the units is substantially the same as the operation of the corresponding unit in the first embodiment described above. The difference from the first embodiment is that the risk level information can be fed back from the risk level information generation unit 81 to the route information generation unit 80 and the control unit 83 determines whether to perform the re-search.

[0065]

FIG. 9 is a flowchart of a process for generating route-related information according to the second embodiment. Steps S91 to S95 in the process are substantially the same as Steps S31 to S35 in FIG. 3 described as the first embodiment. The difference from the first embodiment is that Step S96 for determining whether to perform the re-search is added.

[0066]

In the second embodiment, after the risk level information is generated in substantially the same manner as in the first embodiment, the control unit 83 determines whether to perform the route search again (re-search) (Step S96). The determination is made based on the risk level information. For example, when there is a point (dangerous point) at which the level of risk exceeds a threshold set in advance (or is equal to or greater than the threshold), the re-search is determined to be performed. When the number of the dangerous points is one, when the number of the dangerous points exceeds a predetermined number (or is equal to or greater than the predetermined number), route search is determined to be performed again.

[0067]

The determination in Step S96 may be performed without using the risk level information. For example, an upper limit of the number of times to perform the re-search may be determined in advance, and the re-search is determined not to be performed when the number of times is less than the upper limit, and the re-search is determined to be performed when the number of times reaches the upper limit. In this case, the risk level information can be used for the re-search in Step S94.

[0068]

When the re-search is determined to be performed, the process returns to Step S94, and the route information generation unit 80 generates the route information again (Step S94). In the route search performed again, the route information is generated with reference to the risk level information fed back from the risk level information generation unit 81 in addition to the object information, the spatial information, and the movement condition information.

[0069]

Subsequently, the risk level information generation unit 81 generates risk level information based on the object information, the spatial information, and the route information that is generated after the re-search (Step S95).

[0070]

Steps S94 to S96 are repeated until a determination indicating that the re-search is not to be performed is made in Step S96.

[0071]

When the determination indicating that the re-search is not to be performed is made, the process proceeds to Step S97, and the route-related information generation unit 82 generates route-related information from the generated route information and the risk level information, and displays the route-related information on the display 11A (Step S97).

[0072]

FIG. 10 is a diagram illustrating an example of risk level information (information including a level of risk associated with a route (2)) generated after the route search is performed again. The risk level information of FIG. 10 is generated after the route search that is performed again because the risk level information including a high-risk point as illustrated in FIG. 5 is generated in the first route search and the re-search is determined to be performed again. As illustrated in FIG. 10, the levels of risk are low (10) at all points along the route (2).

[0073]

FIG. 11 is a diagram illustrating a screen of the display 11A displaying the route information and risk level information generated by the information processor 12 according to the second embodiment. The route (1) and the levels of risk associated with the route (1) are displayed as the results of the first route search, and are the same as those described in FIG. 6. The route (2) and the level of risk associated with the route (2) are displayed as the result of the route search performed again (re-search).

[0074]

The route (2) starts by traveling downward from the start point along the passage. In the route (2), the direction changes to the right (on the screen), and then makes a left turn, at the first corner. Then, the direction changes downward, and the traveler makes a right turn, just before the component A. Then, the direction changes to the right, and the traveler makes a left turn in the workspace E. Finally, the direction changes upward, and the traveler makes a left turn, at the dead end, reaching the end point. The route (2) is longer than the route (1), but the passage width is sufficiently wider than the object, and thus each of the levels of risk displayed is 10.

[0075]

When the route-related information is displayed after the re-search, the route (2) and the level of risk associated with the route (2) may be displayed on the display 11A with or without the route (1) and the level of risk associated with the route (1).

[0076]

As described above, according to the second embodiment, since the route information is generated using the risk level information in addition to the object information and the spatial information, the object can safely move by selecting a route having little risk.

[0077]

Third Embodiment

FIG. 12 is a block diagram illustrating a functional configuration for a process for generating route-related information according to a third embodiment. The information processor 12 according to the third embodiment includes a route information generation unit 120, a risk level information generation unit 121, a route-related information generation unit 122, and a control unit 123. The operation of each of the units is substantially the same as the operation of the corresponding unit in the first embodiment described above. The difference from the first embodiment is that the risk level information can be fed back from the risk level information generation unit 121 to the route information generation unit 120, the control unit 123 determines whether to perform re-search, and a user instruction is input to the information processor 12.

[0078]

FIG. 13 is a flowchart of a process for generating route-related information according to the third embodiment. Steps S131 to S136 in the process are substantially the same as Steps S31 to S36 in FIG. 3 described as the first embodiment. The difference from the first embodiment is that Step S137 for determining whether to perform the re-search is added.

[0079]

In the third embodiment, after the route-related information is displayed on the display 11A in substantially the same manner as the first embodiment, the control unit 123 determines whether to perform the route search again (re-search) (Step S137). This determination is made based on an instruction from the user. For example, in the information processing apparatus 1, the display 11A may display the route-related information and display a message such as “Do you want to search a route again?,” and the input device 11B may receive an input of a user instruction. The display 11A may also display an icon image indicating the location of a point (dangerous point) at which the level of risk exceeds (or is equal to or greater than) the threshold in a superimposed manner on the route-related information. Further, a text indicating the location of the dangerous point or a text indicating the number of dangerous points may be added to the message.

[0080]

When the re-search is determined to be performed based on a user instruction in Step S137, the process returns to Step S134, and the route information generation unit 120 generates the route information again (Step S134). In the route search performed again, the route information is generated with reference to the risk level information fed back from the risk level information generation unit 121 in addition to the object information, the spatial information, and the movement condition information.

[0081]

Subsequently, the risk level information generation unit 121 generates risk level information based on the object information, the spatial information, and the route information that is generated after the re-search (Step S135). The control unit 123 causes the display 11A to

display route-related information that is newly generated (Step S136), and determines whether to perform the route search again (re-search) based on a user instruction (Step S137).

[0082]

Steps S134 to S137 are repeated until a determination indicating that the re-search is not to be performed is made in Step S137.

[0083]

When the determination indicates that the re-search is not to be performed based on a user instruction in Step S137, the process ends.

[0084]

An example of the risk level information generated in the third embodiment is the same as that illustrated in FIG. 10, and each of the levels of risk indicates a low value (10) along the route as the result of the route search performed again. An example of the screen of the display 11A displaying the route information and the risk level information generated in the third embodiment is the same as that illustrated in FIG. 11.

[0085]

As described above, according to the third embodiment, when the re-search is determined to be performed again based on a user instruction, route information is generated using the risk level information in addition to the object information and the spatial information.

Accordingly, the user with high transport skills can use the shortest route without performing the re-search, and the user with low transport skills can safely move the object by performing the re-search and selecting a route with little risk obtained after the re-search.

[0086]

Fourth Embodiment

FIG. 14 is a block diagram illustrating a functional configuration for a process for generating route-related information and caution information according to a fourth embodiment. The information processor 12 according to the fourth embodiment includes a route information generation unit 140, a risk level information generation unit 141, a caution information generation unit 142, a route-related information generation unit 143, and a control unit 144. The operation of each of the units except for the caution information generation unit 142 is substantially the same as the operation of the corresponding unit in the first embodiment described above. The difference from the first embodiment is that the route information and the risk level information are output from the risk level information generation unit 141 to the caution information generation unit 142, the caution information is input to the route-related information generation unit 143, and the caution information is output from the route-related information generation unit 143.

[0087]

FIG. 15 is a flowchart of a process for generating route-related information and caution information. Steps S151 to S155 in the process are substantially the same as Steps S31 to S35 in FIG. 3 described as the first embodiment.

[0088]

After the risk level information is generated in the Step S155, the caution information generation unit 142 generates caution information based on the object information, the spatial information, the route information, and the risk level information (Step S156).

[0089]

Subsequently, the route-related information generation unit 143 generates route-related information from the generated route information and the risk level information, and the control unit 144 causes the display 11A to display the route-related information (Step S157).

[0090]

Subsequently, the control unit 144 generates caution information based on the object information, the spatial information, the route information, and the risk level information, and cause the display 11A to display the caution information (Step S158).

[0091]

A specific method for generating caution information will be described below.

[0092]

The caution information is generated as explanatory text corresponding to each point along the route based on the object information, the spatial information, the route information, and the risk level information.

[0093]

FIG. 16 is a flowchart of a process for generating caution information.

[0094]

First, points that are present along the route in the point cloud are extracted based on the route information and the coordinates of the points of the point cloud of the spatial information (Step S161).

[0095]

Subsequently, an explanatory text at each point is derived based on the spatial information indicating the extracted point and the object information on the object that is to pass through the point (Step S162).

[0096]

To derive the explanatory text, an AI for explanatory text derivation including a deep learning version of an input-output problem solution algorithm is applied. The AI for generating explanatory text is pre-trained using machine learning to take the object information, the spatial information at a point of the point cloud of the space, and the risk level information corresponding to the point as inputs and output the explanation data (correct data). The point cloud of the space used for machine learning may be input at once, or may be serially input for each area obtained by dividing the space. When the input is made for each area, the correct data is, for example, text data describing the cautions to be considered when the object passes through the corresponding area.

[0097]

To the derivation of the explanatory text, a deep learning architecture that can perform generative AI tasks that combine three-dimensional spatial data analysis AI models, such as 3D-large language model (LLM), with large-scale language AI models may be applied. For example, 3D Visual Question Answering (VQA) that answers a relatively short answer to a question sentence for a three-dimensional scene represented by a point cloud of three-dimensional information can be applied. Further, for example, 3D-Captioning that generates and outputs a simple explanatory text in relation to a text sentence prompting an explanation about a three-dimensional scene can be applied. In recent years, various data sets that have been created and accumulated and AI models obtained by machine learning of a large amount of information on the Internet have been available. the pre-trained AI model may be used as it is, but using a dataset that pairs point clouds with a text sentence can enhance the performance (fine-tuning).

[0098]

Subsequently, caution information is generated by associating the coordinates of each extracted point with the corresponding explanatory text (Step S163).

[0099]

FIG. 17 is a diagram illustrating caution information that is generated according to the fourth embodiment. The items of route number and coordinates are substantially the same as those in FIG. 5. In the item of explanatory text, the matters of caution for the moving object at points along the route (1) are generated in the text sentences that can be understood by the user. The case of the coordinates (1, 0, h) is the same as that described with reference to FIGS. 5 and 6, and is a case in which an explanatory text indicating that caution is advisable when the height of the object is equal to or greater than h is generated.

[0100]

FIG. 18 is a diagram illustrating an example of a screen of the display 11A displaying the generated route information, risk level information, and caution information. The route (1) and the level of risk associated with the route (1) are the same as those in FIG. 6.

[0101]

The caution information is displayed in balloons each including an explanatory text. The first straight line of the route (1) having a passage width sufficiently wider than the object continues for a while, and the corresponding explanatory text is displayed as caution information.

[0102]

In Area A1 of the component A displayed, when the height of the moving object exceeds (or is equal to or greater than) h and the upper part of the object is harder than the material of A1, an explanatory text indicating caution is displayed for this point (dashed annotation balloon). On the other hand, when the height of the object is lower than h, the corresponding caution information is not generated, and the explanatory text is not displayed for this point.

[0103]

In the next straight line of the route (1), the width of the passage immediately after the right turn is narrow, and thus an explanatory text for informing the danger is displayed (solid annotation balloon).

[0104]

When the object information includes information indicating that the size of the object increases or decreases, the information can be set to indicate, for example, that the size of the object can be decreased at a point where the passage is narrow according to a user operation. In this case, the caution information generation unit 142 may derive an explanatory text “The level of risk will decrease to 20 if the size of the object decreases” for the second straight line of the route (1).

[0105]

FIG. 19 is a diagram illustrating another example of a screen of the display 11A displaying the generated route information, risk level information, and caution information. In FIG. 19, a part of the passage along the route is three-dimensionally displayed. Since there is a large step in the passage along the route and the object may fall and be damaged if the object continues to move forward as it is, the level of risk at the step portion is indicated as 80. In addition, the explanatory text describes, for example, that due to the weight of the object, equipment such as a forklift is necessary when lowering the object.

[0106]

As described above, according to the fourth embodiment, the caution information including the text for explaining the level of risk at each point on the route is generated based on the object information, the spatial information, the route information, and the risk level information. Accordingly, safety along the route can be achieved before the object starts moving along the route, and this allows the user to consider another route.

[0107]

Fifth Embodiment

FIG. 20 is a block diagram illustrating a functional configuration for a process for generating route-related information and caution information according to a fifth embodiment. The information processor 12 according to the fifth embodiment includes a route information generation unit 200, a risk level information generation unit 201, a caution information generation unit 202, a route-related information generation unit 203, and a control unit 204. The operation of each of the units is substantially the same as the operation of the corresponding unit in the fourth embodiment described above. The difference from the fourth embodiment is that the risk level information can be fed back from the risk level information generation unit 201 to the route information generation unit 200 and the control unit 204 determines whether to perform the re-search.

[0108]

FIG. 21 is a flowchart of a process for generating route-related information and caution information according to the fifth embodiment. Steps S211 to S215 in the process are

substantially the same as Steps S151 to S155 in FIG. 5 described as the fourth embodiment. The difference from the fourth embodiment is that Step S216 for determining whether to perform the re-search is added.

[0109]

In the fifth embodiment, after the risk level information is generated in substantially the same manner as in the fourth embodiment, the control unit 204 determines whether to perform the route search again (re-search) (Step S216). The step of determining whether to perform re-search is substantially the same as Step S96 in the second embodiment.

[0110]

When the re-search is determined to be performed, the process returns to Step S214, and the route information generation unit 200 generates the route information again (Step S214). In the route search performed again, the route information is generated with reference to the risk level information fed back from the risk level information generation unit 201 in addition to the object information, the spatial information, and the movement condition information.

[0111]

Subsequently, the risk level information generation unit 201 generates risk level information based on the object information, the spatial information, and the route information that is generated after the re-search (Step S215).

[0112]

Steps S214 to S216 are repeated until a determination indicating that the re-search is not to be performed is made in Step S216.

[0113]

When the determination indicating that the re-search is not to be performed is made, the process proceeds to Step S217, and the caution information generation unit 202 generates caution information (Step S217). Steps S218 to S219 are substantially the same as Steps S157 to S158 in the fourth embodiment.

[0114]

An example of the risk level information generated in the fifth embodiment is the same as that illustrated in FIG. 10, and each of the levels of risk indicates a low value (10) along the route as the result of the route search performed again.

[0115]

FIG. 22 is a diagram illustrating a screen of the display 11A displaying the route information and risk level information generated by the information processor 12 according to the fifth embodiment. The content of FIG. 21 is the same as FIG. 18 except for the caution information regarding the route (2). Since the width of the passage along the route (2) is sufficiently wider than the object and the level of risk is 10, an explanatory text indicating that there are no issues is displayed as caution information (solid annotation balloon corresponding to the route (2)).

[0116]

When the route-related information is displayed after the re-search, the route (2) and the level of risk or the caution information associated with the route (2) may be displayed on the display 11A with or without the route (1) and the level of risk or the caution information associated with the route (1).

[0117]

As described above, according to the fifth embodiment, route information indicating a route with little risk and caution information including text describing the levels of risk at the points along the route are generated using the risk level information in addition to the object information and the spatial information. This allows the user to check the explanatory text about the route and move the object without worry.

[0118]

Sixth Embodiment

FIG. 23 is a block diagram illustrating a functional configuration for a process for generating route-related information and caution information according to a sixth embodiment. The information processor 12 according to the sixth embodiment includes a route information generation unit 230, a risk level information generation unit 231, a caution information generation unit 232, a route-related information generation unit 233, and a control unit 234. The operation of each of the units is substantially the same as the operation of the corresponding unit in the fourth embodiment described above. The difference from the fourth embodiment is that the risk level information can be fed back from the risk level information generation unit 231 to the route information generation unit 230, the control unit 234 determines whether to perform re-search, and a user instruction is input to the information processor 12.

[0119]

FIG. 24 is a flowchart of a process for generating route-related information and caution information according to the sixth embodiment. Steps S241 to S248 in the process are substantially the same as Steps S151 to S158 in FIG. 5 described as the fourth embodiment. The difference from the fourth embodiment is that Step S249 for determining whether to perform the re-search is added.

[0120]

In the sixth embodiment, after the route-related information and the caution information are displayed on the display 11A in substantially the same manner as the fourth embodiment, the control unit 234 determines whether to perform the route search again (re-search) (Step S249). This determination is made based on an instruction from the user. For example, in the information processing apparatus 1, the display 11A may display the route-related information and the caution information and display a message such as "Do you want to search a route again?" and the input device 11B may receive an input of a user instruction. The display 11A may also display an icon image indicating the location of a point (dangerous point) at which the level of risk exceeds (or is equal to or greater than) the threshold in a

superimposed manner on the route-related information. The caution information at a dangerous point may be displayed in a color such as red that attracts attention or may be displayed in a blinking manner.

[0121]

When the re-search is determined to be performed based on a user instruction in Step S249, the process returns to Step S244, and the route information generation unit 230 generates the route information again (Step S244). In the route search performed again, the route information is generated with reference to the risk level information fed back from the risk level information generation unit 231 in addition to the object information, the spatial information, and the movement condition information. An example of the risk level information generated in the sixth embodiment is the same as that illustrated in FIG. 10, and each of the levels of risk indicates a low value (for example, 10) along the route as the result of the route search performed again.

[0122]

Subsequently, the risk level information generation unit 231 generates risk level information based on the object information, the spatial information, and the route information after the re-search (Step S245), and the caution information generation unit 232 generates caution information based on the object information, the spatial information, the route information after the re-search, and the risk level information (Step S246). The control unit 234 causes the display 11A to display the route-related information and the caution information that are newly generated (Step S247, Step S248), and determines whether to perform the route search again (re-search) based on a user instruction (Step S249).

[0123]

Steps S244 to S249 are repeated until a determination indicating that the re-search is not to be performed is made in Step S249.

[0124]

When the determination indicates that the re-search is not to be performed based on a user instruction in Step S249, the process ends.

[0125]

An example of the risk level information generated in the sixth embodiment is the same as that illustrated in FIG. 10, and each of the levels of risk indicates a low value (10) along the route as the result of the route search performed again. An example of the screen of the display 11A displaying the route information, the risk level information, and the caution information generated in the sixth embodiment is the same as that illustrated in FIG. 21.

[0126]

As described above, according to the sixth embodiment, when the re-search is determined to be performed again based on a user instruction, route information and caution information are generated using the risk level information in addition to the object information and the spatial information, so that the user with high transport skills can use the shortest route without

performing the re-search and the user with low transport skills can safely move the object without worry by referring to the route with little risk and the caution information obtained after the re-search.

[0127]

The program executed by the information processing apparatus 1 according to each embodiment described above may be stored in a computer-readable recording medium, such as a compact disc read-only memory (CD-ROM), a flexible disk (FD), a compact disc recordable (CD-R), and a digital versatile disc (DVD), in an installable or executable file format, to be provided as a computer program product.

[0128]

Furthermore, the program executed in the information processing apparatus 1 according to each embodiment described above may be stored in a computer connected to a network such as the Internet and provided by downloading via the network. Further, the computer program executed in the information processing apparatus 1 according to each embodiment described above may be provided or distributed via a network such as the Internet.

[0129]

The embodiments and modifications described above are provided as examples and are not intended to limit the scope of the invention. Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the present disclosure may be practiced otherwise than as specifically described herein. For example, elements and/or features of different illustrative embodiments may be combined with each other and/or substituted for each other within the scope of this disclosure and appended claims. It is therefore to be understood that within the scope of the appended claims, the embodiments and the modifications may be practiced otherwise than as specifically described herein. For example, elements and/or features of different illustrative embodiments may be combined with each other and/or substituted for each other within the scope of this disclosure and appended claims.

[0130]

Machine learning is a technique that enables a computer to acquire human-like learning capabilities, and refers to a method where a computer autonomously generates an algorithm based on pre-acquired training data, for tasks such as data identification, and applies the algorithm to new data for prediction. Any suitable learning method can be applied in machine learning, such as supervised learning, unsupervised learning, semi-supervised learning, reinforcement learning, deep learning, or a combination of two or more of these methods.

[0131]

Aspects of the present disclosure are, for example, as follows.

Aspect 1

An information processing apparatus includes a memory that stores object information and spatial information. The object information is information on an object to move in a space

and the spatial information is information on the space. The information processing apparatus includes an input device that receives movement condition information indicating a condition for movement of the object. The information processing apparatus includes an information processor that generates route-related information including information on the movement of the object in the space. The spatial information includes at least spatial three-dimensional information of the space. The movement condition information includes at least information on a start point and an end point of the movement of the object. The information processor generates the route-related information based on the object information, the spatial information, and the movement condition information.

[0132]

Aspect 2

In the information processing apparatus according to Aspect 1, the object information includes one of object three-dimensional information, object estimation information, and object input information, the object estimation information is information estimated for the object based on one of the three-dimensional information of the object and a brightness image. The input information is information input for the object from the outside.

[0133]

Aspect 3

In the information processing apparatus according to Aspect 1, the spatial information includes one of three-dimensional information of the space, estimation information, and input information. The estimation information is information estimated for the space based on the three-dimensional information of the space. The input information is information input for the space from the outside.

[0134]

Aspect 4

In the information processing apparatus according to any one of Aspects 1 to 3, the route-related information includes route information indicating a route from the start point to the end point and risk level information indicating a level of risk along the route.

[0135]

Aspect 5

In the information processing apparatus according to Aspect 4, the information processor generates additional risk information indicating a level of risk along another route based on the object information, the spatial information, and the movement condition information.

[0136]

Aspect 6

In the information processing apparatus according to any one of Aspects 4 and 5, the information processor generates caution information based on the object information, the spatial information, the movement condition information, and the risk information.

[0137]

Aspect 7

In the information processing apparatus according to any one of Aspects 4 to 6, the information processor determines whether to generate additional route information indicating another route from the start point to the end point.

[0138]

Aspect 8

An information processing method includes reading object information indicating an object to move in a space and spatial information indicating the space, receiving movement condition information indicating a condition for movement of the object, and generating route-related information including information on the movement of the object in the space. The spatial information includes at least three-dimensional information of the space. The movement condition information includes at least information on a start point and an end point of the movement of the object. The generating step generates route-related information based on the object information, the spatial information, and the movement condition information.

[0139]

Aspect 9

A recording medium storing computer-readable code for controlling a computer system carries out a method. The method includes reading object information indicating an object to move in a space and spatial information indicating the space, receiving movement condition information indicating a condition for movement of the object, and generating route-related information including information on the movement of the object in the space. The spatial information includes at least three-dimensional information of the space. The movement condition information includes at least information on a start point and an end point of the movement of the object. The generating step generates route-related information based on the object information, the spatial information, and the movement condition information.

[0140]

The above-described embodiments are illustrative and do not limit the present invention. Thus, numerous additional modifications and variations are possible in light of the above teachings. For example, elements and/or features of different illustrative embodiments may be combined with each other and/or substituted for each other within the scope of the present invention. Any one of the above-described operations may be performed in various other ways, for example, in an order different from the one described above.

[0141]

The present invention can be implemented in any convenient form, for example using dedicated hardware, or a mixture of dedicated hardware and software. The present invention may be implemented as computer software implemented by one or more networked processing apparatuses. The processing apparatuses include any suitably programmed apparatuses such as a general purpose computer, a personal digital assistant, a Wireless Application Protocol (WAP) or third-generation (3G)-compliant mobile telephone, and so on.

Since the present invention can be implemented as software, each and every aspect of the present invention thus encompasses computer software implementable on a programmable device. The computer software can be provided to the programmable device using any conventional carrier medium (carrier means). The carrier medium includes a transient carrier medium such as an electrical, optical, microwave, acoustic or radio frequency signal carrying the computer code. An example of such a transient medium is a Transmission Control Protocol/Internet Protocol (TCP/IP) signal carrying computer code over an IP network, such as the Internet. The carrier medium may also include a storage medium for storing processor-readable code such as a floppy disk, a hard disk, a compact disc read-only memory (CD-ROM), a magnetic tape device, or a solid-state memory device.

[0142]

The functionality of the elements disclosed herein may be implemented using circuitry or processing circuitry which includes general-purpose processors, special-purpose processors, integrated circuits, application-specific integrated circuits (ASICs), field-programmable gate arrays (FPGAs), and/or combinations thereof which are configured or programmed, using one or more programs stored in one or more memories, to perform the disclosed functionality. Processors are considered processing circuitry or circuitry as they include transistors and other circuitry therein. In the disclosure, the circuitry, units, or means are hardware that carry out or are programmed to perform the recited functionality. The hardware may be any hardware disclosed herein which is programmed or configured to carry out the recited functionality.

There is a memory that stores a computer program which includes computer instructions. These computer instructions provide the logic and routines that enable the hardware (e.g., processing circuitry or circuitry) to perform the method disclosed herein. This computer program can be implemented in known formats as a computer-readable storage medium, a computer program product, a memory device, a recording medium such as a CD-ROM or DVD, and/or the memory of an FPGA or ASIC.

[0143]

This patent application is based on and claims priority to Japanese Patent Application No. 2023-208083, filed on December 8, 2023, in the Japan Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

[Reference Signs List]

Reference Signs List

[0143]

- 1 information processing apparatus
- 10 memory
- 11 UI device
- 12 information processor
- 20 route information generation unit

- 21 risk information generation unit
- 22 route-related information generation unit
- 23 control unit

[CLAIMS]

[Claim 1]

An information processing apparatus, comprising:
a memory that stores object information and spatial information, the object information being information on an object to move in a space, the spatial information being information on the space and including at least three-dimensional information of the space;
an input device that receives movement condition information indicating a condition for movement of the object, the movement condition information including at least information on a start point and an end point of the movement of the object; and
an information processor that generates route-related information including information on the movement of the object in the space based on the object information, the spatial information, and the movement condition information.

[Claim 2]

The information processing apparatus of claim 1, wherein
the object information includes one of three-dimensional information of the object, estimation information, and input information, the estimation information being information estimated for the object based on one of the three-dimensional information of the object and a brightness image of the object, the input information being information input for the object from outside of the information processing apparatus.

[Claim 3]

The information processing apparatus of claim 1, wherein,
the spatial information further includes one of estimation information and input information, the estimation information being information estimated for the space based on one of the three-dimensional information of the space and a brightness image of the space, the input information being information input for the space from outside of the information processing apparatus.

[Claim 4]

The information processing apparatus of any one of claims 1 to 3, wherein
the route-related information includes route information indicating a route from the start point to the end point, and risk level information indicating a level of risk along the route.

[Claim 5]

The information processing apparatus of claim 4, wherein
the information processor generates additional risk level information indicating a level of risk along another route based on the object information, the spatial information, and the movement condition information.

[Claim 6]

The information processing apparatus of any one of claims 4 and 5, wherein

the information processor generates caution information based on the object information, the spatial information, the movement condition information, and the risk level information.

[Claim 7]

The information processing apparatus of any one of claims 4 to 6, wherein the information processor determines whether to generate additional route information indicating another route from the start point to the end point based on the risk level information included in the generated route-related information.

[Claim 8]

An information processing method, comprising:
reading object information and spatial information from a memory, the object information being information on an object to move in a space, the spatial information being information on the space and including at least three-dimensional information of the space;
receiving movement condition information indicating a condition for movement of the object, the movement condition information including at least information on a start point and an end point of the movement of the object; and
generating route-related information including information on the movement of the object in the space based on the object information, the spatial information, and the movement condition information.

[Claim 9]

A recording medium storing computer-readable code for controlling a computer system to carry out a method, the method including:
reading object information and spatial information from a memory, the object information being information on an object to move in a space, the spatial information being information on the space and including at least three-dimensional information of the space;
receiving movement condition information indicating a condition for movement of the object, the movement condition information including at least information on a start point and an end point of the movement of the object; and
generating route-related information including information on the movement of the object in the space based on the object information, the spatial information, and the movement condition information.