

# METHOD AND APPARATUS FOR COMBINING SPATIAL PROPERTY INFORMATION WITH 3D INFORMATION

## CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Korean Patent Application Nos. 10-2022-0125788, filed on September 30, 2022, and 10-2022-0149535, filed on November 10, 2022, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

## BACKGROUND

### 1. Field

**[0001]** The present disclosure relates to a method and apparatus for combining spatial property information with three-dimensional (3D) information, and more particularly, relates to a technology allowing data processing to be performed in the background by a method of combining spatial property information, which is applied in two dimensions (2D), with 3D information so that the 3D information can be easily processed even in a popular environment.

### 2. Description of the Related Art

**[0002]** Recently, digital twin technology has attracted attention in various industry fields to improve productivity, economic feasibility, and stability. A digital twin is a virtual model in which physical objects are expressed identically on a computer, and is being used to identify and resolve issues that may arise through simulation tests before making an actual product.

**[0003]** Meanwhile, various methods are emerging to implement a three-dimensional (3D) digital twin, but, they require a large amount of resources to be utilized relative to data due to the volume of the data and the nature of 3D, and thus, are not easily adaptable for driving general functions in a popular environment.

**[0004]** Accordingly, the present disclosure provides a method of combining spatial property information with 3D information, which maximizes the utilization of 3D information relative to resources by allowing data processing to be performed in the background.

## SUMMARY OF THE INVENTION

**[0005]** Provided are a method and apparatus for combining spatial property information with three-dimensional (3D) information. The problems to be solved by the present disclosure are not limited to the technical problem mentioned above, and other technical problems not mentioned can be clearly understood by those skilled in the art from the description of the present disclosure, and will be more clearly understood by the embodiments of the present disclosure. In addition, the problems and advantages to be solved by the present disclosure can be realized by means and a combination thereof disclosed in the claims.

**[0006]** Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

**[0007]** According to a first aspect of the present disclosure, there is provided a method of combining spatial property information with 3D information, the method including setting an occupied region in a grid region, which is a set of a plurality of shells, by determining the shells occupied by a 3D object in the grid region, generating a plurality of semantic regions in the grid region by assigning one or more spatial properties to each of the plurality of shells on the basis of the occupied region, and generating a spatial property map on the basis of the plurality of semantic regions.

**[0008]** According to a second aspect of the present disclosure, there is provided an apparatus for combining spatial property information and 3D information, the apparatus including a memory in which one or more programs are stored, and a processor configured to perform an operation by executing the one or more programs, wherein the processor may be configured to set an occupied region in a grid region, which is a set of a plurality of shells, by determining the shells occupied by a 3D object in the grid region,

generate a plurality of semantic regions in the grid region by assigning one or more spatial properties to each of the plurality of shells on the basis of the occupied region, and generate a spatial property map on the basis of the plurality of semantic regions.

**[0009]** According to a third aspect of the present disclosure, there is provided a computer-readable recording medium having recorded thereon a program for executing the method of the first aspect in a computer.

**[0010]** In addition, another method for implementing the present disclosure, another apparatus, and a computer-readable recording medium for recording a program configured to execute the method may be further provided.

**[0011]** Other aspects, features, and advantages other than those described above will become apparent from the following drawings, claims, and detailed description of the present disclosure.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0012]** These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

**[0013]** FIG. 1 is a plan view illustrating a basic form of a grid relating to an embodiment;

**[0014]** FIG. 2 is an exemplary view for describing a method of defining a connection relationship of shells in a grid relating to an embodiment;

**[0015]** FIG. 3 is an exemplary view for describing a method of setting an occupied region in a grid region relating to an embodiment;

**[0016]** FIG. 4 is an exemplary view for generating a plurality of semantic regions relating to an embodiment;

**[0017]** FIGS. 5 and 6 are exemplary views of a spread region relating to an embodiment;

**[0018]** FIG. 7 is an exemplary view of a plurality of semantic regions relating to an embodiment;

**[0019]** FIGS. 8A and 8B are exemplary views for describing a method of utilizing weights relating to an embodiment;

**[0020]** FIG. 9 is a flowchart of a method of combining spatial property information with 3D information relating to an embodiment; and

**[0021]** FIG. 10 is a block diagram of an apparatus for combining spatial property information with 3D information relating to an embodiment of the present disclosure.

## DETAILED DESCRIPTION

**[0022]** Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. In addition, expressions such as "at least one of", when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

**[0023]** In describing the present disclosure, when it is determined that a detailed description of a known technique related to the present disclosure may unnecessarily obscure the gist of the present disclosure, the detailed description will be omitted, and unless otherwise defined, all terms used in the present specification shall have the same meaning as commonly understood by those of ordinary skill in the technical field to which the present disclosure pertains

**[0024]** Phrases such as " according to an embodiment", "relating to an embodiment", "according to one embodiment implementation", and the like appearing in various places in the present specification are not necessarily all referring to the same embodiment.

**[0025]** The embodiments may be susceptible to various modifications and include various forms, and thus, some embodiments will be illustrated in the drawings and described in detail. However, it should be understood that there is no intent to limit the embodiments to the particular forms disclosed, but on the contrary, the embodiments are to cover modifications, equivalents, and alternatives falling within the spirit and scope of

the present embodiments. The terms used in the specification are only used to describe the embodiments and are not intended to limit the embodiments.

**[0026]** The terms used herein are general terms that are currently widely used in consideration of functions in the present embodiments but may vary according to an intention of those of ordinary skill in the art, precedents, or the emergence of new technologies. In addition, the applicant may arbitrarily select terms in a particular case, and in this case, the meaning of the terms will be described in detail in the corresponding part. Accordingly, the terms used in the embodiments should be defined on the basis of the meaning of the terms and the content throughout the embodiments, instead of the names of the terms.

**[0027]** Some embodiments of the disclosure may be represented by functional block configurations and various processing operations. Some or all of these functional blocks may be implemented by various numbers of hardware and/or software configurations that perform particular functions. For example, the functional blocks of the present disclosure may be implemented by one or more microprocessors or by circuit configurations for a certain function.

**[0028]** In addition, for example, the functional blocks of the present disclosure may be implemented in various programming or scripting languages. The functional blocks may be implemented by algorithms executed in one or more processors. In addition, the present disclosure may employ conventional techniques for electronic environment setting, signal processing, and/or data processing.

**[0029]** Terms such as "database", "element", "means", and "configuration" may be used widely and are not limited as mechanical and physical configurations. In addition, terms such as "unit", "-or/-er", and "module" described in the specification denote a unit that processes at least one function or operation, which may be implemented in hardware or software, or implemented in a combination of hardware and software.

**[0030]** In addition, a connection line or a connection member between components shown in the drawings is merely a functional connection and/or a physical or circuit connection. In an actual device, connections between components may be represented by various functional connections, physical connections, or circuit connections that are replaceable or added.

**[0031]** In addition, terms including ordinal numbers such as "first" or "second" used herein may be used to describe various components, but the components should not be limited by the terms. These terms are used only for the purpose of distinguishing one component from another component.

**[0032]** In addition, some components in the drawings may be shown to be exaggerated in size or proportion. Moreover, components shown in one drawing may not be shown in other drawings.

**[0033]** Throughout the specification, "embodiment" is a random division for easily describing the disclosure in the present specification, and each embodiment need not be mutually exclusive. For example, configurations disclosed in one embodiment may be applied and implemented in other embodiments and may be changed and applied and implemented without departing from the idea and scope of the present disclosure.

**[0034]** The terms used in the present disclosure are intended to describe embodiments and are not intended to limit the present embodiments. In the present disclosure, the singular forms include plural forms unless specifically stated.

**[0035]** Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings so that they can be easily practiced by those skilled in the art. However, the embodiments of the present disclosure may be implemented in various different forms and are not limited to the embodiments described in the present disclosure.

**[0036]** Based on this, hereinafter, the present disclosure will be described in detail with reference to the drawings.

**[0037]** FIG. 1 is a plan view illustrating a basic form of a grid relating to an embodiment.

**[0038]** Referring to FIG. 1, a grid 100 may be formed in a general lattice structure of a two-dimensional (2D) structure. Each grid may be designated as a square in size, and the unit of each grid may be referred to as a shell 110 for convenience.

**[0039]** All the shells 110 in the grid 100 may be set to have a size at a constant interval. Since the shell 110 may be used on a per-region basis or data may be retrieved based on the shell 110, when the size of the shell is not constant, which may require more consideration due to algorithmic changes in search the shell 110. Accordingly, by setting the shells 110 to have a size at a constant interval, an algorithm for calculating a region

and retrieving data based on the shells 110 can be simplified. Specifically, the shells 110 in a certain region can be searched by comparing them to the overall size of the grid 100 without having to retrieve information of each shell 110. However, as necessary, the shells 110 of the grid 100 may be set to have different sizes.

**[0040]** The entire region formed by collections of columns and rows constituting the grid 100 does not need to be maintained in a square shape. As necessary, a horizontal or vertical length of the grid may be longer than the other. That is, the number of columns or the number of rows may increase according to the size of a three-dimensional (3D) object.

**[0041]** The concept of the grid 100 may be similar to the concept of tiling in the field of geographic information systems (GIS), but is different from the concept of tiling in that the method of configuring a tile in GIS tiling divides the tile on the basis of coordinates, whereas the shells 110 of the grid 100 according to an embodiment of the present disclosure have a size at a constant interval, and thus the concept of the grid 100 has a simpler configuration method. However, GIS tiling data is generated by considering linked open data (LOD), and an LOD method may also be considered in the method of the grid 100 to cover a large region.

**[0042]** In relation to setting of the specification when generating the grid 100, length values of horizontal and vertical units of the shell, which constitute the shell 110, may be the same. In addition, a maximum row length and a maximum column length of the grid 100 may be preset, or a maximum row count and a maximum column count of the grid 100 may be preset. In this case, the maximum row/column length may be set as a product of a unit length of the shell 110 and the maximum row/column count, and the overall size of the grid 100 and the number of the shells 110 may be determined based on the maximum row/column length.

**[0043]** FIG. 2 is an exemplary view for describing a method of defining a connection relationship of shells in a grid relating to an embodiment.

**[0044]** A connection relationship of shells in a grid 200 may be described with reference to FIG. 2. In the shells constituting the grid 200, surfaces constituting each shell may be defined as being connected to each other. When configuring nodes 210 and links 220 through center points of the shells, the center point of the shell may be designated as a

node 210 point, and when adjacent shells exist so that the nodes 210 points thereof can be connected to each other, the link 220 may be generated, and the link 220 is a connection relationship between the nodes 210 points. However, the node 210 point is not limited to the center point of the shell.

**[0045]** Meanwhile, in relation to the connection relationship of the shells, each shell may have a unique key value, and a property of the corresponding shell may be designated in each key. Through the properties of the shells, not only simple connection relationship for spatial connection, but also a region range, a spread, a proximity influence, a path, and the like in a background stage may be digitally twinned.

**[0046]** Key information stored through the key value of the shell may include a shell index, a position of the shell on the grid 200 (a row number and a column number), coordinates of the shell in the region of the grid 200, connection information, and information about the node 210 and the link 220.

**[0047]** The shell index is a value that is separately set in relation to the positions of the shells in the grid 200 according to the order. The shell index is important in that the shell index may be used as a key value for the shell to match information of the shell that corresponds to a 3D object, so that the shell index enables a search for the 3D object corresponding to the shell only with the key value of the shell and stores information about layers in the corresponding region, the shell index may be used to search for representative information when designating a region in the grid 200, and the shell index may be a reference value for extracting relevant spatial information in the background using only the shell. A method of representing the grid 200 by using the shell index will be described later.

**[0048]** When the surfaces constituting each shell are defined as being connected to each other as described above, the connection information may refer to information about connections to the adjacent shells. For example, in the case of the connection information for a four-direction connection 230, shell indices (or key values) of the shells adjacent in upper, lower, left, and right directions may be stored, and in the case of the connection information for an eight-direction connection 240, shell indices (or key values) of the shells adjacent in upper, lower, left, right, and four diagonal directions may be stored.

**[0049]** In addition, the shells may be distinguished into shells in a region on the grid 200 and shells in a region not on the grid 200, and the connection information may be defined such that the shells corresponding to the outermost four sides of the entire grid 200 have connection information for only some of the adjacent shells of the four-direction connection 230, and the shells in the region of the grid 200 other than the outermost four sides have connection information for all the adjacent shells of the four-direction connection 230 or eight-direction connection 240.

**[0050]** The information about the node 210 and the link 220 may be stored in the shell property to reduce the amount of searching, but property information of the node 210 may be separately stored. The connection information may be applied to the information about the node 210 and the link 220, and when a search taking into account weights is required while searching the node 210 and the link 220 in the grid 200, the connection information may be determined through property values of the nodes 210.

**[0051]** The weights may be applied to each shell or the node 210 and the link 220, and utilized in various ways. For example, the weights may be utilized for opening and closing for path finding, deciding whether the link 220 is bi-directionally/uni-directionally movable/non-movable, or numerical values for level evaluation for each region, and region classification criteria for designating point of interest (POI) grouping relative to the region. The weights may be values that are set in advance as different input weights are input, but may also be values variably set.

**[0052]** FIG. 3 is an exemplary view for describing a method of setting an occupied region in a grid region relating to an embodiment.

**[0053]** Referring to FIG. 3, an apparatus for combining spatial property information with 3D information relating to an embodiment (hereinafter, referred to as an "apparatus") may set an occupied region 330 to a grid region 300 by determining shells occupied by a 3D object 320 in the grid region 300.

**[0054]** The grid region 300 is a 2D region, and thus, the occupied region 330, which is a set of the shells occupied by the 3D object 320, may be set in the grid region 300 and used to build a spatial property map, such as matching information about the 3D object 320 with the corresponding occupied region 330.

**[0055]** In an embodiment, the apparatus may obtain an outer boundary of the 3D object 320. For example, the apparatus may extract polygons constituting a bottom of the 3D object 320 and extract outermost lines of the polygons as the outer boundary of the 3D object 320. The term "polygon" refers to a polygonal shape of a minimum unit constituting a three-dimensional figure in a computer graphic, and may be based on a triangular shape. The term "bottom" refers to a set of coordinates having the lowest height value in a building model, and in the case of a building model having multiple layers, the bottom may refer to a set of coordinates having a height value corresponding to a height of the corresponding layer whose information is a property value. In an embodiment, the apparatus may extract and obtain polygons of a region in contact with the grid region 300, such as the outer boundary of the 3D object 320 having multiple layers, or coordinates or bottom coordinates having the lowest height value of the 3D object 320. In another example, the apparatus may receive information about the 3D object 320 including outer boundary information to obtain the outer boundary of the 3D object 320. However, the method of obtaining the outer boundary of the 3D object 320 by the apparatus is not limited thereto.

**[0056]** In an embodiment, the apparatus may set a set of shells including a closed region of the outer boundary of the 3D object 320, from among one or more shells in the grid region 300, as the occupied region 330.

**[0057]** A method of defining the shells including the closed region of the outer boundary of the 3D object 320 may vary. In an embodiment, when shells that include even a portion of the closed region of the outer boundary of the 3D object 320 therein are defined as the shells including the closed region of the outer boundary of the 3D object 320, an occupied region may be the same as the occupied region 330 shown in FIG. 3. In another embodiment, when shells entirely including the closed region of the outer boundary of the 3D object 320 therein are defined as the shells including the closed region of the outer boundary of the 3D object 320, an occupied region is the same as an occupied region 340 shown in FIG. 3. In another embodiment, when shells including a predetermined ratio (e.g., 50% of a shell region) or more of the closed region of the outer boundary of the 3D object 320 therein are defined as the shells including the closed region of the outer

boundary of the 3D object 320, an occupied region (not shown) may have a shape other than those shown in FIG. 3.

**[0058]** In an embodiment, the apparatus may set one or more unoccupied regions (not shown) in the grid region 300 by determining a shell region in which the 3D object 320 is not occupied from among one or more shells in the grid region 300. By separately setting the unoccupied region (not shown), the region not occupied by the 3D object 320 may be utilized in various applications such as not only simple region division in the grid region 300 but also path finding, evacuation path prediction, and the like. That is, the unoccupied region (not shown) itself may become a unit semantic region having a predetermined meaning.

**[0059]** In an embodiment, when an occupied region is set as the occupied region 330, a shell region not occupied by the 3D object 320 in the grid region 300 becomes a region (not shown) corresponding to the intersection of the complement set of the grid region 300 and the occupied region 330, and the corresponding shell region may correspond to the unoccupied region (not shown).

**[0060]** FIG. 4 is an exemplary view for generating a plurality of semantic regions relating to an embodiment.

**[0061]** The term "semantic regions" means regions obtained by dividing a grid region 400 into sets of one or more shells according to a characteristic of the region. In this case, any shell in the grid region 400 may be included in all of two or more semantic regions, and may not be included in any semantic region.

**[0062]** In an embodiment, an apparatus may generate a plurality of semantic regions on the basis of any one of an occupied region 420, an unoccupied region, and layer information of a 3D object 410. For example, when the 3D object 410 is a single-layer building object, a plurality of shells in the occupied region 420 may be included in one semantic region due to a characteristic that the 3D object 410 is occupied, but when a 3D object 430 is a multi-layer building object, each of a plurality of shells in an occupied region 440 may be included in a plurality of semantic regions depending on the grid region occupied by each layer of the 3D object 430. Specifically, when a particular shell (not shown) in the occupied region 440 is occupied by first and second layers of the 3D object 430, the corresponding shell (not shown) may be included in both a first semantic region

for the first layer of the 3D object 430 and a second semantic region for the second layer of the 3D object 430.

**[0063]** In an embodiment, when the 3D objects 410 and 430 and the grid region 400 are multiple matched, the apparatus may generate a plurality of semantic regions such that one shell 411 is included in two or more semantic regions. For example, when the 3D object 410 is a building and a closed-circuit television (CCTV) (not shown) is installed on an outer wall of the building, the particular shell 411 of the occupied region 420 occupied by the 3D object 410 may correspond to a region occupied by the CCTV, and thus the apparatus may generate a plurality of semantic regions (e.g., a building region (410) and a CCTV region (411)) so that the corresponding shell 411 is included in two or more semantic regions.

**[0064]** In another example, shells of an unoccupied region (not shown) with respect to the 3D objects 410 and 430 may, by themselves, form one semantic region due to a characteristic that the shells are not occupied by any one of the 3D objects 410 and 430 in the grid region 400, but the shells of the unoccupied region (not shown) may not be included in any semantic region.

**[0065]** In an embodiment, the apparatus may generate the plurality of semantic regions on the basis of the occupied regions 420 and 440 of the 3D objects 410 and 430 and the unoccupied region (not shown). For example, when the 3D objects 410 and 430 is a building object and a large sculpture object, respectively, the occupied regions 420 and 440 are non-passable regions, and thus the apparatus may distinguish the occupied regions 420 and 440 as non-movable regions and the unoccupied region (not shown) as a movable region. In addition, the apparatus may generate the movable region and the non-movable region as separate semantic regions. Specifically, the apparatus may generate the plurality of semantic regions by assigning spatial properties, including whether the occupied regions 420 and 440 and the unoccupied region are (non-)movable, to the occupied regions 420 and 440 and the unoccupied region based on the characteristics of the 3D objects 410 and 430.

**[0066]** The spatial property reflects a characteristic of a particular region in the grid, and may include, for example, shell indices of the shells included in the corresponding region, a unique number of the region, information about the outermost shells of the

corresponding region, information (e.g., a file name, layer information in the modeling, and the like) about a 3D object occupying the grid, properties (e.g., a region name, a characteristic of the region) for space classification, weights, a connection relationship with adjacent shells, and the like. In this case, the characteristic of the region is a characteristic for spatial meaning assignment, and the characteristic of the region may include stories, a floor, a wall, and the like when the 3D object is a building, and a road, a sidewalk, and the like for a region outside the building.

**[0067]** Referring to FIG. 4, each of the plurality of shells of the grid region 400 may have a unique shell index. For example, a shell 401 of a first row and a first column of the grid region 400 may have 0\_0 as the shell index, and a shell of the first row and a second column may have 0\_1 as the shell index.

**[0068]** In an embodiment, the apparatus may assign any one of the shell indices of the shells included in the plurality of semantic regions as a unique number for each of the plurality of semantic regions. Alternatively, the apparatus may generate a plurality of semantic regions each having, as a unique number, one of shell indices of shells to be included in each semantic region.

**[0069]** For example, when the occupied regions 420 and 440 themselves become semantic regions, the shells included in the semantic region (440) have, starting from the left upper end, 6\_6, 6\_7, 6\_8, 7\_5, 7\_6, 7\_7, 7\_8, 7\_9, 8\_5, 8\_6, 8\_7, and 8\_8 as the shell indices, and the apparatus may assign any of the above unique numbers as a unique number for the semantic region (440).

**[0070]** In an embodiment, the apparatus may assign the lowest-numbered shell index among the shell indices of the shells included in the semantic region (440) as the unique number for the semantic region (440). For example, when a semantic region consists of a single shell, the apparatus may assign a shell index of the corresponding shell as a unique number for the semantic region. In another example, when the semantic region (440) consists of a plurality of shells, the apparatus may assign the shell index 6\_6 of the shell belonging to the lowest column among the shells belonging to the lowest row of the semantic region (440) as the unique number for the semantic region (440). Alternatively, the apparatus may assign the shell index 7\_5 of the shell belonging to the lowest row among the shells belonging to the lowest column of the semantic region (440) as the

unique number for the semantic region (440). According to the above embodiment, the unique number for the semantic region (420) may be "1\_1" that is the lowest numbered shell index.

**[0071]** The apparatus may use an algorithm for searching the semantic regions (420 and 440) using the unique numbers in the grid region 400 by assigning the unique numbers of for the semantic regions (420 and 440) based on the same criteria, which has an effect of simplifying the search.

**[0072]** In an embodiment, the apparatus may generate the plurality of semantic regions by assigning, for each of the plurality of shells, a spatial property including a shell index of an adjacent shell.

**[0073]** For example, the apparatus may assign a spatial property including shell indices of two adjacent shells for 14 outermost shells 1\_1, 1\_2, 1\_3, 1\_4, 1\_5, 2\_1, 2\_5, 3\_1, 3\_5, 4\_1, 4\_2, 4\_3, 4\_4, and 4\_5 of the occupied region 420. Specifically, shell indices 2\_1 and 1\_2 of two adjacent shells of the shell 1\_1 may be included as spatial properties. The apparatus may assign the above spatial properties to the occupied region 420 to generate the semantic region.

**[0074]** Likewise, for example, the apparatus may assign a spatial property including shell indices of four adjacent shells for shells 2\_2, 2\_3, 2\_4, 3\_2, 3\_3, and 3\_4, which are not the outermost shells of the occupied region 420. Specifically, shell indices 1\_2, 2\_1, 2\_3, and 3\_2 of four adjacent shells of the shell 2\_2 may be included as spatial properties. The apparatus may assign the above spatial properties to the occupied region 420 to generate the semantic region.

**[0075]** The above-described embodiment is an embodiment in which the spatial property has four-direction connection information, and when the spatial property has eight-direction connection information, the number of the adjacent shells may vary.

**[0076]** FIGS. 5 and 6 are exemplary views of a spread region relating to an embodiment.

**[0077]** Referring to FIG. 5, the plurality of semantic regions may include a spread region.

**[0078]** The term "spread" means to scatter or spread far away, and the spread region may mean a predetermined region adjacent to a particular occupied region (or semantic region). In other words, depending on a characteristic of the particular occupied region (or semantic region), the spread region may mean a predetermined region that is

scattered and spread away from the corresponding occupied region. Hereinafter, the spread region is described as being determined from the occupied region, but the spread region may be determined from the semantic region.

**[0079]** In an embodiment, an apparatus may set a predetermined region 510 adjacent to an occupied region 500 as a spread region 510 corresponding to the occupied region 500. At this time, the apparatus may determine the predetermined region depending on a characteristic of the occupied region 500.

**[0080]** For example, when the occupied region 500 is an occupied region of a CCTV, the apparatus may set an image capturing range of the CCTV as the predetermined region, that is, the spread region 510. In another example, when the occupied region 500 is an occupied region of a disinfection sterilizer, the apparatus may set an injection range of the disinfection sterilizer as the spread region 510. As such, a predetermined region adjacent to an occupied region may be set as the spread region 510 depending on the characteristic of the occupied region 500.

**[0081]** In FIG. 5, a spread in a single direction from the occupied region is illustrated, but a method of setting a spread region by the apparatus is not limited thereto, and the spread region may be set in various directions.

**[0082]** Referring to FIG. 6, an exemplary view is illustrated in which an apparatus sets a spread region 630 within a predetermined radius of an occupied region 600 of a 3D object.

**[0083]** Similar to the embodiment of FIG. 5, the apparatus may set a spread region 610 on the basis of a characteristic of the occupied region 600. For example, when the occupied region 600 is an occupied region of a sprinkler, the apparatus may set a predetermined region corresponding to a sprinkling range 620 around an axial center of a sprinkler head as the spread region 610.

**[0084]** In an embodiment, the apparatus may set a safe region and a risk region on the basis of the occupied region 600 and the spread region 610. In the above-described embodiments, when the occupied region 600 is an occupied region of a CCTV, the spread region 610 may be set as a security safe region, a region not included in the spread region 610 may be set as a security risk region, when the occupied region 600 is an occupied region of a disinfection sterilizer, the spread region 610 may be set as a disinfection safe region, a region not included in the spread region 610 may be set as a disinfection risk

region, and when the occupied region 600 is an occupied region of a sprinkler, the spread region 610 may be set as a water supply safe region, a region not included in the spread region 610 may be set as a water supply risk region. As described above, by distinguishing the safe region and the risk region and generating a plurality of semantic regions on the basis of the characteristics of the occupied region 600 and the spread region 610, the present disclosure may be utilized in various fields depending on characteristics of a 3D object corresponding to the occupied region or the occupied region.

**[0085]** FIG. 7 is an exemplary view of a plurality of semantic regions relating to an embodiment.

**[0086]** Referring to FIG. 7, it is illustrated that an apparatus generates a plurality of semantic regions 710, 720, 730, and 740 according to the embodiments described with reference to FIGS. 4 to 6.

**[0087]** In an embodiment, when a 3D object is a wall, a first semantic region 710, which is generated on the basis of an occupied region of the wall, may include a spatial property of a non-movable region. At the same time, a separate semantic region (not shown), which has a spatial property of a movable region, may be generated for a set of shells included in an unoccupied region of the wall. In addition, when a closed region surrounded by the first semantic region 710 exists, a separate semantic region 740, which has a spatial property of indoors, may be generated for a set of shells included in the corresponding closed region, and a separate semantic region (not shown), which has a spatial property of outdoors, may be generated for a set of shells included in a region outside the first semantic region 710.

**[0088]** In another embodiment, when the 3D object is a CCTV, a second semantic region 720, which is a sum of an occupied region of the CCTV and a spread region of the CCTV, may include a spatial property of a safe region. On the contrary, a separate semantic region 730, which has a spatial property of a risk region, may be generated for a set of shells not belonging to the second semantic region 720.

**[0089]** Meanwhile, when the apparatus generates the plurality of semantic regions 710, 720, 730, and 740, the semantic regions may be generated by automatically determining spatial properties based on the characteristic and the like of the 3D object, but the semantic regions on a grid region may be generated on the basis of separate inputs

received by the apparatus. For example, even for the shell that is not included in the union of the occupied region of the CCTV, which is the 3D object, and the spread region of the CCTV, a separate semantic region (not shown) having the spatial property of the safe region may be generated from the received separate inputs.

**[0090]** In an embodiment, the apparatus may determine a weight on the basis of the characteristic of the 3D object. The weight may vary depending on a field that utilizes spatial property information of the grid. For example, the weight may include a movement weight used for path finding or evacuation path prediction, a safety weight used for prediction of evacuation path prediction and safety path recommendation, or the like, but the present disclosure is not limited thereto. In addition, the weight may be determined in units of semantic regions, but may be determined to be assigned to each of the shells included in the semantic region.

**[0091]** In an embodiment, the apparatus may determine the weight such that the shell belonging to the movable region has a higher movement weight than the shell belonging to the non-movable region. Alternatively, the apparatus may determine the weight such that the shell belonging to the spread region has a higher movement weight than the shell that does not belong to the spread region.

**[0092]** Meanwhile, the apparatus may not assign the same weight to the shells included in one semantic region, but may assign different weights even to the shells included in one semantic region. For example, when the 3D object is a CCTV, among the shells included in the safe region (720), the shell closer to the 3D object may be given a higher safety weight. Alternatively, when the 3D object is a wall, among the shells included in the movable region (not shown), the shell farther from the 3D object may be given a higher movement weight.

**[0093]** In an embodiment, for the plurality of shells in the grid region, the apparatus may assign a weight to a link, which is a connection relationship between adjacent shells, on the basis of the spatial property. For example, the apparatus may assign the movement weight to the link depending on whether movement is possible between adjacent shells on the basis of the spatial property, and when an origin or destination is determined, the apparatus may assign the movement weight to the link depending on whether a path between the origin and destination is the shortest or least time-consuming path.

Alternatively, the apparatus may assign the movement weight to the link based on a pathing algorithm.

**[0094]** In an embodiment, the apparatus may determine a composite weight on the basis of a plurality of different weights. For example, in the case of path guidance, the composite weight may be determined that takes into account not only the movement weight but also the safety weight. Specifically, among the shells (or links) included in the movable region, the shells (links) included in the safe region may be given a high composite weight. and among the shells (or links) included in the movable region, the shells (or links) included in the risk region may be given a lower composite weight than the shells (or links) included in the safe region. However, the method of determining the composite weight may vary, just as the types of weights are not limited to movement and safety weights.

**[0095]** In an embodiment, the apparatus may generate a plurality of semantic regions on the basis of the determined weights. Specifically, the apparatus may generate the plurality of semantic regions by assigning a spatial property including the weight to each of the plurality of shells in the grid. Alternatively, the apparatus may newly assign a spatial property including the weight to each of the plurality of shells included in the plurality of semantic regions.

**[0096]** In an embodiment, the apparatus may generate a spatial property map on the basis of the plurality of semantic regions 710, 720, 730, and 740. The spatial property map may be obtained by matching the grid region and the 3D object by assigning information about the 3D object to each of the plurality of shells in the grid as the spatial property. In other words, the spatial property assigned to the grid region may include information about the 3D object or information generated from the 3D object, and the apparatus may generate the spatial property map in which the grid region and the 3D object are matched by assigning the spatial property to each of the plurality of shells in the grid.

**[0097]** Conceptually, 2D grid information may mean a base frame for matching the shape and information of the 3D object. Information about the inclusion of the 3D object and information about the height of the 3D object may be matched as data and stored in one shell. In addition, the matching may be made only with the inclusion relationship of the

3D object and the shell region, and node and link information may be used as additional connection information.

**[0098]** The matching between the grid region and the 3D object may also be applied to a building consisting of a plurality of layers, and the like. For example, a semantic region may be generated for each layer of the building, and links connecting between inter-layer movable shells are connected (or an inter-layer movement region is generated as a separate semantic region, and the corresponding semantic regions are connected), thereby generating the spatial property map.

**[0099]** According to the spatial property map relating to an embodiment, when a change in spatial property is required, data may be processed in the background over a 2D region, such as by changing only the spatial property that matches the 3D information, thereby increasing a data processing speed and maximizing the utilization of 3D information relative to resources.

**[00100]** FIGS. 8A and 8B are exemplary views for describing a method of utilizing weights relating to an embodiment.

**[00101]** In a method for finding a path connecting two entrances, FIG. 8A is a view illustrating an example of path finding without considering a risk weight, and FIG. 8B is a view illustrating an example of path finding in consideration of the risk weight.

**[00102]** Specifically, when it is assumed that a risk weight is set in a risk zone (corridor), a path extracted when the apparatus does not consider the risk weight passes through the risk zone (corridor) as shown in FIG. 8A, and a path extracted when the apparatus considers the risk weight does not pass through the risk zone (corridor) as shown in FIG. 8B.

**[00103]** In an embodiment, when the apparatus extracts a shortest path using a composite weight that takes into account both the movement weight and the risk weight, a path different from those shown in FIGS. 8A and 8B may be extracted, and according to a value of the risk weight set to the risk zone (corridor), the path passing through the risk zone (corridor) may be extracted even when the risk weight is considered. For example, the apparatus may extract a path for the path finding, which passes through the risk region, when a difference between the sum of risk weights according to the shortest path and the

movement weight due to passing through the risk region is greater than the sum of movement weights due to avoidance paths that does not pass through the risk region.

**[00104]** In an embodiment, the weight may vary according to other parameters. Thus, the path extracted by the apparatus may also be changed. For example, when a first point is a point at which a fire is estimated to occur, and the apparatus generates a semantic region by assigning a spatial property of a risk region to the shells included in the first point and a spread region from the first point, a weight assigned to the shells of the fire region may be changed according to another parameter (e.g., time), and the path (e.g., evacuation path) extracted by the apparatus may be changed according to the another parameter.

**[00105]** FIG. 9 is a flowchart of a method of combining spatial property information with 3D information relating to an embodiment.

**[00106]** In operation 910, the apparatus may set an occupied region in a grid region, which is a set of a plurality of shells, by determining the shells occupied by a 3D object in the grid region.

**[00107]** In an embodiment, each of the plurality of shells may have a unique shell index.

**[00108]** In an embodiment, the apparatus may obtain an outer boundary of the 3D object, and set a set of shells including a closed region of the outer boundary from among the one or more shells as the occupied region.

**[00109]** In operation 920, the apparatus may generate a plurality of semantic regions in the grid region by assigning one or more spatial properties to each of the plurality of shells on the basis of the occupied region.

**[00110]** In an embodiment, each of the plurality of semantic regions may have any one of shell indices of the shells including the semantic region as a unique number thereof.

**[00111]** In an embodiment, the plurality of semantic regions may include a spread region that is a predetermined region adjacent the occupied region.

**[00112]** In an embodiment, the apparatus may generate the plurality of semantic regions by assigning a spatial property that includes the shell index of the adjacent shell to each of the plurality of shells.

**[00113]** In an embodiment, the apparatus may determine a shell region in which the 3D object does not occupy to set one or more unoccupied regions in the grid region, and

generate the plurality of semantic regions on the basis of the occupied region and the unoccupied region.

**[00114]** In an embodiment, the apparatus may generate the plurality of semantic regions by determining a weight on the basis of a characteristic of the 3D object and assigning a spatial property that includes the weight to each of the plurality of shells.

**[00115]** In an embodiment, for the plurality of shells in the grid region, the apparatus may assign a weight to a link, which is a connection relationship between adjacent shells, on the basis of the spatial properties,

**[00116]** In an embodiment, the apparatus may distinguish a movable region and a non-movable region on the basis of the characteristic of the 3D object, and determine the weight such that the shell belonging to the movable region has a higher movement weight than the shell belonging to the non-movable region.

**[00117]** In an embodiment, the apparatus may determine the weight such that the shell belonging to the spread region has a higher movement weight than the shell that does not belong to the spread region.

**[00118]** In an embodiment, the apparatus may generate the plurality of semantic regions on the basis of the determined weight.

**[00119]** In operation 930, the apparatus may generate a spatial property map on the basis of the plurality of semantic regions.

**[00120]** In an embodiment, the spatial property map may be obtained by matching the grid region and the 3D object by assigning information about the 3D object to each of the plurality of shells as the spatial property.

**[00121]** FIG. 10 is a block diagram of an apparatus for combining spatial property information with 3D information relating to an embodiment of the present disclosure. In the following description, descriptions overlapping with those of FIGS. 1 to 9 will be omitted.

**[00122]** As shown in FIG. 10, an apparatus 1000 may include a communication unit 1010, a processor 1020, and a database (DB) 1030. Only components related to the embodiment are illustrated in the apparatus 1000 of FIG. 10. Accordingly, it may be understood by those skilled in the art that other general-purpose components may be further included in addition to the components illustrated in FIG. 10.

**[00123]** The communication unit 1010 may include one or more components for performing wired/wireless communication with an external server or an external apparatus. For example, the communication unit 1010 may include a short-range communication unit (not shown), a mobile communication unit (not shown), and a broadcast receiving unit (not shown). In an embodiment, the communication unit 1010 may receive 3D information or a 3D object.

**[00124]** The DB 1030 is hardware for storing various types of data processed in the apparatus 1000, and may store a program for processes and controls by the processor 1020.

**[00125]** The DB 1030 may include random access memory (RAM) such as dynamic random-access memory (DRAM) or static random-access memory (SRAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), CD-ROM, Blu-ray or another optical disk storage, a hard disk drive (HDD), a solid-state drive (SSD), or a flash memory.

**[00126]** The processor 1020 controls overall operations of the apparatus 1000. For example, the processor 1020 may generally control an input unit (not shown), a display (not shown), the communication unit 1010, the DB 1030, and the like by executing programs stored in the DB 1030. The processor 1020 may control the operation of the apparatus 1000 by executing programs stored in the DB 1030.

**[00127]** The processor 1020 may control at least some of operations of the apparatus for combining spatial property information with 3D information, which are described with reference to FIGS. 1 to 9.

**[00128]** The processor 1020 may be implemented by using at least one of an application specific integrated circuit (ASIC), a digital signal processor (DSP), a digital signal processing device (DSPD), a programmable logic device (PLD), a field programmable gate array (FPGA), a controller, a micro-controller, a microprocessor, and an electric unit for performing other functions.

**[00129]** In an embodiment, the apparatus 1000 may be a server. The server may be implemented as a computer device or a plurality of computer devices that communicate via a network to provide commands, codes, files, content, services, and the like. The server may receive data necessary to combine spatial property information with 3D

information, and combine the spatial property information with the 3D information on the basis of the received data.

**[00130]** Meanwhile, the embodiments according to the present disclosure may be implemented in the form of a computer program that can be executed through various components on a computer, and such a computer program may be recorded on a computer-readable medium. Here, the medium may include hardware devices specially configured to store and execute program instructions, including magnetic media such as a hard disk, a floppy disk, and a magnetic tape, optical media such as a compact disc read-only memory (CD-ROM) and a digital versatile disk (DVD), magneto-optical media such as a floptical disk, and solid state drives such as a read-only memory (ROM), a random access memory (RAM), and a flash memory.

**[00131]** Meanwhile, the computer program may be a program specially designed and configured for the present disclosure or a program known and usable to those skilled in the computer software field. Examples of the computer program include machine language codes generated by a compiler as well as high-level language codes that are executable by a computer using an interpreter or the like.

**[00132]** According to an embodiment, a method according to various embodiments of the present disclosure may be included and provided in a computer program product. The computer program product may be traded as a product between a seller and a buyer. The computer program product may be distributed in the form of a machine-readable storage medium (e.g., compact disc read only memory (CD-ROM)), or be distributed (e.g., downloaded or uploaded) online via an application store (e.g., PlayStore™), or between two user devices (e.g., smart phones) directly. If distributed online, at least part of the computer program product may be temporarily generated or at least temporarily stored in the machine-readable storage medium, such as memory of the manufacturer's server, a server of the application store, or a relay server.

**[00133]** Operations of all methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The present disclosure is not limited to the described order of the operations. The use of any and all examples, or exemplary terms provided herein, is intended merely to better illuminate the present disclosure and does not pose a limitation on the scope of the

present disclosure unless otherwise claimed. Also, numerous modifications and adaptations will be readily apparent to one of ordinary skill in the art without departing from the spirit and scope of the present disclosure.

**[00134]** Therefore, it should be noted that the spirit of the present disclosure is not limited to the embodiments described above, and not only the claims to be described below, but also all ranges equivalent to or equivalently changed from the claims fall within the scope of the spirit of the present disclosure.

**[00135]** According to the above-described technical solution of the present disclosure, it is possible to provide a method and apparatus for maximizing the utilization of 3D information relative to resources, thereby enabling easy processing of 3D information in a popular environment.

**[00136]** The effects according to embodiments are not limited to the above-mentioned effects, and other effects not mentioned may be clearly understood by those skilled in the art from the description of the present disclosure.

**[00137]** It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

**[00138]** While one or more embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope as defined by the following claims.

## WHAT IS CLAIMED IS:

1. A method of combining spatial property information with three-dimensional (3D) information, the method comprising:

5        setting an occupied region in a grid region, which is a set of a plurality of shells, by determining shells occupied by a 3D object in the grid region;  
         generating a plurality of semantic regions in the grid region by assigning one or more spatial properties to each of the plurality of shells on the basis of the occupied region; and  
10        generating a spatial property map on the basis of the plurality of semantic regions.

2. The method of claim 1, wherein  
         each of the plurality of shells has a unique shell index, and  
         each of the plurality of semantic regions has one of the shell indices of the shells  
15        included in the semantic region as a unique number thereof.

3. The method of claim 2, wherein the generating of the plurality of semantic regions includes generating the plurality of semantic regions by assigning the spatial property including the shell index of an adjacent shell to each of the plurality of shells.

20        4. The method of claim 1, wherein  
         the setting of the occupied region further includes:  
         obtaining an outer boundary of the 3D object; and  
         setting a set of the shells including a closed region of the outer boundary among  
25        the one or more shells as the occupied region.

5. The method of claim 1, wherein  
         the setting of the occupied region further includes setting one or more unoccupied regions in the grid region by determining the shell region in which the 3D object does not  
30        occupy, and

the generating of the plurality of semantic regions further includes generating the plurality of semantic regions on the basis of the occupied region and the unoccupied regions.

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6. The method of claim 1, wherein  
the generating of the plurality of semantic regions includes:  
determining a weight on the basis of a characteristic of the 3D object; and  
generating the plurality of semantic regions by assigning the spatial property  
including the weight to each of the plurality of shells.

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7. The method of claim 1, wherein the generating of the plurality of semantic regions further includes assigning a weight to a link, which is a connection relationship between adjacent shells, on the basis of the spatial property, for the plurality of shells in the grid region.

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8. The method of claim 1, wherein the plurality of semantic regions include a spread region that is a predetermined region adjacent to the occupied region.

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9. The method of claim 8, wherein  
the generating of the plurality of semantic regions further includes:  
classifying a movable region and a non-movable region on the basis of a  
characteristic of the 3D object;  
determining a weight such that a shell belonging to the movable region has a  
higher movement weight than a shell belonging to the non-movable region; and  
generating the plurality of semantic regions on the basis of the weight.

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10. The method of claim 9, wherein the determining of the weight further includes determining the weight such that the shell belonging to the spread region has a higher movement weight than the shell that does not belong to the spread region.

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11. The method of claim 1, wherein the spatial property map is obtained by matching the grid region and the 3D object by assigning information about the 3D object to each of the plurality of shells as the spatial property.

5           12. An apparatus for combining spatial property information and three-dimensional (3D) information, the apparatus comprising:

          a memory in which one or more programs are stored; and

          a processor configured to perform an operation by executing the one or more programs,

10           wherein the processor is further configured to:

          set an occupied region in a grid region, which is a set of a plurality of shells, by determining shells occupied by a 3D object in the grid region;

          generate a plurality of semantic regions in the grid region by assigning one or more spatial properties to each of the plurality of shells on the basis of the occupied region; and

15           generate a spatial property map on the basis of the plurality of semantic regions.

20           13. A computer-readable recording medium having recorded thereon a program for executing the method of claim 1 in a computer.