

DESCRIPTION

Invention Title: METHOD AND COMPUTER PROGRAM PRODUCT FOR INDICATING RISK DEGREE IN THREE-DIMENSIONAL MODELING SPACE OF CONSTRUCTION SITE

Technical Field

[1] The present disclosure provides a method and computer program product for indicating a risk degree in a 3-dimensional modeling space of a construction site.

Background Art

[2] In the related art, for safety management of a construction site, a person in charge inspects a site and determines a risk degree of the construction site, based on professional experience, and thus the risk degree is determined subjectively and a risk degree to which a construction progress status of the construction site is applied may not be calculated.

[3] Alternatively, in the related art, for safety education of the construction site, education of well-informing a risk degree is conducted on the basis of verbal explanation of a site supervisor and 2-dimensional site information, such as a computer-aided design (CAD) drawing, before starting a work, but effectiveness of the education is low for daily workers or foreign workers who do not have specialized knowledge.

[4] Accordingly, there is a need for a method of objectively calculating a risk degree that reflects a construction progress status of a site and intuitively delivering the calculated risk degree to workers.

Disclosure

Technical Problem

[5] Provided are a method and computer program for indicating a risk degree in a 3-dimensional modeling space of a construction site. 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 of the present disclosure.

Technical Solution

[6] According to an aspect of the present disclosure, a method of indicating a risk degree in a 3-dimensional modeling space of a construction site, includes: predicting a disaster type by inputting, to a first network, first data including information about a work

type, information about a work site, or information about a work time; calculating a total risk point by inputting the first data and the disaster type to a second network; and visually displaying the total risk point in the 3-dimensional modeling space.

[7] The visually displaying of the total risk point may include displaying a color based on the total risk point in an object within a first space lattice corresponding to the first data in the 3-dimensional modeling space.

[8] The 3-dimensional modeling space may include at least one space lattice, and the visually displaying of the total risk point may include displaying a color based on the total risk point in an object within a first space lattice corresponding to the first data and a color based on a total risk point of at least one object within a second space lattice positioned on a lower floor of the first space lattice.

[9] The information about the work type may include information about a type of a work taken on by a person performing the work and information about a type of a work performed by the person performing the work, the information about the work site may include information about a floor number where the work is performed, and the information about the work time may include information about a date, a day of the week, or a time when the work is performed.

[10] The first network may correspond to a classification learning machine that predicts one disaster type from among a pre-set plurality of disaster types by receiving the first data as an input, and the second network may correspond to a deep neural network that calculates the total risk point by receiving the first data and the disaster type as inputs.

[11] According to another aspect of the present disclosure, an apparatus for indicating a risk degree in a 3-dimensional modeling space of a construction site, includes: a memory storing at least one program; and at least one processor configured to execute the at least one program to indicate the risk degree, wherein the at least one processor is configured to predict a disaster type by inputting, to a first network, first data including information about a work type, information about a work site, or information about a work time, calculate a total risk point by inputting the first data and the disaster type to a second network, and visually display the total risk point in the 3-dimensional modeling space.

[12] According to another aspect of the present disclosure, a computer-readable recording medium has recorded thereon a program for causing a computer to execute the method above.

Advantageous Effects

[13] According to the Technical Solution of the present disclosure described above, an objective risk degree that reflects a construction progress status of a site can be calculated.

[14] Also, according to the Technical Solution of the present disclosure, information about a risk degree may be intuitively delivered to workers in a construction site by visually representing a calculated risk degree in a 3-dimensional modeling space of the construction site.

Description of Drawings

[15] FIG. 1 is a diagram for describing operations performed by an apparatus for indicating a risk degree in a 3-dimensional modeling space, according to an embodiment.

[16] FIG. 2 is a diagram schematically showing a method of predicting a disaster type from first data by using a first network, according to an embodiment.

[17] FIG. 3 is a diagram showing an example of training data used to train a first network, according to an embodiment.

[18] FIG. 4 is a diagram briefly showing training data used to train a first network, according to an embodiment.

[19] FIG. 5 is a diagram showing examples of a disaster type, according to an embodiment.

[20] FIG. 6 is a diagram schematically showing a method of calculating a total risk point by using a second network, according to an embodiment.

[21] FIG. 7 is a diagram showing an example of a second network according to an embodiment.

[22] FIG. 8 is a diagram showing examples of pre-set risk points according to an embodiment.

[23] FIG. 9 is a diagram showing an example of training data used to train a second network, according to an embodiment.

[24] FIG. 10 is a diagram showing an example of a method of visually displaying a total risk point in a 3-dimensional modeling space, according to an embodiment.

[25] FIG. 11 is a diagram showing an example of a method of visually displaying a total risk point in a 3-dimensional modeling space, according to an embodiment.

[26] FIG. 12 is a flowchart of a method of indicating a risk degree in a 3-dimensional modeling space, according to an embodiment.

[27] FIG. 13 is a block diagram of an apparatus for displaying a risk degree of a 3-dimensional modeling space, according to an embodiment.

Best Mode

[28] Provided is a method of indicating a risk degree in a 3-dimensional modeling space of a construction site.

[29] The method includes predicting a disaster type by inputting, to a first network, first data including information about a work type, information about a work site, or information about a work time, calculating a total risk point by inputting the first data and the disaster type to a second network, and visually displaying the total risk point in the 3-dimensional modeling space.

Mode for Invention

[30] Advantages and features of the present disclosure and methods of accomplishing the same may be understood more readily by reference to the following detailed description of the embodiments and the accompanying drawings. However, it should be understood that the present disclosure is not limited to the embodiments presented below, but may be implemented in various different forms, and include all transformations, equivalents, and substitutes included in the spirit and scope of the present disclosure. The embodiments presented below are provided to complete the present disclosure and to fully inform one of ordinary skill in the art of the scope of the present disclosure. In the description of the present disclosure, certain detailed explanations of related art are omitted when it is deemed that they may unnecessarily obscure the essence of the present disclosure.

[31] Also, the terms used in the present specification are only used to describe specific embodiments, and are not intended to limit the present disclosure. An expression used in the singular encompasses the expression in the plural, unless it has a clearly different

meaning in the context. In the present specification, it is to be understood that terms such as "including" or "having", etc., are intended to indicate the existence of the features, numbers, steps, actions, components, parts, or combinations thereof disclosed in the specification, and are not intended to preclude the possibility that one or more other features, numbers, steps, actions, components, parts, or combinations thereof may exist or may be added.

[32] Some embodiments of the present 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. Also, 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 general techniques for electronic environment setting, signal processing, and/or data processing. Terms such as "mechanism", "element", "means", and "configuration" may be used widely and are not limited as mechanical and physical configurations.

[33] In addition, a connection line or a connection member between components shown in 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.

[34] Hereinafter, the present disclosure will be described in detail with reference to accompanying drawings.

[35] FIG. 1 is a diagram for describing operations performed by an apparatus for indicating a risk degree in a 3-dimensional modeling space, according to an embodiment.

[36] An apparatus 100 for displaying a risk degree of a 3-dimensional modeling space, according to an embodiment, may calculate a total risk point indicating a risk degree at a specific work site of the 3-dimensional modeling space by receiving first data. Also, the

calculated total risk point may be visually displayed in the 3-dimensional modeling space of a construction site.

[37] The 3-dimensional modeling space is obtained by modeling the construction site in a 3-dimensional space, based on digital twin. The digital twin denotes expressing physical assets, systems, or processes in software. The 3-dimensional modeling space may include object information, such as structures, materials, facilities, and construction machineries in the construction site, and work type information at the construction site. For example, the object information may be generated through weight lightening of an object polygon in the construction site.

[38] According to an embodiment, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may generate the 3-dimensional modeling space by matching coordinates of the real world and coordinates of a 3-dimensional space and reflecting data of the construction site on a virtual 3-dimensional space. The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may precisely reflect a specific actual location of the construction site on the virtual 3-dimensional space by applying a 3-dimensional lattice precise address.

[39] The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may display, in the 3-dimensional modeling space, a total risk point indicating a risk degree of a specific work type performed at a specific work site of the 3-dimensional modeling space.

[40] For example, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space of FIG. 1 may correspond to an apparatus for displaying a risk degree of a specific work type performed at a specific work site of a 3-dimensional modeling space, based on an artificial neural network. The artificial neural network denotes a general model that has problem solving capability as artificial neurons that form a network through a combination of synapses change combination strength of the synapses through learning.

[41] The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may be realized as various types of devices, such as a personal computer (PC), a server device, a mobile device, and an embedded device, and specific examples thereof may include a smartphone, a tablet device, an augmented reality (AR) device, an Internet

of things (IoT) device, an autonomous vehicle, and a robotics, which display a risk degree of a specific work type performed at a specific work site of a 3-dimensional modeling space by using an artificial neural network, but are not limited thereto.

[42] In addition, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may correspond to a dedicated hardware (HW) accelerator mounted on such a device. Alternatively, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may be an HW accelerator, such as a neural processing unit (NPU), a tensor processing unit (TPU), or a neural engine, which is a dedicated module for driving an artificial neural network, but is not limited thereto.

[43] Referring to FIG. 1, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may receive the first data as an input. The first data may include information about a work type to be performed at a construction site, information about a work site, or information about a work time, but is not limited thereto.

[44] For example, the first data may be received from an external device through a communication unit included in the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space. Alternatively, the first data may be input from a user through a user interface of the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space.

[45] The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output the total risk point corresponding to the first data, based on the first data received as an input. For example, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output a total risk point of a specific work type to be performed at a specific work time at a specific work site.

[46] The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output, based on the first data, at least one total risk point from among a total risk point ϕ_T according to a temporal characteristic, a total risk point ϕ_E according to an environmental characteristic, a total risk point ϕ_W according to a work-type characteristic, a total risk point ϕ_S according to a work site characteristic, and a total risk point ϕ_A according to an accident-type characteristic. Also, the apparatus 100 for

displaying the risk degree of the 3-dimensional modeling space may determine a final total risk point by aggregating the above five total risk points.

[47] In detail, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output the total risk point ϕ_T according to the temporal characteristic, based on the first data. The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may calculate the total risk point ϕ_T according to the temporal characteristic, based on at least one element from among a "month", a "day of the week (week-day)", and "time".

[48] For example, the total risk point ϕ_T according to the temporal characteristic may be calculated according to Equation 1. In Equation 1 below, α_t denotes a coefficient of a "month" risk score, β_t denotes a coefficient of a "week-day" risk score, γ_t denotes a coefficient of a "time" risk score, R_m denotes the "month" risk score, R_d denotes the "week-day" risk score, and R_t denotes the "time" risk score.

[49] [Equation 1]

$$\phi_T = \alpha_t R_m + \beta_t R_d + \gamma_t R_t$$

[50] where $\alpha_t + \beta_t + \gamma_t = 1, 0 \leq R \leq 100$

[51]

[52] The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output the total risk point ϕ_E according to the environmental characteristic, based on the first data. The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may calculate the total risk point ϕ_E according to the environmental characteristic, based on at least one element from among a "temperature", a "wind speed", and a "rainfall".

[53] For example, the total risk point ϕ_E according to the environmental characteristic may be calculated according to Equation 2. In Equation 2 below, α_e denotes a coefficient of a "temperature" risk score, β_e denotes a coefficient of a "wind

speed" risk score, γ_e denotes a coefficient of a "rainfall" risk score, R_c denotes the "temperature" risk score, R_v denotes the "wind speed" risk score, and R_r denotes the "rainfall" risk score.

[54] [Equation 2]

$$\phi_E = \alpha_e R_c + \beta_e R_v + \gamma_e R_r$$

[55] where $\alpha_e + \beta_e + \gamma_e = 1, 0 \leq R \leq 100$

[56]

[57] The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output the total risk point ϕ_W according to the work-type characteristic, based on the first data. The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may calculate the total risk point ϕ_W according to the work-type characteristic, based on at least one element from among a "work type", a "work process", and a "temporary work".

[58] For example, the total risk point ϕ_W according to the work-type characteristic may be calculated according to Equation 3. In Equation 3 below, α_w denotes a coefficient of a "work type" risk score, β_w denotes a coefficient of a "work process" risk score, γ_w denotes a coefficient of a "temporary work" risk score, R_w denotes the "work type" risk score, R_p denotes the "work process" risk score, and R_{tmp} denotes the "temporary work" risk score.

[59] [Equation 3]

$$\phi_w = \alpha_w R_w + \beta_w R_p + \gamma_w R_{tmp}$$

[60] where $\alpha_w + \beta_w + \gamma_w = 1, 0 \leq R \leq 100$

[61]

[62] The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output the total risk point ϕ_S according to the work site characteristic, based on the first data. The apparatus 100 for displaying the risk degree of the 3-dimensional

modeling space may calculate the total risk point ϕ_s according to the work site characteristic, based on at least one element from among a "height (floor)" and an "opening/end".

[63] For example, the total risk point ϕ_s according to the work site characteristic may be calculated according to Equation 4. In Equation 4 below, α_s denotes a coefficient of a "height (floor)" risk score, β_s denotes a coefficient of a "opening/end" risk score, R_h denotes the "height (floor)" risk score, and R_o denotes the "opening/end" risk score.

[64] [Equation 4]

$$\phi_s = \alpha_s R_h + \beta_s R_o$$

[65] where $\alpha_s + \beta_s = 1, 0 \leq R \leq 100$

[66]

[67] The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output the total risk point ϕ_A according to the accident-type characteristic, based on the first data. The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may calculate the total risk point ϕ_A according to the accident-type characteristic, based on at least one element from among "fall off", "fall down", "hit", "struck by", "collapse", "jamming", "mutilation/cut/puncture", "electric shock", "explosion/blast", "fire", "fall beneath/overturn", "contact on abnormal temperature", "imbalance/immoderate motion", "exposure to chemical materials", "occupational diseases", and "others (ETC)".

[68] For example, the total risk point ϕ_A according to the accident-type characteristic may be calculated according to Equation 5. In Equation 5 below, α_1 denotes a coefficient of a "fall off" risk score, α_2 denotes a coefficient of a "fall down" risk score, α_3 denotes a coefficient of a "hit" risk score, α_4 denotes a coefficient of a "struck by" risk score, α_5 denotes a coefficient of a "collapse" risk score, α_6 denotes a coefficient

of a "jamming" risk score, α_7 denotes a coefficient of a "mutilation/cut/puncture" risk score, α_8 denotes a coefficient of an "electric shock" risk score, α_9 denotes a coefficient of an "explosion/blast" risk score, α_{10} denotes a coefficient of a "fire" risk score, α_{11} denotes a coefficient of a "fall beneath/overturn" risk score, α_{12} denotes a coefficient of a "contact on abnormal temperature" risk score, α_{13} denotes a coefficient of an "imbalance/immoderate motion" risk score, α_{14} denotes a coefficient of an "exposure to chemical materials" risk score, α_{15} denotes a coefficient of a "occupational diseases" risk score, and α_{16} denotes a coefficient of an "ETC" risk score.

[69] Also, R_{FOF} denotes the "fall off" risk score, R_{FDN} denotes the "fall down" risk score, R_{HIT} denotes the "hit" risk score, R_{STR} denotes the "struck by" risk score, R_{CLS} denotes the "collapse" risk score, R_{JAM} denotes the "jamming" risk score, R_{MCP} denotes the "mutilation/cut/puncture" risk score, R_{ESH} denotes the "electric shock" risk score, R_{EXP} denotes the "explosion/blast" risk score, R_{FIR} denotes the "fire" risk score, R_{FBO} denotes the "fall beneath/overturn" risk score, R_{CAT} denotes the "contact on abnormal temperature" risk score, R_{JIM} denotes the "imbalance/immoderate motion" risk score, R_{ECM} denotes the "exposure to chemical materials" risk score, R_{OCD} denotes the "occupational diseases" risk score, and R_{ETC} denotes the "ETC" risk score.

[70] [Equation 5]

$$[71] \quad \Psi_A = \alpha_1 R_{FOF} + \alpha_2 R_{FDN} + \alpha_3 R_{HIT} + \alpha_4 R_{STR} + \alpha_5 R_{CLS} + \alpha_6 R_{JAM} + \alpha_7 R_{MCP} + \alpha_8 R_{ESH} + \alpha_9 R_{EXP} + \alpha_{10} R_{FIR} + \alpha_{11} R_{FBO} + \alpha_{12} R_{CAT} + \alpha_{13} R_{JIM} + \alpha_{14} R_{ECM} + \alpha_{15} R_{OCD} + \alpha_{16} R_{ETC}$$

$$[72] \quad \text{where } \sum_{i=1}^{16} \alpha_i = 1, 0 \leq R \leq 100$$

[73]

[74] Referring to FIG. 1, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space, according to an embodiment, may predict a disaster type

from the first data, by using a first network 110. A method of predicting the disaster type from the first data by using the first network 110 will be described below with reference to FIGS. 2 to 5.

[75] Also, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space, according to an embodiment, may calculate the total risk point from the first data and the disaster type predicted from the first network 110, by using a second network 120. A method of calculating the total risk point from the first data and the disaster type, by using the second network 120, will be described below with reference to FIGS. 6 to 9.

[76] Finally, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space, according to an embodiment, may visually display the calculated total risk point in the 3-dimensional modeling space.

[77] FIG. 2 is a diagram schematically showing a method of predicting a disaster type from first data by using a first network, according to an embodiment.

[78] According to an embodiment, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output, by using the first network, the disaster type from the first data including information about a work type to be performed at a construction site, information about a work site, or information about a work time.

[79] The information about the work type may include information about a type of a work taken on by a person performing the work and information about a type of a work performed by the person performing the work. The information about the work site may include information about a floor number where the work is performed or information about whether the work is performed outside or inside a structure. Also, the information about the work time may include information about a month, a day of the week, or a time when the work is performed.

[80] For example, the first network may correspond to a classification learning machine and the first network may correspond to a neural network on which supervised learning is performed to predict a categorical variable. In other words, the first network may be configured to predict one of a pre-defined plurality of class labels. The pre-defined plurality of class labels may correspond to disaster types.

[81] Supervised learning is a learning method using training data in which a feature is pre-determined, and the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may configure training data by analyzing disaster accidents obtained from a collection of disaster cases or the like, based on a certain classification system. The training data may include data including information about a work type, information about a work site where a disaster has occurred, or information about a work time when a disaster has occurred, and a disaster type (corresponds to a class label) corresponding to the data.

[82] FIG. 3 is a diagram showing an example of training data used to train a first network, according to an embodiment.

[83] Referring to FIG. 3, training data 300 used to train the first network, according to an embodiment may include information 310 about a work type, and the information 310 about a work type may include information 311 about a type of a work taken on by a disaster victim and information 312 about a work type that caused a disaster.

[84] Also, the training data 300 used to train the first network, according to an embodiment, may include information 320 about a work site where a disaster has occurred, and the information 320 about a work site where a disaster has occurred may include information 321 about a floor number where a work is performed or information 322 about whether a work is performed inside or outside a structure.

[85] Also, the training data 300 used to train the first network, according to an embodiment, may include information 330 about a work time when a disaster has occurred, and the information 330 about a work time when a disaster has occurred may include information 331 about a month when a work is performed, information 332 about a day of the week, and information 333 about a time.

[86] Also, the training data 300 used to train the first network, according to an embodiment, may include information 340 about a disaster type that has occurred. The information 340 about a disaster type may correspond to information corresponding to data including the information 310 about a work type, the information 320 about a work site where a disaster has occurred, or the information 330 about a work time when a disaster has occurred. The information 340 about a disaster type may correspond to information about a disaster location or a cause of death or injury.

[87] Meanwhile, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may simply express the training data 300 used to train the first network in codes, and train the first network by using simplified training data.

[88] FIG. 4 is a diagram briefly showing training data used to train a first network, according to an embodiment.

[89] Referring to FIG. 4, information about a work time when a disaster has occurred may be simplified to indicate only information about a time when a disaster occurred. Also, information about a work type may be simply represented by coding information about a type of a work taken on by a disaster victim (disaster victim type) and information about a work type that caused a disaster (disaster cause type). Codes of various types of works taken on by disaster victims and codes of various types of works that caused disasters may be pre-set. Also, information about a disaster type may use an abbreviation for simply representing various disaster types as shown FIG. 5 that will be described below.

[90] FIG. 5 is a diagram showing examples of a disaster type, according to an embodiment.

[91] FIG. 5 illustrates various examples of disaster types predicted in response to first data, when the first data including information about a work type, information about a work site, or information about a work time is input to a first network. In other words, FIG. 5 illustrates a pre-defined plurality of class labels.

[92] Referring to FIG. 5, disaster types may include fall off (FOF), fall down (FDN), hit (HIT), struck (STR), collapse (CLS), jamming (JAM), mutilation/cut/puncture (MCP), and the like.

[93] The first network may be configured to output a disaster type predicted in response to the input first data. For example, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output a result that fall off (FOF) is predicted as a disaster type when first data including information indicating that a temporary work will be performed outside a structure of 10th floor above ground at 5 PM on May 12, 2021 (Wednesday) is input by using the first network.

[94] FIG. 6 is a diagram schematically showing a method of calculating a total risk point by using a second network, according to an embodiment.

[95] According to an embodiment, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output a total risk point from first data and a disaster type predicted from the first data, by using the second network. As described above, the first data may include information about a work type, information about a work site, or information about a work time.

[96] For example, the second network may correspond to a deep neural network (DNN) or n-layers neural networks, but is not limited thereto. For example, the second network may correspond to a recurrent neural network (RNN), a long short-term memory network (LSTM), a bidirectional recurrent deep neural network (BRDNN), deep belief networks, or restricted Boltzmann machines.

[97] FIG. 7 is a diagram showing an example of a second network according to an embodiment.

[98] Referring to FIG. 7, the second network may correspond to a deep neural network including an input layer, at least one hidden layer, and an output layer. Only one hidden layer is displayed in FIG. 7, but this is only an example, and the second network may include a plurality of hidden layers.

[99] First data including information about a work type, information about a work site, or information about a work time, and a disaster type output from a first network, based on the first data, may be input to the input layer. Operations may be performed in the hidden layer, based on the input first data and disaster type, and the total risk point may be finally calculated in the output layer.

[100] For example, the total risk point may be calculated in the form of a score or may be classified as a specific risk degree stage according to a score value. Referring to FIG. 7, risk degree stages are divided into 5 stages according to a range of score values of the total risk point, but a method of indicating a total risk point is not limited thereto.

[101] Each layer included in the second network may include a plurality of artificial nodes also known as neurons, processing elements (PEs), units, or similar terms. For example, as shown in FIG. 7, the input layer may include p nodes and the hidden layer may include m nodes. However, this is only an example and each layer included in the second network may include any number of nodes.

[102] The nodes included in each layer included in the second network may be connected to each other to exchange data. For example, one node may receive data from other nodes for operation and output an operation result to still other nodes.

[103] When the second network is implemented in a deep neural network architecture, the second network may include many layers capable of processing valid information. Meanwhile, the second network may include layers of various structures that are different from that shown in FIG. 7.

[104] For example, when first data including information indicating that a temporary work will be performed outside a structure of 10th floor above ground at 5 PM on May 12, 2021 (Wednesday) and information indicating that fall off (FOF) is predicted as a disaster type in response to the first data are input, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may output a total risk point corresponding thereto by using the second network.

[105] Meanwhile, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space, according to an embodiment, may train the second network to output a total risk point by using information including a pre-set risk point for each work process, a pre-set risk point for each floor number, a pre-set risk point for each month, a pre-set risk point for each day of the week, or a pre-set risk point for each time.

[106] FIG. 8 is a diagram showing examples of pre-set risk points according to an embodiment.

[107] FIG. 8 illustrates examples of a pre-set risk point for each work type, a pre-set risk point for each floor number, a pre-set risk point for each month, a pre-set risk point for each day of the week, a pre-set risk point for each time, and a pre-set risk point for each disaster type, which are stored in the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space, but each risk point is not limited to that shown in FIG. 8. Also, various types of risk points required to calculate a total risk point may be further stored in addition to the risk points shown in FIG. 8.

[108] For example, the risk point for each work type, the risk point for each floor number, the risk point for each month, the risk point for each day of the week, the risk point for each time, and the risk point for each disaster type may be calculated based on statistics.

[109] A second network may perform operations as the pre-set risk point for each work type is applied to information about a work type included in first data, perform operations as the pre-set risk point for each floor number is applied to information about a work site included in the first data, and perform operations as the pre-set risk point for each month, the pre-set risk point for each day of the week, or the pre-set risk point for each time is applied to information about a work time included in the first data. Also, the risk point for each disaster type may be applied to a disaster type predicted from a first network for the second network to perform operations.

[110] FIG. 9 is a diagram showing an example of training data used to train a second network, according to an embodiment.

[111] Referring to FIG. 9, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may configure the training data by analyzing disaster accidents obtained from a collection of disaster cases or the like, based on a certain classification system. The training data used to train the second network may include, as described above with reference to FIG. 4, information about a work type (disaster victim type and disaster cause type), information about a work site where a disaster has occurred (floor number and inside/outside), information about a work time when a disaster has occurred (month, day of the week and time), or information about a disaster type that has occurred.

[112] According to an embodiment, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may calculate a work type risk point by applying a risk point for each work type, which has been described above with reference to FIG. 8, to the information about a work type (disaster victim type and disaster cause type). Also, a floor number risk point may be calculated by applying a risk point for each floor number, which has been described above with reference to FIG. 8, to the information about a work site (floor number and inside/outside). Also, a month risk point, a day of the week risk point, and a time risk point may be calculated by respectively applying a risk point for each month, a risk point for each day of the week, and a risk point for each time, which have been described above with reference to FIG. 8, to the information about a work time when a disaster has occurred. Also, a disaster type risk point may be calculated by applying a risk point for each disaster type, which has been described above with reference to FIG.

8, to the information about a disaster type that has occurred. Accordingly, the training data used to train the second network may further include information about each risk point described above.

[113] The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may train the second network by using the training data such that the second network outputs a total risk point in response to input first data and disaster type.

[114] FIG. 10 is a diagram showing an example of a method of visually displaying a total risk point in a 3-dimensional modeling space, according to an embodiment.

[115] According to an embodiment, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may display a color based on a total risk point, on an object corresponding to first data in the 3-dimensional modeling space.

[116] For example, as described above with reference to FIG. 7, the total risk point may be calculated in the form of a score or may be classified as a specific risk degree stage according to a score value. The specific risk degree stage classified according to the score value may correspond to a specific color. For example, the risk degree stage may be divided into 5 stages according to a range of score values of the total risk point, and there may be 5 colors respectively corresponding to the risk degree stages, but this is only an example, and the number of risk degree stages according to the score value of the total risk point and colors corresponding to the risk degree stages may vary.

[117] Referring to FIG. 10, the 3-dimensional modeling space may include at least one space lattice, and the space lattice may correspond to a specific actual location of a construction site. The apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may visually display a total risk point output on an object in any one space lattice corresponding to first data including information about a work type, information about a work site, or information about a work time. For example, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may display a color based on a total risk point output from a second network, on the object in any one space lattice corresponding to the first data. For example, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may display a color corresponding to a risk degree stage according to a score value of the total risk point. For example, in FIG. 10, hatchings indicate colors of different risk degree stages.

[118] FIG. 11 is a diagram showing an example of a method of visually displaying a total risk point in a 3-dimensional modeling space, according to an embodiment.

[119] As in FIG. 10, FIG. 11 illustrates an example in which the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space displays a color based on a total risk point, on an object corresponding to first data in the 3-dimensional modeling space.

[120] Referring to FIG. 11, a space lattice corresponding to first data including information about a work type, information about a work site, or information about a work time may further include at least one space lattice located there below.

[121] In this case, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may visually reflect and display all of a total risk point corresponding to the first data on an object in a space lattice corresponding to the first data, and total risk points corresponding to at least one object in a second space lattice positioned on a lower floor of the space lattice corresponding to the first data.

[122] In other words, the apparatus 100 for displaying the risk degree of the 3-dimensional modeling space may visually display total risk points that overlap from a space lattice positioned on a lower floor to a space lattice positioned on an upper floor.

[123] FIG. 12 is a flowchart of a method of indicating a risk degree in a 3-dimensional modeling space, according to an embodiment.

[124] Referring to FIG. 12, in operation 1210, an apparatus for displaying a risk degree of a 3-dimensional modeling space may predict a disaster type by inputting, to a first network, first data including information about a work type, information about a work site, or information about a work time.

[125] According to an embodiment, the information about the work type may include information about a type of a work taken on by a person performing the work and information about a type of a work performed by the person performing the work. The information about the work site may include information about a floor number where the work is performed or information about whether the work is performed outside or inside a structure. Also, the information about the work time may include information about a month, a day of the week, or a time when the work is performed.

[126] According to an embodiment, the first network may correspond to a classification learning machine that predicts one disaster type from among a pre-set plurality of disaster types by receiving the first data as an input. The first network may correspond to a neural network on which supervised learning is performed to predict a categorical variable. Supervised learning may be performed on the first network by using training data including data including the information about a work type, the information about a work site where a disaster has occurred, or the information about a work time when a disaster has occurred, and a disaster type (corresponds to a class label) corresponding to the data.

[127] In operation 1220, the apparatus for displaying the risk degree of the 3-dimensional modeling space may calculate a total risk point by inputting the first data and the disaster type to a second network.

[128] According to an embodiment, the second network may correspond to a deep neural network for calculating a total risk point by receiving, as inputs, the first data and the disaster type predicted by the first network. The first data including the information about a work type, the information about a work site, or the information about a work time, and the disaster type output from the first network, based on the first data, may be input to an input layer included in the second network. Operations may be performed in a hidden layer, based on the input first data and disaster type, and the total risk point may be finally calculated in an output layer.

[129] The apparatus for displaying the risk degree of the 3-dimensional modeling space, according to an embodiment, may train the second network to output a total risk point by using information including a pre-set risk point for each work process, a pre-set risk point for each floor number, a pre-set risk point for each month, a pre-set risk point for each day of the week, or a pre-set risk point for each time.

[130] In operation 1230, the apparatus for displaying the risk degree of the 3-dimensional modeling space may visually display the total risk point in the 3-dimensional modeling space.

[131] For example, the total risk point may be calculated in the form of a score or may be classified as a specific risk degree stage according to a score value. The specific risk degree stage may correspond to a specific color according to the score value.

[132] According to an embodiment, the apparatus for displaying the risk degree of the 3-dimensional modeling space may display a color based on the total risk point, on an object corresponding to the first data in the 3-dimensional modeling space.

[133] Also, according to an embodiment, the 3-dimensional modeling space may include at least one space lattice, and the color based on the total risk point may be displayed on the object corresponding to the first data in a first space lattice, and a color based on a total risk point of at least one object in a space lattice positioned below the first space lattice may be displayed.

[134] FIG. 13 is a block diagram of an apparatus for displaying a risk degree of a 3-dimensional modeling space, according to an embodiment.

[135] Referring to FIG. 13, an apparatus 1300 for displaying a risk degree of a 3-dimensional modeling space may include a communication unit 1310, a processor 1320, and a database (DB) 1330. Only components related to an embodiment are illustrated for the apparatus 1300 for displaying the risk degree of the 3-dimensional modeling space of FIG. 13. Accordingly, it would be obvious to one of ordinary skill in the art that general-purpose components other than the components shown in FIG. 13 may be further included.

[136] The communication unit 1310 may include one or more components enabling wired/wireless communication of the apparatus 1300 for displaying the risk degree of the 3-dimensional modeling space. For example, the communication unit 1310 may include a short-range wireless communication unit (not shown), a mobile communication unit (not shown), and a broadcast receiver (not shown).

[137] The DB 1330 is hardware storing various types of data processed by the apparatus 1300 for displaying the risk degree of the 3-dimensional modeling space, and may store programs for processing and control by the processor 1320.

[138] The DB 1330 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, hard disk drive (HDD), solid state drive (SSD), or flash memory. The processor 1320 controls all operations of the apparatus 1300 for displaying the risk degree of the 3-dimensional modeling space. For example,

the processor 1320 may execute programs stored in the DB 1330 to control an input unit (not shown), a display (not shown), the communication unit 130, and the DB 1330, in general. The processor 1320 may execute the programs stored in the DB 1330 to control operations of the apparatus 1300 for displaying the risk degree of the 3-dimensional modeling space.

[139] The processor 1320 may be realized 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 electric units for performing other functions.

[140] Various embodiments of the present disclosure may be implemented as software (for example, a program) including one or more instructions stored in a machine-readable storage medium. For example, a processor of the machine may invoke and execute at least one of the one or more instructions stored from the storage medium. Accordingly, the machine is enabled to operate to perform at least one function according to the at least one invoked instruction. The one or more instructions may include code generated by a compiler or code executable by an interpreter. A machine-readable storage medium may be provided in the form of a non-transitory storage medium. Here, the "non-transitory storage medium" only denotes a tangible device and does not contain a signal (for example, electromagnetic waves). This term does not distinguish a case where data is stored in the storage medium semi-permanently and a case where the data is stored in the storage medium temporarily.

[141] According to an embodiment, a method according to various embodiments of the present disclosure may be provided by being included in a computer program product. The computer program products are products that can be traded between sellers and buyers. The computer program product may be distributed in a form of machine-readable storage medium (for example, a compact disc read-only memory (CD-ROM)), or distributed through an application store (for example, Play Store™) or directly or online between two user devices (for example, download or upload). In the case of online distribution, at least a part of the computer program product may be at least temporarily

stored or temporarily generated in the machine-readable storage medium such as a server of a manufacturer, a server of an application store, or a memory of a relay server.

[142] Also, according to an embodiment, a method according to various embodiments of the present disclosure may be provided in the form of a web service through the Internet. For example, users may execute software stored in a cloud server by accessing the cloud server, and the software may include one or more instructions for implementing the method according to various embodiments of the present disclosure.

[143] Furthermore, in the specification, the term "unit" may be a hardware component such as a processor or circuit and/or a software component that is executed by a hardware component such as a processor.

[144] The scope of the present disclosure is defined by the appended claims rather than the detailed description, and all changes or modifications within the scope of the appended claims and their equivalents will be construed as being included in the scope of the present disclosure.

CLAIMS

1. A method of indicating a risk degree in a 3-dimensional modeling space of a construction site, the method comprising:

predicting a disaster type by inputting, to a first network, first data including information about a work type, information about a work site, or information about a work time;

calculating a total risk point by inputting the first data and the disaster type to a second network; and

visually displaying the total risk point in the 3-dimensional modeling space.

2. The method of claim 1, wherein the visually displaying of the total risk point comprises displaying a color based on the total risk point in an object within a first space lattice corresponding to the first data in the 3-dimensional modeling space.

3. The method of claim 1, wherein the 3-dimensional modeling space comprises at least one space lattice, and

the visually displaying of the total risk point comprises displaying a color based on the total risk point in an object within a first space lattice corresponding to the first data and a color based on a total risk point of at least one object within a second space lattice positioned on a lower floor of the first space lattice.

4. The method of claim 1, wherein the information about the work type comprises information about a type of a work taken on by a person performing the work and information about a type of a work performed by the person performing the work,

the information about the work site comprises information about a floor number where the work is performed or information about whether the work is performed outside or inside a structure, and

the information about the work time comprises information about a date, a day of the week, or a time when the work is performed.

5. The method of claim 1, wherein the first network corresponds to a classification learning machine that predicts one disaster type from among a pre-set plurality of disaster types by receiving the first data as an input, and

the second network corresponds to a deep neural network that calculates the total risk point by receiving the first data and the disaster type as inputs.

6. An apparatus for providing an interface in a vehicle, the apparatus comprising:

a memory storing at least one program; and

a processor configured to execute the at least one program to perform operations, wherein the processor is configured to:

7. A computer-readable recording medium having recorded thereon a program for causing a computer to execute the method of claim 1.