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*I HEREBY CERTIFY that under the provisions of the Patents Act, a patent has been granted in respect of an invention having the following particulars:*

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| **TITLE** | : | METHOD AND SYSTEM FOR RISK DETERMINATION IN A FOOD SUPPLY CHAIN |
| **APPLICATION NUMBER / PATENT NUMBER** | : | 10202109991Y |
| **DATE OF FILING** | : | 10 SEPTEMBER 2021 |
| **PRIORITY DATA** | : | 11 SEPTEMBER 2020 - PATENT APPLICATION NO. 10202008889X (SINGAPORE) |
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| **DATE OF GRANT** | : | 06 DECEMBER 2023 |

DATED THIS 06TH DAY OF DECEMBER 2023

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# METHOD AND SYSTEM FOR RISK DETERMINATION IN A FOOD SUPPLY CHAIN

The present application claims the filing date of Singapore patent application Nr. 10-2020-08889X as its priority date, which was filed with IPOS (Intellectual Property Office of Singapore) on 11 September 2020, and has the title of Food Security Exchange System. All relevant content and/or subject matter of the earlier priority application is hereby incorporated by reference wherever appropriate.

An example embodiment of the present invention generally relates to a method and system for determining and managing risks proactively in a food supply chain disruption

Currently, many disasters and threats have either a direct or an indirect impact on food supply which in turn impacts food security and resilience, such as macro-environmental events, socio-political upheavals as well as corporate risks. The macro-environmental events include climatic and weather changes, pandemics (such as Covid-19, bird flu, swine fever), natural disasters and calamities (such as typhoon, flood and drought) and climate change. The socio-political upheavals include geo-political tensions, political turmoil, policy decisions and work stoppages owing to strikes. The corporate risks include corporate bankruptcies, supplier in corporate trouble and scandals. However, the disasters and threats have not been effectively and efficiently dealt with so far for improving food security and resilience of food supply chain which is of great importance to the livelihoods of people and societies worldwide.

Therefore, there is a need to make the food supply chains to become robust and resilient, which leads to a requirement of providing an early warning system to the stakeholders in the food ecosystem and necessary guidance to plan for the disasters and threats by taking both strategic and operational steps to prevent and/or mitigate the impact of the disasters and threats to the food supply chain.

In order to solve the foregoing problem, an aspect of the present invention provides a method for determining and managing risks in the food supply chain. The method comprises receiving a preliminary set of data from a plurality of data source, where the preliminary set comprises trigger event data and non-trigger event data; identifying the trigger event data from the preliminary set of data by machine learning for natural language processing; obtaining weather forecast data from the preliminary set of data, where the weather forecast data comprise values of air temperature, humidity, wind speed, air pressure, air density, surface temperature or a combination of any of the weather forecast data; validating the trigger event data; identifying occurrence of natural disaster from the preliminary set of data; and monitoring growth of crops and plants at one or more physical farms. The method is characterized by comparing the identified trigger event data with a geospatial data, where the geospatial data is obtained for each of the identified trigger event data in real-time; comparing the identified trigger event data with the weather forecast data; calculating a risk value based on the comparison, where the risk value is calculated for each of the identified trigger event data in the food supply chain, where the risk value includes a positive score and a negative score; and determining risk in the food supply chain by calculating impact percentile of the calculated risk value, where the risk is determined when the calculated impact value is greater than a threshold value.

According to an example embodiment, determining risk in the food supply chain further comprises classifying, by a classifier, the identified trigger event data into one of high risk, intermediate risk and low risk based on the calculated risk value; and adding the calculated risk value for each of the classified trigger event data in the food supply chain to determine risk in the food supply chain.

According to an example embodiment, the trigger event data comprises one or more keywords related to pandemic, natural disaster, geo-political tension, and corporate bankruptcy.

According to an example embodiment, the method further comprises performing one or more actions based on the determined risk in the food supply chain, where the one or more actions include notifying a user when the calculated risk value is greater than the threshold value; determining a response plan based on the calculated risk value, where the response plan includes one or more of changing suppliers, and increasing or decreasing orders from the suppliers; and activating the response plan for each of the identified trigger event data by implementing machine learning algorithms.

According to an example embodiment, the method further comprises classifying the determined risk in the food supply chain into at least one of supply side risk and demand side risk.

According to an example embodiment, the threshold value is preset or dynamically set by a user.

According to an example embodiment, the preliminary set of data is obtained by integrating one or more of social media data, government data, news data, weather data, and company data.

According to an example embodiment, the positional information of the plurality of targets further comprises a plurality of concentric half circles arranged round the target to indicate distance from the plurality of targets.

According to an example embodiment, the method further comprises alerting at least one entity of the food supply chain based on the determined risk via Internet of Things (IoT) based sensors.

Another aspect of the present invention provides a system for determining risk in a food supply chain. The system comprises a processor; a memory; a risk determination module communicatively coupled to the processor, where the risk determination module is executed by the processor to receive a preliminary set of data from a plurality of data source, where the preliminary set comprises trigger event data and non-trigger event data; identify the trigger event data from the preliminary set of data by machine learning for natural language processing; obtain weather forecast data from the preliminary set of data, where the weather forecast data comprising values of air temperature, humidity, wind speed, air pressure, air density, and surface temperature. The system further comprises a natural language processing module communicatively coupled to the risk determination module to validate the trigger event data. The system further comprises a natural disaster prediction module communicatively coupled to the risk determination module to identify occurrence of natural disaster from the preliminary set of data. The system further comprises a plant growth monitoring module communicatively coupled to the risk determination module to monitor growth of crops and plants at one or more physical farms. The system is characterized by the risk determination module to compare the identified trigger event data with a geospatial data, where the geospatial data is obtained for each of the identified trigger event data in real-time; compare the identified trigger event data with the weather forecast data; calculate a risk value based on the comparison, where the risk value is calculated for each of the identified trigger event data in the food supply chain, where the risk value includes a positive score and a negative score; and determine risk in the food supply chain by calculating impact percentile of the calculated risk value, where the risk is determined when the calculated impact value is greater than a threshold value.

More advantageously, the plant growth monitoring module (also known as crop growth monitoring module) comprises one or more air temperature and humidity sensors, light illumination sensors and carbon dioxide concentration sensors. Additionally, the system or the the plant growth monitoring module comprises a rainfall detector, a snow detector, a wind direction and wind speed detector, a temperature and humidity detector and a data collector, wherein the data collector is respectively connected with a rainfall detector, a snow detector, a wind direction and speed detector, and a temperature and humidity detector.

According to an example embodiment, to determine risk in the food supply chain the risk determination module is further executed by the processor to classify, by a classifier, the identified trigger event data into one of high risk, intermediate risk and low risk based on the calculated risk value; and add the calculated risk value for each of the classified trigger event data in the food supply chain to determine risk in the food supply chain.

According to an example embodiment, the trigger event data comprises one or more keywords related to pandemic, natural disaster, geo-political tension, and corporate bankruptcy.

According to an example embodiment, the risk determination module is further executed by the processor to perform one or more actions based on the determined risk in the food supply chain, where the one or more actions include notify a user when the calculated risk value is greater than the threshold value; determine a response plan based on the calculated risk value, where the response plan includes one or more of changing suppliers, and increasing or decreasing orders from the suppliers; and activate the response plan for each of the identified trigger event data by implementing machine learning algorithms.

According to an example embodiment, the risk determination module is further executed by the processor to classify the determined risk in the food supply chain into at least one of supply side risk and demand side risk.

According to an example embodiment, the threshold value is preset or dynamically set by a user.

According to an example embodiment the preliminary set of data is obtained by integrating one or more of social media data, government data, news data, weather data, and company data.

The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

In various embodiments, a system and a method for determining risk in a food supply chain is provided. The system is unified as a single digital platform for enhancing food security and resilience in response to food supply chain disruption risks, especially during an occurrence of disaster.

The present invention is illustrated by way of example and not by way of limitation in the figures of the accompanying drawings, in which the like reference numerals indicate like elements and in which:

FIG. 1 is a block diagram illustrating a system for determining risk in a food supply chain according to an example embodiment of the present disclosure;

FIG. 2 is a schematic block diagram of a system architecture incorporating the system of FIG. 1 according to an example embodiment of the present disclosure;

FIG. 3 is a schematic block diagram of a command-and-control center incorporating the system according to an example embodiment of the present disclosure; and

FIG. 4 is a flowchart for a method for determining risk in a food supply chain according to an example embodiment of the present disclosure.

In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without these specific details. In other instances, systems and methods are shown in block diagram form only in order to avoid obscuring the present invention.

Some embodiments of the present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all, embodiments of the invention are shown. Indeed, various embodiments of the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this invention will satisfy applicable legal requirements. Like reference numerals refer to like elements throughout. As used herein, the terms “data,” “content,” “information,” and similar terms may be used interchangeably to refer to data capable of being transmitted, received and/or stored in accordance with embodiments of the present invention. Further, the terms “processor”, “controller”, “processing part”, and “processing circuitry” and similar terms may be used interchangeably to refer to the processor capable of processing information in accordance with embodiments of the present invention. Further, the terms “electronic equipment”, “electronic devices” and “devices” are used interchangeably to refer to electronic equipment monitored by the system in accordance with embodiments of the present invention. Thus, use of any such terms should not be taken to limit the spirit and scope of embodiments of the present invention.

The embodiments are described herein for illustrative purposes and are subject to many variations. It is understood that various omissions and substitutions of equivalents are contemplated as circumstances may suggest or render expedient but are intended to cover the application or implementation without departing from the spirit or the scope of the present invention. Further, it is to be understood that the phraseology and terminology employed herein are for the purpose of the description and should not be regarded as limiting. Any heading utilized within this description is for convenience only and has no legal or limiting effect.

As used in this specification and claims, the terms “for example” “for instance” and “such as”, and the verbs “comprising,” “having,” “including” and their other verb forms, when used in conjunction with a listing of one or more components or other items, are each to be construed as open ended, meaning that that the listing is not to be considered as excluding other, additional components or items. Other terms are to be construed using their broadest reasonable meaning unless they are used in a context that requires a different interpretation.

One of the objectives of the present invention is to determine risk in a food supply chain, which may also be a global food supply chain. The risk determination should be performed such that proactive measures may be taken by the suppliers and distributers to manage the any disruptions in food supply both on demand side and supply side. The food supply chain may be vulnerable to one or more events, such as pandemic, natural disaster, geo-political tension, and corporate bankruptcy. To ensure that such events do not disrupt the food supply, it is important to provide a platform and a technique for predicting such events and its effects well in advance. Further, the platform should also provide one or more response plans in order to manage the any disruptions in food supply both on demand side and supply side. Furthermore, the risk analysis is to be performed, such that high risk events and low risk events are identified thereby enabling to set priority upon the one or more response plans.

Further, the risk determination is performed by a risk determination system that is provided with one or more modules implementing machine learning for natural language processing. The one or more modules function such that upon capturing data by the Internet-of-Things (IoT) sensors, the data is processed and compared with historical data. Also, social media data, government data, news data, weather data, and company data are recorded to identify other events that affect the food supply chain. Thereby, analyzing and highlighting potential occurrence of events that lead to the disruptions in food supply both on demand side and supply side.

In this way, the risk determination system allows accurate determination of the risk in the food supply chain and consequently enables to execute an optimized response plan to counter or mitigate the effects of events disrupting the food supply chain.

FIG. 1 illustrates a block diagram illustrating a system 100 for determining risk in a food supply chain according to an example embodiment of the present disclosure. The system 100 comprises a processor 102. The processor 102 may be in communication with additional components, particularly a memory 104. The processor 102 may be any device that performs logical operations. The processor 102 may include a general processor, a central processing unit, a digital signal processor, a field programmable gate array (FPGA), a digital circuit, a controller, a microcontroller, any other type of processor or any combination thereof. The processor 102 may include one or more components operable to execute computer executable instructions or computer code embodied in the memory 104. The term "memory" 104 should be interpreted broadly to encompass any electronic component capable of storing electronic information. The memory 104 may refer to various types of processor-readable media such as random-access memory (RAM), read-only memory (ROM), non-volatile random-access memory (NVRAM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable PROM (EEPROM), flash memory, magnetic or optical data storage, registers, etc.

The system 100 further comprises a risk determination module 106 communicatively coupled to the processor 102. The risk determination module 106 may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC); a digital, analog, or mixed analog/digital discrete circuit; a digital, analog, or mixed analog/digital integrated circuit; a combinational logic circuit; other suitable hardware components that provide the described functionality; or a combination of some or all of the above, such as in a system-on-chip. The risk determination module 106 may perform logical operations by involving supervised machine learning, unsupervised as well as automated machine learning. The risk determination module 106 may be in communication with a plurality of infrastructures, such as Internet websites, cameras, sensors as well as satellites in order to collect raw data related to macro-environmental events, socio-political upheavals and corporate risks. Specifically, in the embodiment of FIG. 1, the system 100 further includes a first set of transceivers 108 communicably coupled to the risk determination module 106. The risk determination module 106 is executed by the processor 102 to receive a preliminary set of data from a plurality of data source. In an example, the risk determination module 106 may receive the preliminary set of data via the first set of transceivers 108. Here the term “transceiver” may refer to a device such as an integrated circuit including a transmitter (Tx) and a receiver (Rx) so that the integrated circuit may be used to both transmit and receive information (data). Further, the first set of transceivers 108 may be integrated with a plurality of antennae (not shown) for transmitting and receiving information. The preliminary set comprises trigger event data and non-trigger event data. In some embodiments, the preliminary set of data is obtained by integrating one or more of social media data, government data, news data, and company data. Further, in some embodiments, the trigger event data comprises one or more keywords related to pandemic, natural disaster, geo-political tension, and corporate bankruptcy. The risk determination module 106 may determine a particular level of risk and a category of risk from a set of risk categories. In some embodiments, the risk determination module 106 may determine a risk score.

More specifically, to predict precipitation, the risk determination module 106 is conjured to perform a rainfall prediction method comprising: 1$^{st}$ step of extracting radar maps with different heights in different time periods and meteorological information sequences in corresponding time periods; 2$^{nd}$ step of constructing a rainfall prediction model based on a deep neural network; 3$^{rd}$ step of inputting the extracted radar map and weather information sequence into a rainfall prediction model, carrying out time sequence analysis on the input radar map and weather information sequence through the rainfall prediction model to obtain radar map space-time characteristics and weather information time sequence characteristics corresponding to each time period, and outputting rainfall prediction values corresponding to each time period according to the radar map space-time characteristics and the weather information time sequence characteristics.

FIG. 2 illustrates a schematic block diagram of a system architecture 200 incorporating the system 100 of FIG. 1 according to an example embodiment of the present disclosure. The system 100 is similar to the system shown in FIG. 1, with like elements designated by like numerals. The system 100 further comprises a natural language processing module 120; a natural disaster prediction module 130, and a plant growth monitoring module 140. Each of the natural language processing module 120; a natural disaster prediction module 130, and a plant growth monitoring module 140 are communicatively coupled to the risk determination module. The system architecture 200 comprises a plurality of sensors 204-1 to 204-n communicably coupled to a second set of transceivers 206. In an example, the plurality of sensors 204-1 to 204-n may be installed on a physical farm to monitor growth of crops and parameters related to surrounding conditions of the physical farm. In some embodiments, the plurality of sensors 204-1 to 204-n may be Internet of Things (IoT) based sensors. In some embodiments, IoT sensors may include at least one of a light sensor for detecting light condition over the physical farm, a soil moisture sensor for detecting water condition on lands of the physical farm, a temperature sensor for detecting temperature surrounding the crops, and a chemical sensor for detecting inorganic and organic nutrients necessary for growth of the crops. Specifically, in the embodiment of FIG. 2, the plurality of sensors 204-1 to 204-n include the soil moisture sensor, and the temperature sensor. In some embodiments, the risk determination module 106 may be in communication with to multiple physical farms that have access to modern agricultural technologies including but not limited to monitoring by drones and google satellite, Internet of things (IoT) sensors. The risk determination module 106 is further executed by the processor 102 to identify the trigger event data from the preliminary set of data by machine learning for natural language processing, obtain weather forecast data from the preliminary set of data, where the weather forecast data comprising values of air temperature, humidity, wind speed, air pressure, air density, and surface temperature. Raw data generated by the IoT sensors from may be in format including but not limited to texts, audios, images and videos.

More specially, the natural language processing module includes a sub-module for detecting and/or eliminating fraudulent, inaccurate or misleading text data. The sub-module is configured to perform steps of 1) use the first training pattern pair Structuring behavioral data is classified and assigns score corresponding with generic; 2) use the second training pattern pair and the knot. The corresponding text data of structure behavioral data is classified and assigns score corresponding with generic. Structured score of the behavioral data is compared with the score of corresponding text data. According to the knot of the comparison, the sub-module decides whether the corresponding text data is credible or reliable. Here, first and second training pattern can be known as available training pattern, includes, but are not limited to Light GBM algorithm, GBDT algorithm, LR model, neural network etc. At one embodiment, first training pattern can be identical as second training pattern. In another embodiment, described first Training pattern can be different from second training pattern.

The risk determination module 106 is communicatively coupled to the processor 102 to identify the trigger event data from the preliminary set of data by machine learning for natural language processing and obtain weather forecast data from the preliminary set of data, where the weather forecast data comprising values of air temperature, humidity, wind speed, air pressure, air density, and surface temperature.

Further, the risk determination module 106 compares the identified trigger event data with a geospatial data, where the geospatial data is obtained for each of the identified trigger event data in real-time, compare the identified trigger event data with the weather forecast data, calculate a risk value based on the comparison, where the risk value is calculated for each of the identified trigger event data in the food supply chain, where the risk value includes a positive score and a negative score, and determine risk in the food supply chain by calculating impact percentile of the calculated risk value, where the risk is determined when the calculated impact value is greater than a threshold value. In some embodiments, the threshold value is preset or dynamically set by a user. Specifically in the embodiment of FIG. 2 the system 100 further comprises a classifier 110 to classify the identified trigger event data into one of high risk, intermediate risk and low risk based on the calculated risk value and add the calculated risk value for each of the classified trigger event data in the food supply chain to determine risk in the food supply chain. Further, the risk determination module 106 classifies the determined risk in the food supply chain into at least one of a supply side risk and a demand side risk.

The risk determination module 106 is further executed by the processor to perform one or more actions based on the determined risk in the food supply chain. The one or more actions include notifying a user when the calculated risk value is greater than the threshold value, determine a response plan based on the calculated risk value, where the response plan includes one or more of changing suppliers, and increasing or decreasing orders from the suppliers, and activate the response plan for each of the identified trigger event data by implementing machine learning algorithms. Specifically, in the embodiment of FIG. 2, the system architecture 200 may include a user terminal 208 to provide a notification to the user when the calculated risk value is greater than the threshold value.

In an example implementation, the system architecture 200 may be connected to a meteorological station or a weather station (not shown, will be later described in FIG. 3) for receiving a geospatial data, the weather forecast data, and real-time updates related to weather and climate changes. In general, during a regular rainfall season, particularly monsoon season, an expected range of rainfall may be considered by farmers for the growth rice crops in a standard duration of time. However, there may occur a scenario, where the rainfall during the monsoon season is below the expected range or a region accommodating the physical farm may be going through a period of drought.

To this end, the plurality of sensors 204-1 to 204-n e.g., the soil moisture sensor, and the temperature sensor may constantly monitor and detect the soil moisture and the temperature surrounding the crops. Further, real-time values related to the soil moisture and the temperature may be communicated to the system 100 via the use of second set of transceivers 206, where the real-time values may be received by the first set of transceivers 108. In some embodiments, the first set of transceivers 108 may communicate with the second set of transceivers 206 via a communication network. The communication network may include, but is not limited to, one or more peer-to-peer network, a hybrid peer-to-peer network, local area networks (LANs), radio access networks (RANs), metropolitan area networks (MANS), wide area networks (WANs), all or a portion of a public network such as the global computer network known as the Internet, a private network, a cellular network and any other communication system or systems at one or more locations. Moreover, any other suitable protocols using voice, video, data, or combinations thereof, can also be employed by the network. Further, the real-time values may be fed into the risk determination module 106. Further, the natural language processing module 120 communicatively coupled to the risk determination module 106 may validate the trigger event data, such that a text data is obtained from various media (e.g., Internet, radio & news portals) for deciphering information relating to risk of food supply. The natural language processing module 120 may be executed by the processor 102 to analyze the preliminary data and headlines involved in the preliminary data to obtain dependency structures indicating keywords, such as pandemic, natural disaster, geo-political tension, and corporate bankruptcy. The dependency structures may further be transmitted to the natural disaster prediction module 130 to identify occurrence of natural disaster. The natural disaster prediction module 130 may be executed by the processor 102 to analyze the dependency structure related to a type of natural disaster in a target area. The natural disaster prediction module 130 may obtain a maximum value and a minimum value of a probability index related to type of natural disaster. The minimum value is subtracted from the maximum value to obtain a maximum variation range of the probability index. Further, topography factors are extracted and correlated to a landform classification from digital elevation model data in the target area. A normalization processing is carried out for the maximum variation range. Further, the type of natural disaster is identified with reference to the digital elevation model data and based on the natural geographical features. Further, the plant growth monitoring module 140 communicatively may utilize information output from the natural disaster prediction module 130 and may also consider real-time values related to the soil moisture and the temperature to monitor growth of crops and plants at the physical farm 202. For e.g., plant growth may be calculated by considering soil moisture and amount of soil infiltration. A minimum value of soil infiltration rate is calculated, where INF is the infiltration rate and COEFF is the maximum Infiltration loss, S is the infiltration loss index, SMS is the soil moisture, and SMSC is the soil water storage capacity; the remaining flow intercepted by the vegetation is: INR = MAX [(RAIN + INS-INSC), 0], where INR is Vegetation interception residual flow, RIAN is the precipitation during the period, INS is the vegetation interception savings, INSC is the interception storage capacity parameter, and MAX represents the larger of the two values. The risk determination module 106 may compare the weather forecast data received by the weather station with the real-time time values related to the soil moisture and the temperature.

Moreover, the risk determination module 106 may perform logical operations by involving supervised machine learning for calculating the risk value and analyze if the risk value is greater than the threshold value. Upon, determining the risk value to be greater than the threshold value, the classifier 110 may classify the identified trigger event data into a high risk and add the calculated risk value for each of the classified trigger event data in the food supply chain to determine risk in the food supply chain. Further, the risk determination module 106 may classify the determined risk in the food supply chain into at least one of a supply side risk. Upon classification of the determined risk towards the supply side risk, farmers may be provided with a notification via the user terminal 208. Furthermore, the risk determination module 106 may activate the response plan implementing machine learning algorithms to activate the response plan, such as assist the farmers to arrange for adequate water supply before beforehand and indicating in the supply chain to decrease orders from the supplier.

FIG. 3 illustrates a schematic block diagram of a command-and-control center 300 incorporating the system 100 according to example embodiment of the present disclosure. The system 100 is similar to the system shown in FIG. 1 and FIG. 2, with like elements designated by like numerals. Specifically, in the embodiment of FIG. 3, the command-and-control center 300 may refer to an establishment equipped with necessary control and communication instruments. Further, the command-and-control center 300 (hereinafter referred to as “the center 300”) may function as a centralized data center capable of performing various monitoring and controlling operations related to demand and supply in the food supply chain. In some embodiments, the center 300 may also refer to the meteorological station or the weather station as described in FIG. 2. However, the center 300 of FIG. 3 may not be limited to as the meteorological station or the weather station and may function as a dedicated establishment for managing the operations of the food supply chain based on weather predictions. The center 300 may be equipped with a weather radar 310. The weather radar 310 may comprise a radar antenna system (not shown). In an example the radar antenna system may include a pulse doppler radar system that may transmit pulses of energy or a radar beam to detect objects. The objects may be detected based on reflectivity parameters of the radar beam and may provide a detailed mapping of one or more regions. The weather radar 310 may also provide a color map, where each color may be indicative of the objects, such as rain, thunderstorm, hail, drought, higher precipitation or lower precipitation in the atmosphere. The center 300 may operate to perform constant monitoring of weather and may receive real-time values related to weather changes via the weather radar 310. Upon identifying an trigger event data related to weather forecast, the center 300 may issue a warning to a distribution network or the demand side to perform changes related to distribution in the food supply chain. In an example implementation the center 300 may identify a trigger event related to weather forecast that may have potential to disrupt the food supply chain. Specifically, in the embodiment, of FIG. 3, the weather forecast may indicate more favorable conditions to allow higher volume in crops. The higher volume may also bring in possibility of wastage of crop yield, since the distribution network may supply food in a fixed range of quantity. However, any excess volume in crop yield is also required to effectively stored and maintained. To this end, the center 300 may perform logical operations via the risk determination module (not shown) applying machine learning for natural language processing. The center 300 may then provide one or more response plans. The response plans may include increasing the notifying a network 320 of suppliers 320-1 to 320-n to increase the orders from the suppliers 320-1 to 320-n. Therefore, allowing to take proactive measures to prevent the wastage of the yielded crops.

Similarly, the center 300 of the exemplary embodiment of FIG. 3 may further perform the risk determination for a global food supply chain. The network 320 of suppliers 320-1 to 320-n may be associated to multiple countries, where import and export operations for food supply may be required to be monitored in accordance with the risk determination. For example, the center 300 may detect an event of “typhoon” that hits Mekong delta rice fields. Such event may be provided, by the risk determination module 106, the trigger event data. Further, the event may be classified as into high risk by the classifier 110 indicating a severe effect to rice supply in surrounding regions. According to another example, although an event of “disruption of vegetable exports from Malaysia to Singapore” has an immediate and serious impact on Singapore, the disruption problem may be prevented or mitigated expeditiously without much effort. For example, Singapore may import vegetable from many other countries such as the United States, India, China, Vietnam, Australia and Thailand as alternative supply, therefore, the event is identified as an intermediate-risk and the raw data collected therefrom is classified into the intermediate-risk dataset. For another example, an event of “China wants to import more rice from Vietnam” does not have an immediate and severe impact to Singapore which has enough time to import rice from many other counties such as United States, India and Thailand as alternative supply. Therefore, the event is identified as a low-risk event, the raw data collected therefrom is classified into the low-risk event.

FIG. 4 illustrates a flowchart for a method 400 for determining risk in a food supply chain according to an example embodiment of the present disclosure. The method may be performed by the system 100 described in FIGS. 1 to 3 of the present disclosure. The method 400 may be implemented by a processing resource or the system 100 through any suitable hardware, non-transitory machine-readable medium, or a combination thereof. In some embodiments, steps involved in the method 400 may be executed by the processing resource, for example the processor 102 (shown in FIG. 1). The processor 102 may be in communication with additional components. The processor 102 may include one or more components operable to execute computer executable instructions or computer code embodied in the memory 104 (shown in FIG. 1). The method 400 will be described with reference to FIGS. 1 to 3.

Referring to FIG. 1, at step 402, the method 400 comprises receiving a preliminary set of data from a plurality of data source. The preliminary set comprises trigger event data and non-trigger event data. The preliminary set of data from a plurality of data source is received by the risk determination module 106, when executed by the processor 102.

Referring to FIG. 2, at step 404, the method 400 comprises identifying the trigger event data from the preliminary set of data by machine learning for natural language processing. The trigger event data is identified from the preliminary set of data by the risk determination module 106, when executed by the processor 102.

At step 406, the method 400 comprises obtaining, by the risk determination module 106, when executed by the processor 102, weather forecast data from the preliminary set of data, where the weather forecast data comprise values of air temperature, humidity, wind speed, air pressure, air density, surface temperature or a combination of any of the weather forecast data.

At step 408, the method 400 further comprises validating the trigger event data by a natural language processing module 120.

At step 410, method 400 further comprises identifying occurrence of natural disaster from the preliminary set of data by a natural disaster prediction module 130.

At step 412, method 400 further comprises monitoring growth of crops and plants at one or more physical farms plant by a growth monitoring module 140.

At step 414, the method 400 comprises comparing, by the risk determination module 106, when executed by the processor 102, the identified trigger event data with a geospatial data, where the geospatial data is obtained for each of the identified trigger event data in real-time.

At step 416, the method 400 comprises comparing, by the risk determination module

106, when executed by the processor 102, the identified trigger event data with the weather forecast data.

At step 418, the method 400 comprises calculating, by the risk determination module 106, when executed by the processor 102 a risk value based on the comparison, where the risk value is calculated for each of the identified trigger event data in the food supply chain, where the risk value includes a positive score and a negative score.

At step 420 the method 400 comprises determining, by the risk determination module 106, when executed by the processor 102, risk in the food supply chain by calculating impact percentile of the calculated risk value, where the risk is determined when the calculated impact value is greater than a threshold value.

In some embodiments, determining, risk in the food supply chain further comprises classifying, by the classifier 110, the identified trigger event data into one of high risk, intermediate risk and low risk based on the calculated risk value; and adding the calculated risk value for each of the classified trigger event data in the food supply chain to determine risk in the food supply chain.

In some embodiments, the trigger event data comprises one or more keywords related to pandemic, natural disaster, geo-political tension, and corporate bankruptcy.

In some embodiments, the method 400 further comprises performing, by the risk determination module 106, when executed by the processor 102, one or more actions based on the determined risk in the food supply chain. The one or more actions include notifying a user via the user terminal 208 when the calculated risk value is greater than the threshold value; determining a response plan based on the calculated risk value, where the response plan includes one or more of changing suppliers, and increasing or decreasing orders from the suppliers; and activating the response plan for each of the identified trigger event data by implementing machine learning algorithms.

In some embodiments, the method 400 further comprises classifying, by the risk determination module 106, when executed by the processor 102, the determined risk in the food supply chain into at least one of supply side risk and demand side risk.

In some embodiments, the threshold value is preset or dynamically set by a user. Referring back to FIG. 1, in some embodiments, the preliminary set of data is obtained by integrating one or more of social media data, government data, news data, weather data, and company data.

In some embodiments, the method 400 further comprises alerting at least one entity of the food supply chain based on the determined risk via Internet of Things (IoT) based sensors (204-1 to 204-n).

An embodiment provides a special method of managing supply chain risk, the method comprising determining with a computer a degree of supply chain risk to an enterprise as a function of an effect of a disruption of delivery of a production input to the enterprise on a financial performance metric of the enterprise, wherein the determining step comprises factoring an economic impact score (EI) with a supply risk score (SR) to give a supply chain risk score (SCR) that is reflective of the degree of supply chain risk; and wherein the production input is a material or component taken in or operated on by a production process performed by the enterprise, wherein each of EI and SR independently is normalized to a scale of from >0 to 10 and SCR=EI*SR/10, wherein EI comprises normalized annual gross margin in currency (GMc) of the product(s) produced by the enterprise using the production input, wherein the normalized GMc is expressed on a logarithmic scale (log10) of from >0 to 10, wherein the economic impact score is >0 where the annual GMc of the enterprise related to the production input is >0% of total GMc of the enterprise and the economic impact score is 10 where the annual GMc of the enterprise related to the production input is 100% of total GMc of the enterprise; and wherein SR is at least one of an external market factor, internal market factor, supplier factor, or any combination of at least two thereof and SR is normalized to a relative scale of 1 to 10 with 1 being least likelihood of the disruption occurring and 10 being greatest likelihood of the disruption occurring; comparing, ranking, or comparing and ranking supply chain risks of at least two different production inputs; and taking an ameliorating action so as to reduce the degree of supply chain risk.

According to the special method, the production input is optionally a raw material or partially finished material for a chemical process performed by the enterprise.

Advantageously, the special method further comprises a step of determining with a computer a degree of supply chain risk to an enterprise as a function of an effect of a disruption of delivery of a production input to the enterprise on a financial performance metric of the enterprise, wherein the determining step comprises factoring an economic impact score (EI) with a supply risk score (SR) to give a supply chain risk score (SCR) that is reflective of the degree of supply chain risk; and the production input is a material or component taken in or operated on by a production process performed by the enterprise, wherein EI=log10[(product(s) gross margin CR)/(enterprise gross margin CR)*(product(s) gross margin %, scale 0-1)*30,000*10]/log10[(enterprise gross margin %)*30000]; wherein product(s) gross margin CR=(product(s) sales CR)*(product(s) gross margin %, scale 0-1), where product(s) sales CR is total dollar sales from all product(s) manufactured from the production input and sold by the enterprise and product(s) gross margin % is the average gross margin percentage of all such manufactured and sold product(s); wherein “enterprise” and “average” refer to values for the whole enterprise (or, if desired, a relevant division thereof); and wherein CR indicates a currency denominated value; and SR is the highest score from SR(a) or SR(b), wherein SR(a) is Threat-Supply Regulation Score; and SR(b) is the sum of all of the following factors (i) to (ix): (i) number of qualified suppliers score Q, where Q=1.5 if one qualified supplier, Q=0.5 if two qualified suppliers, and Q=0 if three or more qualified suppliers; (ii) (qualification complexity score)*0.1; (iii) (logistics complexity score)*0.1; (iv) (quality complexity score)*0.1; (v) (value of production input score)*0.2; (vi) (value-enterprise score)*0.1; (vii) (historical performance score)*0.4; (viii) (threats to supplier score)*0.6; plus (ix) −4; comparing, ranking, or comparing and ranking supply chain risks of at least two different production inputs; and taking an ameliorating action so as to reduce the degree of supply chain risk.

According to the special method, the ameliorating action sometimes comprises prioritizing and strategically implementing a program for reducing or mitigating supply disruption risks comprising diversifying source(s) of the production input, qualifying an additional supplier thereof, replacing a current supplier with a more reliable supplier of the production input, de-risking the current supplier of the production input by providing it with financial or another form of assistance or by purchasing a higher volume of the production input therefrom, or providing assurance of the higher volume, or improving or securing logistics of the delivery of the production input.

Alternatively speaking, the special method is implemented by a computer system or device that comprises a processor, a memory subsystem in communication with the processer, and computer executable instructions storable in the memory subsystem and executable by the processor to determine a degree of supply chain risk to an enterprise as a function of an effect of a disruption of delivery of the production input to the enterprise on a financial performance metric of the enterprise, the computer executable instructions comprising instructions for determining a degree of supply chain risk to an enterprise as a function of an effect of a disruption of delivery of a production input to the enterprise on a financial performance metric of the enterprise, wherein the determining step comprises factoring an economic impact score (EI) with a supply risk score (SR) to give a supply chain risk score (SCR) that is reflective of the degree of supply chain risk; and wherein the production input is a material or component taken in or operated on by a production process performed by the enterprise, wherein each of EI and SR independently is normalized to a scale of from >0 to 10 and SCR=EI*SR/10, wherein EI comprises normalized annual gross margin in currency (GMc) of the product(s) produced by the enterprise using the production input, wherein the normalized GMc is expressed on a logarithmic scale (log10) of from >0 to 10, wherein the economic impact score is >0 where the annual GMc of the enterprise related to the production input is >0% of total GMc of the enterprise and the economic impact score is 10 where the annual GMc of the enterprise related to the production input is 100% of total GMc of the enterprise; and wherein SR is at least one of an external market factor, internal market factor, supplier factor, or any combination of at least two thereof and SR is normalized to a relative scale of 1 to 10 with 1 being least likelihood of the disruption occurring and 10 being greatest likelihood of the disruption occurring; comparing, ranking, or comparing and ranking supply chain risks of at least two different production inputs; and taking an ameliorating action so as to reduce the degree of supply chain risk.

For example for a given production input that feeds into one or more products of the enterprise, SCR may be calculated from the following EI and SR. EI=log10[(product(s) gross margin CR)/(enterprise gross margin CR)*(product(s) gross margin %, scale 0-1)*30,000*10]/log10[(enterprise gross margin %)*30000]; wherein product(s) gross margin CR=(product(s) sales CR)*(product(s) gross margin %, scale 0-1), where product(s) sales CR is total currency sales from all product(s) manufactured from the production input and sold by the enterprise and product(s) gross margin % is the average gross margin percentage of all such manufactured and sold product(s); wherein “enterprise” and “average” are based on values for the whole enterprise (or, if desired, the division or subsidiary thereof); and wherein CR indicates a currency denominated value. The 10 and 30,000 are numerical corrections. For the same production input, SR may be the highest score from SR(a) or SR(b), wherein SR(a) is Threat-Supply Regulation Score; and SR(b) is the sum of all of the following factors (i) to (ix): (i) number of qualified suppliers score Q, where Q=1.5 if one qualified supplier, Q=0.5 if two qualified suppliers, and Q=0 if three or more qualified suppliers+(ii) (qualification complexity score)*0.1+(iii) (logistics complexity score)*0.1+(iv) (quality complexity score)*0.1+(v) (value of production input score)*0.2+(vi) (value-enterprise score)*0.1+(vii) (historical performance score)*0.4+(viii) (threats to supplier score)*0.6+(ix) −4 (i.e., SR(b)=sum of (i) to (viii) −4). Factors (ii) to (viii) are weighted. In another example where at least two production inputs are obtained from a single supplier and feed into one or more products, in the formula for EI, product(s) sales CR would be total dollar sales from all products manufactured from the at least two production inputs and product gross margin % is the average gross margin percentage of all products manufactured from the at least two production inputs and EI reflects economic impact risk of the supplier on the enterprise. The EI formula optionally may be weighted to give greater impact per unit gross margin on SCR for higher net profit margin products than for lower net profit margin products. The specific numerical values for EI, SR, and SCR may not be important provided their relative values for different production inputs or suppliers qualitatively reflect relative supply chain risks associated with those production inputs or suppliers.

Alternatively, the economic impact score may be the negative type financial performance metric that is total annual spending by the enterprise to purchase the production input from the supplier. For example, the economic impact score may be total annual spending by the enterprise on the production input or a normalized value thereof. For example, the normalized value of annual spending on the production input (normalized production input annual spend) may be expressed as a normalized value on a scale of from >0 to 10, wherein the economic impact score is >0 where >0% of total annual production input spend by the enterprise is on the production input and the economic impact score is 10 where 100% of total annual production input spend by the enterprise is on the production input; alternatively any combination of at least two thereof. Alternatively, the economic impact score may be a combination of at least one positive type financial performance metric and at least one negative type financial performance metric. For example, the economic impact score may be a combination of the aforementioned economic impact scores derived from the normalized production input-derived annual revenues received by the enterprise and normalized production input annual spending by the enterprise.

Many modifications and other embodiments of the inventions set forth herein will come to mind of one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Moreover, although the foregoing descriptions and the associated drawings describe example embodiments in the context of certain example combinations of elements and/or functions, it should be appreciated that different combinations of elements and/or functions may be provided by alternative embodiments without departing from the scope of the appended claims. In this regard, for example, different combinations of elements and/or functions than those explicitly described above are also contemplated as may be set forth in some of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

Claims

1. A method for determining risk in a food supply chain, the method comprising:

receiving a preliminary set of data from a plurality of data source, wherein the preliminary set comprises trigger event data and non-trigger event data;

identifying the trigger event data from the preliminary set of data by machine learning for natural language processing;

obtaining weather forecast data from the preliminary set of data, wherein the weather forecast data comprise values of air temperature, humidity, wind speed, air pressure, air density, surface temperature or a combination of any of the weather forecast data;

validating the trigger event data;

identifying, from the preliminary set of data, occurrence of natural disaster at a geospatial location indicated by a geospatial data; and

monitoring, based on the identified natural disaster, growth of crops and plants at one or more physical farms at the geospatial location indicated by the geospatial data;

wherein the method is characterized by

comparing the identified trigger event data with the geospatial data, wherein the geospatial data is obtained for the identified trigger event data in real-time;

comparing the identified trigger event data with the weather forecast data;

calculating a risk value based on the comparison, wherein the risk value is calculated for the identified trigger event data in the food supply chain, wherein the risk value includes a positive score and a negative score;

determining risk in the food supply chain by calculating impact percentile of the calculated risk value, wherein the risk is determined when the calculated impact value is greater than a threshold value;

classifying the determined risk in the food supply chain into at least one of supply side risk and demand side risk; and

alerting at least one entity of the food supply chain based on the determined risk and the classification of the determined risk via Internet of Things (IoT) based sensors.

2. The method as claimed in claim 1, the determining risk in the food supply chain further comprises:

classifying, by a classifier, the identified trigger event data into one of high risk, intermediate risk and low risk based on the calculated risk value; and

adding the calculated risk value for each of the classified trigger event data in the food supply chain to determine risk in the food supply chain.

3. The method as claimed in claim 1, wherein the trigger event data comprises one or more keywords related to pandemic, natural disaster, geo-political tension, and corporate bankruptcy.

4. The method as claimed in claim 1, further comprises performing one or more actions based on the determined risk in the food supply chain, wherein the one or more actions include:

notifying a user when the calculated risk value is greater than the threshold value;

determining a response plan based on the calculated risk value, wherein the response plan includes one or more of changing suppliers, and increasing or decreasing orders from the suppliers; and

activating the response plan for each of the identified trigger event data by implementing machine learning algorithms.

5. The method as claimed in claim 1, wherein the threshold value is preset or dynamically set by a user.

6. The method as claimed in claim 1, wherein the preliminary set of data is obtained by integrating one or more of social media data, government data, news data, weather data, and company data.

7. A system for determining risk in a food supply chain, the system comprising:

a processor;

a memory;

a risk determination module communicatively coupled to the processor, wherein the risk determination module is executed by the processor to:

receive a preliminary set of data from a plurality of data source, wherein the preliminary set comprises trigger event data and non-trigger event data;

identify the trigger event data from the preliminary set of data by machine learning for natural language processing;

obtain weather forecast data from the preliminary set of data, wherein the weather forecast data comprising values of air temperature, humidity, wind speed, air pressure, air density, and surface temperature;

a natural language processing module communicatively coupled to the risk determination module to validate the trigger event data;

a natural disaster prediction module communicatively coupled to the risk determination module to identify, from the preliminary set of data, occurrence of natural disaster at a geospatial location indicated by a geospatial data; and

a plant growth monitoring module communicatively coupled to the risk determination module to monitor, based on the identified natural disaster, growth of crops and plants at one or more physical farms at the geospatial location indicated by the geospatial data;

wherein the system is characterized by the risk determination module to:

compare the identified trigger event data with the geospatial data, wherein the geospatial data is obtained for the identified trigger event data in real-time;

compare the identified trigger event data with the weather forecast data;

calculate a risk value based on the comparison, wherein the risk value is calculated for the identified trigger event data in the food supply chain, wherein the risk value includes a positive score and a negative score;

determine risk in the food supply chain by calculating impact percentile of the calculated risk value, wherein the risk is determined when the calculated impact value is greater than a threshold value;

classify the determined risk in the food supply chain into at least one of supply side risk and demand side risk; and alert at least one entity of the food supply chain based on the determined risk and the classification of the determined risk via Internet of Things (IoT) based sensors.

8. The system as claimed in claim 7, wherein to determine risk in the food supply chain the risk determination module is further executed by the processor to:

classify, by a classifier, the identified trigger event data into one of high risk, intermediate risk and low risk based on the calculated risk value; and

add the calculated risk value for each of the classified trigger event data in the food supply chain to determine risk in the food supply chain.

9. The system as claimed in claim 7, wherein the trigger event data comprises one or more keywords related to pandemic, natural disaster, geo-political tension, and corporate bankruptcy.

10. The system as claimed in claim 7, wherein the risk determination module is further executed by the processor to perform one or more actions based on the determined risk in the food supply chain, wherein the one or more actions include:

notify a user when the calculated risk value is greater than the threshold value;

determine a response plan based on the calculated risk value, wherein the response plan includes one or more of changing suppliers, and increasing or decreasing orders from the suppliers; and

activate the response plan for each of the identified trigger event data by implementing machine learning algorithms.

11. The system as claimed in claim 7, wherein the threshold value is preset or dynamically set by a user.

12. The system as claimed in claim 7, wherein the preliminary set of data is obtained by integrating one or more of social media data, government data, news data, weather data, and company data.

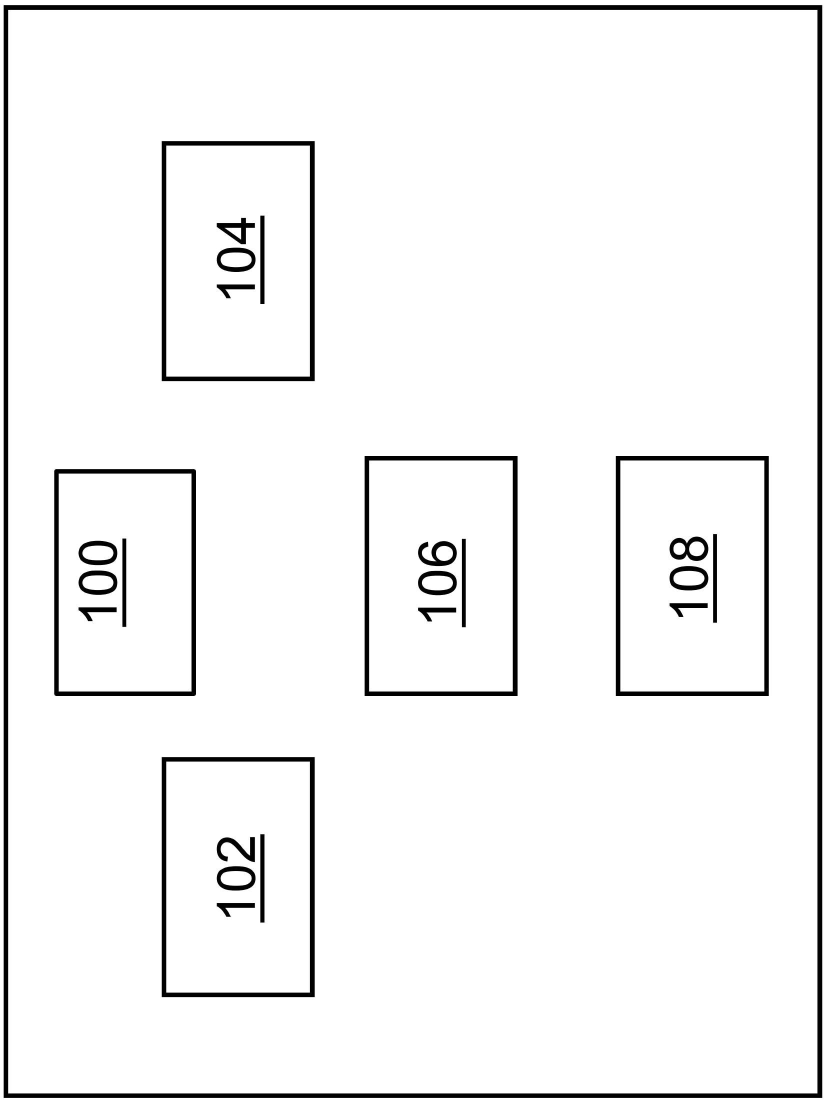


FIG. 1

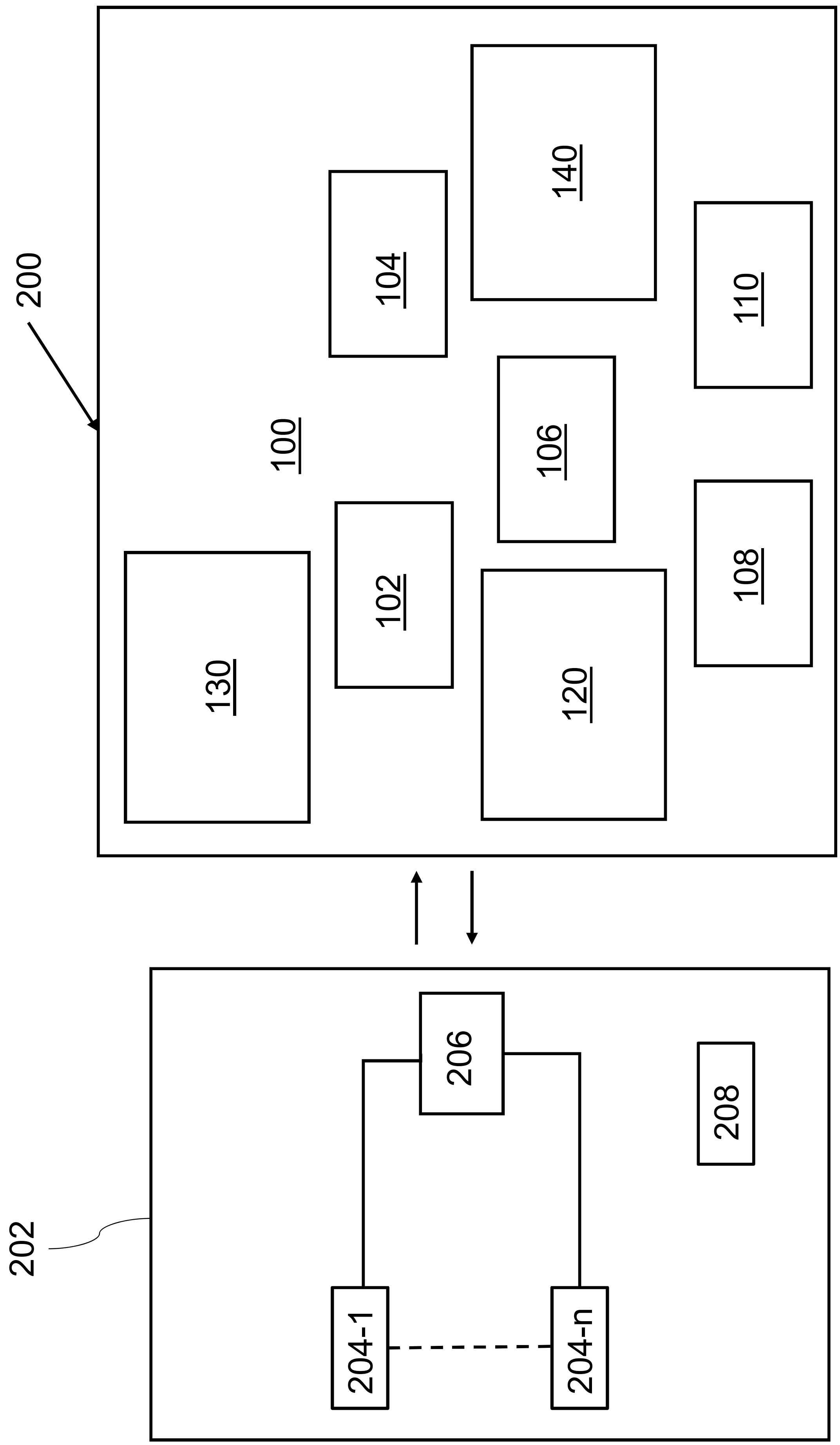


FIG. 2

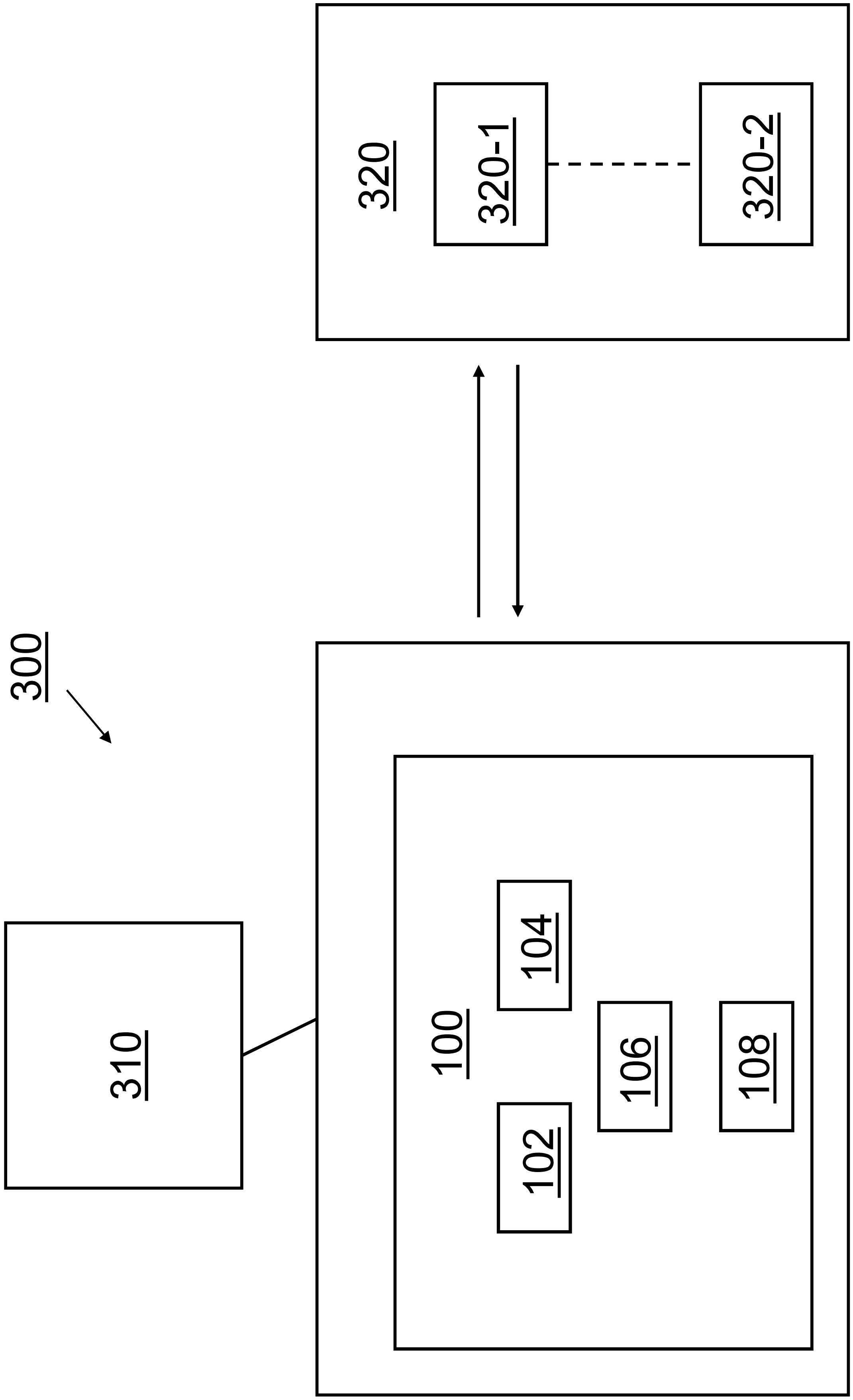


FIG. 3

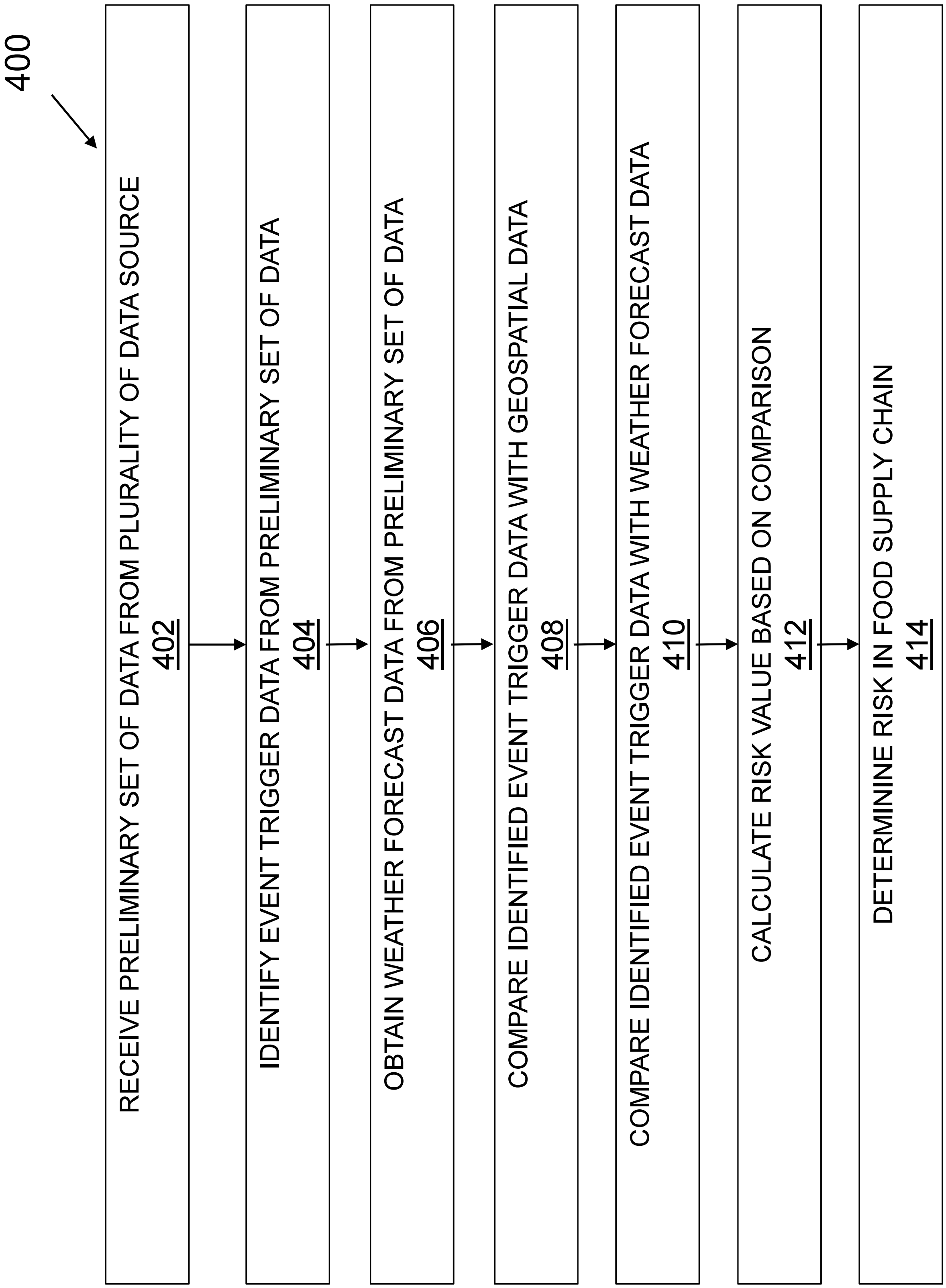
400
RECEIVE PRELIMINARY SET OF DATA FROM PLURALITY OF DATA SOURCE
402
IDENTIFY EVENT TRIGGER DATA FROM PRELIMINARY SET OF DATA
404
OBTAIN WEATHER FORECAST DATA FROM PRELIMINARY SET OF DATA
406
COMPARE IDENTIFIED EVENT TRIGGER DATA WITH GEOSPATIAL DATA
408
COMPARE IDENTIFIED EVENT TRIGGER DATA WITH WEATHER FORECAST DATA
410
CALCULATE RISK VALUE BASED ON COMPARISON
412
DETERMININE RISK IN FOOD SUPPLY CHAIN
414

FIG. 4