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IMAGE ACQUISTION AND PROCESSING FOR SUPPLY CHAIN RISK

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Introduction

Manufacturers of physical products need to manage risk across vast and complex global supply chains, often with little visibility beyond their direct suppliers. Disruptions in the supply chain cost companies millions of dollars each year in lost productivity or one-time procurement costs. Managing, monitoring, and mitigating risk is a meaningful way for a supply chain manager to reduce unplanned supply chain costs.

Summary

Satellite image acquisition is well known in the art. Many companies provide commercial satellite imagery. Existing imaging systems also allow the determination of polygons representing places on Earth from satellite and other imagery. Utilization of such imagery can provide supply chain managers with visibility into real world activity that directly impacts their business across a network of hundreds or thousands of relevant sites and can enable manufacturers to understand, monitor, and mitigate risk across the global supply chain, resulting in savings.

Detailed Description

Described are systems, methods, computer programs, and user interfaces for image location, acquisition, analysis, and data correlation. Results obtained via image analysis are correlated to non-spatial information useful for commerce and trade. For example, images of regions of interest of the Earth are used to monitor supply chain. Major manufacturing companies have very little visibility into their global supply chains, especially beyond their first tier of suppliers. Supply chain disruptions (e.g. a factory fire) are often discovered with little time to react, putting business continuity at risk. The present disclosure describes alerting supply chain managers of anomalous activity (e.g. more vehicles than expected) at critical nodes in their supply chain. Rapidly confirming disruptions and their impact well ahead of when they would otherwise learn from tier-1 suppliers, supply chain managers can quickly identify favorable alternate sourcing, and preserve business continuity, reducing losses.

The geographical coordinates of features on Earth, for example a particular supply chain location, can be mapped to textual descriptions. From these mappings, a polygon of interest on the surface of the Earth is determined. The polygon of interest's dimensions and coordinates control an image acquisition system. This system finds relevant and timely images in an image database and/or controls devices to acquire new images of the area. With one or more images of the polygon of interest available, various image enhancement techniques can be performed. Image enhancements can be performed to increase human and/or machine perception and discrimination of items of interest from the background.

Enhanced images, can then be presented to human workers to perform the visual analysis. The resulting counts are processed by analytic and statistical processes. These processes incorporate the results from many different images, and/or many results from the same image counted by different workers. The processes may include filtering functions to improve the resulting data.

Results of the processing can be correlated with non-spatial data, for example supplier output data. Over time these correlations allow the results of this analysis to be used in predicting the non-spatial data. For example, utilization of imagery to detect changes in a supply chain can create value by improving efficiency, decreasing insurance premiums, and also impacting sustainability. The systems described herein can be utilized in the early stages of planning a new supply chain or in optimizing an existing supply chain for efficiency.

Monitoring flow rates between suppliers and through key transportation infrastructure can allow a supply chain manager to optimize location and routing of supply chain nodes and lines. While visibility may not be provided into flow rates of a specific component through a node, historic data can provide information about the flow variability as measured by the number of cars, trucks, containers, etc. on site over time. Further, by reducing risk with increased visibility across the supply chain, manufactures may be able to doubly benefit by mitigating disruption costs and by negotiating lower insurance premiums by sharing their new monitoring methodology with their insurers. In addition, by increasing visibility across the supply chain, managers can ensure not only that their suppliers do not incur near-term risk that could result in sudden costly disruptions but also that they do not create significant environmental, humanitarian, or other social problems in the areas that they operate. Sustainability is a regular concern for manufacturers because unsustainable operations by their suppliers can create both near- and long-term costs including poor publicity, environmental remediation, and loss of support.

In some embodiments of this system, feedback from the image acquisition, image analysis, and non-spatial correlation is used to improve the data collected. For example, feedback may be used to refine the dimensions of the polygons of interest, the quality of the imagery, and the accuracy of the image analysis.

FIG. 1 shows a block diagram of one example of an imaging system 100, according to one embodiment. Input control parameters 105 specify the operation of the system. These parameters include textual non-spatial descriptions of areas of interest on Earth. Examples of non-spatial descriptions include “Supply Chain Node.” Other control parameters may include the type of data to be collected (e.g., supply chain output indicator), time and date ranges for image collection, the frequency of derived data measurement, or requirements for confidence scores of derived data.

The location search subsystem 110 determines polygons of features of interest on the Earth. The geographical coordinates of features on Earth, for example a particular supply chain node, are mapped to textual descriptions. The geographical coordinates may be obtained from geographical databases or prior imagery of the site, for example. The textual descriptions may, for example, be the Tier-3 Supply Chain Node. From these mappings, a polygon of interest on the surface of the Earth is determined.

The location search subsystem 110 can also be configured to receive feedback 169 from the non-spatial correlation subsystem 140. This may be the case where the non-spatial correlation subsystem 140 determines that additional information needs to be obtained by the location search subsystem 110. For example, the non-spatial correlation subsystem 140 may determine that the correlation between the count at a given location and the relevant output data is inconsistent, suggesting a need for more or different data that can be obtained by location search subsystem 110. The feedback provided to the location search subsystem 110 may include an updated search location, thereby resulting in different locations being searched for use in obtaining results.

The polygons of interest can be passed 115 to the image acquisition subsystem 120. The image acquisition subsystem 120 determines the quality and appropriateness of the polygons based on real images. For example, the image acquisition subsystem 120 may determine that a polygon is enlarged, shifted or refined relative to the real images. This polygon discrepancy information may be provided as feedback 167 to the location search subsystem 110 to improve the quality and appropriateness of polygons determined by the location search subsystem 110.

The image acquisition subsystem 120 can also use the spatial information describing the polygons of interest and the other control parameters to acquire an image, or set of images, that satisfy the control parameters for each polygon of interest. In some cases, image data is accessed from an existing image archive 150. Additionally, if needed, these images are sourced from image archives, including a social image archive. In other cases, image data is obtained from an image collection subsystem 160, such as a satellite or satellite network, array of security cameras, drones, or other purpose built image acquisition systems. Images may be acquired from either or both of the image archives 150 and image collection 160 depending on which images are the most economical and appropriate for the task.

In some cases, feedback information about the quality and alignment of the imagery is passed back 166 to the image acquisition subsystem 120. Based on this feedback, the image acquisition subsystem 120 can acquire more imagery. The image acquisition subsystem 110 is also configured to receive feedback 168 from the non-spatial correlation subsystem 140. The feedback may be used to alter the acquisition of images. For example the feedback may be used to change the frequency or time of day of image acquisition.

The acquired images can be sent 125 to the image analysis subsystem 130. The image analysis subsystem 130 evaluates the images, enhances and prepares the images, presents the images to the human workers with a task specific user interface, statistically processes the results, and passes those results 135 to the non-spatial correlation subsystem 140.

The image analysis subsystem 130 can include a number of methods for improving accuracy and throughput in image analysis. The capabilities of the image analysis subsystem 130 are described with respect to the example of supply chain visibility. However, the principles discussed are general and can be applied to many different image analysis tasks. Image enhancement and analysis can be performed with automated systems and/or human-in-the-loop systems. In some cases, the image analysis subsystem 130 receives feedback information 165 about the accuracy and adequacy of its results from the non-spatial correlation subsystem 140. In these cases, the data is modified, or the image analysis is re-performed according to the feedback information.

The non-spatial correlation subsystem 140 can receive result data 135 from the image analysis subsystem 130, and calculate temporal correlation between that data and output data of interest. For example, a supply chain manager can utilize the described systems to actively monitor the company's most business-critical tier-1, tier-2, and tier-3 suppliers with daily activity data. If an anomalous increase in the number of vehicles on site at one of the tier-2 suppliers is noticed over the course of several days, the manager can call the supplier to determine if an issue has occurred (e.g. a significant fire on-site has resulted in the on-site presence of emergency vehicles, law enforcement, and press). In this manner, an alternate supplier can be identified if needed.

The non-spatial correlation subsystem 140 can collect correlation data over time. The collected data is used to create a prediction of future output metrics based on previously collected correlations between image analysis data and output data. For example, utilization of imagery can provide supply chain managers with visibility into real world activity that directly impacts their business across a network of sites.

Figures

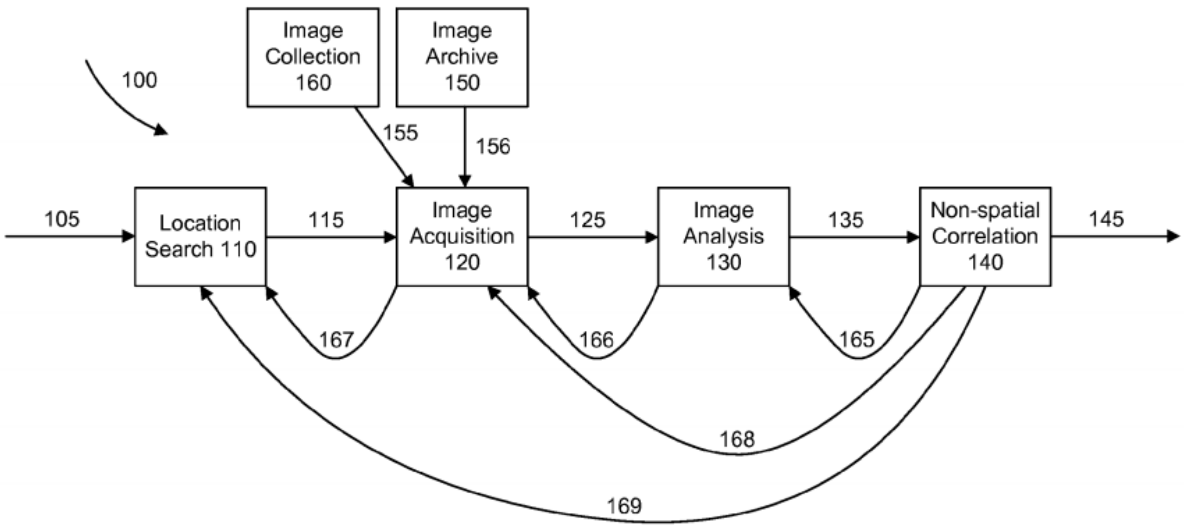

FIGURE 1

Abstract

Described are systems, methods, computer programs, and user interfaces for image location, acquisition, analysis, and data correlation. Results obtained via image analysis are correlated to non-spatial information useful for commerce and trade. For example, images of regions of interest of the Earth are used to monitor supply chain. Major manufacturing companies have very little visibility into their global supply chains, especially beyond their first tier of suppliers. Supply chain disruptions (e.g. a factory fire) are often discovered with little time to react, putting business continuity at risk. The present disclosure describes alerting supply chain managers of anomalous activity (e.g. more vehicles than expected) at critical nodes in their supply chain. Rapidly confirming disruptions and their impact well ahead of when they would otherwise learn from tier-1 suppliers, supply chain managers can quickly identify favorable alternate sourcing, and preserve business continuity, reducing losses.

Keywords associated with the present disclosure include: image acquisition, satellite imagery drone imagery, supply chain, supply chain disruptions.