IMAGE ACQUISTION AND PROCESSING FOR FACILITY LOAD FORECASTING

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Introduction

Companies operating critical infrastructure across global supply chains (e.g. port terminals, warehouses) or the vehicles moving between those infrastructure sites (e.g. ships, trucks) have little visibility outside of the domains they control. Changes at upstream or downstream sites can create unpredictable slowdowns or activity spikes for a company’s own operations, which result in significant operational inefficiencies.

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 visibility into key infrastructure nodes across the transportation/logistics system that impact loads on a company’s facilities. With a better understanding of the flows and choke points across the system, companies can more effectively optimize operations to match expected loads and incur significant efficiency 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. For example, images of regions of interest of the Earth are used for facility load forecasting. Companies operating critical infrastructure across global supply chains (e.g. port terminals, warehouses) or the vehicles moving between those infrastructure sites (e.g. ships, trucks) have little operational visibility outside of the domains they control. Traffic changes at upstream or downstream sites can create unpredictable
slowdowns or activity spikes for a company’s own operations, which result in significant operational inefficiencies. The systems and methods of the present disclosure provide these companies with visibility into other key infrastructure nodes across the transportation/logistics system that impact loads on their own facilities. With a better understanding of the flows and choke points across the system, companies can more effectively optimize operations to match expected loads and incur significant efficiency savings.

The relevant activity at logistics and transportation infrastructure can be measured by tracking large physical objects such as shipping containers, trucks, cars, ships, and dry bulk stockpile volumes. The problem faced by operational managers of infrastructure and freight is rooted in the fact that they have little visibility into sites not under their own control. These sites are part of a larger system where activity or slowdowns at one sites impacts the load on other sites across the system. The network of facilities that make up logistics and transportation systems are vast and global. As supply chains increase their global footprint, the number and distribution of transportation/logistics facilities has expanded significantly. Thousands of ports and exponentially more warehouses/distribution centers/intermodal hubs span the globe.

Infrastructure operations managers’ improved ability to forecast load on their own facility allows them to 1) provide competitive service to their customers and 2) adjust staffing levels to that which are required for a certain operational load. Incorrect load predictions can result in 1) poor service and lost customers and/or 2) excess costs of over-staffing. Avoiding those losses and costs creates significant value. Similarly, freight operations managers’ improved ability to forecast load on the logistics/transportation infrastructure through which they convey their vehicles/vessels allows them to 1) provide competitive service to their customers, 2) win higher-value contracts with tighter delivery windows, and/or 3) reduce fuel consumption and associated
costs through “slow steaming” when they determine that they are ahead of schedule. All three areas create significant value.

The geographical coordinates of features on Earth, for example a location at which a facility load forecasting is to be performed, 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, shipping containers, trucks, cars, ships, and dry bulk stockpile inventories can be correlated with site coverage over time and historical operations data, including for ports, warehouses, distribution centers, intermodal terminals). Over time these correlations allow the results of this analysis to be used in predicting the non-spatial data. For example, utilization of imagery can identify existing or potential sources of activity data associated with facility load forecasting.

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 “Facility Load Forecasting Site.” Other control parameters may include the type of data to be collected (e.g., cars, trucks, shipping containers, construction, ships, oil, dry bulk), 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 facility load forecasting site, 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 Facility Load Forecasting Site. 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 facility load forecasting 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 to the image acquisition subsystem. The image acquisition subsystem determines the quality and appropriateness of the polygons based on real images. For example, the image acquisition subsystem may determine that a polygon is enlarged, shifted or refined relative to the real images. This polygon discrepancy information may be provided as feedback to the location search subsystem to improve the quality and appropriateness of polygons determined by the location search subsystem.

The image acquisition subsystem 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. 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, 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 and image collection subsystem 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 to the image acquisition subsystem. Based on this feedback, the image acquisition subsystem can acquire more imagery. The image acquisition subsystem is also configured to receive feedback from the non-spatial correlation subsystem. 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 to the image analysis subsystem. The image analysis subsystem 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 to the non-spatial correlation subsystem.

The image analysis subsystem can include a number of methods for improving accuracy and throughput in image analysis. The capabilities of the image analysis subsystem are described with respect to the example of facility load forecasting. 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 receives feedback information about the accuracy and adequacy of its results from the non-spatial correlation subsystem. In these cases, the data is modified, or the image analysis is re-performed according to the feedback information.

The non-spatial correlation subsystem can receive result data from the image analysis subsystem, and calculate temporal correlation between that data and facility load forecasting data of interest. The data can add value to facility load forecasting because such data is physically observable, and can relate to remote and/or inaccessible locations. In addition, data freshness or rate of change can be important to such analysis.

The non-spatial correlation subsystem can collect correlation data over time. The collected data is used to create a prediction of future metrics based on previously collected correlations between image analysis data and facility load forecasting data.
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. For example, images of regions of interest of the Earth are used for facility load forecasting. Companies operating critical infrastructure across global supply chains (e.g. port terminals, warehouses) or the vehicles moving between those infrastructure sites (e.g. ships, trucks) have little operational visibility outside of the domains they control. Traffic changes at upstream or downstream sites can create unpredictable slowdowns or activity spikes for a company’s own operations, which result in significant operational inefficiencies. The systems and methods of the present disclosure provide these companies with visibility into other key infrastructure nodes across the transportation/logistics system that impact loads on their own facilities. With a better understanding of the flows and choke points across the system, companies can more effectively optimize operations to match expected loads and incur significant efficiency savings.

Keywords associated with the present disclosure include: image acquisition, satellite imagery drone imagery, facility load forecasting, facility load.