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Cargo Security Early Warning System - The Application of Neural Networks to Detect Cargoes

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Cargo Security Early Warning System – The Application of Neural Networks to Detect Cargoes with Potential Security Fraud

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Abstract

Every year, more than 5,500 vessels carrying 4.5 million cargo containers pass through the airports and harbors of the U.S. With $200 billion worth of goods flowing in and out of Los Angeles and Long Beach, these ports have a large influence on the economy, across several different industries including aerospace, electrical, consumer products, textiles, among others [1]. Given the importance of the ports and their significant influence on the urban population, it becomes more and more important that some type of real-time monitoring/early warning system is needed to ensure the security and safety of the ports. Ever since the terrorist attacks of September 11, 2001, security has become a national epidemic. Great emphasis has been placed on securing the U.S. borders to help minimize any threat of attack. With that, it has been increasingly recognized that the country's ports represent a significant point of entry and vulnerability. For example, in 2004, customs inspectors started scanning more than double the percentage of packages compared with 2003 after recognizing the potential threat. Nevertheless, only 5.4 percent of all incoming cargo is scanned for contraband given the enormous cost and time necessary for manual inspection. Even with the advent of gamma, X-ray, and radiation detection technology, manual inspection of all cargo coming from just the ports of Los Angeles and Long Beach alone would not be practical given the processing time and financial implications, and the fact that these two ports represent 30 percent of all U.S. international sea trade. Known that the current security controls in place at the ports are not adequate for today's environment, an information system solution to support safe movement of cargo would greatly improve safety with a minimum impact on current processes. According to Rod MacDonald, acting assistant commissioner of the U.S. Customs Border Protection's Office of Information and Technology, collecting and reviewing shipment information before arrival is the best solution to combating illegitimate cargo. Application of an information technology solution that takes into account the variability of the cargo process and container variations would be ideal. Therefore, this research explores the possibility of applying artificial intelligence (AI) and machine learning techniques such as neural networks to the security issue at hand. Information is one of the most valuable assets for any organization, and neural networks can exploit this advantage through in-depth analysis and informed decision-making.

SOM Network is a special type of neural network that can learn from complex, multi-dimensional data and transform them into visually decipherable clusters. The theory of the SOM network is motivated by the observation of the operation of the brain. Various human sensory impressions are neurologically mapped into the brain such that spatial or other relations among stimuli correspond to spatial relations among the neurons organized into a two-dimensional map [2]. The main function of SOM networks is to map the input data from an n-dimensional space to a lower dimensional (usually one or two-dimensional) plot while maintaining the original topological relations. The physical locations of points on the map show the relative similarity between the points in the multi-dimensional space. In other words, the data points that were close in the higher dimensional space should remain close in the reduced lower dimensional map. Therefore, when grouped into clusters, the cargoes that possess similar attributes values will be in the same cluster. Besides providing the cluster membership information, the SOM visual map clearly depicts the actual relationship among the cargoes within and among different risk groups.

The objective of this study is to explore the possibility of applying SOM neural networks as an early warning system to alert port authorities with cargoes of potential security fraud. When fed the appropriate data inputs regarding cargo containers, this system would "learn" the differences between potentially lawful and unlawful cargoes. Unlawful cargo would include forms of contraband such as untaxed cigarettes, infested fruit, counterfeit software, illegal immigrants, narcotics, drugs, "dirty bombs" (i.e., explosives filled with nuclear waste), weapons, and other terrorist devices. X-ray, radiation scanners, and cameras can only go so far as to detect these forms of contraband. A neural networks based early warning system will allow for port personnel to focus their investigation

efforts on cargoes that are more likely to contain contraband, which helps to improve detection efficiency and safety.

Because this study is a preliminary investigation of the applicability of SOM to cargo security warning system, we first focused on artificially constructed data. Knowledge of the true data generating mechanisms (the correct cluster membership for each observation) is essential for valid comparisons with respect to the accuracy with which SOM recovers the true cluster structures. A total of 150 random observations were generated that contains 5 observed variables, representing the five important factors: 1) port and country of origin, 2) shipping line/forwarder, type, 3) shipper/exporter and consignee, 4) nature of goods on manifest, and 5) nature of paperwork files/filled out, were equally distributed among the three segments (clusters), low, medium, and high risk.

Predictive models based on statistical techniques have been widely adopted and some techniques perform reasonably well in terms of rate of correctness in their predictions. However, all methods require complex and advanced analytical skill to explain and interpret the output from the prediction model. In this study, we introduce the Self-Organizing Map (SOM) Network that can learn from complex, multi-dimensional data and transform them into visually decipherable clusters on an output map. A salient feature of using SOM method over the other approaches is the added visual map. The 2-dimensional plot provides an easy-to-read graphical interface that does not require specialized analytical knowledge to interpret the results. It is a valuable decision support tool that helps the port personnel visualizes the relationships among inputs. Therefore, the port personnel can interactively determine the composition of the clusters using the output map of SOM and incorporate subjective criteria when desired.

Keywords: SOM Kohonen Networks, cargo security, early warning system, clustering analysis

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