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AN ANALYZIS OF THE PERSPECTIVES OF THE MODERN APPROACH TO THE VESSEL TRAFFIC SERVICES OPERATION AND ITS IMPLEMENTATION

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ABSTRACT

Nowadays, the growth of density of marine traffic is expected due to the development of the world-wide trade and the demand for the resources to be transported all over the world. With the rise of density of traffic, the workload of the VTS in regard to monitor the vessels' behavior is expected to increase, which may result in the growth of the risk to safety of navigation. On the other hand, the availability of the modern algorithms may make it a perspective opportunity to develop an aid to the operation of those services [1].

The goal of this study is to explore the state-of-the-art algorithms' core ideas and analyze their compatibility with the stated task, as well as to projects the implementation issues of them into the current system.

VTS overview

According to the description of Odesa VTS: "Safety control of all vessels in port waters is performed by Vessel Traffic Service (VTS). All maneuvers in controlled water areas and port waters must be done under the VTS control. For all operations including entering the controlled area, dropping and heaving up anchor, mooring and leaving berth, shifting, heaving the log and so on, vessels must request VTS permission."

Marine traffic is controlled by Vessel Traffic Services (VTS). All VTS operations can be split into three categories, as defined by IALA - Information Service (INS), Traffic Organization Service (TOS) and Navigational Assistance Service (NAS). The main point of the interest is the operation of NAS [2].

According to the Dmitry Rostopshin, Director of the Ship Traffic Control and Management Solutions, Transas Marine International, the most discussed ways of increasing the quality of this part of VTS are enhanced route monitoring, automatic under keel clearance calculation tools and active decision-support system.

Modern algorithm overview

Due to the nature of maritime trade, it's impossible to develop a strict set of rules in regard to the most navigation aspects. Even COLREG rules leave room to deviate from them, which makes the idea of developing any aid to the evaluation of maritime traffic an overwhelming task, but there are some ways of approaching this problem.

Artificial Neural Network (ANN) simulates the processes of the human brain. The ANN makes associations between varieties of information. The ANN realizes the intuitive reasoning rather than the logical reasoning normally executed by machine. The main advantage of ANN is the ability to incorporate uncertainty as well as data whose dynamic character has led to a number of studies that establish its applicability in prediction of marine traffic [2].

One of the ANN schemes is the back-propagation (BP) network. The back-propagation neural network architecture is designed by fully interconnected layers or rows of processing units. The inter connections are called weights, and provide the means for the ANN to save knowledge, the process of A learning B. Also, the errors are calculated during this process. These errors are used to back-propagate from the output neurons to all the hidden neurons, so all the weights are adjusted by the errors. This learning process continues till the error is reduced to specified minimum values. After that the weights are saved as the ANN knowledge. The weights are used to perform information processing operation by back-propagation algorithm. The ANN may have as large numbers of neurons as it needs. Likewise, the number of layers is exchangeable. The ANN behavior depends on the simple activation function which could be a linear or a non-linear [3].

The ANN knowledge is training by pre-mined data and the weights are saved. Moreover, the

ANN has the capability to learn with any complex structure of data. So, the ANN is capable to implement a learning algorithm and make decision support ability of marine traffic prediction.

Modern algorithm model

A three-layer neural network model can be developed to predict the turning regions of vessels in marine traffic. The ANN inputs were vessel's:

1. Latitude of turning regions;
2. Longitude of turning regions;
3. Speed;
4. Course;
5. MMSI number;
6. Dimension (length & width);
7. Type of vessel.

The ANN outputs were used to predict the next action of the vessels. The ANN output is a matrix which contains:

1. The angle of vector of further proceeding;
2. The magnitude of vector of further proceeding for each vessel.

The ANN was fully connected and every neuron is connected to second layer neuron. The output of each neuron was calculated by an activation function. All the inputs were summed by neurons with threshold. To develop the ANN, the pre-mined data was divided into two parts: 90% of turning points were used to train the ANN and the rest of observations were used for validation. All data was normalized to common interval of [-1, 1]. The algorithm was solved by python 3 with neuron package. The relationship between the output (yt) and the inputs ($yt-1,\ldots,-p$) has the following mathematical representation:

$yt = w0 + \sum wjg\ (w0j + \sum wijyt-1\ p\ i=1\ ) + et\ Q\ j=1$, (4) Where$wi,j(\ i = 0, 1, 2, \ldots , P,j = 1, 2, \ldots ,Q)$ and $wj(j = 0, 1, 2, \ldots ,Q)$ (1)

The activation function is often used as the hidden layer transfer function. That is, Sig(x) = 1 1+exp(−x)

Once a network structure (P, Q) is specified, the network is ready for training, a process of parameter estimation. The parameters are estimated so that the cost function of neural network is minimized. Cost functions - an overall accuracy criterion such as the following - mean squared error. This minimization is done with some efficient nonlinear optimization algorithms other than the basic propagation training algorithm. After the artificial neuron network receives the inputs, it will propagate them from the input layer through the hidden layers to the output layer, where the responses are obtained. This artificial neuron network learning process deals with speed of convergence and the local minima.

Conclusion

How to implement the described model into the real life? The program that we have described states the expected tendency of the development of the situation. And so, it is now clear how to predict the vesssel's behavior according to the program's data, which means that it may state its awareness about the unusual behavior to the VTS operator, who is responsible for the monitoring. The best part of that approach is that the program does not stop learning after being given the initial data. It continues to absorb the information about the "normalness" of the vessels' behavior and will adapt to the style of the operators of the VTS, which may make it a perfect aid for their work.

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