УДК 629.5.072
DOI: 10.34046/aumsuomt92/5

АНАЛИЗ НЕКОТОРЫХ АСПЕКТОВ ДВИЖЕНИЯ СУДНА В СТЕСНЕННЫХ ВОДАХ ДЛЯ ПРЕДВАРИТЕЛЬНОГО ПЛАНИРОВАНИЯ МАРШРУТА

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В статье рассмотрена проблема безопасности мореплавания. В целях обеспечения безопасности судоходства необходимо спланировать предстоящий переход от причала до причала и произвести предварительную прокладку. Для судов процесс планирования перехода начинается заранее и может основываться на онлайновом расписании судна, информации от оператора или агента судна. Маршрут судна должен быть спланирован таким образом, чтобы свести к минимуму вероятность возникновения опасной ситуации. Различные факторы, описанные в статье, не позволяют правильно оценить всю необходимую информацию для навигации судна. Недостатки могут быть устранены с помощью автоматизации процессов планирования маршрута судна, путем создания искусственно-интеллектуальной системы, в частности использование интеллектуального анализа данных при выборе параметров предварительной прокладки. Первоначальной целью работы было создание системы поддержки принятия решений для судоводителей. Результаты исследования оказались неожиданными, и были сделаны некоторые важные выводы.
Ключевые слова: предварительное планирование маршрута; сбор данных; система поддержки принятия решений; кластеризация.

The problem of safety of navigation has been considered in the article. In order to ensure the safety of navigation it is necessary to plan the upcoming passage from the berth to berth and carry out preliminary plotting. For ships, the passage planning process begins in advance and may be based on the vessel's on-line schedule, information from the ship's operator or agent. Route of the vessel should be plotted in such a way as to reduce the probability of a dangerous situation to a minimum. Various factors described in the article do not allow a good assessment of all the necessary information for the navigation of the vessel. The disadvantages can be eliminated by automating the vessel's route planning processes by creating an artificially intelligent system, in particular the use of data mining when selecting pre-route parameters. The initial goal of the work was a creation a decision support system for navigators. The research results were unexpected and some important conclusions were made.
Keywords: preliminary route planning; data mining; decision support system; clustering.

1. INTRODUCTION

The most important problem of modern shipping is the safety of navigation, despite the scientific advances in the field of automation of navigation, development and implementation of E-navigation. This comes out of various papers about the maritime accident rate analysis, which shows that more than 80% of accidents occur for reasons related to the "human factor"[1,3,4]. The problems arising in the process of human interaction with technical means, as well as the negative impact of the human factor on the efficiency, reliability and safety of interaction of elements of the " human machine" system, devoted to the works of many authors. Most navigational accidents do not occur due to of the failure of technical means of navigation or vessel traffic control, but due to the unavailability of navigators to make the right management decision in time in accordance with the current situation [2]. Often the reasons of this type of accidents are connected with neglect of recommendations for navigation, the choice of a route of the vessel in proximity to dangers, excessive speed of the movement, inappropriate consideration of hydro meteorological conditions [5], lack of discipline, negligence and carelessness, incompetence, and emotional instability of navigators. This problem is solved by various organizational and technical measures, as well as by reducing the influence of the human element in the navigation process by transferring some of the functions from the human operator (navigator) to modern navigation and control systems based on artificial intelligence. These can be simple monitoring and control functions, as well as more intelligent ones related to the development of decisions for the assessment and prediction of the navigation situation, as well as for the management of the vessel (both in normal and emergency situations).

In order to ensure safety of navigation, a more effective organization of the processes of preliminary appraisal, passage planning and prediction of the trajectories of the vessel's movement are necessary. The route of the vessel should be plotted in such a way as to reduce the probability of a dangerous situation to a minimum and to provide for the possibility of maneuvering to prevent a collision at any time.

Prospective directions of development of technical means of navigation and ship control, as defined by the amendments to SOLAS-74 (Chapter V), open up possibilities for the implementation of algorithms for automatic route selection and software trajectories of vessel movement, their continuous monitoring.

At present, information in navigation complexes is presented both as separate elements, and at the level of an electronic chart and the trajectory of a vessel. The use of electronic chart navigation information systems (ECDIS) provides a number of advantages compared with a paper marine navigation chart (MNC) in storing and presenting information, automating the process of proofreading, selecting and changing charts, choosing their scale, possibilities of combining with radar information, etc. . [11].

However, an analysis of the functions of existing and projected ECDIS [2] shows that their potential is not fully used to solve the problems of navigation and ensure the safety of navigation. The ECDIS information base can serve as a starting point for the implementation of solutions to the problems of automated search, planning and optimizing the route of a vessel's transition in terms of safety and efficiency.

Chemical tankers, oil tankers and other types of vessels carrying dangerous goods have short-term berths in ports. At the same time, the workload of watches, due to the reduction of crew members and savings from the largest shipping companies, also cargo operations, various inspections the increase in the volume of work performed by the navigators and create a significant shortage of time, fatigue and other psychophysiological stresses that adversely affect concentration and concentration of attention during planning of the passage. The combination of these factors, as well as the assessment of route safety by the officer of the watch does not allow good evaluation of all necessary information for the navigation of the vessel. These disadvantages can be eliminated by automating the vessel's route planning processes [6], in particular the use of data mining when selecting pre-route parameters

2. SOME WAYS TO CREATE AN ARTIFICIALLY INTELLIGENT SYSTEM

One of the ways to solve the problem of safety of navigation is to reduce the influence of the human element on the navigation process by transferring a part of the functions from a human operator (navigator) to modern navigation systems and artificial intelligence-based control systems. It can be as simple as monitoring and control functions, as well as more intelligent, related to the development of decisions on the assessment and forecast of the navigation situation, as well as on the management of the vessel (in both normal and emergency situations). The use of artificial intelligence in navigation in no way calls into question the qualifications of the person on the bridge, namely, the close interaction of the navigator and the intellectual support system to make informed decisions, especially in difficult situations (when navigating in congested waters, in case of emergency situations on the vessel).

There are several examples of artificial intelligence systems that currently exist: autonomous planning and scheduling, game management, autonomous control, medical diagnostic programs based on probabilistic analysis, providing automated supply planning and scheduling of shipments, robotics, understanding natural language and problem solving, property management. Banks use artificial intelligence systems in their insurance business.

However, artificial intelligence is no more than the common name for disparate efforts to develop various computational models that implement certain aspects of intelligence. Modern successful implementations of artificial intelligence turned out to be the result of efficient data mining algorithms, not artificial intelligence algorithms. Data mining technologies were developed in the 1990s. Artificial intelligence is logic, and data mining is statistics. Until the 1990s, these areas were not related at all [10].

Data mining is the processing of information and the identification of patterns and trends in it that help to make decisions [7]. Data mining can be performed with relatively modest database systems and simple tools, including creating your own. It is possible to work with very large data sets and cluster / large-scale data processing, which makes it possible to make even more complex summaries of data mining by groups and comparisons of data.

Data mining uses well-researched statistical principles to highlight patterns in data. By applying data mining algorithms to data, you can predict trends, highlight patterns, create rules and recommendations, analyze the sequence of events in complex data sets, and discover new dependencies. The tasks solved by data mining methods are usually divided into "descriptive" and "predictive" [8]. In descriptive tasks, the most important thing is to give a visual description of the existing hidden patterns, while in predictive problems the first question is the question of prediction for those cases for which data are not yet available.

According to the methods of solving the problem is divided into supervised learning (learning with a teacher) and unsupervised learning(learning without a teacher. In the case of supervised learning, the data analysis problem is solved in several stages. First, with the help of any Data Mining algorithm, a model of analyzed data is built-a classifier. The classifier is then trained. In other words, the quality of its work is checked, and if it is unsatisfactory, there is additional training of the classifier. This continues until the required level of quality is reached or it becomes clear that the selected algorithm does not work correctly with the data, or the data itself does not have a structure that can be identified. Unsupervised learning combines tasks that identify descriptive models, such as patterns in purchases made by customers of a large store. Obviously, if these patterns exist, then the model should present them and it is inappropriate to talk about her learning. The advantage of such tasks is the possibility of solving them without any prior knowledge about the data being analyzed.

There are several basic methods that are used for data mining: association, classification, clustering, forecasting, decision trees. A good way to apply advanced data mining techniques is a flexible and interactive tool that is fully integrated with the database or data warehouse. Using the same tool that works outside the database / data warehouse is not as efficient as using it will require additional steps to extract, import and analyze. When the data mining tool is integrated with the data warehouse, it simplifies the application and implementation of search results.

When selecting the parameters of the pre-routing of the vessel, the navigator is faced with a large amount of data. It is the clustering method that makes it possible to best group individual data elements together to form a structured conclusion. The clustering method works both ways. It can be assumed that at a certain point there is a cluster, and then use their own identification criteria, and can be applied in the opposite direction: given certain input attributes, identify various artifacts.

Clustering is useful in defining different information because it correlates with other examples, so you can see where similarities and ranges are consistent. It should be noted that the use of intelligent systems in the fleet minimizes the risk of human error and radically increases both the safety of navigation and the efficiency of water transport management.

3. AIM OF THE WORK

At first, authors believed that there may be some potential to create a decision support system from following data combined with a simple idea.

A dataset of various vessels moving through Dardanelles was created, namely, 3 sets of points, speeds and headings. This was collected in close proximity of point Nara, so the vessels were supposed to do maneuvering, and that they did. Looking back to personal past experience of passing through the narrows and other congested waters (as well as Dardanelles themselves), some authors believed that it is possible to create a special layer (perhaps, for ECDIS systems) where the heading could be chosen more or less from current position. A very convenient instrument seemed just a perfect match to prove that – clustering.

4. STEPS OF THE WORK

Information of the vessels movement came in 3 sets, so, bearing in mind the classical FCM method (ever reliable, it is well known, e.g.[9]) we decided to have some variations. At first, there was an attempt to have 3 clusters in each set. In preprocessing we decided to omit the speed, because the conclusion was pretty obvious – speed decreased when the ship vas maneuvering and increased afterwards. For speed and distance from the cell's centre we had somewhat modified approach.

At first it went as usual:

$$\mu_i = [(1 + \frac{s_{i+1}}{s_i} + \frac{s_{i+2}}{s_i})^{\frac{2}{m+1}}]^{-1} \quad (1)$$

Here μ is degree of membership, S is a measured distance between a clustered value and cluster center, *m* is auxiliary parameter which defines the "steepness" of fuzzy "slopes", and *i* is index (however *i* is a ring set index).

There is a standard formula to define the cluster centers *v* of M data lines:

$$v_{0i} = \frac{\sum_{k=1}^{M}(\mu_{ik})^m v_k}{\sum_{k=1}^{M}(\mu_{ik})^m} \quad (2)$$

However, bearing in mind that we have 3 subsets for each cluster, we may do the same for each cluster.

The data fed to the analyzer was processed in the following manner:

- Excluded 3 σ out of mean values for the cluster.
- Values were quantized, to obtain values of coordinate's change that actually mattered to navigator enough to change heading.

$$X_a = q * r(\frac{X_b}{q}) \quad (3)$$

X_a , X_b – values before and after quantizing, q – value of the quant, *r()* – simple rounding function.

- Then values were then re-fed to clustering.

For the experiment we used simple metrics, a Euclid distance [8]:

$$S_i = \sqrt{(X_d - v_d)^2 + K(X_h - v_h)^2} \qquad (4)$$

Here indexes d and h refer to distance and heading, K – normalizing coefficient

Thus, taking into account formulas 3&4 we can rewrite formula 1 as follows:

$$S_i = \sqrt{q_d * r(\frac{X_{dbi}}{q_d}) - v_d)^2 + Kq_h * r(\frac{X_{hbi}}{q_h}) - v_h)^2}$$

$$\mu_i = [(1 + \frac{\sqrt{q_d * r(\frac{X_{dbi+1}}{q_d}) - v_d)^2 + Kq_h * r(\frac{X_{hbi+1}}{q_h}) - v_h)^2}}{\sqrt{q_d * r(\frac{X_{dbi}}{q_d}) - v_d)^2 + Kq_h * r(\frac{X_{hbi}}{q_h}) - v_h)^2}} + \frac{\sqrt{q_d * r(\frac{X_{dbi+2}}{q_d}) - v_d)^2 + Kq_h * r(\frac{X_{hbi+2}}{q_h}) - v_h)^2}}{\sqrt{q_d * r(\frac{X_{dbi}}{q_d}) - v_d)^2 + Kq_h * r(\frac{X_{hbi}}{q_h}) - v_h)^2}})^{\frac{2}{m-1}}]^{-1} \qquad (5)$$

5. RESULTS OF RESEARCH

Results were however, somewhat unexpected. No good cluster set was obtained for almost all reasonable combinations of q (100 iterations for each combination). Alternative analysis did not give other results. Then we started other experiments, to check if the number of clusters was right. This way we deevolved our clustering to a simple check if the clusters are at all definable. And that was our best set, shown on fig.1.

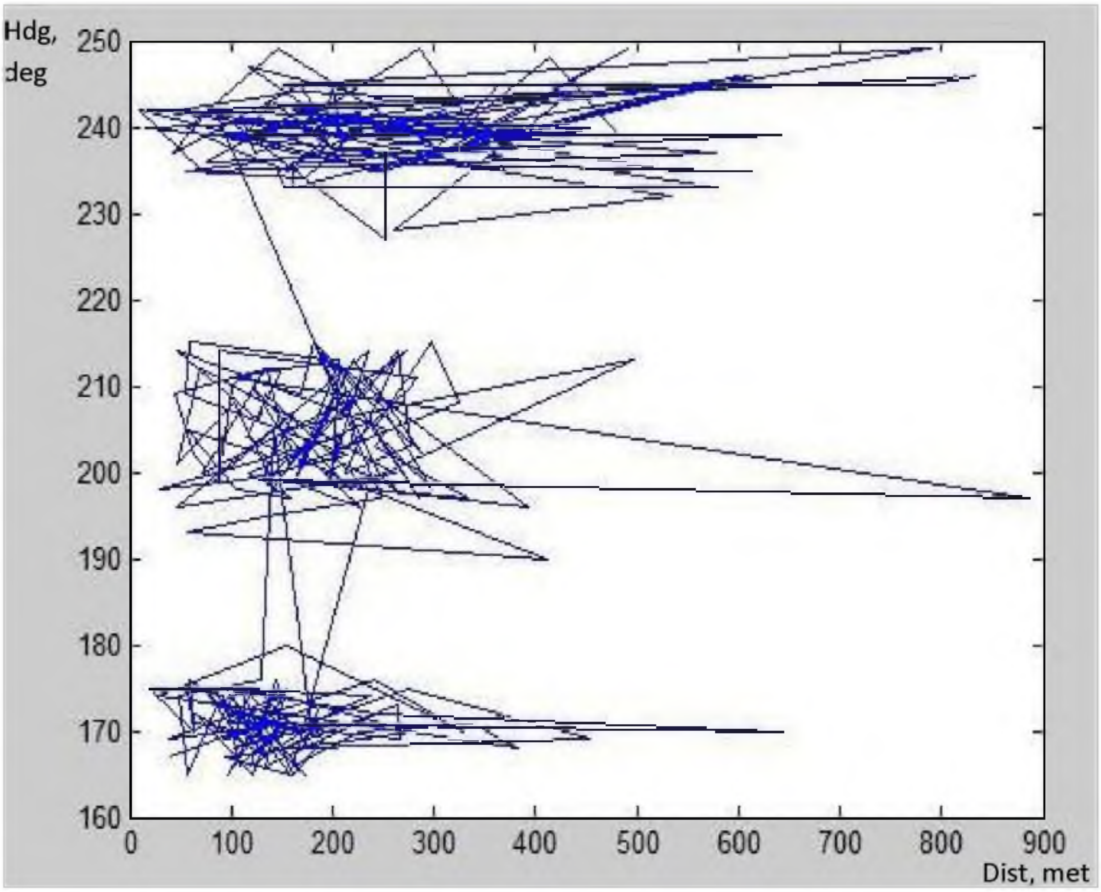

Fig. 1.- Best set of clustering

6. CONCLUSIONS

Despite the failure of reaching preliminary goals, some important conclusions can be made:

1. Vessel's heading depend mainly on the sector of it's route, almost irrespective of position inside.

2. Thus clustering and quick analysis may be not the best way to create a decision support system for navigation, because vessels may actually act very differently and succeed. Even in these congested waters near p. Nara of Dardanelles.

3. Maybe the standard clustering approach is valid in the circumstances, but in respect to 1 and 2 the research for an approach with different clustering means is reasonable.

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