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Unmanned Ship Target Recognition System Based on Association Rules

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Abstract: With the advent of the era of intelligence, the development of unmanned ship technology, greatly improve the efficiency of ocean monitoring, in civilian, unmanned ship can detect the sea surface weather conditions and underwater current, but also can monitor the sea surface ship accidents, illegal fishing and other phenomena; Militarily, unmanned vessels can conduct border patrols to monitor maritime violations and carry military weapons to safeguard China's maritime rights and interests. The purpose of this paper is to study the unmanned ship target recognition system based on association rule algorithm. From the point of view of system development, the hardware structure of unmanned ship target recognition system is put forward, and the system function module is described. The design of video acquisition, intelligent recognition, intelligent alarm, data transmission and other functional modules in the unmanned ship target recognition system is carried out with the idea of modularity. The association rule mining algorithm is used to mine the navigation beacon accident data, and the potential information mining is carried out in a variety of ways. The causes and internal rules of navigation beacon accidents are analyzed. The experimental results show that the southeast wind is easy to cause navigation beacon accidents due to natural causes under heavy rain.

1. Introduction

Modern technology is moving towards intelligence and systems development as disciplines become more prevalent. A series of high technologies such as various environmental recognition technologies, communication technologies and ship-related image processing technologies have also been widely applied, providing a solid theoretical basis and advanced technical support for the development of unmanned ships [1-2]. The unmanned ship target identification system plays an important role in the military field of maintaining maritime security and the need to investigate information such as hydrology, meteorology and seabed topography, as well as in the military and civil fields [3-4].

In order to solve the problem of low accuracy and high computation rate of unmanned target recognition in complex visual field environment, Masatoshi Hatano proposed OpenCV visualization processing structure and established an unmanned target recognition system based on machine learning. The haar cascade classifier training algorithm is used to establish an automatic learning library for the target object. The relationship between the maximum recognition rate and the minimum error rate, as well as the influence of positive and negative sample size and proportion on time and training accuracy are analyzed, and the optimal configuration range of parameter values is obtained. Through the reflection effect of water surface, the correlation coastline recognition algorithm is adopted to accurately identify the coastline and improve the efficiency of target recognition in water [5]. Mahdi Nouri proposed a method for ship detection and recognition based on multilevel hybrid network, and designed a multilevel two-dimensional template filter and a three-layer pyramid structure denoising smooth image enhancement algorithm. Combined with the global and local image gray statistics, the adaptive segmentation detection and ultra-lightweight target classification network model is constructed. The combination of traditional image processing and deep learning methods greatly reduces the need for computing and storage resources. The proposed method can quickly detect and identify ship targets near the sea and air planes, and the accuracy is more than 90%. Compared with Tiny YOLOV3 network, the accuracy is reduced by 5%, but the computational efficiency is increased by 50 times and the parameters are reduced by 550 times [6]. Therefore, it is a very beneficial measure to continuously improve the application value of unmanned vessels, improve the performance indicators of unmanned vessels, and actively promote the application of unmanned vessels in various sea areas, for strengthening ocean construction and consolidating ocean safety.

As one of the modern Marine monitoring technologies, ship target recognition technology has great application value in both military and civil application fields. In this paper, based on the intelligent supervision of maritime ship targets and ship target recognition technology, an unmanned ship target recognition system based on association rules is designed and implemented to complete the intelligent monitoring of ship targets in unattended areas at sea.

2. Research on Unmanned Ship Target Recognition System Based on Association Rules

2.1. Hardware Structure of Unmanned Ship Control System

Unmanned ship systems by shipborne electronic equipment control system module and the bank of electronic equipment modules, including shipboard electronic module is divided into image acquisition processing parts and automatic driving, automatic driving part mainly includes the energy from a ship autopilot control modules, power systems, communications module (Wifi, radio), a positioning module (such as GPS and beidou), It is responsible for the movement control of the unmanned ship on the sea surface; The image acquisition and processing part mainly includes the image acquisition and processing module, the attitude module of the cradle head, the motor of the cradle head, the camera and the 4G module, which is mainly responsible for the monitoring of the unmanned ship on the sea surface [7-8].

2.2. System Function Modules

Unmanned ship target recognition system is mainly aimed at the Marine environment in the unattended situation can not be fully the design of the problems of ship target in real time supervision of a ship target intelligent platform, mainly includes video acquisition module, the intelligent identification function module, the abnormal behavior based on rule template management module, data storage and transmission function module [9-10]. The function module of unmanned ship target recognition system is shown in Figure 1.

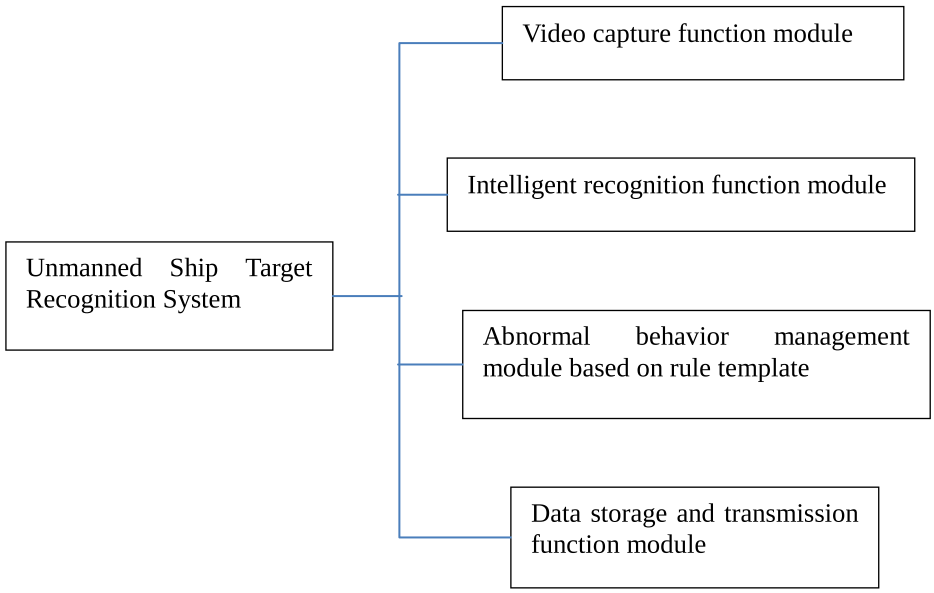

Figure 1. Function module diagram of unattended platform for ship target image recognition

(1) Video acquisition function module

Video data acquisition technology is essentially an automatic video acquisition process through sensors and other equipment, and its main working principle is to convert the collected video signals into digital signals for use by computer equipment [11-12].

The working principle of camera video acquisition mainly is the collection natural scenery image image digital signal is obtained by digital to analog converter, analog signal through the corresponding image processing chips for input digital signal processing, digital image signal after processed by the corresponding computer input devices (USB, cable) input to the computer, By connecting the display, the image acquisition data just now can be visually displayed [13-14].

(2) Intelligent identification function module

Image object recognition is a process of classification and recognition based on the main features of the image, which mainly includes four steps:

Image information acquisition, mainly through the camera or video acquisition device to take image information;

Image information preprocessing, mainly through the image processing method to process the image, the purpose is to strengthen the main features of the image, the commonly used operation methods are denoising, smoothing and transformation operations;

Image feature extraction and selection, mainly using pattern recognition method, to process the image feature extraction and selection of the main features;

The design of classifier is mainly based on the formulation of recognition rules based on training, through which the extracted main features can be classified and recognized [15-16].

(3) Abnormal behavior management module based on rule template

The abnormal behavior management module in this paper mainly uses the camera to detect the monitoring area and the association rules to judge the abnormal situation. If the abnormal situation is identified, the alarm will be timely sent and the alarm information will be transmitted to the supervisor for processing [17-18]. The flow chart of intelligent alarm logic is shown in Figure 2.

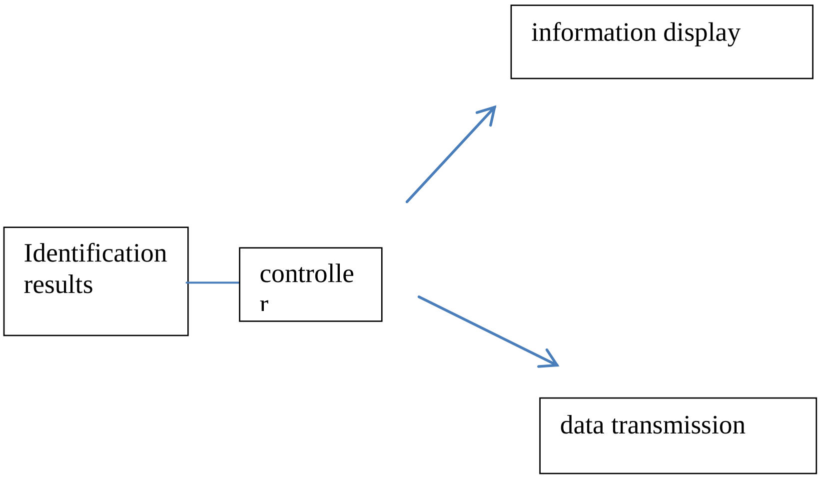

Figure 2. Intelligent alarm logic flow chart

3. Investigation and Research of Unmanned Ship Target Recognition System Based on Association Rules

3.1. System Environment

The system uses Spring as the development platform, Mysql5.7 as the system database, Vue as the front interface display framework, and SpringQuartzScheduler as the task scheduling framework to realize the system functions. On the home page of the system, users can search for the target information they want to view by mmsi number, ship name and port name. When an abnormal behavior warning is displayed, the warning button is yellow, and the notification bar displays basic information about the target with the abnormal behavior trend. The system also has some auxiliary functions such as distance measurement, coordinate positioning, weather display, map scaling and so on.

3.2. Sources of Beacon Accident Data

The beacon accident data in this paper are the beacon related accident information of M channel segment from January 2021 to December 2021, and the data are derived from the unmanned ship target recognition system. In order to improve and enrich the information of relevant factors, the web crawler method is adopted and python3.7.4 is used to obtain the weather data and hydrological data of the corresponding time and waterway segment, which mainly includes four main attributes: weather condition, wind and wind direction, water level information and flow information.

3.3. Association Rule Algorithm

Based on the association rule algorithm, the system mines the association rules of navigation mark accidents in inland waterways, and extracts corresponding data for analysis according to different influencing factors.

An association rule is the implication form like $X \Rightarrow Y$, where $X \subset I$, $Y \subset I$, and $X \cap Y = \Phi$. The support(support) of rule X verb Y in the transaction database D shall be the ratio of the number of transactions containing X and Y to all transactions in the transaction set, denoized by support(X ⇒

Y), i.e.

$$\text{support}(X \Rightarrow Y) = \left|\{T : X \cup Y \subseteq T, T \in D\}\right| / \left|D\right| \tag{1}$$

The confidence of the rule X ⇒ Y in the trading set refers to the ratio of the number of transactions containing X and Y to the number of transactions containing X, denoted by confidence(X ⇒ Y), that is,

$$confidence(X \Rightarrow Y) = \left|\{T : X \cup Y \subseteq T, T \in D\}\right| / \left|T : X \subseteq T, T \in D\}\right| \tag{2}$$

Given a transaction set D, the problem of mining association rules is to generate association rules whose support and confidence are greater than the minimum support (minsupp) and minimum confidence (minconf) given by users, respectively. Such association rules that satisfy both minimum support and minimum confidence are called strong association rules.

4. Analysis and Research of Association Rule Mining Beacon Accident

4.1. Time Factor

Through several experiments, the results are better when the support threshold and confidence threshold of the algorithm are set to 0.1 and 0.6 respectively. After human information screening, association rules with strong information are obtained as shown in Table 1, and sorted by confidence.

Table 1. Accident association rules based on time factor

Serial No	Support	Confidence	Lifting degree
1	0.1	0.2	1.76
2	0.2	0.2	1.85
3	0.1	0.4	1.77
4	0.2	0.4	1.37
5	0.1	0.6	3.88
6	0.2	0.6	2.03
7	0.1	0.8	1.65
8	0.2	0.8	1.44

The above eight strong association rules are interpreted one by one :(1) All side marking accidents in October are caused by ship collisions; (2) In the navigation beacon accident on Tuesday morning, the main carrier was the side beacon, as shown in Figure 3; (3) 80 percent of the beacon accidents Wednesday night were side beacons; (4) In March, 77% of the beacon accidents occurred during daytime were side beacons; (5) Ninety-eight percent of special marking accidents on Saturdays are caused during the day; (6) 80% of the accidents caused during the day on Wednesday in September were designated accidents; (7) 52% of Thursday daytime side marking accidents due to natural causes occurred in July; (8) 60% of side marking accidents due to natural causes during the day on Sundays occur in July. The following rules exist between time factor and beacon accident:

In the M channel section, navigation mark accidents caused by natural causes are the most likely to occur during July to September in summer, and the accidents will almost always lead to navigation mark loss, which may be due to the high rainfall, changeable climate, high water level and frequent severe weather in summer, leading to navigation mark failure. At the same time, it is very easy to cause accidents of special mark in September. The waterway project may be carried out frequently in September, which to some extent increases the accident probability of special mark. Monday and Friday are more prone to ship collision accidents, possibly because Monday and Friday are at the beginning and end of a week's work, during which the driver's attention is easily distracted. Friday and Sunday are also prone to natural causes causing beacon accidents, and most of them are concentrated in July, which may be at the end of working days or holidays. Beacon management and maintenance are neglected, and accidents are caused by the changeable weather in summer.

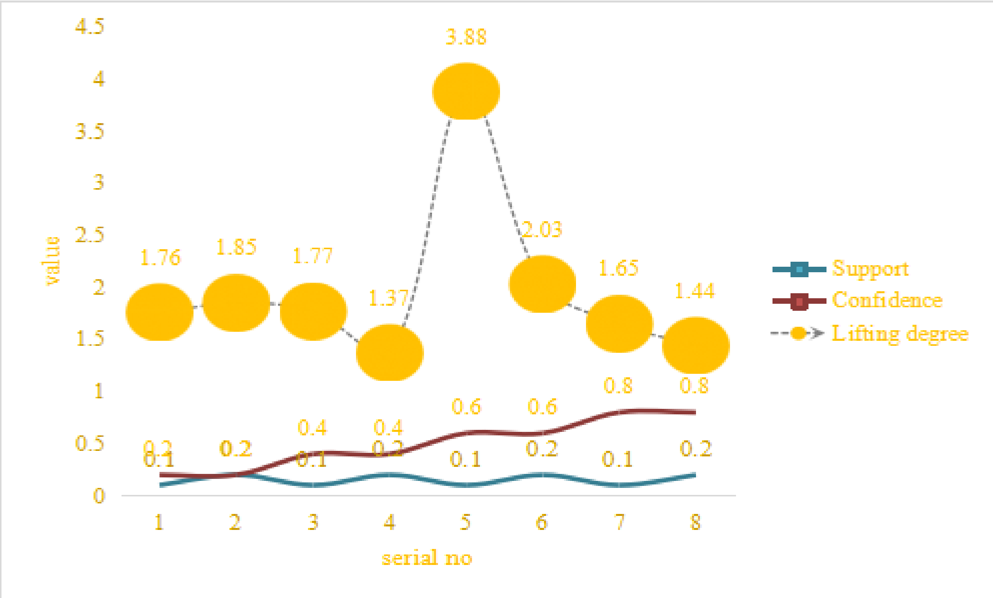

Figure 3. Time factor rule data

4.3. Environmental Factors

Through several experiments, the results are better when the support threshold and confidence threshold of the algorithm are set to 0.1 and 0.6 respectively. Environmental factors include wind speed, wind direction and weather conditions corresponding to the time of accident; After information screening, the following several association rules with strong information are obtained and sorted according to the degree of promotion, as shown in Table 2.

Table 2. Accident Association Rules Based on Environmental Factors

Serial No	Association Rules	Support	Confidence	Lifting degree
1	['Southwest wind','Moderate rain','Abnormal location'] → ['Natural cause']	0.05	0.2	1.28
2	['Level 3','Heavy rain'] → ['Natural causes']	0.1	0.2	1.94
3	['Light rain','Level 4'] → ['Ship collision']	0.15	0.4	1.58
4	['southeast wind','foggy day'] → ['ship collision']	0.05	0.4	1.66
5	['Abnormal mark','Fog'] → ['Side mark']	0.1	0.6	4.72
6	['Ship Collision','Rainstorm'] → ['Side Marker']	0.15	0.6	2.08

It can be seen intuitively that severe weather such as heavy rain and moderate rain in Channel M is more likely to cause navigation accidents caused by natural causes rather than ship collisions. On the contrary, in sunny days, cloudy days, light rain and other good navigable environment, the ship collision probability is higher, the carrier is mainly the side mark, special mark second. The reason for this abnormal phenomenon may be that under extreme environment, the navigable volume of ships is less, and ship pilots are more focused, which reduces the probability of accidents, while in good weather, they are prone to slack off, thus causing accidents. The environmental accidents in foggy weather are mainly ship collision, and the damaged navigation mark is mainly the side mark. On the other hand, the wind direction is not directly affected, but with the weather conditions of the day, water level and other joint action to cause accidents. Through intuitive analysis, the northeast wind and northwest wind in light rain and shower environment are more likely to lead to ship mark collision, and the southeast wind in heavy rain weather is easy to cause natural causes of navigation accidents.

5. Conclusion

With the continuous development of Marine resources, the monitoring and management of maritime activities in various regions is particularly important, and the development of unmanned ship technology brings convenience to the monitoring and management of sea surface. In order to realize the monitoring of sea surface conditions by unmanned ships, this paper designs a set of solutions for automatic recognition of sea surface ship targets, which can greatly improve the efficiency of sea surface activity monitoring and management by unmanned ships. However, there are still some shortcomings, for example, association rule algorithm is adopted in the abnormal behavior management module. In practical application, some more novel classifier algorithms with better training and classification effect can be selected, such as BP neural network algorithm.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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