Electronics, Communications and Networks
A.J. Tallón-Ballesteros et al. (Eds.)

doi:10.3233/FAIA231197

A Study on the Prediction of Illegal Fishing Crime in the Yangtze River Basin

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Abstract. In 2020, the state issued a ten-year ban on fishing in the Yangtze River basin, which has put forward more stringent requirements for public security officers to combat illegal fishing crimes. At present, there are problems such as low control efficiency, limited monitoring scope and no direction for arrests in combating illegal fishing activities in the Yangtze River basin. In this paper, we use police data as samples, extract the characteristics of criminal personnel using the TF-IDF algorithm, then use these characteristics as weights, use the combination of coefficient of variation plus hierarchical analysis algorithm to predict the key suspect, and finally use the trajectory carving model to carve the front, middle and back ends of the suspect's crime execution to establish an early warning model of illegal fishing crimes in the Yangtze River basin. It provides investigative ideas for the detection of illegal fishing of aquatic products, curbs the spread of illegally caught aquatic products, improves regulatory measures and forms a normal and long-term mechanism for prevention and control and governance.

Keywords. Yangtze River basin, illegal fishing, TF-IDF, combined coefficient of variation plus hierarchical analysis algorithm, trajectory inscription

1. Introduction

In recent years, the environmental protection situation in most of China's waters is not optimistic, with water quality and fishery resources deteriorating. Instead of improving, the survival of various organisms in the Yangtze River basin is facing a more serious threat. Although efforts are being made by all sectors of society to protect the ecological environment of the waters and aquatic resources, more and more aquatic organisms in China are facing the threat of extinction and fisheries resources are becoming increasingly scarce. In order to maintain the aquatic ecology of the Yangtze River, the state has had no choice but to introduce a ten-year ban on fishing in the Yangtze River. To protect aquatic resources and put an end to related crimes, it is necessary to combine actual data to accurately analyse the characteristics of illegal fishing of aquatic products crime cases and put forward targeted prevention and control measures to curb illegal fishing of aquatic products crime at source.

Due to the complex identities of illegal fishery criminals, various criminal methods, hidden places of operation and variable fishing time, there were problems such as

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"difficult to find, difficult to seize and difficult to obtain evidence" in combating illegal fishery crimes in the past, and investigators could only use traditional methods such as riverside patrol and watchful ambush to carry out crackdown. By combining the TF-IDF algorithm, variation coefficient plus hierarchical analysis algorithm and Dijkstra's shortest path algorithm, this project proposes a new way of thinking and a new method for public security organs to face the early warning of illegal fishing crimes.

2. Research Overview

2.1. Background of the study

2.1.1. The social context of illegal fishing

Since ancient times, people living on rivers and lakes have generally had a sense of "fishing and hunting", "relying on mountains to eat mountains, relying on water to eat water", and before the ban on fishing, fishing for aquatic products was a way to improve their lives and even a necessary way of life. Some even saw it as an ancestral craft and did not have a deep understanding of the dangers of overfishing. In recent years, the consumer market for wild fishery products has become increasingly large, and many people have a special fondness for wild animals, believing that wild animals have high nutritional value and that wild fishery resources have unique advantages in terms of health and fitness, etc. People's strong demand has led to the high value of wild fishery products, objectively creating a highly attractive consumer market for wild fishery products, forming an industrial chain of fishing, sales and consumption. This has led to the formation of an industrial chain of fishing, marketing and consumption, which has also led to the indiscriminate fishing by illegal means in the pursuit of exploitation by some people.

As society progresses, the tools of illegal fishing have also begun to be updated. In recent years, in addition to the use of "electro-poisoning and frying", "bewitching" and "exterminating nets" to illegally catch fish, a variety of new fishing tools have emerged. For example, martial arts rods, longline fishing with empty hooks, light trapping, visual anchoring and ultrasonic fishing[1].

2.1.2. Difficulties in detecting illegal fishing enforcement

Illegal fishing crime scene forensics, fixed evidence is difficult, the crime has a large range of activities, site changes, activities over a large span of time and other characteristics, and such crimes are often carried out in the rainy season, at night, evidence is easy to lose, personnel easy to escape, directly increasing the difficulty of seizure of illegal fishing, investigation and forensics, fixed evidence and other work can not be effectively carried out.

Illegal fishing occurs in rivers, lakes and other waters and is extremely widespread. For reasons such as the small number of police officers and video surveillance monitoring means, the law enforcement and supervisory forces are unable to effectively cover the waters. Now the more advanced police drones can only last for about 30 minutes at a time, so illegal fishing offences cannot be detected and investigated

in a timely manner, forming an embarrassing situation that is beyond the reach of the whip.

2.2. Current status of domestic and international research

Most domestic research on IUU fishing is currently focused on the legal aspects, with relatively little research on enforcement activities.[2]The study of IUU fishing in China has been focused on the legal aspects and relatively little on enforcement activities. Yang Zhanhai uses a multi-faceted and multi-faceted approach, suggesting a scientific, comprehensive, detailed and practical registration system to regulate the industry in order to deter unscrupulous traders, as well as a combination of drone and public security boat patrols to collect and grasp information and situations on the water, and finally using a large intelligence platform and public security big data to carry out in-depth research and judgment, and build a task relationship information map to implement illegal criminal acts. Precise crackdown and rectification[3] The last step is to use the big intelligence platform and public security data to carry out in-depth research and judgement, so as to build an information map of task relationships and implement precise crackdowns and remediation of offences. Yang Erhui suggested promoting digitalisation and technology to empower investigation and evidence collection. The three systems of "police cloud +" to build a big data support foundation system, "cloud computing +" to build a human-machine collaboration combat system, and "intelligent policing +" to build an online protection system should be established to combat environmental crimes in the Yangtze River basin.[4] The police have established three systems to combat environmental crimes in the Yangtze River Basin.

Japan proposed three specific actions to prevent and combat IUU fishing: a system in which catch identification numbers and data associated with them are stored in a central database; allowing information sharing when needed and establishing information sharing through cooperation with existing "smart fisheries" efforts. Authorities at ports of entry for Russian seafood could conduct dockside inspections to prevent the entry of vessels known to be involved in IUU fishing and share information with other PSMA parties on vessels known or believed to contain IUU fishing activities. The fisheries regulatory bodies are mandated to establish a list of vessels found to be engaged in IUU activities and to make it a hub for information exchange with other States. It can be seen that countries are using statistics and analysis of data as a basis to prevent and combat the crime of illegal fishing of fish products by screening data markers on subjects and objects to monitor in real time the presence of illegal fishing of fish products.

I used the literature research method to study and analyse papers in related fields, and found that the current research on illegal fishing of aquatic products focuses on theory and is light on practice, and most of them put forward suggestions and countermeasures for the shortcomings of the current legal system and legal responsibilities of illegal fishing of aquatic products, which are difficult to adapt to the complexity and specificity of the current public security work, and there are certain subjectivity and limitations, without fundamentally giving The specific measures to deal with the crime of illegal fishing of aquatic products are not given.

2.3. Significance of the study

The project actively advocates the application of a new model of data-based intelligence-guided investigation, exploring the establishment of a data model for combating illegal fishing crimes in the Yangtze River, and providing an all-round, multi-angle data portrayal, information reduction and dynamic tracking of the characteristics of illegal fishing criminal activities in the Yangtze River, thereby leading the actual battle. We will give full play to the role of the public security organs as the main force in the fight against illegal fishing, intensify joint law enforcement efforts along the entire chain from the Yangtze River to the dining table, crack down on illegal fishing crimes in the Yangtze River basin with a "zero tolerance" attitude, and resolutely cut off the underground industrial chain and interest groups in illegal fishing, transportation and sales, forming a The new model of professional crackdown and synthetic operation will promote normal and long-term treatment.

The present time is the age of information and data. Making full use of big data to establish a professional combat model, promote a comprehensive fishing ban on the Yangtze River and allow the Yangtze River to rest and recuperate is a major decision and deployment for the overall situation and for future generations, and is a major political task to implement Xi Jinping's thought on ecological civilization and promote the great protection of the Yangtze River. We should take the work of the Yangtze River fishing ban as a direct test of "two maintenance" and ensure that the "ten-year fishing ban" is enforced and implemented with a resolute attitude, strong measures and pragmatic style.

3. Early warning model construction

The research idea of this study is to extract the characteristics of illegal fishing aquatic products crimes, and to derive the people with abnormal scores in a way that assigns values through the integration and weighting of data from all parties, so as to achieve early warning of illegal fishing criminals, reshape a new generation of illegal fishing aquatic products detection mechanism, and further tighten the social surface security and prevention and control system. The flow of the specific research idea is as follows.

This project is based on big data from law enforcement agencies. It uses TF-IDF algorithm to extract features from identified illegal fishing criminals in police data, and combines data from multiple directions, specific populations appearing in specific areas at specific times for weight calculation, to predict criminal suspects and provide a coefficient. Finally, using route characterization model, the front, middle, and back end of the crime are found and real-time feedback is provided to the intelligence command center. The police officers in the intelligence command center can use the key personnel and their trajectories returned by the model for further analysis. This model solves the problem of difficulty in evidence collection and investigation in illegal fishing, and realizes a data-based illegal fishing crime early warning model.

3.1. Feature extraction model based on TF-IDF algorithm

The model is based on the term frequency-inverse document frequency (TF-IDF for short) algorithm [5]. The TF-IDF algorithm is a text mining algorithm that effectively assesses the importance of a particular word in a given document.

TF means Term Frequency and is generally given by the following formula.

$$\text{TF} = \text{The number of times a word appears in a text} / \text{Total number of words in the article}$$

Equation 3.1

IDF stands for Inverse Document Frequency and it reflects how common a word is. The more common a word is, the smaller the IDF value; conversely, the more unique and rare a word is, the larger the IDF value. The formula is as follows.

$$\text{IDF}=\lg(\text{Total number of corpus articles}/(\text{The total number of articles containing a word}+1)$$

TF-IDF is the product of word frequency (TF) and inverse document frequency (IDF), with the following formula.

$$TF\text{-}IDF = TF \times IDF$$

Equation 3.2

From the above principle, it is clear that the TF-IDF value of a word is proportional to the frequency with which the word appears in a given document and inversely proportional to the number of times the word appears in the corpus as a whole [6]. This principle can also be applied to the extraction of feature words of crime texts, i.e. If the feature words of each crime case are to be calculated, then the TF-IDF values of all words in each crime process document are calculated and the few keywords with the highest TF-IDF values are selected.

However, the conventional TF-IDF algorithm does not take into account the semantic information of the words, for example, the connotations of "electrofishing", "electrofishing", "electroshocking" and "electrofishing The connotations of "electrofishing", "electrofishing", "electroshock fish" and "electrofishing" are the same, and the connotations of "ground cage" and "ground cage net" are the same, but the TF-IDF algorithm classifies them into two categories of words and calculates the TF-IDF value separately, which shows that the TF-IDF algorithm is unable to deal with multiple meanings of words or words with multiple meanings. In the study of the criminal process of illegal fishing of fishery products, there are many cases of multiple words with one meaning, and the above results may only be a small part of them, so if the TF-IDF algorithm is used alone it will treat synonyms as different categories of words, which both reduces the weight of these words and affects the calculation of the overall TF-IDF value. From reading the literature, it can be found that in the past, probabilistic models that can express hidden information were usually used to solve the problem that the TF-IDF algorithm did not take into account the semantic information of words, specifically, the word vector trained by Word2Vec was used as the input of the word vector for calculating the TF-IDF, and then the feature weights were calculated, thus solving the traditional problem that the TF-IDF algorithm could not handle words with multiple meanings or This solves the traditional problem that the TF-IDF algorithm cannot handle one word with multiple meanings or one word with multiple meanings, and makes the results more accurate, hereinafter referred to as "TF-IDF_Vec".

3.1.1. Test method and procedure

1)Construction of the word separation dictionary and word frequency matrix. Like the traditional TF-IDF algorithm implementation, TF-IDF_Vec also needs to assign IDs to each word and build the corresponding word frequency matrix. form and word frequency matrix form that gensim can recognize

2)Word2Vec training word vectors. The word vectors used in this model are the same as the sequence annotation model described above. The results of the word frequency matrix are fed into the invoked Word2Vec model to derive the required word vector for each word. After multiplying the word vector of each word by the TF-IDF value of that word, the numbers in the TF-IDF word vector matrix of that word are added together to obtain a value, which is called "TF-IDF_vec", and the "TF-IDF_vec The "TF-IDF_vec" value is used to condense a TF-IDF word vector matrix into a specific value, which is equivalent to replacing the position of the TF-IDF value of a word in the traditional TF-IDF algorithm, thus not only solving the problem of non-corresponding element positions, but also being used to judge the importance of the word.

3)Word2Vec combined with TF-IDF weights to construct the document vector. Because Word2Vec is called directly from the gensim library, it is also possible to call TfidfModel directly from the gensim library to calculate the TF-IDF weights of individual words for convenience.

4)Output of results. After extracting the keywords of all documents, the two matrices were summed by column to obtain the integrated TF-IDF value of each word, which was converted into data frames and output respectively.

5)In order to make the results of the study more comprehensive and effective, it is not intended to analyse the "entity-based feature words" and " behavior -based feature words" separately, but to combine the lexical properties of nouns and verbs, and to focus on the "overall feature words "The study was conducted on the basis of a combination of nouns and verbs.

This resulted in the following four categories.

Category 1: spring, electrofishing, gear, Yangtze, carp.

Category 2: spring, electrofishing, homemade, electric batteries, inverters.

Category 3: electrofishing, ground cage, daybreak, carp, carp.

Category 4: electrofishing, ground cages, spring, nets, hiring.

3.1.2. Conclusions of the analysis

Clearly, the two characteristic words that appear most frequently in these four categories are spring and electrofishing. Spring is a closed season in most areas, and fishing for fish during this time constitutes an offence, and the state often carries out key crackdowns during this time, so the number of cases in spring is high, but with the 10-year ban on fishing in the Yangtze River basin, this situation will change somewhat. Secondly, spring is the peak season for fish breeding and fish swarm in large numbers to reproduce, triggering a series of illegal criminal activities such as illegal fishing of aquatic products. Electrofishing is also the most common method used by criminals to illegally catch fish. It only costs a few hundred dollars to buy simple electrofishing equipment, but the profit from one electrofishing can reach thousands of yuan. Under the temptation of such high returns, many people start to take the law into their own hands and take the risk of using electricity for illegal fishing. Because electrofishing is not selective in the fish it captures, the electromagnetic field formed by its spreading

current can bring fatal blows to underwater creatures, so it is known as "severed fishing".

Generally, illegal fishermen are divided into hobbyists and professional fishermen. The professional fishermen are the ones who target their illegal fishing activities by predicting when the tide is high and flat. Professional fishermen fish during the flat tide period, where the tide is high and flat at a fixed time each day, with the daily tide level being 45 minutes later than the previous day, and illegal fishing generally takes place one to two hours after the tide level, and will choose the gates and the pinch river to carry out the fishing.

Trading in illegal fishing offences also has certain characteristics. "The suspects will try to sell the catch immediately after they have caught it in order to sell it at a high price, so as to avoid a long period of storage, which will not be fresh and affect the sales price; the object of the transaction is specific, and the customers who buy "river food" are mostly river food restaurants and fishery companies. The customers are mostly river food restaurants, aquaculture companies, etc.; logistics vehicle specificity: river food to be sold to the field, will use special hauling vehicles, these vehicles are modified and closed carriage with oxygenation and cooling equipment, full-time driver driving, daily to and from a fixed number of aquatic markets for distribution.

3.2. Combined coefficient of variation plus hierarchical analysis algorithm

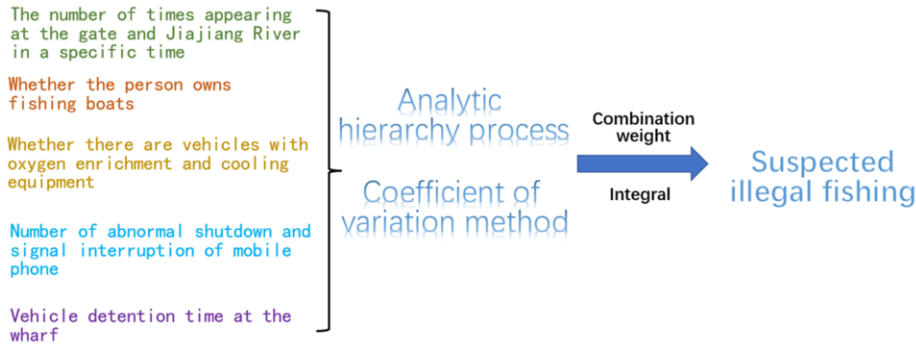

Fig. 1. Combined coefficient of variation plus hierarchical analysis algorithm

As shown in Figure 1, by scoring the above calculated characteristics of illegal fishermen and summing them to obtain a total score, an early warning is given to suspicious persons with high scores. As there are many variables, there is a certain bias in the subjective weighting of the characteristics, and if the objective weighting is calculated entirely from the data, the expert experience will be lost, so the combined coefficient of variation plus hierarchical analysis weighting method is used. The method combines the advantages of both the subjective and objective weighting methods, taking into account both expert experience and data values. The method is implemented in four steps:

3.2.1. Hierarchical analysis to determine subjective weights

The basic operation process of hierarchical analysis includes the steps of constructing judgment matrix, calculating weight coefficients and consistency test. The steps to calculate the weight coefficients are as follows

i. Normalize each column vector of the matrix

$$\overline{b_{\iota J}} = \frac{b_{ij}}{\sum_{k=1}^{n} b_{kj}} \quad \text{i,k} = 1,2,3 \ldots \text{m; j} = 1,2,3 \ldots \text{n}$$

Equation 3.3

ii. Summation by rows

$$\varpi = \sum_{j=1}^{n} \overline{b_{ij}} \qquad i = 1,2,3 \ldots m; j = 1,2,3 \ldots n$$

Equation 3.4

iii. normalize the vector to obtain an approximation to the eigenvector

$$\omega = \frac{\varpi}{\sum_{i=1}^{n} \varpi} \qquad i = 1,2,3 \ldots m; j = 1,2,3 \ldots n$$

Equation 3.5

iv. determine the maximum eigenvalue of a matrix

$$\lambda_{\max} \quad = \frac{1}{n} \sum_{i=1}^{n} \frac{B\varpi_i}{\varpi_i} i = 1,2,3 \ldots m$$

Equation 3.6

3.2.2. Coefficient of variation method for determining objective weights

i. To better reflect the absolute degree of variation of each indicator, the standard deviation of each indicator on the evaluation object should be calculated. I represents the first few evaluation objects and j represents the first few indicators.

$$S_j = \sqrt{\frac{\sum_{i=1}^{n} \left(x_{ij} - \overline{x_j}\right)^2}{n}} \qquad i = 1,2,3 \ldots m; j = 1,2,3 \ldots n$$

Equation 3.7

ii. The coefficient of variation of each indicator is calculated, which can better reflect the relative degree of variation of each indicator.

$$V_j = \frac{S_j}{\overline{x_j}} \qquad j = 1,2,3 \ldots n$$

Equation 3.8

iii. Normalise the coefficients of variation of each indicator to derive the weights.

$$W_j = \frac{V_j}{\sum_{j=1}^{m} V_j} \qquad j = 1,2,3, \ldots n$$

Equation 3.9

3.2.3. Determining portfolio weights

Let wj be the weight of the jth indicator after the combination of the two weighting methods, "be the weight of the coefficient of variation of the jth indicator, "be the weight of the hierarchical analysis of the jth indicator, and "be expressed as a linear combination of "and" (j=1,2,3, ... , m), such as:

$$w_j = \alpha * u_j + (1 - \alpha) * v_j \qquad j = 1,2,3 \dots n$$

In Equation 4, 'a' is the proportion of the coefficient of variation weights to the portfolio weights, and 1- is the proportion of the hierarchical analysis weights to the portfolio weights, and the loss function is solved to minimize the sum of the squares of the deviations of the portfolio weights from the subjective and objective weights:

$$\min z = \sum_{j=1}^{n} \left[\left(w_j - u_j \right)^2 + \left(w_j - v_j \right)^2 \right] \qquad \text{j} = 1,2,3 \dots n$$

Equation 3.10

Equation 5 solved for 'α', taken into equation 1 gives:

$$w_j = 0.5 * u_j + 0.5 * v_j j = 1,2,3 \dots n$$

Equation 3.11

Equation 6 is assigned through a combination of Equation 4, which retains the true reflection of the data by the coefficient of variation method, but also combines the subjective expert experience of the hierarchical analysis method, allowing for a more accurate reflection of the indicator weights.

The above calculations were used to derive the weights assigned to each indicator, and the final suspect scores were then calculated based on the weights.

3.3. Trajectory inscription model based on Dijkstra's shortest path algorithm

Dijkstra algorithm is a graph search algorithm that solves the single-source shortest path problem for a graph with non-negative edge weights, producing a shortest path tree. In practical public security work, it is difficult to obtain the full path data of a person's journey, but only through fixed electronic probes to obtain the location data of multiple path points. This model uses the location data of multiple points to calculate the shortest path between two points using Dijkstra's algorithm, thus predicting the full path of the criminal's activities.

The Dijkstra algorithm uses a breadth-first search strategy and maintains the shortest distance of undefined nodes by using a minimum heap data structure. This algorithm is suitable for directed graphs and graphs with edge weights of non-negative integers. [7] First, the distance from the starting point to all the points is stored to find the shortest one, and then the shortest one is found by relaxing once, the so-called relaxation operation is to iterate through the shortest point just found as a transit point to see if it is closer, and if it is closer, the distance is updated. The shortest distance from the starting point to all other points.

The Dijkstra algorithm is a typical shortest path algorithm, used to calculate the shortest path from one node to another. Its main feature is to expand outward in layers, centered on the starting point (breadth-first search idea), until it expands to the end point.

3.3.1. Test method and procedure

1)download the regional road file, this project uses the graph_from_bbox function in the osmnx library to obtain the required road vector file.
2)Calculate the number of nodes and edges in the road file. Read the location information by time in passing, using the first location point as starting point A, the second point as B, and so on.
3)introduce two sets (S, U), the set S contains the points for which the shortest path has been found (and the corresponding shortest length), and the set U contains the points for which the shortest path has not been found.
4)initialize the two sets, S set initially with only the current node to be calculated, as shown in Figure 2. a->A=0, U set initially with A->B=5,A->C=∞,A->D=1,A->E=∞.

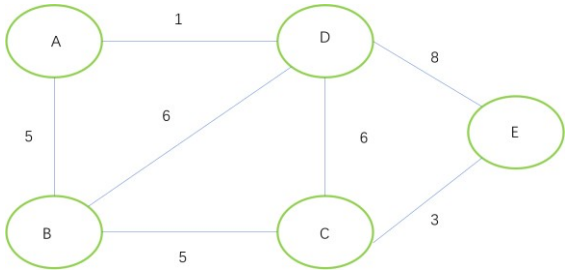

Fig. 2. Initialising the collection

5)find the point with the shortest path from the set U and add it to the set S.
6)if the distance from D to B,C,E plus the AD distance is less than the distance from A to B,C,E, then update the U set, and vice versa, do not update
7)loop through steps 4 and 5 until the end of the traversal to get the shortest path from A to the other nodes

3.3.2. Results of the run

The more location information is obtained, the more accurate the path is portrayed, as shown in Figure 3.

Fig. 3. Results of the run

Illegal fishermen must have a complete chain when committing their crimes, including the purchase of tools, fishing locations, fishing time, and immediately contacting familiar "restaurants" and "diners" to ensure freshness once the catch is available. By using the path mapping model, we can clearly grasp the front, middle and back ends of the illegal fishermen and combat them.

First, we can carry out a detailed analysis of the track to determine the illegal fishing behavior carried out by the person. This can be achieved by evaluating its starting point, destination, route, and other relevant information.

Second, based on the person's behavior and location, we can take preventive measures to prevent them from engaging in illegal fishing again. For example, if the person has engaged in illegal fishing at a specific location, we can increase patrols in that area to prevent them from engaging in illegal fishing there again.

In addition, we can also cooperate with local governments and maritime agencies to jointly combat illegal fishing crimes. For example, we can work with the local government to formulate laws and regulations to strengthen the punishment for illegal fishing activities and carry out propaganda activities locally to make the local people aware of the harm caused by illegal fishing.

Finally, we can also track down the illegal fishing criminals to prevent them from continuing to engage in illegal fishing.

4. Concluding remarks

China has vast waters and rich aquatic resources. Aquatic resources are an important resource on which human beings rely for survival and have important values in terms of economy, ecology and environmental protection. In order to implement the Party Central Committee's requirements of adhering to and improving the system of ecological civilisation, promoting the harmonious co- existence of man and nature and promoting green development, it is necessary to strengthen the protection of aquatic resources. However, with illegal fishing of aquatic products becoming increasingly rampant, the ecological environment of China's waters is deteriorating and aquatic resources are constantly being depleted. Therefore, to combat illegal fishing is to protect the waterecology, which is to protect the beautiful home.

This paper is based on judicial documents and police data, the detection of illegal fishing of aquatic products crime early warning research, through the existing crime information combing, using python language to feature extraction, weight calculation, route portrayal of information, in order to provide early warning ideas for illegal fishing of aquatic products crime, to achieve automated illegal fishing crime detection, to further curb the occurrence of criminal fishing crime. With the "10-year ban on fishing" taking root in people's minds, the increasing efforts to combat illegal fishing, and the continuous promotion of ecological protection, it is believed that in the near future, illegal fishing crimes will eventually be killed in the cradle.

Acknowledgements

This research was support by the 2021 College Students Innovation and Entrepreneurship Training Program (Grant No. 202112213023Z).

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