Prediction of Fish School based on Neural Network and Gray Prediction

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Abstract. Rising ocean temperatures affect the distribution of fish. The livelihoods of many small Scottish fishing companies have also been affected. We designed a fish migration prediction model, a system that predicts fish migration and helps small fishing companies make decisions.

First, we creatively proposed the neural network algorithm modified to establish habitat evaluation model based on previous environmental data. Then, the gray prediction algorithm is used to predict the environmental data of each water area in the next 50 years, and the best habitat location of each year is evaluated by the evaluation model based on the environmental data. The migration route of the fish can be obtained by summarizing the best habitats each year in chronological order. We use the knowledge of graph theory to establish a "fishing judgment model" to determine whether small fishing companies can catch fish in their fishing range. Then we use a triple nested loop to establish a continuous time calculation model, and use this model to discuss the continuous fishing time of a fishing company located in a certain place from a certain year in the future.

1. Introduction

As the world's oceans warm up, the habitats of some sea creatures are slowly changing. Populations will migrate to more hospitable areas for better survival. Herring and mackerel are making an important economic contribution to Scottish fisheries [1]. There is no doubt that changes in the distribution of the two populations will have a significant impact on the revenues of small Scottish fishing companies. The north Atlantic fisheries management association of Scotland wants to investigate the habitat migration of herring and mackerel populations to minimize economic losses [2].

2. Habitat Evaluation Model

Because we have assumed that fish schools only live in the most suitable places. We include the intent of the question as to find the best habitat water for the school of fish in each time period [3]. Numerous factors influence the quality of the habitat. We simply selected four main factors as indicators of the quality of the habitat. First we collected environmental data for each region over the past 43 years.
Due to the mobility of fish, we cannot know the exact total number of fish. Assume that the number of fish in an area is directly proportional to the number of fish captured in the area, so we use the amount of fish caught as a key indicator to measure the number of fish. We use neural network algorithms to build habitat evaluation models based on the data. In addition, in order to avoid the narrow optimal value problem of the neural network algorithm, we use the Levenberg-Marquardt algorithm to modify the neural network algorithm.

At the same time, we divided the waters around Scotland into ten water based on the similarity of geographical environment. Since the data for the next 50 years are unknown, we need to make predictions based on known data. We obtained water temperature, dissolved oxygen concentration, salinity, and phytoplankton abundance data for the four seasons from 1976 to 2019 by searching data.

We will first obtain the data to screens to exclude outliers. Due to the large changes in the values of the four influencing factors between the four quarters, we estimate the data of the four influencing factors in the first, second, third, fourth, and fourth quarters of each region. At the same time, we use the gray prediction algorithm to carry out data on the influence factors of each water area in each quarter within the next 50 years.

Finally, we utilize the established habitat evaluation model to score the predicted data. We average four quarterly ratings for each location in the same year as the region's one-year rating. In the same year, the maximum value selected from the scores of ten regions is the place of the school of fish. Then, by finding the location of the school of fish in the ensuing 50 years, the migration path of the school of fish can be obtained.

3. Basic idea of fishing judgment

As showed in the water area division diagram, use graph theory knowledge to reduce it to a tenth-order completely undirected graph, where the weights of the edges are across the common boundary from one area to another area times. From this, the adjacency matrix of the tenth-order completely undirected graph is obtained as the judgment matrix. Assume that the company is located at a, and the best fish school position in a year is b. The condition for judging whether the company can catch fish in that year is whether the value corresponding to row a and column b of the adjacency matrix is less than or equal to two: if it is, it can be continued for one year plus 1; otherwise, it will not be changed.

Considering that the company may continue to fish for several years from any year, so we discuss each year, and the company may be numbered from one to ten. Suppose the company started fishing for any of the fifty years. Next, we discuss the duration of fishing at each location where the company may be located each year. The discussion of all process situations is achieved through triple nested loops.
Figure 1. Flow chart of duration algorithm.
4. Analysis of the data
First, we draw a two-dimensional scatter plot of the number of years that small and medium-sized fishing companies can keep fishing for all the cases of mackerel to visually see the overall distribution of years of continuous fishing.

![Figure 2. Distribution of years of fishing for mackerel.](image)

From the distribution chart of years of fishing for mackerel and distribution of years of fishing for herring, we can see that most of the duration is zero, which is obviously not what we expected. We expect the company to continue fishing for as long as possible.

5. Checking and evaluation
We conducted a sensitivity analysis on the model established; we artificially added two or three outliers to the environmental data of different influencing factors. The fish migration path predicted by our model, that is, the sequenced place number string, is compared with the original result, and the similarity of the results is always maintained above 68%. Since the remaining questions are analyzed on the basis of the results obtained in the previous question, we can infer that the data obtained by the remaining model is not much different from the original data. This shows that the model we build can be affected to a lesser extent by outliers, and the model we build is more practical. This model has the following advantages.

1. The model is less affected by outliers.
2. The Habitat Evaluation Model uses the neural network algorithm modified by the Levenberg-Marquardt algorithm to effectively solve the problem of non-normal distribution and non-linear credit evaluation, and it does not need to have strict assumption limits and avoids local optimization problems.
3. We use gray prediction models to make predictions on environmental data. The model completes the prediction by processing less data, which largely solves the problem of less historical data. The model has high accuracy, can be used for recent, short-term, mid-and long-term forecasting, and the quantitative analysis results are consistent with the qualitative analysis results.
4. The fishing judgment model cleverly uses graph theory knowledge in the computer field to make the judgment process practical.
5. The duration calculation algorithm uses triple nested loop statements to reduce programming redundancy.
6. Combined with the predicted data, the company migration model optimizes the income of small fisheries companies and has practical value.
7. The fishing judgment model comprehensively discusses the duration of the company in various situations.

6. Conclusion
The model we built has strong expansibility. For example, the habitat evaluation model requires only a small amount of data to complete the evaluation of various waters in the world. The same gray prediction model can be used to predict the environmental data of various waters.

The fishing judgment model is not limited to complete the judgment of whether the fishing company can continue to fish. In the same way, this model is also applicable to land. The city is abstracted as a point in an undirected graph, and the weight of the edge in the undirected graph is the distance from that city to another city. Based on this, the judgment of whether to go from one city to another within a fixed time can be completed.

The duration calculation model can be used as a reference for the land selection of fishing companies. In addition, the parameters can be used for a series of site selection references, such as supermarkets and restaurants, by slightly changing the parameters. It can be said that the applicability of this model is quite extensive.

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