Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Research on shoreline identification method based on partition fitting evaluation strategy

To cite this article: Bowen Xing *et al* 2021 *J. Phys.: Conf. Ser.* **2016** 012009

Research on shoreline identification method based on partition fitting evaluation strategy

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Abstract. In the unknown water environment, unmanned ships' perception of unknown water environment, map construction, and identification and ranging of obstacles have become research hotspots in the field of water environment perception. The visual SLAM (simultaneous localization and mapping) scheme is used to obtain the unmanned ship's navigational waters to obtain the unknown waters environment. The mathematical model is established based on the feature points extracted by the ORB-SLAM2 algorithm, that is, the feature point coordinates are extracted to establish a coordinate system, and the lowest point coordinates are used as the starting point to assume the shoreline, and the shoreline After the upper and lower feature points are partitioned, the feature points in the area above the shoreline are curve-fitted, and then the reflection curve is obtained according to the reflection principle, and finally the variance calculation is performed on the points in the reflection curve and the points in the area below the shoreline. When the variance is the smallest value or Get the shoreline position when it is zero. The results show that the method can accurately identify the location of the shoreline and lay the foundation for the unmanned ship to realize surface target recognition.

Key words: Unmanned ship; SLAM; Feature points; Shoreline identification

1. Introduction

As a kind of intelligent watercraft, unmanned ship has the advantages of fast speed, small size and low cost, and has gradually become the first choice for tasks such as environmental monitoring and fishery resource acquisition[1-2]. The environment perception of unmanned ships mainly relies on lidar and cameras, and the unknown water environment is obtained through sensors, and objects on the water surface are recognized to realize autonomous obstacle avoidance of unmanned ships.

Researchers have put forward different plans to study the extraction of waterfront lines and coastlines. Dazhi Wang of Harbin Institute of Technology analyzed the principle of water surface mirroring and proposed a scheme based on the positional relationship between the image reflection and the original image to realize the shoreline recognition of this water area [3]. Qian Liu of Shenyang Ligong University uses an improved algorithm for the edge information of the LOG (logarithm) operator to realize the identification of the position of the river and coastline [4]. Zheng Youneng of Southwest University of Science and Technology realized the shoreline recognition of the unmanned ship working area by improving the position of the seed point candidate area in the regional growth method, and at the same time improved the KCF (Kernel Correlation Filter) algorithm related filtering ideas to realize the water surface target recognition [5]. The researchers realized the shoreline identification according to their own research methods.

This paper proposes a new algorithm to extract the coordinates of feature points in the image through the ORB-SLAM2[6-8] algorithm and establish a mathematical model. The location of the coastline is obtained using the partition fitting evaluation strategy to realize the shoreline separation, and finally realize the recognition of the water surface target.

2. Feature point acquisition and feature point distribution

2.1. Obtaining feature points

The binocular camera carried by the unmanned ship uses the ORB-SLAM2 algorithm to extract the feature points of the unknown water environment and build a point cloud map, and build a mathematical model based on the location of the feature points. The distribution of feature points in the image is shown in Figure 1. From the figure, it can be seen that the point feature is a common feature element at the ORB (Oriented FAST and Rotated BRIEF) feature point in the visual SLAM [9-10]. Then, the point feature in this method is also the simplest and fastest way to achieve feature extraction and matching.

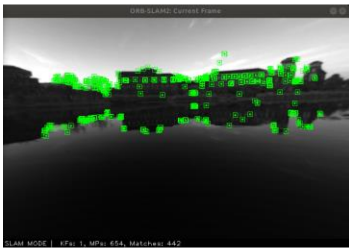

Figure 1. Feature point extraction map of water environment

2.2. Feature point distribution analysis

It can be clearly found in Figure 1 that the distribution of the feature points in the image is relatively uniform, and the extraction of the reflection feature points of the object on the shore and the object on the water surface also basically shows a symmetrical relationship. Due to the characteristics of the water surface, it can be found that the water surface is like a mirror surface, which can present the basic outline of the objects on the water surface, giving people a visual error, which is a natural phenomenon with visual beauty and impact. The real scene and the virtual scene present a one-to-one effect, and the relationship between the two is equal in size, and the reflection of the objects on the shore on the water surface can also reflect every detail of the objects on the shore [11-12].

According to the principle of mapping, the reflection on the water surface is like an upright virtual image formed by an object in a flat mirror. The real and virtual images present the same image size and the distance from the image to the flat mirror is equal to the distance from the object to the mirror. Therefore, a solution based on the distance relationship between image reflection feature points can be proposed to calculate the shoreline position through this feature.

3. Shoreline identification method based on feature point partition fitting evaluation strategy

3.1. Algorithm principle

The binocular camera carried by the unmanned ship uses the ORB-SLAM2 algorithm to extract the ORB feature points of the water environment. As shown in Figure 1, the feature points extracted by the ORB feature are relatively uniform and the edge extraction of the object is relatively accurate. A frame of image in the feature point video collected by the camera is extracted, and the image information is mathematically modeled. By extracting the coordinates of the feature points in this frame of image, a planar two-dimensional coordinate system composed of horizontal and vertical coordinate systems is built and the feature points extracted from the image are copied into the coordinate system, as shown in Figure 2.

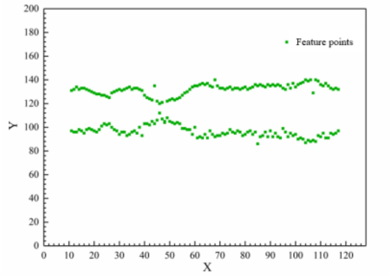

Figure 2. Feature point distribution map

The specific implementation scheme of the shoreline identification method based on the feature point partition fitting evaluation strategy is as follows: extract the feature point with the smallest ordinate in the coordinate system from Fig. 2 and set it as $P(x_p, y_p)$, and set the feature point with the largest ordinate as $Q(x_q, y_q)$. Assuming that the position of the shoreline in the figure is $L = l_0 + \Delta l \times n$, l_0 is the initial position of the shoreline scan, that is, the ordinate $l_0 = y_p$ of the lowest feature point, and Δl is the fixed step length, that is, the step length of each upward scan. Assuming that the shoreline $L = l_0 + \Delta l \times n$ moves upward from the straight line position of point P to the straight line position of point Q, the set of characteristic points in the coordinate system whose ordinate lies on the shoreline and the lower area is defined as set Q_s, set Q_d, Q_s is the collection of points whose ordinate is greater than the shoreline $L = l_0 + \Delta l \times n$, that is, the collection of physical feature points, and Q_d is the collection of points whose ordinate is less than the shoreline $L = l_0 + \Delta l \times n$, that is, the collection of reflection feature points. Then, curve fitting is performed on the characteristic points of Q_s to obtain $F_s = f_s(x)$, and the reflection curve $\hat{F}_d$ can be obtained according to the principle of water surface mirroring, as shown in formula (1):

$$\hat{F}_d = 2L - F_s \tag{1}$$

Extract the abscissas of all the feature points of the theoretical reflection curve $\hat{F}_d$ to get set $\hat{Q}_d^x$, and at the same time extract the abscissas of all the feature points in Q_d to get set Q_d^x, calculate the variance of the abscissas of the two sets, as shown in formula (2) :

$$S_n = \int (\hat{Q}_d^x - Q_d^x)^2 \, dx \tag{2}$$

It can be seen from equation (2) that the smaller the value of the variance S_n of the two sets of abscissas, the closer the shoreline $L = l_0 + \Delta l \times n$ is to the real shoreline position. When the variance $S_n = 0$ is the hypothetical shoreline $L = l_0 + \Delta l \times n$ is scanned to the real shoreline. Taking into account the error of the characteristic point coordinates in the actual situation, when the variance S_n reaches the lowest value, the shoreline $L = l_0 + \Delta l \times n$ is scanned to the real shoreline.

According to the above-mentioned shoreline identification method based on the feature point partition fitting evaluation strategy, the area above the shoreline is determined after the shoreline is determined, and after the area above the shoreline is eliminated, only the water surface area below the shoreline remains.

3.2. Algorithmic process

The unmanned ship equipped with binocular cameras uses the ORB-SLAM2 algorithm to extract the ORB feature points, and establishes a mathematical model based on the distribution of the feature points, and adopts the shoreline identification algorithm based on the feature point partition fitting evaluation strategy. The algorithm is shown in Table 1：

Tab. 1 Coastline identification pseudo code based on feature point partition fitting evaluation strategy

Algorithm 1： Shoreline Recognition Algorithm Based on Partition Fitting Evaluation Strategy of Feature Points

INPUT： Feature point coordinates

OUTPUT： Shoreline position

1. FOR $L = l_0$ TO $l_0 + \Delta l \times n$ (n=1,2,3…) // Δl is a fixed step, l_0 is the ordinate of the lowest point
2. IF $Y > L$ THEN // Y is the ordinate corresponding to the feature point
3. The set of feature points corresponding to Y is Q_s
4. ELSE
5. Let the set of feature points corresponding to Y be Q_d
6. END IF
7. Fit Q_s curve to $F_s = f_s(x)$
8. Definition $\hat{F}_d = 2L - F_s$
9. Define the abscissa set of $\hat{F}_d$ as $\hat{Q}_d^x$
10. Define the abscissa of the point in the set Q_d as Q_d^x
11. Definition $S_n = \int (\hat{Q}_d^x - Q_d^x)^2 dx$ (n=1,2,3…)
12. IF $S_{n-1} > S_n$ THEN
13. $S_n = S_{min}$
14. ELSE
15. $S_{min} = S_{n-1}$
16. END IF
17. END FOR
18. Obtain the minimum value S_{min} of S_n and the number of moving steps n by comparing
19. Get $L = l_0 + \Delta l \times n$ // L is the shoreline position

The execution steps of the shoreline identification algorithm based on the feature point partition fitting evaluation strategy are as follows:

Step 1: According to the coordinate positions of the feature points extracted by the ORB-SLAM2 algorithm, establish a mathematical model that is to establish a coordinate system as shown in Figure 2, and map the feature points to the coordinate system.

Step 2: Compare the size of the ordinates of all feature points to select the lowest and high points, and assume the shoreline $L = l_0 + \Delta l \times n$ between the highest point and the lowest point. l_0 is the initial position of the shoreline scan, that is, the ordinate of the lowest point.

Step 3: Assume that the shoreline starts to move upwards from $L = l_0$, with Δl as the step size, after each movement, the set of feature points in the area above the shoreline will be assumed to be Q_s, and the set of feature points in the area below the shoreline will be assumed to be Q_d.

Step 4: Perform curve fitting on the points in the area set above the shoreline to obtain the curve $F_s = f_s(x)$.

Step 5: Calculate the reflection curve $\hat{F}_d = 2L - F_s$ from curve $F_s = f_s(x)$ according to the principle of mirror image on the water surface.

Step 6: Define the abscissa set of the point on $\hat{F}_d = 2L - F_s$ as the abscissa set Q_d^x of the midpoint between $\hat{Q}_d^x$ and Q_d .

Step 7: Perform variance calculation on the sets $\hat{Q}_d^x$ and Q_d .

Step 8: Suppose the shoreline moves up by one step and then continue to step 3, and then compare the variances. When the variance is the smallest or zero, $L = l_0 + \Delta l \times n$ is the true shoreline position, as shown in Figure 3 .

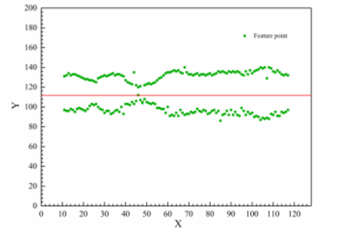

Fig3 Shoreline identification results

From the recognition results, it can be seen that the recognition results of the shoreline recognition method using the feature point partition fitting evaluation strategy are more accurate.

4. Conclusion

In this paper, the feature point partition fitting evaluation strategy algorithm is adopted, and the location of the shoreline is calculated through the feature point partition fitting evaluation scheme, and the shoreline separation is finally realized. Compared with other shoreline recognition algorithms, the algorithm proposed in this paper is more efficient and accurate, and lays a foundation for unmanned ships to better realize surface target recognition and autonomous navigation.

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