A Measurement Method Based on Labelled Feature from Underwater Images

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Abstract. The technique of underwater measurement has been widely used in practice. Focusing on the application of track laying underwater, a measurement method from underwater images, for outputting the dislocation information of two adjacent tracks, is described in this paper. Firstly, a triangle tag which is easy to detect is designed to overcome the disadvantages of underwater images such as low contrast and strong noise; secondly, image thinning of the tag is acquired by morphological operators; thirdly, the measurement features are extracted from the thinning result; and then the dislocation information is calculated by the corresponding measurement features of two adjacent tracks at last. Many practical images are used to verify the performance of the proposed method.

Introduction

The technique of measurement from underwater images means that measuring the real value of the target by certain images processing methods[1][2][3]. Measurement from underwater has been a hot topic in nowadays and there are many applications such as ocean science research, freshwater engineering construction and military affairs fields, and so on.

The generalized measurement includes the measurement of image gray, texture and geometry characters; the narrow sense of image measurement means that the measurement of the geometric feature covering the size of target and the geometric shape, etc.

Up to now, most of the study of measurement based on underwater images focuses on underwater navigation and terrain measurement. To inspect of the target quality, Lu and Chen proposed a method based on structure feature to measure the crack of the target[4]; in [5], the PDI technology of laser image was developed to detect object from underwater; Sun and Zhang studied the transmission of forward-scattering, back-scattering and designed a underwater imagery system [6].

This study proposes a method to measurement the dislocation information of two adjacent tracks based on tags in underwater images. The basic procedure is described as follows: firstly, by using morphological technique to acquire the skeleton of the tags on the tracks, and then by extracting the points and line segments features to obtain the measurement features, the dislocation information is calculated by the measuring features of two adjacent tracks. By using many underwater images which were acquired by a underwater sensor, we calculate the error of the proposed method, and the experimental results illustrate that the proposed method has excellent performance.
Measuring Feature Extraction of Underwater Images

The purpose of feature extraction is to obtain the measuring features, which provide the foundation of image measure. In this section, we first design a tag which was coated on the tracks. And then by using the skeleton extraction to thin the tag, the measuring features including points and line segments are extracted finally.

The Design of a Tag on the Track

To acquire the measuring feature of track, and considering the characteristic of underwater image including low contrast and high noise, we design a tag labelled on the frontispiece and the side surface of a track as shown in Fig.1.

The tag is consisted by several line segments with different distances and a regular triangle. The tag has many points and line segments which is easy to detect, which provides the remarkable feature to measure the dislocation of two adjacent tracks.

Binary and Thinning of an Image

To extract the geometric feature, image binary[7] is often used to obtain a binary image. A binary image can be obtained by a threshold which can be given by certain adaptive method such as OSTU or a fixed value.

Image thinning[8][9] is used to output the refined geometric feature which can be implemented by the technique of skeleton extraction. A morphological based method can be given as follows[10]:

\[ S(A) = \bigcup_{k=0}^{K} S_k(A) \, , \]  

(1)

\[ S_k(A) = (A \Theta k B) - (A \Theta k B) \circ B \, . \]  

(2)

Here, B is a structuring element, S(A) is the skeleton of a set A, and \((A \Theta k B)\) indicates k successive erosions of A,

\[ (A \Theta k B) = \cdots ((A \Theta B) \Theta B) \Theta \cdots \Theta B \, . \]  

(3)

and K is the last iterative step before A erodes to an empty set, that is

\[ K = \max \{ k \mid (A \Theta k B) \neq \emptyset \} \, . \]  

(4)

Fig. 2 give an example of image thinning.
Extraction of Measuring Feature

After the image thinning just discussed, we propose the following process shown in Fig. 3 to extract measuring features including the end points and the short line segments of the tag.

The procedure of Fig. 3 is described in detail as follows:
Step1: searching the largest connected domain in image skeleton
Since there are two vertices in the two tags in the left and right domains, so each of these two rectangular point can be detected in the largest connect domains located in the left and right locations respectively. The searching the largest connected domain can be realized by scanning method.
Step2: searching left and right vertices
In the largest connected domain located in the left part of the image, the vertex can be detected by searching the right hand end point; another vertex in the right part can be detected similarly.
Step3: searching the left and right short line segments
Based on the vertices detected by step2, the short line segments can be easily determined. An example is shown in Fig. 4.

Under Water Measurement Based on Measuring Feature

The purpose of this section is to calculate the dislocation information based on the measuring feature described in section 2.
**Construction of the Coordinate**

The dislocation information of two tracks includes clearance between tracks, horizontal dislocation and vertical dislocation, so the coordinate system can be designed on any crack as shown in Fig. 5. The x and y axes are parallel and perpendicular to the axes of the track respectively, and the z-axes is perpendicular to the x y plane. The origin can be selected as any point which is easy to detect.

![Figure 5. The coordinate of calculating dislocation information of two tracks.](image)

**Calculation of Dislocation Information**

As mentioned before, the so called dislocation information includes three kinds of cases as shown in Fig. 6. Fig 6 (a) indicates the horizontal dislocation. Fig. 6 (b) shows the case of vertical dislocation.

![Figure 6. Dislocation of two cracks](image)

As mentioned in 3.1, we put the coordinate system on crack 1 as shown in Fig. 6 (a), the vertex of the corresponding triangle is selected as the origin. It can be found that $X_0$ and $Y_0$ are the clearance between tracks, horizontal dislocation respectively; and $Z_0$ is the vertical dislocation shown in Fig. 6 (b).

Now, we give the steps to calculate the three quantities $X_0$, $Y_0$ and $Z_0$ in detail.

**Step1:** By using the coordinates of the vertices of the two triangles to obtain the clearance between cracks and horizontal dislocation measured by the number of pixel;

**Step2:** By the coordinates of the initial and end points of the short line segment and the physical length, the space resolution of the image can be computed;

**Step3:** by the dislocation measured by pixel and the resolution provided by Step2, The corresponding dislocation information is output.
Experimental Studies

To verify the performance of the proposed measuring method, we obtain 174 underwater images were acquired, the dislocation information of each case is measured in advance. The comparisons of the measuring values with real values of the dislocations of part of the images are shown in Fig.7.

![Graphs showing comparisons between real and measured values of crack dislocations.](image)

From Fig. 7 (a), (b) and (c), we can find that the two curves are very close each other which means that the measuring error is small. In fact, through these statistical data, the measuring error is not more than 1.55 mm in each case.

Conclusions

This paper presented a measuring method from underwater images. The basic idea is to use the morphological technique and certain searching strategy to extract the measuring features including points and line segments, and then by these points and line segments to realize the measurement of
the dislocation of two adjacent tracks under water. To give the effective measuring feature, the technique of image thinning is utilized. Many practical underwater images test the excellent performance of the proposed method.

References


