Contour Accentuation for Transfer Learning-Based Ship Recognition Method

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ABSTRACT

This study proposes a ship recognition system which includes intelligent bridge piers and a ship recognition server. The ship recognition server can analyse the contour features of ship images from intelligent bridge piers by the proposed contour accentuation method; the ship image with contour accentuation can be adopted as the inputs of transfer learning-based neural network for ship classification by the proposed transfer learning-based ship recognition method. In practical experiments, the results showed that the proposed transfer learning-based ship recognition method with contour accentuation can obtain higher accuracy, and the accuracy of the proposed method was 97.79%.

CCS CONCEPTS

• **Computing methodologies → Machine learning**.

KEYWORDS

ship recognition, contour accentuation, transfer learning, convolutional neural network

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1 INTRODUCTION

With the increase of demand for inland waterway transport, the security issue of inland water transport has been seriously attended. How to build a ship recognition system in inland waterway transport in accordance with ship images for detecting the type and status of ship is an important issue. In recent years, deep learning models and convolutional neural networks (e.g. ResNet [1], DenseNet [2] and VGG network [3]) have been powerful tools or image recognition. Therefore, this study proposes a ship recognition system which includes intelligent bridge piers and a ship recognition server (shown in Figure 1). The ship images can be captured by intelligent bridge piers and sent to the ship recognition server via web services (i.e. RESTful services). Furthermore, a ship recognition method based on contour accentuation and transfer learning techniques can be performed by the ship recognition server to detect ship types.

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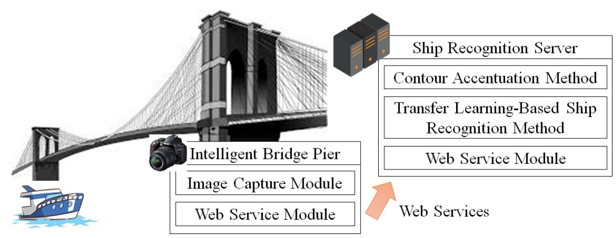

Figure 1: The architecture of ship recognition system

The remainder of the paper is organized as follows. Section 2 presents the proposed ship recognition method. In Section 3, practical experimental results are analysed and discussed. The conclusions and future work are given in Section 4.

2 THE PROPOSED METHOD

A contour accentuation method and a transfer learning-based ship recognition method are proposed to analyse ship images from intelligent bridge piers for detecting ship types. The flow of the proposed ship recognition method is presented in Figure 2.

2.1 Contour Accentuation Method

Contour accentuation may enhance the features of targets in images, so this study proposed a contour accentuation method to extract the contour features of ship images for improving classification accuracy. The matrix of original image pixels with m x n size is

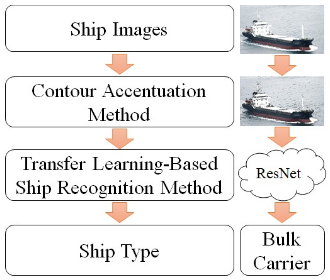

Figure 2: The flow of ship recognition method

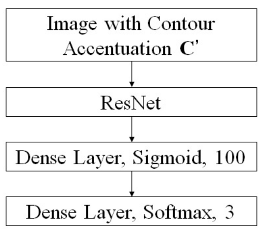

Figure 3: The structure of neural network

denoted as $\mathbb{C} = \{c_{1,1,1},\ldots,c_{x,y,k},\ldots,c_{m,n,3}\}$. The levels of red, green, and blue in the (i,j) pixel are $c_{i,j,1}$, $c_{i,j,2}$, and $c_{i,j,3}$, respectively. The function $f(c_{x,y,k}, c_{i,j,k}, d)$ in Equation (1) is adopted as a contour detection function to mark the contours with zero. If the significant differences between the (i,j) pixel and the neighboring pixels are detected, the (i,j) pixel is marked. The neighboring pixels of each pixel can be analysed by Equation (1), and the image with contour accentuation $\mathbb{C}' = \{c'_{1,1,1},\ldots,c'_{x,y,k},\ldots,c'_{m,n,3}\}$ can be obtained by Equation (2) in accordance with the contour marks.

$$f(c_{x,y,k}, c_{i,j,k}, d) = \begin{cases} 0, & if \left|c_{x,y,k} - c_{i,j,k}\right| \geq d \\ 1, & otherwise \end{cases} \quad (1)$$

$$c'_{x,y,k} = \begin{cases} 0, & if \prod_{i=x-1}^{x+1} \prod_{j=y-1}^{y+1} \prod_{k=1}^{3} f(c_{x,y,k}, c_{i,j,k}, d) = 0 \\ c_{x,y,k}, & otherwise \end{cases} \quad (2)$$

2.2 Transfer Learning-Based Ship Recognition Method

The proposed transfer learning-based ship recognition method adopts the structure of neural network combining ResNet in Figure 3 to classify ship images into three classes (i.e. bulk carrier, container ship and cruise ship) for the ship type detection. The image with contour accentuation $\mathbb{C}'$ is adopted as the inputs of the neural network, and the output layer includes three neurons; furthermore, the ResNet model with weights pre-trained on ImageNet [1] is used to extract image features, and a fully-connected layer with 100 neurons is constructed to link the ResNet model and the output layer.

Table 1: Training and testing datasets (Unit: images)

Ship type	Training dataset	Testing dataset
Bulk carrier	174	43
Container ship	172	44
Cruise ship	204	51

Table 2: The comparison of ship recognition methods

Method	Original	Contour-only	CA
Combining ResNet [1]	94.12%	91.91%	**97.79%**
Combining VGG [3]	88.24%	79.41%	**92.65%**
Combining DenseNet [2]	92.65%	88.24%	**94.12%**

3 PRACTICAL EXPERIMENTAL RESULTS

3.1 Experimental Environments

In experiments, this study used Python, Tensorflow and Keras to implement the proposed system and method. Ship images were obtained by the Yangtze River Nanjing Waterway Bureau. The sizes of training and testing datasets are showed in Table 1.

3.2 Results and Discussions

For the evaluation of the proposed method, Table 2 shows indicated that adopting the image with contour accentuation as inputs can improve the accuracy of ship recognition. Furthermore, this study also compared the classification model combining ResNet with the classification models combining VGG network [3] and DenseNet [2]. The results indicate that the accuracies of the classification model combining ResNet were higher than other models. Moreover, the proposed contour accentuation (CA) can improve the accuracy for each classification model.

4 CONCLUSIONS

The contributions of this study are summarised as follows. A contour accentuation method is proposed to detect the contours of images for the improvement of ship recognition accuracy. A transfer learning-based ship recognition method according to a pre-trained ResNet model can be used to extract image features for ship recognition.

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REFERENCES

[1] Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun. 2016. Deep Residual Learning for Image Recognition. In *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*.
[2] Gao Huang, Zhuang Liu, Laurens van der Maaten, and Kilian Q. Weinberger. 2017. Densely Connected Convolutional Networks. In *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*.
[3] Karen Simonyan and Andrew Zisserman. 2015. Very Deep Convolutional Networks for Large-Scale Image Recognition. (2015). arXiv:arXiv:1409.1556v6