

A Study on the Composition of Image-Based Ship-type/class Identification System

Jiwon Lee, Do-Won Nam, JungSoo Lee, Sungwon Moon, Arum Oh, and WonYoung Yoo

Telecommunications Media Research Laboratory,

ETRI(Electronics and Telecommunications Research Institute), Korea

ez1005@etri.re.kr, dwnam@etri.re.kr, jslee2365@etri.re.kr, moonstarry@etri.re.kr, aro@etri.re.kr, zero2@etri.re.kr

Abstract— Ships, coastal posts, and control centers need to verify the information, location, and speed of nearby vessels for various purposes, such as traffic control or maritime warfare. In the field of defense where accurate information on nearby ships is important, radar is used to acquire location information on nearby ships. However, the selection of the opponent's position as well as the high-value units must be more important and prioritized, and image-based warship type/class identification techniques are required in naval warfare. This paper presents a detailed method for system construction that supports detailed identification of warship type/class through structural analysis. Through the development of the proposed system, reliable warship identification can be used for tactical applications in the defense field, thereby contributing to the enhancement of defense capabilities.

Keywords— Ship classification, Warship identification, Structural analysis, Deep learning, Pattern matching

I. INTRODUCTION

In ships, coastal posts, and control centers, there is a need for information, location, and speed of nearby vessels for a variety of purposes, such as traffic control and marine accident support. For this, a system such as an automatic identification system (AIS) or a V-pass that can transmit and receive the information or position of the vessel through wireless communication is used. However, there are cases in which wireless communication alone does not sufficiently acquire information on nearby vessels, such as the absence or failure of a communication device or the intentional turning off of the device so as not to be detected by an opponent in a war situation. To compensate for this, techniques for recognizing nearby vessels based on the images taken on board were introduced.

Among them, *Zhang et al.*[1] proposed a technique of classifying ships into six types according to their appearance, and recognizing the type of ships in the image based on deep learning technology. *Zhang* and his team trained one of the deep learning models, CNN, based on daytime optical and nighttime infrared (IR) images, and presented a classifier with 87.4% accuracy for the input vessel image. *Huang et al.*[2] proposed a classifier with 85% accuracy by extracting feature points from images and classifying ships based on a combination of multiple feature points.

These studies have been proposed to classify what type of ships are recognized based on images, but they do not support detailed identification according to class within a ship type. In general, ship type classification alone is sufficient, but in special cases such as military purposes, ship class identification is also necessary in the case of a ship is classified as a warship. For example, even if a certain ship is classified as a warship, warships are divided in detail according to the purpose of destroyers, cruisers, and patrol ships. In addition, the destroyer can be divided into various class such as King Kwanggaeto, Lee Sunsin, and King Sejong. Different class of destroyers have different weapons, so military countermeasures vary with each destroyer. Therefore, detailed warship class identification is also required.

In the case of patents[3, 4], the purpose of image/video-based ship recognition is to avoid risk situations such as collision. Therefore, it recognizes the ship itself and concentrates on inferring the dangerous situation such as the distance, speed, and direction of around ships, but it does not identify the type or class of the ship. Such patents have different objectives from the system presented in this paper, which aims to identify the exact type/class of counter-ships for military purposes and to assist in establishing an appropriate military strategy.

II. PROPOSED SYSTEM

The problem with existing image-based ship classification technologies is that only the type of target ship can be classified. General ships can be used for many applications with just a type classification, so they can use existing technologies. However, in case of warships, they are divided into various types according to their use, and within one type, they are divided into subclasses according to their size. In addition, different classes of warships have different weapons, so it is necessary to identify the type/class for proper response. This paper proposes a system that can classify ship types through input images, and if the recognized ship is a warship, it recognizes the components in detail and analyzes the structure to identify the type and class of the warship in detail as shown in Fig. 1.

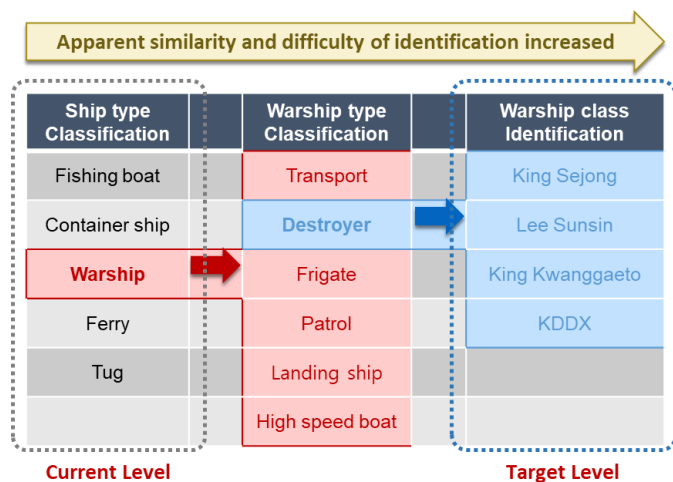


Figure 1. Goal identification level of the proposed system

Figure 2 is a block diagram showing the structure and data flow of the system that classifies the type of ship and the detailed type/class of a warship from the input image. The proposed ship and warship type/class identification system consists of three steps. Step 1 is a marine image preprocessing block that removes a ship identification deterioration factors that can be issued in a maritime situation such as surface reflected light and sea fog. Step 2 is a general ship classification block that classifies the type of ship from the preprocessed image. In the case of the object identified by the warship in step 2, the detailed type/class of warships are finally determined through the warship part segmentation subblock (Step 3-1) and the identification of warship based on structural analysis subblock (Step 3-2).

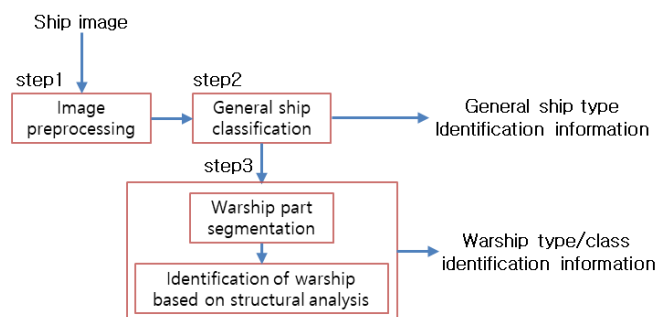


Figure 2. Data flow of Warship type/class identification system

Step 1 removes or marks the distracting elements when identifying objects of interest in the image using traditional image processing techniques. Examples of removal elements may be such as sea fog, surface reflected light, raindrops. Examples of marking elements, such as wakes and lands, can be removed from the process to significantly reduce the rate of ship misidentification.

Step 2 is to recognize the type of ship from the preprocessed image received in the previous step. For this purpose, it is necessary to classify ship types based on their external structure or characteristics. As an example of classifying ship types, this paper established the ship

classification criteria of Table 1 and collected data based on the ship classification system in Korea's Ship Safety Act. After that, the model is trained to identify ships according to Table 1 using deep learning techniques, and ship type identification is performed through this. In this case, a model that performs transfer learning based on AlexNet[5], VGGNet[6], ResNet[7], etc. may be used as a deep learning model of a general ship classification block.

TABLE 1. SHIP CLASSIFICATION CRITERIA

primary classification	secondary classification	Classification ID
Fishing boat		V_01_01
Ferry	Cruise ship	V_02_01
	Ferry	V_02_02
Cargo ship	Container ship	V_03_01
	LNG ship	V_03_02
	Other cargo ship	V_03_03
Tug		V_04_01
Barge		V_05_01
Coastal police ship		V_06_01
Warship		V_07_01
Other ship		V_08_01

If the result of Step 2 is not a warship, the result is immediately presented to the user. However, if the classified ship is a warship, it goes to the third step to identify the type/class details of given warship. As shown in Fig. 3, the third step consists of the warship part segmentation subblock (Step 3-1) that recognizes the components of the warship in detail and the identification of warship based on structural analysis subblock (Step 3-2) that determines the type/class of the warship to be identified by analyzing the relationship or structure between the identified elements of the warship.

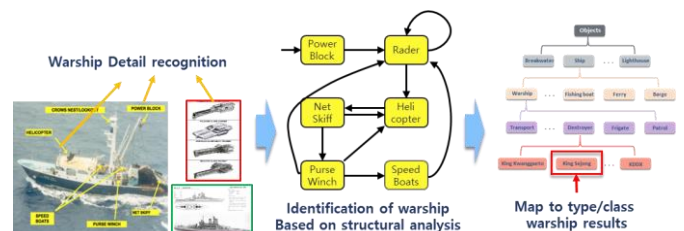


Figure 3. Type/class identification flow of given warship

In Step 3-1, the warship is divided into components by object part segmentation technology. In order to segment the warship, PSPNet[8] or DeepLab[9] can be used, and it aims to identify the main components of the warship, such as body, artillery, radar, and house.

In Step 3-2, n warships with high similarities is presented to the user compared to the warship structure database with the location of the warship components received in the previous step by the 3D pattern matching technique.

Here, the reason for passing the final decision to the user by recommending n final candidates using a pattern matching method is as follows. First, when performing ship type/warship type/warship class identification through deep

learning, errors accumulate step by step and the final accuracy greatly decreases. In order to minimize this error accumulation problem, it is designed as shown in Fig. 4 to go through a two-step deep learning process. (One of the deep learning models recognizes only the warship components that may not affect the identification even if a certain level of error occurs.) In addition, in case of ship type/class identification through the deep learning model, an accurate analysis has not yet been performed on which features of the objects are distinguished by the deep learning network. Therefore, it was judged that the method of measuring similarity of warship through pattern matching is generally similar to the way that people distinguish similar objects. Finally, since the warship type/class identification results are used for military and tactical purposes, it is judged that it is safe to judge the expert by presenting n candidates and to make the final confirmation by the expert.

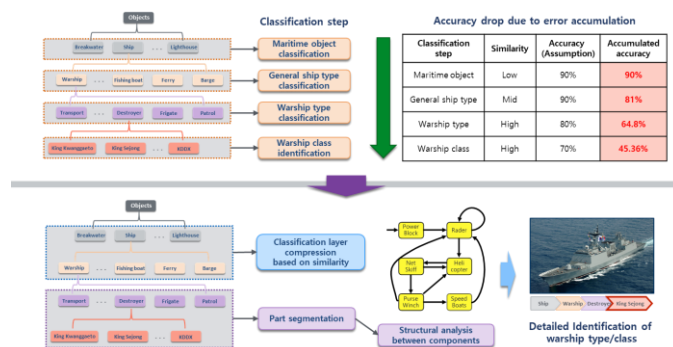


Figure 4. Design of detailed warship identification for error minimization

III. CONCLUSIONS

In this paper, the proposed system classifies the type and detailed class of warship by using deep learning and pattern matching technique step by step in the optical image.

The proposed image-based warship type/class identification system finally identifies similar marine warships through stepwise classification by mixing deep learning and pattern matching techniques. Therefore, the error accumulation problem that can occur when identifying similar objects step by step through deep learning can be solved. Also, reliable identification information derived through this can be used for tactical applications in the defense field.

ACKNOWLEDGMENT

This work was supported by Institute of Information & Communications Technology Planning & Evaluation(IITP) grant funded by the Korea government(MSIT) (No. 2019-0-00524, Development of precise content identification technology based on relationship analysis for maritime vessel/structure)

REFERENCES

- [1] M. M. Zhang, J. Choi, K. Daniilidis, M. T. Wolf, and C. Kanan, "VAIS: A dataset for recognizing maritime imagery in the visible and infrared spectrums," in *Proc. Computer Vision and Pattern Recognition Workshops*, pages 10-16, 2015.
- [2] L. Huang, W. Li, C. Chen, F. Zhang, and H. Lang, "Multiple features learning for ship classification in optical imagery," *trans. Multimedia Tools and Applications*, vol. 77, no. 11, pages 13363-13389, 2018.
- [3] Korea Institute of Ocean Science and Technology (KIOST), "Automatic Identification System and Method for Ship by Using Image of Monocular Camera Vision," Korea registered patent (10-1379636), 2014.
- [4] Electronics and Telecommunications Research Institute (ETRI), "Apparatus and Method for Providing Other Ship Information based on Image," Korea public patent (10-2015-0075505), 2015.
- [5] A. Krizhevsky, I. Sutskever, and G. E. Hinton, "ImageNet Classification with Deep Convolutional Neural Networks," in *Advances in Neural Information Processing Systems*, 2012.
- [6] K. Simonyan and A. Zisserman, "Very Deep Convolutional Networks for Large-scale Image Recognition," in *Proc. ICLR*, May 2015.
- [7] K. He, X. Zhang, S. Ren, and J. Sun, "Deep Residual Learning for Image Recognition," in *Proc. CVPR*, June 2016.
- [8] H. Zhao, J. Shi, X. Qi, X. Wang, and J. Jia, "Pyramid Scene Parsing Network," in *Proc. CVPR*, July 2017.
- [9] L. C. Chen, G. Papandreou, I. Kokkinos, K. Murphy, A. L. Yuille, "DeepLab: Semantic Image Segmentation with Deep Convolutional Nets, Atrous Convolution, and Fully Connected CRFs," *trans. Pattern Analysis and Machine Intelligence*, vol. 40, Issue 40, Apr. 2018.



Jiwon Lee received the B. S. degree in Computer Engineering from Kyungpook National University, Republic of Korea, in 2008, and the Ph. D. degree in Computer Science from Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea, in 2013. Since 2013 he has been a senior researcher in the Creative Content Research Division, Telecommunications Media Research Laboratory, Electronics and Telecommunications Research Institute (ETRI), Republic of Korea. His research

interests include multimedia security, image/video deep learning, and image/video processing.



Do-Won Nam received the B.S. degree in Computer Science from Korea Advanced Institute of Science and Technology (KAIST) in 1996 and M.S. degree in Information Technology from Pohang University of Science and Technology (POSTECH), Korea in 1998. He is working as a principal researcher in the Electronics and Telecommunications Research Institute (ETRI) since 2001. His research interests include data mining, digital rights management, digital cinema system, sports video analysis, and image based ship

classification.



Jungsoo Lee received his B.S. and M.S. degrees from Jeonbuk University, Korea in 1995 and 1997, respectively and his Ph.D. degree in Electronic Engineering from Hanyang University, Seoul Korea in 2005. From 2000 to 2005, he was a senior member of MarkAny Research Institute. Currently, he is a senior member of Electronics and Telecommunications Research Institute (ETRI). His research interests are digital watermarking, fingerprinting, image

processing, digital rights management, digital cinema and digital signage, and image based ship classification.



Sungwon Moon received his B.S and M.S degrees of computer science from KAIST, Korea in 2010 and 2012. Since 2012 he has been a researcher in the Creative Content Research Division, Telecommunications Media Research Laboratory, Electronics and Telecommunications Research Institute (ETRI), Republic of Korea. His research interests are Digital Watermarking, Video Forensic, and Video Processing.



Ah Reum Oh received the B. S. degree in Control and Measurement Engineering and the Master degree in Control and Instrumentation Engineering from Chungbuk National University, Korea, in 2003 and 2005, respectively. And she received the Ph. D. degree in Electronics and Electrical Engineering from the University of Southampton, UK, in 2016. Since 2016 she has been a senior researcher in the Content Information Retrieval Research Section, Telecommunications and Media Research Laboratory, Electronics and Telecommunications Research Institute (ETRI), Republic of Korea. Her research interests include computer vision, image/video processing, robotics and machine learning.



Wonyoung Yoo received his Bachelor's, Master's and Ph. D. degrees in Electronic Engineering from Jeonbuk National University, Republic of Korea, in 1996, 1998 and 2003, respectively. Since 2001, he is working as a Managing Director of Electronics and Telecommunication Research Institute(ETRI). His research interests include image/video watermarking, fingerprinting and video analysis