Towards the Implementation of Ship Recognition and Identification System in Costal and River Information Services

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***Abstract*— The scope of the ship recognition and identification (SHREC) project covers development of three main system modules based on: detection and tracking, classification, and identification methods. First method allows to detect and track a moving ship while maintaining system performance, so it can be used to process data from multiple cameras (20 and more). Second method allows for classification of non-conventional ships into 5 to 7 classes using two Convolutional Neural Networks (CNN). This allows to recognize a type of ships when the identification is not possible. The identification method locates and recognizes hull inscriptions of detected units and matches them with records from available ships registers. Obtained information on ships can be automatically pushed into service oriented architecture of River Information Services (RIS) for alerting, statistics and authentication purposes. Currently, the integration and performance tests in marine and inland on-shore environment are close to finish. The obtained results imply that the SHREC is suitable for further integration with smart city services.**

Keywords- surveillance; ship identification; detection and tracking; river information services.

I. INTRODUCTION

Ships identification problems is addressed by many existing systems, as it is vital for safety and security of all on-water traffic participants and facilities on shore. Most solutions are directed in identifying large ship covered by Safety Of Life At Sea (SOLAS) [1] convention, which are oblige to use Automatic Identification System (AIS) transponders, have assigned unique International Maritime Organization (IMO) numbers, and have their hulls properly marked. The Ship Recognition and Identification System (SHREC) is being developed to automate the identification of non-conventional vessels in ports, harbors of both marine and inland waterways. It uses both traditional image processing and artificial intelligence methods (deep neural networks) to analyze video streams from existing monitoring systems as part of ship and port information systems.

In addition to the detection, classification and identification of units, the system's task is to transmit information about the ship to other system services and their recipients. This allows the information to be marked on electronic navigational charts and sent to interested services and authorities for notification, warning or statistical analysis.

The paper is organized as follows. Section 2 contains the description of three main modules of the system – detection and tracking, classification and identification. Section 3 summarizes the research emphasizing obtained results and pointing out some main constraints of the proposed solution.

II. GENERAL SYSTEM OVERVIEW

The system contains three main modules related to three main tasks of the system, together with an operator console module, the interfaces to the external systems, and a system core that contains systems logic that allows for interoperability between all mentioned parts. The core also stores the data and feeds the operator application with it. The system can use existing video monitoring system by capturing an analyzing its streams. These surveillance systems are usually part of vessel traffic information services implemented in critical water areas of moderate to heavy traffic or in proximity to crucial on-shore facilities. The services usually store or use information on ships coming from different hull registries of different kinds of vessels scattered in different authorities. SHREC system exchanges the data with such services by using it as reference data for ship identification purposes and sending back the information on detection, recognition or classification to RIS/VTS. For the communication with on-shore monitoring system 5G network is used together with a radio line set up between nodes further away from the city or port. Achieved results of systems main methods are presented below.

A. Detecting and Tracking

The method assumes that for each camera view there is a determined detection zone that eliminates areas of the scene where either ships cannot appear (e.g., on land) or they are too far for the detection process to make sense. The background subtraction algorithm is used for each frame from a video stream to obtain foreground objects, find their contours, and to obtain bounding boxes for each detected ship. The method is designed to detect all kinds of moving vessels and to work efficiently, so it can be used to process data from multiple cameras (20 or more) with usage of economically acceptable amount of server resources. The algorithm works in variable lightning conditions and with slight changes of the background. It detects water artefacts (by measuring number and length of edges). Furthermore, it identifies the same ship across the frames and is able to filter

 ISBN: 978-1-61208-863-1

out artifacts based on a 5 frame window. Exemplary scene is presented in Figure 1. Green frame shows a detected ship, yellow show places from 8 second were the ship was spotted, other colors show other objects (not ships) that were correctly rejected Movement direction is detected based on camera location. The HD resolution 1280x720 and GSOC background subtraction algorithm provide best results considering performance.

The method was tested using a test computer (Core i7-8700K, 32GB RAM, SSD 1TB, NVIDIA 311 Quadro P4000). The method returned around 90% of correct detection events for test sets of good quality scenes and around 80% for test sets of streams of bad quality. The incorrect detection events mainly arose from a few video samples with unfavourable lightning conditions. Some errors are corrected during later identification stage. More details can be found in [2].

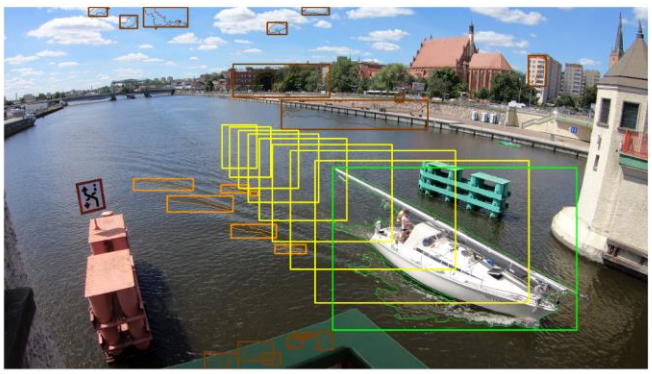

Figure 1. Detection method in action.

B. *Classification*

The module has two classification algorithms implemented. The first one is an implementation of the original CNN developed for the project, described in detail in [3]. Using only own-gathered data (recorded ships images) on 16 different architectures gave maximum ~20% efficiency during training. Training with the additional older database attached was ~41%. Finally, classification accuracy between 60 and 70% was achieved, but for only 5 classes.

For the purpose of achieving a proper classification quality, a second one was implemented using existing GoogleNet solution trained with thousands of images of non-SOLAS ships acquired during last 3 years the area cover by Lower Oder RIS System (Figure 2). The result that was achieved gave a classification accuracy of 84% for 7 classes (barge - together with pushed kit, motorboat, sailing yacht, kayak, service unit, passenger, and others). More information can be found in [4].

SHREC classification service can execute both classification algorithms at once. It also displays the last classified ship. Classification module is especially needed when identification is not possible due to unreadable vessel inscriptions.

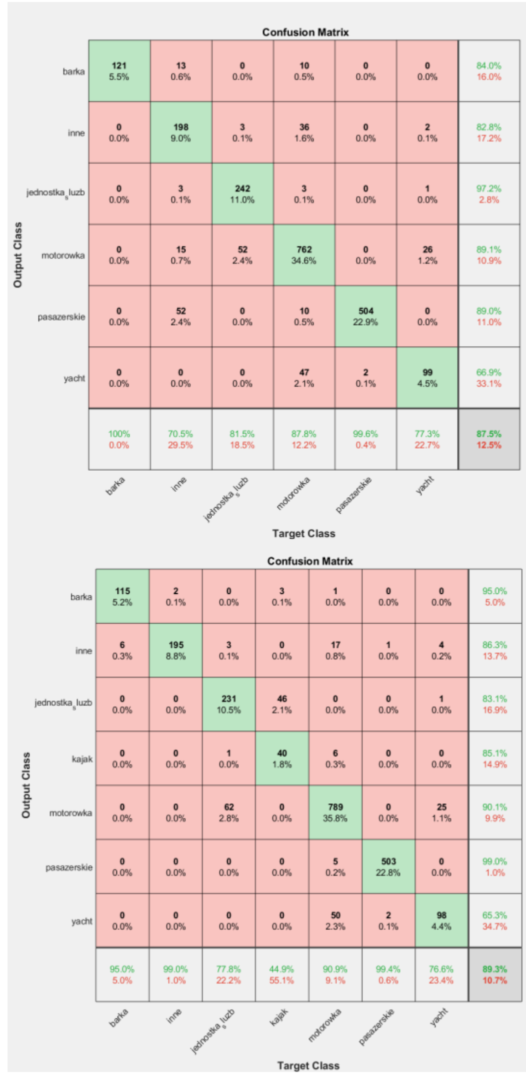

Figure 2. Exemplary confusion matrixes for different number of classes in pre-trained GoogleNet solution [4]

C. *Identification*

Vessel identification is based on the location and recognition of the hull inscriptions of the detected ship by the detection module. Our hybrid approach uses three text localization methods (CCA [5], MSER [6], EAST [7]) and Tesseract OCR to recognize inscriptions. The module uses its own ship registry (that can be fed from ships data bases from external services) and compares the found inscriptions with its records. It runs in near real time, in 5-second-rounds.

The degree of correct identification is determined depending on the degree of text matching. Conducted tests showed that the proposed method produced the 69% full matches of hull inscriptions (matched with no errors), 25% high matches (matched with one allowed error), 3% low matches (matched with two allowed errors), 3% multiple matches (matched simultaneously with more than one ship), and 9% of vessels were not identified. The methods architecture and tests were described in detail in [8].

 ISBN: 978-1-61208-863-1

The method works well identifying commercial vessels, as their inscriptions are placed according to the binding rules. With the recreational craft situation varies. When the visible inscription exceeds 10-12 pixels in height, the OCR returns satisfying results. Usually, the module analyses 10 to 20 vessels frames per vessel passage in front of the camera, while one with clear, visible characters is enough for proper recognition (identification).

III. Summary

The tests results show that the system is able to recognize and identify all kids of ships using only video surveillances that are part of many already existing vessel monitoring systems. In a case when the identification is impossible, it classifies passing vessels into one of determined categories. The system detects vessels in less than a second with the background model updating 3 times per second during that process. Pre-identification is performed once per five-second round and the final identification outcome is given after the ships pass (after a round where tracking ID of the passing ship is lost). Deployment of proposed solution enables for automatization of operators work in monitoring centres and significantly reduces its cost. At the same time, it offers historical logs of identified and classified units and allows pushing statistics or alerting information to other services. This system is a smart management system for port and costal traffic services. The approach is in line with current trends for digitization, data sharing, and the development of the information society.

The main constrain of this solution is that the system is usable mainly in the daytime, in moderate to good weather conditions. Its operability is directly dependant on the quality of used cameras. A good night operability requires better than average hardware solution, such as CMOS sensors with low noise and suitable sensitivity, deliberated cameras placement, and the artificial source of light. Additionally, the classification module of the system was not trained using night-time ships' images as the traffic during night in summer months is very low and therefore, the classification accuracy during the night is unknown.

Acknowledgment

This work was supported by the National Centre for Research and Development (NCBR) of Poland under grant No. LIDER/17/0098/L-8/16/NCBR/2017.

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