VIDEO ANALYSIS APPLICATIONS AS PART OF AUTONOMOUS SHIP'S IOT

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ABSTRACT:

Advances in autonomous ship's technology are tremendous, but there are a lot of unsolved or problems that need improvement. Production and design of the autonomous ships implies a lot of development stages, smart devices connected through ship's local area network, and connection to the ship's control onshore center. In this paper we propose a small part of the complex autonomous ship system. This part includes artificial intelligence algorithms for video processing, and smart abilities. These abilities are generated by usage of connection to the local Internet of Things by the on-board surveillance cameras. This combination is expected to improve safety of the navigation.

Ključne riječi: obrada video signala, umjetna inteligencija, pomorska industrija, industrija 4.0, Internet stvari

SAŽETAK:

Napredak u tehnologiji autonomnih brodova je ogroman, ali i dalje postoji mnogo neriješenih ili problema čije rješenje treba poboljšati. Proizvodnja i projektiranje autonomnih brodova podrazumijeva mnogo razvojnih faza, pametne naprave povezane kroz brodsku lokalnu računalnu mrežu te vezu s brodskim upravljačkim centrom na kopnu. U ovom članku predlaže se mali dio složenog sustava autonomnog broda, koji uključuje algoritme umjetne inteligencije za obradu videa, pametne sposobnosti brodske nadzorne kamere spojene preko lokalnog Interneta stvari, a sve sa svrhom poboljšanja sigurnosti plovidbe.

1. INTRODUCTION

Surveillance cameras aboard autonomous ships should provide input signal for the analysis to improve safety of maritime traffic. Possible detections are:

- small boats,
- sailboats,
- yachts,
- swimmers,
- smacks,
- pirates,

- other moving objects.

Some cannot be seen on radar screens. Hence sensors' fusion should be used and one of the sensors is the surveillance camera.

Hardware realization is not complicated with nowadays technology, since IP wireless cameras exist. This is the basis for the usage in the ship's IoT (Internet of Things).

Autonomous cargo vessels were analyzed in [1]. Major challenges of unmanned vessels was considered in [2]. Basic forms of IoT are already present in shipping industry [3]. As stated in [4], we are witnessing autonomous revolution in maritime industry, which is based on IoT and 5G systems installed on board. Aspects of such digitalization in maritime transport was considered in [5, 6], where [5] deals with control of unmanned maritime traffic.

According to [7], one of the most innovative IoT applications involve video analytics. This technology applies deep learning algorithms allowing smart cameras to recognize people, objects, and situations automatically. It is expected that this market will have impact from 4 to 11 trillion by 2025. Video analytics provide a higher-value information to the typical IoT. Typical IoT sensors are low-complexity, with binary data, linear algorithms, and a single variable for decision models. High-value video analytics provide sensors with high capability, complex visual-data feeds, pattern recognition analytics, and multiple variables for decision making process. These characteristics are ideal for autonomous ships.

According to [8], one of specific problems that should be resolved by the video analytics applications is "obstacle and small objects detection". The paper suggested optical cameras, laser range finders, IR systems etc. Except on the fixed position in the maritime zone, cameras can be placed aboard automated ships, which generates moving camera detection problem, or by aerial surveillance [9].

Nowadays, maritime industry is in the testing phase of near-shore voyages of autonomous ships, such as ferry lines. There are usually a lot of small objects in near-shore maritime traffic, i.e. boats, yachts, sailboats, pilot, tugboats, etc. Some of them do not generate radar reflection or the reflection is below detection threshold. Hence, visual or visual plus IR sensors are imperative for such situations. This is the reason for development of computer vision algorithms designed for maritime conditions.

2. PROPOSED SYSTEM

System can be divided into:

- image acquisition,
- image communication to the ship's AI,
- image processing, and
- decision making on action if necessary.

2.1. Input signals

Image acquisition is performed by cameras, but the choice is discussable. Video spectra is not perfect choice for the sea applications. Hence, IR and video fusion is preferable. Another problems are choice of the cameras' range and resolution. It is very possible that two types of cameras should be used – short range for security aboard, and middle-range for the maritime traffic safety. Obtained signals are transmitted over local IoT to the ship's computer center, where it is used to make decisions.

Figure 1 shows the illustration of cameras roles aboard autonomous ships. Several security cameras are positions aboard to cover possible intruder alerts, as well as other risks detectable by visual sensors.

Long range cameras are expensive, but have satisfactory range for ocean-going ships. Furthermore, it is usual that such cameras incorporate IR part of the spectrum, which is additional advantage for ocean surface surveillance. The surveillance data are sent to the computer center, which performs further algorithms and actions.

The role of long-range camera is to observe maritime zone and serves as an input to the computer vision algorithm, which deals with the maritime traffic problems.

On the other hand, additional inputs for computer vision systems are video security cameras, which are used for security in short-range (decks range). Security cameras can detect moving un-authorized movements aboard automated ship. Consequently, an alarm is triggered. It is interesting to recognize that such movements do not need to be made by humans, but also robots, drones, or any other potential tool for harming the ship. The security cameras should be carefully placed to cover all sensitive areas of the ship.

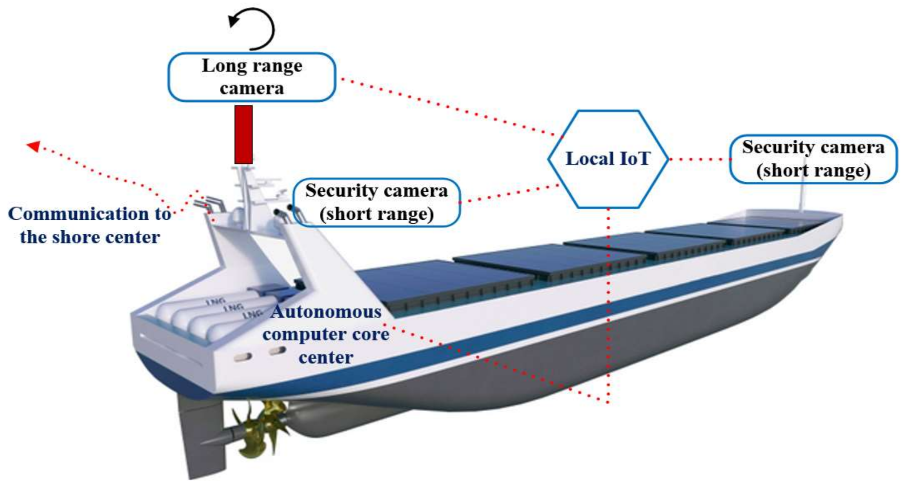

Figure 1: Video surveillance role aboard autonomous ships

2.2. Local communication and image processing

Figure 2 shows components of the system and its interactions. Connected devices plays vital role in situation awareness, by providing data for sensor fusion, and consequently, for situation awareness of the autonomous ship. This system includes data fusion techniques, and decision making in the ship's computer core, which possess AI capability. Based on decision, actions should be executed. Furthermore, shore center should be informed on sensor data and made decisions.

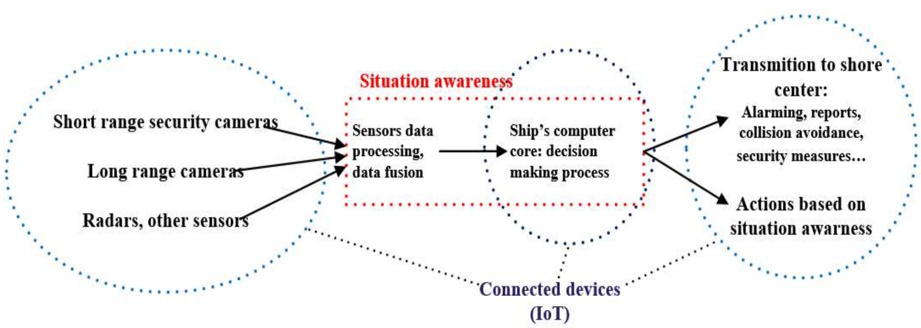

Figure 2: Role of IoT in situation awareness of autonomous ships

All sensors are connected by the local IoT, and sends the signals to the ship's computer. Tagging of input devices is necessary in order that processor knows how to handle data from various sources. Data fusion from various sensors increase localization and recognition of threats. The system reduces the data necessary to send to shore center, because image based of united data has less bits than separate images/data from various input sources. Due to vulnerability of the ship's communications, improvement is necessary in that segment. Possibly with block chain technology.
In order to implement such system, there are a lot of challenges in every part of it. For example, in video acquisition, there is a lot of problems [10, 11] regarding weather conditions, costal line detection [12], techniques for moving object detection from moving camera, etc. Moving object detection methods are divided into four categories:

- modelling based background subtraction,
- trajectory classification,
- low rank and sparse matrix decomposition,
- and object tracking [13].

In general, these methods work very well for complex motions. However, they depend on initial selection of the moving object in the first frames of the sequence [13] and they do not provide accurate information on the silhouette of tracked moving object [14]. These problems are part of the image processing subsystem.

2.3. Decision making

The last subsystem deals with decision making process. It can contain collision avoidance system which is achieved by predicting own movements and detected obstacle movements [8]. Early detection of obstacles is important, earlier the information comes the better optimization for direction change can be made, distance between own ship and the obstacle provides enough time for collision avoidance [8]. It can be performed by advanced computer system aboard incorporating AI. For this purpose, such system has to possess the knowledge of nautical experts, which includes maritime regulations, and knowledge of ship propulsion, as well as the maritime zone situation awareness. In order to make autonomous ship "situation aware", sensors' input, data fusion, and data link should be as well as possible under the real scene.
Ship should also operate as independent from shore center, because of possible situations with communication black out. Hence, ship should operate without commands from shore, but it should follow the commands when there are received.
Figure 3 is a real scene example of possible problems. If the ferry is autonomous, it should recognize small moving objects around it. Furthermore, it should know how to detect possible problems and threats to traffic safety.

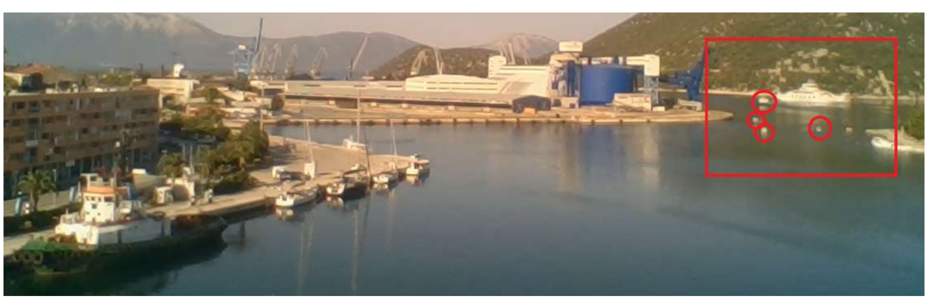

Figure 3: Small ships and boats traffic around ferry

There are a different size and function of moving objects around ferry:

- a pilot,
- a tugboat, and
- private boats.

In this case, the autonomous ship should recognize that tug boat and pilot are not moving to intercept it, but with their own mission (to other ship not in the picture). Furthermore, small boats should be avoided if there are on ferry's route. If there are not acting by maritime codes, there should be reported to the port authority by recognizing registration. But the ship should recognize attentional movement directly to the ferry (terrorist attack or piracy).

3. CONCLUSIONS

This paper describes an overall system of automated ship. Every subsystem, with its components and interactions, is a study of its own. It shows a great potential for researches and investigations in both science and technology. Emphasis is on making autonomous ship "situation aware" by using computer vision i.e. moving object detection from moving camera, sensor's input, data fusion and IoT. Some problems regarding object detection are mentioned, and will be a topic of a future work.
The proposed system is necessity in future development of automated ships. The goal is to enhance the input signals into the automated ships' systems. This is important in maritime zones with dense traffic of non-AIS ships, such as yachts, sailboats, and similar. Such small sailing objects are not connected by the AIS system and have small or none radar reflection. Hence, there are invisible to automated ship without video/IC vision capabilities. Enhanced input will result in safer maritime traffic, reduce number of accidents, reduced material damages, ecological incidents, and reduce human casualties.
It is also our attention to test this idea as possible topic for PhD thesis into open scientific environment and with international review.

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