Ship Intrusion Detection System - A Review of the State of the Art

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Abstract. Surveillance is a serious problem for border control, protection of sea surface areas, port protection and other security of commercial facilities. It is specifically challenging to secure the border areas, battlefields from human and nonhuman intruders and to protect sea surface areas from trespassing of unlicensed marine vessels. In this paper, a review is made on various ship intrusion detection systems. The review analyzes the whole active ship intrusion detection system. Through the extensive survey, the whole pose of the active ship intrusion detection system is analyzed. Since the security issues are at an increased level, the study and survey about ship intrusion detection system have paid a lot of attention.

Keywords: Border control · Intrusion detection system · Marine vessels
Wireless sensor network

1 Introduction

Intrusion detection is a major problem in border areas. It is very hard to detect the intervention in large areas because it is difficult to human to check out those areas often. Nowadays our society facing major problems like Terrorism, Insecurity and other crimes. In our society people are having a panic for being attacked by bandits, robbers, pirates, and crooks. Surveillance is the primary issue in today's world and 24 h human security is just not practical. To overcome above mentioned security problems, it is necessary to introduce a brilliant security system.

CCTV cameras also have an important role in maritime surveillance system used Ship Intrusion Security System based on CCTV camera can be used to produce video recordings for security purposes. Most commonly used surveillance techniques are Ship Intrusion Security System based on RADAR and Ship Intrusion Security System based on the Satellite image. In this Ship Intrusion Security System based on the Satellite imaging, to perform the monitoring task the system architecture based on an object-oriented methodology [2]. This Ship Intrusion Security System has a completely automated shoreline intrusion security detection device, completely or partially automated intrusion security detection device in seashore areas and a partially automated intrusion security detection device in border areas. The high security in the maritime harbour and border areas importance cannot be undervalued. In the world, 80 percent of world business trade operations are done with the help of sea transportation. Surveillance in

I. Zelinka et al. (Eds.): ICSCS 2018, CCIS 837, pp. 147–154, 2018.
https://doi.org/10.1007/978-981-13-1936-5_17

seashore area is the major problem encountered by the whole world. Nowadays, video surveillance is necessary in the protection of port areas and border areas. In order to overcome the security issues, harbour areas request a recent advanced supervision camera technology.

Wireless Sensor Network (WSN) has been emerging in the last decade as a powerful tool for connecting the physical and digital world. (WSNs) are developed for terrestrial ship intrusion detection recently. These wireless sensor networks deploy sensors in the border area to monitor the intervention and to detect intrusions [16–18].

2 Evolution of Ship Intrusion Detection Security System

2.1 Ship Intrusion Security System Based on CCTV Camera

CCTV (Closed-circuit television) camera plays a important role in maritime security. Ship Intrusion Security System based on CCTV camera can be used to produce video recordings for security purpose. A Basic Closed-circuit television (CCTV) camera system architecture consists of a camera, which is straightly connected to a LCD display (Liquid Crystal Display) using a coaxial cable. The camera captured the information in the form of video, each video consist of several frames. This captured video and images can be displayed using the LCD display, which is used to detect trespassing unauthorized marine vehicles. Even if CCTV (Closed-circuit television) camera-based surveillance system is very easy and simple solution, but 24 h continuous checking of the video recording is not possible because of the human error (Fig. 1).

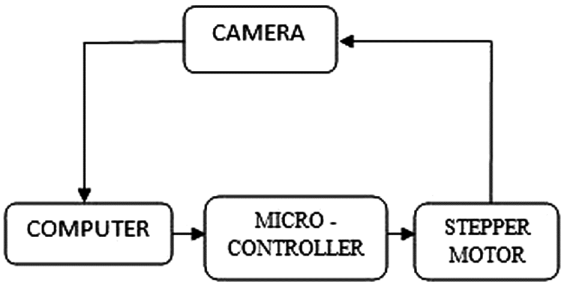

Fig. 1. CCTV camera based surveillance system block diagram

Motion Detection and Tracking based Camera Surveillance System
In this method [2], the surveillance system has used the camera with artificial intelligence. This security system has the camera which has 360° rotation in order to monitor the movements of the intruders, which is called object tracking. The security system has a microcontroller and a computer along with the high-resolution camera which operates together with the system. To detect and track the intruders this security system uses some image processing techniques as well as some basics of microcontrollers. The integration of both tracking and motion-based methods detect intrusion smartly and provide better performance.

2.2 Ship Intrusion Security System Based on Radar

Ship Intrusion Security System based on Radar method is used to detect the trespassing of marine vessels. In this RADAR based detection system, seashore environment background is shown as dark and targets are shown as bright in the SAR images, which makes this method easy to detect trespassing of marine vessels. But when the wind is ferocious, large ocean waves will be stirred, due to this strong backscattering echo can be raised. This situation causes more difficulties. The overall accuracy of security system turns out to be poor, due to the worst weather conditions.

LSMDRK based PolSAR Ship Detection
In this method [3], the local scattering mechanism difference based on regression kernel (LSMDRK) is developed as a discriminative feature for ship detection. In this method, local scattering mechanism difference based on regression kernel (LSMDRK) is developed for ship intrusion detection. In this, the intrusion detection can be done by using a RADARSAT-2 data set. This method provides better detection on weak targets compared to some classical intrusion detection methods.

SAR Ship Detection based on Haar-Like Features
In worst weather conditions, the ship detection is at seashore environment is more complex due to the absence of night visibility, and wide areas of concern. The surveillance of an exclusive economic zone (EEZ) areas are a essential part of the world. Synthetic Aperture Radar (SAR) images can be effectively used to monitor an exclusive economic zone (EEZ) areas. In order to protect the border areas, scientific investigations on present and future methods for intrusion detection security systems are needed to be evaluated constantly. The multiple sources of SAR data can be used to create the data set, which is used for ship detection. Synthetic aperture radar (SAR) [4] images provides a required coverage of area at a poor resolution. A SAR based ship intrusion detection method is used standard constant false alarm rate (FAR) prescreening, which is $1.47 \times 10 - 8$ across a large swath Sentinel-1 with cascade classifier ship discriminator and processed with RADARSAT-2 newly created SAR data set. Ships detection is done by using adaptive boosting training on the classifier based Haar-like features with an accuracy of 89.38%.

CopSAR based Maritime Surveillance
In this intrusion detection method [5], a synthetic aperture radar (SAR) images based security technique used for maritime surveillance, in order to detect bright targets over a dark background, to reduce the amount of processed and stored data, to increase the range swath, with no geometric resolution loss. Accordingly, this method can be used for maritime surveillance. This method developed a new synthetic aperture radar acquisition mode, which is a simple processing technique. This new synthetic aperture radar acquisition mode used coprime array beamforming concept, in this two pulses which having Nyquist pulse repetition frequencies (divided to coprime integer number) transmitted separately, these sequence processed with standard synthetic aperture radar processing. After the synthetic aperture radar processing, the aliased images are

combined in order to eliminate the aliasing. CopSAR based Maritime Surveillance provide the better performance in the ship intrusion detection.

DNN (Deep Neural Network) and ELM (Extreme Learning Machine) based ship detection on Spaceborne Optical Image

In maritime surveillance, spaceborne images [6] based ship detection is very attractive. Because of their higher resolution and more visualized contents, optical images based ship detections are more suitable compared to other remote sensing images. However, marine vehicle intrusion detection system based on spaceborne images has two shortcomings are available. (1) Spaceborne Optical Image-based ship detection results are affected by fog, clouds and sea surfs, when compared to infrared and SAR images. (2) due to their higher resolution, the ship detection is more difficult. In order to solve these problems, Deep Neural Network and Extreme Learning Machine algorithms can be used to detect a ship in seashore environment. In the Deep neural network algorithm, the extracted wavelet coefficients from compressed JPEG2000 image are combined with DNN and Extreme learning machine. Deep Neural Network can be used for high-level classification and representation of features and ELM can be used for decision-making and feature pooling. Deep Neural Network (DNN) and Extreme Learning Machine (ELM) based ship detection system has less detection time and achieves high detection accuracy.

Undersampled SAR based maritime surveillance

In surface monitoring scenarios, synthetic aperture radar (SAR) based intrusion detection systems need low-pulse repetition frequency (PRF) (which is smaller than the Doppler bandwidth) for wide swath image, depending upon the minimum antenna area constraint, which cause azimuth ambiguities. Undersampled SAR [7] based maritime surveillance system used to detect the intruding marine vehicles over the border areas. In this method azimuth ambiguity signals are adopted a range sub spectra concept, to misregister the azimuth ambiguity signals. In addition, undersampled SAR based maritime surveillance system uses both principal component analysis (PCA) and k-means clustering algorithms. By adjusting the ambiguities in the corresponding undersampled SAR image, it can be mitigated. This security system is only suitable for undersampled SAR images which having bright targets with dark backgrounds. Undersampled SAR based maritime surveillance system provides better performance compared to other traditional surveillance systems.

Maritime ship intrusion detection on high-resolution remote sensing images using RIGHT algorithm

In this ship detection method [8] RIGHT (Robust Invariant Generalized Hough Transform) algorithm can be used for the detection purpose. The ship-detection method is based on High-resolution remote sensing images. The RIGHT (Robust Invariant Generalized Hough Transform) algorithm is an extraction algorithm. In order to increase the adaptability of the RIGHT (Robust Invariant Generalized Hough Transform) algorithm, some iterative training methods are used for learning robust shape model automatically. This robust shape model can take target's shape variability, which is available in the training dataset. According to their importance, each targets used in this model equipped

with corresponding individual weights, which will reduce the false positive rate. In this RIGHT (Robust Invariant Generalized Hough Transform) based ship detection framework the effectiveness can be improved through the iteration process.

SVM based Ship Intrusion Detection Security System
Surveillance is a serious problem in border control, protection of sea surface areas, port protection and other security of commercial facilities. It is specifically challenging to secure the border areas, battlefields from human and nonhuman intruders and to protect ocean surface areas and active port areas from trespassing of unlicensed marine vehicles. Support vector machine (SVM) algorithm [9] is combined with image processing techniques, to detect trespassing of unauthorized marine vessels, to provide better detection. So, this SVM based Ship Intrusion Detection Security System used as a real-time surveillance system in seashore environments.

2.3 Ship Intrusion Security System Based on Satellite Imaging

In this Ship Intrusion Security System based on Satellite imaging, to perform the monitoring task the system architecture based on an object-oriented methodology [20]. This Ship Intrusion Security System has a completely automated shoreline intrusion security detection device, completely or partially automated intrusion security detection device in seashore areas and a partially automated intrusion security detection device in border areas. At the time of intrusion detection sometimes satellite images are not clear due to clouds. Due to this problem, this method cannot produce the better result. Apart from this, the Satellite imaging based Ship Intrusion Security System is very expensive.

2.4 Ship Intrusion Security System Using Terrestrial Sensor

Terrestrial sensor based Ship Intrusion Security System is widely discussed [14–16]. Wireless Sensor Network (WSN) has been emerging in the last decade as a powerful tool for connecting the physical and digital world. In order to improve the security level in the border areas, sensors can be deployed in the border area to monitor the intervention and to detect intrusions. Still, these wireless sensor networks may work well on the earth surface area, it is challenging to deploy these sensors on the sea surface for ship intrusion detection. When terrestrial sensors are deployed on the sea surface area, they move around randomly, because the sensors get tossed by ocean waves. When the sensors tossed by the ocean waves, the sensing operation will affect. Due to this above-mentioned problem, the intrusion detection task becomes difficult and this will reduce performance of the system (Fig. 2).

Fig. 2. Wireless sensor network deployment

Wireless Sensor-Based Ship Intrusion Detection
Wireless sensor network-based intrusion detection system [10] armed with three-axis accelerometer sensors. These sensors can be deployed on the sea shore areas to detect intrusion of unlicensed marine vehicles. In order to detect the trespassing of unauthorized marine vessels, the Wireless sensor network-based intrusion detection system is combined with signal processing techniques by distinguishing the ocean waves and ship-generated waves. To improve detection reliability, this ship intrusion detection system introduces spatial and temporal correlations of the intrusions. The real data obtained from this experiments are evaluated and from these evolution results, the intrusion detection system provides better detection ratio and detection latency.

Intruder ship tracking in the wireless environment
Intrusion detection is a challenging task for all Harbours or Naval Administration to restrict and monitor the movement of defence or commercial ships are challenging task for all port areas and naval administration. Most commonly used surveillance techniques RADAR based Ship Intrusion detection Security System and Satellite imaging based Ship Intrusion detection Security System. In this RADAR based detection system, seashore environment background is shown as dark and targets are shown as bright in the SAR images, which makes this method easy to detect trespassing of marine vessels. But when the wind is ferocious, large ocean waves will be stirred, due to this strong backscattering echo can be raised. This situation causes more difficulties. The overall accuracy of security system turns out to be poor, due to the worst weather conditions. At the time of intrusion detection sometimes satellite images are not clear due to clouds. Due to this problem, this method cannot produce the better result. Apart from this, the Satellite imaging based Ship Intrusion Security System is very expensive. This wireless based intrusion detection security system [11] introduces a reliable intrusion detection algorithm, Which classifies different kinds of objects approaching the experimental setup and that objects present out of phase with the ocean waves. The intrusion detection algorithm depends upon the superimposition of temporal and spatial correlation values of sensor nodes that are deployed in the sea surface up to a certain distance. This intrusion detection system detects intruder ship more efficiently.

Maritime Surveillance System Using LABVIEW
The main aim is to detect the this maritime surveillance system is used to detect the unlicensed marine vehicles, which cross the border areas in sea surface using axis sensors and ultrasonic sensor [12]. These sensors deployed on the grid, which is separated by the distance of 40 km. If the intruder ship crosses the border, the sensors sense the objects and measure the intruder distance and angle. This framework can be graphically displayed in the LabVIEW (Laboratory Virtual Instrumentation Engineers Workbench) in the form of graphical representation. If the intrusion is detected in the border area an alert message sends to the consent authorities using GSM (Global System for Mobile communication).

FPGA based Ship Intrusion Detection
This method points out the advantages of Wireless Sensor Networks (WSN) in oceanography, which introduce Reconfigurable SoC (RSoC) architecture [20] to detect ship intruders. The tri-axis digital accelerometer sensor is interfaced with FPGA-based Wireless sensor node. To detect trespassing of ships, the ship-generated waves are distinguished from the ocean waves, by using signal processing techniques. This framework is a three level detection system, Which can detect intrusion of unlicensed marine vehicles in the border areas. This framework uses Xilinx ISE simulator for simulation.

3 Conclusion

In this paper a survey of various intrusion detection security system based on CCTVs (Closed Circuit Television), RADAR (Radio Detection and Ranging), Satellite Imaging are discussed. In order to protect the border areas, harbor areas and secured industrial spaces from the intrusion of unauthorized marine vehicles, various researchers proposed various ship Intrusion detection security systems. Some of the Ship Intrusion Detection system has most advantages over intruder detection and some may have some challenges. This review will help the researchers to know about the various ship intrusion detection techniques with its strength and challenges.

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