

Intelligent Security Robot for Warehouse Security ("WATCHMATE")

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Abstract: Robots are already playing a major role in human life. With the development of technology various types of robots have been built up to apply in different fields. i.e. security, healthcare, education, military etc. With the current security condition in Sri Lanka following the explosions which occurred in several places in the country, security has become the most important factor helping the civilians to continue their daily routine. To ensure the security of places, security personnel play a vital role. Since they are aided by CCTV camera system, if there is some unauthorized incident the only action which can be taken is only by the security team. Hence, they risk their lives to ensure the maximum security. But as the cost of a life cannot be redeemed, an option to reduce the damage that may happen to security personnel must be thought of. The present research focuses on a machine-based solution for this, and this system is named WATCHMATE. It is an intelligent system which can act as an assistant to the security guard in detection and neutralization of an intrusion with remote control.

Keywords: Motion detection, Security, Intelligent system, Remote control

Introduction

Security robots are kind of machines which are designed to gain maximum security in many fields such as transportation, military, healthcare, business environments like shopping malls etc. Traditionally, security robots are designed

to monitor the environment for a security threat and to notify the necessary persons through alarms or notifications but not to take actions required to neutralize the threat. Although there are robots with weapons developed for the military arena it is difficult to find a robot with a weapon designed to engage on other fields. Security means the safety, as well as the measures taken to feel protected from harm. Security does not always concern about the human safety; it also concerns of material safety as well as the safety of properties. In warehouses all these aspects must be considered in means of security. Most common security measure taken these days is the installation of CCTV cameras. CCTV cameras can be used to monitor an area interior or exterior through videos by transmitting signals to a PC monitor or a set of monitors. Intelligent system is a system which is capable of monitoring and sensing the changes happen around it and taking necessary actions on real time by the system itself. Theodora's Theodoridis and Huosheng Hu (2012) conducted a survey to claim what defines an Intelligent Security Robot (ISR) and what are the characteristics that make a security robot intelligent. The two parameters which defines ISR are perception parameter and action parameter. The perception parameter incorporates the robot's realization of its environment, dynamically occurring events, and the acquisition of features via a ground-truth fashion. On the other hand, action parameter involves decision making and actions taken by the

robot in an autonomous fashion. Project WATCHMATE was built as an Intelligent Security robot which could replace human security guards engage in emergency fields such an unauthorized intrusion. The name WATCHMATE was selected with the meaning of Security Assistant (WATCH - MATE) Project suggests a system which can respond to the changes in the environment and notifying of those changes to a responsible party to take required next steps. Most importantly system will be composed of techniques to neutralize a threat remotely.

Methodology and Approach

G. Modular Design

The research project commences by solving the problems which have been identified within security required infrastructures such as Warehouses. Following figure shows the flow chart of methodology.

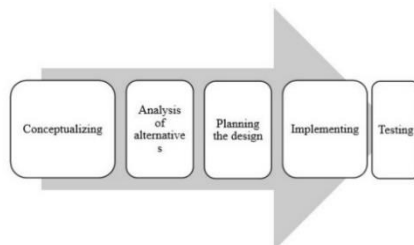


Figure 1. Methodology flow chart

Design contains 4 modules.

- v. Intruder identification and notification system.
- vi. Intruder neutralizing system with high accuracy.
- vii. A rover with high mobility.
- viii. IoT Based Sensor system. (Temperature, Gas level)
- ix. Remote control system

H. Intruder identification and notification system.

An intruder is anyone who does not has authorised access to the premises and behaving suspiciously within the

environment. Intruder identification and notification system is responsible for monitoring the area to detect intruders and notifying about them on real time when an intrusion occurred. High accuracy and low latency are expected from this system if not, false notifications and delay of conveying them will mislead into security breaches. In regard of this requirement CCTV camera systems already exists which can transfer live video streaming to a monitor. But they do not facilitate with detecting or notifying about an intruder. To detect an intrusion via a CCTV system someone needs to keep a constant eye on what monitor displays. Hence a system capable of detecting and notifying an intrusion must be introduced. To achieve this target, a new camera system sensitive for motions was implemented. This specific camera system can take pictures of an intruder who entered the premises within restricted hours and forward that picture to a responsible person through email. Hence the notification requirement is fulfilled.



Figure 2. Intruder identification and notification system

I. Intruder neutralizing system with high accuracy.

Once an intrusion detected, neutralizing the intruder with minimum life threats is another objective to be satisfied. For that a weapon system which would not take the life of intruder but neutralize him for some time should be developed by considering the following facts.

- Must be able to cover at least 180° in horizontal plane

- Must be able to cover 90° in vertical plane
- Accuracy should be maximum
- Autonomous and manual modes
- Fast switching between manual and autonomous modes



Figure 3 Intruder neutralizing system

A rover with high mobility

Rover is the actual engaging element of this project. The weapon system to neutralize an attacker, a camera to support the navigation of the rover and other controlled devices are required to be mounted on this rover. Therefore, the rover must be designed support all of those and required to meet up with the following requirements.

- High mobility
- High controllability
- Durability

This rover is going to be controlled and navigated remotely with the support of real time video streaming. Hence a camera appropriate for the purpose would be used.

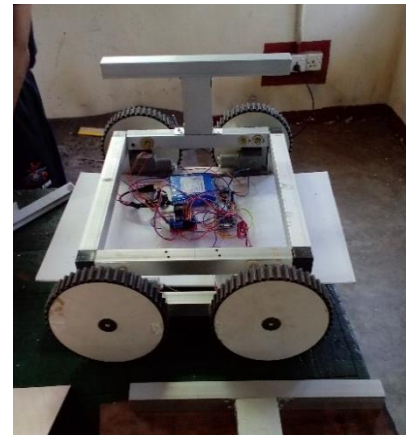


Figure 4. Four wheel rover

D. Iot based Sensor system

For real time monitoring of the environment a camera is not enough. So, Sensor system must be implemented on the robot. So, the user can real time monitor the temperature and gas level of the environment. So, if there is a fire or gas leak in the environment the user can identify it and get required action.

We used DSD11 temperature and humidity sensor for the rover to sense more data. This sensor is very accurate due to its classifications.

- Temperature Range: 0-500c
- Humidity range: 20-80%
- Operating Voltage: 3-5v
- Maximum current during Measuring:

2.5mA To get the feedback of the sensor we use nodemcu inbuild Wi-Fi programming board.

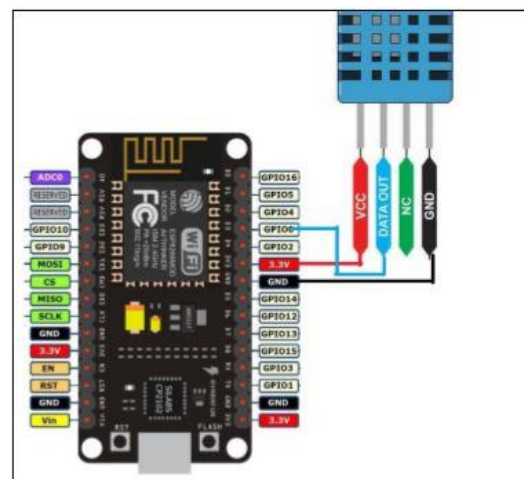


Figure 5. Circuit diagram of temperature sense system

We used MQ2 sensor to detect the gas. If there is a gas leakage robot can detect it and give a feedback. • Detection range: 300-10000ppm

- Target gas: Flammable gases
- Output Voltage:

2.5-4v MQ2 sensor is connected with the nodemcu board to take feedback to display.

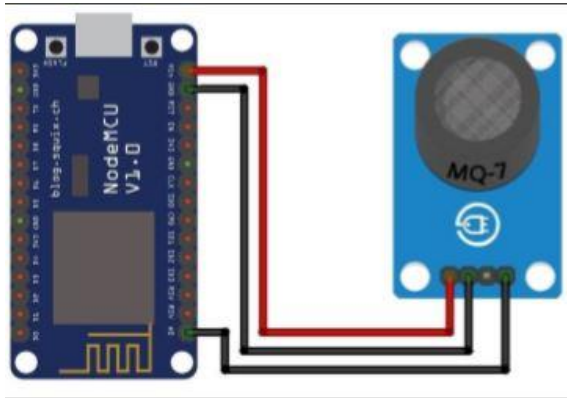


Figure 6. Circuit diagram of gas sensing system

E. Remote control system

After implementing the system remote access to the system should be enabled. So that the system could be controlled remotely at anywhere in the world. The application used for that purpose must be precise and user friendly. Remote desktop is such an application which could be used to access and control the robot remotely through internet. In this application it is essential of implementing a secure and reliable connection for the better performance. Thus, the connection must be encrypted appropriately.

F. Final Design

After assembling all the above mentioned systems a robot system with the capabilities of detecting and neutralizing an intruder



Figure 7. Final design of the robot

Test and Results

The Robot was tested after the implementation. While testing we obtained following observations,

- The Robot is taking 32 seconds to move 10m in linear direction.
- The Robot is taking 10 seconds to rotate one round around own axis.
- In the weapon system It rotates 1700 in X axis (pan) and 850 in Y axis.
- It is taking 2 seconds to activate trigger.
- Weight of the robot is 4kg.
- The Intruder notification system is taking 6s to take a picture and send an email.
- The Distance between a point in camera feed and actual target position is 5cm.
- The latency of the connection was highly affected for the performance of robot

According to above observations following test results were concluded.

- The speed of the robot is 31.25cm/s.
- Error – 5 cm.
- Latency depend on the connection speed

Application and Implementation

The purpose of this project is to explore loopholes in current security systems in warehouses and to introduce an enhanced security system with minimized human interaction.

This robot must be capable to replace human security guard. Since human are the most intelligent and most sensible creature in earth replacing a robot with a human is much challenging. But in this project, we tried to reach a satisfactory level. So, we implemented Temperature and gas sensors in the system. So, the robot is dwelled with vision, hearing, smell, and touch. So, the robot is a satisfactory approach to replacing a human security guard with a robot.

Future Improvements

There are several further developments explicit through the work carried out and the experiences gained from the project. Suggestions for the future work are listed below

- Improving the system to be behaved in a fully autonomous manner with help of Artificial Intelligence and Machine learning technologies.
- Development of a mobile application for the controlling of the system.
- Development of the weapon system to cause less damage but to do the task in required level along with high accuracy to track and fire on a target.
- Implementation of a database to improve the intruder detection process including all the details of the people authorised to behave in the protecting environment along with face recognition and object verification technologies.
- Improvement of the remote logging system to work from anywhere with real time application.
- Development of the mobility system to move easily at any terrain with capabilities of climbing walls, stairs, and hills. Hence robot will move easily even in a battlefield.
- Development of fast switching mechanism with manual and automatic control, so the robot can be operated in both modes as per the requirement.

- Improving the system to be more efficient by developing a self-recharging mechanism. monitor and can neutralize unauthorized intruder while on anywhere in world.

Conclusion

The study of Intelligent security robot for warehouse security presented a developed prototype of the robot. The proposed system can replace security guards and minimizing the risks to the lives of security guards. System was proposed to design featuring detection of an intruder and taking necessary actions to the threat of intruder on real time action. For the neutralizing part of the project a weapon system mounted with the robot was suggested. Controllability of the robot is from anywhere with remote access to the robot. While preparing for the project, we have specified our scope to the protection of a warehouse environment in which security concerns must be at highest level in any establishment. So, the robot is decided to be develop matching to an indoor environment. During the planning process of the project we studied regarding the currently available security robots and the technologies associated in developing those products. In parallel with the technologies we studied about different programming languages, platforms to build up the systems, controlling mechanisms, wireless communications models and then approached for the implementation of work. When proceeding with the project work, we faced several problems. To overcome some of those problems we had to follow up with the trial and error method. In building the structure of the robot we had to adjust the structure for several times in matching for the requirement. Wheels system assisting the mobility of rover had to be designed by ourselves even including brackets as we did not find them in the market matching

with our expectations. Another problem was what technology should be used to identify an intruder. There were several suggestions like use of a sensor node or use of a camera system with video processing ability are two of them. After analysing all options, we decided to build the intruder identification system with a Raspberry Pi camera which detect motions in both day and night and notifying them appropriately. MotionEyeOS was used to fulfil the requirement of surveillance. While working with Raspberry Pi we faced issues with serial port communication and proceedings were carried out by taking care of those issues as well.

The most important part of the project was developing of intruder neutralizing part. The weapon used in that task must met with several requirements and suggestion was to use a taser which will cause serious damage to a person's life. In the implemented prototype we used a toy weapon but in a real case implementation taser weapon could be applicable. For the control of the robot remote desktop application was used, so the controller can control the robot remotely from anywhere after at any time after receiving a notification or even without. Just required to have an internet connection and an appropriately installed remote desktop environment on your PC. Finally, we can conclude that project output is gained as the robot response in detecting, notifying and neutralizing an intruder. Mainly we could point out that robot can behave in the required process without a human engagement directly on the field to take actions against a threat.

Acknowledgment

We express our sincere gratitude to the support rendered by Department of Electrical Electronic and Telecommunication of General Sir John Kotelawala Defense University, and to our

Squadron commanders, troop commanders, friends and comrades for supporting us.

References

- [1] "SentryBot - Projects - Robotics Innovation Center - DFKI GmbH." [Online]. Available: <https://robotik.dfki-bremen.de/en/research/projects/sentrybot.html>. [Accessed: 07-Nov-2019].
- [2] "Security Robots | SMP Robotics Unmanned security systems." [Online]. Available: https://smprobotics.com/security_robot/. [Accessed: 07-Nov-2019].
- [3] Ludovic Righetti et al., "Autonomous Weapon Systems: Technical, Military, Legal and Humanitarian Aspects," *Auton. Weapon Syst. Tech. Mil. Leg. Humanit. Asp. Expert Meet.*, no. March, p. 102, 2014.
- [4] "South Korea's autonomous robot gun turrets: deadly from kilometers away." [Online]. Available: <https://newatlas.com/korea-dodamm-super-aegis-autonomosrobot-gun-turret/17198/>. [Accessed: 14-Nov-2019].
- [5] "Face Recognition." [Online]. Available: https://www.nec.com/en/global/solutions/safety/face_recognition/NeoFaceWatch.html? [Accessed: 14-Nov-2019].
- [6] "US6803945B1 - Motion detecting web camera system - Google Patents." [Online]. Available: <https://patents.google.com/patent/US6803945B1/en>. [Accessed: 14-Nov2019].
- [7] R. Association, "Applying Artificial Intelligence and Machine Learning in Robotics", *Robotics Online*,:
- [8] <https://www.robotics.org/blog-article.cfm/Applying-Artificial-IntelligenceandMachine-Learning-in-Robotics/103>. [Accessed: 11- Dec- 2019]
- [2]"Meet Sophia, the Robot That Looks Almost Human", *Nationalgeographic.com*

[9] C. Barriquello, F. Silva, D. Bernardon, L. Canha, M. Ramos and D. Porto, "Fundamentals of Wireless Communication Link Design for Networked Robotics"

[10] Robot Platform | Knowledge | Wireless Communication", Robotplatform.com, 2019. [Online]. Available: http://www.robotplatform.com/knowledge/communication/wireless_communication.html.

Author Biographies



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