ACADEMIC
World Academic Union

ISSN 1746-7659, England, UK
Journal of Information and Computing Science
Vol. 14, No. 1, 2019, *pp*.052-080

A Comprehensive Design of Unmanned Ground Search and Rescue Robot

Hesham Enshasy[1], Ibrahim Al-Badi[1], Qasem Abu Al-Haija[2],
Muath Al-Saleh[1], Abdulrahman Bu-Shalf[1], Abdullah Al-Dosseri[1]

1 King Faisal University, Department of Electrical Engineering, College of Engineering, Al-Ahsa, Saudi Arabia
2 Tennessee State University, Computer & Information Systems Engineering Department, Nashville, TN, USA
(Received January 13, 2019, accepted March 12, 2019)

Abstract: Rescue workers and fire fighters' job mostly require entering to disaster zones such as factories accident areas, collapsed mines, or burned buildings to perform rescue operations. In addition to human caused disasters, the aftermath of natural disasters such as tornados, earthquakes and tsunamis requires them to be present in order to contain the disaster, help injured victims, and guide trapped victims to a safe exit. The lives of the rescue workers and fire fighter are always at risk in such accidents, since they have no prior knowledge of accident source, environment, and location. Thereby, Search and Rescue Robot (SRR) is an excellent alternative, in which it can perform certain tasks of rescue workers and fire fighters without endangering their life. In a case of disaster, SRR can be sent directly to the danger zones to navigate and provide helpful information regarding the cause of the accident, location of the hazard spots, number of trapped or injured victims, the conditions inside the danger zone, and several other functions. The use of SRR will improve the quality of rescue missions because it can provide important data from the heart of the accident where it is too risky for human to go in. In addition, it can identify the number and the status of the trapped victims and even supply basic equipment, which in some cases can be lifesaving, such as masks and fire blankets in accident which include fires. In this project we designed and fabricated a prototype of search and rescue robot that can perform multiple tasks and can navigate in rough surfaces. The SRR can be controlled from a distance station where the operator can manipulate the SRR movement and its grapping arm while monitoring the surrounding environment using video camera and different sensors. The fabricated prototype successfully passed all the tests that was set to examine its performance.

Keywords: Arduino Microcontroller, Search and Rescue Robot, Geared DC motors, lightweight design, H-bridge module, MQ-Sensors, First Person View (FVP) camera.

1. Introduction

The rapid growth of petrochemicals industry and manufacturing sectors have increased the potential of industrial accidents that could be the result of natural disasters, negligence or incompetence [1]. The scale and number of industrial accidents and natural disasters is unpredictable and even with the strictest precautions, they are still a major threat. There are several types of industrial accidents, which include chemical explosions, mines explosion or collapsing, fires, and chemical leaks. These disasters result in major damages to human lives and properties. In such cases, it is necessary to contain the accident and reduce the damages. Response to an accident or a disaster is always a race against the time. Thus, quick interventions must take place in order to save as much lives as possible and to prevent further damages. Hence, many devoted solutions were shown up in to mitigate these problems such as the development of Search and Rescue Robot. Recently, robotics became a prosper science since many companies and governments are interested in investing in this emerging technology. This resulted in huge robotics research development in which various types of robots were introduced with various characteristics. Moreover, countless features and components were implemented in the designs aiming toward a more practical, intelligent, and efficient robotic systems. Motion is one of the main characteristics of modern robots. In addition, sensory systems allowed scientists and engineers to create more intelligent robots, in which they are capable of sensing physical phenomena. Many sensory systems are available now and can be implemented easily in robots, e.g. rangefinders, ultrasonic, infrared, temperature, gas, distance, and proximity.

Search and Rescue Robot (SRR) is designed to be sent inside the danger zones prior sending the rescue team to explore the area and provide valuable information for them which helps the rescue team to

plan more effective and organized rescue mission. Certainly, SRR will not replace the human rescue workers since humans have a better and faster decision making and actions in critical conditions, however, SRR and rescue workers can work cooperatively in order to perform quality rescue mission. Accident may result in various damages such as building collapse, explosions, harmful gases leakage, fires, and a risk of high temperature through fires. As a result, rescue process is extremely dangerous in such cases without prior knowledge of the accident environment. Furthermore, heavy machinery, which is used to remove the collapsed buildings, cannot be used near an accident site, since the mass of the machinery may disturb the structure of the location and cause further damages. As a result, SRR can be deployed for structural inspection to help the rescue workers avoid actions, which may cause a second collapse. Industrial accidents, which include gas leakage, are another hazard risk because some gases are extremely toxic and flammable. Without a prior knowledge of the presence of such gases, rescue team may suffer bad consequences. The size and design of SRR allows it to move and navigate freely through rough terrains. It can be equipped with video camera placed on the arm, in order to provide 360º live view of the area. Moreover, the SRR can contain number of gas sensors, which cover the most common toxic and flammable gases expected to be found. A temperature and humidity sensors are good addition to the system that can provide needed information. The combination of sensors and camera provides the rescue team with a good insight of the accident environment. This is an important advantage of using SRR, because it allows the team to prepare enough manpower, equipment, and supplies for their rescue mission. The design criterions of SRR (such as size, platform, and features of the robot) are largely influenced by the disaster and function. Consequently, each type of SRR can provide a variety of information according to the working conditions and position. There are three main categories of SRR: Unmanned ground vehicle (UGV), Unmanned aerial vehicles (UAVs), Unmanned underwater vehicles (UUVs). Fig.1. demonstrates Illustration Examples of UGV, UAV, UUV respectively which can be used for different types of search and rescue missions [2, 3, 4]. UGV is a land-based vehicle that operates without the presence of a human on it. They are used in situations where it is dangerous or inconvenient for a human to be onboard. Usually it is remotely controlled from a distant control base, in which all the information communicated or captured by the UGV is sent to the control base. UGVs usually divided into large UGVs and small UGVs. The large UGVs are used to remotely remove large objects such as rocks or rubble. The small UGVs are used mainly for research purposes since they can easily access places that are too small or extremely dangerous. They can perform wide variety of tasks such as finding the location of trapped victims and communicating with them, measuring level of gas leakage/radiations, and capturing live videos. While UAV (drones) is an aircraft that is remotely controlled and widely used for military, inspection, and search and rescue purposes. They can provide a wide coverage of live video or photographs on a certain area from high altitude. In addition, UUVs are unmanned vehicle, which operates underwater. These vehicles are capable of diving underwater and provide valuable information, such as live video, temperature, pressure, and depth. They are employed in rescue operations for marine accidents.

Fig.1. Illustration Examples of UGV, UAV, UUV respectively

In this paper, we propose a complete microcontroller-based design of UGV-SSR, that can offer a great assistance for rescue workers. It can be sent to areas where man can't enter for search and rescue purpose. The robot must navigate its way, sending useful information to the control base and it should be able to perform certain tasks, such as rescue a human, take certain samples from the environment, carry light load and/or run a process in the designated area. The proposed SSR provides wide range of services that are demonstrated in Fig. 2. This diagram shows the wide range of services offered by the proposed design to mitigate risky issues of rescue workers since they are subjected to major and unpredictable hazards such as fires, explosions, and mines or buildings collapsing. For example, the proposed SSR can measure the common dangerous gases in mines and petrochemical facilities [5] such as Methane (CH4), Ammonia (NH3), Liquid Petroleum Gas (LPG), and Carbon dioxide (CO2).