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Rescue Robotics: A Review

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Abstract —Technology has become the solution to many long-standing problems, and while current technologies may be effective, it is far from fully addressing the hug, complex, difficult and challenging tasks associated with disaster missions and risky intervention. So robotics researchers have a dream which is building autonomous robots that assist humans in critical circumstances. Rescue Robots have been designed for the purpose of rescuing people .This paper offers the definitive guide to the theory and practice of disaster robotics. It can serve as an introduction for researchers and technologists.

Keywords — Rescue; Autonomous Robot; Sensors; Actuators.

I. INTRODUCTION

Nowadays "Rescue Robotics" has become an international demand. It's one of the interesting field for protecting and rescuing a human being's life who is the most precious thing in existence. Facing disasters without any previous plans, they might turn on sequences of catastrophes. Therefore, risk pervades our daily life. Rescue Robotics provides a safety environment which is a prime intension for proper functioning. As Robin rightly notes, 'the impact of earthquakes, hurricanes, flooding is increasing, so the need for robots for all phases of a disaster, from prevention to response and recovery, will increase as well." This is particularly true of aerial robots, or Unmanned Aerial Vehicles (UAVs), which represent the first wide-spread use of robotics in international humanitarian efforts. As such, this blog post relays some of the key insights from the field of rescue robots and aerial UAVs in particular. ,[1] The main use-case for rescue robotics is data collection. "Rescue robots are a category of mobile robots that are generally small enough and portable enough to be transported, used and operated on demand by the group needing the information; such a robot is called a tactical, organic system" Tactical means that "the robot is directly controlled by stakeholders with 'boots on the ground'—people who need to make fairly rapid decisions about the event. Organic means that the robot is deployed, maintained, transported, and tasked and directed by the stakeholder, though, of course, the information can be shared with other stakeholders" These mobile robots are "often referred to as unmanned systems to distinguish them from robots used for factory automation.",[2]. So, it can be consider "The Mine Disaster Robots (MDRs) are the most frequent users or requesters of rescue robots." ,[3]

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II. SYSTEM DESCRIPTION

II.A Hardware

The robot is designed to perform in a high vibration environment with strong shock absorption during movement along a rough-terrain. The robot is relatively light-weight and strong based on its structure. The folding size of this robot is very compact while the workspace is optimized by using both rotation and prismatic joints. The victim sensing unit is attached to the end-effector of the robot, which improves the ability to search and identify the victim's conditions.

II.A.1 Robot Actuator Types

Actuators are the muscles of robots. There are many types of actuators available depending on the load involved. The term load is associated with many factors including force, torque, and speed of operation, accuracy, precision and power consumption:

1- Electric Motors
- Servomotors
- Stepper motors
- Direct-drive electric motors

2- Hydraulic actuators
3- Pneumatic actuators
4-Shape memory metal actuators
5- Magnetostrictive actuators.

II.A.2. Robot Sensor Types

The robots are equipped with a victim sensing unit which contains various necessary sensors to detect victim life-signals. The sensors utilized in our system are listed as shown in fig.1. The autonomous robot detecting system is divided into 2 types: 1) image detection from camera is used to monitor and analyze the data from victim such as motion detection, and reading the text in an image and 2) heat sensor detection to determine the heat of the victim inside the arena. Thermal sensors are mounted on a servo motor to allow for the sweep to search the heat of a victim. It shown in fig.3.

There are different sensors to choose from and we will identify the characteristics of few sensors, and also understand why and where they are used.

- Light Sensors

A Light sensor is used to detect light and create a voltage difference.

- Photoresistor Sensors

It is a type of resistor whose resistance varies with change in light intensity; more light leads to less resistance and less light leads to more resistance.

Photovoltaic cells convert solar radiation into electrical energy. This is especially helpful if you are planning to build a solar robot.

- Sound Sensor

As the name suggests, this sensor (generally a microphone) detects sound and returns a voltage proportional to the sound level.

- Temperature Sensor

What if your robot has to work in a desert and transmit ambient temperature? Simple solution is to use a temperature sensor.

- Contact Sensor

Contact sensors are those which require physical contact against other objects to trigger. A push button switch, limit switch or tactile bumper switch are all examples of contact sensors.

- Proximity Sensor

This is a type of sensor which can detect the presence of a nearby object within a given distance, without any physical contact.

Infrared (IR) Transceivers:

An IR LED transmits a beam of IR light and if it finds an obstacle, the light is simply reflected back which is captured by an IR receiver. Few IR transceivers can also be used for distance measurement.

- Ultrasonic Sensors

These sensors generate high frequency sound waves; the received echo suggests an object interruption.

- Photoresistor:

It is a light sensor; but, it can still be used as a proximity sensor.

- Distance Sensors
- Most proximity sensors can also be used as distance sensors, or commonly known as Range Sensors; IR transceivers and Ultrasonic Sensors are best suited for distance measurement
- Infrared Distance sensors

IR circuits are designed on triangulation principle for distance measurement. A transmitter sends a pulse of IR signals which is detected by the receiver if there is an obstacle and based on the angle the signal is received, distance is calculated.

Laser range Sensor:

Laser light is transmitted and the reflected light is captured and analyzed. Distance is measured by calculating the speed of light and time taken for the light to reflect back to the receiver.

- Encoders:

These sensors (not actually sensors, but a combination of different components) convert angular position of a shaft or wheel into an analog or digital code.

Stereo Camera:

Two cameras placed adjacent to each other can provide depth information using its stereo vision.

Pressure Sensors

Tactile pressure sensors are useful in robotics as they are sensitive to touch, force and pressure.

Tilt Sensors

In a typical analog tilt sensor, a small amount of mercury is suspended in a glass bulb. When mercury flows towards one end, it closes a switch which suggests a tilt.

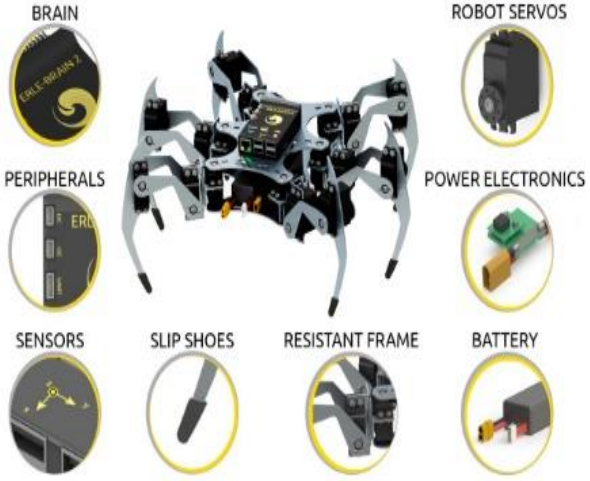

Fig. 1 Robots Components

The autonomous robot is divided into two main physical structures, the platform and the robot. The platform of the robot has the driving system whereas the second part consists of the robot and sensors. The sensors that are attached to the robot include: camera, heat sensor, carbon dioxide sensor, and the laser range finder. Special properties of the robot are: rotation and extension. The robot works with the sensors shown in fig.2.

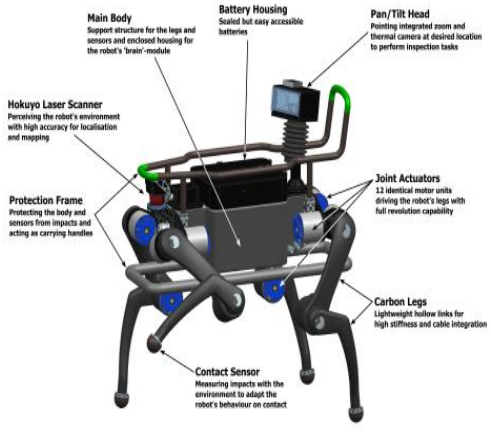

Fig. 2 Components of Autonomous Robot

II.B. Software

Control Method and Human-Robot Interface Our control method and human-robot interface can be split into two groups:

1) Control and interface on tele-operative robot system
2) Control and interface on autonomous robot system

These two groups are discussed in further detail below. The onboard controlling system communicates with the operator station via Wireless access points. The onboard access on the robot is connected to an onboard Microcontroller. Various USB devices and sensors, for example, cameras, microphones, speakers, and laser range finder or scanning range finder, are connected to the Microcontroller, fig.5-7. The robot also has an emergency resetting system which prepares and recovers the robot's control system when it is operating in a remote area, far from the operator station. Teleoperation scheme has identical control systems therefore allowing more flexibility to add robots to the team in the future.

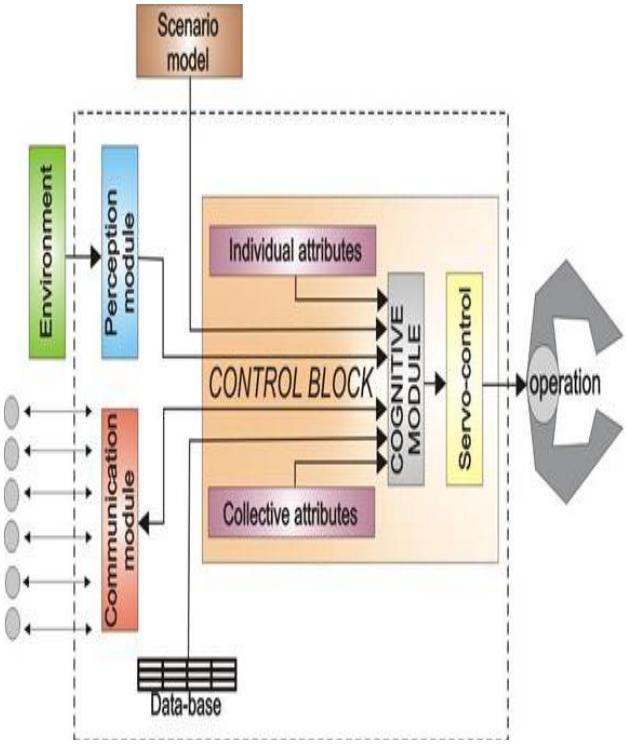

Fig. 3 Illustration of the Control Scheme for Teleoperation Scheme

III. APPLICATIONS

Effective risk management includes early and aggressive risk identification through the collaboration and involvement of relevant stakeholders. Strong leadership across all relevant stakeholders is needed to establish an environment for the free and open disclosure and discussion of risk. Although technical issues are a primary concern both early on and throughout all project phases, Rescue Robotics must consider both internal and external sources for cost, schedule, and technical risk. Early and aggressive detection of risk is important because it is typically easier, less costly, and less disruptive to make changes and correct work efforts during the earlier, rather than the later, phases of human daily life.

Six distinct applications have emerged from working with emergency experts, [8-10]

- property damage assessment
- flood mapping and projection of impact
- verification of flood inundation models
- flood monitoring over time
- justification for publicly accountable decisions
- public information

IV. CONCLUSION

Common situations that employ rescue robots are mining accidents, urban disaster, hostage situation, explosions and unreachable areas. Robots can be considered very useful tools and can be depended on the field of "Rescue Robotics" when or where humans can't deal with risk situations on the land, under the water or in the sky. This paper presents an extensive review for Rescue Robots basics.

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Ayman A. Aly nominated and selected for inclusion in Marquis Who's Who in the World, 30th Pearl Anniversary Edition, 2013. As, Taif University awarded him the prizes of excellence in scientific publication 2012, 2013 and 2014.

Ayman A. Aly is the author of more than 100 scientific papers and text books in Refereed Journals and International Conferences. He supervised some of MSc. and PhD. Degrees Students. His main areas of research are Robust and Intelligent Control of Mechatronics Systems, Automotive Control Systems, Thermofluid Systems Modeling and Simulation.