Robots as Rescuers in Disasters

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***Abstract*—Due to the physical limitation of the human body the application of robots has become more prevelant in the last years. Especially when there are harsh surroundings like extreme temperatures or the occurrence of radiation. This is often the case in disaster relief, thus robots are the first choice to save lives or prevent the environment from pollution or devastation.**

Keywords— Emergency robots, Centauro, microbots, humanoid robots, robots in the future;

I. Introduction

The primary aim of Botball is to create consciousness of the modern world's needs. Therefore, robots are the main focus in this tournament. But what is a robot exactly? Robots are stationary and mobile devices or machines, which can be controlled by computer programs for doing certain work for humans. They are therefore “subjects” of humanity and do the work for which we have no desire, or we cannot accomplish. In this paper some of the countless robots used in disaster relief will be discussed and the discussion will address the importance of robots in this sector.

II. State of the Art

In the following section current models of disaster response robots and Botball’s efforts to encourage the research and development in this sector are described. DARPA (Defense Advanced Research Projects Agency) is often used as a reference, because it is the initiator of a robotics tournament, which has a similar task as Botball, but on a much larger scale.

A. The Centauro

The Centauro, a new disaster response robot is a Centaur- like robot consisting of a four-legged base and an anthropomorphic upper body. It was developed, assembled and tested by researchers at IIT- Istituto Italiano di Tecnologia.
The robot is capable of robust locomotion, high strength manipulation and harsh interactions that may be a necessity during the execution of diverse disaster relief tasks.[1] Centauro has a height of 1.5 m, while the shoulder width is 65 cm and it weighs 93 kg.
It consists of aluminium, magnesium and titanium alloys, while cover parts are made from plastic using rapid prototyping fabrication. It’s powered by a battery, which can last at least 2.5 hours.
The aim of the Centauro project is the realization of a robotic platform for assisting rescue workers executing emergency response tasks in hostile environments. The robot is therefore designed to navigate in man-made environments, enabled by its hybrid mobility skills that combine legged articulated locomotion and wheeled mobility. To operate within human infrastructures its body has dimensions compatible to those needed to operate within human infrastructures. Therefore, it can pass through doors, navigate standard stairs and narrow corridors.[1]

Figure 1: The Centauro

The manipulation, mobility and whole-body control skills of the robot have been recently validated in the breaking of wood pieces and the manipulation of heavy objects.
The robot can adopt different configurations, like the typical leg arrangements of quadruped robots, including both inward and outward knee arrangements, and a spider leg formation, which can be steadier, while manipulating powerful tools. In addition to the articulated locomotion the wheels allow the Centauro to demonstrate wheel-based mobility.

[1] www.centauro-project.eu
[2] https://spectrum.ieee.org/automaton/robotics/industrial-robots/centauro-a-new-disaster-response-robot-from-iit

Human tools can be used to execute manipulation tasks and can demonstrate manipulation strength capacity that is higher than that of a normal human adult. Moreover, its high performance and impact resilient actuation system allow the robot to perform manipulation tasks which require severe physical interactions without risking physical damage to robot components.

The robot perception system, placed in the head, incorporates a series of sensors including a set of cameras, RGBD sensors and a Lidar scanner that provide a spherical coverage of the environment around the robot. Furthermore, they have thermal state monitoring sensors and the robot joints incorporate high fidelity torque sensing.

The robot is armed with computation power delivered by three on board computers dedicated to hard real time control, perception processing respectively and high-level motion planning. The data exchange and the robot control in this distributed computation system is coordinated by the software framework developed by the identical IIT team.[2]

B. Micro Robots

From time to time, big problems require small robots, so DARPA has instituted a new program to improve the technologies needed to build micro-robots on the millimeter to centimeter sizes. The aim is to produce new navigation, power, and control systems that would allow such microbots to enter and search the holes and crevices left by natural and synthetic disasters that are too small and dangerous to be dealt with by human responders or larger robots.

Robots nowadays have become more prevelant, finding their way into everything from the battlefield to the burger bar, however there is literally no one-size-fits-all solution when it comes to using robots in disaster areas. True, large robots can go into areas, which are too hostile for humans and carry out useful work like closing off valves or clearing debris, but if they cannot get to where they are needed, they have no use.

One option of getting robots to the right place is to make them smaller so they can squeeze through tiny crevices and cracks in rubble. Though one microbot might not be capable of much, a swarm of tiny robots designed to carry out diverse tasks can potentially do a lot. But, by shrinking robots, they do not just become simpler, they also encounter some significant technical barriers.

Microelectromechanical systems (MEMS) have already advanced the case for the microbot, because engineers now have 3D printing, low-power sensors and piezoelectric actuators to play with. Too bad, that microbots still face problems in the fields of navigation, power and control due to shape, weight and power constraints.

To overcome these limitations, DAPRA has established the new Short-Range Independent Microrobotic Platforms (SHRIMP) program to enable multi-functional micro-to-milli robotic platforms by working on new materials, new sources and mechanisms for actuators to improve the dexterity, strength, and independence of microbots. So the SHRIMP is basically an improved microbot.

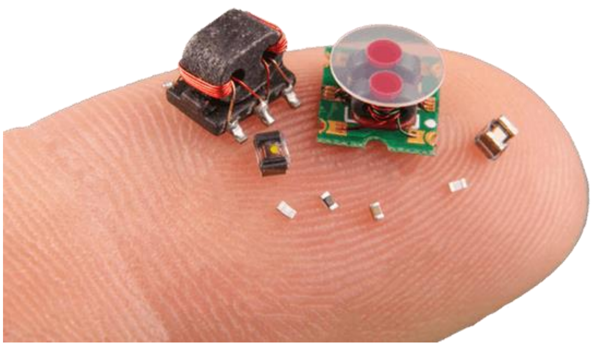

Figure 2: SHRIMP

For actuators, SHRIMP looks to boost the strength-to-weight ratio to improve endurance and load bearing. This way, microbots will be able to carry out grueling, complex tasks for a longer amount of time.[3]

As most microbots currently rely on tethers for power, control, and data processing, SHRIMP is seeking to develop more energy-efficient, high-voltage power conversion circuitry, batteries and other power storage devices to make the microbots less dependent yet can support powerful actuators. One aim is to produce power converters that can handle frequencies in the tens of Hertz range with exceptional efficiency.

To accomplish these goals, SHRIMP will be modelled on the National Institute of Standards and Technology (NIST) Robotics Test Facility, with development teams competing in "Olympic-style evaluation" to test each microbot's various capabilities, including mobility, capacity to maneuver on level as well as inclined surfaces, load bearing, and speed.

Whether in a natural disaster scenario, a hazardous environment, a search and rescue mission, or other critical relief situation, robots have the potential to provide much needed aid and support. However, there are numerous environments that are inaccessible for larger robotic platforms. Smaller robotics systems could provide significant aid but shrinking down these platforms requires significant advancement of the underlying technology. [4]

[3] https://phys.org/news/2018-07-centauro-disaster-response-robot-workers.html
[4] https://newatlas.com/darpa-tiny-robots-disaster-releif/55520/
[5] https://www.therobotreport.com/darpa-shrimp-microbots-disaster/

C. DRC-HUBO

The winner of the 2015 DARPA Robotics Challenges was the DRC- HUBO. The tasks included driving a car, opening a door, operating a valve, and climbing a flight of stairs. To prevent the teams from pre-programming the robots to run the course, a surprise task was included, which on the final day of the two-day competition required the robots to remove an electrical plug from a socket and set it in a different socket.[5]

The robot's "transformer" ability to switch forth and back from a walking biped to a wheeled machine proved key to its success. Many robots lost their balance and collapsed to the ground while trying to perform tasks such as operating a drill or opening a door. Not DRC-HUBO. Its unique design allowed it to perform tasks faster and perhaps more important, stay on its feet—and wheels. This lessens the risk of falls, which is the biggest disadvantage of a humanoid formed robots.
In the following part the most significant technical aspects will be listed and discussed.

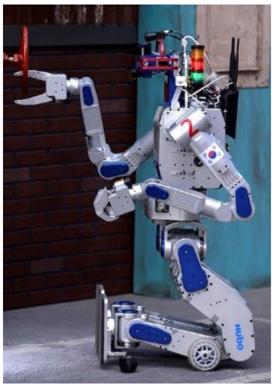

Figure 3: DRC- HUBO

- Wheels on knees: DRC-HUBO has motorized wheels on both knees and casters on its feet. The wheels allow the robot to move around in a stable and fast manner. When rolling on the ground, it uses optical sensors on the shins for optical flow odometry.
- Compliance: The team wanted to make their robot compliant, however they did not want to use a conventional feedback controller force-torque sensor (which they feared would introduce instabilities). In order they implemented compliance on their custom motor driver, using a special amplifier.
- DRC-HUBO can turn its upper body up to 180 degrees. That allows the robot to have its knees pointing one way and its eyes looking at the opposite direction. This competence works both in standing mode and kneeling mode. The robot relied on it during several tasks, including cutting a wall, driving a vehicle, pushing away rubble, and climbing some stairs.
- Long arms: The KAIST Team realized that the arms of HUBO 2 were too short for a few tasks, so they designed longer 7-degrees-of-freedom arms for DRC-HUBO, as well as tucking all cables inside, to prevent them from getting caught on things. Each arm can lift up to 15 kilograms and has an "adaptive gripper" capable of grasping soft or hard objects.
- Simplified sensing: Instead of a sensor-packed head with a lidar and stereo cameras which are continuously scanning the environment. DRC-HUBO uses a simplified vision system; operators rely on a regular camera most of the time, and a lidar, attached to a servo, which scans the environment only when needed.[6]

III. BOTBALL TABLE

This year's Botball table gives a perfect overview of how different and difficult the circumstances in disasters could be. For instance, the Botguy located in a higher area or the gas valve, which must be gripped and placed elsewhere. These tasks appear very realistic and are a huge challenge to achieve.

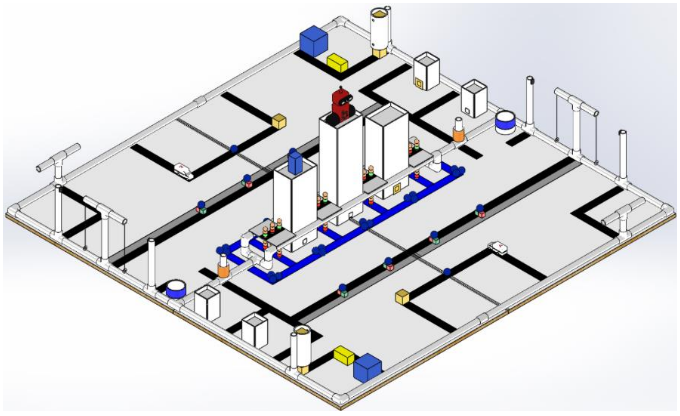

Figure 4: Botball Table

IV. FUTURE

It is obvious, that robots will play a major role in disaster relief in the next years. The progress in technical engineering is unstoppable and will lead to new solutions for making the robots smaller, cheaper and more endurable. Also, AIs will become more prominent. The possible applications of an independently thinking robot, which can be built in any shape and size, are nearly limitless.

V. SUMMARY AND CONCLUSION

The purpose of this work was to explain which robots already exist and how they are used in disaster relief. For instance, the Centauro is developed to assist rescue workers with it is immense power, while the microbots are chosen, when humans cannot reach the desired location, due to our size. With the assistance of robots, human victims can be rescued out of tricky situations in time. Furthermore, the consequences of disasters, like the Fukushima nuclear accident, can be curbed and no more humans will be

[6] https://newatlas.com/darpa-drc-finals-2015-results-kaist-win/37914/
[7] https://spectrum.ieee.org/automaton/robotics/humanoids/how-kaist-drc-hubo-won-darpa-robotics-challenge

endangered. So, we all should appreciate Botball for the introduction of such an interesting and pioneering topic.

VI. References

[1] www.centauro-project.eu (Date: 2.15.2019)
[2] https://spectrum.ieee.org/automaton/robotics/industrial-robots/centauro-a-new-disaster-response-robot-from-iit (Date: 2.15.2019)
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[4] https://newatlas.com/darpa-tiny-robots-disaster-releif/55520/ (Date: 2.15.2019)
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