Reconstruction of a Quadruped Robot for Application in Hostile Environments, Research and Teaching in Robotics Area

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Abstract. *This article describes the project of restoration of a quadruped robot brought from Japan, the TITAN-VIII. The restoration process covers the complete renewing of its electronics, adding sensors to allow the robot move in hostile environments, the development of control software to make the robot operate autonomously. The changes made on the robot reconstruction process aim to create a quadruped robot capable of assisting in activities where the human beings are not able to act directly and simultaneously using the robot as a learning and researching platform in the field of robotics.*

1. Introduction

Nowadays, the world and the society in general are susceptible to disasters of all types, for instance fire, toxic gas leaks, or even radioactivity, these facts make impossible that people could approach areas of disasters for analysis or search. Robots can offer a great help in cases where extreme conditions such as high temperature, restrict the human access. The main advantages of these systems consist in the easy way to adapt and move on uneven terrains, since it only needs a finite number of contact points with the surface and does not matter what exists between these points. Another interesting point is that the legs allow the robot to avoid obstacles, go over uneven surfaces and through holes if the widths of them are not very large (STEEVES, 2002). All these advantages point out to consider a robot that uses legs as locomotion as a versatile solution for the tasks of location and demining.

Robotics system can offer an efficient, adaptable, safe, reliable and economical alternative to solve the problem of humanitarian demining. The main advantage of these systems consists in their capacity to adapt and maneuver on uneven terrain easily. Thus, leg robot can be exposed to extreme conditions, and be able to easily remove and overcome obstacles (HIROSE and KATO, 2000).

The article is divided into four parts. In the first part a brief introduction showing the used robot is done, in the second, the description of each necessary step for the reconstruction of the robot is referred, the third section shows the process of sensory expansion capacities, and finally in the last part the conclusions and future work are described.

2. TITAN-VIII

The TITAN-VIII is a quadruped robot, which was developed by Fukushima Robotics Lab in 1996. It was originally created for the purpose of developing research in mobile robotics. However, the adjustments being held will let the robot be used as a landmine detection system, operating in environments with toxic gases emission, unsafe environments, and many other applications. The TITAN-VIII, mounted by Hirose, has a special mechanism that enables their paws to rotate more than 90 degrees. The entire robot weighs about 24 kg and achieved 0.8 m/s speed in skating mode, doubling the walking speed of TITAN-VIII (HIROSE, 2009).

Based on the demand for standard hardware for research on legs locomotion, it was developed the TITAN-VII. So far, approximately a total of 40 sets of robots are being used in colleges and research institutes in Japan. The characteristics of this kind of robot are: Light weight and high power output; Adoption of a new driving mechanism; Introduction of a leg mechanism based on unitary module (POTTS, 2011).

3. Reconstruction Process

The reconstruction process of the quadruped robot is divided into five stages, explained below.

3.1. Interior Structure

In order to distribute the electronical components and the wiring, three aluminum plates were cut and fit inside the quadruped as drawers. So, six Monster Moto Shield were fixed in the structure for the motor control, two printed circuit boards that were designed in the project, one Arduino Mega 2560 and a Fit-PC. The components cited are explained below.

3.2. Wiring Construction

In order to connect all the robot components, it was necessary to prepare several wires. First of all, the wires that connect the motors and the potentiometers to the servo motor controllers and to the Arduino. Also, six-pin wires were used to connect the Arduino to the Monster Moto Shields that send the PWM signals and digital direction. Three 15V batteries connected in parallel are responsible for feeding the twelve motors. The cables that make these connections were developed and Deans connectors were used to connect the batteries, which are the best option for the case.

3.3. Set of Potentiometers

The best position for the potentiometers in each joint of the robot were seek initially. When the wires are connected, the sensors signals are read with a program implemented in the Arduino microcontroller. So, we calibrated the potentiometers zeroing all the joints in the same angle.

3.4. Printed Circuit Board

A PCB was developed, in Eagle software, as a shield to make possible the connection with the 48 Arduino pins. Thus, the necessary connectors were bought for six-way cables and solder the board. To connect the analog inputs to the twelve potentiometers outputs a flat cable of twelve routes was used. The PCI is shown in Figure 1.

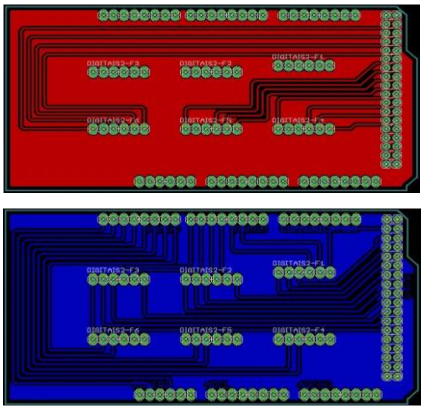

Figure 1. PCI(Bottom and Top) developed in the shield shape for the Arduino

3.5. Control Algorithm

The algorithm implemented in C begins in a loop with a function, which reads all potentiometers, detecting the position of each joint. Another function is responsible to update the targets, so, the angle that the robot leg must stand when the engines are operating correctly, following the stipulated target and obeying the direction and appropriate rotation speed. For this task, a PID (Proportional - Integrate - Derivative) control algorithm was implemented.

4. Architectural Design for Augmenting Sensory Capabilities of the TITAN-VIII

The robot will move using a navigation system and spatial mapping based on a KINECT sensor and a GPS. In addition, it will feature a metal detector to perform the task of detecting landmines. Ultrasound sensors are also used to measure the distance of obstacles during their displacement.

It was also developed an outline of the Pan-Tilt mechanism for the robot vision system. The equipment will consist in two servo motors. These will enable the Kinect to have a wide vision of the environment surrounding the robot. The structure for fixing the Kinect and GPS sensor in the quadruped robot was designed using a CAD software. The proposed mechanism is shown in Figure 2.

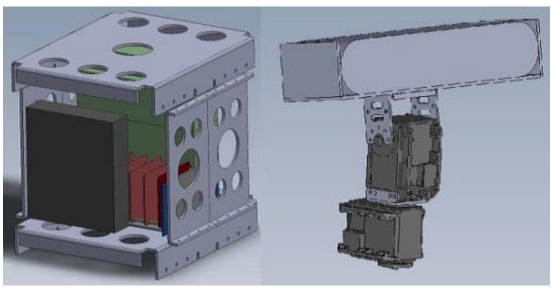

Figure 2. CAD project for the vision system

5. Results

With full hardware and the low-level algorithm finalized, it started the study of a method used for humanoid walking robots proposed by the NimbRo team(MISSURA and BEHKE, 2013), which will be implemented in the FIT-PC in Python language. This method will be modified in order to implement it in the quadruped robot, with its four legs. The restored robot is shown in Figure 3.

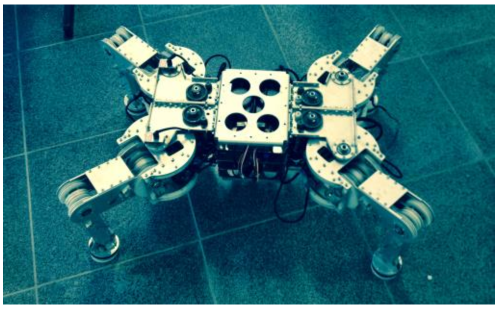

Figure 3. Quadruped robot restored

6. Final Consideration

The robot was successfully restored and it is starting to be developed the control algorithm for the walking using all the four legs. We expect the quadruped robot become a useful and safe alternative and that, directly or indirectly, assist in identifying the risks present in certain places and prevention of accidents. Furthermore, it is expected that the TITAN-VIII serve as research and teaching platform, so robotics concepts can be applied, studied and demonstrated.

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