UNESP autonomous mobile robots in Robots for Bombs Detection and Disarmament task: mechanical and computational issues

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Abstract -- **This paper describes the UNESPTroyers robotic team in Robots for Bombs Detection and Disarmament task, proposed on the 7th Latin American IEEE Student Robotics Competition in the Open category. This article aims at to describe our interpretation of the task and solution found for the same one. For this, we will show and illustrate the mechanical and computational functioning of the robot.**

1. INTRODUCTION

In proposed Robots for Bombs Detection and Disarmament task, one autonomous robot will localize and disarm in an arena , two bombs without explodes themselves. For that, two of three wires in each bomb have to be pick off in the correct sequence, and raise it or knock it down is forbidden.

The robot must projected and be constructed from zero, it can be used any electronics and mechanics components commercially available in the market (as gears, wheels, resistors, microcontrollers, motors, sensors, actuators, etc), as well as any software functions can be designed. The approach made by the task is defy the players giving freedom to construct a robot having disposal all the current technology, and unifies in a way to solve the task.

2. ROBOTS FOR BOMBS DETECTION AND DISARMAMENT

This section presents a description of the RBDD task and our understandings of the necessary robot abilities to accomplish it.

TASK DESCRIPTION

A robot constructed from the zero, that is, mounted part for part, must locate and move itself to disarm two bombs without they blow up or the time expires. The more recently developed high technology robots are capable to navigate virtually any terrain. For simulating slopes and mountains, the arena terrain was designed with elevations like illustrated at Figures 1.

The task starts in one of two places of beginning determined randomly. The count of time only stops if the robot disarms the two bombs or the count of 10 minutes dies.

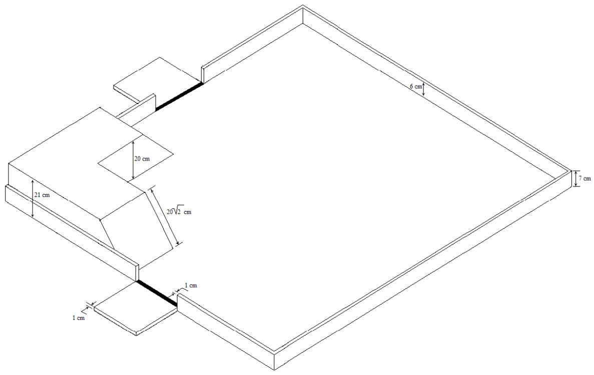
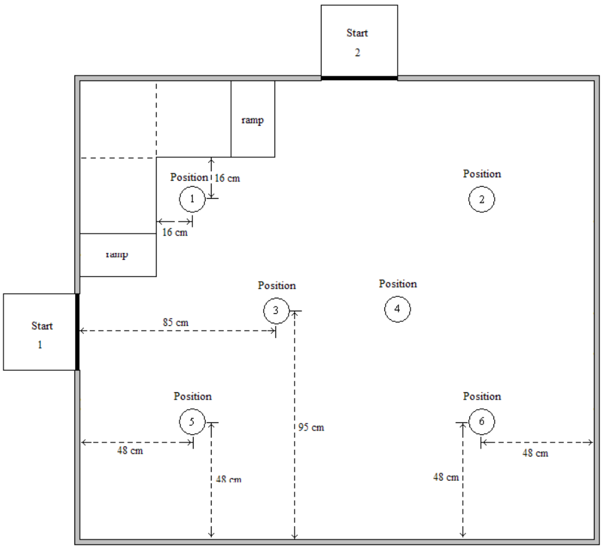


Figure 1. Environment for Open Robotic Competition

THE BOMBS

The bombs are composed for three wires (Red, Black and Green), arranged randomly, three in the same face for yellow bomb, and two in a face and one in the adjacent face in the case of the blue bomb, and must be pulled out two of them following the order, first red and then the green, to disarm it. Raises it or knocks it down is forbidden, taking the explosion of the same one. The bombs are distributed in arena by the way that one if locates in the rise and possess the blue coloration and to another one of yellow coloration if it locates randomly between six preset positions as it is shown in figure 2 and figure 3.

The side for which the face of the bomb will also be turned is random, fitting to the robot to disarm the bomb without knowing where it meets and so that side is turned wires.



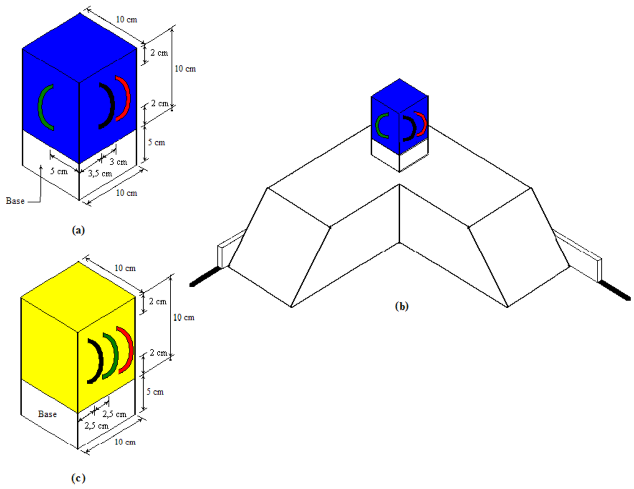


Figure 2. Positions to location Bomb2.
Figure 3. (a) Bomb1 above the base; (b) Bomb1, joint with its base, above the elevation; (c) Bomb2 above the base.

3. MECHANICAL ISSUES

This section describes in details the most significant mechanical aspects of the robot. A computational model of the robot in a *Computer Aided Design* (CAD) environment was used in order to allow a deeper study of its complex mechanics. An overview of the implemented robot is shown in figure xx. The following sub-sections gives details on some of its parts.

It can be checked in figure xx that the body of the robot has a 'U' design. This geometry is due to the fact that, in the time conception, the robot gets better performance in disarming the bomb.

Acrylic and aluminum were the materials used to manufacture the robot. These materials were chosen to offer resistance and minimize robot weight.

The proposed robot has three distinct parts: the moving platform, the grab and the tool to disarm the bomb.

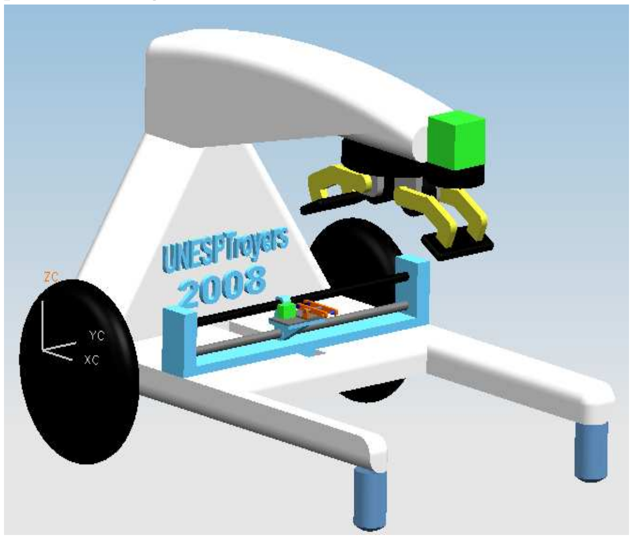


Figure 4. CAD model of the UNESPTroyers team robot.

3.1 ROBOT MOVEMENT

To the robot movement is proposed two wheels for traction at the back side and two support beads at the front side, as is shown in figure 5.

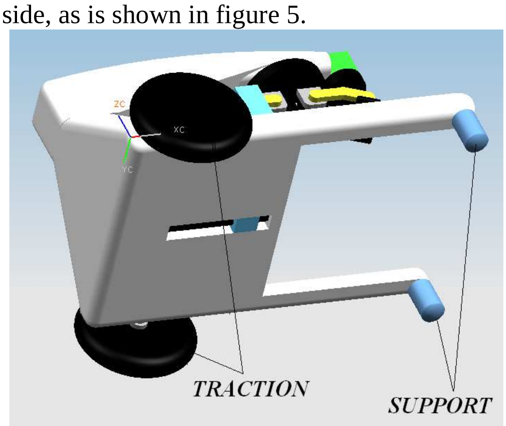


Figure 5. The wheels for traction and the support beads.

It is used two steps engines for traction, one for each wheel. Each wheel is coupled the same axis of its respective engine without gear. Using step engine to move the robot we can get more control of the robot rotation.

3.2 THE GRAB

It can be verified a stem at the top of the robot with a grab in the end. This grab makes an "open-close" movement when a DC engine is started. In figure 6 is shown the stem stated early.

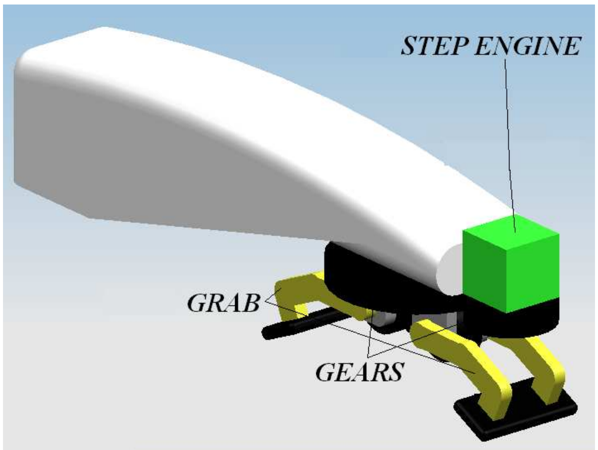


Figure 6. The Grab.

The stem has a transmition, made of two gears, to couple the gripper at the step engine. This transmition allows the grab rotate 360º in its axis. It can be checked in figure 7. Using this system we can reduce the speed, checking that exist two gears, one small (plugged at the step engine) and one big (plugged at the grab).

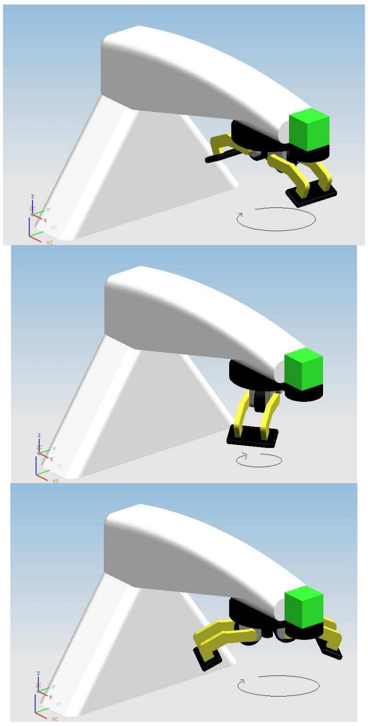


Figure 7. Gripper rotation.

3.3 TOOL OF DISARM

The tool of disarm is made of two distinct parts; one is the base of displacement and another is the "iron brace", the last one is like a pliers that "hugs" the wire to remove it the bomb. This tool can be checked in figure 8.

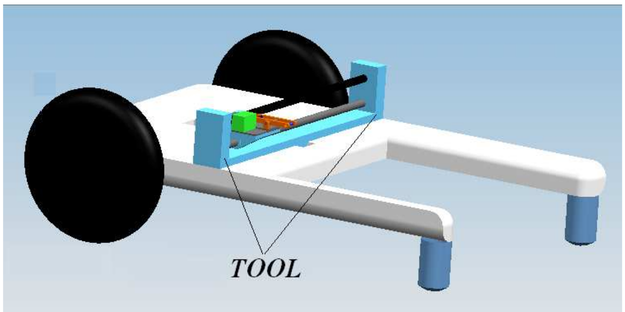


Figure 8. General vision of the robot tool.

The tool has displacement in two axis, longitudinal displacement (front-back) and horizontal displacement (right-left). The longitudinal displacement happens when a DC engine is started, in the other hand, the horizontal displacement happens when a step engine is started. The displacement of tool is shown in figure 9.

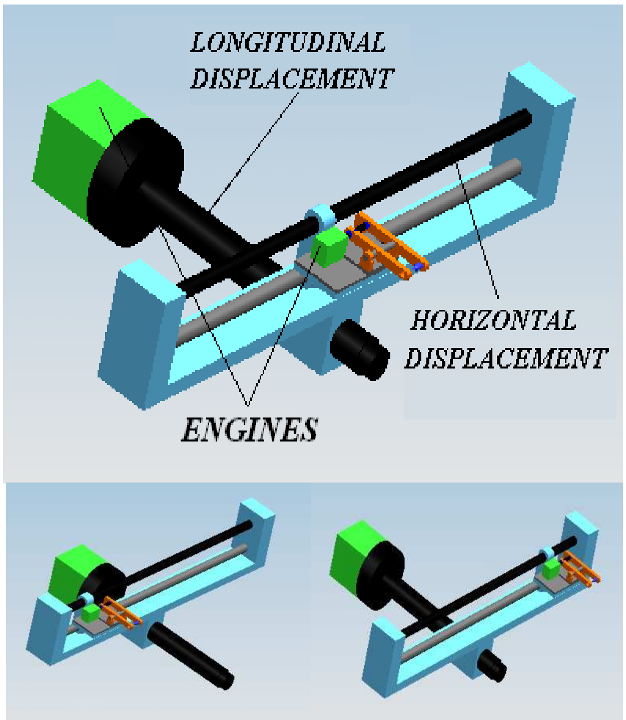


Figure 9. Displacement of the tool**.**

For the longitudinal displacement the tool dislocates by a never-ending thread connected to the DC engine. This movement makes the tool reach the bomb.

In similar way to the longitudinal displacement, differing only for the use of the step engine, the gripper moves in the horizontal displacement.

The gripper is made of two stems, one is fixed and another is mobile. The mobile stem moves to the fixed one when a DC engine is started, until it "hugs the wire". This functioning this schematized in figure 7.

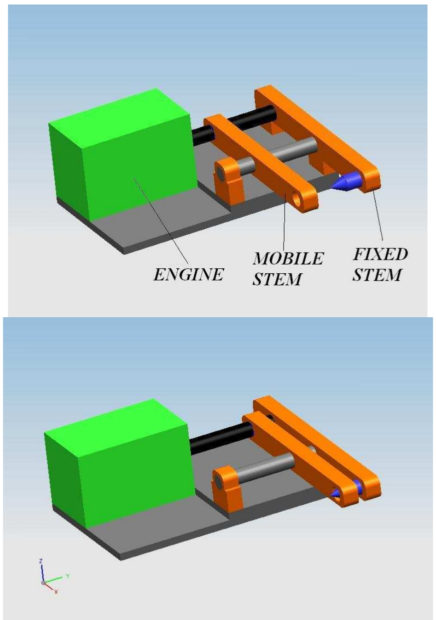


Figure 10. Gripper (a) Opened. (b) Closed.

4. COMPUTACIONAL ISSUES

The actions of the robot can be analysed as composed by four different phases: *i) phase I*: the robot looks for the elevation and go up; *ii) phase II*: the robot disarms the first bomb (above the elevation) and go down; *iii) phase III*: the robot looks for the second bomb (on the floor); *iv) phase IV*: the robot disarms de second bomb. All the process are compiled by a manufactured personal computer motherboard located in the backside of robot.

Particularly, the fourth phase of the task is the most critical phase and must be analyzed carefully. The wires will be placed randomly in one of the four faces of the bomb, due to this reason the robot has to be able to identify the correct face and then disarm the bomb.

In the whole task it is essential to assure a high degree of alignment of the robot.
The actions of the robot are shown in figure 11.

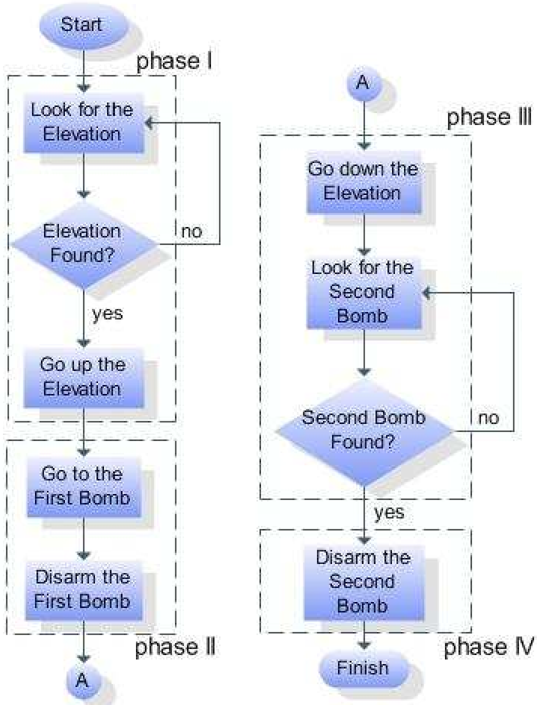


Figure 11. Flowchart representing the actions of the robot.

4.1 DISARMING THE FIRST BOMB

When the robot gets over the elevation an image is captured by the cam. Analysing this image the robot can find out how many wires are placed in that face and their respective colors.

The first bomb has only two faces that wires can be placed, one wire in one face and two wires in the adjacent face, both overturned to the elevation ramps, as stated earlier. Due to this reason and knowing how many wires are placed in one face and their respective colors, the robot is able to know the exactly localization of each wire.

Analysing which wire has to be removed firs and rotating the bomb if necessary, the robot can disarm the first bomb.
These steps are shown in figure 12a.

4.2 DISARMING THE SECOND BOMB

The robot rotates the bomb until the correct face is identified. After that, an image is captured by the cam and analysing this image the robot can find out the localization of each wire and disarm the bomb.
These steps are shown in figure 12b.

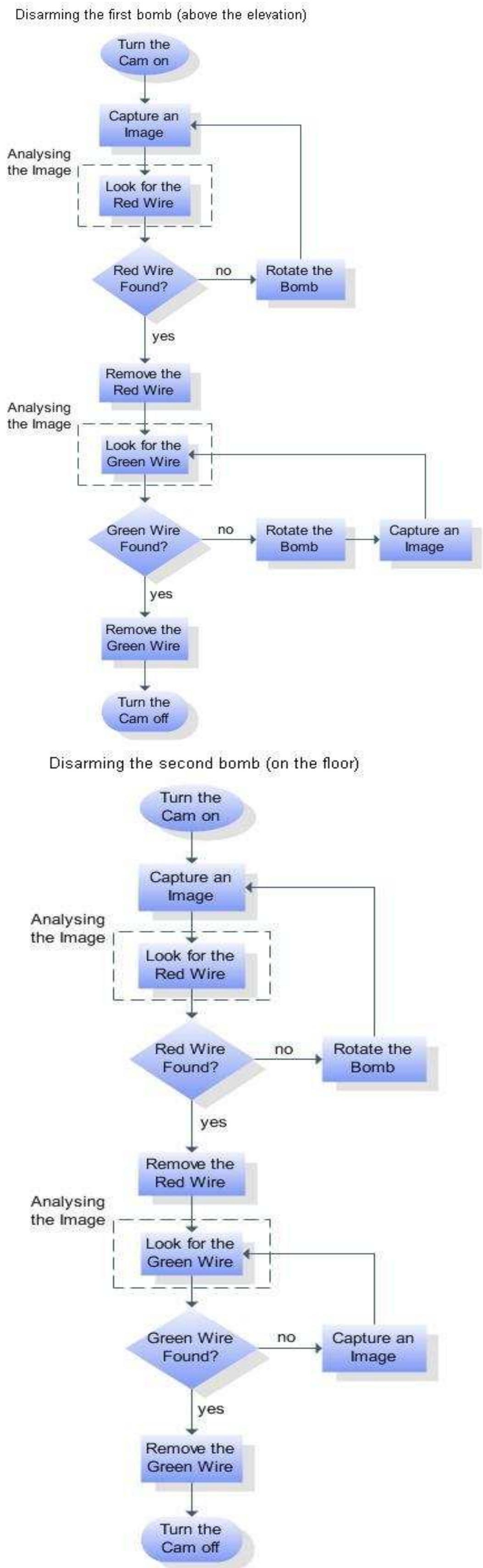


Figure 12. (a) Disarming the first bomb routine. (b) Disarming the second bomb routine.

5. CONCLUSION

This paper described the UNESPTroyer robotic team developed to accomplish the Robots for Bombs Detection and Disarmament, proposed on the *7th Latin American IEEE Student Robotics Competition*. Concerning the mechanical aspects of the team, the “U” form showed itself capable to catch and disarm the bombs. Concerning the computational aspects of the team, the strategy chosen allowed the robot to act autonomously with robustness. Due to all these reasons the robot is supposed to complete the task successfully.

6. REFERENCE

BEER, F. P. AND JOHNSTON JR. E. R. (2004) “Vector Mechanics for Engineers: Statics and Dynamics”. McGraw-Hill.

BROOKS, R. A. (1986) “A robust layered control system for a mobile robot”. IEEE journal of robotics and automation, vol. 1, n. 1, pp. 1-10.

IEEE. 7th Latin American IEEE Student Robotics Competition rules for the Open category: Robotic for Bombs Detection and Disarmament. Avaliable in: ftp://jri2008:web@users.dca.ufrn.br/regras/Open2008_pt.pdf . Access in June 1st, 2008.

SIMÕES, A. S.; CARRION, R. MARTINS, A. C. G.; COSTA, R. B.; SCHVARCZ, A. F.; BUZO, V. R.; FELIPE, M. H.; FERRARI, B. A. UNESP autonomous mobile robots in the medical trash collector task: mechanical and computational issues. In: Anais do XXVI Congresso da Sociedade Brasileira de Computação (SBC). ENRI'06: Encontro de Robótica Inteligente. Campo Grande, 17-20 de julho de 2006.