# CROSSFIRE LEGEND: THE FASTEST FIREROBO

## POLYTECHNIC INSTITUTE OF GUARDA

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## ABSTRACT

Crossfire Legend Robot is developed autonomous mobile robot which is a hardware based model used to extinguish any fire.

The main goal is to find room which has fire as soon as possible and extinguish it in spite of some obstacles. The robot kit was settled on a chassis and differential drive configuration. IntelliBrain Microcontroller is used for the brain of the Robot and the algorithm of the Robot was developed with the Java API of the IntelliBrain.

The Robot has been developed which features to move through right wall. When the Robot extinguish any fire it can return to its starting point.

The principle used, was designed and experimented in a home simulation. The most added advantages of the Robot are that it travels in the home simulation really quick and it is a reliable Robot about the extinguishing the fire (%83.3). The reason for the margin of error is the robot detects sunshine as a fire.

## INTRODUCTION

This poster describes the development of the autonomous mobile robot 'CrossFire Legend' to participate in the 16th edition of Portuguese FireFighting robot completion. The Project was developed in the Robotics class of the Politechnic Institute of Guarda.

## OBJECTIVES

We defined the following final functionalities for the robot:

- Finding the room which the flame exist in the home simulation.
- Extinguishing the flame.
- Being sensitive to some noises like sunshine, camera flash and ambient sound.
- Running with a specific frequency sound.
- Seeing the flame which is behind of an obstacle.
- Turning back to the starting point after extinguishing the flame.
- Running the robot in a random rooms of the home simulation.

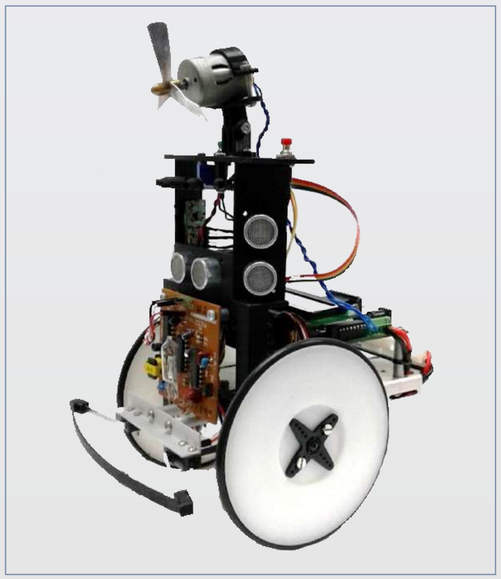

*Figure 1*
*Source: [1]*

## MATERIALS

Figure 1 shows the didactic robotic kit used in the Project. The robot kit was settled on a chassis and differential drive configuration. It has following components:

**IntelliBrain 2**: IntelliBrain 2 robotic controller is a microcontroller programmable with Java language. The controller has Atmel Atmega128 processor. IntelliBrain API is used to programming it.
The IntelliBrain 2 microcontroller has 13 Digital I/O ports, 7 Analog/Digital inputs ports, 8 Servo ports, 2 DC Motor ports, COM1 port, 5 I2C ports, 1 LCD display, 6 programmable LEDs, 1 battery power, 2 Push Buttons(start and stop), 1 Thumbwheel and 1 Buzzer.

**Sonar Sensor:** It is used to calculate the distance between walls and obstacles like any furniture in front of the flame and to navigate the robot straight forward. These sensors sends ultrasounds and catch the echo from objects. It helps to measure the distance from passed time between sent ultrasound and echo from the object.

**Infrared Flame Sensor**: This sensor is used on this robot for detect the flame location in the room. It works as detect the flame (fire) between limitations. If the sensors detect any flame, it sends pulses to main board and these pulses are between 0-5V. If the sensors can't detect any flame, it doesn't send any pulse so main board get 0V that means not detected any flame from the sensors.

**Photo Reflective Sensor:** This sensor is used to check the robot whether it is entrance of the room or not by detecting white lines. If the sensor detects lower value than a limit which we specified in our code, it means white color, but if it detects higher value than the limit, it means dark colors.

**Ultraviolet Flame Sensor:** It is an ultraviolet ON / OFF sensor which is really sensitive and quick response ultraviolet detection. It has range for visible light and it can be reacted quickly, that's why it is used with the "Crossfire Legend". It is used to detect whether any flame is in room or not when the robot is in the entrance of any room. If it detects the flame, it responses as value higher than '0'. If it detects nothing, it responses as '0'.

**Servo Motor:** A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback.This component is used to maneuver the robot according to walls.

**Motor DC:** This motor is used for extinguishing the flame when phototransistor detect the flame and the robot in front of the flame.

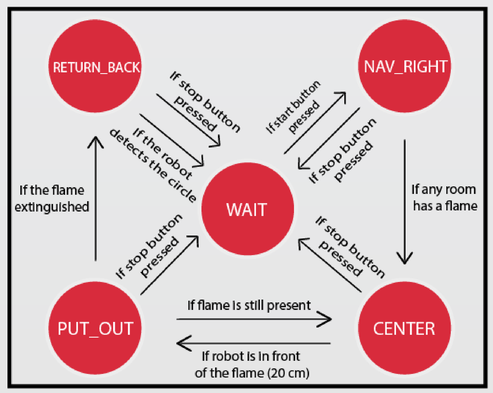


*Figure 2*

## CONTROL ARCHITECTURE

Figure 2 shows the behaviour based control architecture of the robot. First of all, in the WAIT statement, if the start button is pressed, the robot checks which way it's looking. If there is wall on the left side, in other words if it is looking to the wrong direction, robot rotates 90 degrees to right, it changes its direction to the correct way but if there is no left wall (if it is already looking to the correct direction), it enters to NAV_RIGHT statement.

First of all, in the WAIT statement, if the start button is pressed, the robot controls its direction and change according to correct direction which we specified in the code. Then it moves to the NAV_RIGHT statement. When the robot came to the entrance of the room, Ultraviolet Flame (UV-tron) Sensor checks if there is any flame inside.

In the NAV_RIGHT statement the robot follows the right wall and looks for a flame. During following the right wall, if the Photo Reflective Sensor detects a white line, it understands if it's inside of a room or not, according to number of white lines. If UV-tron doesn't detect any flame, it rotates back, goes out from the room and continues to follow right wall. (Doesn't travel along the empty room). If the UV-tron sensor detects a flame, the robot enters to the CENTER statement. If the robot can't find any flame in any room until it reached to its starting point (circle), it checks the last room which is connected to no wall. In this situation, the robot rotates back on circle and move straight a bit. After that it again follows the right wall and gets into the inside room then again enters to the CENTER statement.

In the CENTER statement first the robot finds the flame using by Infrared Flame Sensor and centers itself according to the flame through by this sensor. Then it moves to front of the candle, until the front distance is 20 cm between robot and candle. The robot centers itself because the robot's air extinguisher is located in the center direction of the robot that's why when the robot came in front of the flame, it should look directly to the flame. After the robot settled in front of the flame, it enters to the PUT_OUT statement.

In the PUT_OUT statement the robot runs its fan to extinguish the flame. Then the robot controls whether the flame still exist or not. If the flame still exist, the robot enters back to the CENTER state and repeat these two statements things until the flame is extinguished. If the flame is extinguished successfully, the robot turns right 90 degrees and go straight until the front distance is 25 cm. The robot does that because it has to catch the left wall to turn back. After that the robot enters to the RETURN_BACK statement.

In the RETURN_BACK statement the robot starts to follow left wall to go back to the starting point. When the robot detects the circle (starting point), it stops and enters back to the WAIT statement.

In addition, if the stop button is pressed in any statement, the robot enters back to the WAIT statement.

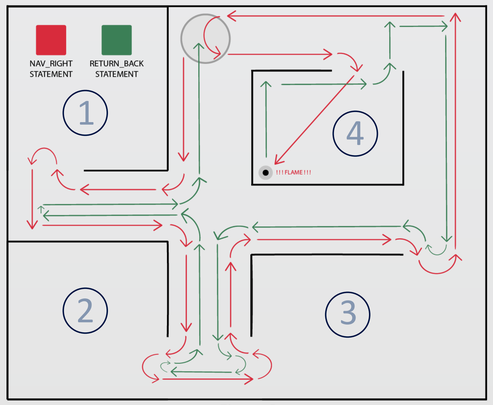


*Figure 3*

## NAVIGATION STRATEGY

Figure 3 shows the robot behaviour in the area of the competetion. When the robot is following the right wall, the robot moves approximately 20 cm away from the right wall. It maneuvers left or right a bit with calculating the difference between itself and the walls. When the robot gets a value which is smaller than 20 cm from front Sonar Sensor, it turns left.

When the robot is following the left wall, it does similar things like the right wall. The robot still maintains 20 cm distance with the left wall but as a difference, when the robot sees a wall in front of it, turns right. Also it maneuvers to the reverse direction of the NAV_RIGHT statement.

## TESTS AND RESULTS

For each room, the flame is located 3 different corner of the room to test the robot.

Totally 12 tests were done and 2 tests failed, so the robot achieved %83.3 success in the tests. The Figure 4 shows the average time for finding and extinguishing of the flame.

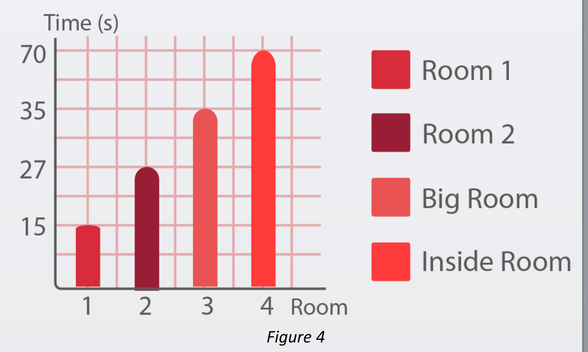


*Figure 4*

## CONCLUSIONS

As a result of the tests, the robot gave several errors. Sometimes the robot didn't detect the white lines or the robot detected white lines which are not white and also sometimes the robot detected the sunshine as a flame. We tried to solve the sunshine problem by adding a filter to our Infrared Flame Sensor.

At the end of this work, the robot can achieve most of the objectives. As we told in the previous sections, the robot can find and put out the flame, whether there is a furniture in front of the flame or not. Also it can return back but the robot still needs to be started from a prespecified place like the white circle.

In future, the robot will be able to achieve this mission. The robot can start in an arbitrary location and it will be able to find flames in any room. For arbitrary mode, the robot can be started in any room. The robot will understand in which room it was started with calculating distance through sonar sensors and understanding exit direction from the room through compact sensor. After the robot understood in which room it was started, it counts the lines until finding the room in which the candle exists. It extinguishes the candle, then it returns to the room where it started thanks to counting down the lines.

## REFERENCES

[1]: https://drive.google.com/open?id=16v75BeblhAAYJevzGQp_ElOr7g0W5On9(W2-Introduction Page 2 / 1.2)

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