Bahia RT-IEEEOpen - Team Description Paper

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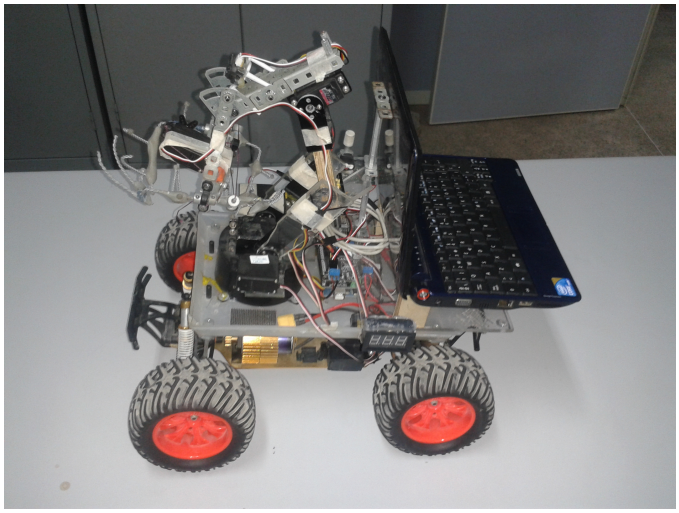


Fig. 1: Robot.

***Abstract*— This article intend to explain the study and build process to the funcionality of a robot that will work in the IEEE Open 2013 competition, in this competition the robot is designed to pick up trash from the beach in an environment with several cans scattered, some obstacles and a repository for depositing cans collected, the robot must have the capacity of to turn off obstaculous and to transfer the cans to determinated local in competition.**

I. Introduction

The build of a robot (Figure 1) to actuate with the capacity of to detect colours and identify determined objects in a competition with dimension and time limit, requires many a study to choose the best components, including sensors and actuators, adapting to the best performance in the tasks environment of the competition and trying to maximize the performance to complete the tasks in the determinated time on competition.

In section II, will be showed the hardware and software components and libraries used in the robot development. In section III will be explained the implemetation, mounting and operation of each robot part, and finishing in section IV that will be presented the conclusion and future works.

II. Used components and softwares

The robot was builded following the architecture demonstrated in Figure 2. It's composed of the following components:

One arduino board Mega with processor ATmega 1280, 23 I/O pins (of which 13 provide PWM output and 10 analog input pins (Figure 3) [3]. The control and communication of the arduino were programmed in C++ language; One netbook with 512 MB of memory and Intel (R) Atom 1,60 GHz, responsible by the processing of the images and control of the robot, using the vision, control and communication modules, implemented with the libraries: OpenCV (version 2.2) [1] used to image analysis and libserial (version 0.6) [2], used to communication nettop-arduino and arduino-nettop; One webcam 1.3 megapixel of 60 fps (Figure 4) responsible by capture images; One distance sensors SHARP GP2D120, to detect objects between 4-30 cm (Figure 5); And actuators controled by arduino, described below.

A. Actuators:

The actuators are represented by the navigation system and the manipulator system.

The navigation system consists of a 550 high speed motor, a default servo for steering control, four wheel off road and a suspension system. this system is responsible for controlling the direction and speed of the robot, allowing it to move over rough terrain. For the 2013 competition, the vision is used to detect the cans, the obstacles and the repository, for that the images received from the camera are processed and objects are recognized based on their shapes and colors. The vision is used of two forms, first seeking the soda cans

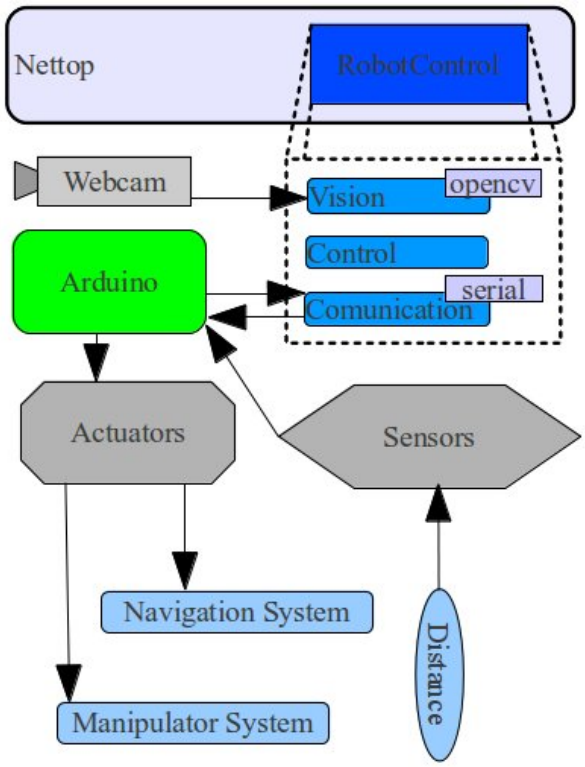


Fig. 2: Robot Architecture

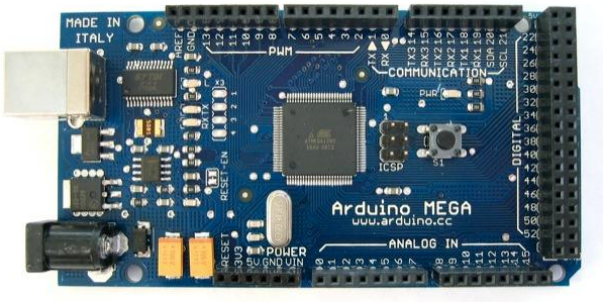


Fig. 3: Arduino used by robot [3]

Fig. 4: Camera used by robot

Fig. 5: Sensor used by robot

and selecting the can closer to your field of vision and passing this information to the control module, when a can is collected, the vision quest the repository, and again passes direction information for module controte.

The system of the manipulator (Figure 6) is composed of a robot arm with six degrees of freedom and a claw which operates on a system of pulleys by a servo controlled. It is responsible for collecting the cans scattered around the environment and puts them in the repository when the robot is next to him.

III. Operation of the Robot

Each module of the robot is responsible for one feature during the competition, the modules are divided between software and hardware. We describe how each of these modules work below:

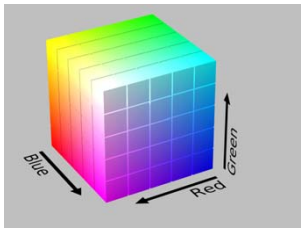
A. *Software:*

The software called here of RobotControl was developed in C++ and runs on nettop. It's responsible for the vision, control and communication modules.

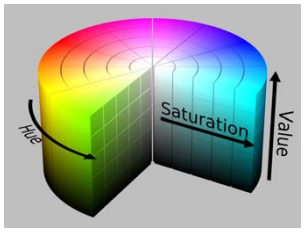
- **Vision Module**

  The vision module has been developed since 2011, as part of the development of the Computer Archicteture and Operating Systems Group (ACSO) [5]. To the colors detection, three patterns were studied: RGB, HSL and HSV (Figure 7), and the HSL pattern was chosen by the ease to define colors.
  In HSL pattern, the colors have specific values of

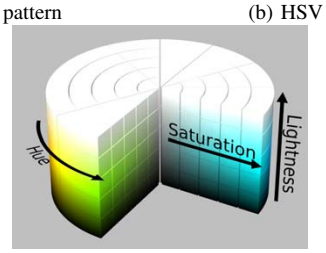
Fig. 6: Robotic arm.



(a) RGB pattern



(b) HSV pattern



(c) HSL pattern

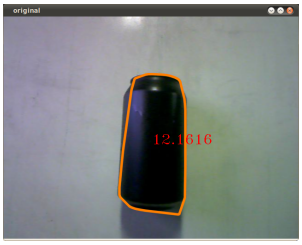
Fig. 7: Colors patterns [4]

Hue, Saturation and Lightness. To define which color will be detected, we use a range of HSL values $((H_i, H_f), (S_i, S_f), (L_i, L_f))$, this way it is possible to identify objects through color. There are some problems in this method, two should be highlighted: the contours generated from color detection are irregular and the HSL interval must be modified as the luminescence of environment varies.

To alleviate the first problem (irregular contours, see in figure 8a), which can harm the relative measurement of distance and area, the contour convex points were interconnected, creating a better defined contour (see in figure 8b).

On the second issue, whenever the luminescence changes, the range of values HSL should also be changed, since the HSL pattern depends on the light-

(a) Irregular.



(b) Regular.

Fig. 8: Contornos.

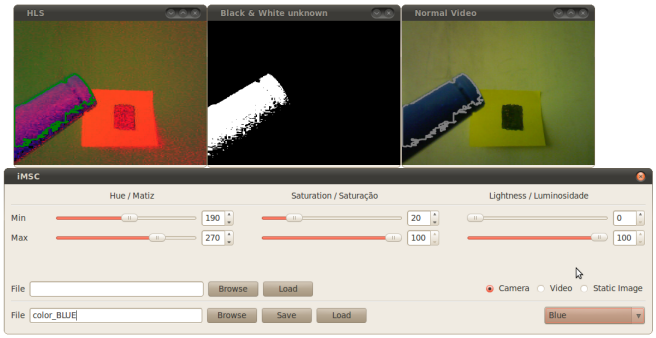


Fig. 9: Calibration tool.

ness. That way, every time we needed to change the values corresponding to a color, it was necessary to change them directly in the code, rebuild it and check if the values were correct, otherwise the process should be repeated. This was no effective way and spent a lot of time to set the values, which were not always the best for a particular color. To solve this, we created a tool (Figure 9) that enables change these values in real time and saves them in a file that is loaded by the robot vision. With this tool easier to change the values of a color, and allows assign a better range of HSL values to a color.

For the 2012 competition, the vision is used to detect the cans, the obstacles and the repository, for that the images received from the camera are processed and objects are recognized based on their shapes and colors. The vision is used of two forms, first seeking the soda cans and selecting the can closer to your field of vision and passing this information to the control module, when a can is collected, the vision quest the repository, and again passes direction information for module controte.

- **Control Module**

  This module is responsible for all decisions taken during the competition. It receives information from the vision module, the control module uses this information to take the decision, and send its commands to the navigation and collect module.

  First the robot need to take the soda empty cans, painted

in flat black, they simulate the garbage, and leave the can to the garbage depot, a red ring of a height of 10 cm and a diameter of 70 cm. Using the vision, the control module decides which way to go (left or right) depending on the nearest can, the robot go forward until the vision module detecting the can, the vision module tries to centralize the robot with the can, at a certain distance enough to collect, if the vision module not can see the garbage then the control module send the navigation beginning search, rotation to (left or right), until the vision module detect the garbage.
From the location of the can, the control activates the collect module, which capture the garbage, storing in the claw, after the robot need to leave the garbage at the garbage depot. The control uses the vision to know the location of the deposit, if the vision module don't know this location the control module send the navigation beginning search, rotation to (left or right), until the vision module detect the garbage depot, the robot go forward until the vision module detecting a safe distance to deposit the garbage.
This process is repeated for each the cans in the field.

- **Communication Module**

  The communication module uses the serial library, it's responsible by the communication between control module and arduino.
  All decisions made on the control module are sent in the form of messages by the communication module for arduino that runs each command and responds if these commands were executed successfully or not.

B. Hardware:

The arduino, from the commands received from control module, active the modules below:

- **Navigation Module**

  The navigation module consists of a base with four-wheel traction differential. The intent is to provide the necessary traction for locomotion on sand. The direction of the robot is done through a servo that controls the steering axis of the rear wheels on the base of movement.

- **Collect Module**

  The collection module is composed of a robotic arm with six degrees of freedom and an elastic counter-balance system to minimize the effort made by servos that comprise the body of the robotic arm, in order to achieve a freer movement and broad. The robotic arm has three positions: rest, collect and deposit used in specific moments of the competition. In the end of arm is attached a claw constructed with a large gauge wire and a metal support with the aim to reduce friction with the sand and collect the cans with minimal effort. The closing of the claw is through a system of cables pulled by a servo.

IV. Future works and conclusions

This article described in details the build and implementation of all modules that exist in the robot that intend to participate of the IEEE Open 2013 competition. Until the championship day, will be made adjustments and improvements, with the objective to reduce the conclusion time of the task, eg fine-tune of navigation

V. Acknowledgment

The authors are grateful by staff of the CNPQ and ACSO/UNEB that make possible the achievement of this project.

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