IEEE Open EDROM
LARC/CBR Team Description Paper

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***Abstract*—This paper describes the development, architecture and programming of the project FIONA, by the group of undergraduate students named EDROM (Equipe de Desenvolvimento em Robótica Móvel), from the University of Uberlândia, Brazil, Minas Gerais. FIONA is a robot competing on the LARC 2010 IEEE Open Category. The main ideas for the robot to complete its task are shown in this paper. The team hopes to acquire experience for future competitions.**

I. INTRODUCTION

EDROM is a group for development of robots from University of Uberlândia, Brazil, Minas Gerais. This team developed a project named FIONA, for the LARC 2010 IEEE Open category. It began in May 2010, the NXT Lego Mindstorms was chosen to the project, since then, it is being built side by side with programming tests.

The objective of IEEE Open Category is developed an autonomous robot should manipulate products sent by producers and to organize them in packages that will be sent to sales points later on.

This paper describes operating principles of the FIONA, such as, programming logic and architecture. It also shows the engineering techniques used.

II. ARCHITECTURE OF THE ROBOT

The beginning of the project was to build a structure for the robot for it to be able to develop a predetermined task, following the rules of LARC 2010 IEEE Open category.

Therefore, FIONA has the following parts:

- 6 Servo Motors
- 2 PLC
- 2 Four-bar Mechanisms
- 4 Wheels
- String
- Ramp
- Claw
- Sensors
- Lock-gate

The first idea was to find a way for the robot to carry five cubes at a time. A space inside the robot was created, and the cubes would be dragged on the ground. However, that would cause damages to the scenario. To solve this problem, a ramp was built, as shown in Fig. 1, where the cubes are dropped on and placed.

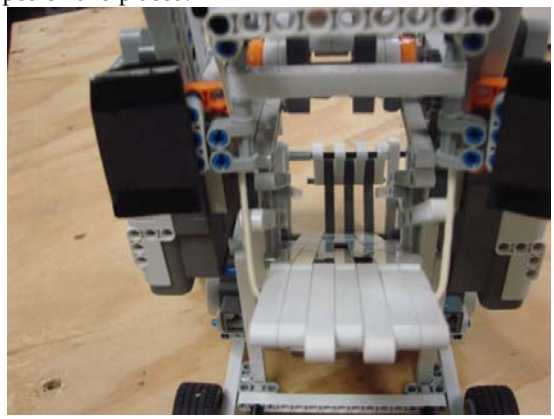

Fig. 1. Ramp inside the robot. The cube is dropped and carried on it.

A claw was made for grabbing the cubes. It was built with the servo motor in the vertical position to reduce one of the robot's dimensions. Gears were used to transfer rotation and torque from the motor to the claw. The claw is illustrated in Fig. 2.

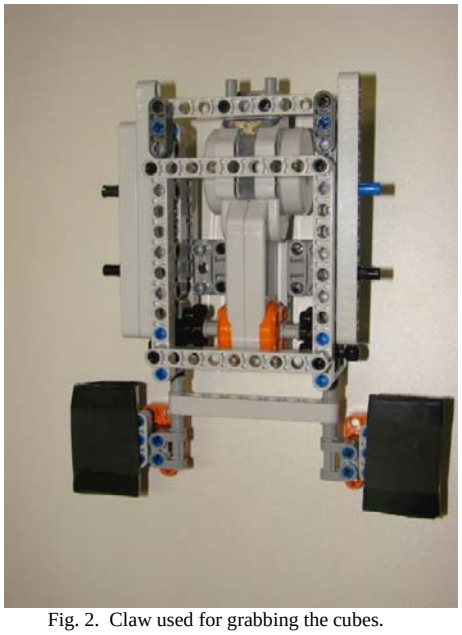

Fig. 2. Claw used for grabbing the cubes.

Two four-bar mechanisms were used to lift the claw and maintain its vertical position, as shown in Fig. 3. Besides two motors, gears were also needed to increase torque.

Manuscript received August 23, 2010. This work was supported in part by the FEMEC (UFU) and has financial support from FAPEMIG.

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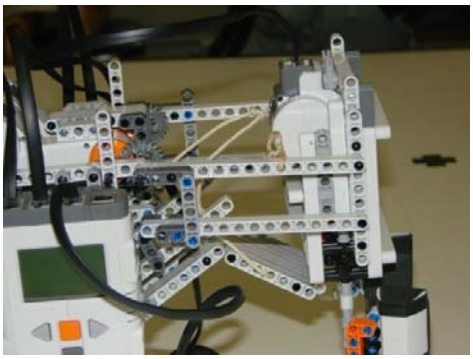

Fig. 3. Four-bar mechanisms and gears lifting claw.

A string was used linking the four-bar mechanisms to the highest part of the ramp, which can freely rotate around its linkage to the rest of the ramp. When the claw is lifted, this highest part gets under the cube, enabling it to be correctly dropped on the ramp. That linkage with the string was used to reduce one of the dimensions of the robot, and also to avoid the ramp to interfere on the claw´s lifting. Fig. 4 shows how the string works.

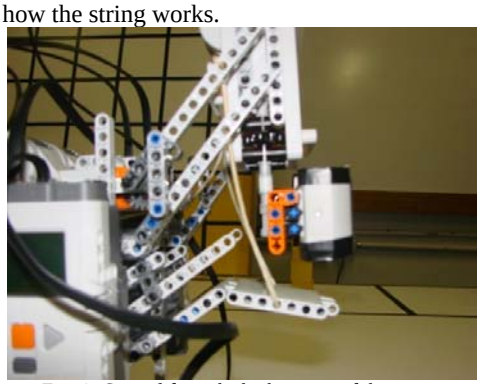

Fig. 4. String lifting the highest part of the ramp.

The lock-gate function is to hold the cubes inside the robot while it is moving, and release on the vendors' zone of the scenario. It is illustrated in Fig. 5.

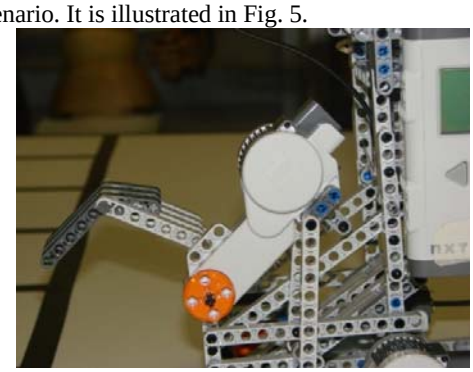

Fig. 5. Lock-gate that holds the cubes while FIONA moves.

The servo motors are used as shown in Table I.

TABLE I
SERVO MOTORS CONNECTIONS WITH PLC'S

PLC	Connections	Function
1	A	Claw movement
	B	Claw lifting
	C	Claw lifting
2	A	Open/Close lock-gate
	B	Robot movement
	C	Robot movement

III. PROGRAMMING LOGICS

The programming was made using the Lego MINDSTORMS NXT 2.0 editor [1-9]. It is a graphical development environment of programming.

As the Lego MINDSTORMS NXT's PLC only handles three servo motors and the project needs six of them, it was necessary to use two PLC's.

The fact of using two PLC's led to two separated programming routines. The Bluetooth is used to combine the two routines.

The PLC 1 is responsible for counting the number of cubes collected, lifting and opening/closing the claw. The PLC 2 is responsible for the movement of the robot, and open/close the lock-gate.

This particular choice of the PLC's and motors was made to reduce the number of times the PLC's send and receive messages to each other, as that increases the task performing time.

The robot´s task starts with finding out the position of the cubes in the producers´ zone. As the robot starts at a random position, it needs to decide which group of cubes is the nearest. It moves towards those cubes and reads the color of them. This action repeats for the next groups, creating a database that describes which is the location of each group of cubes, as they can also be randomly decided. Fig. 6 shows the robot in a random starting position.

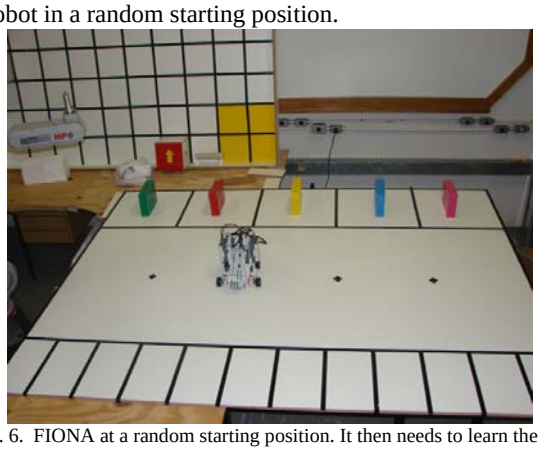

Fig. 6. FIONA at a random starting position. It then needs to learn the position of each group of cubes.

After the robot learns the location of each group by their

colors, it starts grabbing and dropping them on the ramp, in the following order: magenta, green, yellow, red and cyan.

The next step is delivering the package of five cubes kept inside the robot. It moves to the vendors´ zone, opens the lock-gate at the end of the ramp and slowly moves forward, so that the cubes slide down until they reach the scenario. For adjusting the package in the correct way, according to the rules, the robot moves again backwards, making the cubes stay together. Fig. 7 illustrates the delivering of one package of cubes.

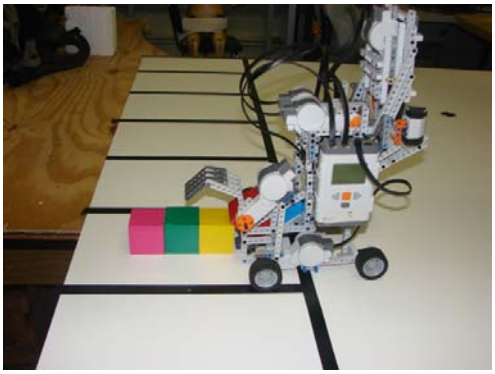

Fig. 7. Robot delivering cubes.

After delivering a package, the robot starts the task again, skipping the first part, as it already has the database previously mentioned.

A scenario, shown in Fig. 8, following the descriptions of the rules was built, so that the team could test the programming and optimize it.

Fig. 8. Scenario built for tests.

IV. Conclusion

The task given for the team to resolve illustrates a real engineering problem, which is highly rewarding for the members to see working, besides the amount of experience it provides.

The team found some adverse conditions while developing FIONA, such as malfunction of sensors, high consumption of batteries and difficulty of matching the members´ schedules.

Finally, although there were difficulties, the project has succeeded, and represents an excellent extra-curricular activity for all the team members.

Acknowledgment

The authors are thankful to Federal University of Uberlândia (UFU) and Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) for the partial financing support of this IEEE Open competition and research work.

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