ARDUINO PLATFORM AND OBJECT-ORIENTED PROGRAMMING APPLIED TO AUTONOMOUS ROBOTS FOR DETECTION OF PIPELINE

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ABSTRACT
The aim of this work is to Demonstrate a prototype that inspects pipelines buried through an autonomous robot. The inspection aims to follow the route of the pipeline, capturing its coordinates (x, y, z), storing and sending data through the Arduino platform, electronic boards and specific programming. For data storage we used a Micro SD Card Shield and in order to sending the data we used the General Packet Radio Services, allowing the data traffic integrating mobile with internet. The electromagnetism was used for that the robot accompany the pipeline buried through the its magnetic field. The coordinates captured by the vehicle are compared with the coordinates of setup project. After the capture of the coordinates, some decisions may be taken: monitoring the pipeline that may be positioned in slopes; regions with high pluviometric index and risks of possible oil spills. The project uses innovative technologies, accessible and low cost.

Keywords: Inspect pipelines, Autonomous robot, Specific programming, Arduino platform.

1. INTRODUCTION

Nowadays, Brazil has installed approximately 22000km oil and gas pipelines on land (Monitor Mercantil 2010). According to the regulation of ANP Technical 2/2011, is generic designation duct installation consists of pipes connected together, including Components and Accessories, for the transport or transfer of fluids between the frontiers of geographically distinct operating units. The ducts are composed of pipelines and mostly buried about 2 feet deep.

The pipelines are constructed for transporting substances, often dangerous, both in gaseous state to the liquid state. The transport of these substances through pipelines is considered not only the safest, but also, for large quantities, the most practical and economical, even if confronted with road transport or rail. Nowadays, there is a growing preference for this mode of transport, prompting the pipeline network grow quickly and consistently (Cardoso 2004). It is recognized that there is a potential risk of accidents classified as grave. As natural precaution for all pipelines should be developed risk analysis, evaluation of consequences and prepared their plans.

1.1. Studies of Techniques Inspection

In Brazil and in the world, the technique used to inspect pipelines depends on the particular fault that you want to find. There are defects that may be recognized externally to the pipeline. In the case of pipelines located in the external surface inspection can be performed visually. With this purpose, the translation of inspection through the external wall of the duct, for a exhaustive analysis, there is not a problem of great difficulty. In the atmosphere, the technologies of non destructive metallographic tests, broadly used in industrial fields, are applied with relative ease. However, when the external inspection occurs in places with water (rivers, lakes and seas) is complicated in that it increases the depth where the pipeline is located. For this type of problem, one of the most promising solutions is the development of Autonomus Underwater Vehicle (AUVs), sailing in deep sea without physical connection to a vessel or platform surface (Avia 2000)

The AUV presented can be utilized for military purposes, inspected areas with possibilities of existence and pumps for commercial purposes to finish locations for future installations of oil platforms and pipeline inspection. Thus, it is able to follow the trail of submarine pipelines by acoustic and magnetic sensors.

Figure 1: Autonomu Underwater Vehicle

As previously mentioned, the inspection can occur internally or externally to the pipeline. However, the main problem of internal inspection of pipelines is not really a technical failure analysis, but the difficulty in accessing the area of interest.

In the next figure, the article text demonstrates a robot with camera and mats for visual inspection of pipelines. This type of robot is in common use in the inspection of sewer networks, cleaning air conditioning ducts and nuclear plants. The device with high degree of autonomy, known as DAVID, is not a good example of inspection robot internal buzzing with wheels (FERASOLI et al .., 1999). This type of robot is able to move by means of wheels driven by electric motors, has a structure suitable mechanical pipes of circular cross section, and can be altered according to constraints imposed by the environment.

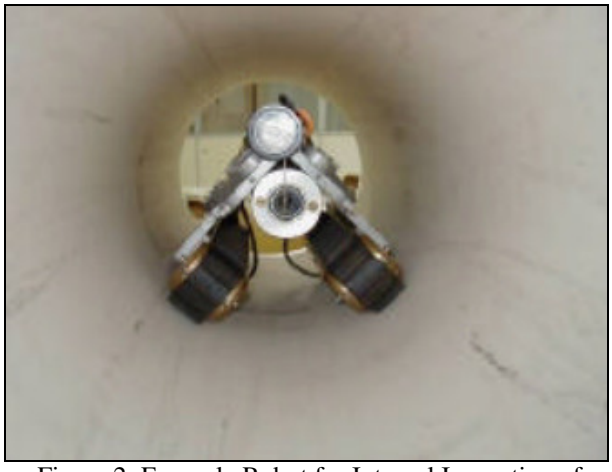

Figure 2: Example Robot for Internal Inspection of pipelines with treadmills

Another robot model that uses suction cups to clin'g to inspect the walls. This is the case SADIE robot that climbs walls with the aid of his paws, designed in England for non-destructive testing of welding a nuclear reactor (Luk et al., 2003).

However, there is a lot more complex cases of internal inspection, occurs when the flow in the pipeline can not be interrupted. In this case, the most used technique of internal displacement in ducts for this condition is the impulsion of inspection tools making use of the same fluid transported. This type of inspection tools is called Pipeline Inspection Gauge-PIG (Cardoso 2004). The PIGs collect information on the walls of the ducts through sensors and require no cord, since they use the energy of the fluid to move. The following are some models PIGs used in internal inspection of pipelines in the oil industry.

Figure 3: PIG of a Foam

Figure 4: PIG Geometric

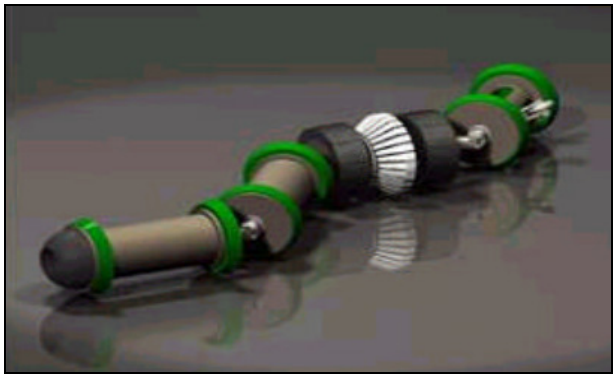

Figure 5: PIG Magnetic

1.2. Histories Duct in Brazil

Today, Brazil has kilometers of pipelines installed in regions with different geological characteristics, presenting several unstable areas called "high impact" as slums, urban agglomerations and varied underground or aerial crossings of roads and rivers (A Tribuna 2013). "Duct is the generic installation consists of pipes

connected together, including Components and Accessories, for the transport or transfer of fluids between the borders of geographically distinct operating units." (ANP 2011).

In several regions of the country, pipelines are subjected to stresses imposed by earth movements. To ensure the structural integrity of the ducts installed in these areas, it is necessary to examine all areas and to map unstable and studying the movement of the soil mass. The movements usually involve trawling extensive areas and feature a slow speed. In general are difficult to detect by visual inspection risk areas (Santos 2013).

The National Agency of Petroleum, Natural Gas and Biofuels (ANP) published in several newspapers to inspect pipelines that crisscross the country (A Tribuna 2013).

To improve the operational safety of the pipeline, new technologies are being developed to detect unstable areas and to estimate its effect.

The inspection of pipelines must be observed by all range extension, as irregularities that give rise to abnormal mechanical stress on the pipes or likely to endanger the existing facilities. Some conditions can be cited, such as erosion, earth movement, landslide, vehicular traffic and / or heavy equipment on track, growth of vegetation, drainage system deficiency range, fires, invasion of track by third parties, conducting works nearby or interfering with range (buildings and explosions), deficiency in its demarcation and warning signs, outcrop duct, crossing streams with apparent duct, subjected to currents of water or erosion processes may create a risk to the pipeline (Sampaio 2012).

2. THE MOTIVATION

The main motivation of the proposed article was tedious due to existing teaching methods in technical and higher education in Brazil. Thus, it was necessary a search for innovations, in order to attract the interest of new students. Technology arising from globalization has brought many benefits to the population, however, had no such technology as its main focus new methods to improve the education system. The project in question is intended to motivate these students, improving their performance and transforming learning into a moment of pleasure and not just an obligation. These improvements were made possible by the tools selected for the project development that facilitate student understanding. An innovative tool, flexible, with an environmental vision and low cost.

2.1. Development Platform: Arduino

The Arduino platform or simply Arduino (Banzi 2011) is a platform that was built to promote physical interaction between the environment and the computer using electronic devices in a simple form and based on free software and hardware.

Considering a more succinct form, the platform consists of a circuit board with inputs and outputs to a microcontroller AVR development environment and the boot loader already recorded in the microcontroller. The microcontroller is composed of a microprocessor, memory, and peripheral input / output and can be programmed for specific functions, for example, different control and automation machines.

Studies show that there are many other platforms built for microcontrollers, but the Arduino has excelled on the world stage for ease of programming, versatility and low cost. Even for those who want high-level interactions, the Arduino has fulfilled expectations.

Besides all the adjectives preceding the development platform Arduino still differs from the others in the market by being a multiplatform development environment. Thus, its applicability is feasible in various types of operating systems, as well as being open source, where anyone has the possibility to download the tool, and is based on the Processing programming IDE, a development environment easily used.

Figure 6: Platform of Development Arduino
Source: Arduino.Cc

According Banzi, the Arduino is a physical computing platform open source, based on a simple plate of inputs and outputs, which can be used to develop interactive objects independent or connected to software, such as Flash, Processing , Java and etc.. Another concept on one of the main advantages of the platform Arduino, according to the thoughts of McRoberts, is: The biggest advantage over other platforms Arduino microcontroller development is the ease of use, people who are not technical area can quickly learn the basics and create their own projects in a relatively short time interval.

2.2. Java Platform

Nowadays there are on the market various types of programming languages, where each has a specific characteristic.

Java is a programming language object oriented very differently from conventional languages, which are only compiled or interpreted, it is hybrid, ie, compiled and interpreted by a virtual machine. The methodology of object-oriented programming is highly suitable for software development for large-sized companies, however, it is also suitable for school projects because it is simple and succinct. It also introduces concepts of modularity and reusability and approaches which enable

the programmer to visualize your project running as a collection of cooperating objects that communicate via messages (Deitel 2010).

3. THE DEVELOPMENT

The project goal was to create a shopping autonomous remotely controlled, using the knowledge gained in scientific initiation, following several steps. In the next picture can be seen the evolution of students' knowledge.

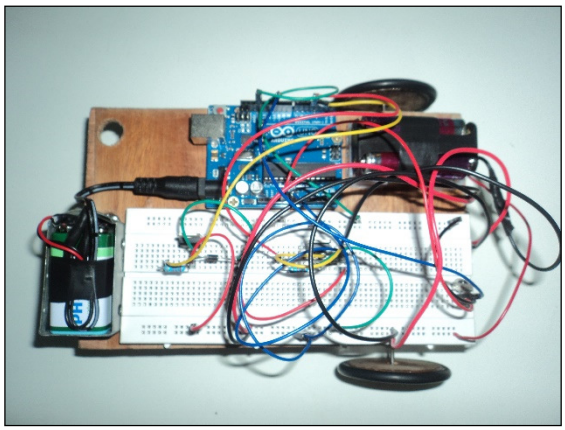

Figure 7: First Prototype of Stand

The beginning of the activities related to the use of robotics as a tool for teaching support occurred through the explanation on topics related to the research object. The weekly group meetings undergraduates, can bring greater knowledge, involving concepts about arduino, electronics, robotics and computer systems, as well as the description of the advent of technology in support of industrial process and society.

The central idea of the weekly meetings was to awaken the sense of awareness of the students about the practical usefulness in curricular subjects in teaching computer science, electronics and graphic interfaces.

3.1. The First Steps

A small representation of card use of components mounted on a breadboard display for ease of programming and immediate results.

The configuration is intended to turn on and off a small LED from the output of the Arduino and programming itself.

After acquiring greater knowledge and studies in the area, the group got the Proteus software that has a simulation environment for electronic circuits and ISIS program to design printed circuit Ares professional. This software is used to simulate microprocessors, schematic capture and printed circuit board.

in the following figures can be seen the evolution of the first steps through the images, the software interface design and the chosen card that had to fabricate.

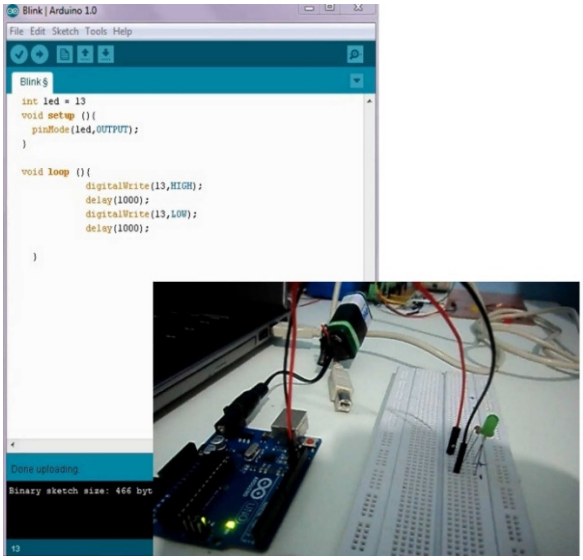

Figure 8: Arduino Programming and Representation in Breadboard

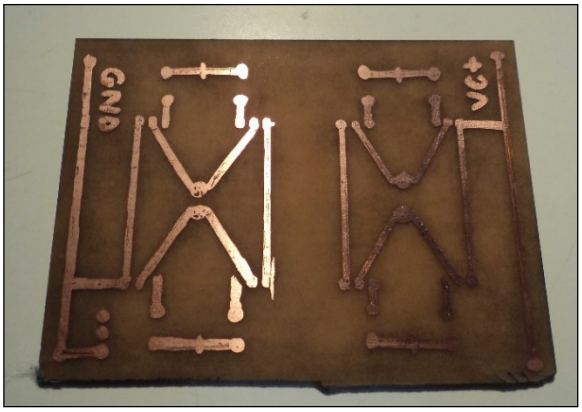

Figure 9: Plate Manually Manufactured

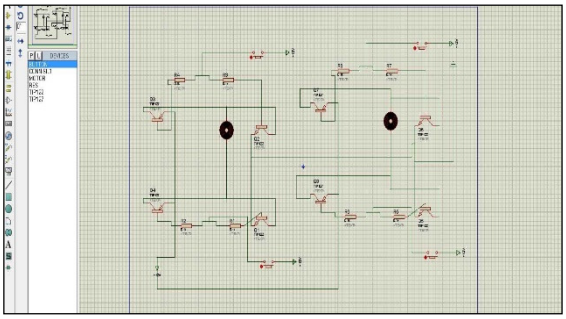

Figure 10: Interface Software Proteus

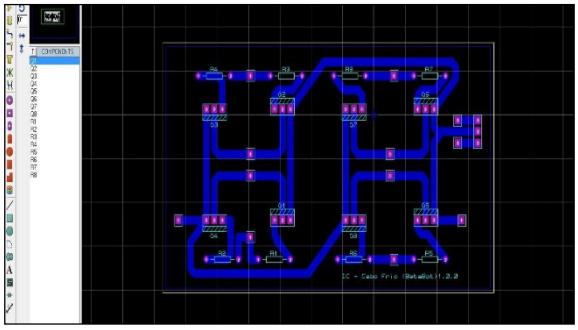

Figure 11: Interface Software Proteus

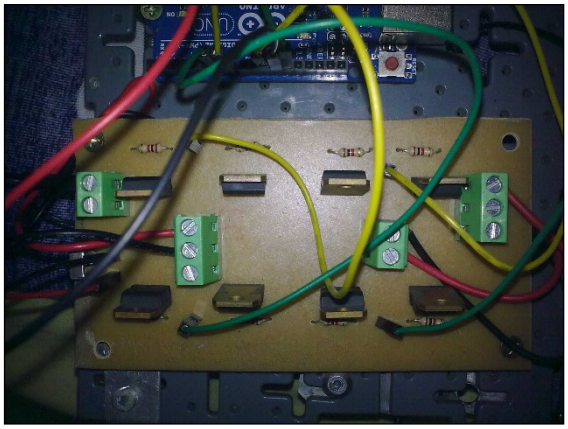

Figure 12: Made Plate and Applied to Model

3.2. New Components

From the limitations of the first prototypes, new devices have been researched and placed in the cart.

3.2.1. Micro Shield SD Card

The model Arduino UNO has 32k of flash memory, which are intended to 2k bootloader ATmega328P microcontroller. With this limitation it becomes unrealistic to to store data on the platform, since its capacity is greatly reduced (Banzi 2011). However, the simplest way to solve the problem is to use a shield Micro SD card, for the purpose of expanding the storage capacity of the card. Thus, the prototype would have a greater storage capacity of the captured data, the coordinates x, y and z.

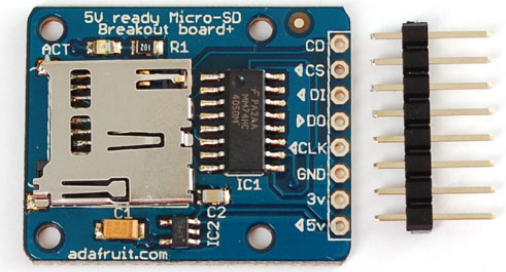

Figure 13:Micro SD CARD Model

The facility of handling of the Micro SD Card Shield make it widely used in the market. In the prototype was only necessary to save the files, because reading it was made by a external program. In the following figure is shown in the code language and the Arduino special facility to save and read files in *. Txt.

```
sketch_jul11c §
//Add the SdFat Libraries
#include <SdFat.h>
#include <SdFatUtil.h>
#include <ctype.h>

//Create the variables to be used by SdFat Library
Sd2Card card;
SdVolume volume;
SdFile root;
SdFile file;

char name[] = "Test.txt";      //Create an array that contains th
char contents[256];            //This will be a data buffer for w
char in_char=0;
int index=0;                   //Index will keep track of our pos

void setup(void)
{
    Serial.begin(9600);        //Start a serial connection.
    pinMode(10, OUTPUT);       //Pin 10 must be set as an output
    card.init();               //Initialize the SD card and conf
    volume.init(card);         //Initialize a volume on the SD c
    root.openRoot(volume);     //Open the root directory in the
}
void loop(void){
    file.open(root, name, O_CREAT | O_APPEND | O_WRITE);    //Op
    sprintf(contents, "Millis: %d    ", millis());    //Copy the
    file.print(contents);      //Write the 'contents' array to the
    file.close();              //Close the file.

    file.open(root, name, O_READ);    //Open the file in read mo
    in_char=file.read();              //Get the first byte in th
    //Keep reading characters from the file until we get an erro
    while(in_char >=0){               //If the value of the charact
        Serial.print(in_char);        //Print the current character
        in_char=file.read();          //Get the next character
    }
    file.close();     //Close the file
    delay(1000);      //Wait 1 second before repeating the proces
}
```

Figure 14: Basic Programming - SD CARD

3.2.2. General Packet Radio Services

The initial proposal for the acquisition of the data obtained in the path traveled by the vehicle were restricted to collections performed manually, where user in question would have to remove the memory card micro shield installed so he could make reading the data via an external computer . This acquisition method was quite hard, causing future problems if the prototype needed to operate on a larger scale.

Studies were initiated in order to meet this new barrier. Important to note that one of the purposes of this project is to bring convenience and ease for inspection of pipelines. A technology widely used in the market today is the General Packet Radio Services (GPRS), whose purpose is to enable packet data traffic to the cellular network can be integrated internet. The GSM system with integrated GPRS named 2.5G generation, having been an important development for mobile data communication. GPRS allows transfer rates around 40 kbps (Rulik 2003).

Currently there are many GPRS Shields for Arduino platform, however, tests were performed based on GPRS SIM900, a module to operate in the mobile network GSM / GPRS cellular, capable of performing all the functions of a conventional device as: Make and receive calls, send and receive SMS, to connect to the internet through GPRS connection, and sending FAX. It is based on SIM900 chip low power and size summarized, SIMCOM the manufacturer, and is widely used for telemetry, remote sensing and actuation. The module is fully controlled and configured via AT commands (Sverzut 2005).

Figure 15: GPRS SIM900 Model

With the coordinates once saved the Shield Micro SD Card, GPRS SIM900 send the file. Txt for the external program treats the data obtained. Below a simple approach, where an SMS is sent to the desired message.

3.3. New Models

With developments and new research, a new cart is designed. The main objective was to detect metal buried about 10cm from the surface. For that detection was possible was initially used a coil in the rear of the prototype and a circuit for detecting plate with metals.

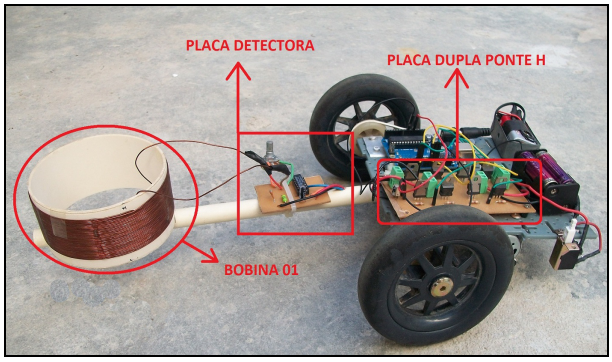

Figure 16: Prototype with a Coil

A board dual H-bridge was installed in the prototype to make it possible to change direction. The board dual H-bridge consists of an electric motor current (DC) is a common type of electric motor. Its main feature is that it has two electrical terminals, one positive and one negative. If an electric current travels in the normal motor shaft rotates to one side. If the current is reversed, the shaft rotates to the other side. Therefore with this card, we can reverse the direction of rotation of the shaft simply by reversing the polarity of the electrical terminals, and thus reversing the flow.

The prototype with only one coil was not sufficient to follow the route of the pipeline buried. Thus, a new project for a new prototype was implemented with For all the foregoing, we conclude first that technological innovations and form of teaching, objectifying an improvement the interaction between the student and the content available, directly inflicts the use of the same. If present technologies are currently utilized in the right way, a way to work in favor of the population, it tends to generate numerous and incalculable benefits. Once it possible to carry out projects far beyond the boundaries imposed by the old barriers, it becomes much easier the emergence of new ideas, where these same students will be developing fruit, resulting eventually in the labor market. two coils and the sum of the magnetic fields would direct the cart to keep the pipeline.

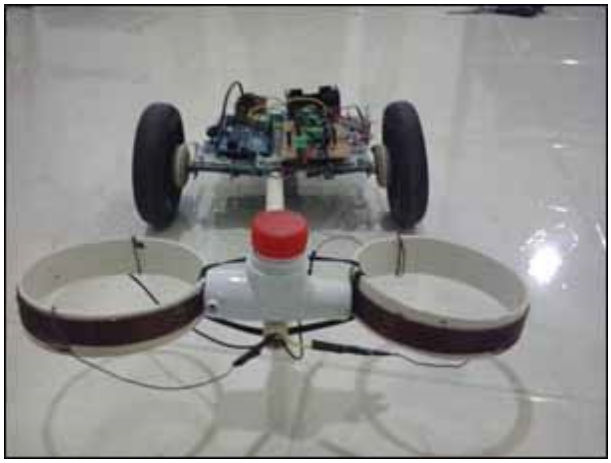

Figure 17: Prototype with two Coils

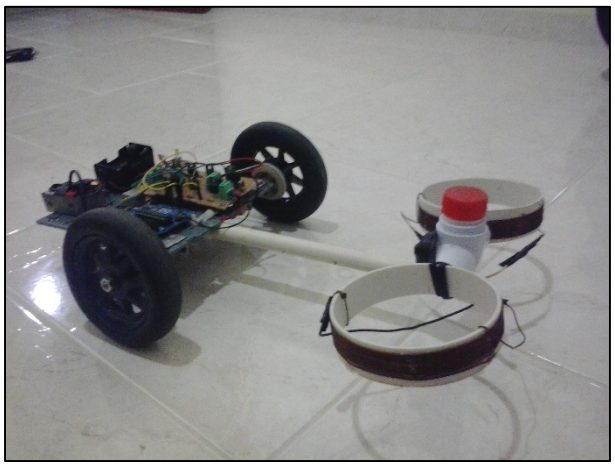

Figure 18: Prototype with two Coils

The project has a sustainable view and thus the construction of the prototype uses recyclable objects and equipment.

4. CONCLUSIONS

For all the foregoing, we conclude first that technological innovations and form of teaching, objectifying an improvement the interaction between the student and the content available, directly inflicts the use of the same. If present technologies are currently utilized in the right way, a way to work in favor of the population, it tends to generate numerous and incalculable benefits. Once it

possible to carry out projects far beyond the boundaries imposed by the old barriers, it becomes much easier the emergence of new ideas, where these same students will be developing fruit, resulting eventually in the labor market.

It is also remarkable that there are numerous such technologies with applicability, such as: Houses automated mechanical arms to aid in several areas among other projects. The technologies are there to be used, just to educators innovate in the how to teach, thereby rousing the creativity in each student.

All the Arduino platform, both in software and in hardware, it is open source, which greatly facilitates its use and dissemination. In other words, there is an endless number of libraries and tutorials available on the web for many applications.

These factors allow us to emphasize the simplicity of using the Arduino platform as data acquisition and automation, coupled with the relatively low cost and good results, contributing significantly to make the didactic laboratory.

All technologies presented led the group the Scientific Initiation to develop a prototype of an autonomous robot for the detection of buried pipelines. Considered proportionalities in size, the following figure can demonstrate that the group is on the path of developing a tool that can be useful in the petroleum industry.

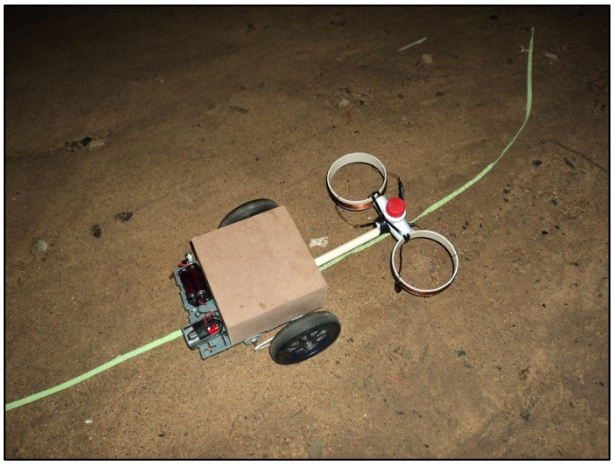

Figure 19: Prototype with Improved Protection

Studies have led students to prepare a route burying an iron tube 3 "in diameter about 10cm from the ground. The initial coordinates were determined, typed into a text file and passed to a spreadsheet, soon after, the students put the autonomous robot at the starting position to verify its efficiency. At the beginning, some adjustments were necessary, but the following graph can be proved that the robot came very close to the expected result.

In the following graphic can be seen the original trajectory and the layout of the autonomous robot. Some considerations such as the output of the robot's margin of error of GPS should be revised in future prototypes.

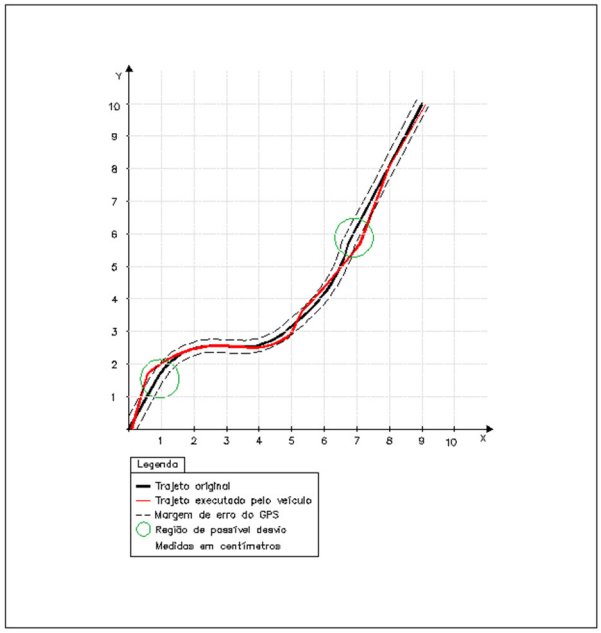

Figure 20: Graph showing the routes

If the graph showed a pathway of a pipeline suffering efforts soil, and the robot could find possible locations ranging from the initial position, responsible for the pipeline could take some decisions. Such a decision would be to install a containment barrier to prevent breakage thereof and oil spill.

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