Robotique, Systèmes autonomes

Project report

Academic year 2022-2023

"Autonomous Radio-Controlled car"

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INTRODUCTION:

The Artificial Intelligence sector has been marked by the evolution of the number of scientific searches and publications over the past decade. Its goal is to design systems capable of reproducing human behavior and reasoning. It has many advantages when you know how to use it.

Artificial intelligence allows machines to learn by experience, adapt to new data and perform human tasks. Most of the AI examples that make headlines these days rely heavily on “deep learning” and natural language processing. For example, a robot is a mechatronic device designed to perform tasks automatically using AI, and it is also capable of manipulating objects or performing operations according to a program.

As part of our first year in Robotics Engineering, we will have the opportunity to carry out a project that will allow us to implement the knowledge we will see during the year and discover new ones. The aim of this report is to offer an autonomous car that can drive in any circuit and on any terrain without being driven, but also be able to control it by its own mobile phone, as an example, by sending a text message.

You might think, why use a robot?

The robot is present in almost every task that we carry out in our daily life, in addition, it is very useful because it makes our life easier.

Robots represent very numerous advantages, we can mention:

Safety

Safety is the most obvious advantage of using robots. They can work in hazardous conditions, such as poor lighting, toxic chemicals, high temperatures, or tight spaces. By delegating dangerous tasks to a robot, the employees will be safer. Robots increase worker well-being by preventing accidents since humans are not performing risky jobs.

Speed

Robots are autonomous machines and don’t need to take breaks. They don’t request vacation time or ask to leave an hour early. Robots can work all the time, which can be very beneficial for the company.

Consistency

Robots never need to divide their attention between a multitude of things, thus getting the assigned job done in the specified time. They won’t have unexpected emergencies, or need special care in order to function. Automation is typically far more reliable than human labor.

Perfection

Autonomous machines will always deliver quality and will maintain the quality of the product from the beginning till the end. And they’re less likely to make mistakes. There exists a type of artificial intelligence (AI) that can even learn from their mistakes to become even better at processing the data or product.

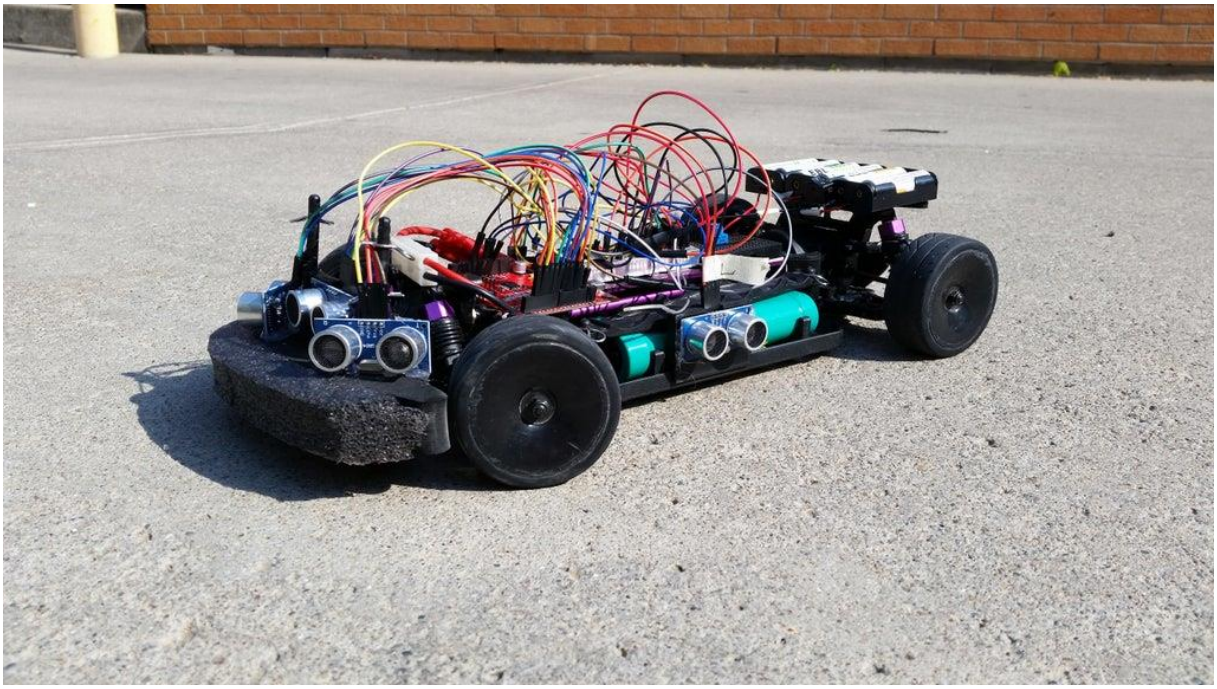
Some previous projects of autonomous cars available on the internet:

⇨ https://www.instructables.com/Autonomous-RC-Car/

The following project was used in Engineering Design and Robotics classes and received an award for best autonomous vehicle at a high school STEM competition.

Instead of starting from scratch, the owner opted to use an RC car that he already had and paired it with a RedBoard Arduino Uno board. He chose the Arduino board due to its ease of use and programming.

In sum, the RC car collects data from several Ultrasonic sensors. This data goes back to the Arduino, where it makes decisions on how to move. The Arduino then controls the servomotor and motor accordingly.



The car is capable of variable speed control via a potentiometer and backing up when it hits an obstacle. In addition, the car can correct itself if it drifts too close to a wall by easing itself away.

⇨ https://dev.to/ivanorsolic/a-self-driving-rc-car-and-a-complete-guide-to-build-your-own-23el

In this next project, the owner built a self-driving RC car model that can do a lot than just drive. It can autonomously switch lanes, track and detect objects and finally use a simulator to rapidly prototype models and pre-train for real-world conditions.

The owner states that the RC car was something similar to us humans traveling to a certain point or commuting to work.

The RC car did the same, and succeeded to identify the roads it was taking and obeyed to the traffic roads just like a human driving a car in the public road.

→ As you can see, all of the projects previously shown have some very interesting features along with very few quirks. The autonomous RC car's primary mission is to go from its current location to a destination that is chosen by the owner, with the least number of collisions possible. The RC car that we are building is going to have much more functionalities all for the sake of the owners' well-being. We will certainly be taking consideration of the experience of each one of the aforementioned RC car projects, and will try to extract all the good characteristics and blend them together, and banish any disturbance that will be brought about along the making of the autonomous RC car.

Project subject:

The idea to build an autonomous car came from the IRON CAR project, which is an autonomous car racing competition. The objective of this competition is to do three laps of the circuit, with cars driven by artificial intelligence, making as few mistakes as possible, that means going off the road.

Manufacturing an autonomous car involves developing an artificial neural network that is optimized by probabilistic learning methods, meaning artificial intelligence methods to which they provide a perceptual mechanism independent of the implementer's own ideas, and input information to formal logical reasoning (Deep Learning).

The goal of our project is to be able to build a car that will be able to run any circuit as quickly as possible and independently as possible. For this you have to do some practice laps on the circuit and then the car will be ready for the race.

Hardware used to build the robot:

An autonomous race car requires several components for its proper functioning. Below is the list of components that will be needed to start the construction of the autonomous car:

- L298N Card (Figure a):

The L298N module is a development board based on the L298N integrated circuit, a double H-bridge, allowing the control of a DC motor or a stepper motor, it can control up to two motors. The user can change the speed of each engine to suit their needs. This board will enable us to control the motors of the car very easily.

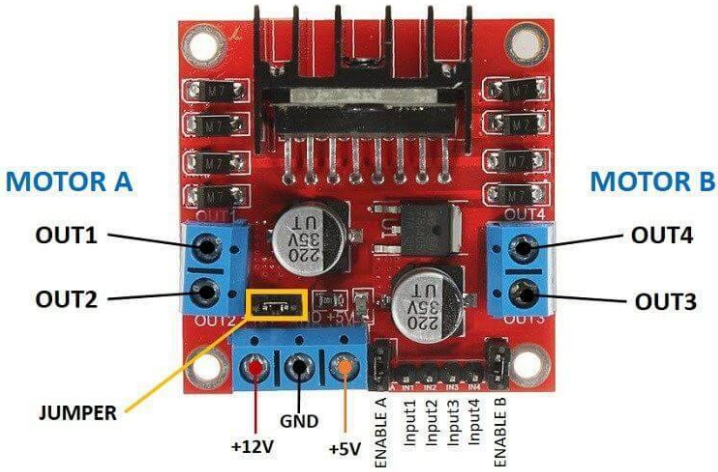


Figure a

- HC-SR04 ultrasonic sensor (Figure b):

The HC-SR04 sensor uses ultrasound to determine the distance of an object. It also makes it possible to calculate precisely (up to 0.3 cm) the distance between it and the obstacle. It works by emitting an ultrasonic burst and detecting the echo back. Its functioning is not affected by sunlight or dark materials, although materials such as clothing may be difficult to detect. We will be using this sensor to detect obstacles like walls and flat surfaces.

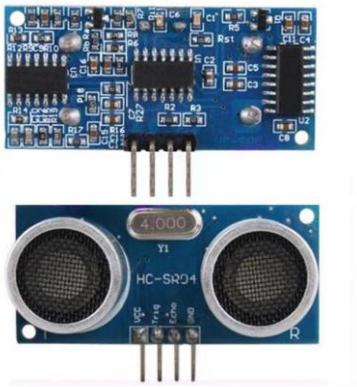


Figure b

- The Arduino Card:

There is a whole range of Arduino cards (about twenty!) but the most answered were the MEGA and UNO board, we chose the MEGA because it offers the most analog and digital inputs/outputs as you can see on this table (figure 1 below).

	Arduino Uno	Arduino Mega 2560
		
Price Points	$19.99-$23.00	$36.61 - $39.00
Dimension	2.7 in x 2.1 in	4 in x 2.1 in
Processor	Atmega328P	ATmega2560
Clock Speed	16MHz	16MHz
Flash Memory (kB)	32	256
EEPROM (kB)	1	4
SRAM (kB)	2	8
Voltage Level	5V	5V
Digital I/O Pins	14	54
Digital I/O with PWM Pins	6	15
Analog Pins	6	16
USB Connectivity	Standard A/B USB	Standard A/B USB
Shield Compatibility	Yes	Yes
Ethernet/Wi-FI/Bluetooth	No (a Shield/module can enable it)	No (a Shield/module can enable it)

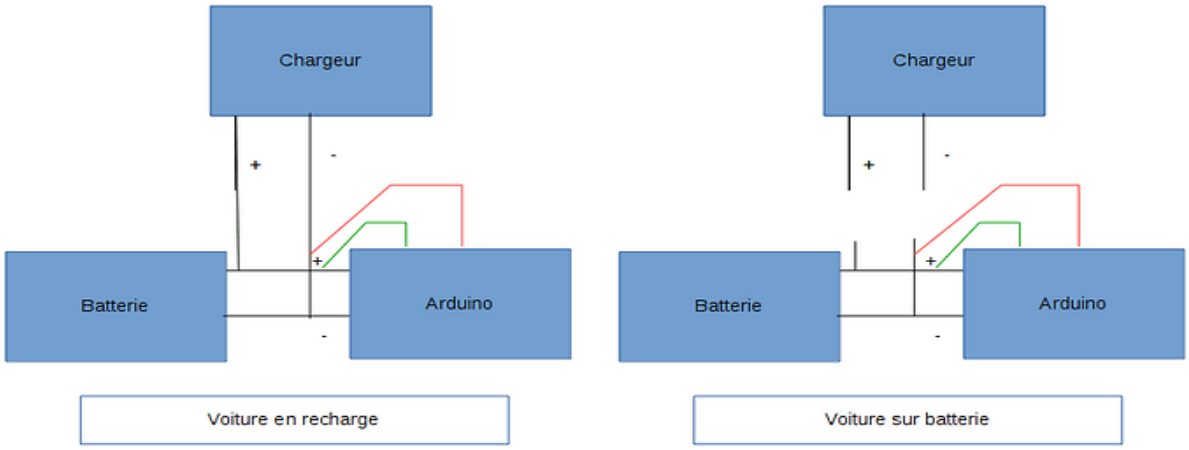
Figure 1

Figure 1.1

The Arduino MEGA 2560 microcontroller (Figure 1.1 above) represents the brain of the robot that will allow communication with the car's components.

- Power supply for robot components:

For the Arduino microcontroller to work perfectly, it will require a 7-12 VDC power supply, and the brushless motor will require at least 5 volts. Two “LiPo 2S” batteries will be required, since they are the most common ones, which can provide the voltages needed for each of



these components. In addition, they have a range of 11.5Wh, and they charge fairly quickly (2h for a full charge)

- Taidda RC Car Servo Motor (Figure 2):

Figure 2

The Taidda servo is a miniature servo with very compact dimensions. It is economical and easy to use, with a very low energy demand, so it is the best choice to control the steering of the autonomous car. We also chose this servo motor because it supports up to 2,2Kg load.

- The ESC controller (Electronic Speed Control) (Figure 3):

Figure 3

The ESC is an electronic power controller that will be used to vary the speed of the brushless motor. The ESCs have a 3-wire servo motor control interface. The two power wires (black/brown and red) are intended to be used to power the other components connected to the same system.

- Camera module OV7670 (Figure 4):

The camera will allow us to see exactly where the car is and will give us more information about its condition and its surroundings.

Figure 4

- GPS NEO-6M module (Figure 5):

This module will help us to locate the robot and see if it has accomplished its task (delivery for example).

Figure 5

- GSM SIM800L module (Figure 6):

This module does almost everything a normal mobile phone can do, such as sending SMS messages, making phone calls, connecting to the Internet via GPRS, and much more. We're going to use it as a priority to send and receive messages.

Figure 6

- A GSM Antenna for SIM800L (Figure 7):

This component amplifies the signal emitted by the car and thus allows it to travel longer distances.

Figure 7

- Experimental plate (BreadBoard, figure 8):

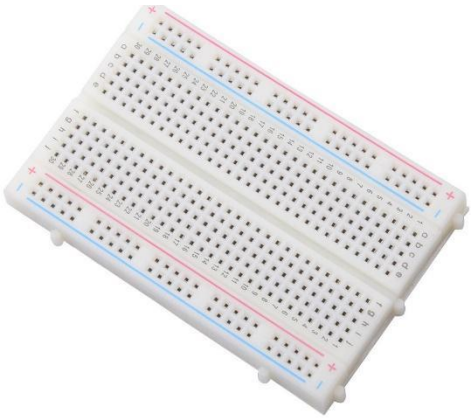


Figure 8

The experimental board (called breadboard) will make it possible to connect all the components of the robot, thus creating prototypes of seamless electronic assemblies.

- An infrared sensor (Figure 9):

Figure 9

The MH-Senesor Flying-Fish is the perfect infrared distance and obstacle sensor for detecting objects at an angle of 35° and a distance of 2 to 30 cm. Its mode of operation: an infrared LED lights up and the photodiode next to it measures the reflection.

- A brushless DC motor (brushless, figure 10):

Figure 10

The brushless DC motor is the ideal choice because it offers not only high reliability, but also high efficiency. In general, a BLDC engine is considered to be a high performance engine and capable of delivering high torque. There are also several other advantages such as :

- Reduced energy consumption, for greater autonomy.
- Reduced maintenance of the engine.
- Significantly increased lifespan.

- Remote-controlled car body (Figure c):

Figure c

We'll need a slightly large frame (maximum dimensions 40x20x30cm) so that we have enough space to put the Arduino board and the other components. The body we will be using measures 30,88x18,84x13,99cm.

- Finally, we will add, for the pleasure of the eyes, LEDs (2 white, 2 red, 1 orange for obstacle detection)

Product Specifications:

N°	*Function*	*Criterea*	*Requirement level*
1	Able to go to a defined destination	Speed	Brushless motors with ESC (variable speed)
2	Inexpensive cost	Materials	3D printing Plastic housing/cover
3	Avoid obstacle collision	Sensors	HC-SR04 sensors to be put in several places of the body
4	Running time of at least 30min	Power	LiPo 2S battery with the appropriate voltage and amperage
5	Attractive	Aesthetics	Body with attractive colors (Black-Red)
6	Be carriable	Weight	3Kg max Removable body Lightweight material
7	Be trackable and able to send messages from long distances	Modules	GPS module SIM800L module with amplifier
8	Able to go on all kinds of terrain	Tires	All-Terrain tires

Requirements diagram:

« function Requirement »
Autonomous car

Id = "1"
Text = " basic structure "

« Requirement »
Move the Autonomous Car

Id = "1.1"
Text = " Drive without collisions "

« Requirement »
Autonomous Car Movement

Id = "1.2"
Text = " the car must run on any type of terrain "

« Requirement »
Information channel

Id = "1.1.1"
Text = " implant into the chassis "

« Requirement »
Stock énergie

Id = "1.1.2"
Text = " implant into the chassis "

« Requirement »
Motorisation

Id = "1.1.3"
Text = " implant into the chassis "

« Requirement »
Forward and backward

Id = "1.2.1"
Text = " the car must move forward and backwards with maximum acceleration thanks to the brushless motor"

« Requirement »
Direction

Id = "1.2.2"
Text = " the front gear shall be directional and the rear gear shall be fixed "

« Requirement »
Suspension

Id = "1.2.3"
Text = " for good grip the body must be suspended "

« Performance Requirement »
Components

Id = "1.1.1.1"
Text = "page 7"

Learning phase:

- Can be driven by means of a wireless controller.

- Capture a picture every 0.1 second with the implanted camera.

- Store captured images in a database and assign a label to them.

Autonomous driving phase:

- Be able to drive autonomously on the same track where she completed her training.

- Recognize more or less large turns and straights and adjust speed accordingly.

- Detect a runway exit without using sensors other than the camera.

- Be able to run the code of the neural network by Arduino fast enough to react as quickly as possible.

Structure du support Arduino et la communication :

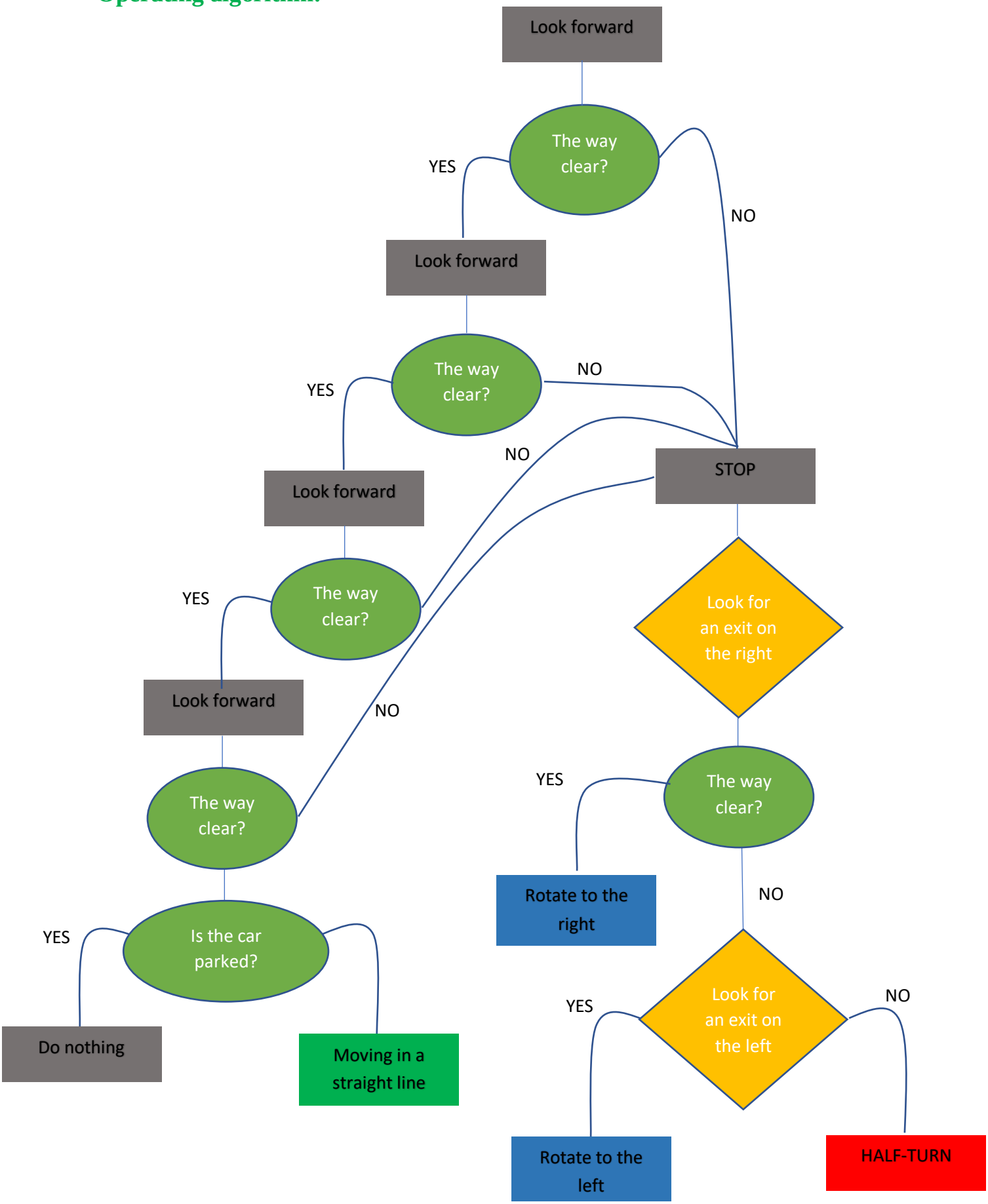
- Provide a strong support so that the camera does not move or fall as a result of a jolt.

- Be able to communicate wirelessly with the Arduino from a computer or mobile phone (optional).

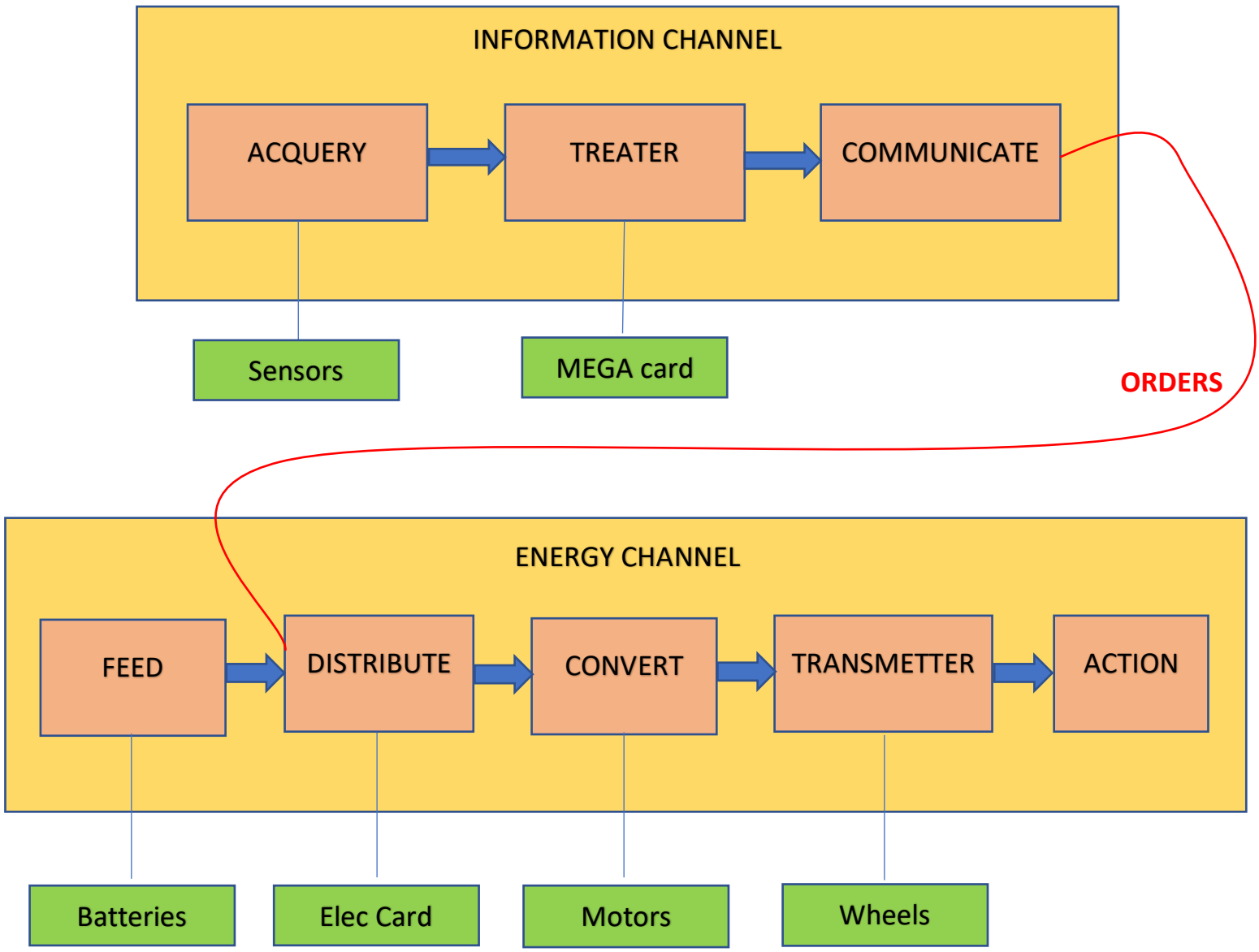
Constraints :

- Places with no network
- Bad weather conditions
- Inability of detecting some obstacle
- A lot of code lines and functions
- Energy-hungry components due to code inefficiency

Operating algorithm:



Energy operation:



Planning for the first semester of the year:

1st session (4h) (Anas)	Become familiar with the different components, while doing extensive research on how they work and on the libraries we will need to use to code on Arduino
2nd session (2h) (Youness)	Find a strategy so that we can put all the components into the car frame and start writing the operating code for each component separately and testing them.
3rd session (4h) (Anas)	Continue the work of the last session
4th session (4h) (Youness)	Continue the work of the last session
5th session (4h) (Anas)	Start linking the codes of the few components we've been able to implement.
6th session (4h) (Youness)	Continue the work of the last session
7th session (2h) (Anas)	Have the complete code so that at least the car can run without autonomy
8th session (2h) (Youness)	See if there are any changes to be made and develop a new strategy and goal for the second half of the year

SUMMARY:

Our project, the autonomous RC car, still has a long way to go. We need to code a program for the Arduino card that we are using to control the car, and then we will need to pair each one of the components (sensors, modules…) to the card. Moreover, the robot will certainly need some housing modifications in order for the modules and sensors to be able to interact with the environment surrounding the car.

We believe that by the end of the year, we will have a fully functional autonomous RC car that travels distances with very little errors and mistakes. It will have the ability to do delivery of packages by its own, thanks to the modules and sensors that it is equipped with. Lastly, knowing that this project will be competition to all the already existing autonomous RC cars on the internet, my colleague and I are trying to do our best to get the most of this project, and perhaps make it the best among all of them.

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Battery pack:

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Brushless motor with ESC:

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Camera module:

https://www.amazon.com/HiLetgo-OV7670-640x480-0-3Mega-Arduino/dp/B07S66Y3ZQ/ref=sr_1_1_sspa?crid=2MHD8YA3JKUKI&keywords=module+OV7670&qid=1665129035&qu=eyJxc2MiOiIxLjYzIiwicXNhIjoiMC4wMCIsInFzcCI6IjAuMDAifQ%3D%3D&sprefix=module+ov7670%2Caps%2C240&sr=8-1-spons&psc=1

GPS NEO-6M module:

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