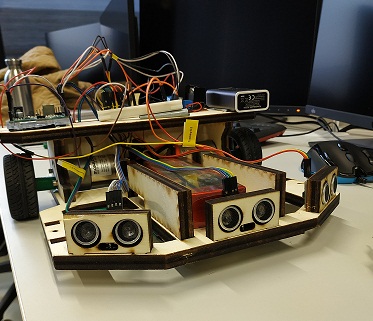
**Autonomous driving vehicle**

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1. **Introduction**

The autonomous driving vehicle is an electronic device, or miniaturised car to be more precise, which, with the aid of different electronic components all intended to work with each other, is capable of autonomously drive within an environment potentially full of obstacles and to follow a straight black path placed/taped on the floor. The main purpose of the creation is to get familiar with the use of electronic sensors and microcontrollers that allow the engineer or the projectist to obtain information from the physical world, throughout the use of the sensors, and consequently transform these information in electric signals or quantities that will be delivered by the sensors to the microcontrollers. Therefore, once the information is being received by the microcontrollers, these will do some actions that are predetermined in the code that has been created from zero by the software developer or programmer. The possible scenarios that the car has to deal with are the following:

* The car must be able to drive following a black path taped on the floor, without ever going off track.
* It must be able to avoid obstacles that may appear within the track and afterwards going back to the track.
* The vehicle must be able to stream a video from the small camera mounted on top of the car frame.
* (optional) The car must follow the instructions given by a specifically designed user interface made of buttons, sliders and indicators.

1. **Assemblying the frame**

This specific paper will discuss about the overall construction process of the car, the assemblying, the hardware management and the importance of the creation of a user manual. With that being said, to get deeper into the topic let us begin step by step by describing the processes just mentioned. The main part to initially deal with is obviously the construction part. Wooden parts of the frame were given and they needed to be connected and assembled together in order to create the so called “skeleton” or frame of the car. The parts are several and they are listed in the following segment: a main part that is the flat wooden base, in which every other part must be mounted and assembled on and it is also the base where the batteries and the microcontrollers will be laid on. Following there are different wooden “walls” that are needed as barriers and delimiters for the components that belong to the car. Then there are the motor supports and the sensor supports, such as the ultrasound sensor supports. The last wooden part is a wooden arm that holds up the Raspberry Pi camera. The beginning of the assembly starts with the placement of the small rotating sphere, used to allow the car to change direction in a 360° range, on the bottom part of the wooden base, and the I/O switch fixed on the wooden rear part of the car, once both are in place it is possible to continue the assemblying process with the other wooden parts. Once these 2 small elements are in place, there are 2 specific parts that need to be pre-assembled before being mounted on the main car frame, and these are the motors supports. The motors need to be screwed first to these supports with 3 to 4 bolts, much awareness is required in this step in order to avoid possible cracks or fractures in the wooden frame. After the motors have been placed it is possible to proceed by mounting the pre-assembled supports onto the base. During this part one of the motors, unfortunately, resulted to be in bad conditions and had to be swapped with a new one. The assemblying procedure goes on as the ultrasound sensors supports must be screwed in the front top of the wooden base, these supports will serve the purpose of keeping the ultrasound sensors stuck in position to fulfill their task (explained in the next section). Lastly it is necessary to build in the last 3 wooden parts which will be placed in the middle of the car and as a cover for the motors, but after an attentive analysis it has been decided it was better to keep these parts for the last steps of the construction as they would result in occupying useful space needed in the next steps.

1. **Hardware and cable management**

At this point the most sensitive part of the construction process begins. First of all it is good practice to list the required hardware components and equipment. Beginning with the power suppliers, only two batteries are required: a 12 volts DC battery to supply energy the motors and a 5 volts DC battery or powerbank to supply energy to the microcontrollers. Moving on to the motors, a pair of 12 volts DC motors were provided, with a couple of rubber wheels that were pre-adapted for the motors with two 3D printed supports. Next, considering the Arduino cannot deliver a high enough current to the motors to make them run, an L298N module was needed, which has the capability of delivering up to 2 A for each output and can pilot up to 2 motors at the same time. Following up a pair of infrared sensors was given alongside 3 ultrasound sensors. The infrared sensors with the purpose of being mounted on the bottom of the frame to detect the black path taped on the floor and the ultrasound sensors serving as obstacle detectors. The number of ultrasound sensors and infrared sensors is not random but is based on the concept of having 2 infrared line detecting sensors on the bottom to keep the car always centered on the black path, not allowing it to go off track. The 3 ultrasound sensors, on the other hand, are placed on 3 specific positions in the car, exactly at the top front of the car, the middle one is perfectly horizontal meanwhile the other 2 are placed on the sides with an angle of around 30° in opposite directions. The concept here is to make the car able to detect obstacles that are not only in front but also on the sides and act by consequence. Moving on to the construction part, it is important to point out that there is no specific placement of the hardware and components so everything is up to the constructor. First of all, as already said, the DC motors were placed in the rear sides of the car, then the 3 ultrasound sensors were stuck in their apposite supports with the aid of hot glue, in order to keep them fixed. A similar process was applied to the infrared line detecting sensors, they have been stuck in the bottom part of the frame base, here it is necessary to state that the team required different trials before finding the perfect placement and width of these 2 sensors as the black path is not always the same and it might differ in width and reflectiveness. With that said, after many tries, a decent spot was found for both sensors, now being able to really keep the car on the track. Once all the sensors were in place all the final components have been placed on the car, components such as the arduino, the raspberry pi, the small breadboard for the cable connections, the powerbank and the 12 V LiPo battery. All these lastly mentioned components were only taped to the car with the idea of being able to easily remove them if needed. At this point the only thing missing was the cable connection. To approach this part it was first necessary to carefully analyze all the possible free space that could be used to let the cable freely move inside the car to the position they were supposed to be connected. 4 cables are originated from each ultrasound sensors (Rx, Tx, 5 V, GND) that makes a total of 12 cables that were stuck together in groups of 4 to make them look cleaner and visually better. From the line detecting sensors 3 cables are originating (Signal, 5 V, GND) and similarly to the ultrasound sensors, the 3 cables have been grouped together to save space and avoid possible interferences with other cables. One extra cable connection has been made between the camera and the Raspberry Pi to serve the purpose of streaming a real-time video from the car point of view. At this point not many cables were left, beside the connections to the L298N module which included the 4 cables coming from the motors, respectively 2 for each motor (5 V and GND) and the enabling connections with the arduino. At the very end the microcontrollers have been connected to the whole system. Since both Arduino and the Raspberry Pi need a tension of 5 V to be able to function and there was only a single powerbank with a single output, it has been decided to give power only to the raspberry pi and from it a 5 V output was taken and connected to the Arduino input in order to supply power to it. After this long process that took several steps, the car was ready to be tested and drive around in an artificial environment.

1. **User manual**

Within the construction process an extra task needed to be solved and after discussing how all the construction process works it is important to clarify some extra things regarding the device. As an electronic device it is necessary to deliver it alongside a user manual that contains all the necessary instructions needed to make the device function in the correct way and also all the warnings and details one has to be aware of while using it. The user consulting the manual has the possibility to find out, in a very easy manner, how everything in the car works, how to set everything up before turning on the car and how to deal with possible problems that may occur as a result of software or hardware accidents.

1. **Results**

From the construction point of view, the final results have been very satisfying. Despite encountering some early problems with the assemblying part and discovering some defects in some parts, the overall project was a success. Regarding the frame, the main structure held everything perfectly without giving troubles although at some point it was necessary to fasten the bolts and screw one more time just for safety. In terms of hardware and components everything had its own working space and the cable management made sure that there was enough space to deal with the cables at a later point in case of changes in the structure or the circuit. The car was able to keep everything fixed and behave in the correct manner doing what it was supposed to do at every moment.

1. **Conclusions**

As the main purpose of the whole project, was to be able to learn and deal with the interaction between the physical world and the electronical world, the main concepts discussed in the paper are useful to understand how this interaction occur via the use of specific equipment and devices. The main points proven in this project are in fact, the capability of the car of adapting to the surrounding environment and interacting with it following instructions that are given by the creator/s.