Technical Design (TD)

Project: Race car

Company: ACE car

Place, date: Enschede, 24th March 2022

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1 Introduction

This document is a Technical Design Document for use by Ace Cars Projects. It provides guidance which is intended to assist the relevant management and technical staff, whether client or supplier, in producing a project-specific Technical Design Document. It is also useful background reading for anyone involved in developing or monitoring the Ace car project.

Problem:

Developing a self-driving car using the ISH010 as a platform, the car can be left on a track and guide itself through it, evading obstacles, driving over a hill and stopping at the end of the track.

Background:

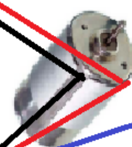
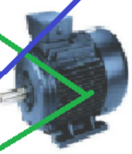
We were proposed to design a concept that would achieve automatization by our stakeholder, Saxion University of Applied Sciences, as a developing project to increase our skills and knowledge in this field.

Goals:

1. The drive is completely autonomous.
2. Evasion of obstacles in track.
3. Completement of the trial track.
4. Stop at the desired target.

Non-Goals

1. Develop our own platform system. Reason: we will be provided an already existing platform which we can modify.

Drive Mechanism	Front wheel drive	Rear wheel drive	Free wheel chain drive	4x4 wheel drive	
Processing platform	FPGA	Microcontroller	PLC	PC	Raspberry Pi
Sensor	Acoustic	optic	IR (Infrared)		
Sensor amount	1	2	3	4	5
Motor type	linear 	Rotating DC 	Rotating AC 	stepper 	Servo 
Motor amount	1	2			
Storage	Battery	capacitor	Capacitor and battery		
Car body	Pick up truck 	minivan 	Convertible 	Sports car 	coupe 

Option 1:

Front wheel driven with a microcontroller as a processing platform, 1 optical sensor, 1 rotating DC motor type, capacitors, and batteries as energy storage, and with a sports car design.

This car will have great overall mechanical performance but may be compromised by the automation procedure.

Pros

- The pros of a FWD vehicle are that they are more energetically efficient. A FWD vehicle can maintain better traction since the weight of the engine is located over the driving wheels.
- The pros of using a microcontroller are the low time requirements for performing the operation. It is easy to use and troubleshooting and system maintenance are simple. At the same time, many tasks can be performed, so the human effect can be saved. The processor chip is exceedingly small, and flexibility occurs.
- The pros of using optic sensors are that they sense all kinds of materials, have a long life, have the longest sensing range, and have an extremely fast response time.
- The benefits of using capacitors and batteries as storage are that you will have a steady energy supply as well as fast bursts of energy from the capacitors when needed.
-

Cons

- The cons of FWS are that, since all the weight is in the front of the vehicle, front-wheel drive cars tend to understeer. During sudden acceleration, front-wheel-drive vehicles tend to veer to the right or left because of something called "torque steer." Front-wheel drive has worse acceleration than rear-wheel drive.

- The microcontroller cannot interface with high-power devices directly. It has a more complex structure as compared to the microprocessor. It only performs a limited number of executions simultaneously. It is used in micro-equipment.
- In optic sensors, the sensing range is affected by contamination by colour and reflectivity of the target, which might be a problem, especially for obstacle detection.

Option 2:

Front wheel driven with a microcontroller as a processing platform, 3 optical and acoustic sensors, 1 rotating AC motor type, a battery as a type of storage, and a convertible design.

This car will have great overall mechanical performance and automation performance. Even though it could lack of electrical capability.

Pros

- The pros of a FWD vehicle are that they are more energetically efficient. A FWD vehicle can maintain better traction since the weight of the engine is located over the driving wheels.
- The pros of using a microcontroller are the low time requirements for performing the operation. It is easy to use and troubleshooting and system maintenance are simple. At the same time, many tasks can be performed, so the human effect can be saved. The processor chip is ridiculously small, and flexibility occurs.
- The pros of using optic sensors are that they sense all kinds of materials, have a long life, have the longest sensing range, have an extremely fast response time, and by using an optic sensor, the system will be able to sense all materials.
- The pro of using batteries as storage is that you will enjoy the benefits of a steady energy supply and enormous amounts of it.
-

Cons

- The cons of FWD are that, since all the weight is in the front of the vehicle, front-wheel drive cars tend to understeer. During sudden acceleration, front-wheel-drive vehicles tend to veer to the right or left because of something called "torque steer." Front-wheel drive has worse acceleration than rear-wheel drive.
- The microcontroller can not interface with high-power devices directly. It has a more complex structure as compared to the microprocessor. It can only perform a limited number of executions simultaneously. It is used in micro-equipment.
- In optic sensors, the sensing range is affected by the colour and reflectivity of the target, which might be a problem, especially for obstacle detection. In acoustic sensors, the

resolution of the frequency is a problem, as is the repeatability, and they are sensitive to temperature changes.

Option 3:

Rear wheel driven with a microcontroller as a processing system, 1 optical sensor, 1 rotating DC motor type, a battery as a type of storage, and a coupe design.

This car will have great overall mechanical performance but may be compromised by the automation procedure.

Pros

- Allowing the front tires to specialize in steering while the rear tires do the driving vastly improves both steering feel and ultimate cornering grip (mid-or rear-engine): Engine weight over drive wheels, plus dynamic rearward weight shift during acceleration, optimizes accelerative traction.
- The pros of using a microcontroller are the low time requirements for performing the operation. It is easy to use and troubleshooting and system maintenance are simple. At the same time, many tasks can be performed, so the human effect can be saved. The processor chip is exceedingly small, and flexibility occurs.
- The pros of using optic sensors are that they sense all kinds of materials, have a long life, have the longest sensing range, and have an extremely fast response time.
- The pros of using batteries as storage is that you will enjoy the benefits of a steady energy supply and large amounts of it.

Cons

- The cons of FWD are that the weight of the rear-wheel vehicle is much greater than that of a front-wheel vehicle. Because the engine is packaged outside the wheelbase and opposite the steering wheels, there may be reduced steering ability when the car accelerates. RWD has a slight loss in the efficiency of the drivetrain. The efficiency losses depend on the vehicle transmission.
- The microcontroller can not interface with high-power devices directly. It has a more complex structure as compared to the microprocessor. It only performs a limited number of executions simultaneously. It is used in micro-equipment.
- In optic sensors, the sensing range is affected by contamination by colour and reflectivity of the target, which might be a problem, especially for obstacle detection.

Option 4:

4x4 wheel driven with a PC as the processing system, 2 IR sensors, 2 rotating AC motor types, a battery as a type of storage, and a pickup design.

This option will provide good mechanical and drive performance but will lack weight and efficiency as the number of electrical components is high, draining a large part of the energy. It will also have very poor self-driving as the system is quite complex and has sensors that will not suit the job.

Pros

- Allowing the front tires to specialize in steering while the rear tires do the driving vastly improves both steering feel and ultimate cornering grip (mid-or rear-engine): Engine weight over drive wheels, plus dynamic rearward weight shift during acceleration, optimizes accelerative traction.
- The pros of using infrared sensors It gives assurance about correspondence because of the view or highlight point method of correspondence. The batteries utilized in infrared gadgets keep going for a long time because of their lower power utilization. Infrared movement sensors identify movement in the daytime and evening dependably. Infrared gadgets can quantify the distance to delicate items that may not be effortlessly identified by ultrasound.
- The pros of using batteries as storage is that you will enjoy the benefits of a steady energy supply and large amounts of it.

Cons

- The main disadvantage of 4WD is the added cost of purchase, maintenance, and energy. The extra equipment (differentials, transfer case, etc.) adds complexity and weight to the vehicle, increasing its initial market value, tire wear, and the cost of repairs and maintenance.
- *Infrared frequencies are influenced by hard objects (for example, dividers, entryways), smoke, dust, haze, daylight, and so on. Thus, it doesn’t work through dividers or entryways. Infrared waves of high force can harm the eyes. It underpins its more limited reach and, consequently, its execution corrupts longer distances.

Pros and cons motor types.

The most obvious difference is the type of current each motor turns into energy: alternating current in the case of AC motors, and direct current in the case of DC motors. AC motors are known for their increased power output and efficiency, while DC motors are prized for their speed control and output range.

Conclusion:

Our options provide very good overall performances. Thinking of efficiency, we could save some energy by modifying our current platform, which is an AWD chassis, to an FWD, making the power consumption less and having considerable powertrain performance. Even though this could make the steering of the cars less efficient and precise,

2 Elaboration of chosen principle to technical design

2.1 Overview of technical design.

To develop this project, we must look at the technical design. We must look at some of the systems features, such as mechanical, electronics, electrical, and software design, in a more detailed way. The purpose of a technical design document is to aid in the critical analysis of a problem and its proposed solution while also communicating priority, effort, and impact with stakeholders. A technical description describes a process in terms of its purpose, design, parts, and other key details.

We must start by analysing the specifications of the components' power consumption or the functions we could write in our code that will run in our system. Variables such as mass, forces, and velocities must be considered along with the way we are going to test them. It is incumbent upon us to make these calculations and analyse the ways to achieve the functional requirements from the technical part.

However, there is a big possibility that something will change in the technical part of our project because of innovative ideas or even better ideas to implement, and the team is willing to take a risk to make the job as best as possible.

2.2 Elaboration of technical design

For the elaboration of technical design, they split the workload into various parts and levels to better understand what must be done.

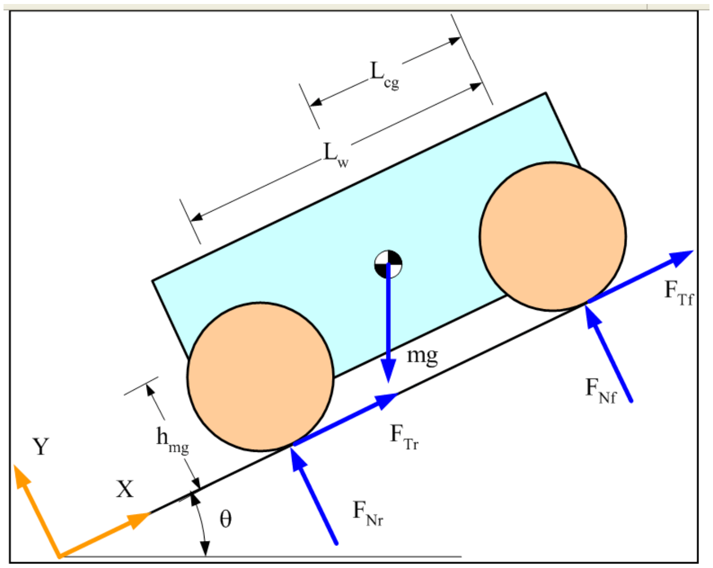
The main parts of elaboration are:

- Introduction
- Overview of technical design
- Mechanical part
- Electrical part
- Electronical part
- Software part
- Technical design integration.

Every section is detailed, described, and done with careful research into all the problems encountered by the team. Project activities take place after the detailed design but before the construction contract is tendered. The technical design stage develops the design in sufficient detail for co-ordination to be completed and enables packaged production information to be prepared, which can be passed to the contractor and their supply chain to construct the development.

2.2.1 Mechanical

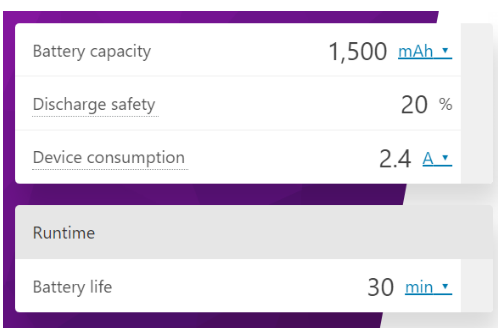
Free body diagram [1]:



Base frame: ISH-010

Transmission and power design

2.2.2 Electrical



Battery: Li-ion 2s 1p 7.4v 1500mAh

Discharge safety: 20% (The percentage left that is considered “fully discharged” to protect the battery from over discharge may be possible to go a bit lower but a lithium-ion (Li-ion) battery cannot be discharged below 2.5 volts and a lithium polymer (Li-Po) battery cannot be discharged below 3 volts, or battery damage will occur!).

Without Risking over-discharge, we could draw 2.5A continuously to get 30 minutes of power (if discharging 80% of the battery’s capacity)

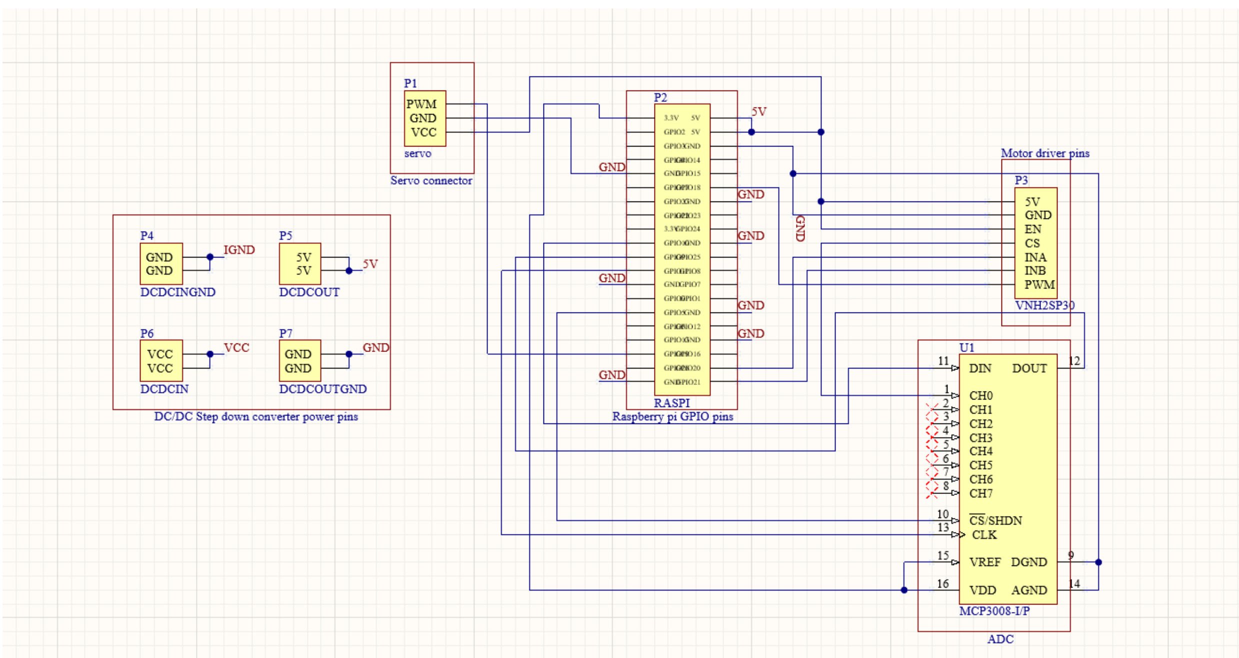
Voltage conversions:

- Battery charger ->7.4v Li-Po
- 7.4v Li-ion -> Step-down converter (5v, 3.3v, …)
- 7.4v Li-ion-> Motor driver-> Motor(s)
- Step-down converter 5v-> Raspberry Pi, servo motor, Arduino, Camera, sensors…
- Step-down converter 3.3v-> Sensors

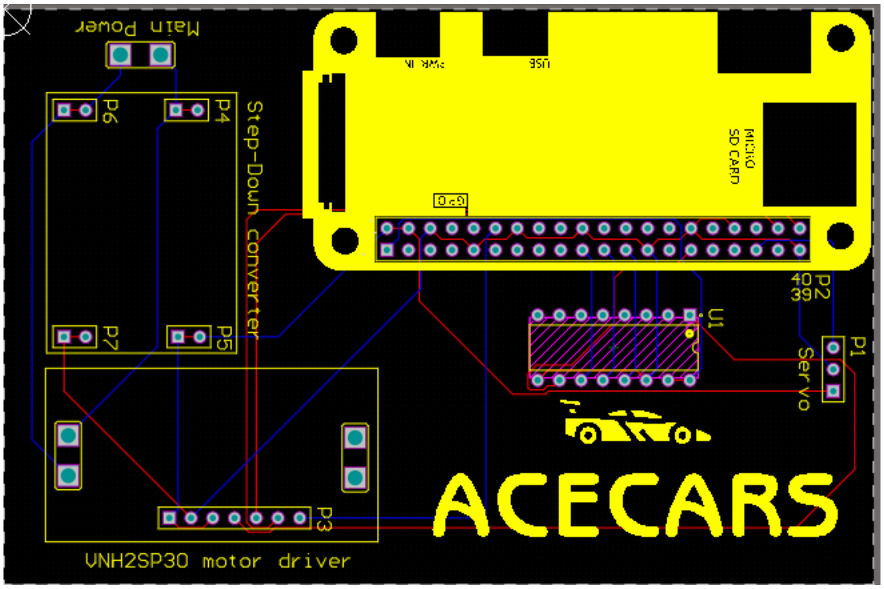
2.2.3 Electronic

ACE car decided to choose a Raspberry Pi microcomputer to communicate with a PC. The Raspberry Pi will transmit video data using either a camera connected directly to the raspberry pi's camera port or a USB camera. It will send the video data to the PC, where it will then use OpenCV to process the frames and detect the track, obstacles, and hills. The PC will then send back control data to the Raspberry Pi, i.e., speed, steering, direction. ACE car has figured out a way to transmit smooth video through the network without much latency. As a result, our team is ready to move onto the next step.

Schematics:



Board Layout:



2.2.4 Software

- Machine Learning algorithms, Neural Networks Architecture.

Machine Learning allow a car to collect data from cameras and other sensors, interpret it, and decide what actions to take. Machine learning even allows cars to learn how to perform these tasks as good as humans or even better.

- Servo turning algorithm, Initialization of servo, DC motor, batteries etc.
- Appendix B.

Low level flow chart.

- Appendix A.

Software block diagram.

- Appendix C.

Architecture Overview

- C++, Python.

Python library allows to retrieve up to 90 FPS.

- Arduino IDE, Visual Studio Code, CLion IDE, ROS.
- Minimum required 3.20(CLion).

2.3 Technical design integration

Safety:

- The most dangerous part of the car is the battery. If a lithium-based battery experiences damage, it could potentially lead to a serious fire or explosion hazard.

Speed:

- AceCar’s current goal is to complete the track in under 1 min.

Accuracy:

- The car should measure the distance from the obstacle and find a way to avoid it. Typically, an ultrasonic sensor will be a good fit for this problem (other options exist).
- The car should be able to follow the white line without swinging side to side too much, or it will reduce the speed.

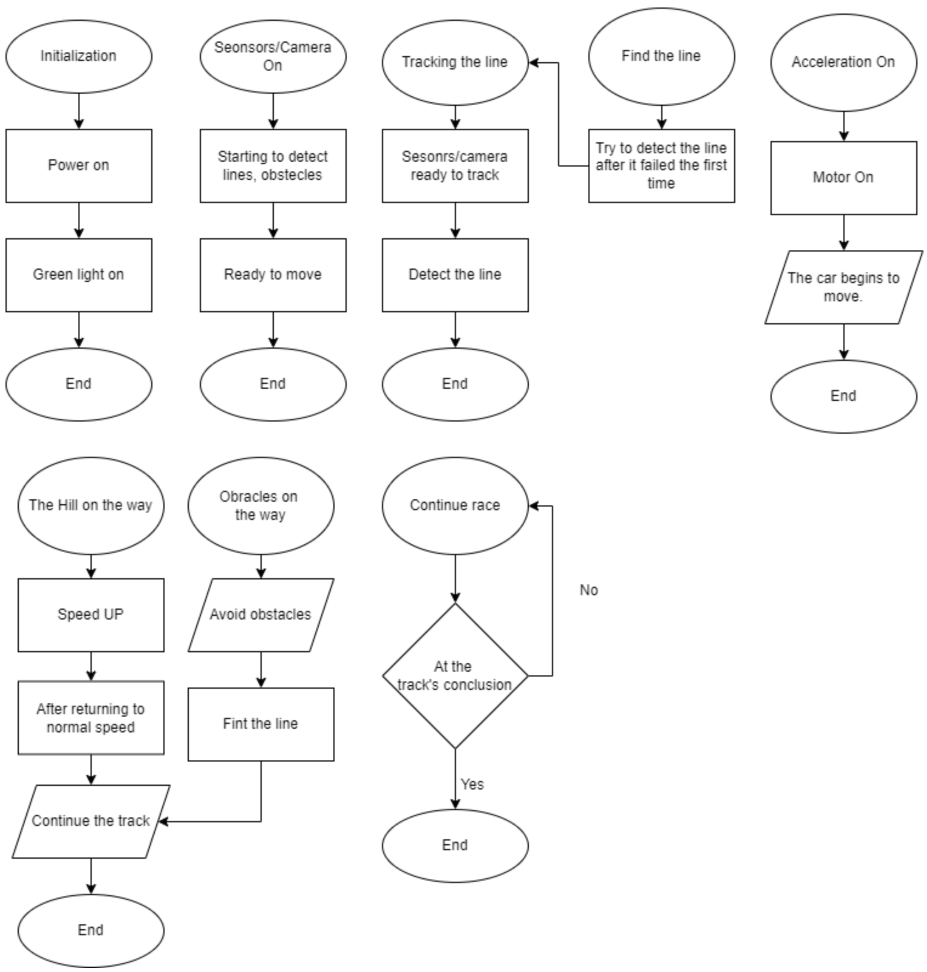
Cost:

- With the provided parts, the goal of an autonomous self-driving car simply cannot be achieved. Therefore, extra parts will be required. Depending on the parts used, the price will vary greatly.
- The base budget is around 50 euros, but if provided with satisfactory arguments, the budget limitation may be lifted.

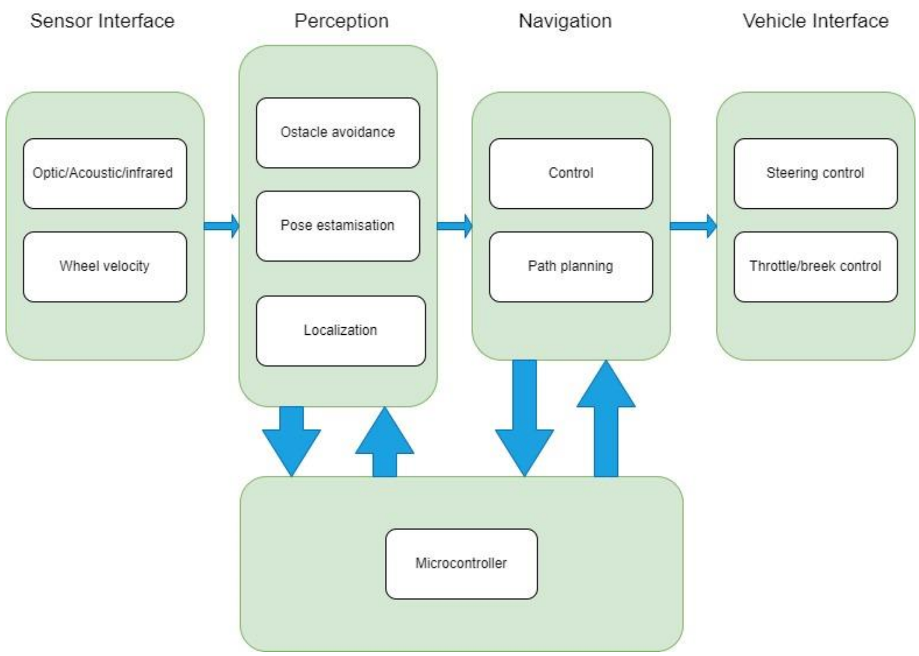
Maintenance:

- The provided motor is a "brushed" DC motor, meaning as time goes on, the carbon "brushes" will wear out and will typically require replacing the whole motor or replacing the brushes if the motor has such capability.
- The battery is considered a consumable and will lose its capacity bit by bit, until one day it will require replacing.
- Gears: It is possible for the gears to break or wear out, thus requiring replacements.

Appendix A: Software high level flow chart:



Appendix B: Software Block Diagramm [2]:



Appendix C: Architecture overview: