ABSTRACT

This project aims to build a small-scaled car that using INS (Inertial Navigation System) and LiDAR sensor to localise and navigate itself autonomously. INS will let the car know it's current and target location and with these data car will able to plan it's motions to reach target location. On the other side, while the car is going in it's way from A location to B location we need to be sure that car will not crash obstacles which are in it's path. To do that we are using a laser range finder sensor.

LITERATURE ANALYSIS

Driverless cars are became very popular with advancement of navigation, localisation and mapping technologies. There are lots of different works have been accomplished. Driverless cars are products of several disciplines. To understand whole system it should be done research for each technology. However when we search for more high-level researches we found more than we expect. Especially Sebastian Thrun, the man behind Google Driverless car, made huge contributions to this field of area. Today most of the companies like Volvo, BMW and Mercedes work on autonomy of their cars. On the other hand autonomous navigation is also very important topic for robotic field. There many applications such as military, space exploration and service robots. When we were looking projects like ours we saw that a large number of universities and professors are working in that field of area. After our literature analysis, we collected some papers. The list can be found below.

Papers:

1. *THE USE OF LIDAR TECHNOLOGY IN AUTONOMOUS CRUISE CONTROL SYSTEMS FOR AUTOMOBILES : http://136.142.82.187/eng12/history/spring2013/pdf/3124.pdf*

2. *Mobile Robot Positioning - Sensors and Techniques : http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA422844*

3. *Autonomous Ground Vehicles—Concepts and a Path to the Future http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6179503&tag=1*

4. *TELE-OPERATED LUNAR ROVER NAVIGATION USING LIDAR 5509 (Pederson)*

5. *A low power laser rangefinder for autonomous robot applications http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=570946&tag=1*

METHOD

We are going to build all computing and sensor system on top of RC car that can be seen in Figure 1. The RC car has two brushed motors for going forward and back, a servo motor for steering and an ESC to control motors with PWM signal.

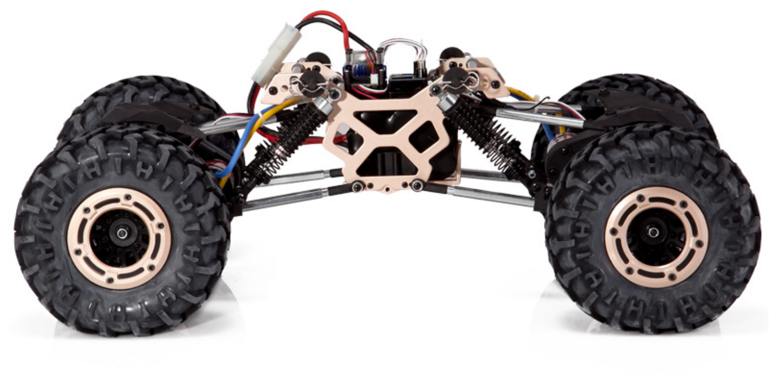

Figure 1 - 1/8 scaled RC car

The infrastructure of the car is shown in Figure 2.

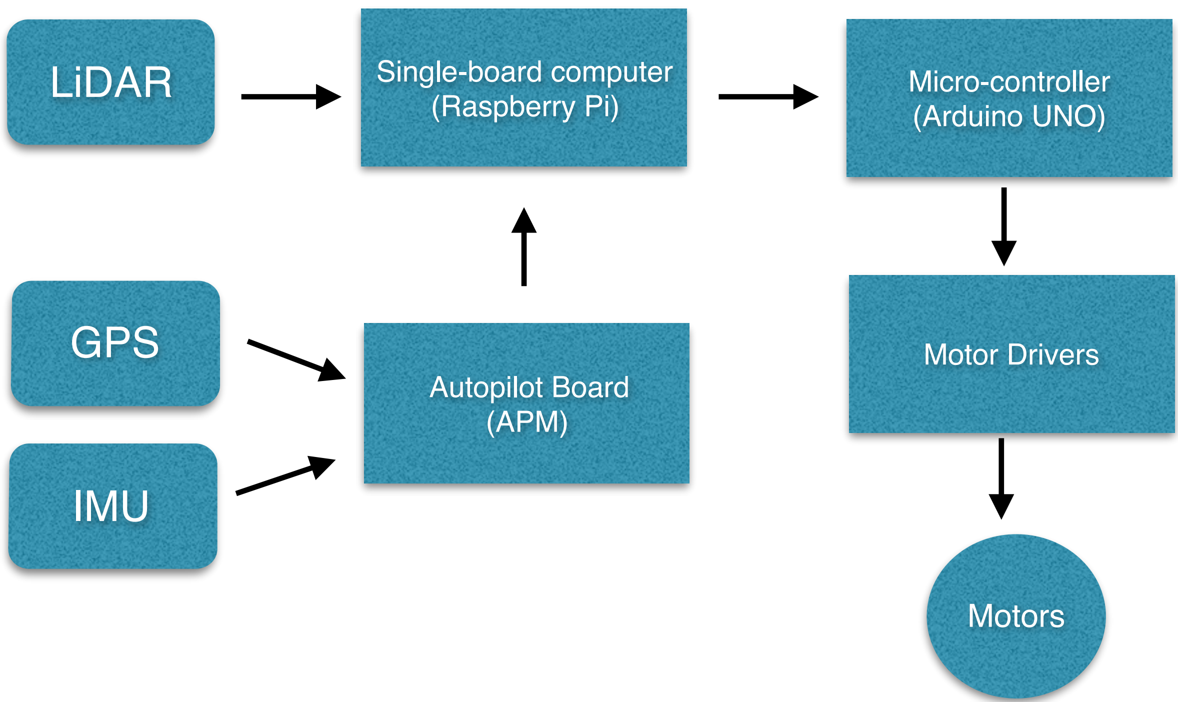

Figure 2 - Block Diagram of the System

As can be seen in Figure 2, we will use an autopilot card for for navigation. INS includes two essentials sensor: IMU and GPS and these sensors provide speed and location datas simultaneously. We will use an autopilot card called APM that is built for this kind of applications. It has built-in IMU and GPS sensor.

While the car is going it's path we will use the LiDAR sensor to detect obstacles. The software that we have written for LiDAR sensor will look front, left and right side of the car and it will detect if there any obstacle in our pre-defined range. If there is nothing, INS will continue to navigate car but if car sees something it will interrupt INS navigation and start to navigate car with obstacle-avoidance algorithm. Since there are many obstacle-avoidance algorithms and much that time we will start with wall-follower algorithm. And if time lefts, we will test advanced obstacle-avoidance algorithms.

In general we have three challenges:

1. Running obstacle-avoidance algorithm with car and LiDAR
2. Sending LiDAR data to workstation PC using Xbees
3. Running INS system with car and APM autopilot card
4. Combining these two system for full-autonomous driving

Below we explain how we are planning to accomplish these challenges.

First challenge:

We are using Hokuyo URG 04-LX LiDAR sensor. It has 4meters range and capable of giving 240 degree area of range data. It runs at 100 sec/scan, scanning speed means that we are able to get all range data in every 10 mili-seconds. In Figure 3 the detectable are can be seen. However we are going to use only between -90 and +90 degree.

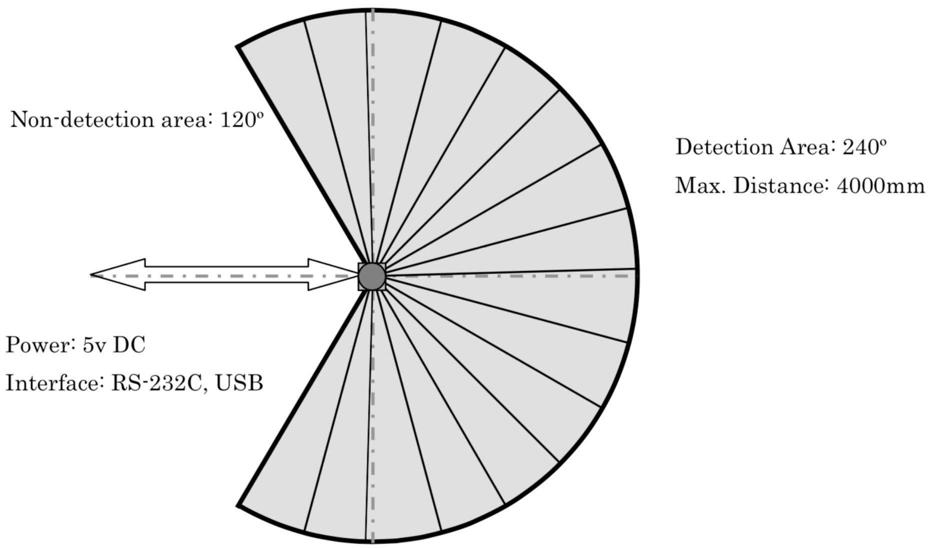

Figure 3 - Detectable are of LiDAR sensor

LiDAR sensor has both USB and RS-232 serial communication protocols. Since we are using Raspberry Pi (a single-board computer) we are able to use USB protocol.

For software side we are using a C++ library which is provided by LiDAR manufacturer company. We coded and tested our first algorithms to make sure that LiDAR is working without problems. In Figure 4 and 5 our demo setup can be seen.

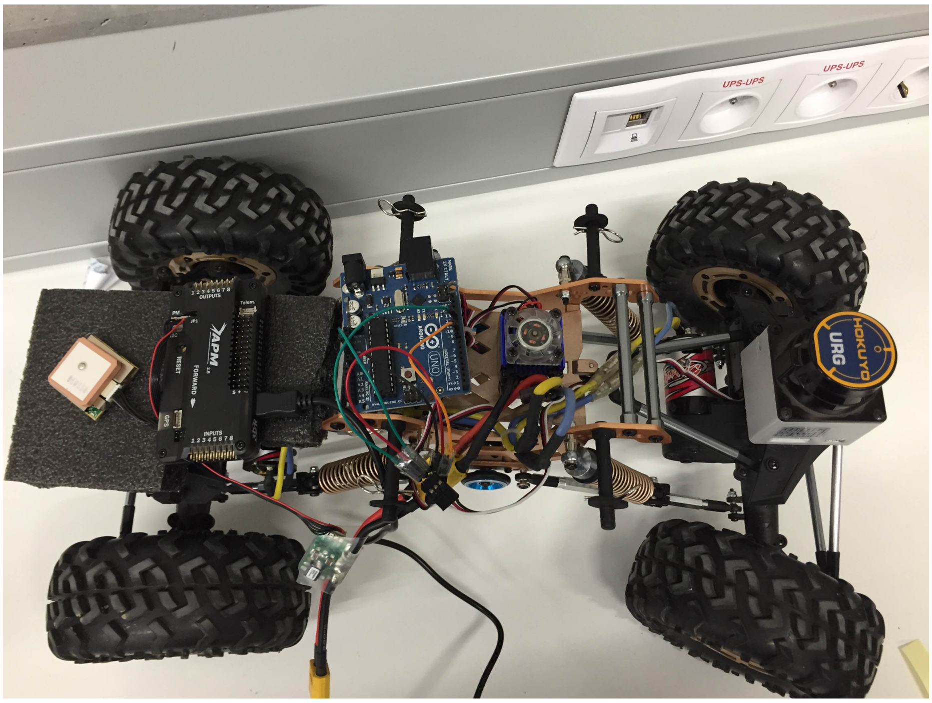

Figure 4 - Car setup with LiDAR

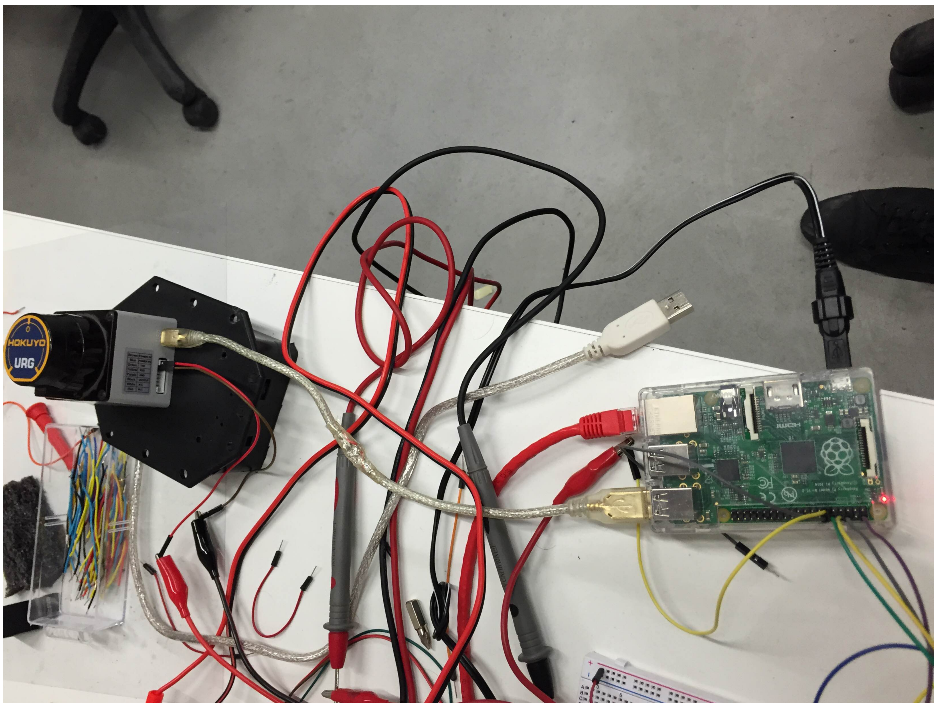

Figure 5 - Testing LiDAR with Raspberry Pi

Second challenge:

As a part of our on-board navigation we also want to send the sensor datas to our workstation PC in order to make sure everything is working well. To do that we are using two Xbee 2.4GHz wireless modules. For now we are just sending only LiDAR data every time we get from sensor. We will build basic application for our workstation PC that visualise these LiDAR data.

Third challenge:

Because our main goal is building a navigation system that performs well we have decided to use a ready-to-use localisation system. As we mentioned before we are going to use APM autopilot card and a software called APM:Rover for INS. This card includes a micro-controller with several sensor(GPS, gyroscope, accelerometer, barometer etc..). This card has three modes : manual mode that you can drive car with your remote controller, learning mode that you can select waypoint of the road that car will drive and lastly auto mode that navigate autonomously.

Fourth challenge:

After we make sure that the both system (INS and obstacle-avoidance) is working without problems we will combine these two system. Main algorithm will run on Raspberry Pi and it will decide when to use INS or obstacle-avoidance in terms of datas that we get from LiDAR sensor. The decision tree of the how algorithms is going to work can be seen in Figure 6.

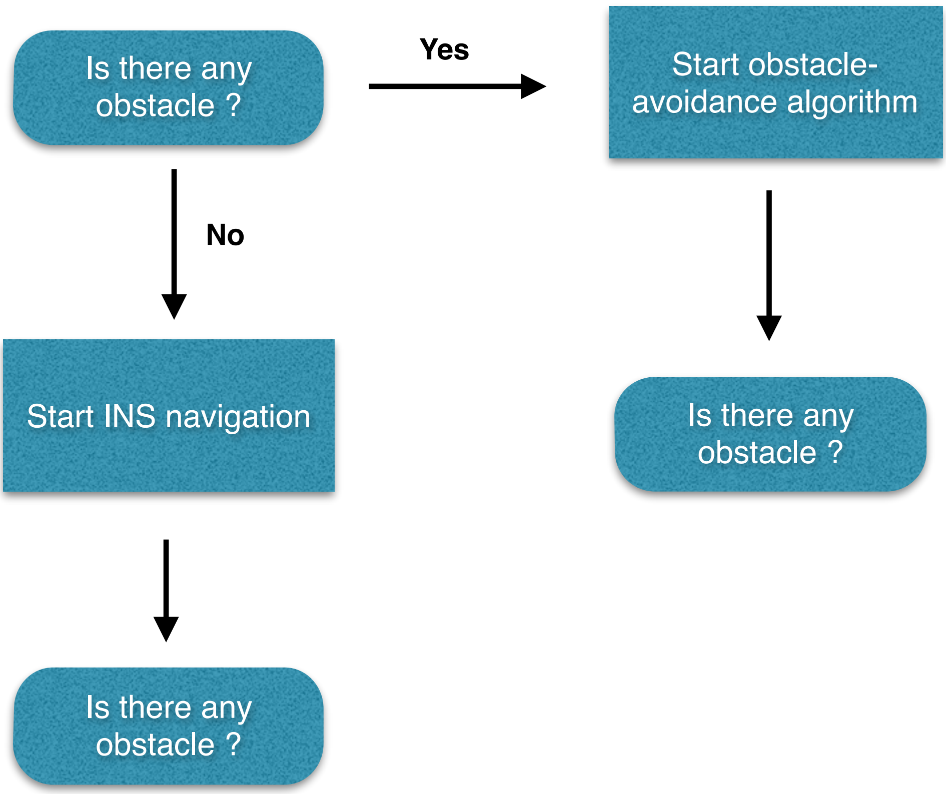

Figure 6 - Decision Tree of main algorithm

TIME PLAN

Our weekly simple can be seen below.

JANUARY			
WEEK 1 (5-12 January 2015)	WEEK 2 (12-19 January 2015)	WEEK 3 (19-25 January 2015)	WEEK 4 (26 January - 2 February 2015)
1) Component Research **2)** Ordering Components	**1)** Lliterature Analysis **2)** Meeting With Professors **3)** Configuring Raspberry Pi **4)** Testing With Different C++ Libraries for Hokuyo LiDAR	**1)** Solving Compatibility Issues Between Components **2)** Building APM Autopilot Board on Top RC Car	**1)** Writing Motor Driver Firmware with Arduino **2)** Testing With Different C++ Libraries for Raspberry Pi Serial Communication
FEBRUARY			
WEEK 5 (2-9 February 2015)	WEEK 6 (9-16 February 2015)	WEEK 7 (16-23 February 2015)	WEEK 8 (23 February - 2 March 2015)
1) Trying First Obstacle-Avoidance Algorithm with LiDAR and Raspberry Pi **2)** Sending LiDAR Range Data to PC Using Xbee	**1)** Improvements on Obstacle-Avoidance Algorithm **2)** Sending LiDAR Range Data to PC Using Xbee	**1)** Improvements on Obstacle-Avoidance Algorithm **2)** Minimize Sending Data Bytes	**1)** Testing GPS Sensor **2)** Testing IMU Sensor **3)** Testing APM Telemetry
MARCH			
WEEK 9 (2-9 March 2015)	WEEK 10 (9-16 March 2015)	WEEK 11 (16-23 March 2015)	WEEK 12 (23-27 March 2015)
1) Trying First Driveless Ride with GPS **2)** Sending GPS Data to PC Using Telemetry	**1)** Embedding Obstacle-Avoidance Algorithm in to APM **2)** Making Simulation on PC Using LiDAR Data	**1)** Trying First Driveless Ride with GPS and Obstacle-Avoidance **2)** Preparing of Final Report	**1)** Last Checking **2)** Final State Test of RC Car

LABOR DIVISON

We have separated works in terms of our background knowledge.
Responsibilities for team members:

Tarık Keleştemur:

- Writing codes for both INS and obstacle-avoidance algorithms
- Building LiDAR sensor to work with car
- Building APM board to work with car
- System integration

Furkan Duyar:

- Writing codes for data transmission between car and workstation
- Building desktop application to visualise LiDAR data
- Building APM board to work with car
- Building power management system for APM, LiDAR and Raspberry Pi