ZEIT4230 Electrical Engineering Design Practice

Project Brief S1, 2018

Autonomous Indoor Navigation of an Unmanned Ground Vehicle

Scope

The aim of this project is to design and build a prototype for an autonomous navigation and propulsion system for an unmanned ground vehicle that is capable of operating in an indoor, GPS-denied environment.

Functional Description

The navigational functionality required from the vehicle is as follows:

1. Autonomous navigation to a known target position.
2. Autonomous obstacle avoidance.
3. Autonomous return to start position.

The system must also be capable of providing a wireless telemetry signal between the vehicle and a computer. The telemetry signal must provide the following information:

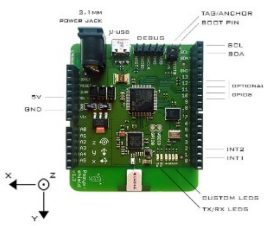
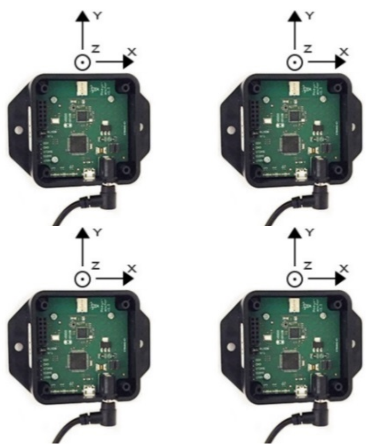
1. The current position, heading and speed of the vehicle
2. The position of any obstacles detected

Software on the computer is required to indicate the current position of the vehicle and any obstacles detected on a graphical display.

Prototype Description

The components available for the construction and evaluation of the prototype are shown in Table I.

Table I: Components supplied for construction and evaluation of the prototype.

Pozyx Indoor Positioning System	 Pozyx Tag  Pozyx Anchors (4)

Arduino Uno R3 Microcontroller and USB cable	 
HC-SR04 Ultrasonic Ranging Module (3)	
7.4 V 850 mAh Lithium-Ion Battery	
9 V 400 mAh Lithium-Polymer Battery and 9V to Barrel Jack adapter cable	 
Chassis from 1/12th Scale Electric Powered 2WD Truggy/Truck	

The prototype system is to be constructed on a custom-designed 3D-printed platform. The platform must be mounted on the existing struts on the 1/12th scale car chassis. The navigation system is required to use a Pozyx tag mounted on the Arduino microcontroller to determine the location of the vehicle. The propulsion system is required to use signals from the Arduino, via a motor speed controller, to control the rotational speed of the DC motor on the car chassis. The Arduino must also send signals to the steering servo on the car chassis to control the heading of the vehicle. The Arduino and the motor speed controller must be powered using separate batteries. If the same battery is used to power both devices, when the motor requires a surge in power, the resulting large current spikes may damage the Arduino. The navigation system is required to detect obstacles using three ultrasonic ranging sensors connected to the Arduino microcontroller. The system must be capable of controlling the position of the vehicle in order to avoid contacting any obstacles in its path. The system is also required to transmit telemetry data from the Arduino to a computer via a wireless transmitter mounted on the car platform to a wireless receiver connected to the computer. Software on the computer is required to convert this telemetry data into a graphical display of the location and heading of the vehicle and the location of any obstacles detected by the vehicle. The required architecture of the prototype system is shown in Figure 1:

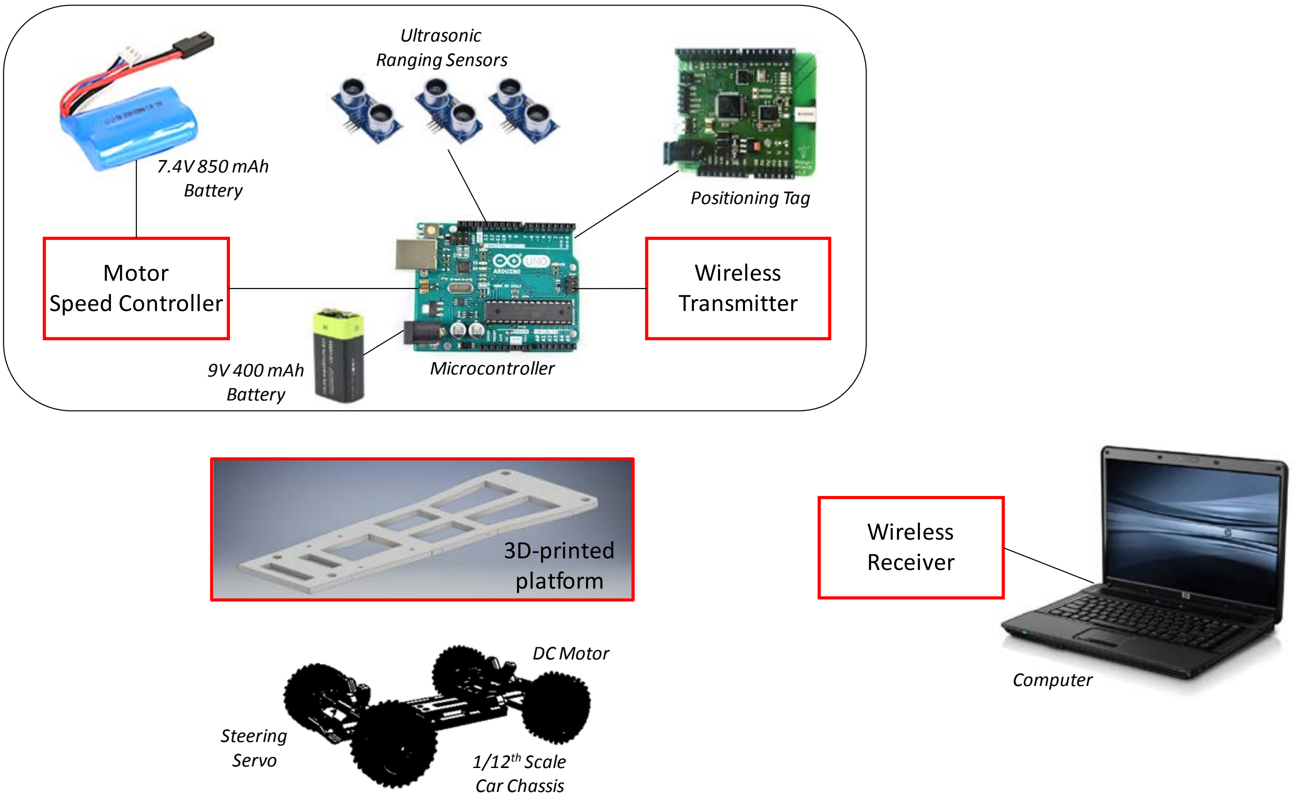


Figure 1: Required System Architecture.

Timeline

The due dates for the deliverables of the project are shown in Table II:

Table II: Deliverable due dates.

Assessment	**Due Date**
Planning Review	20th Mar
Project Planning Report	23rd Mar
Progress Review	1st May
Project Progress Report	4th May
System Verification	4th Jun
Project Final Report	15th Jun

Budget

The navigation and propulsion system will require extra components, other than those initially supplied for the project, to meet the specifications of the project. These extra components (shown with a red border in the system architecture diagram) are to be purchased using school funds. A budget of AUD150 is available for the procurement of these components.

System Verification

The ability of the prototype system to meet the design specifications will be tested on a 5m x 5m course that is divided into a grid of 50 cm x 50 cm squares as shown in Figure 2. First, the ability of the navigation and propulsion system to move the vehicle through the course will be assessed. The vehicle must move from the start square to the target square, without making contact with any of the obstacles. Once the vehicle reaches the target square, the ability of the vehicle to travel, via the fastest path, back to the start square will be tested. To quantify the capabilities of the system, a time will be recorded for the initial obstacle discovery phase, when the vehicle is moving from the start to the target, and for the return to home phase, when the vehicle is moving from the target back to the start square. A time penalty will be incurred for every contact the vehicle makes with an obstacle and for every time the vehicle moves outside of the course. The start and target grid squares will be advised on the day of the critical design review. The obstacles on the course will be placed at random locations that will also not be revealed until the day of the critical design review. A physical inspection of the system will be conducted to verify the build quality of the prototype. A physical inspection of the graphical display will be conducted to verify the accuracy and timeliness of the position data being displayed and the quality of the appearance of the graphical interface.

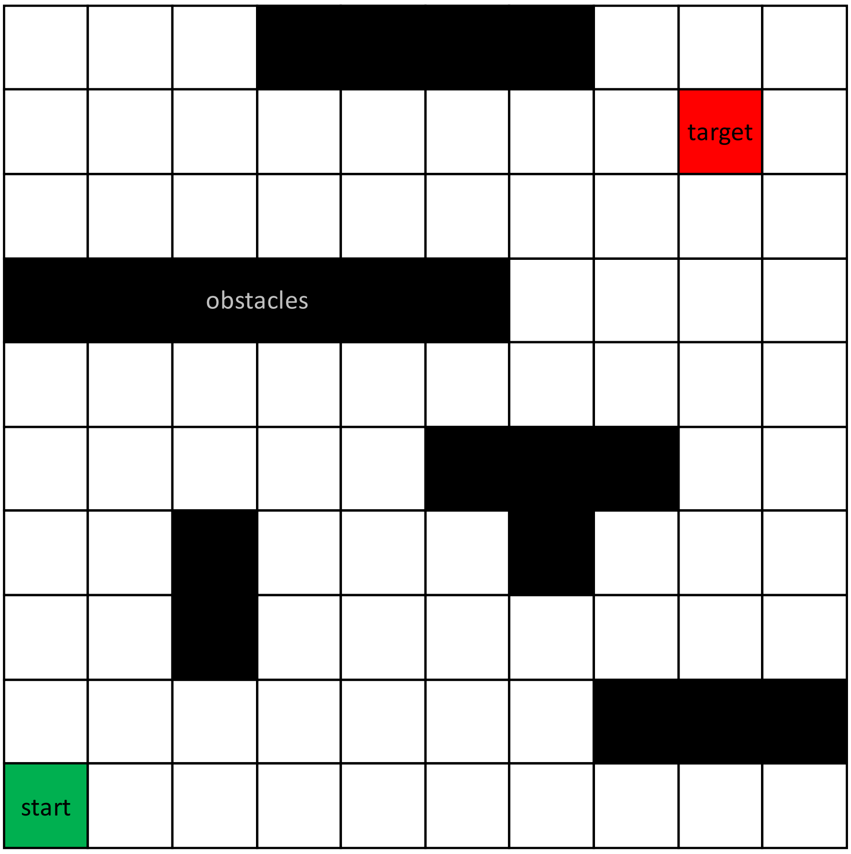


Figure 2: Example course for the verification of the prototype system

Resources

The Arduino software development environment and code reference documents can be found at the following URL:

https://www.arduino.cc/

Documentation on the Pozyx indoor positioning system can be found at the following URL:

https://www.pozyx.io/Documentation

Autodesk Inventor tutorials can be found at the following URL:

https://knowledge.autodesk.com/support/inventor-products/getting-started/caas/CloudHelp/cloudhelp/2018/ENU/Inventor-Tutorial/files/GUID-25E3BABE-0FF4-4542-854E-AD2F59E4BB4A-htm.html