

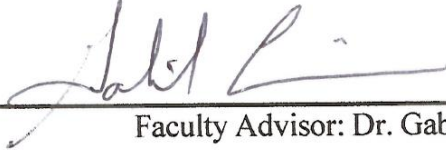
PROJECT BREAKPOINT

2015 IGVC DESIGN REPORT

UNIVERSITÉ DE MONCTON – ENGINEERING FACULTY

IEEEUMoncton Student Branch

I certify that the design and engineering of the vehicle by the current student team has been significant and equivalent to what might be awarded credit in a senior design course.



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15 MAY 2015

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UNIVERSITÉ
DE
MONCTON

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1. Introduction

IEEEUMoncton, founded in 2013, is a new student branch of the IEEE association situated in Moncton, New Brunswick, Canada. This year, the group, consisting of undergraduate students in electrical engineering, has built a new vehicle named BreakPoint. This document will show the functionality and abilities of the robot as well as the components used and systems designed. Further, this report contains the budget as well as the predicted performance for this year's competition.

2. Design Process and Team Organisation

This year's team consists of 17 electrical engineering students all in different years of their undergraduate degree. The 4th and 5th year students, who account for 10 members, were responsible for the majority of the project. Between September and December 2014, these 4th year students worked individually on different aspects of the project, including the GPS, IMU, cameras, structure etc. Following this initiative, the 5th year students completed the larger portion of the work, which lasted from January until the time of the competition. This involved the integration of the individual parts and the main code of the vehicle.

3. Mechanical Systems

We are using an electric wheelchair as the base for the robot. The base is equipped with an electric motor for each drive in the front and two swivel wheels in the back. The seat, cover, arms and reclining system have been removed to place a frame that will hold the computer and all the electrical components.

3.1. Structure

The structure consists of an aluminum frame. A plexiglass cover secures and seals the computer as well as the components inside to ensure that they will not be damaged by rain or other weather conditions.



Figure 1: General view of the robot

A sliding shelf has been added inside the structure for location of the computer (laptop). The electrical components are fixed to the base of the structure. In order to promote airflow, the cabling has been strategically separated for each component inside the frame of the robot.

4. Sensors

4.1. LIDAR

The robot uses a Hokuyo UTM-30LX-EW for its measurement system. The LIDAR has a sensing range of 30 meters with a +/-50 millimeters of tolerance. The sensor also has a field of vision of 270 degrees. It is the robot's primary obstacle detection sensor.



Figure 2: Measurement system : Hokuyo UTM-30LX-EW

4.2. Cameras

The cameras that have been used this project are the Logitech HD pro Webcam C920. The robot has 2 side cameras, left and right, as well as a frontside camera. This strategy has been chosen for security purposes. To preserve calibration, 3D printed supports have been created to be rigidly fixed to the cameras. Using the LIDAR and the cameras, the computer is able to determine any object or obstacle that may be in the robot's path.



Figure 3: Logitech HD Pro Webcam C920

4.3. Global Positioning System

The robot is equipped with a Ag Leader 1600 for its Global Positioning System. This GPS has a 0.6m accuracy at a 95% confidence interval. The GPS automatically finds and connects to the GPS and SBAS signals and outputs them as a standard NMEA string at 5 Hz through serial communication. The Ag Leader 1600 is robust and can withstand any operating conditions.



Figure 4: AG Leader 1600

4.4. Odometry

To calculate the position of the vehicle, two encoders were purchased and attached onto the shaft of each motor. These encoders allow the vehicle to record every rotation of the wheel since the initial start period. The count of each of these encoders can be used to perform a navigation technique called “Dead Reckoning”. This technique allows the vehicles to know how far it has travelled from the starting point while considering its direction.

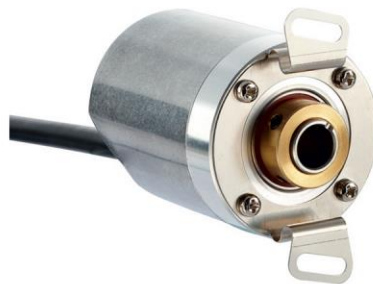


Figure 5: Encoder SICK DBS36E

The combination of the LIDAR and encoder can be used to obtain the raw data necessary to create a map of the surrounding of the vehicle. The creation of this map can be done by implementing SLAM in the vehicle. The SLAM algorithm is already implemented in ROS, which is how the laptop onboard the vehicles is able to generate a map. This map can be used to remember useful points that the vehicles has seen or can see. A sample map can be observed in the figure 6.

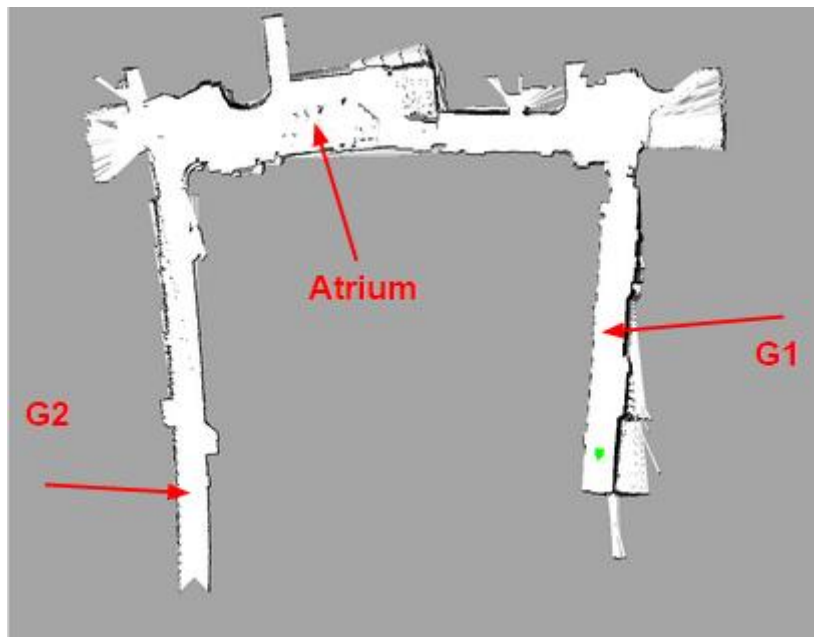


Figure 6: Map generated

5. Power Distribution and Battery Systems

The vehicle is powered by two 12V DC batteries in series. Only the Motors and the GPS are connected by a direct 24V DC input. A DC-DC converter is used to ensure both batteries drain at the same rate and that there is an almost perfect voltage of 12V DC. The converter powers the wireless E-stop, the LIDAR, the USB hub and the 120V AC Inverter which power the laptop. The remaining components are connected by USB with the USB hub.

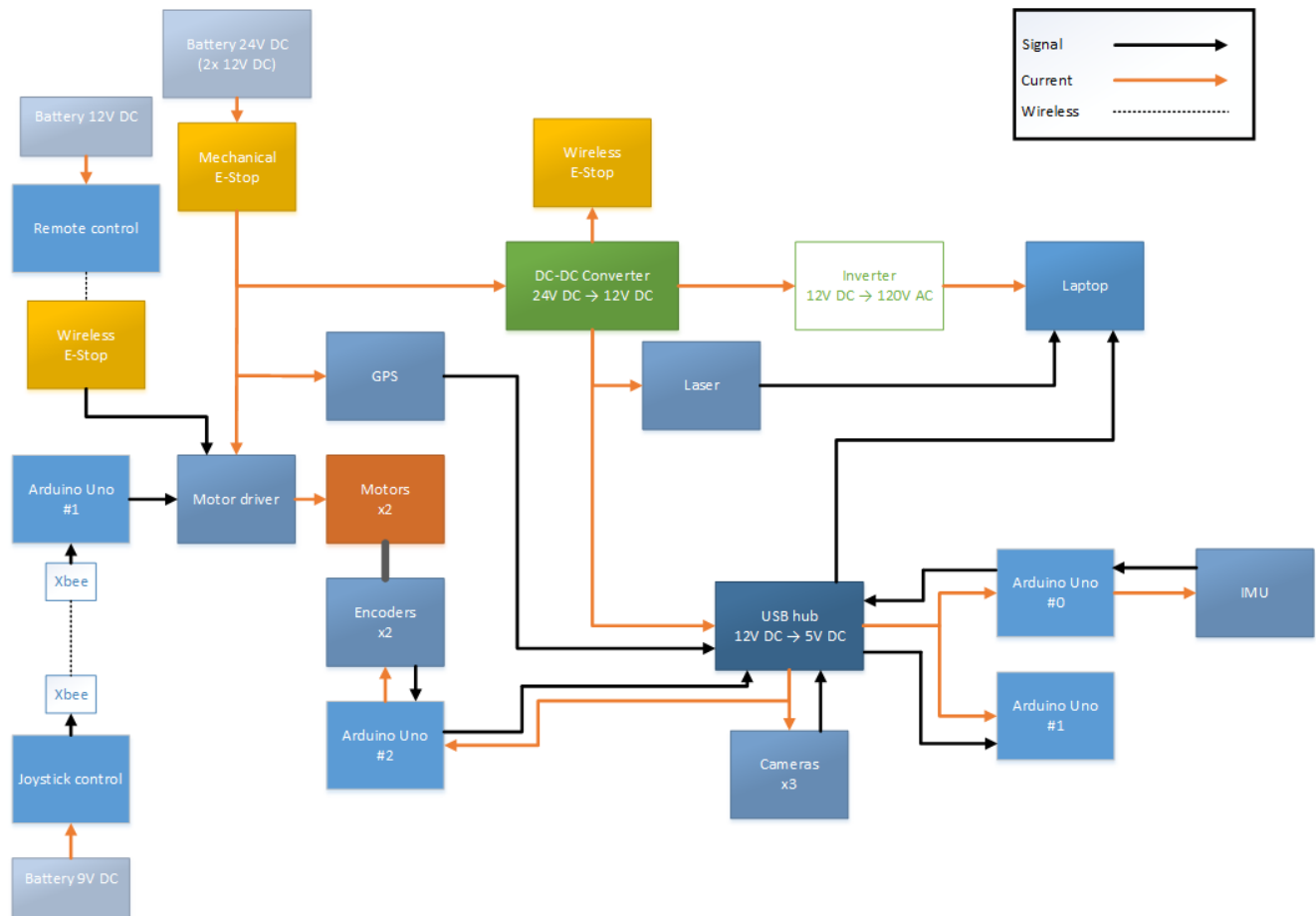


Figure 7: Power distribution schematic

6. Electronics and Computer Systems

6.1. Main Computer

The main computer of the robot is a Lenovo Y50-70 laptop, it was chosen because it successfully met all our requirements while being relatively inexpensive. It is composed of i7-4710HQ processors with 6 MB of cache clocked at 3.5 GHz with 4 physical cores and 8 threads. As our codes use a lot of different threads, opting for an 8 thread processor was our best option. Additionally, the laptop was chosen for its low power consumption, small size and ventilation. We also added a 120V inverter to allow any laptop to be charged using the vehicle batteries.

6.2. Security Systems

Given the IGVC requirements, the vehicle has an emergency stop fixed on top at the back of the structure for easy and rapid access. The vehicle also has a wireless emergency stop which only stop the motors driver and not all the power of the vehicle. The remote has a range of up to 200 feet within a line of site.

The vehicle has two different modes, only the laptop on the vehicle can control it or only the wireless joystick. It is possible to switch from one mode to another by simply pressing a switch that cuts the communication between the joystick and the receiver and informs the microcontroller to follow the laptop's commands. A beacon was placed on the top of the vehicle to signal that the vehicle is in operating mode. If the light is blinking the laptop is controlling the vehicle and if the light is solid the wireless joystick is in command.

7. Software Strategies

The IEEEUMoncton student branch is made up of undergraduates electrical engineering students that have an interest in robotics and similar topics. In consideration of future students, it is necessary that the work done is simple and robust so it is easily alterable and can be rapidly assimilated.

For the success of the project, it was mandatory that the students have a strong base in programming and read plenty of documentation. The software design is based on an object-oriented approach.

8. Systems Integration

8.1. Vision

The detection of flags, white lines and obstacle make up the three critical functions for the vision of the vehicle. In order to detect flags of different colors, a color detection algorithm was created using the functions in the OpenCV library. As a result of online research and by reading other student team reports, we noted that the HSV color space is most often used for color detection. It is advantageous to have the detection in the hue, saturation and value fields because the light variation has lesser effect on the received image. If the detection would be completed in the RGB field, the light variation would have an effect on the color detected. For instance, a red flag may be perceived as darker when placed in the shade. Ultimately, because the vehicle will be outdoors where light variation will occur, the HSV system will offer the best results. In addition to the detection of colors, the area and the contour detection of objects is measured to make sure that the color detected is a flag. The same functions as that used in flag detection is also used to detect white lines. However, the difference is the color of detection and the area and the contour detection are not used. After calibration, both codes return the distance of different points of the detection, which will be used by the vehicle to make his decision. For the obstacle detections, the LIDAR gives highly accurate measurements that can be used directly.

8.2. Navigation

The navigation of the vehicle is measured by three different components, the GPS, the encoders and the IMU. To detect if the vehicle has arrived at a waypoint, the fairly accurate GPS gives the latitude and longitude measurement which is used to determine it's location. Also, while the vehicle is in motion speed and orientation data can be collected. The disadvantages of the GPS is that it only work outdoors and can possibly have a bad connection. The encoders help balance the negative effects of the GPS, which allows for proper measurements in the result of a failure of the global positioning system. The information received by the encoders is identical to that of the GPS, with the exception of the position that will be in meters instead of the latitude and longitude. The IMU is currently only used for the orientation of the vehicle, but has the

potential to be used for the acceleration, speed and position with the proper calculations. A Kalman filter should be integrated with the three components but this will be added in one of the group's future projects.

9. Predicted Performances

The vehicle speed will be approximately 3.7mph at full speed and 2.96 mph (or 80% it's full speed) when it detects an object in its way. The vehicle's battery life is approximately 3.5 hours but has never been field-tested to know the precise amount of time which they can power all systems on the robot. At full speed, the vehicle needs 10A to operate properly. If the laptop's battery is running low on power, this can be charged using the batteries on the vehicle.

Given the high speed of the algorithm reaction time compared to the sensor processing time, the limitation on the reaction time comes from the update rate of the sensors informations.

10. Budget

The following table presents the cost of the various components used in the BreakPoint project.

Table 1 : Cost of the components used in the Project

Component	Value	Cost	Comments
Hokuyo UTM-30LX-EW	\$6,517.86	\$0	Engineering Faculty donation
SICK encoders	\$393.30	\$393.30	
Laptop	\$1,015.87	\$1,015.87	
Frame/body	\$400.00	\$400.00	Electric wheelchair donation
Motor Systems	\$800.00	\$0	Electric wheelchair donation
GPS	\$960.50	\$960.50	
Batteries	\$226.00	\$180.80	Store discount
Cameras	\$338.97	\$271.17	Store discount
Motor Driver	\$150.80	\$150.80	
IMU (Inertial Measurement Unit)	\$1,639.75	\$0	VectorNav donation
Total	\$12,443.05	\$3,372.44	

11. Conclusion

The student group, IEEEUMoncton, is a new group that has rapidly grown over the last 2 years. The hard work and dedication of its members will allow them to participate for the first time in the IGVC. The group was founded with the objective to create a robot for this competition, as the branch of electrical engineers at Université de Moncton were the only type of engineers without a competition. Since discovering IGVC, the small group was able to generate interest with this project and recruit new members. By participating for the first time in this annual competition, we hope to acquire valuable experience in order to improve on our design for next year's competition.