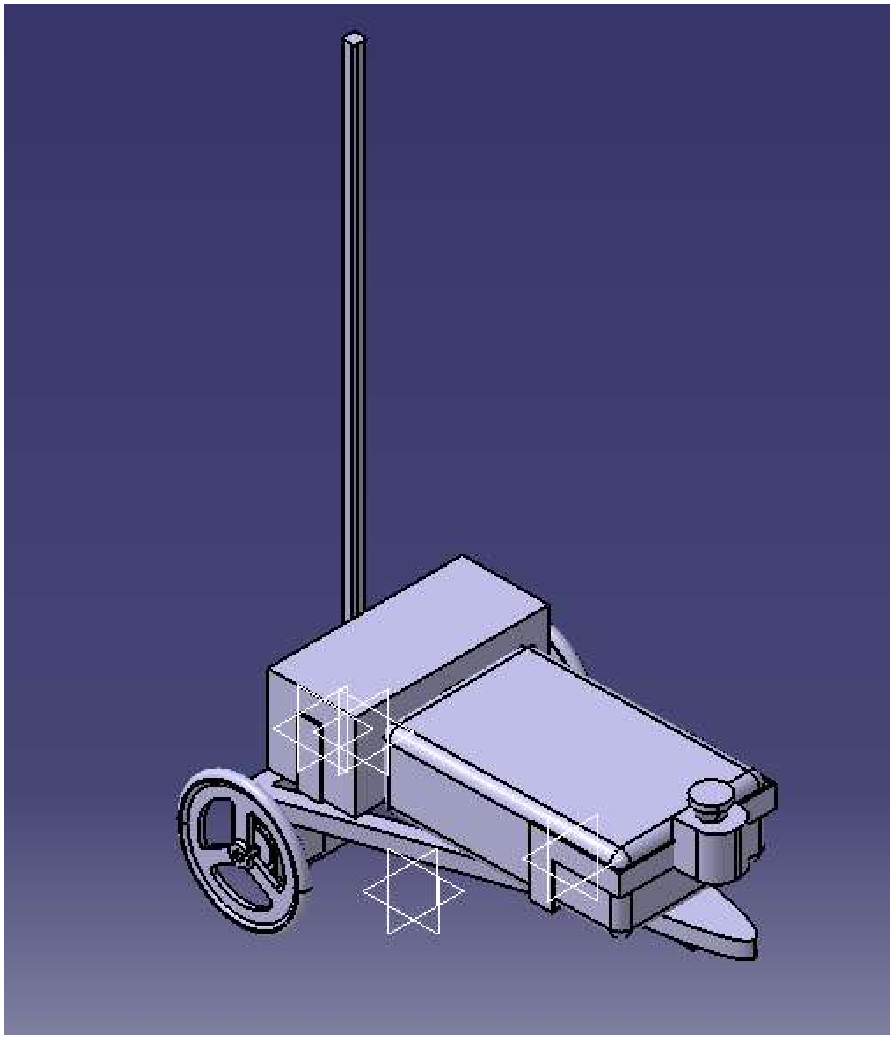
Embry-Riddle Aeronautical University

Detailed Advanced Improvement System Initiative (DAISI)



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May 10, 2018

Intelligent Ground Vehicle Competition
AUVSI Foundation

Dear IGVC Judges,

I certify that the engineering design of DOLLE, as described in the accompanying report, has been significant and is equivalent to that required of a senior design project.

Sincerely,

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Introduction

DAISI, the Detailed Advanced Improvement System Initiative, is an autonomous vehicle designed for navigation in unknown environments. The latest vehicle designed at Embry-Riddle, DAISI was built to improve upon a few of the shortcomings of last year's system. Although this is an improvement of the DOLLE platform, the platform has been redesigned and optimized in order to better improve the mechanical and software systems. These improvements assist in producing a safer, more simplistic, and easier to use platform. This advanced IGVC vehicle includes desirable features not seen in many other competitors including portability, ruggedness, and remarkable agility during operation. This report outlines the development of these systems and the methods used for system integration.

Team Organization

The development of DAISI required a multidisciplinary engineering team capable of working on several different aspects of the vehicle. The team consisted of 8 team members, each with their respective areas of focus as denoted by the symbol "X" and the lead(s) of each area are denoted with a "*". These members cumulatively put more than 3430 hours into the design, manufacturing, and implementation of DAISI and its software.

Table 1: Team Member Areas of Concentration

Team Member	*Major*	*Mech.*	*Soft.*	*Elect.*	*Doc.*	*Hrs*
Nick Middlebrooks	Mech. Eng./Grad Student		X	X	X	120
Zachary Bryant	Mech. Eng./Junior	X	X*		X	420
Kody Miller	Mech. Eng./Junior	X	X*		X	410
Parker Tyson	Aero. Eng./Junior	X*	X*	X*	X*	440
Christopher Leirer	Aero. Eng./Junior	X*			X	400
Mark Sterling	Mech. Eng./Sophomore		X		X	230
Dakotah Stirnweis	Mech. Eng./Sophomore	X			X	320
Matthew Williams	Aero. Sci./Sophomore	X			X	320

Design Process

The development of DAISI uses a seven-step design process as seen in Figure 1 that began with determining the problem presented by the competition. For the IGVC competition, the problem is to develop a robot that can successfully navigate through an obstacle course and a series of waypoints, while reacting from visual cues from painted lanes and colored flags. The customers are the IGVC competition judges, advising faculty, and future team members. With those customers in mind, new specifications were developed to meet the new competition standards.

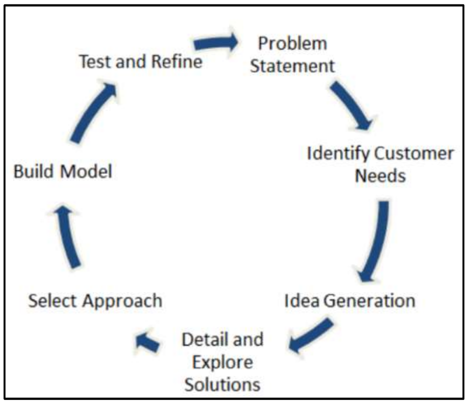


Figure 1: Design Process Approach

Innovations

LED Information Panel

Within the rules, it is required to have a solid or flashing indicator light which indicates when the vehicle is powered and when the vehicle is under autonomous control. While the competitors and the judges understand the meaning of these safety signals, other possible parties do not. For this reason, a LED information panel is used in order to add an additional level of clarity to the operation of the vehicle. The purpose of this panel is to display the current operation of the vehicle for E-Stop, Autonomous and Remote Operation. In addition, the panel can be used to display additional information necessary for identifying the performance of the robot during operation without needing to access the onboard computer.

Rocket M5 Communication System

During the process of testing the vehicle, the difficulty of adjusting and editing the software becomes tiresome, and difficult under many circumstances. In order to edit the software during testing, it becomes necessary to work off the laptop within the Pelican Case. This can become difficult during specific weather conditions. During sunny weather, working off the laptop can be difficult due to glare on the laptop screen, making it difficult to read. On the other hand, during rainy weather opening the pelican case would compromise the waterproof capabilities of the electronics box. In order to combat these problem, an Ubiquiti Network Rocket M5 system, seen in Figure 2, was integrated into the vehicle in order to allow for software editing and tweaking from a ground station with limited latency in the connection. While this function will be disabled during competition runs, it is highly helpful in the productivity during test runs.

Figure 2: Rocket M5 Antennas

Updated Power Board Microcontroller

The power board microcontroller now has more responsibilities than just running motors, as it also interfaces with the LED panel. To accomplish this, the 8-bit Arduino Mega previously used wasn’t enough, so it was upgraded to a Mbed-based 32-bit microcontroller. This increases the processing power significantly to run the motors and the LED concurrently. In addition to the increased processing power, the microcontroller now has expansion ports to allow for a more modular system in the future, aligning with the modular philosophy seen on other platforms produced by our association.

Mechanical Design

Vehicle Structure

The chassis of DAISI was designed to best make use of the minimum size requirements. The base was a simple triangular design which allows for maximum efficiency in placement of the components. By utilizing the space, the electronics case and the payload became much more accessible. This allows for easier assembly and disassembly in the field. In addition, the entire frame is constructed of Aluminum for a very light but strong and rigid base.

In order to protect the sensitive electronics, a waterproof IP65 rated Pelican Air Case was utilized in order to protect these electronics in addition to providing a means for the electronics to be modular and easily transportable. The electronic connections are phased through a connection panel which is also IP65 rated in order to allow sensor communication with the internal laptop while allowing for the system to remain waterproof. When combined, the overall base system is designed to be modular and allow for ease of assembly, disassembly and transport. The system frame design can be seen in Figure 3.

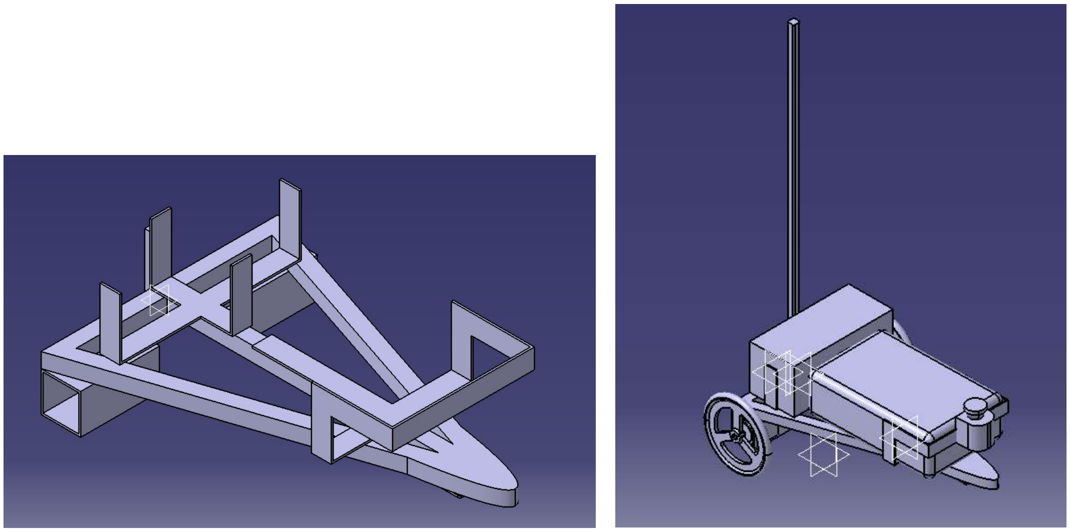


Figure 3: DAISI base system frame and loaded configuration

The sensor pole, seen in Figure 4, is made of 1” square carbon fiber tubing mounted upright from the base of the frame. Carbon fiber was chosen for its rigidity, durability, and lightweight properties. The sensor pole holds the Ion Action Cam, Hemisphere GPS, safety lights, the emergency stop button, and the new Ubiquiti Omni-Directional Antenna. The wires for the components are fastened to the sensor pole to allow for quick-swapping of cameras or light options. The components are mounted using 3D printed friction mounts designed to allow for steady attachment to the sensor pole, while not disturbing the structural integrity of the carbon fiber. A new mount was constructed specifically for the Ubiquiti Antenna. The mounts allow for lightweight and rigid structural attachment which contribute to the highest amount of stability for the sensors.

Figure 4: Sensor pole with close-up of updated 3D printed mounts

The motor assembly consists of a pair of 24 Volt Quicksilver motors and OEM NEMA 23 Series gearheads connected to two 12 ½” diameter Skyway tires. The motors are mounted directly to the frame to allow for ease of access. The motors generate the 20 in-lb. of torque needed to reach the maximum 5MPH speed limit while still keeping traction even when going over the ramps.

Weather Proofing

Due to the location of the competition, rainy weather is unavoidable. In order to combat this issue, the vehicle was design and built in order to be waterproof, at least IP65 rated. This allows for testing in rainy conditions without additional changes needed to be made to the platform. This decreases the amount of downtime the system has to face during competition and allows for maximum efficiency when testing and making software changes.

Vehicle Cost

The cost of the vehicle can be split up into two different cost models, as seen in Table 2. The first model represents the raw cost of the platform if constructed brand new. The second model represents the cost to the team of the platform. Due to sponsorships and the reusability of a number of parts on the platform, the vehicle was of minimal cost to the team. The final cost of this system was designed to be considerably lower than other possible designs used by competitors. This allowed for a versatile system in which sensors, and mechanical parts can be swapped at a low cost. Overall, this allows for a very low-cost system that is both versatile and efficient.

Table 2: Vehicle Cost

Item	Unit Cost ($)	Qty	Raw Cost ($)	Team Cost ($)
Laptop	**$750**	**1**	**$750**	**$0**
Wiring and misc.	**$180**	**1**	**$180**	**$180**
Power Board	**$150**	**1**	**$150**	**$150**
ION Action Camera	**$40**	**1**	**$40**	**$0**
Digital Compass (IMU)	**$1,350**	**1**	**$1,350**	**$0**
LiPo Batteries (6s)	**$45**	**3**	**$135**	**$0**
Motors	**$2,200**	**2**	**$4,400**	**$0**
Wheels	**$30**	**3**	**$90**	**$90**
GPS	**$3,000**	**1**	**$3,000**	**$0**
LiDAR	**$8,000**	**1**	**$8,000**	**$0**
Aluminum Frame	**$120**	**1**	**$120**	**$120**
Transmitter	**$255**	**1**	**$255**	**$0**
Ubiquiti Network System	**$380**	**1**	**$380**	**$380**
Pelican Case	**$200**	**1**	**$200**	**$200**
Total			**$19,050**	**$1,120**

Electrical Design

Overview

The central hub of DAISI's power system is a custom developed power board. Unregulated 24V power flows from the batteries to the power board, which can provide regulated 24V, 12V, 5V, and 3.3V to the sensors. The system overview can be seen in Figure 5.

The electrical system is one of the more complex subsystems leading to a high number of potential failure points. For this reason, the team spent substantial time working to design and document the electrical system of DAISI before implementing it into the hardware. The DAISI team designed and manufactured a custom power distribution and control circuit board, which acts as the central hub for DAISI's power system. This minimized the risks that are associated with incorrect internal wiring.

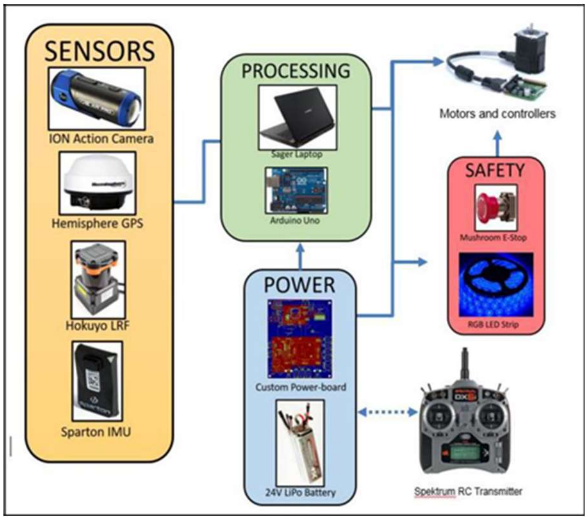


Figure 5: DAISI system Integration Diagram

Power Distribution System

The custom printed circuit board provides all necessary operating voltages for each of DOLLE's components. Unregulated 24V power flows from the batteries to the power board, which is then regulated and sent to the sensors. The power board can run the overall system for 1 to 1.5

hours on a 5Ah 6-cell LiPo battery. The overall runtime of the vehicle can be extended with a built-in hot swappable battery system that keeps the system running continuously. Each power connector for each of the components is protected by a fuse in the case of a power failure. The breakdown of which power rail each component in the system uses is broken down in Table 3.

Table 3: Sensor power ratings

Component	Power Consumption	Voltage Range	Operating Voltage	Sources
Sparton GEDC-6E IMU	0.32 W	3.3 V	3.3 V	Laptop via USB
Ion Action Cam	1.5 W	3 – 5 V	3.7 V	Battery Pack
Hemisphere A325 GPS	4.6 W	7 – 36 V	12 V	Power Board
Hokuyo UTM-30LX-EW	8 W	10.8 – 13.2 V	12 V	Power Board
Ubiquiti Rocket M5	8 W	24 V	24 V	Power Board
Quicksilver Motors	150 W	12 – 48 V	24 V	Power Board
Laptop	6 W	19V	19V	Laptop Battery

The power board has an extra connector slot at each voltage rating to allow for new components to be integrated in the future. The board also provides remote control function from an R/C transmitter and both wired and wireless e-Stop capability. This all-in-one board is critical to the compact packaging layout in DAISI.

Hot-Swap Capability

Thanks to the design of DAISI's electrical system, it is possible to swap out batteries during testing without having to re-initialize all of the hardware and software. This innovation was implemented in order to reduce the down-time of DAISI during testing and competition runs.

Electronics Suite

Computer

The central point of sensor and communication integration is DAISI's onboard laptop with a Core i7 2.50 GHz processor, 8 GB RAM, and 250 GB solid state hard drive. The laptop runs a custom LabVIEW 2016 software package for hardware communication and implementation of the autonomy algorithms. The LabVIEW programming environment is a critical tool used to receive and organize data from the sensors and run all software algorithms in parallel. DAISI uses the following commercial off-the-shelf (COTS) sensors: a Hokuyo UTM-30LV-EW, a Hemisphere A325 GPS, a Sparton GEDC-6E IMU, and an Ion Action Camera.

LiDAR

The Hokuyo UTM-30LX-EW laser range finder scans for obstacles in a 270° planar sweep in .25° increments at 20 Hz. The maximum sensing range is 30 m, but DAISI limits detection of obstacles within 15 m. Resolution is 1 mm, and accuracy from 0.1-30m is ±50mm. Time-of-flight technology is used to calculate the distance to an object from the vehicle. This sensor scans in front of the vehicle and is used for obstacle detection and avoidance algorithms. The LIDAR data is transmitted to the laptop via Ethernet using TCP/IP protocols.

GPS

The Hemisphere A235 is a single unit GPS receiver and antenna that can gather GNSS and GLONASS L band signals and updates at 20 Hz. The uncorrected accuracy is typically between 1 to 2 m. However, the corrected accuracy with OmniStar HP brings the CEP down to around 0.1 m. GPS data is transmitted to the laptop via RS-232 and a serial-to-USB converter. Sensor fusion with the IMU takes place in the software for better positional accuracy.

Digital Compass IMU

The Sparton GEDC-6E Inertial Measurement Unit (IMU) is a 9-DOF system with an accelerometer, gyroscope, and magnetometer, which allows for highly accurate measurements of roll, pitch, and yaw. The accuracy in the heading is a 1° RMS accuracy at 0.1° resolution. The orientation data update at 20Hz and communicates over a RS-232 serial line with a built-in USB converter. Sensor fusion with the GPS takes place in software for better heading accuracy.

Digital Camera

The Ion Action Camera is an outdoor sport, consumer grade 12-megapixel digital camera with a wide 170° field of view lens. The camera is configured to output 720x480 standard definition video. This video is streamed to the computer with a digitizer and captured at 20Hz. The camera runs off its own battery power with a typical use time of 2.5 hours of continuous streaming.

LED Panel

The LED panel is a 8 x 32 LED pixel panel that allows up to show basic operating information at a glance. This system interfaces with the microcontroller on the power board to display any information passed to it in a simple format. Currently it can display the state of the robot in RC, Autonomous, or Remote Operation mode, but has also been tested showing what waypoint it is the current goal heading.

Motor Interface

DAISI uses a new onboard Mbed-based microcontroller that is embedded inside the custom power board to relay commands to the motors. The microcontroller receives motor commands from both the laptop over the RS-232 serial interface and the radio controller, meaning DAISI can be controlled manually independent of a computer.

Safety Devices

DAISI incorporates a direct voltage cutoff system built into the power board as part of the safety system requirements. This system cuts off power to the motors but keeps the sensors running to avoid a long restart time. E-Stop buttons are located both on the sensor pole and on the RC controller. In addition to the mechanical emergency stop system, an LED strip indicates to bystanders when the system is under autonomous or manual control.

In addition to the hardware E-Stop, the power board also has a software E-stop for the motors as a redundant system. Where the hardware E-stop kills the power to the motors, the software E-stop sends a zero-speed command to the motors, which allows for a quicker restart time after being E-stopped compared to the hardware E-Stop. The RC controller emergency stop has a range of 0.25 miles, and when DAISI exits that range, it is automatically stopped.

Software Design

Overview

The software was developed in the National Instruments LabVIEW environment. As part of this software DAISI has an intuitive Graphical User Interface (GUI) to monitor, modify, and tune system functionality in real-time. The GUI helps verify real-time sensor statuses and path planning decisions for the current course. The flow of the code is organized for parallelized decisions that feed into a centralized trajectory planner. The highest priority for DAISI's trajectory planner can be seen in Figure 6.

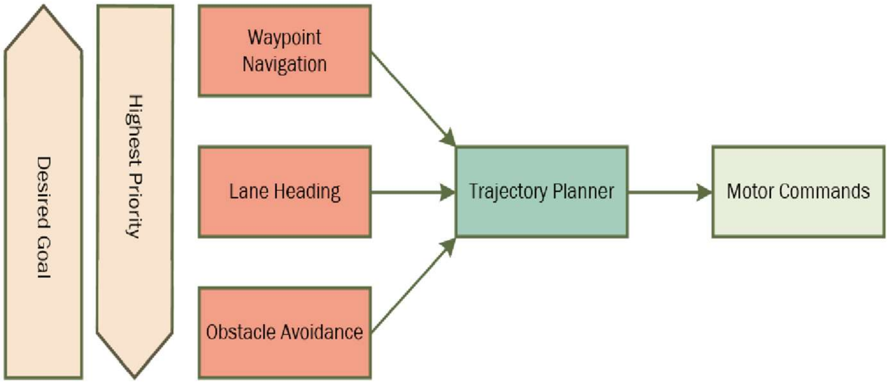


Figure 6: Software Priority

The software overview can be seen in Figure 7. The sensor modules feed the data into the MAIN program, which handles data queuing for any process to pull from. The sensor data is then fed in the Basic Robotic Autonomous Navigation (B.R.A.N.) module where the data is utilized by path-planning algorithms. The output of the path-planning is sent back into MAIN, where it is processed and sent out to the motors.

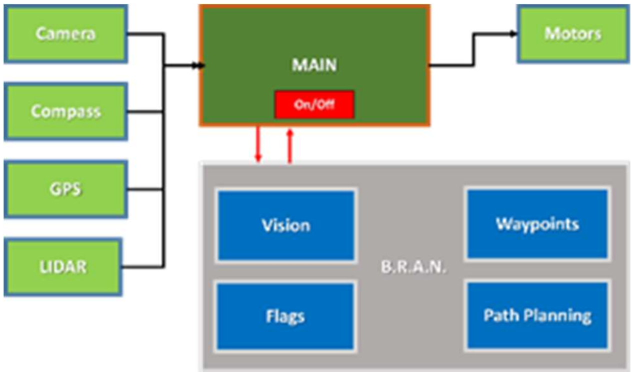


Figure 7: Software flowchart

Obstacle Detection and Avoidance

DAISI's obstacle avoidance algorithm uses a LabVIEW function called "Advanced VFH" to create a new heading around obstacles. This function implements a use of a Vector Field Histogram (VFH) to determine location of obstacles. The Lidar data is passed into the Advanced VFH module, and when an object is detected within 2 meters of the robot, it is classified as an obstacle. The function uses the previous heading and the values of classified obstacles to output a new heading that avoids the obstacle field.

Software Strategy and Path Planning

Waypoint Navigation

The lowest priority for DAISI's trajectory planner is to follow the current waypoint location. This means that DAISI's final destination is the waypoint, but the lane heading and obstacle avoidance determine the actual path on how DAISI will reach the waypoint goal. The waypoint navigation algorithm calculates the angular difference and error to the waypoint by using the GPS's position data and the IMU's heading data. The navigation data is sent to the trajectory planner as the goal point for all navigation data.

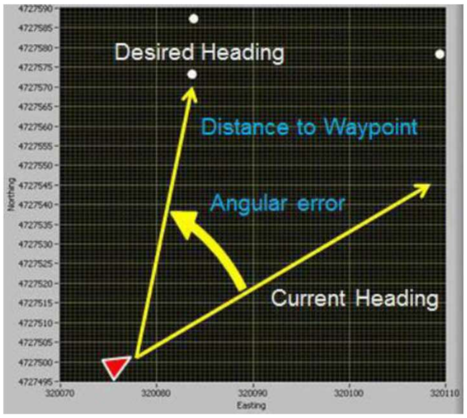


Figure 8: Waypoint Angular Error

Lane Following

Once the direction to the waypoint is determined, the next section of code implements Lane-Following. The Lane-Following flow diagram, shown in Figure 9, illustrates the primary steps in the line extraction algorithm. The algorithm's goal is to first prepare the image feed for image processing, then extract the location of the lanes. To prepare for image processing, irrelevant data such as the sky's horizon and the robot's frame are cropped out from the image. The image is also resampled at 360 X 180 resolution and blurred with a Gaussian filter to reduce processing time and blur out noise respectively from the image.

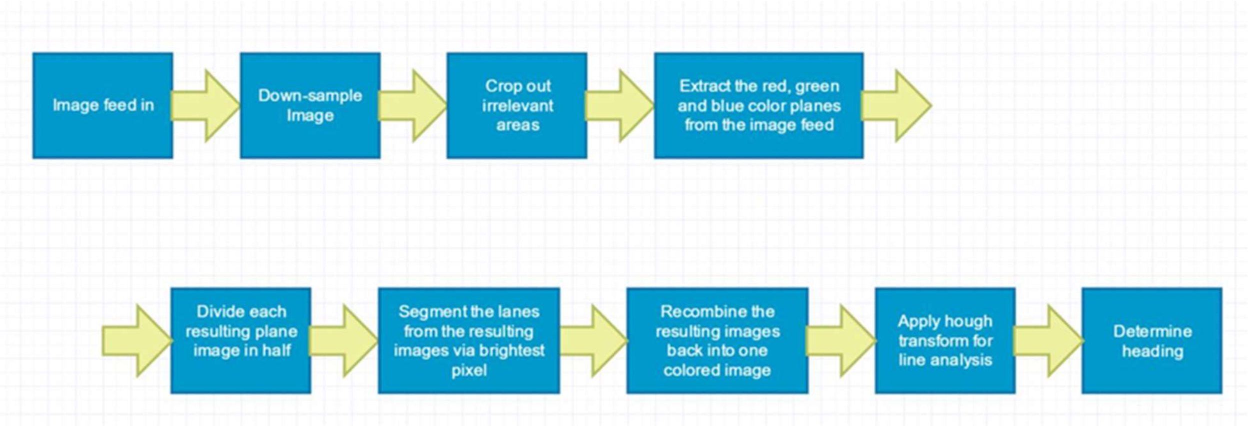


Figure 9: Lane-Following flowchart

After preprocessing, lane segmentation takes place by extracting the three primary color planes, red, green and blue from the image feed. Each color plane image is divided in half for parallelized image processing, and a brightest pixel algorithm is applied to each divided image. The brightest pixel algorithm isolates the white pixels by scanning both horizontal and vertical axis of the image for the pixel(s) of highest value. The result is the segmented lanes within each color plane. To be robust to various lighting conditions, the results from the three primary color planes are combined into one final colored image as seen in Figure 10.

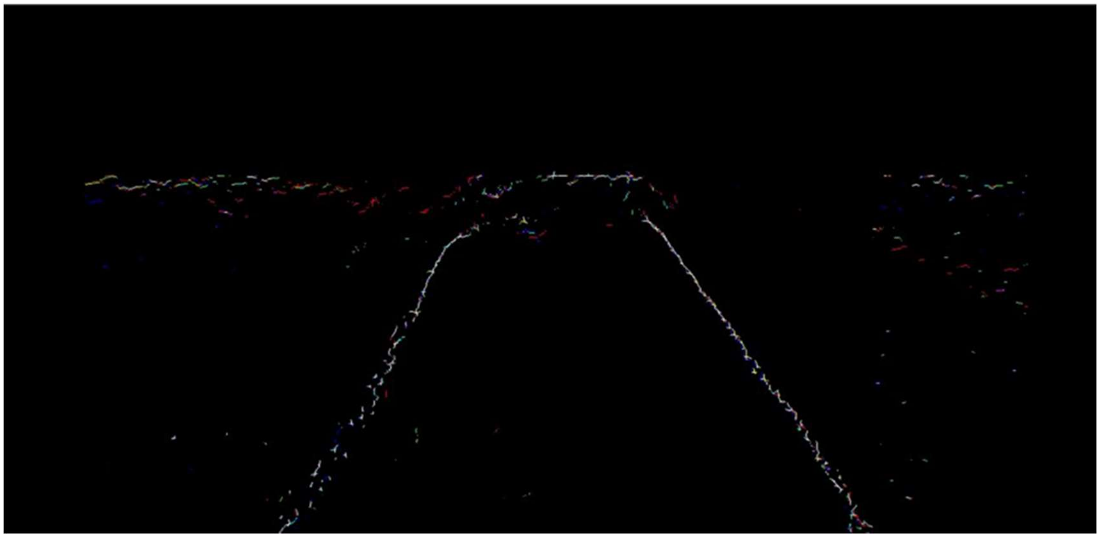


Figure 10: Segment the image

After this, a Hough transform is used to find the best fit lines in each image half. It is possible that no line is detected in the image if no candidate receives a minimum number of "votes" in order to be considered a line. If lines do exist, they are categorized as horizontal or vertical, and compared with each other as parallel or intersecting. The last step is to recombine the half-images and draw an overlay on the location of the lanes as seen in Figure 11.

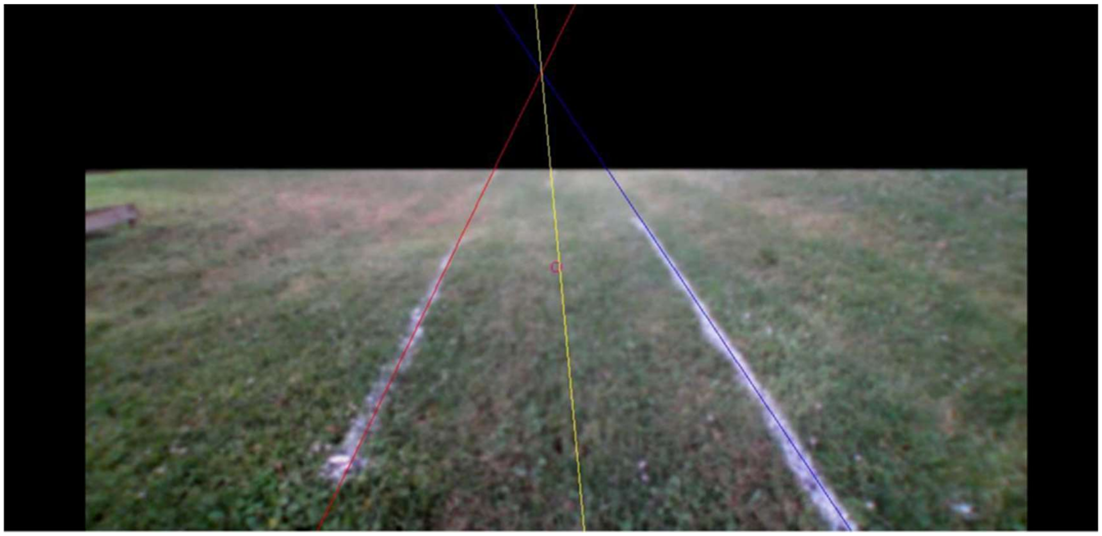


Figure 11: Identified lane

A red line represents a line on the left, a blue line represents a line on the right. A decision tree is then used to select the heading given the possible combinations of lines as seen in Figure 8. A yellow line is then displayed in the image to represent this desired heading. For example, if two lines are detected, the heading should be between them. If only one line is detected, then the heading will be a few feet left or right of this line as appropriate to stay within the course. In addition, this algorithm works for both solid and dashed lines.

Pothole and Ramp Detection

The next stage in the vision processing is to identify the potholes and the ramp in the image. In both cases, the algorithm checks the image for a particular shape of a set area: a circle or a rectangle. If the circle criteria is met, the algorithm will identify this as a pothole; whereas, if a rectangle criteria is met, the algorithm will identify this as a ramp. When the ramp is detected, its entire visual appearance shines as bright as the surrounding lines due to its high spectral reflection. The ramp problem is solved by generating a blank strip down the center and using the edges of the ramp as a pseudo-lane. The pothole information is then passed to the Obstacle Avoidance algorithm to ensure the pothole is treated as an obstacle.

Goal Selection and Path Generation

The trajectory planner is responsible for generating an appropriate heading for DAISI to follow based on all the information fed to it from the active algorithms. It is made up of two parts: the desired heading and the desired goal. The heading is selected based on available algorithm data from the software subsystem hierarchy seen in Figure 12.

The desired path goal uses a reverse priority order: waypoint navigation, lane heading, and then obstacle avoidance from the Advanced VFH. The goal heading is the next desired waypoint. The desired heading is the desired outcome from the algorithm.

Figure 12: Path planning flowchart

The waypoint navigation subsystem is the first step in finding the goal heading by initially finding the most direct route to the desired goal. Next the desired heading is updated with the input from the lane heading subsystem. This accounts for lanes up to five feet in front of DAISI to keep DAISI inside the course. Finally, the obstacle avoidance subsystem is used to prevent DAISI from hitting any obstacles. The combination of these algorithms will choose to find the heading to meet the priority heading criteria while attempting to converge to the goal heading.

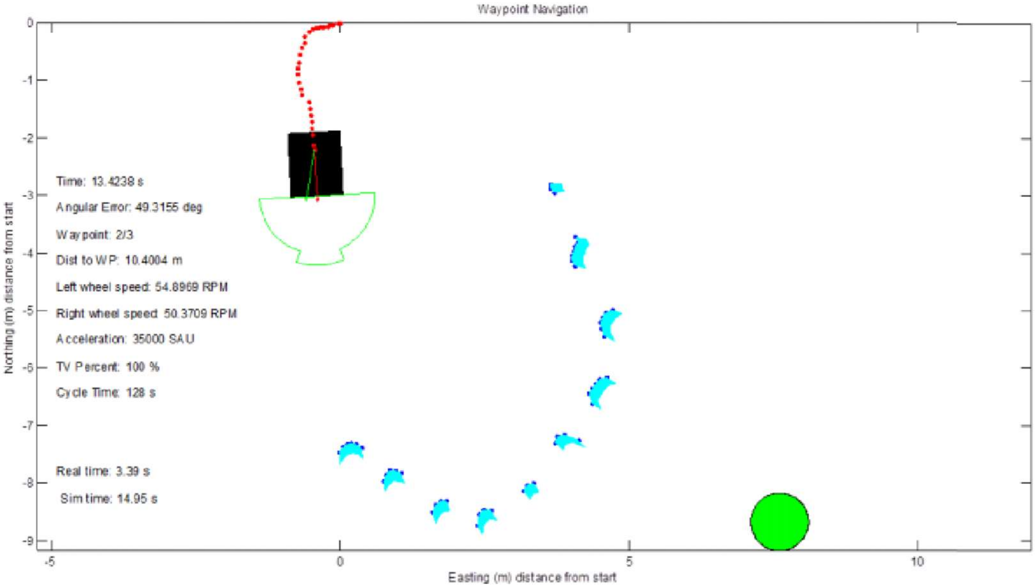
Additional Feature: Modularity

The software integrates a messaging protocol structure which was developed by students within the Robotics Association of Embry-Riddle for the Maritime RobotX competition. This structure, referred to as “Minion Core”, allows the software to work as a system of modules, by passing data stored in “messages” across different computer processes. This allows LabVIEW to handle parallel-processing tasks more efficiently while retaining the ability to hot-swap sensors. This structure consists of individual modules that implement libraries consisting of publisher/subscriber protocols similar to JAUS. The modules can run parallel and communicate asynchronously.

Map Generation

DAISI doesn’t rely on previously generated maps, but instead works on a reactive system in the same style as how an autonomous car does. It has a local state of information plus the goal heading which it aims for. This is because the real world does not stay constant, such as construction and other moving vehicles, and is reflected in the IGVC competition because the judges can and do change the course between runs. However, all this information is not gone to waste, as it is logged and can be played back to understand how DAISI reacted to the environment in the MATLAB simulator.

The data logging system helps immensely with the testing and refining process by identifying problems that cannot be immediately noticed by vehicle performance inspection during a test. The output of the program is shown in Figure 13. The black rectangle represents the robot, while the blue represents obstacles, and the green circle is the target waypoint. The green semi-circle extending from the vehicle is the obstacle avoidance range, which will cause a reaction from the robot. The red dots show the vehicle’s GPS trail. On the left-hand side are numerical values that can be customized to whatever the user wishes to see, including elapsed time, wheel speeds, and latency. Data can be fed into the system simulator from the data simulator to observe the output of the system, which is useful in determining software issues without needing to go outside and have a test run for each new change.



```
Time: 13.4238 s
Angular Error: 49.3155 deg
Waypoint: 2/3
Dist to WP: 10.4004 m
Left wheel speed: 54.8969 RPM
Right wheel speed 50.3709 RPM
Acceleration: 35000 SAU
TV Percent: 100 %
Cycle Time: 128 s

Real time: 3.39 s
 Sim time: 14.95 s
```

Figure 13: MATLAB system simulator

Failure Modes and Resolutions

Vehicle Failure Modes and Resolutions

Although DAISI was designed for maximum rigidity and modularity, failures are always possible. To combat this possibility, a number of different failure modes have been identified, and resolutions have been put in place in order to minimize the negative results of any failure.

Mechanically, the vehicle continues to use a few hardware components and sensors from previous years. These components were thoroughly tested in order to ensure their integrity. In the event of a failure, the vehicles design and construction were focused around the concept of modularity. Due to this focus, components are easily removable and replaceable. Attached to the vehicle is an onboard toolbox which contains necessary tools to swap out any physical structure necessary.

In addition, if a sensor fails a replacement can be swapped with no software changes due to the health monitoring system in place. Some sensors tend to lose connection when connectors are jolted or other general software crashes. The software is constantly monitoring the sensor connections for any errors that may arise from communication protocol issues or disconnections and attempts to reset sensor connection. While the sensor is down, the previous set of data is then used until the senor is reconnected. This data then produces a trigger that allows the map to take over navigation until the newly installed sensor updates.

Failure Prevention Strategy

Health Monitoring

The software is only as durable as the communication with the sensors. Some sensors may lose connection if connectors are jolted and/or general communication crashes. The software is constantly monitoring the sensor connections for any errors that may arise from communication protocol issues or disconnections and attempts to reset sensor connection. During the reset, the algorithms send a dummy set of data, as if the course is free, and then uses the existing feedback data to aid in temporary travel. The dummy data sends a trigger to show that the map should take over until new sensor updates occur or if the approximated location has no new data.

Vision Processing

With vision-based algorithms, the toughest part of maintaining great results is dynamic lighting impeding the detection of white lines. The physical and solar interference affect the actual image quality due to washing out the scene. The most pertinent change is the change in sunlight: the direct sunlight versus a cloudy day can change mid-run and affect the amount of luminance on the ground. The software combats the chance in sunlight issue by preparing to find a very sunny set of lines on the ground. With the dead grass and flowers in the lanes, these objects could be considered as potholes or the ramp (based on size of patches) to help filter them appropriately (based on vision algorithms) and continue navigating accordingly.

Performance Testing

DAISI was tested in an outside environment that was similar to the IGVC competition layout. The white lines painted on the grass with orange traffic barrels placed throughout made for a great place to test DAISI in a pseudo- competition environment.

Before the outdoor test could be conducted, each subsystem had to pass a quality assurance check to make sure the systems were still working. Each of the sensors, being reused from last year, were checked in the lab to ensure the cables still had a good connection for both power and data.

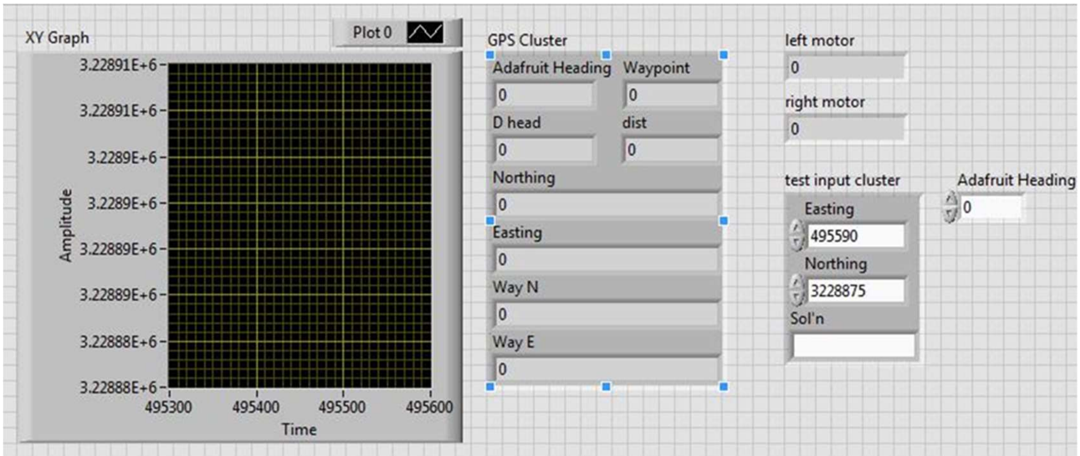
Before physically making the new frame, it was first created as a CATIA model, where the stresses and strains on the frame could be measured and adjusted before making the first prototype. This ensured that the frame could withstand the force of the payload and computing system on top of it.

The subsystem tests were performed before each time DAISI was tested outside to ensure no problems had arisen between tests. This allowed for problem-free tests of the software. As each software algorithm was tested, from waypoint to obstacle avoidance, a remote E-Stop, operated by a secondary team member, was always at the ready to prevent unexpected drive patterns for a safer test environment.

Simulation

LabVIEW

To troubleshoot issues with software a simulator was created so that DAISI's GPS position and IMU heading could be manually controlled to observe how DAISI would react. This program allows software to be bench tested from the lab and the team can use it to troubleshoot issue that could typically only be seen when driving the system. Not only does this save team members' time in the troubleshooting phase of software development, this also prevents hardware modifications from delaying initial software tests. The simulator can only be used when the GPS and IMU are turned off, as manual control of the GPS position and IMU heading requires that those values aren't being overwritten by the sensors or their health monitoring system. Figure 14 below shows the front panel of simulator.



GPS Cluster

Adafruit Heading 0

Waypoint 0

D head 0

dist 0

Northing 0

Easting 0

Way N 0

Way E 0

left motor 0

right motor 0

test input cluster

Easting 495590

Northing 3228875

Sol'n

Adafruit Heading 0

Figure 14: LabVIEW data simulator interface

Conclusion

DAISI is a fully autonomous robotic vehicle designed, manufactured, and tested by engineering students at ERAU. The DAISI team gave special attention to both the requirements of the IGVC competition and the requirements set forth by their professors and peers. DAISI accomplishes the team's goals of creating a lightweight, safe, maintainable, and accessible robot with a modular design. DAISI will be completely fine-tuned and ready for the Summer 2018 IGVC competition. The team feels confident that DAISI will not only be capable of completing both the basic and advanced practical course, but that it will also impress the judges with its intelligent and innovative design.

References

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