Florida Tech IGVC Milestone 6 Report

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Milestone VI

Florida State University did not deliver the robot with enough time for us to prepare for the senior design showcase. However, the robot will be delivered to Florida Tech on April 13th and remain at Florida Tech until the competition. In the time remaining before the competition we hope to integrate most of our capabilities into the robot and be able to navigate the course.

Task Matrix

#	Task	Brent Allard	Adam Hill	Chris Kocsis	Will Nyff.
1	Lidar & Lines	0%	25%	75%	0%
2	Testing & Integration	25%	25%	25%	25%
3	Motion Planning & GUI	100%	0%	0%	0%
4	Startup, Control, & IOP	10%	60%	0%	30%
5	Comm. Maintenance	10%	10%	10%	70%
6	Demo Video	25%	25%	25%	25%
7	Documentation	25%	25%	25%	25%

Discussion

Task 1

Lines detection has been tested extensively on a CPU and gives good algorithms implemented for a GPU will be tested in the next several weeks. The algorithms used may be applied to obstacle detection, which in time will remove the Lidar thereby drastically decreasing the cost of the robot. Higher angle images are possible using polarized film; however, there is a practical limitation on how the camera handles light changes. The camera normalizes light levels within its own driver by optimizing the time used to take an image. When drastic changes in lighting occur the camera must renormalize itself over a few frames. Those frames will need to be recognized as poor frames and removed.

A GPU implementation will be tested and documentation written for the next team to implement obstacle detection using the distance map provided by the ZED and arc detection algorithms similar to the line detection algorithm.

Task 2 & 3

A simulation was written to comprehensively test the performance of the motion planner concerning several factors:

- Modifying a map at run time
- Dynamically re-planning course traversals as the map is modified
- Sending executable commands to a motor control unit

The motion planner performs admirably as does the communication framework which facilitates the simulation. The planner itself seems to perform optimally when it sends commands that can be executed in one tenth of a second and adjusts well to new obstacles.

Concerning integration, the robot has still never been at Florida Tech long enough for us to integrate everything together. On April 13th the robot will be driven from FSU to FIT and at that point integration will really begin.

Among other tests that need to be conducted; we need to consider durability especially of the communication framework to bad messages.

Task 4

Startup scripts still need to be written; however, Adam made a breakthrough concerning the interoperability challenge and has instead focused on that aspect of the competition. With luck, we will be able to complete that challenge. Concerning scripts all of the Java behavior is handled; however, scripts for remotely starting components need to be written.

Task 5

FSU was unable to complete their localization work; however, the LiDAR now outputs occupancy grids. Work concerning the LiDAR only requires us to send those messages to the motion planner with timestamps. That will require implementing a single message. Similarly, the INS message output is fairly simple.

Task 6 & 7

Documentation for both this milestone and next year’s team has been completed. Additionally, most of next year’s team has already been recruited and is being brought up to speed. We are potentially going to clean the entire code base between now and the competition depending on the time available.

Contributions

Everyone collaborated to produce adequate documentation and demos

Adam Hill

Adam made a breakthrough concerning the interoperability challenge and has been working on producing the entire frame. After reading through a series of documents he has found a way to autogenerate the SAE JAUS required interfaces and begin integrating them with our code. There is one significant error concerning networking which prevents him from completing the task outright. Adam has also worked with the team's mechanical and electrical engineers to do software-hardware integration.

Brent Allard

Brent improved the motion planning algorithm and implemented the interface for the motion planning system with incoming lines and obstacles. The course map built by the component is modifiable; recalculating paths costs a trivial amount of time. Brent also worked on a simulation for showcase which demonstrates how the motion planner performs in real time. This simulation is being extended to help with software-hardware integration. Components of the simulation may be replaced by actual data or live software components.

Chris Kocsis

Chris implemented his line detection code on a GPU and now has results concerning lines. The algorithms used will be extended to obstacle detection in the future. Chris has converted lines on camera images into lines on the ground (transforming data). Chris has also improved the fidelity of the lines detected by combining images from both cameras and estimating when the line detection itself has failed. Failures in line detection can occur briefly during rapid changes in light levels or when an extremely bright image suddenly becomes visible.

Will Nyffenegger

Will worked on the simulation for showcase and on the communication framework. Will also worked on the implementation of remote control and on determining how to conduct position estimation.

Lessons Learned

Our lessons learned range from mundane to unique as dictated by the project. Lessons center on management, research, software development, and software engineering. Everyone on the team has gained knowledge of subject areas previously not possessed including a general understanding of autonomous robotics.

Concerning management the team learned about the expected scheduling, planning, etc. More interestingly, the team learned how difficult it is to work remotely with another group especially when that group does not share the same vocabulary. The Florida State University team was composed entirely of mechanical and industrial engineers. While those engineers are qualified, the difficulty of breaching the technical experience gap caused many errors on both sides. The incompleteness of the robot can be attributed mostly to those errors. The team used several tools—Slack, OneDrive, GitHub, etc—to stay organized. Slack has great potential as a tool to integrate many of these tools together using plugins. Communication tools are valuable, but do not substitute for in person conversations in work.

A detail which surprised the team was the difficulty of producing a prototype. A prototype robot would have made testing much simpler. However, a prototype is useless if it does not accurately model the actual robot. Particularly for the motion planner, an inaccurate prototype would make parameterizing the motion planner useless. Splitting one robot between both schools did not work; but, developing a prototype was an added expense that we could not accommodate money or time wise. The team designed simulations for the course, took test data from sensors, and integrated systems as possible. Unfortunately, simulations do not simulate for full integrations of the system. Furthermore, Florida State University possessed hardware that FIT did not. That hardware, and the code for that hardware, were rarely in our possession. Just because FIT used the software mentioned above for organization does not mean that Florida State University did.

Research, though not often mentioned in class, is a limiting factor. Autonomous robotics contains many problems related to computer vision, artificial intelligence, software standards, which are not covered in class. Ideally a sufficient amount of time would be dedicated to research before development; but, decisions had to be made early in the project. Later, the team discovered challenges like localization that continue to impede the team. Realistically, there is nothing we could have done to discover those challenges sooner and still finish many of the components of the project. Breaking into a new area with a project requires several iterations of design and the resources necessary to extensively survey a field.

From a software engineering perspective the team relied less on many software engineering concepts than we initially expected. Attempts at setting up continuous integration, issue tracking tools, and test suites fell flat from the limitations on time. Even the software for an autonomous robot is not a large enough system to truly require that much testing. Writing the software with a focus on modularity provided more value. Components developed independently were integrated based on the interfaces defined by their tests. The tests were defined by the communication framework used. The base of the software provided more value than any testing software could. For large projects the value of testing may be amply demonstrated; but, for smaller projects the value is limited. The project demonstrated how useful existing libraries and tools can be for fast development of a product. Dozens of open source libraries are used in the project with many others peripherally used for testing and development.

The scope of even single components of the software demonstrated how useful iterative design is. Software development occurred by running experiments on data obtained either through tests or simulations. The initial software developed during the fall has for the most part been scrapped in favor of improved designs. The motion planning component and image processing component have gone through several iterations to reach their current state. The FSU team created problems for themselves by trying to implement solutions in one iteration instead of experimenting.

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Evaluation:

William Nyffenegger	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
Chris Kocsis	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
Brent Allard	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
Adam Hill	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10