

# **GPS Guided Robotic Car**

Progress Report 4

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# “GPS Guided Robotic Car”

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## Objective

The objective of this document is to describe the completion level of the project.

## Discussion

The work done on the project during the past three weeks can be broken down into several categories:

1. Enclosure enhancement. The previous period of work on the project was concluded with construction of the new enclosure (see Appendix 1, figure 2, 3). As a logical continuation of this process the enclosure was perfected yet farther. As one can see in figures four and five, an all-new clear plastic box was used in conjunction with a bigger LCD. The new four lines by twenty characters LCD was acquired as to communicate greater amounts of data as compared to its predecessor (two lines by sixteen characters).
2. Traceability and visibility of project. When the work on the project began there was a thought to develop a website (possibly a blog) describing the progress achieved on the project. This thought survived and recently became a reality. The MTU Supermileage website<sup>1</sup> now has a new branch – a GPS blog page.<sup>2</sup> This site is dedicated entirely to the navigation system development project and lists major achievements with dates, pictures, maps and videos to further substantiate the visibility of the project.
3. Test bed completion. As it was stated in the preceding progress report, an RC car was acquired. It was modified as to allow the navigation system’s hardware be easily installable and serviceable. Some additional modifications

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<sup>1</sup> <http://www.enterprise.mtu.edu/ase>

<sup>2</sup> <http://www.enterprise.mtu.edu/ase/GPSblog>

were performed on the electrical circuitry side of the car. Original thought was to discard all the onboard circuits. However, farther analysis showed that most of the devices on the car could be reused. One of these devices was an H-bridge driver board for the car's rear propulsion DC motor and front steering DC motor. Another piece used was the remote that came with a car. The reason that it was kept is that it is much easier to send control signals<sup>3</sup> from the main microcontroller to the remote as compared to sending signals straight to the motors.

4. Functionality enhancement. The last progress report stated that one of the future goals will be to activate the Inertial Measurement Unit. This goal was accomplished during this quarter. The analog to digit conversion routine required for converting IMU acceleration values into digital values that microprocessor can understand was programmed into the main loop of the navigation system code. As soon as a working release of the code was finished (version fourteen), the system was transferred onto the RC car and tested in a rather simple but very informative way. The car was programmed to accelerate at a steady pace forward and at constant acceleration the left (in casual language, it was told to keep on a circle of constant radius). Even though this challenge might seem trivial, it has provided an insight into how the code should have been restructured. Initially the IMU was serviced every loop<sup>4</sup> which was quite infrequent (about 1-2 Hz). The video and a map of part of this test run is available on the project's website or at the following direct link.<sup>5</sup> Any casual observer can notice that the car was driving rather jaggedly. As it was logically deduced, the reason for that was the fact that the IMU was serviced very seldom. From that rare information the car 'could not make

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<sup>3</sup> Such as: accelerate forward or turn left or right, etc.

<sup>4</sup> In small scale RISC microprocessor world there is no operative system running on chip. All there is, is a one big main loop that is repeated as soon as it's finished.

<sup>5</sup> [http://www.enterprise.mtu.edu/ase/gps/videos/MVI\\_1320.AVI](http://www.enterprise.mtu.edu/ase/gps/videos/MVI_1320.AVI)

sense' of the situation. It didn't know what was happening during that second or two that it had no fresh acceleration data. Was it accelerating too fast or is it time to turn again yet?

The revised version of the code (see Appendix 2 and 3 for flowchart) dealt with this problem by using interrupts. Interrupt is a subroutine that is called in the main loop as soon as an event occurs. There are many preset interrupts in the microprocessor used and some are left open to be generated by user. For example, as soon as the microprocessor is done converting the analog voltage coming from the X-axis accelerometer, it will set a flag (a bit in register space) and call the X-acceleration interrupt handling subroutine. As soon as this change was in place, the system was tested again. The result was unbelievable – the car was making steering decisions much more frequently and in a much more accurate fashion. As it can be seen in the map available on the website<sup>6</sup> the car drove in shapes resembling circles. One might also observe that these circle-like figures are elongated in the North-direction. This can be explained by the fact that the place where the testing took place<sup>7</sup> where the testing took place is sloped in North-South direction. Another reason for this effect would be the fact that the GPS positioning data was not enabled in the navigation process during these test runs. These runs were designed to test the vehicle's behavior with no GPS assistance. In future, however, the two sensors combined will produce a much higher degree of accuracy.

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<sup>6</sup> <http://www.enterprise.mtu.edu/ase/gps/map2/2.jpg>

<sup>7</sup> In front of EERC building on MTU's campus

## **Conclusion**

The accomplishments produced during the final quarter of this program can be classified as a breakthrough in both hardware system design and modular code assembly. The provided the researcher with some of the most satisfying and reliable test samples of system's behavior in real-life conditions. At the same time, every achievement was a lesson how one thing could be done and how it really should be done to work properly.

Even though the term of SURF research is over, the work on the project will continue in September. The tasks that are still on the to do list are Kalman filter design and integrating the navigation system into the MTU Supermileage car.

## Appendix 1. System comparison: previous setups vs. current setup

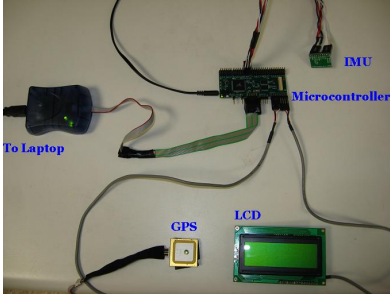


Figure 1. Original setup



Figure 2. Intermediate setup

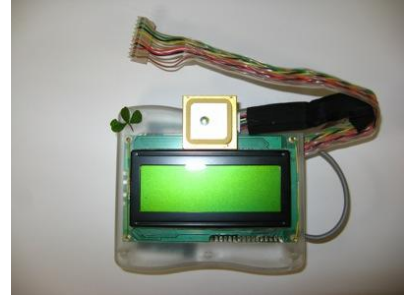


Figure 4. Current setup

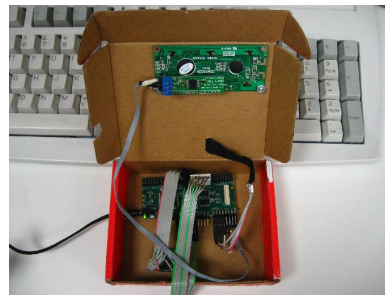


Figure 3. Intermediate setup



Figure 5. Current setup

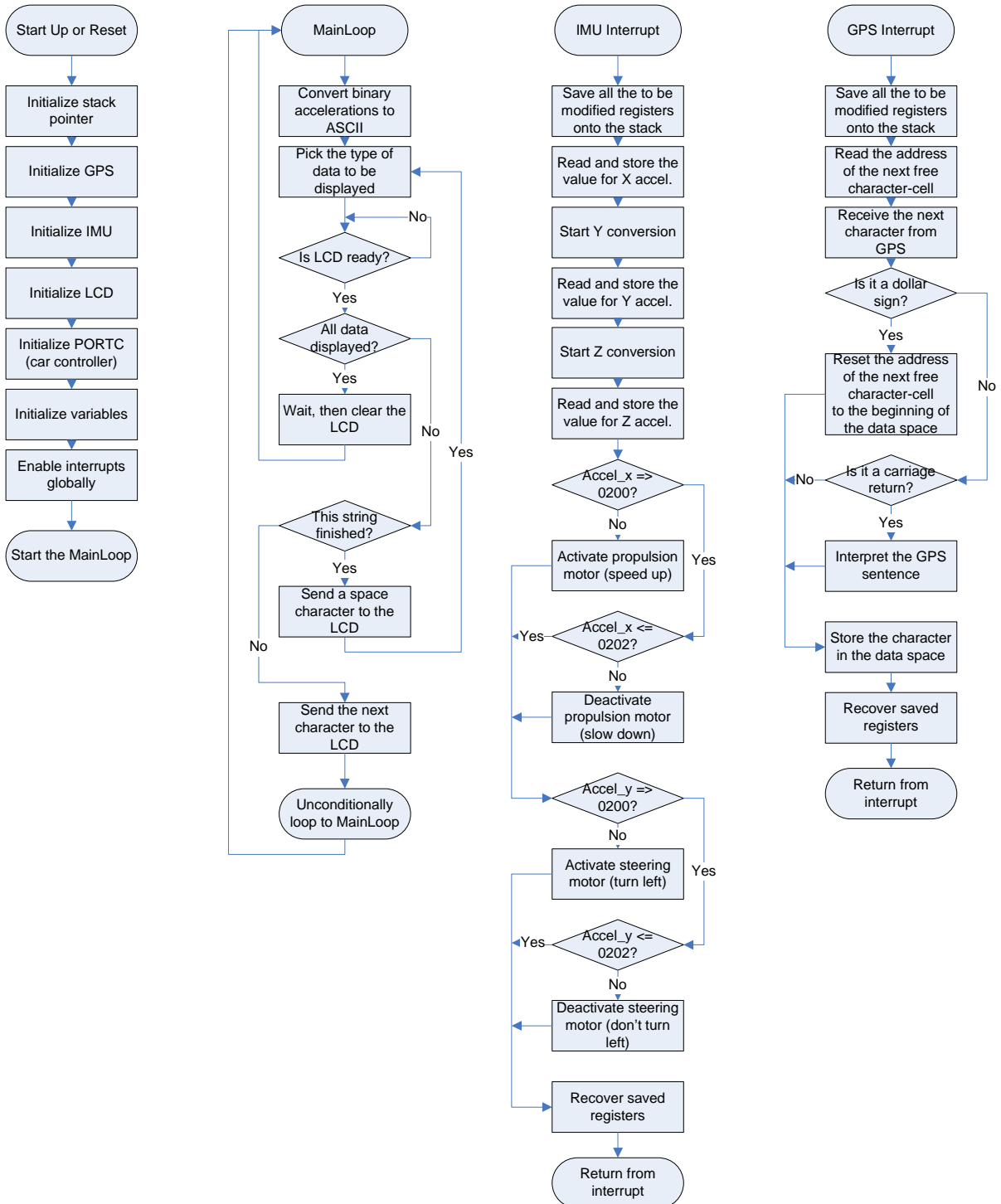
## **Appendix 2. The latest version of the assembly code (v 15)**

For electronic version: Please see attached file or go to the following address for an online copy  
<http://www.enterprise.mtu.edu/ase/gps/inprogress/gps15.pdf>

For an electronic version of a flowchart to accompany this code, please see next Appendix or go to  
[http://www.enterprise.mtu.edu/ase/gps/inprogress/flowchart\\_gps15.pdf](http://www.enterprise.mtu.edu/ase/gps/inprogress/flowchart_gps15.pdf)

# Appendix 3. Simplified flowchart to accompany the latest version of the code (v 15)

## Navigation System Code (v 15)





## Appendix 4. Images of the latest test-bed-system

