Autonomous Wheeled Experimental System for the Investgation of Multiple Objectives(Awesimo) robot

a vision based experimental platform

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3. Abstract

The Awesimo robot will use a detailed ranging sensor and autonomously move over varied terrain (floor, carpet, hilly dirt, grass) avoiding obstacles and ultimately moving from point to point using GPS or other local navigation methods. Ultimately Awesimo will cooperate with another robot to move in formation with this robot. My short-term objective is to integrate the Swiss Ranger, a device that can detect detailed range data over short (.05-15 meters) distances. The project objectives are as follows:

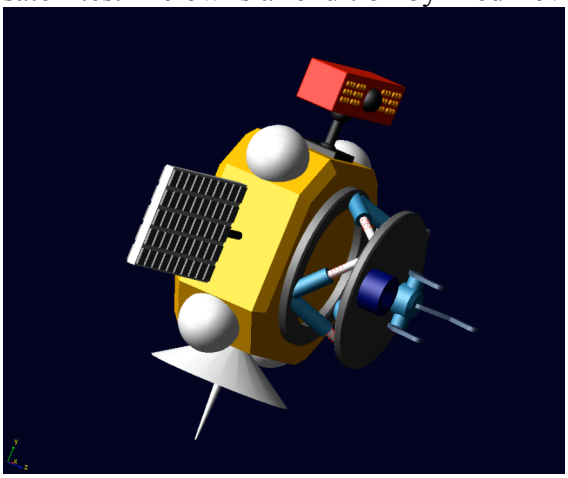
1. Integrate the Swiss Ranger onto the robot.
2. Learn to control the Ranger settings in onboard software and take usable data. This is in progress.
3. Make Awesimo exhibit basic obstacle avoidance behavior. This will only use a few pixels of the Rangers capability and simple avoidance logic but will provide a basis and template for further development.
4. Imbue greater intelligence into the avoidance algorithm and use more of the ranger's capability to create a more detailed view of the world. This could take a while.
5. Integrate some memory fitting so the robot will create an image in memory of the world around it.
6. Integrate GPS or inertial position sensing onto the robot so…
7. Make the robot follow waypoints while avoiding impassible terrain and obstacles.

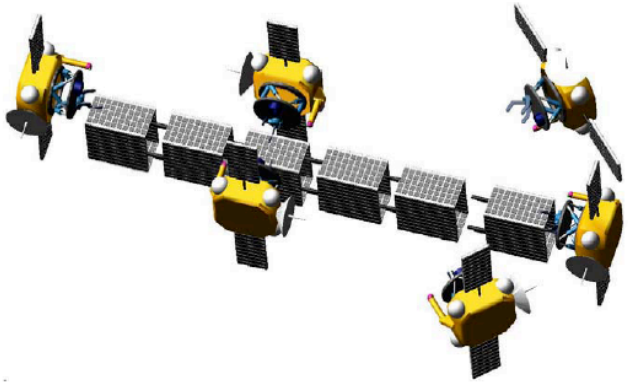
4. Executive Summary

The Awesimo Robot is a test bed for the integration of the Swiss Ranger sensor. The Vehicle is a modified electric RC monster truck with an embedded EPIA-M x86 based computer onboard. The computer controls the truck with a servo controller board and can communicate over a wireless Internet connection. The Ranger is mounted on the front and provides the vision, giving a range image the computer can use to make decisions and image the world. The Awesimo project goals are to integrate the Ranger onto the robot, demonstrate obstacle avoidance, integrate the past images and the present to create a memory of the surroundings; plan and act based on those surroundings, and lead a formation of other specialized robots. Further uses are not defined but the robot is intended to be a test bed and many uses have been proposed.

5. Introduction

The Awesimo robot is motivated by the requirements of the Heros Autonomous Satellite project to have an earthbound test bed for subsystems and control methodologies. The Heros Project is a DARPA funded study of an autonomous swarm of small, semi-disposable, specialized cooperative. The goal of Heros is to prove the feasibility of on orbit servicing, manufacturing, and exploration by small, relatively inexpensive cooperating specialized robotic satellites. Below is a rendition by Fred Leve of what the Heros might look like:





To help achieve this goal, Awesimo was conceived to test, among other things, the feasibility of integrating cutting edge range sensors with autonomous control in a small package. Additionally, once Awesimo is a proven platform, it will be used to test formation and orientation algorithms with other mobile robots. Awesimo is intended to last beyond even this purpose, serving as a test platform for yet to be defined purposes relating to autonomous intelligence and utility.

For the purposes of this IMDL class, work focused on integrating the Swiss Ranger vision system with the robot, developing obstacle avoidance routines, and creating a graphical interface with output to facilitate creating a world in memory.

6. Integrated System

Awesimo is basically a computer on wheels. It uses the E-MAXX! Model 3906 RC monster truck for movement and an embedded VIA EPIA-M Mini-ITX Mainboard with a VIA C3TM E-Series Processor. The onboard computer is running the latest stable build of Gentoo Linux, a flavor of Linux designed for customization and ease of maintenance. Awesimo can be used like a conventional computer with attached keyboard, mouse, and monitor or is can be used thru a Virtual Network Computer, or VNC over a wireless IEEE 802.11g card. Awesimo can also interface thru ssh but the ultimate goal will be an embedded QT interface that will enable a user on a remote machine to control the behavior choice, set waypoints, and better evaluate the robot's performance. Please see the attached flowcharts to get an idea of how the robot works.

7. Mobile Platform

While operating independantly, Awesimo's movement is powered by two 7.2V Ni-Mh batteries, controlled by the motor controller. All other systems, including the computer, ranger, servo controller, servos, and any other sensors, are powers by a 15V Li-ion battery. The expected operation time for both is in excess of 30 minutes given normal driving conditions, providing ample time to test sensors, algorithms, or maneuvers before discharge.

One noticable feature of the structure is the Aluminum cage separating the RC parts, including the servo controller and the electric motors, from the computer and sensors. This is intended to act as a Faraday cage and reduce errant signals.

New springs have been added that greatly improve will be added to the suspension to improve this problem but it still must be considered.

8. Actuation

The only planed actuation is thru the three channels of the E-maxx monster truck, actuated by the Mini SSC II serial servo controller. This uses one servo to control steering, one to control the gear setting(high or low) and a servo signal sent to a motor controller provided with the RC monster truck. The motor controller can be set to many throttle settings in forward and back, and can also be set to brake the robot. Further testing will be required to determine if these settingw will be sufficianly fine for these purposes.

It should be noted that there are no plans to ever change the gear setting from the low speed, high torque postion as it is capable of perhaps 10MPH in this state, far faster than it should ever be driven autonomously and the high speed setting the E-maxx is capable of over 25 mph. The gear has been glued to the lower setting, freeing a servor for other future uses.

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9. Sensors

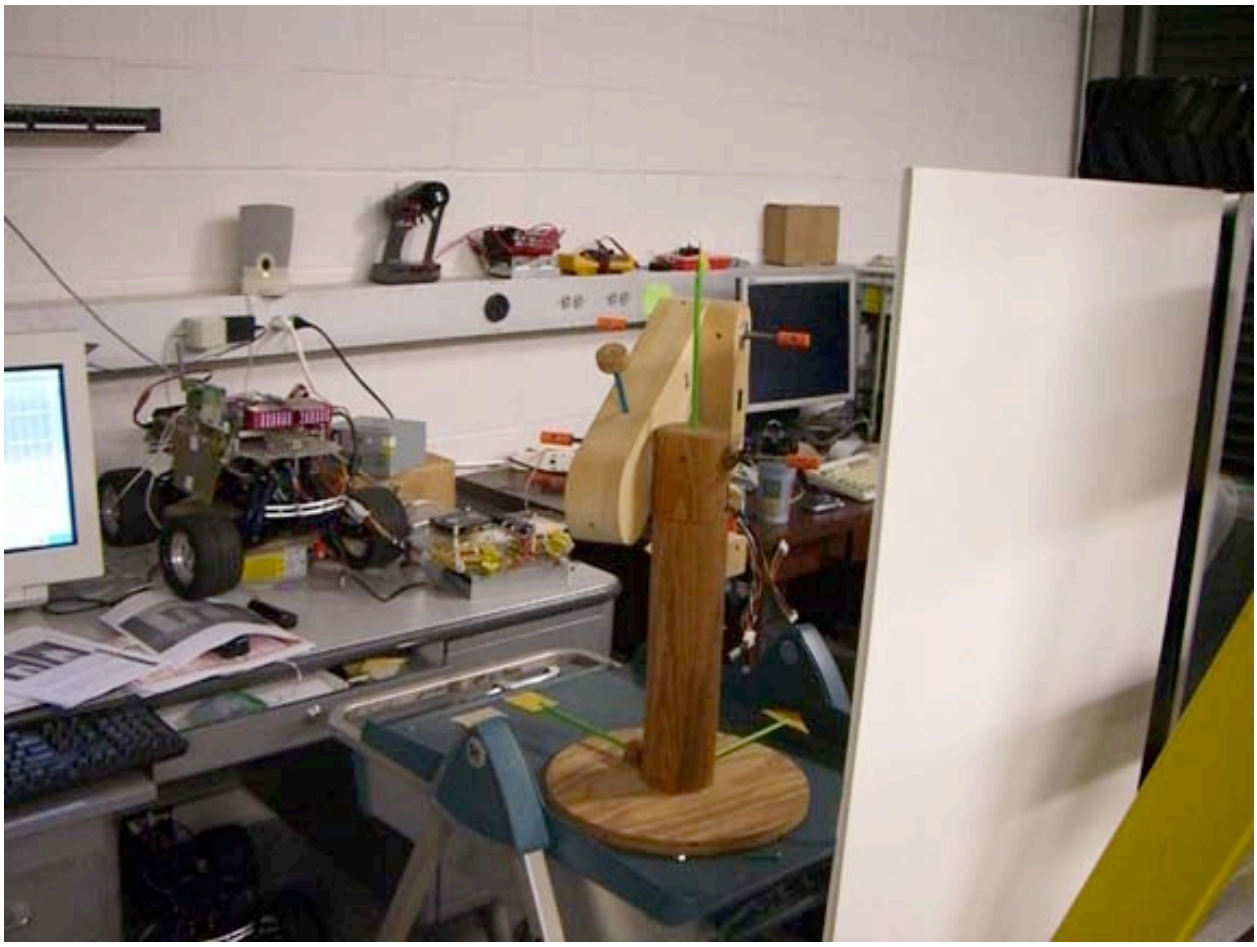
See separate s sensor report

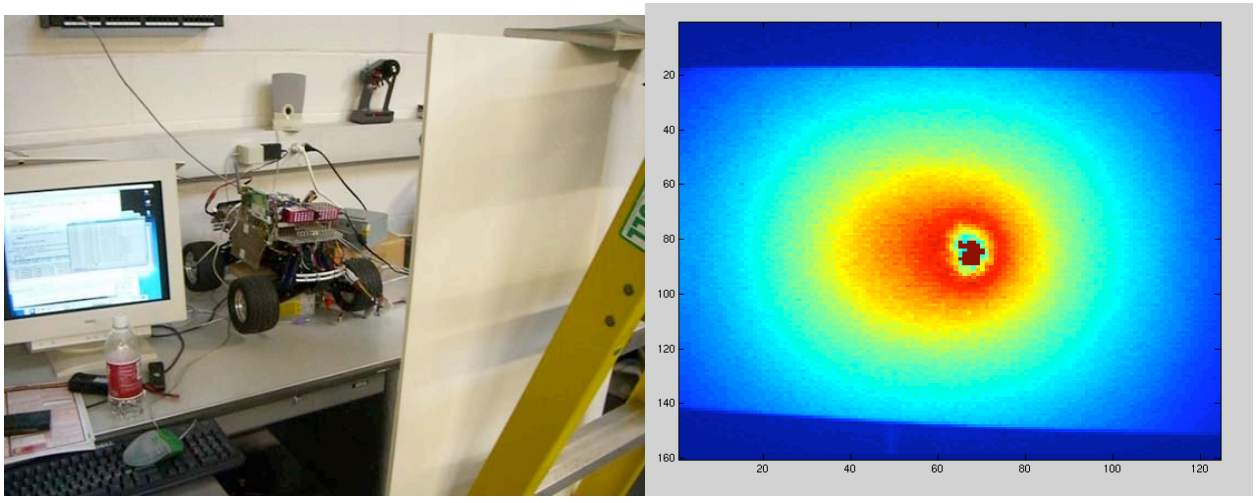
10. Behaviors

Awesimo has limited behaviors so far. With only the single visual sensor, it is limited in what it can do. Right now it can execute several different obastacle avoidance routines, some very robust, others more basic. Theoretically, Awesimo could do wall following and even line tracking though these would be a disctaction from the primary purpose of the robot. Given some orientation sensor Awesimo will follow waypoints and later, lead other robots. See attached program stop.c for current behaviors.

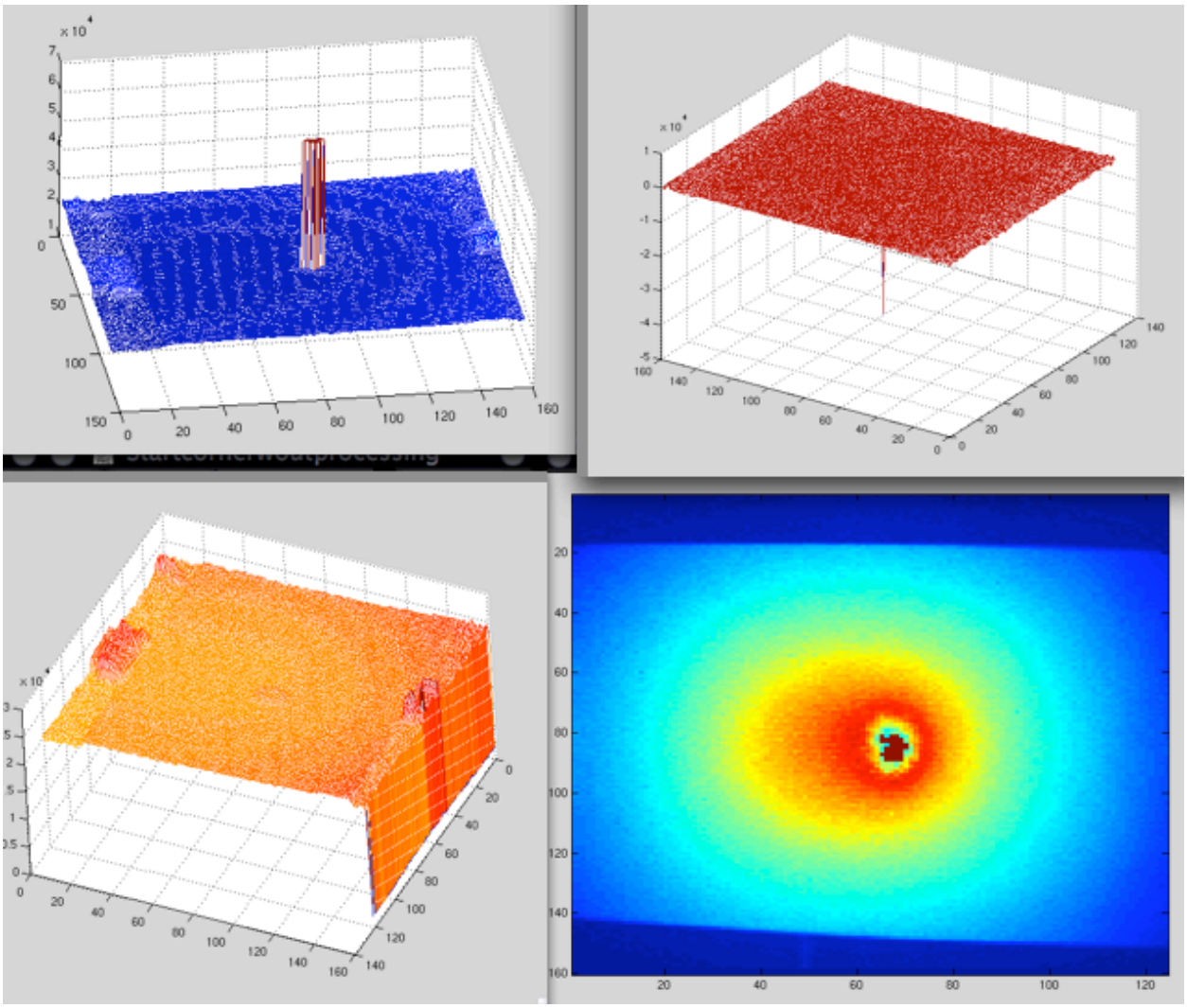
I was surprised how easy it was to get Awesimo to turn around in a small space. I had problems with jerky behavior untill I set a limit on the quality of data by analyzing the intensity as well as the range.

11. Experimental Layout and Results

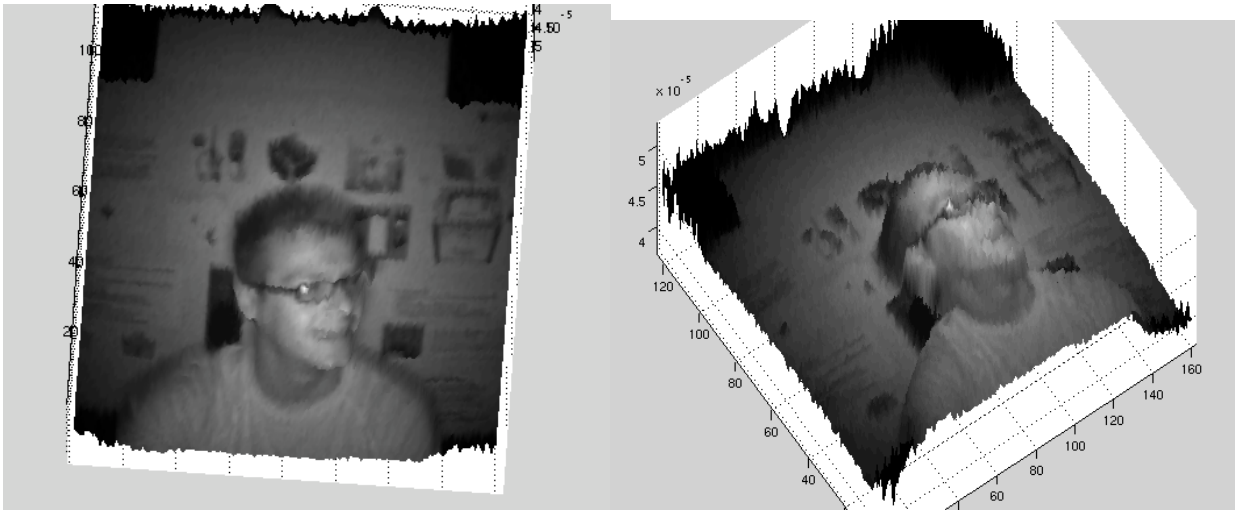




This is my experimental setup and my first decent image. As you can see, the intensity saturates in the middle. You can find out about that in the Sensor report. Note also that the natural raster pattern of the Ranger is sideways from conventional methods. Here are a few more imaged gleaned from the working ranger:



Here the 3D image above left is shown in comparison to a couple of images subtracted from each other, above right, to eliminate “noise”. Below right is the same board seen on the previous page and below left is the range surface plot off all the saturated pixels are averaged out. Note the subtle concentric rings on the above left image. This was my first indication that I had a real image and when I learned about the saturated pixels. I believe the rings are an artifact of the frequency of light the ranger uses.



Finally, a couple of images that have the intensity value gray scaled and overlaid the range information.

12. Conclusion

I feel like I accomplished a lot, though I did not get to the level of functionality I was hoping for. I feel like a guy who looked across a field and said," I can get there." but then discover the landmines. This semester I started with a stream of unintelligible numbers and picked though saturated pixels, bad settings, bad drivers, and poor documentation to get decent images from the ranger. Along the way I spent over a month dealing with fundamental computer problems and reinstalling the Gentoo Linux operating system. I feel that half of what I leaned this semester is Linux related.

Anyone planning on using the Swiss Ranger should know they are on their own. I will be making some supplemental documentation to stay with the ranger but even that is not enough. Expect problems. Also, while ready-made RC cars are a temptation because they are quickly able to move and act, they are also less customizable and I have had to customize almost every part of the vehicle at this point. As a former RC car enthusiast, I can say with some confidence that it is not hard to put one together and there are many more options for customization.

I will continue to work on Awesimo and the other RC Trucks. I will next work on creating a world in memory, what I wanted to do for this semester. After that there are several hardware improvements I want to make like mounting the Ranger on a servo so it can look left and right. Perhaps also up and down. To do this I will have to move the computer farther back on the frame and should also make a cover for it. I still plan on implementing live power switching though this will have to wait for now. Also, Awesimo will get at least one more sensor, like GPS, and I would like to put simpler sensors like bump and IR like other IMDL robots to supplement the Ranger's limited field of view. Later in the summer I hope to have Awesimo leading a team of monster trucks in formation down halls and perhaps out the doors. The future is bright for Awesimo.

13 Documentation

The only reference I used was the online PDF documentation for the ranger that proved

inaccurate. I will include a copy of it in the attached CD.

14 Appendices

- Program Code