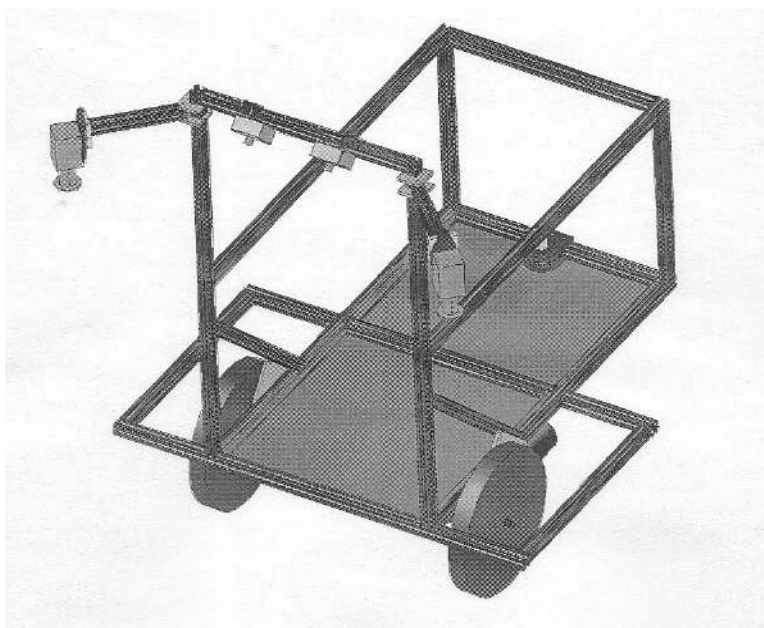


MichiganTech

UNMANNED ROBOTICS TEAM

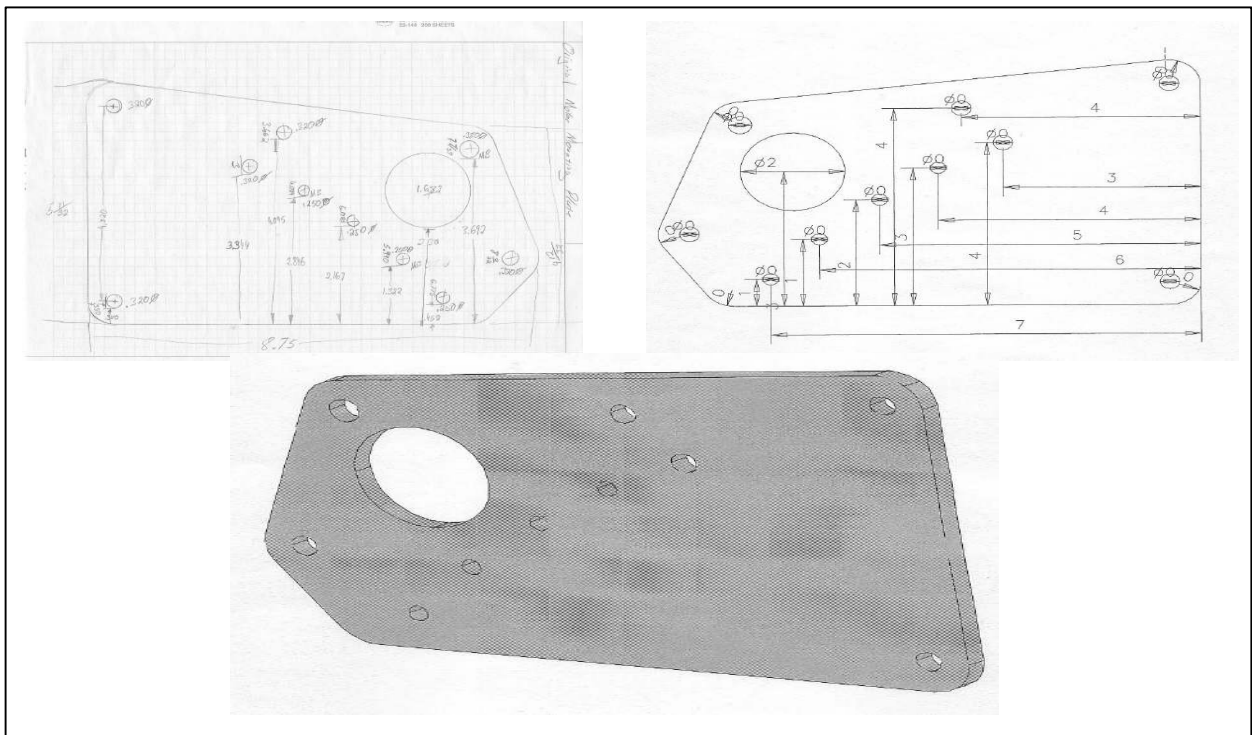


Betty, 2004

1. Background

1.1 Design Process

The design process for the robot was short as the team. The team consisted of only a hand full of members from the respective fields of study: one mechanical engineering student, two electrical engineering students, two computer engineering students, and one computer science student split up to form the three main branches of the design. Each branch of the design was entirely self-sufficient only having to consult the others when they were required to consider their interactions. Mechanical design was done with hand drawings that were then used to create a dimensioned drawing and then a solid model in I-Deas, a three dimensional solid modeling program. Using I-Deas allowed us to better visualize the outcome of the robot and any interferences between parts. The process is documented here with a part that shows the process from beginning to end.



Part is first hand drawn, then transferred to the computer for dimensioning, and then is made into a 3-D part.

1.2 Personell

The following is a list of people whose continued effort made this project possible:

- Cory Cross
- Brian DeSot
- David Hardzinski
- Daniel Henry
- David Olson
- John Zaya

2. Mechanial Systems

2.1 Chassis Design Considerations

Initial design meetings produced a chassis similar to that of a rear wheel drive/front steering vehicle. After comparing the costs for raw material and special hardware, the skill level of the team members and time constraints for construction, it was decided to build an independent front wheel drive chassis with a third rear caster wheel. This was a simpler chassis that allowed more room for design changes during the construction. For example, after the second frame was designed the cargo area/top could be a simpler flat area in stead of incline. This will allow the team to fit larger components next year or add a second level within the robot that could house more electronics.

2.2 Construction

The chassis of the robot is constructed of an extruded aluminum product called 80/20 or T-Slot Bar. The construction and design of the chassis was hastened by the modular design of the material. After cutting to length and squaring the ends; the lower portion of the frame was assembled in less then one and half hours making it well worth

the extra money spent to purchase it. Producing the same type of frame via welding would have taken much longer lengthening the design and construction process. Mounting the drive motors and the third wheel was also very simple. It bolted together very quickly and after adding an angled member that spanned both the motor mounting plates and the uprights of the camera mast the frames major components were done. The secondary cameras that point directly down required more design time to mount securely and still have adjustability. To solve this problem one end of the camera outrigger was turned down on a lathe to allow a clamp to secure the camera's mounting plate. Many of the aluminum plates used for the rear caster wheel and the camera mounting hardware were recycled which further reduced costs.



Aluminum sheet metal was formed to create the trays upon which the computer and the electronics are mounted to. The computer motherboard is mounted to a standard motherboard mounting plate and then fastened to the aluminum tray. This allows for a stable yet, easily removable, computer. The robot is shielded from the environment by sheets of polycarbonate. Both quarter inch and one-eighth inch thickness were used.

Thinner for the sides and end where there is less likelihood of any forces being applied. The thicker polycarbonate is mounted to the top where the payload item will be stored and it will also provide an area to mount the E-Stop.

2.3 Drive Train

The drivetrain for the robot is also very simple. Two recycled wheelchair motors with reduction gearboxes drive the robot from the front and also provide the steering. Turning is achieved by varying the direction and speed of the wheels. A third wheel in the rear acts as a caster and was manufactured in house. It has a gas spring suspension to provide a stable platform for the imaging system. Taper bearings and sealed ball bearings were used to provide smooth pivoting and wheel turning.

3. Electronic Systems

3.1 Microcontrollers

The electronics system on the robot would be responsible for taking directions from the computer and making the robot respond accordingly. It would be responsible for controlling the two drive motors and making sure the robot didn't exceed the speed limit. It should also consume as little power as possible.

These goals were met through the use of microcontrollers. Microcontrollers offered the advantage of being small, extremely versatile, and consumed very little power. The idea was to have one master controller that communicated with the computer and have it control other microcontrollers which in turn were in charge of the I/O of a particular piece of hardware.

The implementation of this idea stuck close to the original scheme with a few variations. One microcontroller does serve as a master controller, and is in charge of all communications with the computer. However, this microcontroller is also in charge of generating the logic signal that drives the motors. Two other microcontrollers are used to determine the speed of each wheel, and signal the master when the speed limit is

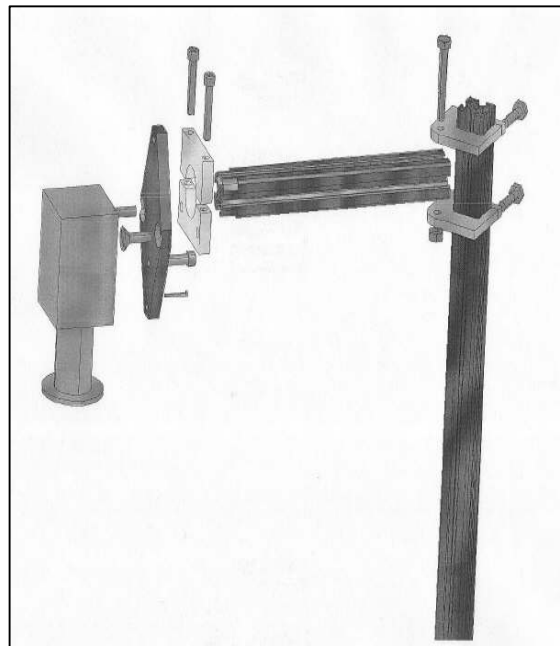
exceeded.

The microcontrollers selected for this project are Atmel AVR ATmega16s. The AVR family of microcontrollers seemed to be the most powerful, feature rich, and inexpensive microcontrollers on the market. The ATmega16 in particular seemed to be suited to the project. After some research, it was determined that these would indeed fulfill the requirements of the team.

Programming the AVRs was a challenge for those working on it as one person on the team had experience with assembly language. However, after time the AVRs were successfully programmed.

3.2 Computer Systems

Two CCD cameras provide path-finding input to the computer. Looking at all the sample picture feeds available to the team, the path to go on was clear in every case; therefore, the team concentrated on code for processing the camera input.



The cameras are connected to the main computer via a group of PCI video capture cards. The computer itself is based on an ASUS A7A266 motherboard and using an

AMD 1000 MHz processor. The computer is run using Linux with customized software for the image processing and pathfinding.

3.3 Power Systems

Power to the computer is conditioned and regulated using discrete switching regulators for each voltage necessary. Power to the motors is controlled by two pulse-width-modulated electronic torque controllers, built by our team. Each device is internally protected from power surges.

4. Software

4.1 Operating System

The on-board computer runs a UNIX operating system that was selected for its stability and efficient operation. All software development was done using the C programming language. The choice of this language rested mainly on its efficiency in integrating hardware components in a real-time environment.

4.2 Image Processing

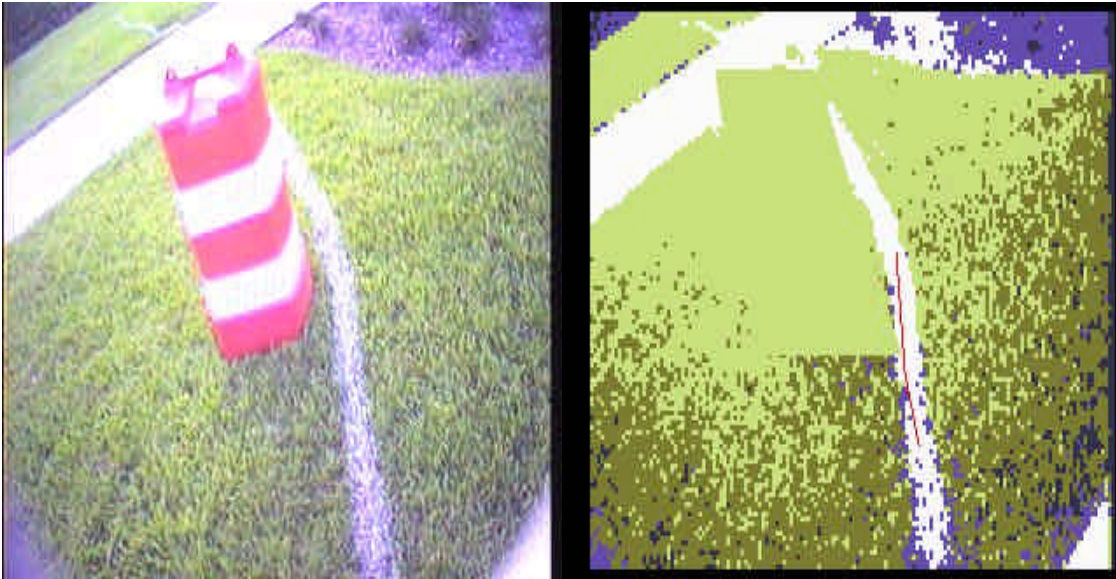
Image processing made up a majority of the software development. It consisted of getting the images from the cameras, applying various filters to said images, and detecting obstacles and lines on the image.

The first step was getting the image from the cameras. We used two main colors to take the pictures in color. The two images received from the two cameras are then processed separately.

Once the pictures are taken, we applied various filters to the images to allow us to detect lines and cones easier. If the picture was too dark, we made it brighter. The image is then converted to 5 basic colors. Each pixel is made either green, dark green, white,

orange, or brown based on the pixels around it. This gets rid of extraneous objects that we do not care about.

The next step involves finding the obstacles on the image. Once found, the object's location is stored and then removed. The line(s) for the image is found next using a line that finds a clump of white pixels and then moves to the closest area of white pixels. No objects are on the screen after being removed in the previous step so the line will not go away. Once the line is found, the objects are put back in there places.



Here's the original image.

This is the image after the filters are applied and the cone is found and removed. The red line is part of the line that was found.

4.3 Path Finding

After the image has been broken down and the obstacles/lines have been detected, the next step involves finding the best path to advance the robot along the obstacle course. The basic idea was to try various paths and take the one that went the farthest without hitting anything or crossing a line. Potential paths are determined by choosing different start locations and avoiding both objects and lines while moving upwards on the picture. Once a path is found, instructions are sent to move the robot in that direction.

5. Funding

5.1 Funding & Donations

Funding was provided by three groups outside the team: The Undergraduate Student Government (USG) / Student Activity Fee (SAF), Michigan Tech Electrical and Computer Engineering (ECE) Department, and MTU's IEEE Student Branch. Team members, in addition to the incredible number of hours put into the project, also donated some parts themselves. We'd like to thank all our supporters for making this competition possible!

Travel and lodging was paid for by the ECE Dept.; the batteries, frame, and motor controllers were provided for by the USG SAF; and miscellaneous help provided by members of IEEE. Team members donated the motors and computer.

5.2 Financial Breakdown

Device	Total Value	Total Cost
1GHz computer	\$100.00	\$0.00
Raw metals/plastics	\$150.00	\$150.00
80/20 "Industrial Erector Set"	\$200.00	\$200.00
Video Capture Cards	\$65.00	\$65.00
Main Drive Motors	\$96.00	\$0.00
NiMH Batteries	\$410.00	\$410.00
Motor Controller	\$175.00	\$175.00
Registration	\$200.00	\$0.00
Travel(approx)	\$500.00	\$0.00
	\$1,896.00	\$1,000.00