MicroMouse EE296
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Team DAT
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EE 295 Project Report

For our micromouse, I primarily worked on the design and fabrication of the mechanics and frame. When we first started, we wanted to do something different from the other teams. From previous experience from working with FRC robots, I realized that by using omniwheels, we could build a robot that could move in any direction. These robots tend to use either three or four wheels, with each wheel driven by a separate motor. The question was whether we could build a robot that could use the side-to-side movement of omniwheels using four wheels and only two motors at the expense of not being able to turn. This posed some challenges in design and assembly.

The first challenge I faced was how to get a two motor, four omniwheel drive system working. The easiest way to get two motors driven by one motor is by

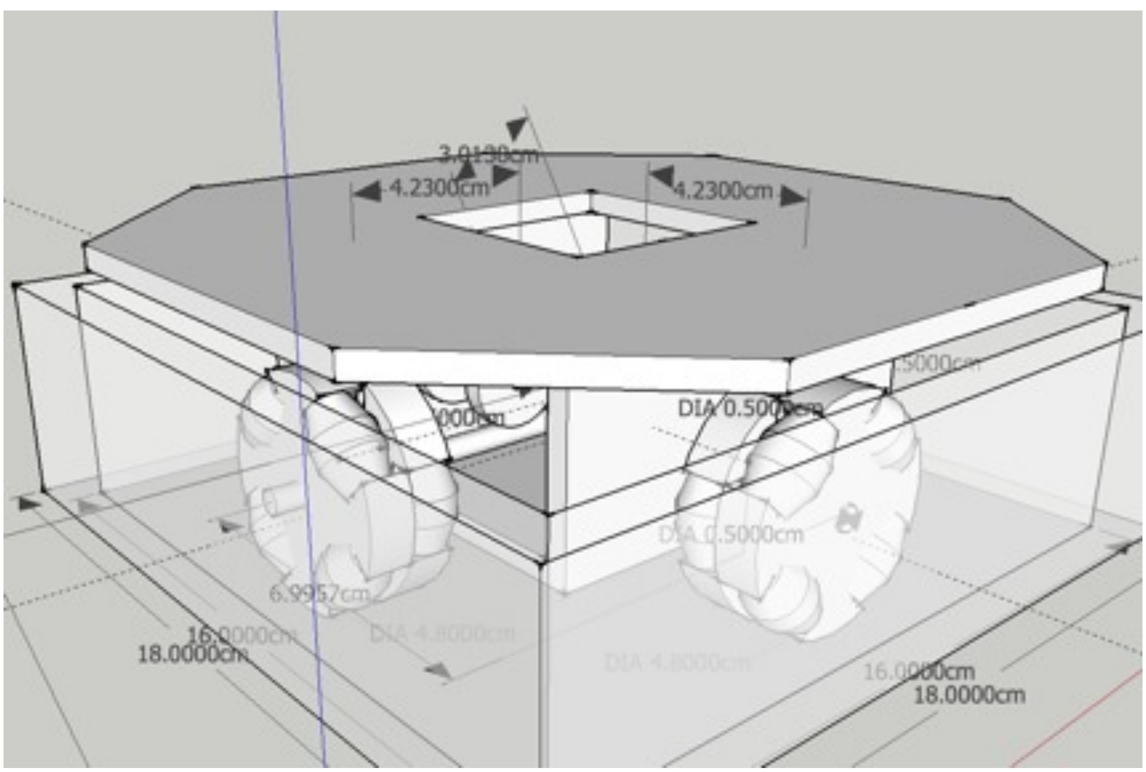

Fig 1 The first design

running an axel down the middle of the robot. The problem is that you can only do this for one set of wheels as the axel of the second rod would intersect the other. Since proper functioning omniwheels require all to be lying on the same surface, we had to use a system with multiple axels using a rotational energy transfer mechanic.

The first design had both motors on the same plane. While this worked, there were some problems that needed addressing. The major flaw was that the footprint was too large at about 15 cm. This size gave us a clearance of only .5 cm on each side. While we could, theoretically, could use this to compete as we did not have to worry about a turning radius, we had heard about another doesn't-turn-robot which failed as its large footprint required it to do many course corrections. While our robot used a different mechanism which allowed us to change direction quickly (the robot we heard about apparently used a system of raising and lowering wheels to move sideways, requiring it to move up and down different sets every time it had to turn), I did not want this to become a problem. This design also made

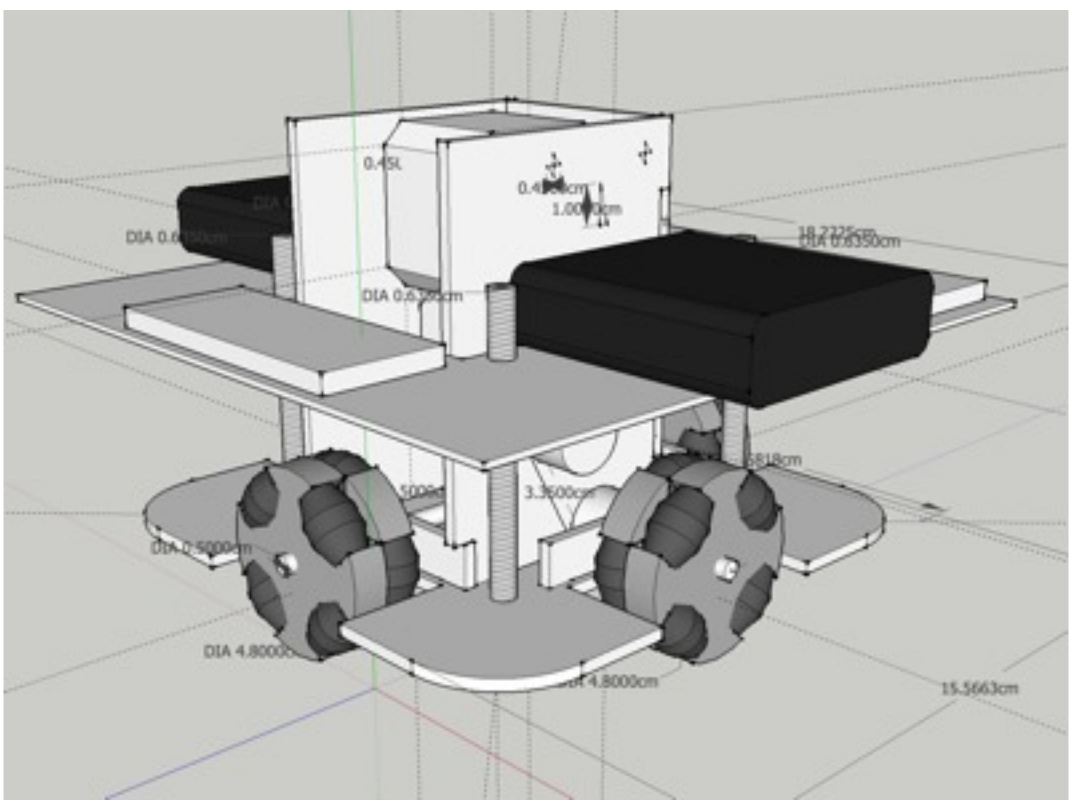

Fig 2 Second design

everything hard to assemble, and did not leave much room for axel mounts on the structure. While we wanted our drivetrain to be unique, we did not want the uniqueness to be its downfall. In the field of engineering, a good design should not sacrifice functionality for the sake of just being different.

The next major design change we did was switching from belts to gears. One thing I learned from this project is that you should order things well in advance, as parts may take longer to arrive than you think. After giving him the parts list and the places to order from, Babak uploaded our order to Laulima on March 14. We ordered parts from several different suppliers and got our first shipment, which included wheels, axels, battery boxes and protoboard, about week later; a very reasonable amount of time. What we were missing were the timing belts from SDP-SI. These were a very important part of our design at the time. A month later, we received an email that said that our parts had just been shipped. I'm not 100% sure this is the case, but I have heard that the process to get funds appropriated and items ordered through UH can take more time than expected. We should have reevaluated our design at least a week earlier before finding this out. Since we were running out of time, and I knew we would run into mechanical problems that we would need time to fix. Timing belts, while being lighter and able to transfer motion farther than gears, require specific tensioning. If the two pulleys are too close, the belt will be loose, slip, not work at all or fall off; if the pulleys are too far, the belt will be tight and will create too much friction or be unable to be slipped onto the pulleys. While I gave my design areas to account for tensioning, this process would take time. I decided to look locally for a solution locally. Our design called for toothed timing belts. Nick and I looked at several alternatives. We visited a hobby store and perused their selection of belts; none of them fit. We decided to use toothless belts with pulleys bought from a hardware store; they were too slippery. I then decided to fall back on the final backup design choice: borrow gears from my high school robotics lab. Since these gears did not fit our axels, I had to change our design to use axels that did fit. To get the gears to fit the motors' axels, I used a lathe. The axels that came with the gears fit bronze bushings that reduced friction. Since friction was a concern I incorporated these into our design as well.

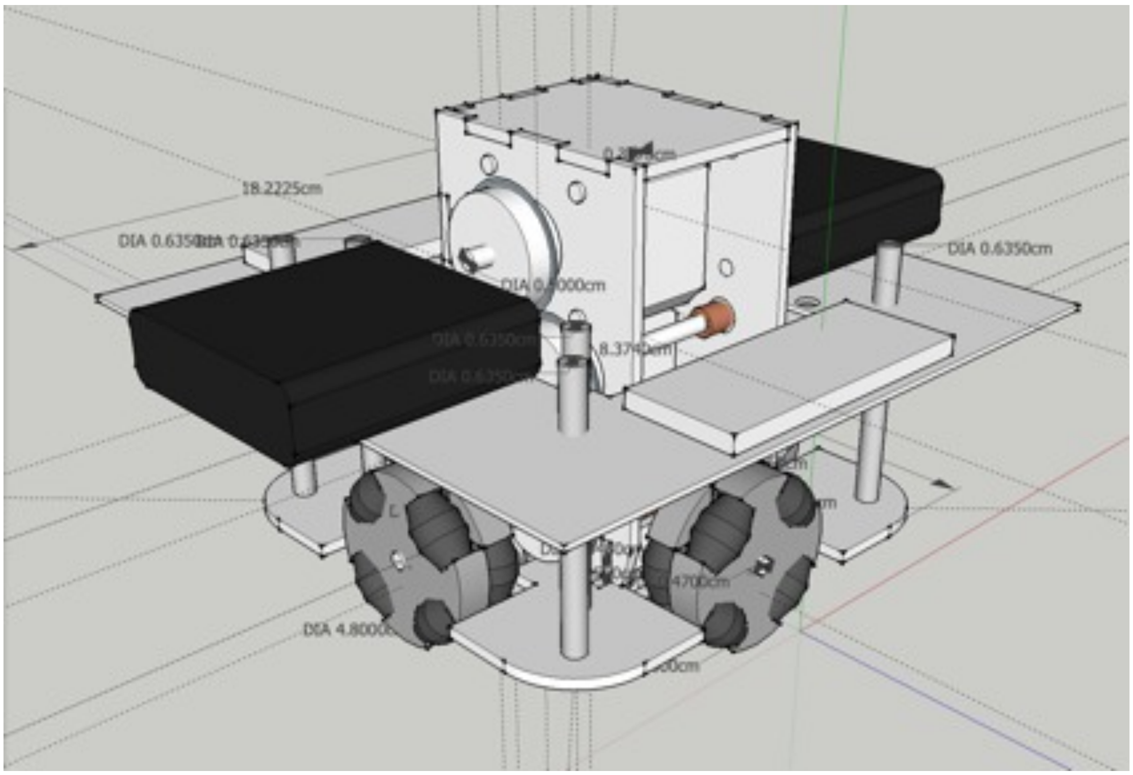

Fig 3: Our final design

Most teams who build robots using the standard stepper motors usually use frames that are made from metal that has been cut using a saw and then bent against a table or in a vice before being joined using screws and bolts through holes drilled with a drill press. While these processes are effective and usable for the basic micromouse designs, our design required a structure that was more complex and would be difficult to precisely manufacture by hand.

I have had experience and access to laser cutters in the past and was able to use them for our project. Laser cutters use focused light to burn precise, clean lines. Since all the burning is controlled by computer, provided you have the power and speed settings for the laser set for the material being burned, the material being the correct distance away from the lens, the CNC motors and origin point calibrated, lenses cleaned and the air filters working, whatever you design on the computer is what will be cut by the laser. Another option I considered was 3D printing; the same place that had the ULS laser cutter had a uPrint® SE which printed a thermoplastic into the shape of the .STL file you fed into it. There are several reasons why I opted not to do 3D printing. While 3D printing would eliminate assembly and would allow us to design our frame in ways that would be impossible to manufacture using other techniques, doing 3D printing would have caused several problems. A small 3D print I did in 2012 (Fig 4) took about an hour, not counting the time spent dissolving the support plastic. I estimate that if we were to print our frame it would have taken at least three to four hours just to print. When I cut our frame using the laser cutter, it took about five minutes to cut, a minute to clean and a minute to assemble. I was also wary about the strength of the thermoplastic and whether it was easy to modify using regular tools. Since each print is made of layers of thermoplastic precisely laid out in patterns, there is a possibility of the layers separating if further machined or if enough pressure is applied. If I found there was a problem with the design that needed to be changed, I would have to create a whole new print.

Fig 4: 3D print from 2012.

Initially, I decided that our frame should be built from a plastic we used on my highschool's FRC robot called Lexan–a plastic which I mistakenly called Cintra during our CDR (Cintra is another type of plastic we used on our FRC robot, but mostly for colorful decoration, not for structural or shielding). In FRC, we used Lexan as the clear shielding for the internals of our robots. Acrylic was another possibility I considered but I eliminated that option due to weight. After considering availability, weight and ease of cutting on the laser cutter, I opted for the material that I have had the most experience with: 1/8th inch plywood. Plywood is cheap, easy and quick to cut, easy to obtain, simple to machine using traditional tools and I had an ample supply already in my possession. I have had experience designing laser cut boxes made from plywood, so I knew the easiest and best way to design the body of the robot would be to use a tongue and groove system joined using cyanoacrylate glue. Usually to make boxes with the tongue and groove system I use a 2D vector design program called Corel Draw by directly drawing the lines that the laser cuts. This process can have a lot go wrong; it is difficult to check that all the pieces will line up without rearranging all the parts on the screen. There have been countless times in the past where I have designed simple boxes that looked like they would work on the program, but would not assemble after I cut the pieces due to some oversight in how they fit together. Due to the complexity of the robot and the addition of mechanical parts, I decided to

Fig 5: 2D vector image of the sides and top of the robot explore a different approach to designing the robot. I used a 3D design program called Trimble SketchUp to first design the basic shape of the frame with all the other parts on it. I then intersected all the parts onto the frame of the robot. This automatically placed lines where all components went through the sides. After adding the tongue and grooves, I then used a free Ruby script plugin that I got off the internet (http://flightsofideas.net/?p=638) to export to a .SVG file that I could open in Corel, clean up and then send to the laser cutter for burning. If I ever have to use a laser cutter to cut parts for 3D objects again, this is the process I will do; the only reason I had to redo a cut was because the gears didn't mesh due to improper measuring of the gears (which I solved by reading the precise dimensions of the teeth off a datasheet for the part, a practice that I then replicated for the rest of the prefabricated parts before recutting the frame).

While I have worked on a few designs for robots and have used most of the materials at least once, I have never really had the chance to design and build a robot's drive train from scratch using these tools and materials. In FRC, I always worked in a team to assemble the drive trains. At the same time, I was working in a team; the mechanics was only one portion of the robot. Babak did a great job on soldering the components to the protoboard and finishing the sensor placement while Nick did the programming and most of the troubleshooting of the wiring. I feel that we excelled in working together.

While our robot failed to fully run a maze, I feel that if we were able to solve our power and sensor problems and perhaps get motors with more torque, this design could be viable. I would have also redesigned our robots to use lighter plastic gears bought from McMaster-Carr (this was also the first time I got to order parts from them) or return to the belt system as I originally intended. Our sensor system used a top down approach with sensors sensing walls in all directions. It might be possible that a side facing sensor system with sensor on each side would have been a better choice. Perhaps by using gates and outputs from the PIC, we could control which direction the robot was sensing eliminating the need for more input pins.