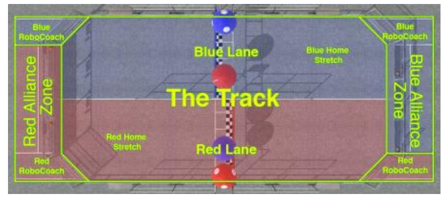
Team 67

2008

Tech Notes

This year the HOT Team shifted into "Overdrive" as we designed the 2008 HOTBot. The HOT Team is collaboration between mentors from the General Motors Milford Proving Ground and students and teachers from the Huron Valley School District.

FIRST Overdrive Strategy



This year's game, ***FIRST* Overdrive,** consists of two periods: Hybrid period and Teleoperated period. During Hybrid period, the first 15 seconds of the match, robots operate autonomously but may also respond to digital signals sent by the teams Robocoach. During the Hybrid period, robots traveling in a counter clockwise direction score:

• **8 points** for each of their Trackballs knocked off of or passed over the overpass
• **4 points** whenever their robot crosses a line on the track
• **2 points** whenever their trackball crosses their finish line

The next two minutes of play is the Teleoperated period. At this time, robots are radio controlled by team operators standing at either end of the field. During the Teleoperated period, robots traveling in a counter clockwise direction score:

• **2 points** whenever their robot or Trackball is herded across their finish line
• **8 points** whenever their Trackball is hurdled over their overpass

Alliances score an additional 12 points for each of their Trackballs that are positioned anywhere on the overpass at the end of the match.

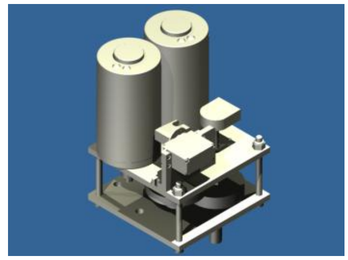
The HOT team decided that a powerful and maneuverable robot capable of operating effectively in both Hybrid and Teleoperated would be essential to excelling in this year's game. During Hybrid period, our goal is to have the capability to complete one lap and knock both Trackballs off the overpass. During Teleoperated period, our goal is to be able to efficiently hurdle trackball and have the ability to place a trackball on the overpass at the end of the match.

The 2008 HOTBot was designed and modeled using both AutoCAD and the 2008 Autodesk Inventor software. Engineering mentors lead the design process by creating 2D AutoCAD designed parts; Students assigned to Engineering / Design group create 3D models of the designed parts using Inventor. Once parts are designed, drawings are given to Machining mentors at the GM Proving Grounds Prototype shop. Under the guidance of the Machining mentors, students manufacture all the parts for the HOTBot. For 2008, our robot contains many new and unique features never before used on previous HOTBots.

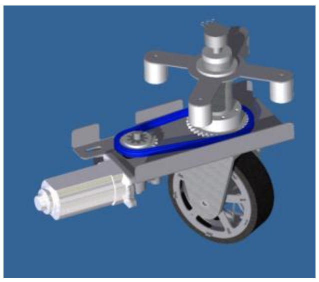
The Chassis

In previous years the HOT team has created custom chassis designs specific for that year's game, using square, thin wall, aluminum tubing. This type of chassis required a large amount of specialized welding time to manufacture. This year HOT team engineers decided that a more reusable design, that could be assembled easily, would be created. The result is a pop riveted, sheet-metal chassis created from 1/16" thick, water jet aluminum parts. A large amount of design time was invested to include; hole patterns for gear box mounting and axles, and also slots for mating parts and lightening holes. This process was very design intensive, but it greatly eased the final assembly of our machine. The benefits of this chassis design are that our frame is over 2 lbs. lighter than our tube frame last year, and is also stronger and more rigid.

The Drivetrain



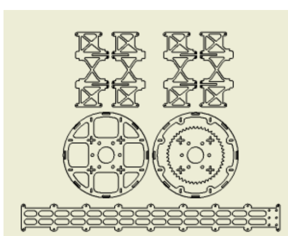
The 2008 HOTBot packs 1.8 hp under its hood. The HOTBot uses two-speed AndyMark Supershifter gearboxes, with two CIM Motors mated to each gearbox. These two-speed transmissions allow us to shift from high torque (25:1 gear ratio) to high speed (9:1 gear ratio). Since pneumatics are not used on our robot, servos are used to shift between gears. Students modified the gear boxes to increase their precision and to reduce the rotational inertia of the gears. The transmission output is a direct drive to our center driven wheels and a 1:1 chain drive to our front driven wheels. This combination gives the 2008 HOTBot a top speed of approximately 15 feet per second.



To achieve the maneuverable aspect of our "Overdrive" strategy, HOT team engineers designed; non-powered, turreted rear wheels to improve the robots agility. These turreted wheels allow for quick lane changes and improved cornering over a traditional skid steer drivetrain. The turrets are powered by Keyang window motor, and have the potential for an unlimited 360 degrees of rotation.

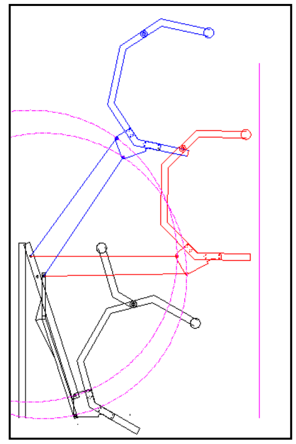
The Wheels

Our 2008 HOTBot wheels have a very innovative design which we believe has never been done before. Instead of machining wheels out of aluminum billet or purchasing wheels from AndyMark or IFI, HOT team engineers designed the lightest weight wheel we have ever used on a robot. The wheels start as 3/16" thick, sheet aluminum, which are water jet into two webs, four cross supports, and one tread piece for each wheel. The cross supports were designed to simply slide together, then the tread and side pieces slide on both sides. The tread piece is rolled to the proper diameter and placed in between the sides. The entire wheel is held together with 3/32" roll pins. The 6" drive wheels were designed to have integrated water jet sprockets directly mounted to them. Finally, high traction tread material is riveted to the outer circumference of each wheel.



The Arm and End Effector

Our arm design this year is a unique modification of the team favorite four-bar linkage. Due to rule <R16>, limiting the robot from expanding greater than 80” horizontally, multiple design iterations of our arm were created until we achieved a powerful, smooth, and fast arm movement.

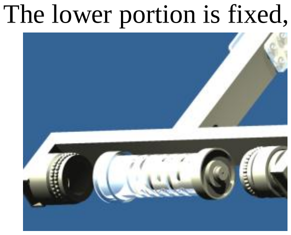


Our first design incorporated a sliding lower link of the four-bar, to allow for the end effector to be in the correct position to pick up a trackball, then as the arm raised, the lower link expanded and tipped the end effector back to satisfy <R16>, until it reached a point were the end effector would be tipped out to release the ball at the correct angle. Unfortunately, there were discontinuities in the force required to raise and lower the arm, due to the two 90 lbs. gas spring required to expand the lower link and hold it from tipping out and breaking <R16>.

To eliminate the discontinuities in applied force, a new design was created by removing the sliding lower link and incorporating a three position linkage design. By placing the end effector in three positions (start, middle, and end) that satisfy <R16>, we determined the lower link pivot point required to incorporate a four bar linkage design that is within all the rules. The drawback to this design is that the position of the lower link pivot point is above the upper link. A Y-Frame lower link was designed to allow for the upper linkage to swing through the lower link pivot point. Water jet aluminum structure parts were welded to the lower link to provide strength in both tension and compression as the arm is operated.

The arm is driven by two Fischer-Price motors, custom mounted to a unique setup of dual coupled AndyMark ToughBox gearboxes. With each gearbox contributing a 12.76:1 ratio, this arrangement gives the arm a two second cycle time from full down to full up, and has 163 times more torque than the motors alone.

Our end effecter is made of welded 2” square aluminum tubing, constructed into a clamping device to securely hold the ball. The lower portion is fixed, while the top portion and roller acts as a clamp. The roller is driven by a modified Globe motor mounted internal to the roller. Custom delrin ball bearings allow it to roll smoothly. The motor is held in place via a PVC flex coupling.



The end effector is designed to contact the ball near the front-top, and then roll over it, sucking it in and clamping down on it on the other side. This clamping force is achieved using two 40 lb. gas struts. These struts are mounted to a piece of lexan, which serves as a designed failure point should our end effecter ever be subjected to an overly excessive force. This designed safety feature protects the rest of our end effecter and arm in the case of a forceful collision.

The Controls and Programming

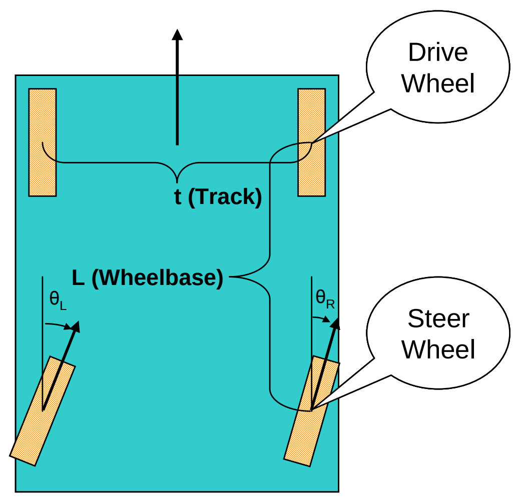
This year we had four discrete controls groups: motor control for the drive train, motor control for the arm, IR board implementation, and additional sensor development to aid the Hybrid mode. Each group consisted of student programmers and an individual mentor to tackle their respective task.

This year, we are again using the chicklet adapters for the operator interface. This allows us to use USB game pads to control our robot. These have many advantages over conventional joysticks, such as a greater variety of available buttons and programming options. Our drive controller is set up similar to remote-controlled cars, with the left joystick operating the robots fore and aft movement and the right joystick controlling the turning radius. The trigger buttons are used for shifting to low gear and turning within the footprint of the robot. Our arm controller uses the joysticks to control the height of the arm and the roller. In addition, our arm has four preset heights, which are controlled by buttons numbered 1 through 4. For possible use in elimination rounds, we also have programmed presets for giving and receiving balls from our partners.

Our programming this year includes many different features, including Ackerman steering, hybrid programming, and sensor navigation.

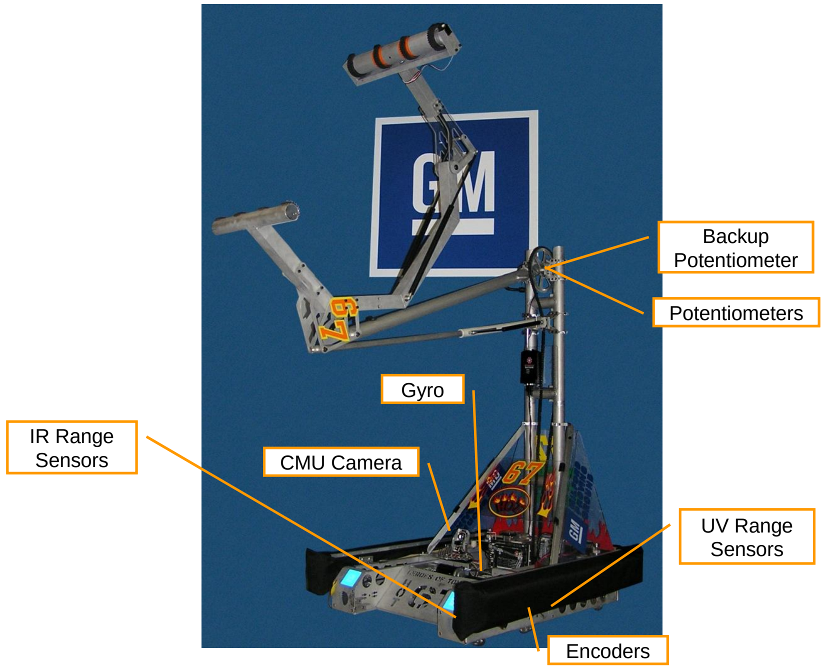
ACKERMAN STEERING

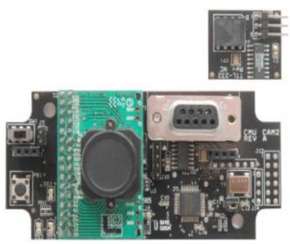
Ackerman steering is based on the idea that, around a constant radius turn, the inside and outside steering wheels take paths of differing radii, requiring them to be turned at different angles. Based on the design of our drive system, implementation of this steering method requires the use of PID set points. This integrates the drive wheels and steering wheels by taking readings from the potentiometers mounted to the steering wheels and encoders geared to the drive wheels. This allows our robot to steer smoothly and efficiently.



HYBRID PERIOD

Our hybrid programming makes use of sensors including the camera, a gyroscope, encoders, accelerometers, and ultrasonic and infrared sensor. We use the camera to identify and track the balls based on color. This allows us to move towards our alliance's ball and knock it down. For hybrid-mode navigation, we use a combination of a gyroscope, encoders, ultrasonic and infrared sensors. This allows us to track how far we have turned and traveled. The ultrasonic and infrared sensors, one mounted on each corner allow us to follow walls and detect and navigate around obstacles. This should allow us to navigate an entire obstacle-strewn course.





This year we are using the camera's 'Virtual Window' and 'Get Mean' functions to locate the track balls. 'Virtual Windows' are scanned across the field of view encompassing our alliance lane at the height of the overpass. The virtual windows are approximately the size of the track balls. Typically ten windows are stepped across the field of view. Following each issue of the 'Virtual Window' command, a 'Get Mean' command is sent to the camera. The camera then returns the average Red, Green, and Blue color values within the virtual window. We have found that the ratio of the color values Red: Blue is a positive and reliable identifier of the red ball; similarly the ratio of the color values Blue: Red is a positive and reliable identifier of the blue ball. At each Virtual Window step the two ratios are calculated. The maximum of each ratio identifies the location of each ball. It takes less than 1.5 seconds to locate both track balls upon the start of Hybrid Mode. This allows us to displace only our track ball during the Hybrid Period.

Conclusion

The HOT Team went into "Overdrive" when we designed, built and rolled out the 2008 model of the HOTBot. The HOTBot is designed with speed and control in mind. We hope the 2008 HOTBot will hurdle its way to another successful FIRST competition season.