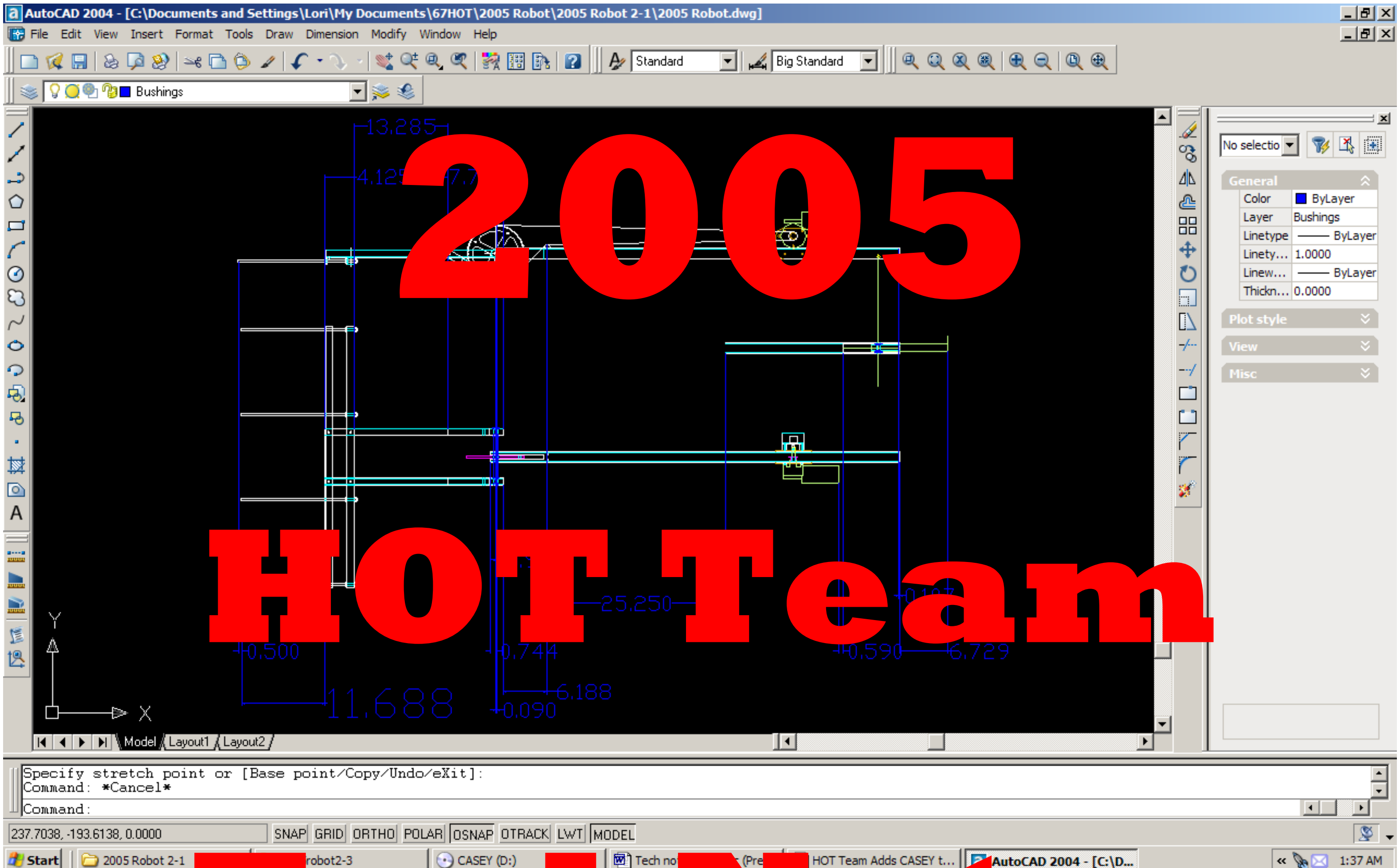
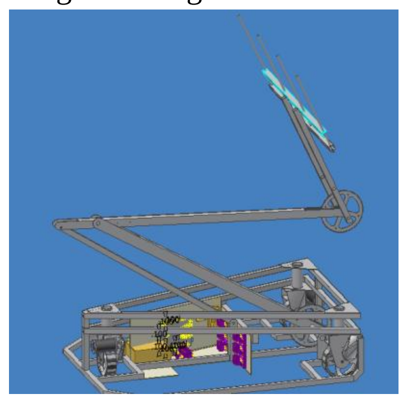
2005 HOT Team TechNotes



Design Strategy

FIRST had a plethora of threes this year, with their game: "Triple Play." The HOT team followed this theme with the design of the 2005 HOT Bot. The chassis of the HOT Bot was based off of a triangular frame with three wheels. Our end effecter was designed to have three prongs. Our four-bar linkage forms a triangle when the arm is fully extended. We have three different controllers for our operators. Three is a magic number and it has brought us much success in this year's game.

This year's field layout required the robot to be highly maneuverable. We designed our bot to have independent steering of all three wheels. The play of the game requires that the robot be agile so we strived to keep the weight of our robot to a minimum. This allowed us to achieve maximum acceleration. The height of the goals and the required extension of our robot made it important that we maintain a low center of mass and a large base of support. This will prevent us from tipping as we place tetras on the goals. Since multiple tetras will be placed on the goals, there are certain requirements about arm length. We kept this in mind as we were designing our four-bar linkage and end effecter. We also needed to interact with open-centered tetrahedral objects; therefore we came up with the idea of a pitch fork. The pitch fork allows us to manipulate tetras quickly and easily.



Mechanical Design - The Frame

The HOT team originated the concept of the "flop bot" last year as we drove down the wall to land on a large support base. This year's game again demands the stability of a large base of support, so we designed our bot with the two largest dimensions (60" x 38") as the base. The robot starts on the required 38" x 28" side, but as soon as the autonomous period starts the robot rolls to its competition base. We have a stacked triangular frame with drive turrets in each corner. Another major part of the frame is the horseshoe-shaped lower frame. The horseshoe provides protection for the rear wheel and internal components. The whole frame is constructed from 1/16" wall, 1" square aluminum stock. We welded the frame to reduce weight and provide a strong mechanical connection between frame members. Heat sink was necessary during this process to prevent the aluminum pieces from melting or otherwise deforming. We covered the frame and internal components with a 1/16" Lexan skin. Bullet-proof Lexan should be enough to protect our robot from the rigors of competition. Inside this frame is the support for the four-bar linkage that makes up our arm. The internal support for the robot consists of a 1 ½" support axle for the input arm of our

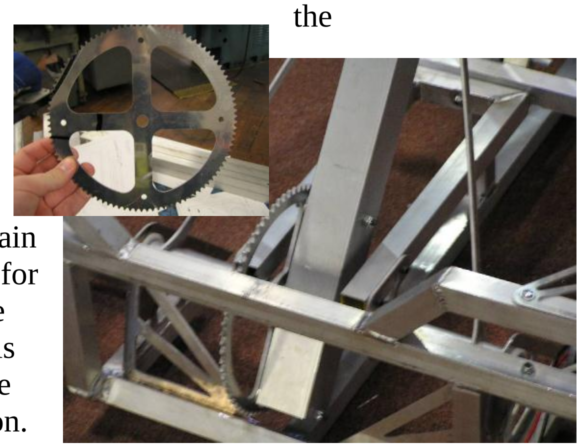
four-bar linkage. Both triangular frame components have a cross member support to provide strength and a point of attachment for the follower arm and electrical box. Lower protection for the turrets and wheels is provided by rectangular inner frame which is attached to the lower frame. Support pieces for the input arm axle and turrets were water-jetted with low stress areas removed to further reduce weight. To sum it up, our frame was designed to maximize structural integrity with emphasis on minimizing mass.

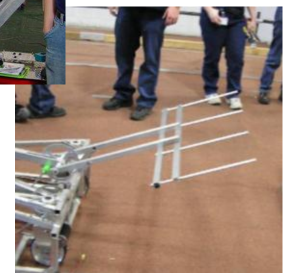
Mechanical Design-The Turret and Wheel

The turret and wheel were designed to provide maximum maneuverability. The turret design allows for nearly 900 degrees of rotation. The wheel is driven through a gear box. The combined gear ratio in the box is 20.57. This gear ratio reduces the speed and increases the torque output to optimize performance for competition conditions. Our final speed tops out at 7.5 feet per second. Power to the gear box is supplied by a Chiaphua motor. Each turret is independently steered in front by FP motors, in the rear with a globe motor. The globe motor and the FP's in their transmission cases are mounted to the frame and connected to the turret by a sprocket system. The wheel design removed as much mass as possible. Each wheel weighs less than 1 pound. The low-mass wheel reduces rotational inertia and allows for quick acceleration and deceleration. High-traction belting is added to the wheel for traction.

Mechanical Design-The Arm

In the past several years, the HOT Team has become known for the design and functionality of their robot arms. This year's arm is unique from our previous arm design because the arm itself is a four-bar linkage. How a four-bar linkage behaves is controlled entirely by the length of the bars and the placement of the pivots. As far as length goes, the maximum length of a bar is limited by the diagonal of the 5' x 2 1/3' box which makes up the side profile of our bot (5.52'). The longest bar in our four-bar is the coupler bar at 4.5'. The coupler bar is designed from 1.5" square tubing. To make the coupler rise to its maximum height, the pivots on the coupler are placed relatively close together (7"). The input and follower bars are 49.2" and 40.48" long respectively, with their pivots placed 47.5" and 39.5" apart respectively. The input is manufactured from 2" square tubing stock; the follower, from 1" square stock. The pivots of the ground are 14.895" apart. The shorter follower raises the coupler into the air as the input rotates forward. The four-bar combination allows for an arm extension of 93.2" (when the wheel base and end effecter are combined a maximum extension of 11.24ft). The arm is powered by the fourth Chiaphua motor. The Chiaphua motor is inserted into a modified kit gear box. The output is sent to a 21-tooth sprocket, which is connected to the input bar with 35-pitch chain to a custom water-jetted 100-tooth sprocket. The heavier chain allows for a maximum working load of 480 lbs. Combining the sprocket from the gear box with our arm sprocket, the overall lower arm ratio is 226. This increases the torque by that factor. Also, this means that the arm can be raised in less than 0.5s when accounting for the necessity of acceleration.





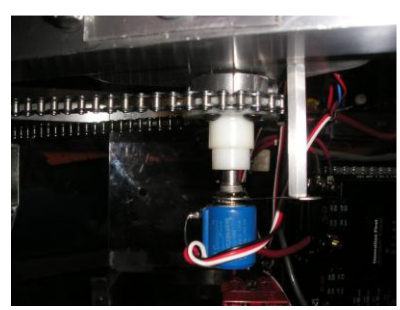
End Effecter
The 2005 HOT Bot end effecter is our "pork fitch" pitch fork. The pitch fork contains three 17" tines. The tines are designed to be easily replaceable in case of damage during matches. The tines terminate in a cross bar assembly. The pitch fork has up to 300 degrees of rotation. This rotation is controlled by a sprocket system driven by the van door motor. The sprocket system increases the gear ratio by 8 for more torque. Extensions to the cross brace have been added to prevent the tetras from rotating around the side of the fork. This makes the manipulation of tetras on the game field much more efficient.

The Control Station

The control station contains three diverse devices for robot control. One of these components is the joystick. This controls the X-Y translation of the robot. The second control is a video game-style steering wheel. This controls the rotation of the robot. It is used in conjunction with the joystick to provide mobility control to the robot. Another drive control is a trigger that slows down the motion of the robot. At the critical point of positioning the robot for tetra placement the robot can be put in slow motion. This allows our drivers more precision and control and eliminates the need for repeated attempts. The third control feature is our "mini-bot." We have been using this idea since 2001 and we think that our team originated the concept. It uses a system of potentiometers to provide the operator interface with certain resistance/voltage values based on the position of the arm on the actual robot. It corresponds directly to potentiometers placed in similar locations on the robot in a feedback control system. In such a system, an input is provided to communicate what position we want the robot to be in. This input is compared to the potentiometer values on the robot and the robot itself will move until the values match. The "mini-bot" also boasts a button for automatically positioning the arm for tetra loading. This allows our drivers to complete the loading process more efficiently. Our control station also holds two autonomous buttons, which allow for 4 separate autonomous modes. If needed, additional buttons can be added for additional autonomous maneuvers. A final and very important button is our Arm Enable button. This button provides a huge measure of safety, eliminating and curtailing unexpected arm behavior.

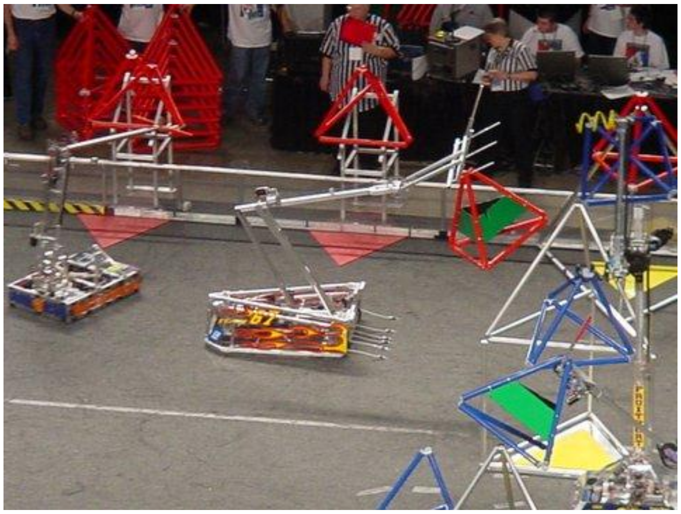
Robot Control

Our robot has two main types of control devices. These are potentiometers and encoders. The use and behavior of the arm potentiometers were detailed in the Control Station section above. The potentiometers used for steering will be discussed in the next section. The encoders function by counting the rotations of the encoder axle. This information is processed by the control program to determine the location of the robot on the field. This is used exclusively for autonomous purposes. Our encoders work well enough to allow us to position ourselves within 6 inches of our intended

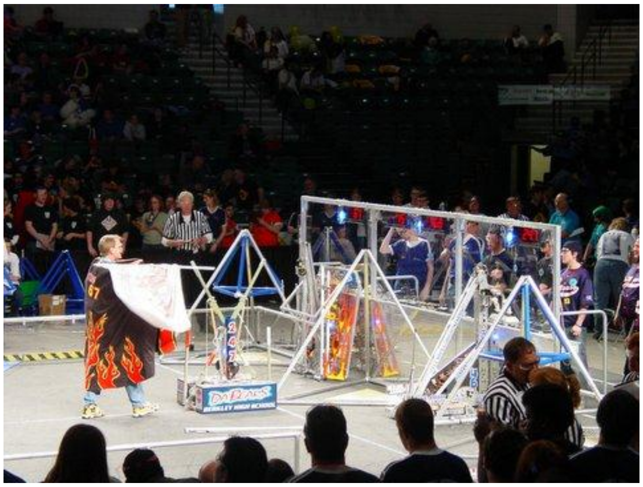


target. We were intending to use the camera to locate the vision tetras in autonomous mode, but we found that there was insufficient room in the code after including our basic function algorithms (steer, drive, arm).

"Tetra Trundle"



With 3 independently-steering wheels, a variety of motions can be performed. The most interesting would be the "Tetra Trundle." Using this, the robot moves in the X- and Y-directions without rotation. This makes our robot appear to hover over the playing field. To accomplish this, when changing from X- or Y-directions, the wheels all turn 90 degrees and begin to drive again. Our robot also can maneuver more mundanely by combining forward or reverse motion with rotation input from the steering wheel. Control algorithms were needed to provide more intuitive response to the driver's input. As the speed decreases and the rate of rotation increases, the center of rotation moves from far outside the robot frame to directly in the center of the robot frame. The motion is precisely determined by the readouts from the potentiometers on the steering motors, which are analyzed by the control program. Because of the complexity of these algorithms, very little room was left in the code for any other complex functionality (including the camera).



The HOT Team Won the Delphi - "Driving Tomorrow's Technology™" Award at the Great Lakes Regional

This award celebrates an elegant and advantageous machine feature. We earned this award for our elegant steering system. The HOTBOT is by far the most maneuverable machine on the "Triple Play" field. The "Driving Tomorrow's Technology" award recognizes any aspect of engineering elegance including, but not limited to: design, wiring methods, material selection, programming techniques, and unique machine attributes. All aspects of engineering; design, material selection, wiring methods, control systems and programming; work together to steer our robot to success. The well designed steering system created by the Heroes of Tomorrow is definitely Driving Tomorrow's Technology.

HOT Team Adds CASEY to Tools for Spreading the Message of FIRST

This year the Heroes of Tomorrow took a new step in spreading the message of FIRST. For years, the HOT Team has taken their competition FRC robot to the community to discuss FIRST. This was good, but there were always comments such as, “If we had a playing field, you could see how the robot could place the balls into the scoring zones.” Or, “If we had a bar ten feet high, we could lift our self off the floor.”

To answer these problems and to build a robot that had personality, the HOT Team created CASEY (Community Awareness of Science and Engineering Year-round). CASEY has just one agenda – have fun with people, especially kids.

CASEY has been kept very simple. This was by design to keep the SHOBOT simple enough for small children to operate. AT this time, CASEY can move around, lift his/her right arm, and blow air out of his/her left hand. CASEY can be either a boy or a girl, depending on his/her clothes. The HOT Team “dresses” CASEY for the occasion. Right now, we have several costumes for CASEY with more on the way.

The team also uses an old computer for the head. Using PowerPoint, several faces have been created that change from time to time. Future plans are to add speakers and music and maybe even voices.

The air on the left are is used to blow up balloons. The HOT Team members then twist them, making animals and hats for the children.

For several years, the HOT Team has competed in the Oakland County Competitive Robotic Association (OCCRA), which is a very good program. But this year, the team decided to take that time in the fall to build a robot that had a life of more than a few months. This is the time when CASEY was born. CASEY is new, so he/she has only been to the Johnson Elementary Science Day, but the people there were very receptive and excited about CASEY.

CASEY has already appeared in the Milford Times. He/she also has been invited to the Detroit Science Center and will spend part of the summer at Automation Alley in Troy. Plans are in place for him/her to visit several schools later this spring. CASEY comes to entertain and inspire kids that they, too, could build a robot like CASEY.