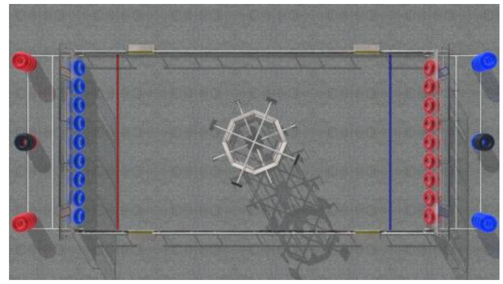
TEAM 67

2007

TECH NOTES

"HEROES OF TOMORROW!"
HOT

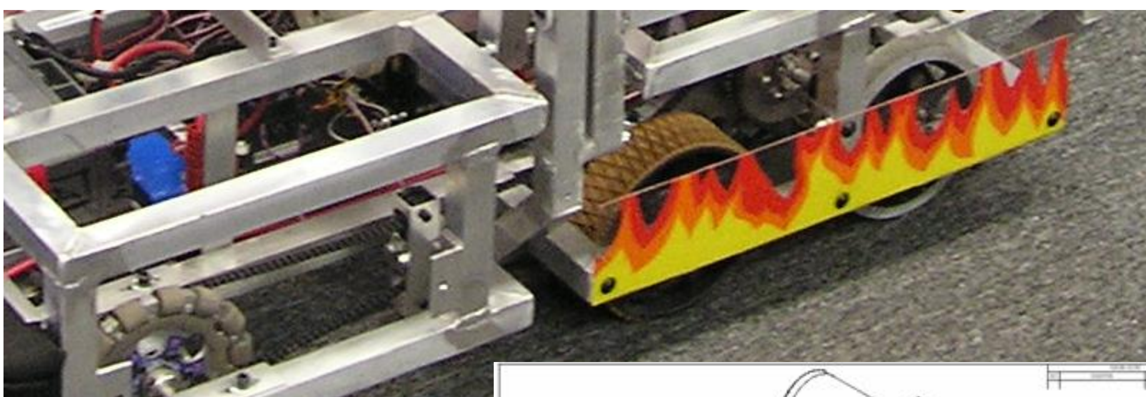
Rack 'N' Roll Strategy

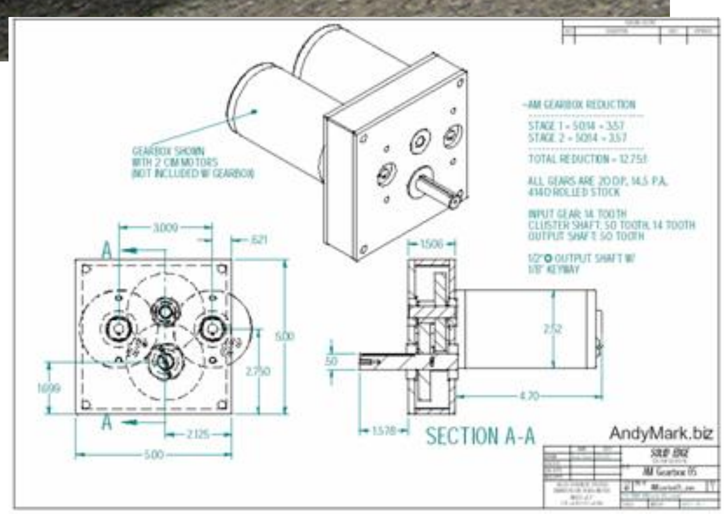


This year's game, Rack 'N' Roll, has three periods: autonomous, teleoperated, and the end-game period. During the autonomous period, robots attempt to place a "Keeper" tube onto the one of the spider legs of the Rack. Because the Rack may be moved before the autonomous period, the Heroes of Tomorrow (HOT) team decided that it would be important to use the 2007 kit camera to detect the position and orientation of the rack. During the teleoperated period, drivers remotely control their robot, attempting to score "Ringer" tubes onto the Rack. The HOT team determined that a quick and agile robot, with the ability to score ringers quickly, would be essential to excelling in this year's game. During the end-game period, teams are given an opportunity to score bonus points by ending the game with robots elevated above the ground. Fifteen points are awarded for each robot elevated four inches above the ground and thirty points are awarded for each robot elevated 12 inches above the ground. The HOT team designed the robot with the ability to elevate two robots at least 12 inches above the ground.

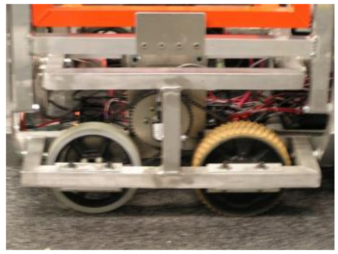
The Drivetrain

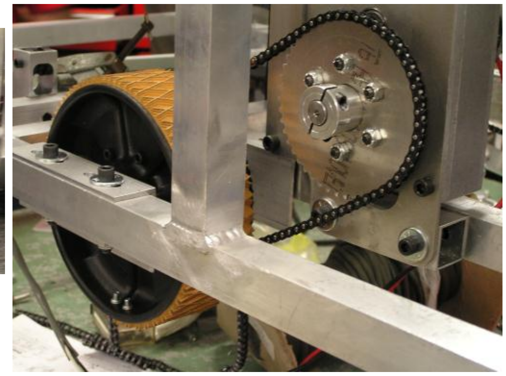
The 2007 HOTBOT is a six-wheel drive machine consisting of two Andy Mark Omni wheels in the front, two Andy Mark Traction wheels in the middle, and two wheels in the rear that were provided by FIRST in the kit of parts. Omni wheels were chosen to allow for increased rotational agility. The kit wheels were added to allow for increased stability when driving and also to aid if the HOT team is to drive up another robot's ramp.

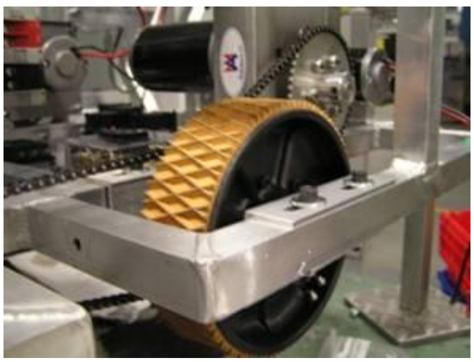




The traction wheels have been placed on each side, close to the middle of the robot, to enable the HOTBOT to achieve a near "zero point" turning radius. Each main traction wheel is powered by a CIM motor attached to an Andy Mark gearbox. By choosing a 6-inch wheel diameter, in conjunction with the 12.75:1 gear ratio in the gearboxes and a 1:1 ratio from the gearbox to the wheels, we can achieve a linear speed of 12 feet per second. The middle and rear wheels are chain-driven off of the motor to provide a dual redundancy in case we lose a chain during the match. Based on the power of the CIM motors, the chosen gear ratio, and the available traction of our wheels, we think our drive train is an optimum combination for the Rack 'n' Roll game.

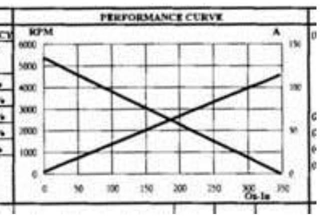






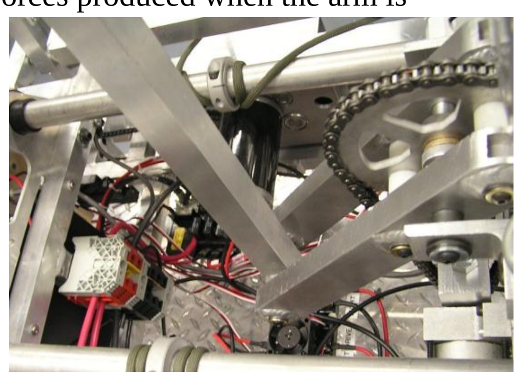
TYPICAL PERFORMANCE @ 12 Vdc	TORQUE	SPEED	CURREN	POWE	EFF'CY
	Oz-In	RPM (±10%)	A MAX	Wa	%
FREE LOAD	0	5342	2.4	0	0%
NORMAL LOAD	64.0	4356	23	206	75%
@MAX EFFICIENCY	45.0	4649	16.9	155	76%
@MAX POWER	173.4	2671	58.2	343	49%
@STALL	346.9	0	114.0	0	0%

HIPOT: 600 Vac/0.5 mA/1 sec
INSULATION RESISTANC 10 MΩ
INSULATION CLASS: B

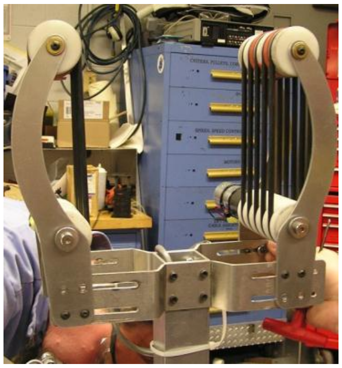


The Arm

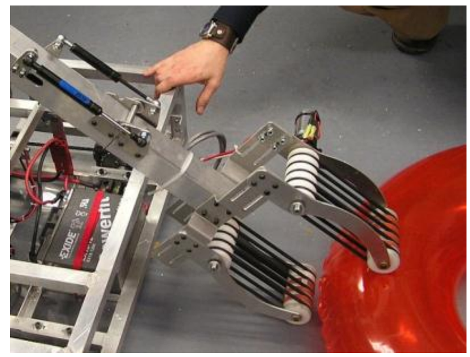
The HOT team designed an arm that is capable of scoring tubes on all three levels of the rack. The arm was designed as a four-bar linkage system to keep the motor as low as possible, which allows our robot to have a low center of gravity. We also avoided long lengths of chain, simplifying our design by eliminating complicated chain tensioning devices. The arm is powered by a CIM motor paired with an Andy Mark planetary gearbox that has a 181:1 gear ratio. This combination, along with a 3:1 external ratio, gives us a 10 rev/min rotational arm speed. We feel this rotational speed will give the arm operator good control, but will remain fast enough to score quickly on the top level of the rack. A 90-pound (lb) gas spring counter balance was mounted on the arm to aid the motor when the arm is rotated up. A chain tensioner was engineered into the arm drive system to counteract high strain on the motor, motor mounts, and arm brackets. The chain tensioner absorbs the forces produced when the arm is powered, allowing the motor mounts to counteract only the rotational inertia produced by the motor.



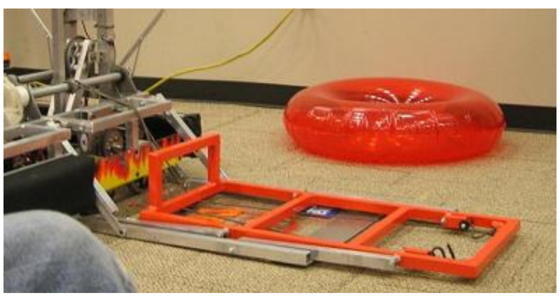
The End-Effector



The end-effector allows the HOTBOT to pick up tubes in any orientation and place them in any position on the rack. The end effector is mounted on a hinged joint to meet the initial packaging constraints. The end effector is forced into its game configuration by a 60 lb gas spring. A 50 lb gas dampener is also used to smoothly change configurations at the start of the match. This joint allows the arm some flexibility during game play to resist damage if the arm is lowered onto another robot. Orientation of the game piece is achieved by a pulley system utilizing four delrin pulleys connected by ¼-inch round neoprene belting, and powered by independently-controlled Globe motors. Independent forward/reverse control of each pulley system allows the arm operator to pick up the game piece, rotate it up or down as needed, and eject the piece on demand.

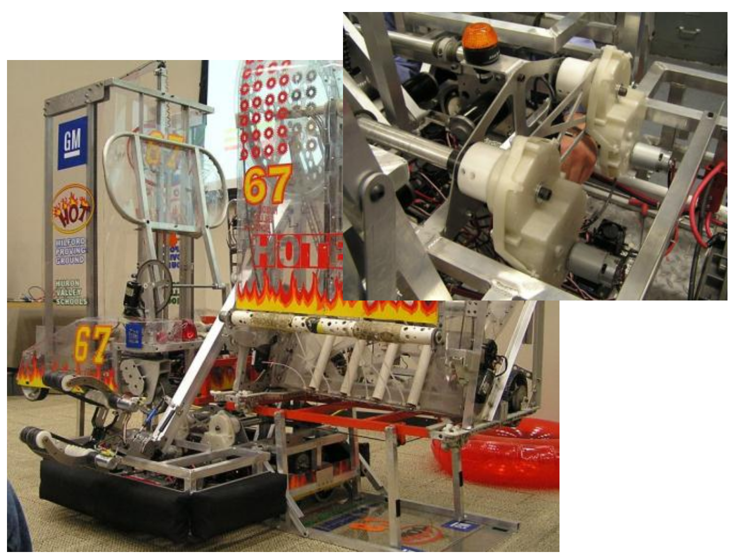


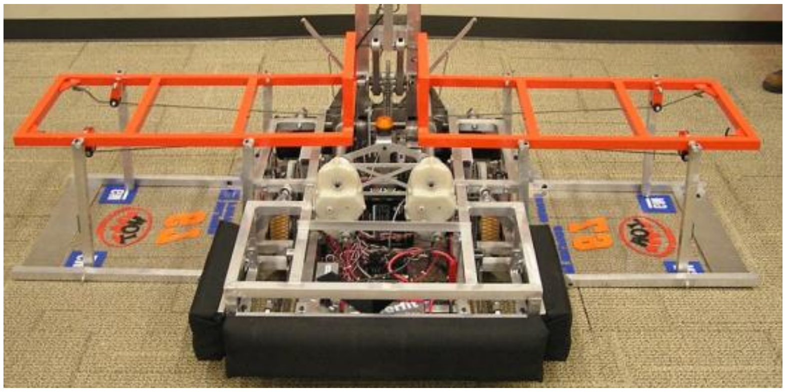
The Lift System



The HOTBOT lift system was engineered with two four-bar linkages on each side of the robot. The lift system was designed to package as thin as possible. We assumed when the lifts were designed that the majority of robots have at least 1 inch of ground clearance. If another robot has this clearance, they should have no trouble entering onto our lift system. We felt that a four-bar linkage lift system was the most efficient way to elevate a robot 12 inches from the ground while keeping the system simple and lightweight. Each lift is actuated by an independently-controlled winch powered by Fisher Price motors and gearboxes. To deploy the lifts, cams mounted to the winch release spring-loaded lift locks that allow the lifts to spring out into lift configuration.

Once the lifts are deployed, spring-loaded locking pivot arms lock the platforms to the ground to prevent our robot from tipping when the lifts are powered. By exerting the lifting forces into the ground instead of our robot, we can independently lift each robot when they are available. To assist our lifts at the start of lifting, before we gain the mechanical advantage of the four-bar linkage, we extend two kickstands at the outer edge of the platform. These kickstands provide a 2-inch mechanical lift to the platform, which relieves some of the stress applied to the linkages.



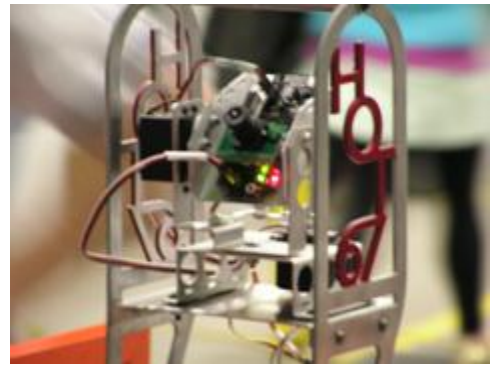


The Controls

This year the HOT team chose to take advantage of the USB chicklets that were available. Two Logitech game pads are being used for both the driver and the arm operator. The driver's controls are fairly simple. The driver uses the two analog sticks to drive the robot in a tank configuration. The driver can also hold down some of the shoulder buttons to cut the speed of the robot down by varying amounts. The arm operator's controls are a little more complicated. The left analog stick controls the arm up and down manually. The right analog stick is used to control the end-effector. By moving the stick up or down you turn the motors on out of phase (meaning one spins clockwise and the other spins counter-clockwise). This rotates the tube up or down depending on which direction you move the stick. To pick tubes up or eject them, the motors need to run in phase (meaning that they both spin in the same direction) this is accomplished by holding down the L1 button and using the right analog stick. To make it easier for the arm operator, we used the four buttons on the right side of the controller to set up pre-programmed positions for the arm. The four pre-programmed positions include: picking up tubes and placing tubes on the top, middle, and bottom levels of the rack. The arm uses a potentiometer and a

PID algorithm in order to position the arm correctly every time. The controller takes a measured value from a process or other apparatus and compares it with a reference set point value. The difference (or "error" signal) is then used to adjust some input to the process in order to bring the process' measured value to its desired set point. Unlike simpler controllers, the PID can adjust process outputs based on the history and rate of change of the error signal, which gives more accurate and stable control. The R1 and R2 buttons on the controller serve to move the arm up and down by small amounts for minor adjustments you couldn't do using the left analog stick. Another feature on both controllers is that each one of them controls one of our lifting platforms. By tapping the select button, they will run the winch motors and release the platforms from their packaged position. When you hold the select button down, the winches will be powered lift the platforms. The start button is used to release the platforms.

The Camera



The camera is another integral part of our programming. In order to achieve the best results, we tweaked the original parameters to create a slower moving search pattern. We also narrowed our search from the default as well as corrected where the center point was based on our robot. We used the virtual window command to create a smaller window in the center of the view so that our camera would only lock onto one light at a time. For the autonomous code we command the robot to lift the arm from the packaged position and move slowly forward as the robot searches for the light. Once the camera is locked on, based on whether the light is to the right or the left of the center pixel default, the robot corrects itself to point towards the light. This is also controlled by a proportional algorithm so that the closer you get, the less the robot turns to try to correct itself. Once it gets to a certain tilt position, the robot stops driving, lowers the arm, and powers out the tube.

Conclusion

This year, the HOT team strived to build a robot that accomplished all of the game objectives as efficiently and simply as possible. The end result is an elegantly engineered robot that has a reliable autonomous mode, is able to score ringers on all three levels, and can lift two robots over a foot off the ground during the end-game.