1. Historical Information

Over time, interest in robotics has increased due to technological advances. The most important advancement – the ability to repeat a particular task- can be obtained through programming the robot with a series of tasks or by reproducing human movements [1]. Robots are designed to perform tasks that would otherwise be carried out by humans. They are normally used to perform repetitive motions or to perform “jobs that are dangerous for humans” [3].

Robotics is a very specialized area inside the field of Electrical and Computer Engineering. Because of this, the Institute of Electrical and Electronics Engineers has sponsored an annual student robotics competition. The Southeastern Conference (SECon) hardware competition allows competitors to utilize their knowledge, resources, and technology to develop a robotic solution to a specific problem. Brainstorming, teamwork, and timelines are just a few challenges teams must face while preparing for the conference. Participating colleges and universities come from Alabama, Florida, Georgia, Indiana, Jamaica, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

2. Problem Definition: Rules, Regulations, and Design Constraints

FedEx has presented a real-world problem for the SECon robotics competition of 2006. In order to reduce the cost of shipping a package, FedEx wants to automate most of the process. Thus far, FedEx has automated the sorting process that occurs inside the hub (shipping and sorting center) at the Memphis International Airport. Although this procedure is in place, people still have to manually load each plane with crates crammed with a multitude of different parcels destined for other cities around the world. FedEx would like to find a way to automate this process of filling the planes with these large crates.

The objective of this year’s competition is to use an autonomous robot to load these crates, also called packages by competition designers, into each of three airplanes. The packages start in a large vertical queue and can be extracted from the bottom. After the package is removed from the queue, the robot must determine the package’s corresponding airplane. Once the appropriate airplane has been determined, the robot will take four packages that are designated for one of three planes and place them into that airplane. As soon as all three planes are filled, the round is over. Points will be awarded for correctly placing packages in their appropriate airplane. After several rounds, the school with the most points wins the competition.

The playing field, called a ramp, is a 4’ x 4’ sheet of plywood that is divided into several different areas by paint. All of the important areas- starting square, airplane location, and chute location- are painted white while the rest of the board is black. There are also several one-inch white lines that act as guides to help the robot travel to each ramp location. The outer edge is also painted white to warn the robot that it is about to leave the playing field. The starting location is an 8” x 8” square in the lower-left corner of the ramp. Directly across from the starting square is the “package stacking chute consisting of a triangular FedEx mailing tube” [2]. Near the other two corners, airplanes two and three sit just inside the outer white line. Airplane number one is located on the bottom edge, about halfway in between airplane number two and the starting square.

The FedEx package chute initially contains 12 packages. Each package is a 2-1/8” segment of a pine 2” x 4” [2]. A barcode label is located on the top and front (the side that is facing out of the chute) of each block which designates its location [2].

Each airplane is represented by a small cardboard box that is 6” x 12” x 3” tall. Each airplane fits directly over a white area on the ramp. “Planes must be loaded from the ‘loading zone’ side of the plane,” [2] which is the face closest to the starting side of the board.

In addition, the robot has several requirements specified by the competition. The robot cannot be larger than 8” x 8” x 12” high and cannot separate into multiple units. Once the round has started, the robot may expand to a maximum size of 14” wide by 14” long by 20” high. After the robot has delivered all the packages and is ready to be scored, it must return to its starting size. The robot also is given a verbal starting signal by the judges. After the start signal, a team member may push a start button on the robot, after which there cannot be any other human interaction with the robot. Thus, the robot must make all decisions necessary to complete the task. Upon filling three airplanes with their four designated packages, the robot must illuminate a blue LED to signal that it has completed the task and is ready to be scored.

Time is the biggest constraint in the contest. Each airplane will leave the ramp and take off at a different time after the start signal has been given. The first airplane will leave after three minutes, the second after four minutes; the last airplane will take off five minutes into the round.

The competition is scored by a point system. Each package that is correctly loaded before the departure time into its corresponding plane earns eight points for the team. If a package is loaded onto an incorrect plane, two points are deducted from the team. Also, if an airplane is moved enough for the white paint beneath it to show, the team will be penalized 12 points. In the case of a tie, the robot with the shortest delivery time wins the round.

The SECon team must construct a robot that will conform to the rules mentioned above and will deliver the 12 packages to their designated airplanes before they depart.

3. Competitive Analysis

Although the challenge is the same for all competitors, the design of the autonomous robots is a key factor in determining the winner. Simplicity and reliability are the vital factors in determining who will rise to the occasion. The SECon 2006 team from Mississippi State University knows that if each part of the robot does not perform efficiently then the team has no chance of winning. Thus the team has optimized the individual functions of the robot to achieve its peak performance.

The biggest factors impacting every the teams are time, space, and speed. In order to optimize the robot’s traveling, the MSU team has used motors with enough torque to carry the heavy load of the robot and the packages quickly to each destination. These motors are not servo motors but stepper motors; which allow the team to have more power and torque, thus giving a greater overall speed. With a combination of stepper motors and appropriate coding, the robot has the ability to know its location. This allows the white lines to be used as warning lines instead of guides, since the robot will not have to follow the lines but drive directly to the desired location. Since space is critical, the robot can enlarge in order to give more room for package storage. The problem with increasing the size of the robot is that the mechanics are very difficult to implement and prone to failure. The MSU team decided not to expand past the starting requirements in order to reduce complexity and increase repeatability. Because of the smaller size, the robot has been able to maneuver with greater ease and does not have to waste time expanding and returning to its original size. Time has been optimized by keeping moving parts limited to one axis and allowing the robot to drop off four packages simultaneously.

Overall, the winner of the Southeastern Conference hardware competition is largely dependent upon the assembly and approach taken by the competitors. The combination of the simplistic task and the stringent rules make the differences in implementation vast while the differences in approach are minute. These differences could include stepper motors vs. servos, line sensing techniques, or expansion. Because of our exceptional implementation, Mississippi State University's 2006 team believes it will win the competition.

4. Implications of Success

After winning the SECon competition in 2003 and 2005, Mississippi State University has gained the reputation for performing better than many of the other schools at the SECon competition. This reputation makes MSU the school to beat in 2006. The 2006 MSU team has felt this added pressure, and it has helped the team to perform at its best. After bringing home the first place trophy, MSU will prove to the rest of the southeastern schools that its reputation for being a great Engineering school is justified.

References:

[1] "Robot," in *Wikipedia*, 28 Aug 2005. [Online]. Available: http://en.wikipedia.org/wiki/Robotics.html

[2] "SoutheastCon 2006 Hardware Competition Description," SECon Hardware Competition Rules, 28 August 2005. [Online]. Available: http://ewh.ieee.org/reg/3/secon/06/hardwarerules080805.PDF

[3] "Robots Take dangerous jobs", Robots, 2 September 2005. [Online]. Available: http://www.pcworld.com/news/article/0,aid,110127,00.asp