Robotic Systems Challenge
2006

An engineering challenge for students in grades 7 – 12

Competition Date: 1 April 2006

Sponsored by:

Johns Hopkins University
Engineering Research Center
Computer-Integrated Surgical Systems and Technology

Glass Pavilion, Levering Hall
JHU Homewood Campus

Introduction:

The purpose of the Robotic Systems Challenge is to complement classroom instruction by providing students with a unique opportunity to apply classroom skills and knowledge in a fun and competitive environment. This year's robotic systems challenge consists of four separate challenges. A short description of each is provided.

<u>Challenge 1</u> ***Petite Slalom***

The Petite Slalom is a course in which competitors robots travel from the starting gate to the finish line while traveling through "gates." The gates are selected from pre-determined points on the rough side of a 3' x 6' section of tempered hardboard. Teams will be able to practice on practice tracks they can construct from provided directions. When they arrive at the competition they will be told which gates they must pass through to get points. The most successful robots will traverse the course correctly and be the fastest to accomplish the route. Since all the points where gates can possibly be placed will be known in advance, teams will be able to program their robot to run segments of the course in preparation. They will then have to join these segments together at the competition to run through the correct gates. There are two categories of this slalom. Category 1 uses the Parallax Boebot and Category 2 is any other robot.

<u>Challenge 2</u> ***Mystery Course***

Teams will arrive at the competition with no knowledge of what the course will be. The course will be some type of blind course that requires robotic sensors to maneuver. They must come to the challenge equipped with a complete Boebot and the knowledge required to effectively use the sensors provided in the kit. Teams will be given 90 minutes to assemble the sensors on the robot and program the robot. The course will not be available to the competitors during the programming and assembly phase. The students will place their robot in line when they feel they have programmed it successfully. All robots will be tested and the ones that complete the maze will be ranked by time, with the fastest time being the winner.

<u>Challenge 3</u> ***Innovative Use of the Board of Education***

Teams will design an innovative and practical new use for the Basic Stamp board of Education. They will display a working model of their idea in an oral presentation along with a written report. Teams will be judged on quality of the idea, operation of the prototype, the oral report and the written report. This challenge is designed to be the result of innovation and robotic exploration and is considered the premiere challenge of the day's event.

<u>Challenge 4</u> ***Search & Destroy (Robotic Brain Tumor Surgery)***

Teams of Robotic Brain Tumor Surgeons will design and program their Boebots to find all the "tumors" (large dark circles) at various unknown locations in the patient's brain, a 3' x 3' enclosure. The BoeBot will be placed in a random point inside the brain and should be able to detect the corners and sides of the enclosure and to search the entire brain for tumors on its own. When a tumor is found, the robot must signal to the surgeons(possiblty a buzzer or LED). The robot should stop once the entire brain has been searched. Teams will be judged on their robot's ability to find all the tumors, time to complete the search, and efficiency. Bonus points will be awarded for creative signals!

General Information:

The competition will be held in the Glass Pavilion of Levering Hall on the JHU Homewood Campus from 8:00 AM and last until 4:00 PM on Saturday, 1 April 2006. A meeting will be held for information purposes on 1 December, 2005 from 6:00 to 8:00 PM. The cost to enter will be $35.00 per team per challenge but is reduced to $25.00 if the fee is mailed in prior to 15 December 2005. It is recommended that teams are accompanied by a sponsoring adult.

Schools may enter as many teams as they wish and a team must consist of 2 or 3 students. Since the competitions run simultaneously it is recommended that teams exercise caution in entering more than one challenge. Start times will not be delayed if a team is participating in another event. Teams may only enter one robot in any event and robots cannot be shared between teams. Robots must be marked for easy identification. Robots and programs for the robot are subject to inspection at any time during the competition.

During the competitions students and accompanying adults are responsible to act in a gracious and professional manner. Arguing with contest judges and poor conduct will result in immediate disqualification.

Teams have particular times during each competition when they are allowed to modify the programming of the robot. Sufficient computer equipment must be brought by the team, there will be none available for lend.

Practice tracks may be brought by a team if appropriate, but differences in tracks will not be cause to protest the contest results. Changes in surfaces, lighting, and slight size variations are normal and part of any engineering challenge.

First, second and third place trophies and prizes will be awarded for all four of the challenges and each of the 2 categories of the petite slalom. All judging will be based on the criteria listed in each challenge's rules. Judges are allowed to interpret the rules to ensure a fair and equitable challenge. Judges decisions are final and inarguable.

Any question or comment concerning these rules can be addressed by sending an email to Cynthia Ramey [cmiller@cs.jhu.edu], Director of Education, ERC CISST.

CHALLENGE 1
Petite Slalom

In the Petite Slalom competitors will program their robot to travel through a slalom course set up on the rough side of a 3’ x 6’ sheet of tempered hardboard. Robots are programmed to run a designated path through a series of gates.

There are two categories for this competition. In the Boebot category (**Category 1**), only Boebots can be used. The Boebot must be powered only by 4 AA batteries. Information about the Boebot can be found at www.parallax.com. In the open category (**Category 2**) any programmable robot can be used. For example the small robot, available at www.smallrobot.com can be used with a TI83 calculator or a LEGO Mindstorm robot could be used. These robot types are all easily available and can be built and programmed in a relatively short period of time.

Rules

The track consists of a 3 foot by 6 foot piece of tempered hardboard. As shown in figure 1. Robots will run on the rough side of the track. The track is unadorned with sides and the spacing dots are done with a marker. No paint or tape is used, to ensure that the surface provides consistent traction.

Practice tracks can (and should) be produced at your school based on the measurements shown in figure 1. Teams should remember that minor differences in track material and construction are not justifiable cause to argue the outcome of a competition.

Each category will have its own track and the setup of the track may vary between the categories.

A gate consists of a pair of 9 ounce party cups to be used as gate markers. The cups will be placed upside down centered on the dots on the track; the dots are 12 inches apart. One cup will be green or plain colored and marked with an “L”. The other cup will be red or a plain colored and marked with an “R”.

Robots must pass forward through the gate with the green cup on the robot’s own left and the red cup on the robot’s own right.

One special (optional) gate may be used at the judge’s discretion that is considered a reverse gate. The robot must pass through this gate backwards. This gate will be marked with a green cup with a horizontal strip of masking tape (or a plain cup marked LB) and a red cup with a horizontal strip of masking tape (or a plain cup marked RB). The robot must pass backwards through this gate with green striped cup on the robot’s own left and the red striped cup on the robot’s own right.

Dots in the drawing (figure 1) indicate possible positions for gate markers. The dots are centered 12 inches apart. The lower left dot in the figure is at (x,y) coordinate (6 inches, 1 foot). The upper right dot is at (x,y) coordinate (2 ½ feet, 5 feet).

The location of the starting line is shown in figure 1. The robot may start with the axle of the drive wheels on the starting line to achieve a consistent start. The starting line may be marked every inch to aid in alignment. The starting line is not a gate.
The finish line will be a paving brick placed at one of the four locations abutting the edge of the track. These positions are marked as A,B,C, and D on figure 1.

At the beginning of each round, the judges for each category will place the finish line and up to four gates on the track. Another brick, in addition to the finish line, will be placed on the track to encourage robots to go through the established gates. The arrangement of gates and finish line will then be revealed to the contestants.

All teams will begin to program their robots to travel the course. Predetermined sections of code can be used in both categories.

When a team completes their programming they will place their robot into the line (queue). Part of the score for the course is determined by their position in line. The run will start when all robots are in line.

Any robot removed from the line must be placed at the end of the line when returning. A maximum of 15 minutes will be allowed for programming. No robot will be allowed into the line after the 15 minutes has expired. After one run the robot may be placed back in line for a second attempt. No changes to programming will be allowed between attempts.

Scoring

Scoring will be based on time and deductions. The time will be the time required to travel from the starting line to the finish line. Time starts on first movement of the robot and ends when the finish line brick is touched. A maximum of 40.0 seconds will be recorded. Deductions for correct movement and placement in line will be made as follows:

> The first four robots in line will get a deduction from their score based on their position, position 1 = 4 points, position 2 = 3 points, position 3 = 1 point and position 4 = 1 point.
>
> 3 seconds will be deducted at each gate if the robot passes through the gate in the right direction without touching a gate marker (cup).
>
> 2 seconds will be deducted at each gate the robot passes completely through in the correct direction but touches a gate marker. In this case the gate marker moves butt he robot stays between the dots without touching the dots.

1 second will be deducted for each gate the robot partially passes through or the robot passes through in the wrong direction. In this case some of the robot but not the entire robot passes through the gate or the robot goes in the wrong direction.

2 seconds will be deducted for touching the finish line brick.

1 second will be deducted for moving backwards 1 inch after touching the finish line brick.

There will be a 10 second penalty for passing through a gate out of order. This penalty is incurred when a robot passes through a gate or touches the finish line without passing through the previous gate. This penalty may not be used to make the exceed 40.0 seconds for any round.

Each round ends when robots have had at the most two opportunities to run, or as directed by the judge.

The team with the shortest time including deductions will be declared the winner.

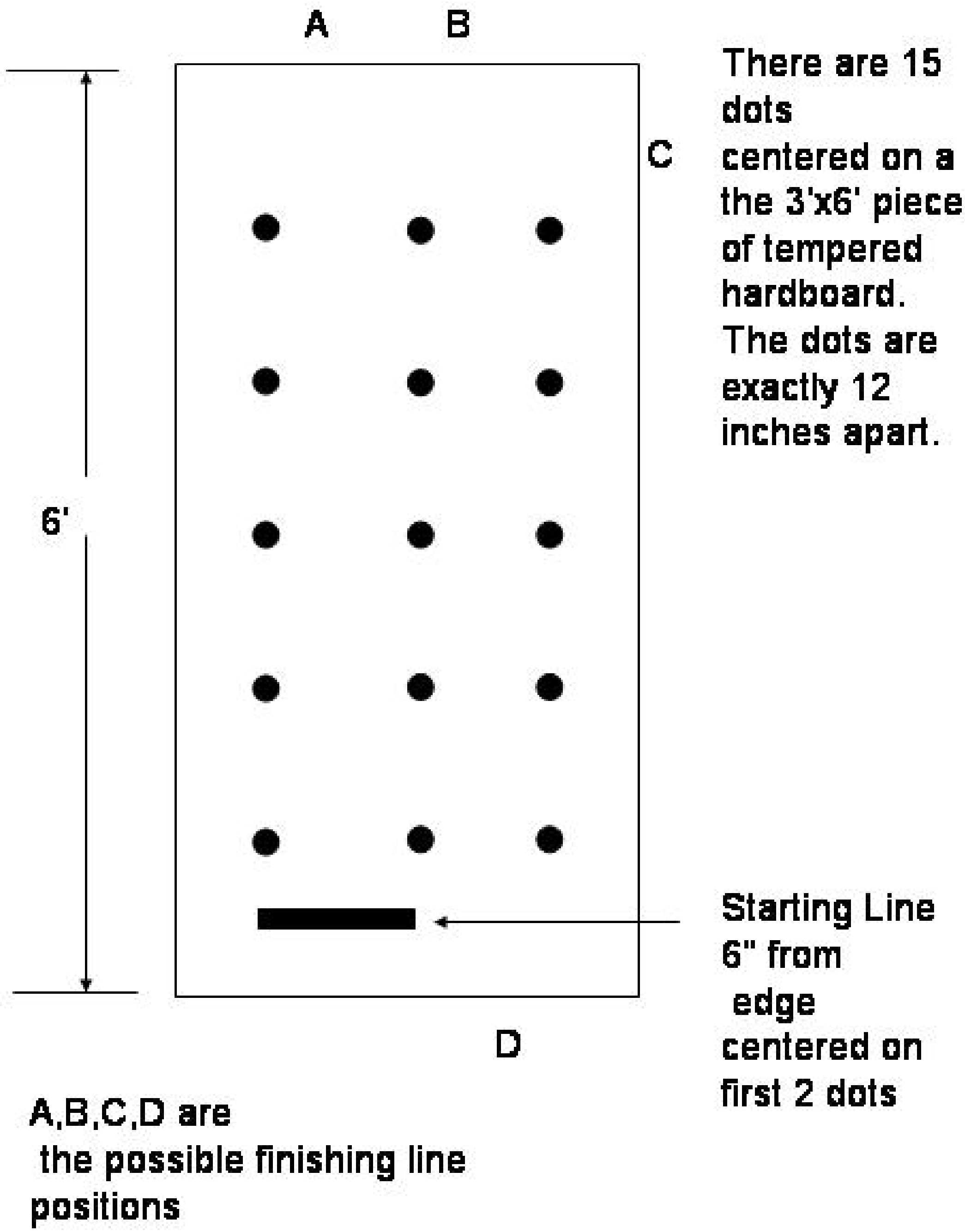

Figure 1 Petite Slalom

CHALLENGE 2
Mystery Course

Teams are encouraged to practice with the sensors available in the Boebot kit prior to arrival at this competition. The mystery course will be unveiled upon arrival at the challenge and teams will have 90 minutes to select the appropriate sensor and program their robot. The course may be a blind course that cannot be seen or an open course that is established after the programming period ends. For example the course could be open to view but has moveable walls.

Teams must arrive at this competition with a good working knowledge of how to program the Boebot and its sensors.

Rules

Teams are restricted to use only the sensors available in the Boebot kit, no other sensors may be used.

Robots must be powered by 4 AA batteries only.

Teams must provide their own computing devices; none will be available for loan. Teams must insure any computer they bring has the proper programming environment.

Teams may not be assisted in programming by any person other than a team member.

Teams may use portions of programs they have previously written.

Many details of the course will be provided at the beginning of the programming period. There will be no other communication between the judges and the competitors except for minor clarification of the details provided. Those clarifications will immediately be made available to all teams participating.

No more than two attempts to maneuver the course will be made by any team.

The winner will be determined by timing. The team with the shortest time to complete the course will be declared the winner. There will be a second and third place trophy awarded as well.

CHALLENGE 3
Unleashing the Mad Scientist
Innovative Use of the Board of Education

The Board of Education is a parallax product that interfaces a basic stamp processor. The board of education can easily be programmed in basic programming language. The board of education is the same board that is used on the Boebot to program the Boebot robot. The challenge is to design an innovative and practical new application for the basic stamp board of education. Teams selecting this challenge will present their idea in an oral report and submit a written report. Teams will also demonstrate a working model their proposal.

Standards

Product Idea 20 points

Teams will identify a need and develop a solution for that need. Your idea will be scored based on the innovation and practicality of that idea. The teams are responsible to present their idea in a way that enhances the usefulness, innovation, or uniqueness of that idea.

Registered teams must email their abstract no later than 48 hours prior to the start of the competition to Brian Bruneau, Dulaney High School at bbruneau@bcps.org.

Product Prototype 30 points

Teams should be prepared to demonstrate their proposal with an actual working model (prototype). Teams can show video during their presentation but a working model must be displayed. The prototype will be judged on quality of construction, efficiency of operation, reliability, and achievement of design specifications.

Product Oral Report 20 points

Each team will be given up to 10 minutes to make a presentation to the judges and to answer questions. The presentation should cover the design and development of the idea and the scientific principles behind the design. Program code and flow charts should be shown. Teams will be judged on content (knowledge of the project, organization of the presentation, and completeness of the information) and presentation (poise, speaking ability and visuals).

The three teams with the best score will be asked to present their product during the awards ceremony.

Product Written Report   30 points

Teams must provide a written report in the following format.

Title page. Include the name of the challenge, team name and logo, name of school, names of student team members, names of teachers assisting.

Table of Contents. List each section and the page on which it first spears.

Summary (abstract). Must be less than 1 page in length and clearly summarize the project.

Body. The body is the main part of the report and can be divided into several sections. The information that should be included in the body is listed.

An explanation of the reasons behind your design.
An explanation of the scientific principles behind your design.
Drawings (with titles and labels) and design calculations.
An explanation of design testing, and any improvements made after testing.
A description of problems encountered in building your product and your solutions to those problems.

Conclusions. Describe how successful your project was and what did you learn by doing this project. How can your idea be applied to future projects.

Acknowledgements. List the names of the adults who assisted you in the project with a brief description of what they did. Include a certification, signed by all student team members and adults assisting, stating that: "We hereby certify that the majority of the ideas, design and work was originated and performed by the students, with limited assistance by adults, as described above."

Bibliography. List all references used, including internet, books and periodicals.

Appendix A. Team Members. List the team members with a short description of how each person contributed to the project.

Appendix B. Scheduling and Accomplishments. Show on a timeline or similar method how you scheduled your project. Include brief records of meetings and work sessions telling how the schedule was managed.

Appendix C. Material Resources. Provide a list of all materials used the cost of the material and how they were obtained. Please provide an estimate of the cost of donated material.

Appendix D. Flow Chart, Drawings and Code. Include your program code, a flow chart of your program and any drawings not included in the body.

CHALLENGE 4
Search and Destroy
Robotic Brain Tumor Surgery

Robotic Brain Tumor Surgery Teams of Robotic Brain Tumor Surgeons will design and program their Boebots to find all the "tumors" (large dark circles) at various unknown locations in the patient's brain, a 3' x 3' enclosure. The BoeBot will be placed at a random corner inside the brain and should be able to detect the corners and sides of the enclosure, and to search the entire brain for tumors on its own. When a tumor is found, the robot must signal to the surgeons (possibly a buzzer or LED). Once the entire brain has been searched, the robot should send a different signal to the surgeons. Teams will be judged on their robot's ability to find all the tumors, time to complete the search, and efficiency. Bonus points will be awarded for creative signals!

The purpose of this competition is to simulate the planning, searching, and signaling that takes place during robotically-assisted surgery. The number and location of tumors inside the brain (enclosure) will be random, so the robot should be pre-programmed to search the entire brain for hazardous tumors.

Rules

The brain (enclosure) consists of a 3 feet x 3 feet white poster board base with surrounding white poster board walls that are 4 inches tall. The base and walls of the brain are white. Tumors will be represented by 2 inch radius circles drawn with black permanent marker

The robot will be placed at a randomly picked corner of the brain and several tumors will be placed at various locations in the brain (see figure 2). The number of tumors will be announced at the beginning of the competition. The robot should be able to turn whenever it encounters a wall or corner and search the entire enclosure. If a tumor is detected, the robot should signal its presence to the judges. For example, an LED can be flashed or a buzzer sounded. The signal that the team wishes to use must be announced to the judges prior to the competition starting.

When the robot determines that it has finished searching the entire area, it should send a different signal to the judges. For example, the LED can be flashed several times, or the buzzer sounded for longer or a completely different signal used. The robot does not have to end where it began its search.

Scoring

Each team will be given 3 trials in the enclosure and the scores from the 3 trials will be averaged. The team with the fewest points is declared the winner.

Scoring will depend first on tumor detection.

> True Positive (robot signals when tumor is present) = 0 pts
> False Negative (robot does not signal when tumor is present) = 10 pts
> False Positive (robot signals when tumor is not present) = 10 pts

Next, the time in seconds that it takes the robot to search the entire brain is added to the score. Of course, the less time it takes to complete the search, the better.

Judges will then judge the efficiency of the search method on a scale of 1 to 5, with 1 being the most thorough and efficient and 5 the least efficient. A good search method consists of the robot accurately detecting walls or corners and systematically searching the entire brain quickly.

Judges will also score the creativity and effectiveness of the signaling system on a scale of 1 to 5, with 1 being the most effective and 5 the least effective.

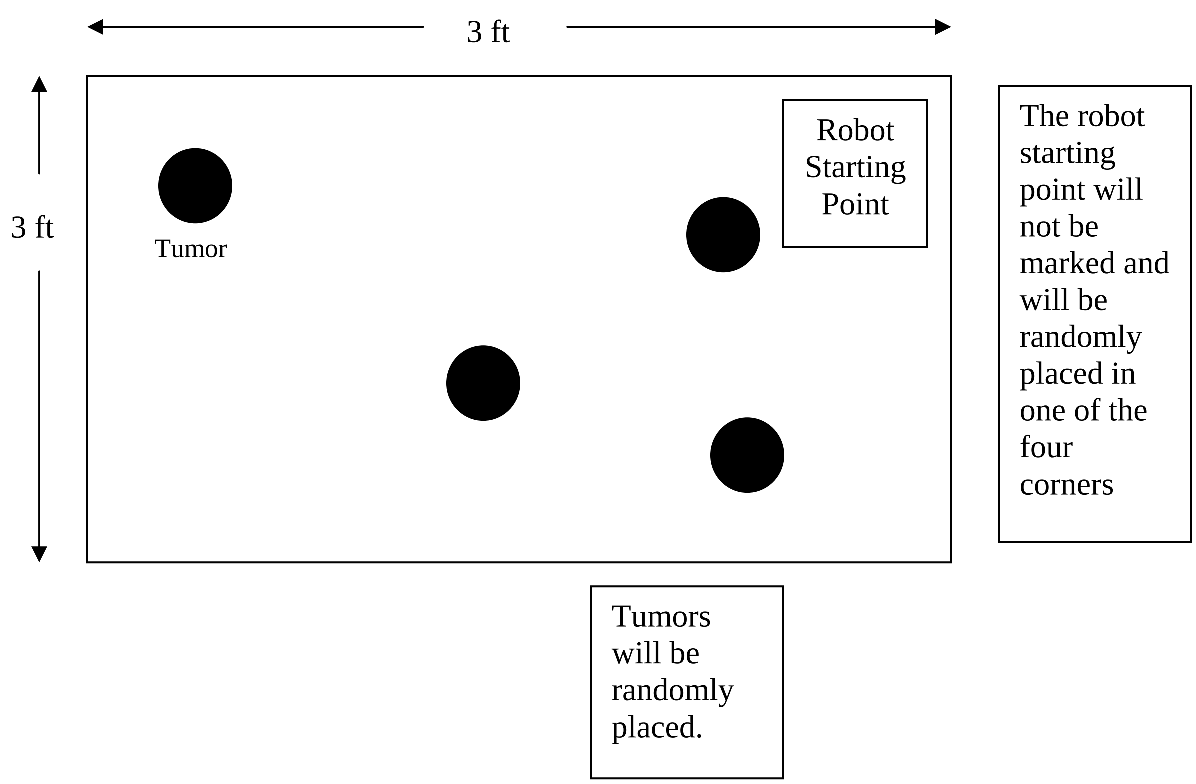

Figure 2 Search and Destroy Brain Layout