Firefighting Mobile Robot Contest (R&D Project)*
ITEC 467, Mobile Robotics
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***Contest and Rules Adapted and/or cited from the 2007 Trinity College Home Firefighting Robot Contest**

1. CONTEST OBJECTIVE

The main challenge of this contest is to build an autonomous robot using a *Teensy* Microcontroller that can find its way through an arena that represents a model house, find a lit candle that represents a fire in the house, and extinguish the fire in the shortest time. This task simulates the real-world operation of an autonomous robot performing a fire protection function in a real house. The goal of the contest is to advance robot technology and knowledge while using robotics as an educational tool. The contest shall also teach students about the limitations of technology, and how to deal with complex control problems and situations.

2. DIMENSIONS AND SPECIFICATIONS

The goal of the contest is to make a robot that can operate successfully in the real world, not just in the laboratory. Such a robot must be able to operate successfully where there is uncertainty and imprecision. Therefore, the dimensions and specifications listed in the rules are not exactly what will be encountered at the contest and they are provided as general aids. Contestants may take measurements on the contest maze located in Osburn Hall.

However, the size limits on robots are absolute and will be enforced by the Contest Judge.

3. THE HOUSE FLOOR PLAN STRUCTURE AND FEATURES

The arena/maze **r**epresents a home, a more realistic fire-fighting environment.

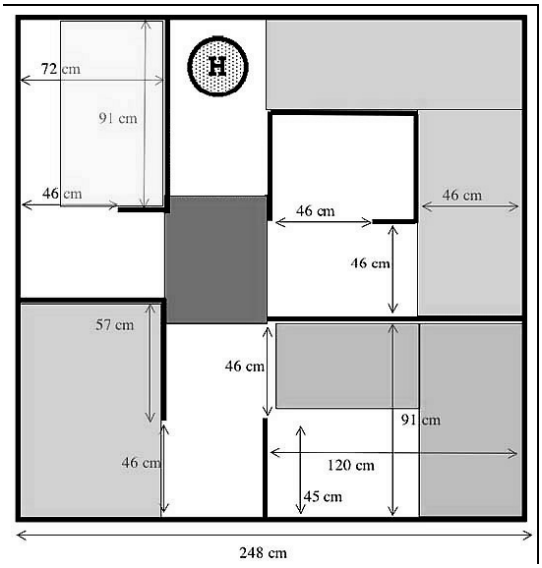
Rugs will be placed in some or all of the rooms and hallways. There will be no shag rugs. Wall hangings including mirrors may be hung from the walls of rooms and hallways. The floor will be painted black and the walls will be white. The condition of these surfaces may vary due to age of the maze and use and therefore are not guaranteed to be “pure” black or white. You must design your robots to deal with this potential imperfection.

A mirror will not be placed in the room where the candle is located but may be placed anywhere else in the arena.

Two ~5cm diameter circles will appear on the floor marking the hallway between all four rooms, and in the two adjoining hallways next to the Home Circle location. One will be Red in color and the other will be green in color. They will be placed ~14cm apart (center to center measurement). Two home occupant (The Green Lantern or The Flash) will exist/stand on one of the like-colored Red/Green circles. During each of the three maze attempts, a location will be randomly selected (one of three) along with occupants (The Green Lantern or The Flash) – they will not stand next to each other, however during any round. You must not touch an occupant with any part of your robot or it will result in a disqualification for that run. Should your robot be able to accurately identify the occupant as The Green Lantern or The Flash and advise them to leave the building using an LCD module, the occupant will be removed from the maze.

All hallways and doorways to room will be approximately 46 cm wide. There will not be a door in the doorways, just a 46 cm opening. There will be a white tape (~width of the walls), stuck to the floor across each doorway to indicate room entrances. The carpeting will not cover up the white tape. However the floor coverings may be light in color.

The robot will start at the Home Circle location. The Home Circle will be a solid white circle on the floor (No H labeled on actual circle). The ~20 cm diameter white Home Circle will be roughly centered in the hallway and may not be taped down/secured to the maze floor. The robot must start within the Home Circle (position determined by the Contest Judge), but once started, it can go in any direction desired.



4. AMBIENT LIGHTING

Part of the challenge of the contest is to make a robot that can operate in real world situations and that includes inconsistent lighting, shadows, glare, etc. Many sensors used by fire-fighting robots are thrown off by stray light sources including IR sources and UV sources present. Participants are urged to devise shades, covers, and other means to reduce the effects of stray sources.

5. ROBOT OPERATION

Once turned on, the robot must be autonomous without any human intervention. That is, they are to be computer controlled and not manually controlled devices.

A robot may bump into or touch the walls of the arena as it travels, but it cannot mark, dislodge or damage the walls in doing so. There will not be a penalty for touching a wall, but there is a penalty for moving along the wall while in contact with it for more than 3 continuous seconds. Should more than 3 seconds of continuous contact occur, the robot will be disqualified for that run.

The robot cannot leave anything behind as it travels through the arena. It cannot make any marks on the floor of the arena that aid in navigation as it travels. Any robot that deliberately, in the judges' opinion, damages the contest arena (including the walls) will be disqualified. This does not include any accidental marks or scratches made in moving around.

The robot must show the Contest Judge by using the provided LCD module/screen that it has found the candle before it attempts to put it out (i.e. “Candle Found” / “Scanning for Candle” or similar messages). For example, the robot cannot just flood the arena structure with CO2 thereby putting the candle out by accident. Failure to use the LCD module properly will result in a disqualification for that run. It is the responsibility of the teams to ensure accurate use of the LCD to the Contest Judge.

6. PUTTING OUT THE CANDLE

The robot must not use any destructive or dangerous methods to put out the candle. It may use such substances as water, air, CO2, etc., but any method or material that is dangerous or will damage the arena is prohibited. Halon is not allowed because it is harmful to the environment.

It will be permissible to put out the candle by blowing air or other oxygen-bearing gas (pure oxygen is not allowed). However, this is not a practical method of extinguishing a fire in the real world. So, robots that do not use air streams to blow out the candle will receive a 30% Extinguishing Time Reduction (ETR).

A robot is not allowed to knock over the candle. Should this occur, a robot would be disqualified for that run. Touching the candle is permitted, yet is not recommended.

The robot must come within 30 cm of the candle before it attempts to extinguish the flame. There will be three provided circle segments of different sizes that will be provided to the 467 teams at the onset of the semester. These segments may be of different sizes during the competition.

7. ROBOT SIZE
Robot must be able to fit in a box 31 cm long by 31 cm wide by 27 cm high. The robot cannot separate into multiple parts and must never extend itself beyond the dimensions allowed.

8. ROBOT WEIGHT
There are no restrictions on the weight of the robot.

9. ROBOT CONSTRUCTION MATERIALS
There are no restrictions on the types of materials used in the construction of the robot except that all robots will use the provided chassis/drive motors and microcontroller. Sensor use is also restricted to those introduced/provided for the challenge as to make for a fair contest. This is a contest primarily focused on the successful design and execution of code. Teams will be provided NiMH rechargeable batteries (chargers are located in the lab), but the robots may utilize other power sources provided that the servo drive power be limited to 7.2VDC or below. One may use a different battery chemistry such as Alkaline non-rechargeable batteries, but the servo drive voltage may not exceed 7.2VDC. Lithium battery chemistry of any type is prohibited. Other power sources (non-drive) on board may exceed 7.2VDC, but teams are responsible for all sensors, microcontrollers, fans, etc. Exceeding the voltage rating of a device may damage the technology.

10. THE CANDLE
The candle flame will be from 15 cm to 20 cm above the nominal floor level. The candle thickness normally will be between 1 cm and 3 cm. The exact height and size of the flame will change throughout the contest depending upon the condition of candle and its surroundings. The robot is required to find the candle no matter what the size of the flame is at that particular moment.

The candle will be placed at random in one of the rooms in the arena. The candle has an equal chance of being in any of the 4 rooms in each of the robot's 3 official trials or runs. It is possible for the candle to be in the same room on two of the robot's three runs. If it happens that the candle is placed in the same room for both the 1st and 2nd trials, then the contest official will make sure that it is a different room for the third and last trial. Thus every robot will have the candle in at least 2 rooms and possibly 3, during its 3 trials.

The candle will not be placed in a hallway, but it might be placed just inside a doorway of a room. It will be randomly placed in one of three valid potential corners identified in the maze.

The contestants cannot measure or touch the candle before it is used. Any violation will result in immediate disqualification from the competition of the team and the robot.

The candle will be mounted on a small gray plastic box/container. This base is used to help keep the candle from tipping over easily, but it will be possible to knock the candle over by bumping into it (which you don't want to do)!

11. SENSORS
Sensors are restricted to those identified at the onset of the semester by the Course Instructor/Contest Judge. Additional types of sensors are prohibited from the contest.

Contestants are not allowed to place any markers, beacons or reflectors on the walls or floors to aid in the robot's navigation.

During the course of the contest, sunlight may come into the contest room through open outside doors. The sunlight will not shine directly on the arenas, but may be detectable by very sensitive sensors. Part of the challenge of this contest is to design a robot that can find the candle flame and ignore everything else.

12. THE ORDER OF RUNNING
The robots will be assigned numbers to determine the order in which they will compete in the contest. Each robot will make a trial run in the arena in the order in which it is assigned. The robots will compete consecutively and when everyone is done with their first attempt the whole process will repeat for the second and third attempts.

While the robots will be impounded during the contest week, contestants will have time between their trials (during the contest) to make any adjustments, modifications or repairs to their robot, but once the robot before them has completed its trial, then they will have 1 minute to get their robot in the arena and started on its trial. There will be a special clock at each arena that the judges will start when they call for the next contestants to get ready. The robot must begin its trial before that clock reaches 1 minute. Any robot that is not ready to run after 1 minute will forfeit its

chance at that trial. It may still compete in any other trials. Once assigned, the order of running will not be changed. If you are not ready, then you've missed your turn. The time between turns is undetermined and is controlled by how long the other competitors take to complete their trials.

The contestants will show the judge how to start the robot, and identify the front of the robot.

Once the robot is ready and the judge knows how to start it, he/she will then place the robot into the maze on the home circle (position/direction determined by the judge). The two home occupant's location and identity will then be selected along with the location of the candle and the size of the circle segment to be used. This process shall be determined using a random number generator program. The judge will then place the candle in proper room/corner/white corner segment location.

Finally, the judge will then press whatever button is necessary to start the robot.

13. TIME LIMITS

In order to achieve the contest objective of building a robot that can find and extinguish a fire in a house, finding the fire within a reasonable period of time is very important. The maximum time limit for a robot to find the candle will be 5 minutes. After 5 minutes the trial will be stopped. Any time the robot does not move at all for 30 seconds, the trial will be stopped and result in a disqualification for that run. Stopping a trial run for any of the above reasons will have no impact on any of the other two trial runs that the robot has.

14. STARTING THE ROBOT MANUALLY

There can be one and only one button that can be pressed to start the robot. This button must be labeled as such, i.e., "START". "RUN", "GO", etc. The button must be easily accessible, however. If a wire or connection of any sort should become loose due to difficulty in reaching the start button, it will not be grounds for another contest run. It is the responsibility of the teams to ensure a robust robot design.

Also, any program necessary must be downloaded to the robot before it is put into the arena. Once that is done then the specific "start button" and only that "start button" can be pressed to start the robot. If for any reason the robot does not start, that trial is over resulting in a disqualification for that run should the robot not move within 30 seconds.

15. ROOM FACTOR

In order to make the contest realistic and to encourage the creation of smart robots, we have deliberately added uncertainty into the contest. The robot does not know in which of the 4 rooms the candle has been placed. Sometimes a robot gets lucky and the candle is in the first room it searches and sometimes the candle is in the 4th room searched. The unfairness of this is that finding the candle in the 4th room you look in is a lot harder and takes longer than finding it in the 1st room you search. To reduce the impact of "luck" and give some credit to the more sophisticated robots that can search multiple rooms successfully, there will be a Room Factor involved in the scoring that will be multiplied by the Time Score to get the Operating Score. The more rooms a robot has to search before it finds the candle, the lower the Room Factor and thus the better the Operating Score.

If the candle is in the 1st room searched, the Room Factor will be 1.0
If the candle is in the 2nd room searched, the Room Factor will be 0.85
If the candle is in the 3rd room searched, the Room Factor will be 0.50
If the candle is in the 4th room searched, the Room Factor will be 0.35

It does not matter in which order the robot searches the rooms. The only thing that matters is how many rooms the robot has searched before it finds the candle.

After searching a room with a lit candle in it, there is no further reduction of room factor. This is true whether or not the robot extinguishes the candle. No matter how many more rooms the robot searches, there will be no effect on room factor. Should a robot completely enter a room, it may not enter any additional rooms whether the candle is present in that room or not.

16. SCORING PROCEDURE

A. Record the Actual Time (AT) in seconds needed to put out the candle

B. Record the Room Factor (RF)
1st room = 1.0, 2nd room = 0.85, 3rd room = 0.50, 4th room = 0.35

C. Multiply the Time Score by the Room Factor and Extinguishing Time Reduction (ETR is optional) for that trial. (OS = AT x RF x ETR)

D. A OS < 5 min will qualify as a successful run.
See 467 Syllabus for grade determination for the Performance portion of the evaluation.

E. A disqualified run = 60 min for each run that a robot is disqualified.

F. Total Time (TT) for the Contest Winner is determined by adding the times from the top three trials. An awesome, coveted, custom trophy will be awarded to the contest team with the lowest TT for their robot, and the winning team will automatically earn an A for the 467 final course grade. Contest teams that extinguish all three candles will be excused from the code exam (100% eval).

17. SAFETY

The Contest Judge may stop any robot at any time if he/she feels that it is performing, or is about to perform, any action that is dangerous or hazardous to people or equipment. No robot is allowed to use any flammable or combustible processes.

18. UNKNOWN FACTOR

Part of any automation project “in the real world” will present unknown challenges to the automation engineers that are developing the controls solution. This may include a change in the scope of work, a change in the deadline, a change in the technologies to be implemented, etc.

So in this contest, an unknown change or event, referred to as the Unknown Factor, will be inserted into the contest before the final evaluation at discretion of the Contest Judge. The “Unknown Factor” will test the teams’ ability to react for unforeseen circumstances that typically happen during a final install of an automated solution. Reacting to this type of issue is as much of a test as any other element presented in the rules as stated. It is important for all engineers to keep their composure and react to the change as a challenge in a positive manner.

19. PROFESSIONALISM & ETHICS

Any unprofessional AND/OR unethical behavior exhibited by a team member during the course of this R&D project may result in a grade reduction for that student at the discretion of the Course Instructor/Contest Judge.

20. INTERPRETING THE RULES & CHANGES

In all matters of interpreting these rules before and during the contest and in any issues not covered by these rules, the decisions of the Contest Judge will be final, and the runs may be modified as needed for clarification or “at will” by the Contest Judge. If a team should have any question or concern about anything related to the rules and their interpretation, they are encouraged to speak with the Contest Judge ASAP for further information.