Engineering Design Constraints for Mobile Wirelessly Communicating Maze Solving Robots

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Abstract- **Create and document the design of mobile robots that are capable of solving a maze as well as communicating path guidance, orientation, and position to other mobile robots wirelessly. During the duration of the project, the following engineering design constraints will be considered: economic, environment, sustainability, manufacturability, ethical, health and safety, social, political, and time.**

I. INTRODUCTION

There are many aspects of any design project that must be considered to determine the feasibility of a system. These aspects are considered to be the constraints of the project and include economic, environmental, sustainability, manufacturability, ethical, health and safety, social, political, and time. One must consider each constraint individually to determine the practicality of attempting to design mobile robots that are capable of communicating path guidance, orientation, and position wirelessly as well as solve a maze. This paper will discuss each of these topics as they relate to this project.

II. DESIGN IMPACT

A. Economic

Generally one of the largest limiting factors of any design project is the economic constraint. To maintain economic feasibility, the maze solving, orientation and position, and wireless aspects will build off an existing MSU robot designs; namely the ECEBOT (Fall 07' Model) which is the robot design developed by professors at Electrical and Computer Engineering Department (ECE) of Montana State University. The ECEBOT (Fall 07' Model) is currently produced in mass quantity for Montana State University's EE 101 class making it an excellent economic platform for many reasons including that it is proven technology and has already been designed with price of components being a major factor in choosing of the components that make up the robot. The ECEBOT itself makes up most of the cost of this design project considering that it contains the Freescale HCS12 microprocessor integrated on a PCB as well as the motor servos and many other small dollar parts to make it a fully functional robot. Other costs involved in the project are the position sensors, wheel sensors, and Freescale Zigbee modules. For this design project the needed Zigbee modules were obtained from Freescale as free samples, also some were donated for use on the project by the ECE. The sensors however did need to be purchased from a distributor. The sensors chosen were of the lowest price that would still be able to fulfill the requirements of their intended use. Shortcomings in the operation of these devices is planned on being compensated using control logic and sound supporting design using large margins of error.

B. Environmental

Environment can be defined as the surroundings, and conditions that influence performance of a design. Considering the mobile robot, the environment will be indoors on the IEEE Micromouse maze. Modification of the ECEBOT (fall 07 model) will be necessary for the robot to be able to traverse the maze. Modifications of the mobile robots will include repositioning the servo motors that operate the wheels and redesigning the chassis to reduce the overall width of the mobile robot. Also, the height of the PCB must be elevated to prevent contact with the walls of the maze. Furthermore, the positioning sensors must be located low enough to have an unobstructed view of the maze walls. An environmental influence that will reduce the ability of the robot to keep traction while traversing the maze is dust on the maze platform. This project will attempt to correct the traction difficulties due to dust by operating the servos at slow speeds avoiding the fast starts and stops that cause the wheels to slip, also the maze platform will be kept as clean as possible. Temperatures constraint on the robot will be defined by the components that make up the robot; this project is assuming that the robots will only be operating indoors at room temperature. One final environmental design consideration deals with the wireless interface. The Zigbee wireless protocol was chosen due to low interference of existing wireless networks. Because the robot will be operating indoors Wi-Fi and cellular phones within the building will be presenting a large amount of noise so the modules must transmit at a high enough amplitude or separate frequency to reject these interferences, which the Zigbee protocol does.

C. Sustainability

Sustainability refers to the ability of an engineering design to perform under normal operating conditions for given length of time. Due to the robot being built off of the Fall '07 design of the ECE robot, all documents pertaining to the purchase and parts list should be frozen and milestoned to allow for the further development of the ECEBot without causing issues with the modifications being made and documented. Also, because the code is built off of existing Freescale libraries and open source code provided by MSU it will be branched from the main code and continued as a second internal project. In the choosing of the parts and modifications, manufacturing lifetime was considered by choosing the most generic parts possible with multiple providers to ensure a long manufacturing lifetime. Last the batteries that will be used in the robot will be rechargeable AA so that maintenance cost can be reduced as much as possible.

D. Manufacturability

The ability of a system to be produced with as few resources possible be it parts, labor, or maintenance alludes to a system's manufacturability. Examining, the manufacturability of this design project one can conclude that because the robot will be building off existing technology manufacturability will consist of simple soldering and creation of wires to connect to sensors. The modifications to the board to make it compatible will be made using tools in the ECE Stockroom using as much scrap materials as possible. In this instance they will be made with copper coated PCB board. This creates the potential that with some simple modifications to the PCB, chassis, and source code will allow each new ECEBOT that is manufactured to be capable of maze solving, keeping track of orientation as well as position, and communicating wirelessly with a Zigbee module add-on.

E. Ethical

Ethical constraint can be identified by using the IEEE code of ethics [1]. If a design or system violates the IEEE code of ethics in any way than it should not be considered as a viable solution to a design problem. Subsequently, during the duration of the robot design project consideration will be made by all team members to not violate this ethical code.

F. Health and Safety

Next, in order for a system to be ethically plausible it must also be safe and not pose any health hazard. The safety of wireless communications must be considered because some emitted electromagnetic waveforms could have harmful effects on the surrounding environment. However, the Zigbee technology already has Radio Approval, Electromagnetic Compatibility (EMC), and Safety Approval (LVD). In addition, the materials being used will be ordered with a preference of using RoHS parts to minimize impact on the environment. For these reasons one can conclude that this project has a low health and safety constraint.

G. Social

With any design the social impact must be considered. Concerning this project, a positive social impact is desired within MSU's community is the design can be used to aid in the education of undergraduate electrical and computer engineers; specifically at the time those engineers take Montana State University's EE 101 course. Moreover, it can also be used to ignite prospective student's interest in Montana State University's electrical and computer engineering programs. This project will also give a presentation to the local IEEE chapter and explain all engineering and design decisions made.

H. Political

Just as the social impact of a design must be considered, a design's political impact must also be taken into account. Although, the social and political aspects are generally similar or the same for this project they differ. The main political impact of this design project is the ability of the mobile robots to communicate orientation, position, and path guidance information with each other. These characteristics of the mobile robots are desired objectives and needs of the military and law enforcement agencies. Considering, that these characteristics could be expanded on to create useful mobile military robots is of great political importance. Due the project being of academic nature and non-commercial the political impact is minimized.

I. Time

Possibly one of the most overlooked constraints in any design project is time. Particularly, for this project many factors created time constraints. Other than the economic objectives, one important reason the design team chose to build onto existing proven technology and implement modules rather than build everything from ground up is the project has only been allotted 16 weeks from conception to delivery. Due to this fact, time is the greatest encumbrance of this project. To mitigate this constraint as much as possible a very aggressive stance was taken on the scheduling of milestones for the project. This allows for the adaptation to unforeseen events and hurdles to be given the proper amount of attention.

III. Conclusion

In Summary, many factors contribute to the how the overall design of a project will be carried out. These factors include economic, environmental, sustainability, manufacturability, ethical, health and safety, social, political, and time. Objectively, some of these factors may not be inhibiting and others may. In the case of the mobile wirelessly communicating maze solving robots project the most hindering of all these factors are time, and economic. By meeting these two constraints the project will not be impeded much by any other factors.

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References

[1] IEEE, "IEEE Code Of Ethics," February 17, 2008, http://www.ieee.org/portal/pages/iportals/aboutus/ethics/code.html