Abstract:

This design project is designed to produce a working prototype of a small reconnaissance robot. It is designed to meet the needs of the now-defunct HeliOS project's sub-vehicle. The robot must meet several requirements, among them small size, low weight, image capturing ability, autonomous operation, and durability. The principal challenge of the project is balancing all of these requirements in an effective solution. This paper marks out all matters relating to the proposed project. This begins with a review of the project's history before discussing its general outlines. Following that is a listing of its overall problems, followed by a more complete catalogue of its specific problems. After that, the report presents potential solutions to those problems. Also included in this proposal are budgets, timelines and a summary of the whole project as proposed. On the whole, the construction of this robot should provide sufficient challenge so as to qualify as a Senior Design project. If it later turns out that it does not, then this project is scaleable to the point where it becomes a worthy challenge again.

II. Project Proposal Plan

II-1. Introduction

Originally, this design project was intended to address the need of the HeliOS project for a sub-vehicle. In that capacity, it would have accompanied an autonomous aerial vehicle (AEV). The AEV, developed by several other Senior Design teams, was supposed to be able to navigate some distance by air and find a target building. After finding the building, the AEV would have somehow launched its sub-vehicle (our robot) through an open window.

Our autonomous exploratory robot should be capable of searching and mapping a small room without any outside aid. It would do so in even, indoor fluorescent lighting with the room containing standard amount of office furniture. According to the requirements for the HeliOS project, this robotic entity would have to survive being roughly thrown through a window and remain entirely functional. This variables require a complex yet rugged design platform adaptable enough to be reconfigured for use in many more situations. These requirements remain the same for our project, even though the HeliOS project now seems to be entirely abandoned.

We are borrowing experience from another previous Senior Design group. One group tried to modify a Roomba robot to collect toxic waste. We plan on using a variation on their search program in order to ensure full coverage of the target room. We may also be salvaging parts from their robot, perhaps a microprocessor, sensors, and/or various other parts.

The intent of this project is to continue the work that has already been started in constructing a small reconnaissance robot. It is believed that this constitutes a worthwhile and challenging design project. Even if the HeliOS project is no longer in need of such a robot, we think it has enough value as a stand-alone product to pursue it. There are sufficient potential military, law enforcement, and rescue applications to justify this robot's continued development.

II-2. Design Requirements

There are a number of design requirements that should be met for this project to be considered successful. All of these relate to capabilities of the robot, and they are thus directly linked to our prototype. The requirements fall into a number of categories, as described in the following paragraphs.

First, the robot must be capable of capturing images. It is not important whether these images are still or video. This is the most important feature of the robot, because its primary function is to provide information about its surroundings to whoever decided to use it. In addition to capturing the images, the robot must somehow communicate them to the user. Ideally, the robot will image all of the room, but realistically we expect it to be able to provide sufficient view of the walls.

Second, the robot needs to be able to move and navigate. Movement is critical, because we do not expect the camera to be able to see the entire room all at once. While the robot could be planned to move randomly, we hope to put some kind of guidance into it so that it can efficiently explore its environment. That entails some kind of processing and mathematics capability. In addition, we will most likely need some kind of navigation system, composed of some combination of compasses, wheel encoders, and distance sensors, to provide the robot with the information it needs to make decisions.

Third, the robot should be physically sturdy. The robot should be able to withstand a tossing impact, estimated as a fall from 4 or 5 feet and possibly a forward speed of up to 5 to 10 mph. This capability is desired because the ideal method of deploying this machine is by lobbing it through an open window.

II-3. Design Approaches

The three major design requirements can each be addressed in a number of ways. Hopefully, the most reliable and efficient combination of these solutions will be combined in the design prototype.

The requirement of image capture is perhaps the easiest to solve. There exist already on the market several devices which can wirelessly transmit images, both still and video. The easiest and probably ideal answer to this requirement is to use one of these off-the-shelf cameras, and to wire its power control or picture control buttons into the control chip, so that it can take pictures when it needs to. In this solution, the camera merely has to be mounted correctly on the chassis in order to function. Later on, it may be desirable to allow the camera to move, or to allow the CPU to process the images before they are transmitted.

Motion and navigation will probably be the thorniest problem, and thus the most important to get correct. The solution involves the integration of many devices: the CPU, the sensors, the compass, the encoders, and the motors. In addition, a software solution will have to be found that can provide all of the behavior we need. In the whole, a system must be developed that is superior to random motion, or else that may as well be used. This problem also includes obstacle detection/avoidance and speed control, behaviors which are key to providing satisfactory images for analysis.

The importance of the processor selection we make cannot be stressed enough. The processor we have chosen is the Gumstix. The Gumstix boards are about the size of a stick of gum. The tiny 20mm x 80mm x 8mm Gumstix boards allow the design flexibility for many embedded electronics applications. Gumstix products use the latest Intel XScale processors and open source Linux to provide for a stable functional development environment. These Gumstix platforms offer high performance and low power consumption. Running a 400Mhz, the Gumstix platform can accept any MMC and SD memory as well as an onboard 64MB SDRAM and 4MB flash for plenty of application space for the Linux 2.6.11 kernel and a bootloader. The Gumstix acts as a motherboard for further expansion boards to add even greater functionality to the system. It is our group's view that this board would be an excellent platform for current and future development on a sensory-based embedded system application such as our small exploratory robot.

The third problem, that of durability, can be addressed in many ways. One method could be to use such large wheels that the vital parts of the vehicle are never in any danger. Another might be to employ very robust roll bars, which would shield the electronics more closely, but provide less room for error. The ideal solution is probably a combination of standoff hardware and cushioning that can ensure the safety of all mechanical and electronic parts within the given parameter.

II-4. Financial Budget

Funding is not expected to be a problem. In general, we plan to buy a wide assortment of parts, and our software development environment is free. Therefore implementing any solution will have the same approximate cost. These estimated costs are broken down in the following table.

Item	Cost ($)
Parts (Electronic)	170.00
Parts (Mechanical)	40.00
Equipment	0.00 (open source environments)
Travel/Telephone Charges	0.00 (online interaction)
Printing/Documentation Costs	20.00
Total	230.00

II-5. Project Schedule

Please see Appendix A-1 for the Gantt chart relevant to this section

III. Conclusion

The core intent of this project is to familiarize students with the design process, both the technical and non-technical aspects. We plan to do this by developing a small, autonomous scouting robot. They key word is ‘develop’, not ‘build.’ We need to understand all aspects of the design process, including financial and administrative. However, we must keep in mind that the technical aspect is the central focus. If we get caught up in the paperwork, all our ideas will be for nothing.

With that in mind, we come up with a series of identifiable problems and challenges, and then systematically apply solutions and techniques to overcome them. The camera problem will probably be solved by using a cheap wireless video camera, the navigation problem will find a solution in some clever code-writing, and the durability requirement will either be met or forgotten, depending on how the navigation system works out. We expect that at least one of our combinations of approaches will succeed. It may be that we end up trying and failing repeatedly, and end up having to submit an inferior prototype. In that case, our final report and presentation will have to focus more on our difficulties and tribulations. However, we are confident that in the end, this will be a successful and worthwhile design project.

IV. References

Note: At the time of this writing, the references we have are not available in any easily accessible location.

HeliOS Design Group Report:

Roomba Design Group Report: