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HOWARD
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Howard University

Senior Design Project:

Autonomous Robotic Drop Table

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1. Introduction

1.1 Objective

Convenience is an essential in the lives of busy individuals; everyone looks for ways to make their lives a little easier and our project intends to do just that. The objective is to produce an autonomous robotic system that is programmed to collect dishes during a gathering, without exceeding a specific carrying weight, and return them to the kitchen where they will be unloaded by a human being. It should roam around the room and maneuver its way throughout the party space without bumping into any surrounding objects, and also detect when to enter and exit the kitchen. We intend to produce a robot that can perform all aforementioned duties by approximately March 31, 2013.

1.2 Background

The idea behind the project was first introduced through a conversation with our professor however we decided to take on the project and bring the concept into fruition. After brainstorming and doing some exploration on autonomous robotic systems, we realized that this project could be easily attainable with time. When conducting research on the definition of autonomous robots, there were a couple definitions that stood out to the group. One source cited that an autonomous robot is one that not only can maintain its own stability as it moves, but also can plan its movements, and another states that it is a robot that can perform desired tasks in unstructured environments without continuous human guidance. This sort of robot has a bumper sensor to detect obstacles. When you turn the robot on, it zips along in a straight line. When it finally hits an obstacle, the impact pushes in its bumper sensor. The robot's programming tells it to back up, turn to the right and move forward again, in response to every bump. In this way, the robot changes direction any time it encounters an obstacle. The team expects our robot to be able to adhere to both of those definitions.

2. Problem

2.1 Definition

The problem revolves around time management. When many functions are to be performed by one individual at the same time, it is easy to become overwhelmed. This is needed because when hosting a gathering you must be able to attend to many things at once. You must be hospitable, oversee the event, and keep it clean simultaneously. Depending on how much attention is needed for either of those things, it is very easy to allow one or more to get out of hand, resulting in a stressful situation rather than a pleasant one. Creating this robot would eliminate one of the key components that you have to maintain to have a successful function, and ultimately create an enjoyable experience for the guests and lower the stress level of the host.

2.2 Design Requirements

There are a couple things that fall under the field of design requirements. It deals with all aspects, and constraints that the design must adhere to in order to be functional and unique to our own design. It must have an interface that is both wired and wireless as its battery life is up to 5 hours. The robot should be able to function on wireless while it performs its duties without being plugged up similar to that of a personal computer. It must weigh approximately 40lbs so that the weight of the motor, battery and load (15lbs of dishes) are accounted for. The bot will have dimensions of 24" x 36" x 30" so that it is compact enough to not interfere with the atmosphere of the party, as well as allowing for easy storage. The figure will be traveling through a designated space and therefore it should be collision safe. One way we plan on making sure that it does not collide is by placing sensors in the architecture of the robot that allows it to detect when it is near an obstacle and also signal is to stop back up and re-route if it does happen to bump into something. The robot should be able to travel comfortably between 2 and 5 miles/hour with respect to the minimum and maximum speed, and the machine should function with a noise level less than 20db at 1ft from the device, as 20 dbs. is equivalent to that of a whisper. This robot will automatically shut it off the running temperature exceeds 90 degrees F. In a normal cycle, (cycle meaning circling the party to collect dishes then returning them to the kitchen), the robot must be able to hold up to 30 pounds comfortably. It will be programmed to not accept any more dishes once the weight exceeds 28 pounds to account for some other some shift as the robot travels. There will be a container integrated in the design that allows all liquid to drain into a basin without causing any damage to the wiring, and also allow for easier unload of the dishes while minimizing spills. Once the basin has reached ¾ of its capacity, a signal will show to alert the user that it needs to be discarded. All of these functions shall be assimilated into the design and produced with the well-designed final product.

2.3 Required Compliance

Our device must follow EMC standards as well as FCC part 15. It must be marketable and not interfere with the audio/visual systems of the party. It must not infringe on any patents previously created in regards to autonomous robots however some of the concepts can be used and refined to fit our prototype. It cannot be named after any other autonomous robots and/or their systems and must be unique with respect to all design constraints, appearance, and functionality.

3. Current Status of the Art

3.1 Available Devices

There are several personal-use robots on the market today that will do such things as vacuum the floor or pick up small objects. Although currently we are unaware of any such robot that can avoid obstacles in crowded settings while carrying heavy objects.

Hammacher Schlemmer, has created "The Room Tidying Pick Up Robot". This robot picks up objects on your command then loads them onto its cargo bed. The robot will then empty the contents at your desired location. The robot has six rubber wheels so that it can easily maneuver over surfaces. It is 2lbs with dimensions 13" L x 8 1/2" W x 8" H. It requires six AA batteries and three AAA batteries. The robot is equipped with a remote that will drive it left, right, forward and backward. There are audio alerts such as skidding for stops and beeps when the robot is moving in reverse. The robot can handle items around 1oz. such as balls, toys or socks with its two articulated arms and hands. Along with using the remote the robot can operate autonomously using its four infrared "eyes". This allows it to seek and discover objects that are within an 8-12” range. Once an object is secured the robot will pivot its torso to deposit the object into its cargo bay. The robot will vibrate in order to dislodge the objects from its bay. The robot will also alert you if objects are too large or cannot be removed by saying "too heavy for me" or if it gets stuck it will say "uh…a little help, please".

Willow Garage is a robotics firm located in Menlo Park, California that offered 11 teams of roboticists at 11 different institutions to take in a beta robotics project in June 2010. Each of the teams will receive a two-year loan of a Personal Robot 2. This Personal Robot 2 (PR2) is a sophisticated machine that is completely programmable and has two arms, a "rich sensor suite", a mobile base and 16 CPU cores. The teams will also be provided with free, open-source Robot Operating System (ROS) framework that controls the PR2. It also comes with software libraries for perception, navigation and manipulation. Willow Garage’s goal is getting its robots worth $4 million-plus to foster breakthroughs in personal robotics. This will aid in building an open-source robotics community; developing new productivity tools and components. This will create never-before imagined applications for personal and general-purpose robots; thus accelerating the progress of new robotics development. One team is looking at getting the robot to learn how to carry an object through a crowded space.

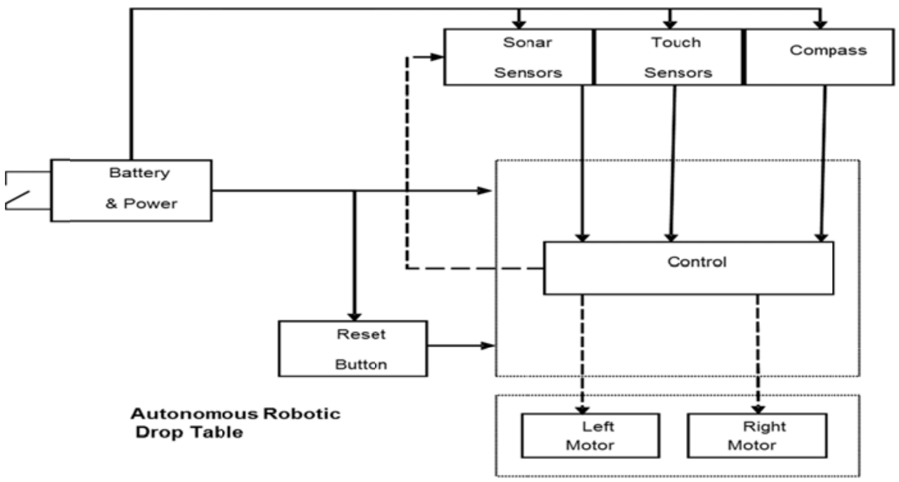
3.2 Drawbacks of Available Devices

Although there is a similar device on the market concept-wise, this device is not able to handle the specifications we want to implement. We did not find any such evidence that the Willow Garage teams were able to successfully create this robot.

4. Engineering Approaches

4.1 Solution and Expectation

Most importantly the robot must be able to maneuver in a crowded setting and make use of sensors to avoid obstacles that would result in damage. We expect the robot to run wirelessly for up to 5 hours during the party. We will make use of sensors and the Atom Board Processor to implement these features.



Through this design will equip our bot with a digital compass for navigation between the party and the kitchen. Two sensors will be placed on the robot. A touch sensor and a sonar sensor. These sensors will ensure that the robot avoids any obstacles. The touch sensors will make sure the bot does not bump into anything and the sonar sensors will act as a back to signal that the robot has some in close contact with an object and will then reset itself and continue on its desired route. The Atom Board Processor will act is the Control. It will of course be equipped with a left and right motor as well as a battery and reset button.

4.2 Test Strategy

A robot will be built from scratch to desired specifications. A party like atmosphere will be created to determine how the robot will handle the task and move about effortlessly in a crowd. We will test the ease of operation from the desired location of a kitchen back into the party. Modifications and adjustments will be made after the assessing the robot's performance.

4.3 Alternative Approaches

Some alternative approaches would be to have the robot operate non-autonomously. There are a couple of approaches to that solution. The most common way would be to control it by a Direct Wired Control also known as a remote control. There are several advantages to this approach, the robot is not limited to an operating time since it can be connected directly to the power supply. Losing the signal will not become an issue and there will be minimal electronics and complexity with the robots design. There are also disadvantages of this method, the tether could be tangled or snagged, which could potentially cut the line. The distance is also limited to the length of the tether and this tether could also add friction and slow down or stop the robot.

Another option would be to operate the robot through an Ethernet connection. Some of those advantages would be that the robot can be controlled through the Internet from anywhere in the world. The robot is also not limited to an operating time since it could use Power over Ethernet (PoE). Also, the Internet Protocol (IP) can simplify and improve the communication scheme. Some of the disadvantages to this method are that the programming involved would be more complex. This method also presents some of the same issues with the tether as expressed in the previous alternative solution.

5. Tasks and Deliverables

5.1 Tasks

(i) Tasks involving engineering solutions are more simply stated than achieved but are as follows:

- Hardware Design for the autonomous robot
- Hardware Building for the autonomous robot
- Software Design for all programming: including sensors, weight requirements, heat requirements, etc.
- Software implementation (i.e. coding for the atom board)
- Assembling of the entire autonomous robot both hardware and software

(ii) Verifying solution meets design requirements are being executed by respected team members. Though assistance may be granted for an individual by another team member each following member is responsible for:

- Hardware Design and Building- Joseph Ignatius
- Software Design and Implementation- Mecaela Holmes & Tiffany Hall
- Assembling of the entire autonomous robot – Team required

5.2 Deliverables

As the team works diligently to complete the task at hand, the team will have a working autonomous robot available for the presentation of ECE Day. The finish product should consist of a demonstration in which the autonomous robot will move around in a designated area in which a 'simulated party' is engaged. The autonomous robot will have dishes piled on top to prove its durability, while moving effortlessly around the party to prove is reliability and the team will also demonstrate its capacity to prove its accountability. The demonstration shall answer all question with the autonomous robot in which a sales representative will demonstrate a working product and have the product sale itself.

6. Project Management

6.1 Safety Issues

As a safe product is number one priority, the team will ensure that the autonomous robot meets all engineering requirements for any product on the market. The safety mechanisms put in place are described throughout the proposal with all talk of the designs. Safety such as the movement through the party, keeping of the dishes, and returning back to the party are all key.

6.2 Timeline and Milestones

- **November-** Through the month of November the team should prepare in all aspects of the preparation. This includes the gathering of all materials for the design requirements and which they require.
- **December-** The beginning of the implementation for the design. With tasks being split up, both hardware and software implantation are underway.
- **January –** With the holiday season involved the group will not only work through this vacation time, but due to it being the holiday season, the group will continue will the implementation of both hardware and software.
- **February-** By mid-February the group should have completed most of what is required by our own design requirements. The final product should start taking form and testing shall begin by the end of the month.
- **March-** Throughout the month of March testing will be implemented. The group should have a tangible (rough draft) project which undergoes the series of testing. The series of testing is the only thing that is ensuring the developed product is a finished product. Once the autonomous robot completes all tests available, then the team will declare a finished product.
- **April-** Finishing touches are available at this time. Anything between the cleaning of the wheels or final paint job. Only final touches are being implemented in the event of for getting ready for ECE Day. No last minute changes are being added for which this is a set back and April is the month for the team is prepared and ready to go.

6.3 Resources and Budget

Resources are already available for the team for which the team has a base design and materials for the hardware design for the autonomous robot. The budget will include additional materials such as sensors and any other hardware requirements the team doesn't already meet. Any other board purchasing may come from resources the professor and his sponsors may sponsor. The anticipated budget for the project is up to $500 (not including the atom board).

Materials			
Battery	$60-$100	(possibly free)	
Sonar Sensors	$80-$130		
Touch Sensors	<$80		
Compass	<$40		
Weight Senor	$10-$50		
Control (Atom Board)	(Sponsored)		
Motors	$10-$50 (per motor)	(possibly free)	
Hardware Materials	Max $100	(possibly recycled)	
Miscellaneous	$50		
		Total [Max] Cost:	<$500

7. **Conclusion**

Overall after assessing the situation, we have decided that creating this robot would be beneficial because its completion can assist its user in a great deal. It does not have a need that is substantially large however since convenience is an aspect that humans strive for on a daily basis this will prove to be a worthy device to purchase. From the design requirements that we mapped out, to the price that it is going to cost this device can be constructed and be fully functional by the project completion date.

There have certainly been a lot of developments made with robots over the years. Although just as with any relatively new concepts there must be new and innovative ideas brought to the table that have not been successfully implemented. We want this robot to be the embodiment of efficiency, so that other applications can be developed from this model.

8. **References**

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