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Creating Serious Robots That Improve Society

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Abstract

The Grace Hopper conference has many lectures/activities for participants. Tech Node presentations at this conference are two hours and focus on encouraging open discussion around a topic. This "not so grand" challenge, originally created for this conference, requires participants to brainstorm a robot creation that could somehow improve society in one of four societal areas: Elder Care (non- medical), Search and Rescue, Environment, and Affordable Home Health Care. This project format also can be used as an unplugged activity for a CS0/CS1 class or as a more advanced project that employs image processing and AI techniques such as machine learning.
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Introduction

Many robot curriculum activities are centered on a competitive task. Many times these tasks illustrate and use some type of AI algorithm, be it searching or machine learning. (Imberman, 2004). The amount of AI knowledge/skill varies with the activity. Task time allocation also varies from semester-long to a few class sessions to a single lecture/lab session. As well as the time allocation, the level at which the task is suited also varies from a CS0 to a higher level robotics class. There are few activities that are suited for a CS0/unplugged activity as well as an advanced robotics course. This paper describes one such activity.

Background

The activity described in this article was conceived as a Tech Node activity for the October 2016 Grace Hopper Celebration of Women conference. Tech Nodes are run by two co-chairs, both experts on the topic, one from industry and one from an academic institution. Tech Nodes are not lecture/hands-on activities. Rather, some background information is provided to participants with the intention of encouraging open discussion and exchange of ideas while learning about new and current technology. Tech Nodes are open to all conference attendees and usually run two hours in length. As many as 200 participants can participate. Our activity resulted from a collaboration between Verizon Labs and a faculty member from The College of Staten Island who teaches robotics and publishes in the area of robotic education.

With the advent of mobile apps, the game development community has branched off into a subgroup that develops what has been termed "serious games". These games have some societal use such as educational instruction, engagement of children with autism, etc. The thesis of this TechNode was to engage Grace Hopper participants in the creation of a robot that would in some way benefit society in contrast to the current popular perception that robots are "hobby toys", used in robot competitions such as BattleBots and RoboCup, as well as their use in the military and manufacturing. "Serious robots" already exist to some extent, and the success of robots such as the Roomba® Robot Vacuum, have demonstrated the potential for robot commercialization. The self-driving car is another example of a serious robot that has the potential to make an immense impact on society.

It was along the theme of societal improvement that Grace Hopper participants were challenged to create a serious robot within a two-hour timeframe.

Methodology

The Tech Node session was broken into four segments: Learning, Creating, Sharing, and Winning, with times devoted to each segment of 45 minutes, 30 minutes, 30 minutes, and 15 minutes, respectively. The participants were divided into teams of five, each tasked with creating a robot that will improve society in some way. In order to further focus the task, four societal areas were identified from which the participant teams could choose: Elder Care (non- medical), Search and Rescue, Environment, and Affordable Home Health Care. The overall session was run as a competition among teams.

Learning

The learning segment was the most lengthy of the four segments. The purpose of this segment was to give participants an overview of robotics so they could create their robots with an eye towards the possible and the plausible. The learning session started with several working definitions of a robot. Of these definitions, we used Rodney Brooks' definition -- a robot is "something that senses the world in some way, does some sort of computation, deciding what to do, and then acts on the world outside itself as a result" -- as a template for further explanation, along with examples of robots and how they work.

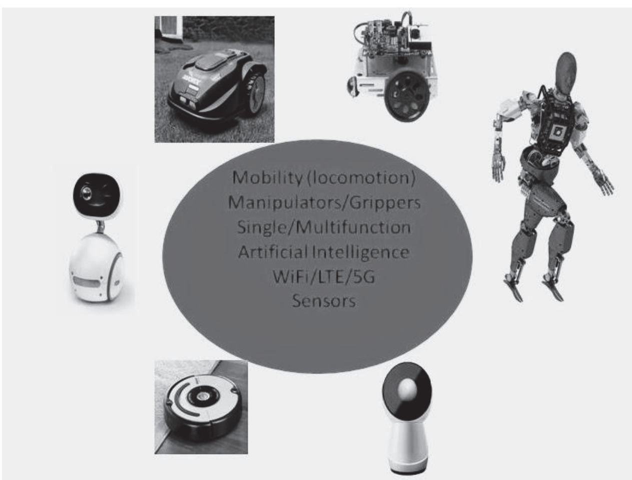

Figure 1. The Robot Spectrum

From the definition, we gave an overview of the variety of robot platforms or the "Robot Spectrum" one finds in today's robots. Figure 1 illustrates this overview. Directly from our working definition, we talked about how a robot "senses the world". Robots use various sensors, from the simple, such as a push button, to the complex, such as a camera. "Deciding on what to do" involves the processing of sensor information. This is discussed by mentioning the various ways to control a robot, via simple controllers, such as an Arduino controller, to using cloud services and a remote "heavy duty" computer. Lastly we stressed that when a robot "acts on the world outside itself" the constraints imposed by the physical world need to be considered. The laws of physics prevail. For example, objects can't overlap. Hence, we need collision avoidance. (*300-Pound Security Robot Runs Over Toddler At California Shopping Center,* Huffington Post, July 13, 2016, *http://www.huffingtonpost.com/entry/security-robot-toddler_us_57863670e4b03fc3ee4e8f3a*) Robots need a source of power. Size and shape impose other restrictions on movement. When moving, robots take time to speed up and slow down. Newton's laws of motion apply! Robot movements also are restricted by the controllable degrees of freedom for each effector. Figure 2 illustrates the concept of controllable vs. total degrees of freedom.

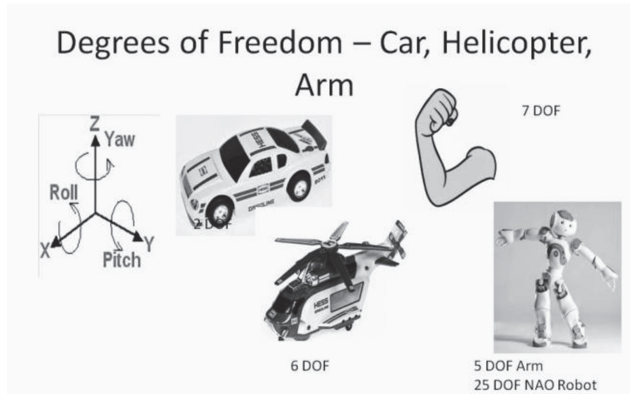

Figure 2. Controllable vs. Total Degrees of Freedom

The learning segment concluded with live demonstrations of several robot platforms.

Creating a Serious Robot

Once equipped with a sense of what a robot is and can and cannot do, participants were tasked with creating a robot that performs some service within a societal area. To bound the problem, one of four possible service areas were selected by each group of five participants. To further guide the development of their serious robot, and because the Tech Node was run as a competition between groups, each group submitted a form, which was later used to judge their creations. The form content, along with the point value, is listed below.

What is your service and why is this important to the societal area selected? (30 pts)

What features does your robot need with respect to hardware (sensors, effectors, etc) and software? (30 pts)

What additional capabilities need to be included beyond the robot, e.g., network, cloud computer, etc.? (15 pts)

What types of physical obstacles would your robot have to overcome? (15 pts)

What types of challenges would your robot have to overcome to be accepted? (15 pts)

Using what was gleaned in the "Learning" segment, groups were tasked with engineering and prototyping a robot that could accomplish the described task. Given the time frame, this design was embodied as a robot model, the "sticky bot". The sticky bot is a schematic of what hardware features the robot would have and how they would be arranged on the robot. The sticky bot consisted entirely of sticky notes. The components included a base, which initially was a 20"X20" large sticky note but in the actual tech node an 11"X17" sheet of card stock was used. The rest of the robot architecture was represented by various sizes, shapes, and colors of sticky notes. These represented sensors, effectors, controllers, etc. Figure 3 shows a sample sticky bot . The sticky bot allowed for discussion within groups of how one could embody and engineer a real robot with the components and organization needed to do the social service. Participants were given 30 minutes to create their robots.

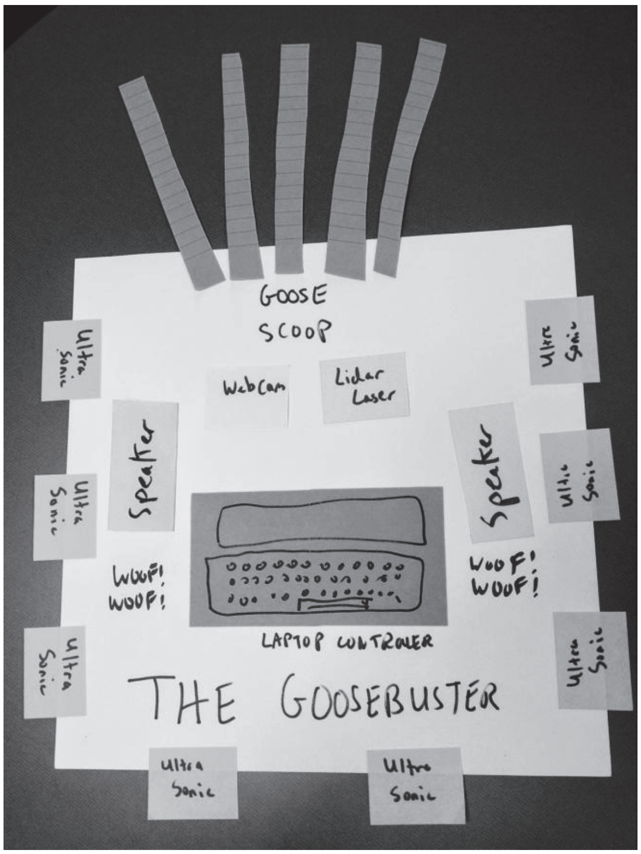

Figure 3. Sample of a Sticky Bot of a Goosebuster Robot

Sharing

Tech Nodes are organized to encourage discussion. After participants created their robot, they were encouraged to share their creation with the larger group. To prompt further discussion participants were asked to consider other factors one needed to take into account when designing a serious robot. Designing for a specific targeted group was motivated by watching the classic Saturday Night Live skit about Old Glory Robot Insurance. (http://www.nbc.com/saturday-night-live/video/old-glory-insurance/n10766). Other factors participants were encouraged to consider included safety, the need for redundancy, power, etc.

Ethical issues when designing robots were explored. An ethical problem was posed for discussion. Assume a large heavy item falls off truck in front of a self-driving robotic car. Should the car swerve to the right and hit the pedestrian on the side of the road? Should the car swerve left and collide with the SUV next to it? Or should the car maintain its course and crash into the large item that fell from the truck, potentially causing harm to the car's driver and passenger(s)? This example of an ethical dilemma poses the problem of how self-driving cars, and robots in general, should be programmed. Do we preserve the driver at all costs, or do we take into account the path of least harm to all concerned? What is the individual cost versus the global cost? (Markoff, 2016)

After discussion of design, implementation, and ethical issues, participants were given time to revise their designs accordingly.

Pedagogical Implications

The "not so grand challenge" of creating a serious robot for societal improvement can be modified to be applicable in a wide range of curriculum levels. The Tech Node presentation can be used with minor modification as an unplugged activity in a CS0/CS1 class as well as a secondary school Computer Science Principles or Exploring Computer Science (ECS) class.

For upper level courses, this project can be scaled to become an encompassing project for a robotics course, an AI class, or a class in image processing. As an example, Figure 3 shows a sticky bot mock-up of a "Goosebuster". The societal area for the Goosebuster is the environment. Many parks, campuses, etc., have problems with flocks of Canadian geese roosting on lawn areas and near small ponds along their migration routes. This can lead to the spread of disease and pollution from bird droppings. Various methods have been deployed to alleviate this nuisance, with some methods resulting in geese being euthanized.

The Goosebuster is a modified Power Wheels Jeep that is controlled by a laptop computer. This robot platform was first proposed by Zachary Dodds, Ph.D, a computer science professor at Harvey Mudd College. (Dodds, 2008) The Jeep is equipped with a LiDAR laser, several ultrasonic sensors, and front and back web cams. For the goose chasing task, we envisioned the addition of two speakers to imitate dogs barking since dogs have been used to chase geese. At the front of the robot, a goose scoop is added to nudge the geese away in the same manner that a cow catchers on old time locomotives pushed cattle off the train tracks. In order to recognize a goose from its surroundings, image processing and machine learning algorithms are employed. This is an ongoing project that has been offered to students at CSI as an extracurricular activity. This also will be a part an assignment in an the image processing course being offered at CSI in the Spring 2017 semester. Machine learning algorithms such as neural networks also can be employed in the goose recognition task. As one can see, within this “not so grand” challenge there are many possibilities for enhancement and extension.

Observation

As described, this project was originally created for presentation at the Grace Hopper Celebration of Women, but we also facilitated this activity with the College of Staten Island's (CSI) Computer Science Club. Although Grace Hopper attracts both women who are employed in the industry and undergraduate students, our presentation at Grace Hopper saw a participant pool of mainly industry professionals. Given that the group at CSI were mostly undergraduate computer science majors, the contrast and similarities of how each of these two groups implemented the activity was very interesting

The robots created by the CSI students were more imaginative and not as plausible as those created by the Grace Hopper participants. This might be explained by the circumstance of having industry experience makes one tend to look toward possible/plausible implementations as opposed to looking towards unfettered possibilities. For example, one CSI group explained their search and rescue robot would have, "a magic cover that will protect from any damage imaginable". Another CSI group, citing the lack of technical skills by the elderly, included an "elderly-friendly" Skype capability so the elderly person could communicate with family and friends. Student robots contained sensors and mechanics to implement multiple tasks within the selected category. The Grace Hopper participants' robots were more focused on a specific need within the category. For example, a CSI robot that collected bottles and cans could do this in any environment. It also was able to differentiate between glass, cans, and animals. ("You want to make sure you don't scoop up [any] squirrels.") The Grace Hopper team's robot, the "Dumpster Diver", was specifically designed to rummage through garbage dumpsters. The robot had sensors in its mechanical arm that could differentiate recyclable materials from other refuse. It was able to analyze garbage and determine the household’s wastefulness. It also was able to detect "questionable" items and could be used to aid police.

Two other notable serious robot implementations from Grace Hopper participants were the "Skinect" and the "Nursebot" The Nursebot was notable in that the Grace Hopper participants first researched medical needs and then created a serious robot model to address one of them. From the World Health Organization web site, the participants found that the nurse-to-patient ratio in Third World countries, such as India, was 1:40 where 1:4 was ideal. The team decided their Nursebot would "aid and monitor patient health indicators and vitals".

Another example of how a Grace Hopper team focused on a specific purpose robot rather than a multipurpose robot was exemplified in the "Skinect" robot. The Skinect was envisioned as a robot that would treat surgical or burn wounds that were difficult to manage because of either their location or possible mobility issues with the patient. The Skinect used a Kinect LiDAR laser to help assess skin wounds, hence the name of the robot. Visual and touch sensors were designed to help exert the right amount of pressure to wounds during treatment so as to render effective treatment without causing pain.

In comparing these two implementations, we gained some lessons learned. We found there were more participation and interest when we posed ethical issues. We realized we could have done this earlier in the session as a motivator. We also found transparent tape was essential if the sticky bots were to be preserved for grading or judging. Although the ability to rearrange sticky notes in the planning stage of the sticky bot was very useful, they did not necessarily stay stuck! Also, we found the 11"X17" card stock worked better as a base than the 22"X22" large sticky we initially used. There was a tendency to fill the larger page, which became cluttered with sticky notes that didn't add to the overall robot prototype design.

Conclusion

This paper described the "not so grand" challenge of creating a serious robot that can improve society. The described project can be used as an unplugged activity in a CS0/CS1 class or as a more advanced project that employs image processing and AI techniques, such as machine learning. This project also is an excellent recruiting tool. To show the diverse spectrum and level at which one can use this activity we described its implementation in two very different groups: Grace Hopper Celebration of Women conference participants and College of Staten Island Computer Science Club students. Feedback on the exercise was positive from both groups. All were involved and many indicated they enjoyed the experience.

This activity can be modified to make it suitable for many age/grade/academic levels. A reviewer suggested the project can be expanded by elaborating on one facet of the design by researching "a) technologies currently available for that piece of the design, (b) whether those technologies suffice, and (c) tradeoffs or alternatives to that particular facet of the brainstormed robot". One Grace Hopper participant requested the workshop PowerPoint slides so she could use this activity with her Girl Scout troop.

In summary, the proposed challenge activity is an excellent way to introduce the topic of robotics and can be extended to be used broadly across the secondary and college curriculum space.

Acknowledgments

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