Neato Robotics® Robots as a Robust Mobile Base for Modular HRI Research

Lilia Moshkina, Frank Meyer
8100 Jarvis Ave, Newark, CA 94560 USA
lilia.moshkina@neatorobotics.com, frank.meyer@neatorobotics.com

Abstract

To enable a wide range of HRI research, a robust low-cost mobile base with a large sensor suite is essential. Neato robots provide such an alternative: they present a robust mobile platform with spring wheel suspension able to negotiate uneven surfaces, an impressive sensor suite including a LIDAR, a payload capability to host additional sensors and/or other light-weight robot platforms, such as a robot head or a manipulator, and safe, aesthetic design, suitable for interaction with a wide range of people in diverse, real-life environments.

Introduction

Research topics in Human-Robot Interaction can be as numerous as there are people interested in using robots, and as daring as modern Science Fiction authors can dream. It is unlikely that a single physical robot platform can support the entirety of HRI research efforts, but there are a number of common features which would enable customization and a wide variety of applications. Such desirable features would include: 1) stable mobility; 2) sensor suite to support navigation; 3) support for modularity (including payload capability); 4) aesthetic, non-threatening design;; 5) robust, consumer-grade components; 6) out-of-the-box usability; and 7) affordability.

In this position paper, we propose that there is such a low-cost hardware robot platform in existence already, and we invite you to examine it with regards to its applicability to promote HRI research. First, we will describe the aforementioned features and their importance to HRI research, and then we will present a robust, modular, mobile platform as a potential solution.

Features Enabling HRI Research

There are a number of requirements a robotic platform has to fulfill in order to become a research enabler for advancing the field of human-robot interaction. These features, or requirements, stem primarily from the fact that such research generally presupposes interaction with people, preferably in people-inhabited diverse environments, including long-term interactions in living and work spaces. Though the following is not an exhaustive list, we believe it highlights a large number of necessary components of a successful platform.

Stable Mobility

While not all aspects of HRI research require a mobile platform, mobility allows to move from the lab to real life, and study a much wider variety of robot behaviors and interaction phenomena that a stationary platform would. Furthermore, lack of mobility precludes certain active areas of HRI, such as exploring navigation around people and pets, performing spacially-separated tasks, and generally, anything requiring interaction in natural environments. In terms of stability of locomotion, wheeled platforms have a big advantage over the current state-of-the-art biped robots, as they are significantly less prone to falls and mishaps during movement, at least at a comparable price point.

Sensor Suite for Navigation Support

In order to enable autonomous navigation, a mobile platform must be equipped with an adequate collection of sensors which would enable and facilitate obstacle avoidance, accurate map building and navigation in them, prevention of falls down the stairs and other navigation-related tasks. While it may be possible to acquire such necessary sensors separately, there's a great advantage both in cost and platform "real estate" to have such sensors as an integral part of the mobile platform.

Support for Modularity

An anthropomorphic mobile platform may be impressive, and allows to conduct certain types of research, but it will limit the variety of research which it can be used to conduct, as in the near future, it is far more likely that the robots which share human spaces are indeed not anthropomorphic. For example, the most common robotic consumer product, apart from toys, is a robot vacuum cleaner, and delivery robots are also making headway (e.g., Savioke's Relay; Relay URL). Therefore it would be desirable to have a mobile base which can be used by itself, or could carry additional components, such as a small manipulator, a robot head, a laptop or an entire other stationary robot (e.g., Romibo; Origami URL, or Jibo; Jibo URL). Such a platform could also support addition of any research-specific sensors, such as a camera, Kinect, and others.

Aesthetic, Non-Threatening Design

Unless a particular study examines the effects of form factor on people's perception of it, a robot platform used in HRI research has to follow a pleasant, non-threatening design to make the interaction with the robot more natural, realistic and not filled with anxiety or fear for one's safety. For example, though an impressive platform otherwise, Xitome's MDS robot can be rather intimidating, is not altogether safe to be around, and may appear “creepy”. In close interactions with people it would be better to avoid creating such unfavorable impressions.

Robust, Safe, Consumer-Grade Components

In the past, many research labs have traditionally used either home-built robots, or those made just for research purposes. Such robots were by design not meant to last, and had issues with using and maintaining them. As HRI research is moving out of the lab and into the real world, and from minutes in duration to months, it is increasingly important to have a platform which can withstand long-term, real-life interaction without falling apart or presenting danger to research participants.

Out-of-the-Box Usability

HRI research is interdisciplinary, and can involve anthropologists, sociologists, psychologists, user researchers, and even marketing specialists, who may not be computer-savvy enough to program robots for their experiments. Therefore it is a big plus to have a robot platform which can be used out-of-the-box, without having to write a line of code, especially for conducting Wizard-of-Oz experiments.

Affordability

This is the aspect particularly relevant to the present venue. The vast majority of currently available research platforms, especially anthropomorphic mobile platforms, are prohibitively expensive, and only better funded research labs can afford them. This is partly due to the "economies of scale" issue: the smaller the demand, the more expensive the item. Leveraging a commercially available product would provide definite cost advantages, especially if the producing company is willing to design specific accessories and components to augment their product.

Neato Robots as Mobile HRI Base

Neato Robotics (Neato URL), a consumer electronics company in Silicon Valley, has a line of commercially available user-friendly low-cost robots, which we believe satisfy all the requirements delineated above to serve as a modular base for HRI research. Neato robots are small, light-weight vacuum cleaners suitable for indoor navigation and safe enough to be used by general populace; see Figure 1 for a top and bottom view of the latest model, *Neato Botvac Connected*. Neato can provide a public API to access all available sensors and wheel motors, so that third parties can easily create their own software which can control the robot and produce desired behaviors. In fact, ROS community has been using Neato robots extensively, and there is a Neato ROS node already available to the general public. Furthermore, its low cost and impressive sensors made Neato robots the platform of choice for teaching a hands-on robotics class at CMU’s Robotics Institute (Alonzo, K.).

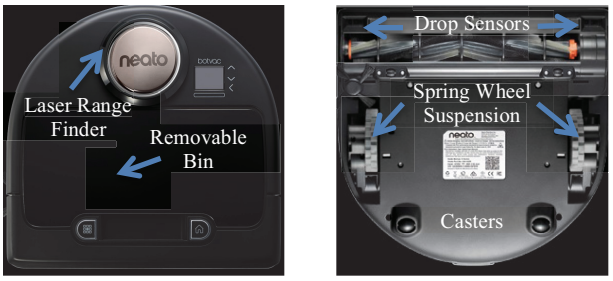

Figure 1: Top and Bottom View of Neato Botvac Connected.

A Neato robot is D-shaped, about 33 cm in diameter, stands 10 cm high, and weighs 3.7 kg. It has a long-lasting high capacity Lithium Ion battery, allowing longer experiments without having to recharge the robot. It also provides a micro-USB port for easy sensor data and motor commands transfer.

The following features make Neato Botvac Connected an ideal mobile robot base for conducting extensive HRI research:

- **Stable Mobility**. Neato has 2 spring-based suspension wheels in the front, and 2 caster wheels in the back. It can navigate over all types of floor surfaces, easily negotiate uneven surfaces, and climb over low obstacles. Though not specifically designed for outdoor navigation, it can handle most types of benign terrain (e.g., sidewalks, short grass, etc., though not wet surfaces).
- **An Impressive Embedded Sensor Suite**. First and foremost, all Neato robots are equipped with a laser range finder located on top of the robot surface, which allows robust navigation under most lighting conditions. In addition to the laser range finder, the robot also has a full range of other sensors in support of navigation: an accelerometer to detect tilt, 2 proximity (drop) sensors facing downwards to detect negative obstacles, a proximity ("wall") sensor in the right side to detect obstacles and allow precise wall/obstacle following, 4 bumper sensors for safely navigating around obstacles below the laser level, and finally, 2 magnetic sensors to create virtual boundaries for the robot to avoid using magnetic strips (included with the robot). All the sensor data are available to researchers/developers via API commands.
- **Support for Modularity**. Neato robots have a removable dust bin, which provides protected space for an embedded inexpensive board for basic computation, such as a Raspberry Pi II, or additional power supplies for extra sensors or any other additions to the base. The robots can carry a payload of up to 3.5 kg (8 lb), without significantly impacting their mobility. With a platform placed on top of the robot, it can accommodate additional modular components, such as any additional sensors, a small manipulator, a laptop, or even another robot not capable of independent navigation, without interfering with the laser range finder.

Figure 2: Neato Botvac equipped with a payload platform (left), and carrying an iPad and a webcab (right)

- **Aesthetic, Non-Threatening Design**. Neato robots were designed with people in mind, to operate around them and fit well in their day-to-day lives. They have a smooth profile, have no sharp corners, and in general, produce an impression of technology well-suited to human environments. Being targeted as an electronic appliance, they naturally avoid any "uncanny valley" phenomena, and are non-threatening even to children.
- **Robust, Safe, Consumer-Grade Components**. Neato robots are a commercial product, which has robust, well-tested chassis, sensors and other components. They are rated for general consumer use, and have successfully passed IES Testing for consumer electronic products in their category. Being a commercial product, they are generally fool-proof, with all electronic components safely contained in the chassis, and have high reliability.
- **Out-of-the-box Applicability**. Neato's newest addition, *Botvac Connected*, has WiFi capability allowing users to teleoperate the robot remotely, using a smart phone or a tablet (both Android and iOS are supported). This provides a great opportunity for those researchers who are unable or time-constrained to do significant programming to use the robot out-of-the-box, controlling it remotely in Wizard-of-Oz experiments. As Neato also has speakers, a combination of navigation and dialogue-based interaction can be explored without a significant time investment.

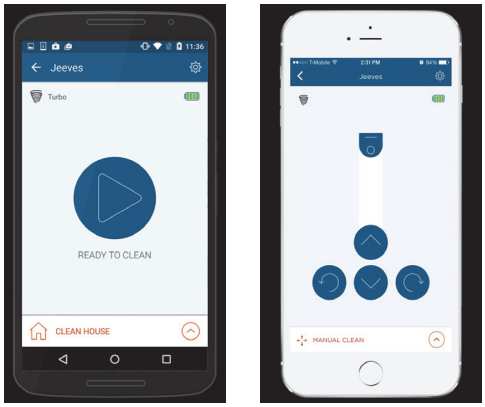

Figure 3: Teleoperation app for Neato Botvac Connected

- **Affordability**. For a robot capable of autonomous navigation and equipped with a laser range finder and a large number of other sensors, Neatos are surprisingly affordable. The prices range from $399.99 for an earlier model (XV Signature) to under $700 for the newest Neato Botvac Connected. This is over 5 times less the price of the nearest research platform providing similar affordances (minus the sensor suite) – a Turtlebot costs over $2,000.

Conclusion

In this paper, we highlighted a number of requirements essential for a robotic platform used to conduct extensive and diverse Human-Robot Interaction research, namely, stable mobility, sensor suite to support navigation, support for modularity, aesthetic, non-threatening design, robust, consumer-grade components, out-of-the-box usability, and affordability. We also showed how a commercially available low-cost hardware platform from Neato Robotics® admirably fulfills all of these requirements, and we could like

to propose it for consideration during the upcoming AAAI Symposium as potentially suitable base for HRI research.

References

Relay URL. “Meet Relay”, http://www.savioke.com, accessed on 01/22/2016

Origami URL. “Origami Robotics”, http://origamirobotics.com, accessed on 01/22/2016

Jibo URL. “Jibo”, https://www.jibo.com, accessed on 01/22/2016

Neato URL. “Neato Robotics”, www.neatorobotics.com, accessed on 01/22/2016

Alonzo, K., “Intro To Mobile Robot Programming”, www.frc.ri.cmu.edu/users/alonzo/teaching/16x62/16x62.html, accessed on 01/22/2016