Narrow the Scope to Deepen the Study: A Recommendation for Undergraduate Robotics Courses

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Robotics is a highly technical field that incorporates advanced topics from a diverse set of disciplines, including engineering, computer science, and mathematics. With the rapid growth of robotics in both academia and industry, there is an increasing interest in and need for introducing robotics education into undergraduate curricula for these disciplines.

A brief survey of current undergraduate robotics courses reveals that the variety of topics covered is as diverse as the field itself, ranging from introductory programming, fundamentals of electronics, foundations of physics, overview of control theory, and the basics of sensing to studies in planning and artificial intelligence. With such a diverse set of topics, it is difficult to provide both breadth and depth that can have an impact to a large number of undergraduate students.

The question we, as teacher-scholars, are now faced with is how to appropriately deliver this diverse and highly technical material to undergraduates, who commonly have relatively limited technical background and experience. There are three key considerations in answering this question:

1) the scope of topics to be covered, including the depth of each topic
2) the curricular elements leading up to the course
3) the career goals and motivations of the student body.

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Although these considerations seem straightforward in developing any course, we need to reevaluate them given the varied skill sets required to excel in robotics. As an example, computer science majors might 1) have a strong desire to program and focus on algorithms; 2) lack many fundamentals of physics, electronics, and mathematics; and 3) have the goal of working in Silicon Valley.

From our survey of current undergraduate robotics courses, many take the approach of giving a general overview of robotics. These sorts of approaches start with robot hardware, a wide variety of locomotion configurations (e.g., wheeled, tracked, and limbed), and a good number of sensor types and configurations; they then progress all the way through motion planning, environment representation, and mapping. Even though this course layout lends itself to familiarizing students with the diversity of the field, it does not easily lend itself to an undergraduate curriculum. With students' limited background and knowledge, it is difficult for them to engage in and retain information in a course that quickly moves through a large array of topics. It would better suit the student to develop a course that goes into more depth on fewer key topics. We recommend that instructors consider focusing the course more narrowly, e.g., exploring all of the aforementioned topics specifically with a wheeled robot.

With this narrower focus, we can still overview key concepts needed by robotics practitioners (e.g., sensing, planning, and kinematics) without overloading students with a barrage of material. For example, if we focus on wheeled robotics, we can fine-tune all of examples, projects, and lectures to that theme, thus improving student engagement with and retention of the material. Of course, there are important technical challenges when one moves outside this limited scope, but we believe these topics are not a good fit for the single undergraduate robotics course common in many undergraduate curricula.

The other key benefit of narrowing the course focus is to allow for a little more depth. Every course we surveyed was at the upper level in the respective curriculum. Most upper-level courses are more rigorous and conducted at a deeper level of understanding than general overview courses. A course in robotics should do the same.

If you have bought into the notion of a more narrowed scope for a robotics course, then you must now consider what focus would best fit into your respective curriculum by understanding the skill sets average students are expected to obtain during their undergraduate career. For example, let's say you are developing a robotics course for computer science students at a nonengineering school. These students may have a stronger background in programming than in mathematics or physics. In this case, a wheeled robotics focus may be appropriate. A common wheeled robot platform is based on differential drive, the kinematics for

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This study group will work to develop a set of test methods that can be employed by end users to assess the kind of robotic system that will best meet their particular needs. For more information about the group or to get involved, please contact Anthony Downs at anthony.downs@nist.gov.

Harmonization of Robot Terminology

As a direct result of the September Madrid meeting, the IAB organized a follow-on assembly in conjunction with the IEEE International Conference on Robotics and Automation in Montréal on 19 May 2019. The meeting focused on the harmonization of robot terminology among the various standards organizations. Specific goals include

1) determining the best mechanism(s) for the various standards organizations to work together to address this issue
2) deciding on the best approach to address the harmonization issue, whether it be a mapping between terms, a common ontology, or something else
3) working through a small set of terms/concepts that are common among the various standards to narrow the problem to a manageable scope.

All of the standards organizations represented at Madrid are expected to be represented at this meeting, along with the American Society for Testing and Materials and the Object Management Group.

The RAS has recently focused on formal robot terminology standards, including IEEE 1872 (*Core Ontologies for Robotics and Automation*) and IEEE 1873 (*Standard for Robot Map Data Representation for Navigation*). In addition, numerous working groups are specializing and extending these standards and also exploring whether these standards, or others, are sufficient to provide a basis for robot-terminology harmonization among the standards organizations.

For more information about the group or to get involved, please contact Craig Schlenoff at craig@schlenoff.com.

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need more attention in future years if social robots are to be integrated in our daily lives.

This special issue of *IEEE Robotics and Automation Magazine* covers a plethora of challenges faced when socially assistive robots interact with vulnerable populations and illustrates the potential benefits of using assistive robots to help meet current societal needs.

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which we know is rather straightforward. This would allow you to ease students into the more difficult concepts of robotics without overburdening them at the beginning of the course.

Finally, it is important to know where our students are going after they graduate. The surveys conducted by Data USA [1] show that most undergraduates never pursue a graduate-level degree. This means that most students taking our robotics courses will not take an advanced robotics course—an important consideration when developing the goals and objectives of the course. An education in robotics has much more to offer an undergraduate than knowledge about robot systems. Through a robotics course, students can hone their problem-solving, algorithm design, programming, and mathematics skill sets.

Reference

[1] Data USA. 2018. [Online]. Available: https://datausa.io/profile/cip/110701/