Developing an Online Learning Platform for an Undergraduate Robotics Course

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Introduction

- Teaching robotics using web-based technologies supplements traditional classroom training.
- The use of a robot simulator in a robotics course enables the students to better understand the fundamental concepts by practical application.

Proposal: Development of an online learning platform for an introductory course, Robot Kinematics and Dynamics, based on Robotics Toolbox.

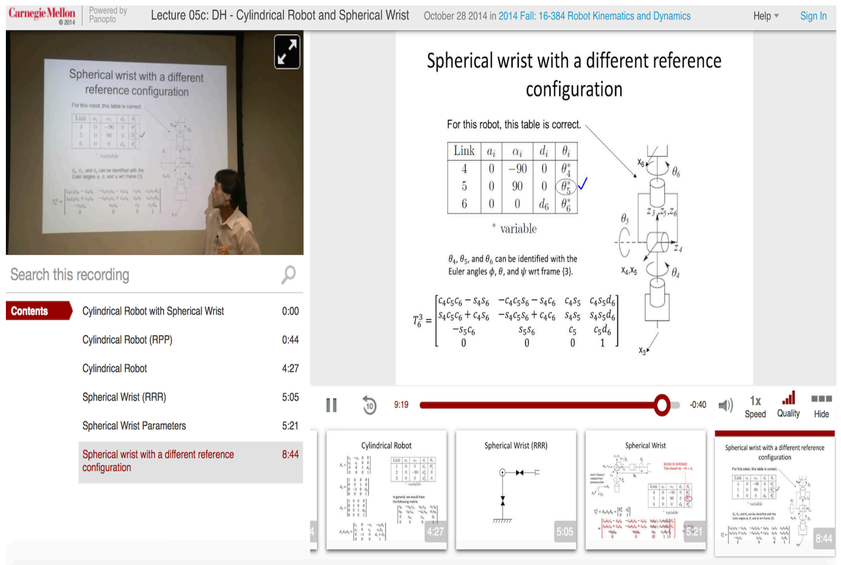

Figure 1. A video-based lecture on the Online Learning Platform.

Methods

1. Comparison of open-source robot simulators for teaching robotics.

Simulator	Description
V-Rep	Robot Simulator with integrated development environment. It offers an educational license.
Gazebo	3-D simulator for populations of robots in complex indoor and outdoor environments.
Robotics Toolbox for Matlab	Software package that allows a Matlab user to develop datatypes fundamental to robotics.

Table 1. Comparison among robot simulators.

2. Supplement the current homework and laboratory assignments using Robotics Toolbox for Matlab.
3. Elaborate new examples for the course based on the Robotics Toolbox.
4. Improve the video-based lectures in terms of quality, educational method, and pedagogical benefits.
5. Analyze surveys conducted with students of the course and develop new assessment methods in form of review and quiz questions.

Robotics Toolbox Problems

The programming problems based on Robotics Toolbox explore classical topics in robotics, such as homogeneous transformations, forward and inverse kinematics, differential kinematics, and dynamics.

Problem 1: Finding the workspace of a robot using a program rather than inspection.

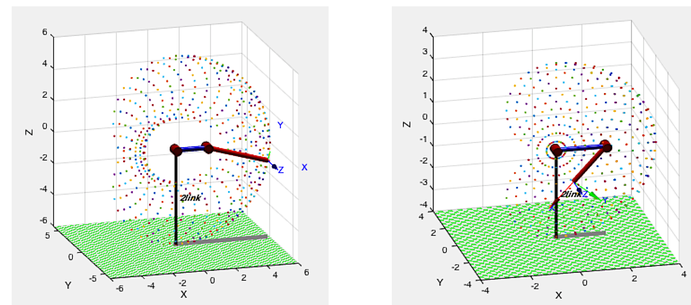

Figure 2, 3. Workspace of a two link robot. In the figure 2, the second link is bigger than the first link. In the figure 3, the two links have the same size.

Problem 2: Finding multiple solutions for the inverse kinematics problem through visualization.

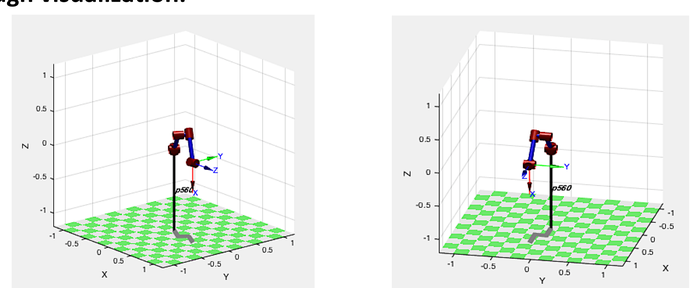

Figure 4, 5. Inverse Kinematics Solutions. In the figure 4, there is a right-handed solution. In the figure 5, there is a left-handed solution.

Problem 3: Finding a new way of understanding the columns of the Jacobian through small changes in one joint coordinates that affect the pose of the end-effector.

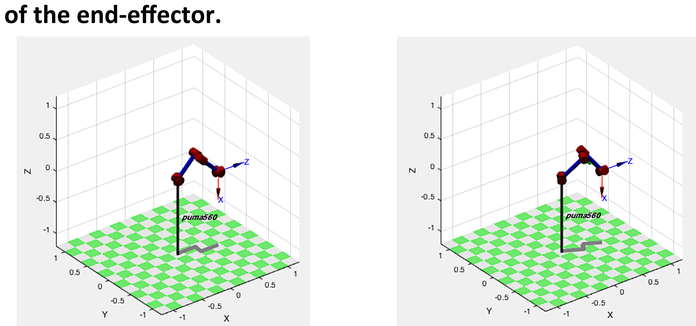

Figure 6, 7. Jacobian solution before and after small changes in one joint coordinates.

One of the important contributions is being able to visualize these problems, as opposed to before which was just solving them on paper.

Video-Based Lectures

- The lectures are taught in class using PowerPoint slides.
- The course also offers video-based lectures recorded outside the classroom, which are available via Panopto video platform software.
- Some of our pedagogical goals are: avoid making class sessions too redundant with videos recordings and reduce the amount of time students spend watching videos.
- The new videos are 43% shorter, in terms of both average and total length, than the old videos recorded inside the classroom.

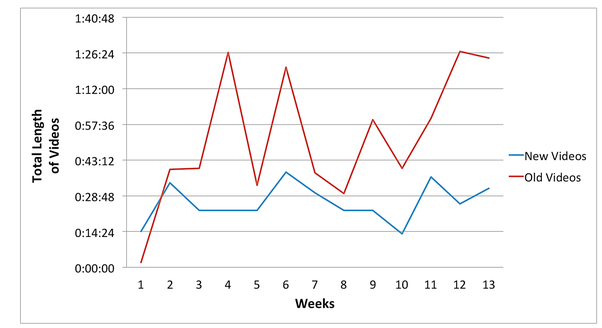

Figure 8. Comparison between the total length of new and old videos per week.

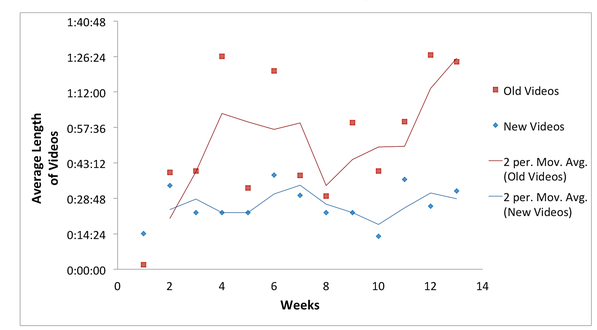

Figure 9. Comparison between the average length of new and old videos per week.

Conclusion

Our Robotics Toolbox problem development and video-based lectures will be important aspects in building the online learning platform for introductory robot kinematics.

Future work

- Implement the Robotics Toolbox problems in the next Fall semester.
- Connect Robotics Toolbox to a 3D simulator such as V-Rep and Gazebo.
- Develop a public online course in a platform known worldwide.

References

Corke, Peter. "A robotics toolbox for MATLAB." *Robotics & Automation Magazine, IEEE* 3.1 (1996): 24-32.

Robot Kinematics and Dynamics. Retrieved from <http://robotkinematics.org>. Accessed in May, 2015.