Projected-Based Hands-On Education in Tohoku University

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Abstract

Tohoku University has been offering a project-based hands-on program to the first year of graduate level (MSc) students. The program was initiated under the support from ministry of education, culture, sports, science and technology (MEXT), Japan in 2005, and designed so that the students can learn how to make a mechanical system work in a real world through the experience of a short-term project with a small size of group members. The goal of each project is, for example, to develop a model airplane that can fly autonomously, to develop an autonomous mobile robot that can travel and reach a given destination in outdoor field, or to develop a robot system for a world championship. In order to achieve their goals, the students experience a number of trials and errors. They also learn the importance of the communication among the members, the consequence of the scheduling and time management, the hardship of the troubleshooting, and finally the joy of the success. In this paper, the author describes some examples of such hands-on projects conducted both in domestic and international education programs.

Keywords: Design, Build and Fly a Model Airplane; Mobile Robots; Project Management; Systems Integration

1. Introduction

Mechanical Engineering Division in Graduate School of Engineering, Tohoku University has been offering a project-based hands-on program to the first year of graduate level (MSc) students. The program was initiated in 2005 under the support from ministry of education, culture, sports, science and technology (MEXT), Japan. The program is titled “Innovative Education Program for Frontier Technology in Mechanical Engineering.” This graduate education program provides an extensive curriculum to foster innovative engineers through the project-based, hands-on experiences on broad research topics of mechanical engineering, such as aerospace engineering at the beginning of the program, then extended to robotics, nano-technology, bio and medical engineering.

The curriculum is designed so that the students can learn how to make a mechanical system work in a real world through the experience of a short-term project with a small size of group members. The goals of the student projects are diverse; for example, to develop a model airplane that can fly autonomously, to develop an autonomous mobile robot that can travel and reach a given destination in outdoor field, to develop a robot system for a world championship, or to build test pieces of advanced materials or mechanisms and measure their characteristics or performances in different conditions. The specific goals, approaches and timelines are discussed and determined by the students. In order to achieve their goals, the students experience a number of trials and errors. They also learn the importance of the communication among the members, the consequence of the scheduling and time management, the hardship of the troubleshooting, and finally the joy of the success.

In this paper, an outline of graduate education program in Mechanical Engineering departments is overviewed, then the project-based hands-on education is introduced with selected examples.

2. The Graduate Curriculum in Mechanical Engineering

Figure 1 depicts an outline of the education curriculum in Mechanical Engineering departments (Dept. of Mechanical Systems and Design, Dept. of Nanomechanics, Dept. of Aerospace Engineering, and Dept. of Bioengineering and Robotics) in the Graduate School of Engineering.

We have 2-year master and 3-year doctoral programs, and in the master level, students are required to take the coursework of Basic Subjects and Advanced Subjects, then conduct Master Research. In the Innovative Education Program for Frontier Technology, we introduced two new courses: “Project-Based Learning for Frontier of Mechanical Engineering” and “Innovation Oriented Seminar on Mechanical Engineering.”

(1) “Project-Based Learning for Frontier of Mechanical Engineering” is designed for the first-year, fresh graduate students to offer a hands-on, mini-project for six-month (one semester) term length. The later half of the term includes summer vacation time, then some of the projects encourage the students internship activities in industries, research institutions, or foreign couriers to expand their experiences. Some students go and participate in an international competition or student seminar bringing their results of the hands-on projects.

(2) “Innovation Oriented Seminar on Mechanical Engineering” is designed as an alternative option of the Master Research. It offers an opportunity of innovative research and development with industries, research institutions, or international universities for advanced project-based studies.
3. Selected Examples of Project-Based Learning

"Project-Based Learning for Frontier of Mechanical Engineering" (termed as Frontier Hands-On hereafter) offers around 30 different hands-on topics for students to choose. Each topic provides an important basis for future advanced research projects in a corresponding research area. However, because of limited pages, this paper gives short description about three topics.

3.1 Project “Aerial Robots”

A project to develop an aerial robot was set as a subject of the Frontier Hands-On program. The goal of the project is to develop a model airplane that implements an autopilot control system to conduct autonomous flight along a specified route. Students develop micro controller electronics and software that can fit on a commercial model plane using a micro processor, GPS receivers and attitude sensors (See Fig. 2). At the beginning stage, even flying a commercial model plane was not easy and the plane crashed many times, but after some while, they learned how to fly an airplane stably and became successful in GPS based autonomous flying route control. After some years, this student project has been extended to an advanced research of Unmanned Aerial Vehicle that has a sophisticated control capability from level flight to vertical hovering [1].

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Fig. 1: An outline of the education curriculum in Mechanical Engineering

Fig. 2: A model airplane (left) and on-board electronics system [1]
3.2 Project “ARLISS”

A Rocket Launch for International Student Satellites (ARLISS) is a project to provide hands-on experience of space engineering with which students can learn a whole process of design, build, test, launch and retrieve of their own payload. The payload is launched into the sky of 4,000m altitude by using a high power solid rocket provided by an American rocketry group named the Association of Experimental Rocketry of the Pacific (AERO-PAC). The launch site is Black Rock desert, Nevada, U.S.A. Since 2001 “Come-Back Competition” has been organized as an international competition, in which participants challenge to maneuver the payload to reach a goal marked on the ground. Various approaches to attain the goal are allowed, such as performing the aerodynamic maneuver in the sky, or the surface locomotion after the landing, or combining these. However, the requirements say the payload has to fit in the specified size and weight of 1050 g, and to be navigated completely autonomously.

Participating in the ARLISS Come-Back Competition was set as a subject of the Frontier Hands-On program. The goal of the project is to develop a mobile robot to fulfill the ARLISS requirements and come back to the designated point as close as possible by using GPS based navigation (see Fig. 3). This is a very challenging project that requires high level of systems integration of mechanical and electrical components and onboard software, and high level of reliability so that all of the components should work in an appropriate way even after the shock of rocket launch and surface landing.

The student teams of the Frontier Hands-On program, Tohoku University recorded good scores. The first and second positions were taken by Frontier teams of Tohoku University in 2006 and the first position was taken again by another Frontier team of Tohoku University in 2008. Winning the competition is a good evidence for the success of the project management [2].

3.3 Project “RoboCup Rescue”

The RoboCup Rescue Robot League is an international competition for urban search and rescue robots, in which robots compete to find victims in a simulated earthquake environment. The rescue robot league is run alongside Robocup Rescue Simulation, as part of the RoboCup robot competition. Robots perform 20 minute search and rescue missions in a test arena measuring approximately 10m by 6m, which features a number of obstacle zones designed to challenge autonomous operation, mobility during tele-operation, and object manipulation. Points are allocated based on the number of victims found, the detail with which victims were detected, and the quality with which the arena has been mapped.

Participating in the RoboCup Rescue Robot League competition was set as a subject of the Frontier Hands-On program. The goal of the project is to develop a sensing and navigation system for mobile robots to fulfill the RoboCup Rescue requirements, while the robot hardware platforms are provided from the corresponding research project (see Fig. 4) [3]. This is another challenging to international championship and the student teams of the Frontier Hands-On program recorded good scores. In the competition of 2009 in Graz, Austria, the Frontier team of Tohoku University took the first place in “Innovative Sensing, Manipulation and Operator Interface” and “Mobility”, and the second position in “Autonomy”, then the second position in the total evaluation ranking.

![Fig.3: Mission sequence of a payload for ARLISS Come-Back Competition (left), a snapshot of the rocket launch (center), the winning team of the 2006 competition (right-top) and their robot (right-bottom).](image)
4. Conclusions

In this paper, a project-based hands-on education program in Tohoku University was introduced. The program is conducted in Mechanical Engineering Division, Graduate School of Engineering, Tohoku University, for the MSc level students. The program was initiated under the support from ministry of education, culture, sports, science and technology (MEXT), Japan, with the title of “Innovative Education Program for Frontier Technology in Mechanical Engineering.” Two new courses “Project-Based Learning for Frontier of Mechanical Engineering” and “Innovation Oriented Seminar on Mechanical Engineering” were developed in this framework. The hands-on program has been conducted successfully in drawing up the students’ motivation and problem-solving ability with a variety of options of experiences for challenging tasks of systems integration in mechanical engineering. Three such examples were highlighted. But as a total figure, in 2008, 131 students took this program and worked on 31 different projects, then 43 students went abroad related to this program. In 2009, 118 students took this program and worked on 27 different projects, then 31 students went abroad.

References


Biography

Dr. Kazuya Yoshida received Doctor of Engineering from Tokyo Institute of Technology in 1990. He served as Research Associate of Tokyo Institute of Technology from 1986 to 1994, and Visiting Scientist of Massachusetts Institute of Technology, U.S.A. in 1994. From 1995 to 2003, he was appointed as Associate Professor and since 2003 Full Professor in Department of Aerospace Engineering, Tohoku University, Japan. He has also been contributing to space robotics education for international students at International Space University, Strasbourg, France. He has been appointed as Visiting Lecturer since 1998, Adjunct Faculty since 2007, and Faculty of International Space University since 2009. His research activities cover dynamics and control of space robotic systems ranging from orbital free-flying robots to planetary exploration rovers. His activities are extended to the development of university-based micro satellites and also the terrestrial applications of space technology, such as robotics remote exploration for search and rescue missions.