軌道自動化技術實作（自動化與機器人技術課程深化）成果摘要報告

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This project conducts a teaching methodology that uses robot kits for railway engineering. We designed a 4-week courseware for training the railway engineers. The students' feedback and performance were collected and analyzed to evaluate the feasibility of applying this new teaching style to other engineering courses.

Railway is the more energy efficient transportation mode compared to highway and air. Unfortunately, as the demand for rail transportation increases, the industry faces a significant shortage of engineers, due to the lack of infrastructure in railway education in the past. Consequently, the more railway education these engineers can obtain beforehand, the faster they can adapt to this industry, and the better their performances.

In terms of railway education, universities are usually responsible for providing the fundamental railway knowledge to future engineers. Current railway engineering courses focus more on the theories of railway design and management. The lack of hands-on experience may cause design defects for students in practice. A better course plan should include opportunities for students to design and implement these control logics in a model railway system. In this way, students can validate their design concepts and realize the complex logics behind the scene. Consequently, there is a need for an educational tool to accomplish these opportunities.

Automation and Robotics, an optional course designed for senior students in the Department of Civil Engineering, has included a 4-week courseware. The courseware provides theoretical lesson, robot kit instructions and term project scenarios for students to prototype and implement the main control mechanisms of the railway system. Besides studying the theory of the railway control system, students were required to implement the railway control systems using a robot toolkit, LEGO Mindstorm NXT (Figure 1), and a robot platform, Microsoft Robotics Developer Studio, MSRDS. Through this hands-on process, students can become familiar with the design concepts and realize the difference between simulation models and real situations.

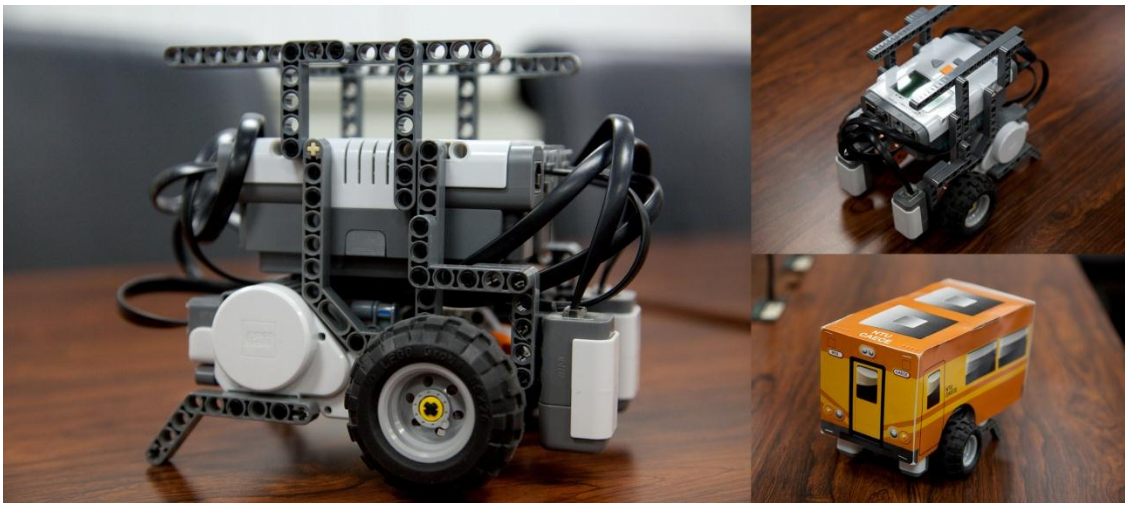

Figure 1. Train assembled using LEGO Mindstorm NXT

In the 4-week course, the essential elements of an Automatic Train Control (ATC) system are arranged into four lessons: track guidance, blocking mechanisms, passing movement, and system integration. In the first lesson, we cover basic knowledge concerning the tracks of the ATC system, such as the introduction of track types, track components and so on. The second lesson is about blocking. It is a control mechanism for preventing train collisions by setting blocks on the tracks and localizing every train among the railway systems. In the third lesson, students are taught a common strategy used frequently in ATC systems, called passing movement. It allows a fast train to come across a slow train for the sake of efficiency. In the final lesson, we integrate the elements of the previous three lessons, and ask students to develop their own railway system design and implementation. These lessons have been taught by lectures and hands-on practice according to the schedule of the 4-week course.

After the 4-week course, the students were divided into six teams to demonstrate their automatic train control (ATC) systems as a final project. The required ATC scenario is a simple loop railway system with three stations and two trains as shown in Figure 2. As managers of the railway, each team has to first decide the ticket price for each origin-destination pair (OD pair), number of types of trains to operate and the stopping pattern of each train in order to maximize the total revenue.

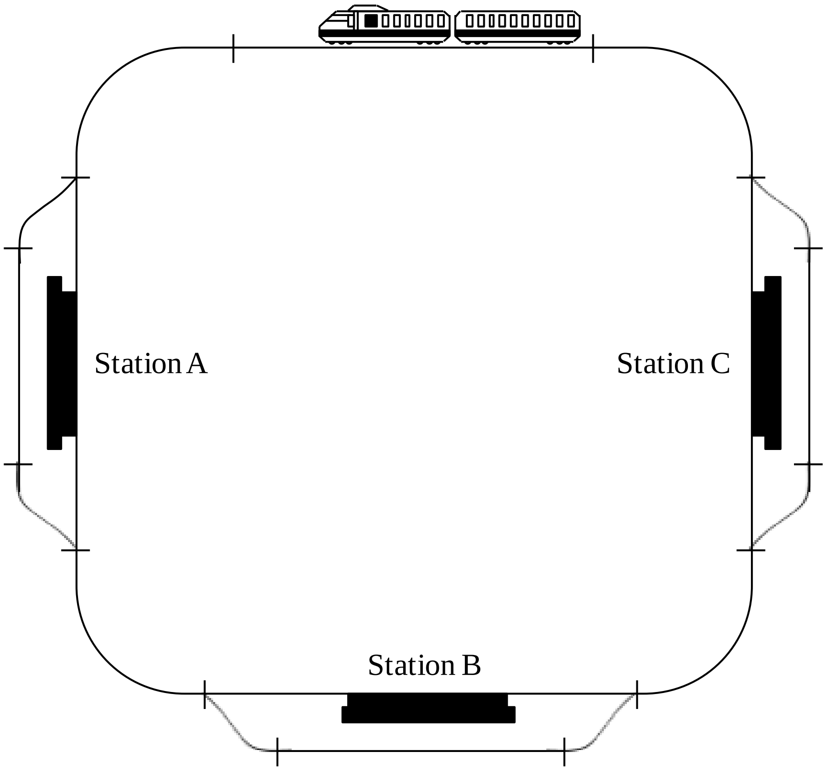

Figure 2. The scenario of the small-scaled ATC system.

After designing the ATC system, the project teams should start implementing their designs which include the following three essential elements: (1) Track and Train Integration: each team should design and implement the integration mechanism of trains; (2) Block Signaling: the adjacent trains should be controlled by the mechanism of block signaling to avoid collisions. Students may choose one of the methods mentioned in the class; (3) Passing Movements: the train is capable of performing passing movements on the stations in order to let fast train overtake slower ones.

From the project demonstration as shown in Figure 3, we found that the designs of all six teams are conceptually very similar in the concept, differing only in certain characteristics. Four of the six teams successfully delivered stable ATC systems. According to feedback from the questionnaires, students were very positive towards the learning experiences. According to the results of the project performance and feedback, it was evident that the robot kits are a very effective tool for educating future railway engineers on railway signaling systems and control. A list of lessons learnt is presented as follows.

- *Clear Understanding of the Control Logics*: By using robot kits as teaching aids to prototype the conceptual model of the railway system, students can easily understand the theorems taught in the class. They can easily describe the problems among the complex railway system due to the implementation and testing time spent on their works.
- *Consideration of Uncertainty*: From the hands-on project, students can notice the complexity of the railway system and uncertainty between theorems and practical situations. It can be observed from the integration problems among the projects teams.
- *Practice Opportunities*: The course helps students have the opportunities to examine their design and at the same time figure out the practical problems for building further error handling mechanisms. This will be highly

beneficial when they face these tasks in practice.

- *Consideration of Integration Issues*: From observing the results of each team, the integration issues and difficulties between hardware and software when developing a railway system have been brought up by all students. It will become a foundational concept when the students need to design or implement relative works in practice.
- *Disadvantage of the Course*: Too many project materials and not enough instructions for may be difficult for students to handle. It should be improved by providing better project description and designing appropriate scenarios next time.

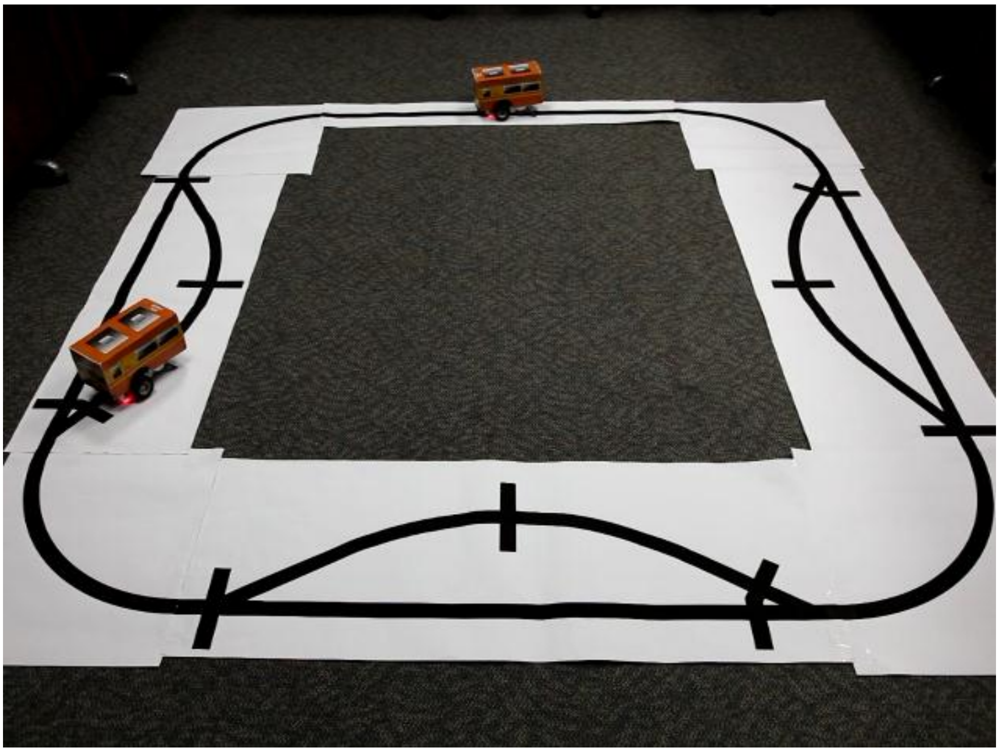

Figure 3. An Example of Project Implementation.

We therefore conclude that the incorporation of these hands-on elements into advanced design courses will be a great success. In the future, this teaching method for railway engineering may be improved by providing more appropriate scenarios and clear instructions for enhancing the implementation experiences. The robot kits can also transfer to enhance those advanced design courses involving automation and control systems.