THE INTERACTIVE SURVEYING INSTRUCTOR (ISI) FOR TEACHING OPTICAL-MECHANICAL INSTRUMENT READINGS IN SURVEYING ENGINEERING

Jaime Garbanzo León and Gustavo Lara Morales
Surveying Engineering School, University of Costa Rica.
Edificio Administrativo de Ingeniería, Ciudad de la investigación, P.O. BOX: 11501-2060, San Pedro de Montes de Oca, San José, Costa Rica

ABSTRACT

The Interactive Surveying Instructor (ISI) is an extension of the work developed by Garbanzo and Lara (2018), who created a web 2.0 app for teaching differential leveling in surveying engineering. Two improvements were done to enhance the user experience and include surveying equipment that is important in the first stages of the engineering training: developing a new web interface using bootstrap 4.0.0 and a module for optical-mechanical theodolites. Often, these students have problems to practice on the field because they need a peer to assist them with the equipment, this situation can restrict their learning. ISI was developed using PHP, MySQL, JavaScript and it is a light web application designed to simulate equipment readings. Furthermore, the readings made by students are stored in a database to analyze them. ISI is operational but still is not suitable for mobile screens. This adaptation to mobiles is the next step in this project.

KEYWORDS

Surveying, e-Learning, Leveling, Theodolite

1. INTRODUCTION

Automatic levels and optical-mechanical theodolites are instruments taught in the early stages of the surveying engineering training at the University of Costa Rica. These instruments are important because students can learn the fundamental computations and methods of 2D and 3D precise positioning. However, traditional teaching of these instruments can be demanding due to various reasons: instructors must explain the methods to students individually, not every student gets the same practice, and an instrument just allows one student reading at the time. These circumstances motivate the development of an e-learning tool, which allows practicing without the need of a partner and/or instructors. The tool focuses on the equipment readings and computations because these are easy to reproduce in a virtual environment. The web 2.0 app Interactive Survey Instructor (ISI) was developed to teach differential leveling and optical-mechanical theodolite traversing. This e-learning tool is designed to be used in a blended approach, and its purpose is not to substitute the traditional teaching but to support it. ISI is currently being used to teach early stages of Surveying Engineering.

Nowadays, e-learning has made the delivering of the class material easier (Soon, 2011) but there is always room for developing new teaching applications. In fact, e-learning not only includes online apps but offline such as the Computed Aided Learning (CAL) (Commission 2- Professional Education, 2010; Harasim, 2006; Nicholson, 2007). In the 90s, a CAL application was developed in Nottingham University to support surveying engineering teaching and it was updated with an online component in 2009 (Roberts & Gray, 2010). Also, simulation-based training tools are useful for training that involves fragile and expensive equipment (El-Mowafy, Kuhn, & Snow, 2013; Moroney & Lilienthal, 2008), such as the surveying engineering one. These simulation tools have been also developed for surveying engineering. For example, Gulland, El-Mowafy, and Snow (2012) developed a flash-based simulation tool for teaching differential leveling. This tool is split into 3 parts: a staff leveling reading component, a computation component, and a procedure checking module to ensure that the field work and computations are correct. On

the other hand, Dib and Adamo-Villani (2013) developed a virtual environment for teaching differential leveling. Although the foundation is the same as the one created by Gulland, et al. (2012) this tool has a more sophisticated and expensive graphic design. Moreover, Dib and Adamo-Villani (2014) reported another virtual environment tool and described a chaining module used to determined horizontal and slant distances. Furthermore, Garbanzo, Kingdon, and Stefanakis (2016) created an online application in order to support students in field practices. This application was designed to test students' measurements before they submit the final report and to show them where the errors might be made. Finally, Garbanzo and Lara (2018) developed a Web 2.0 application for differential leveling using PHP, JavaScript, and MySQL. This application was well received by students and instructors.

In this paper, we extend this previous work that has been done by Garbanzo and Lara (2018); the web interface was updated using bootstrap 4.0.0 and a module for an optical-mechanical theodolite added. Also, we describe how the tool can be used to educate students in the early stages of the engineering training. Finally, the importance of ISI is outlined to give a better understanding of the contribution.

2. METHODS

Differential leveling (DL) is a process for obtaining precise elevations or elevation differences. Surveyors carry out this process with an automatic level and perform computations easily. However, the challenging part is to read the leveling rod correctly. The sketch of the DL process is shown in figure 1 (A). The elevation of point B is computed by adding the backsight reading to the Point A elevation and subtracting the forwardsight reading. The traversing is a process where lengths and directions of lines are determined to compute the position of the end points. There are two types of traverse open and closed: the closed traverse starts and ends at the same point while an open traverse starts and ends in different points (Wolf & Ghilani, 2012). Optical-mechanical theodolites are instrument to measure angles precisely and surveyors can measure distances by measuring vertical angles together with a calibrated rod. Figure 1 (B) shows the fundamentals of this process The formulae for the computations of differential leveling and traversing can be retrieved from Wolf and Ghilani (2009).
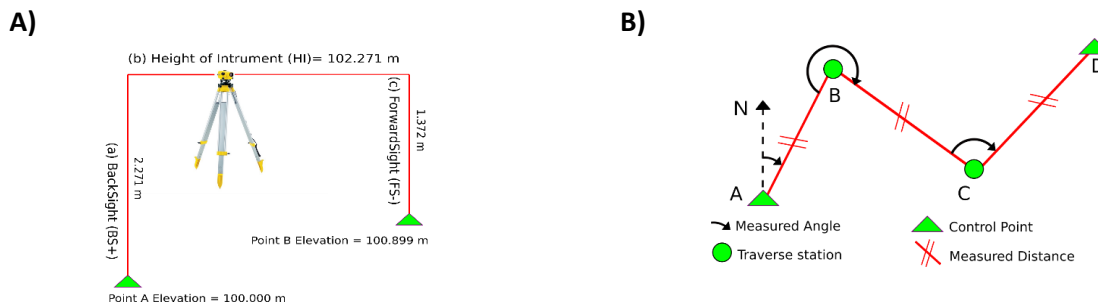

Figure 1. (A) Sketch of the differential leveling process (source: the authors) and (B) the leveling process
(Source: Wolf and Ghilani (2012) modified by the authors)

The programing strategy of this application is to balance the task between the server and client. For this reason, this application was developed using JavaScript, PHP and MySQL, which are programing languages and a database manager commonly used to program web apps. We use PHP to manage user profile, communicate to the database, and create a training session for instrument readings. On the other hand, all the computation for each training session is done in the client side using JavaScript. All computations are stored by user in a database to further assess them. The procedure of ISI contains 5 general steps such as to (a) construct a random session with the images equipment readings, which simulate real life measurement, (b) gather student's readings and computations, (c) compare students' readings and computations to those computed by the application, (d) give feedback, (e) store students' readings and computations, and those computed by ISI.

3. RESULTS

The ISI interface was updated to distribute the contents better. We added a user profile navbar that can be personalized. Also, this e-learning tool supports an open traverse exercise based in a theodolite Pentax FX-1 and a calibrated rod. ISI shows students a set of images that contain readings of horizontal and vertical angles of the theodolite, and a rod image that simulates the reading of the theodolite through the objective lens. Also, students can decide if they want to practice readings and computations or just readings in this module. After students fill in the blanks with readings and computation, ISI reviews their work and provides feedback. Moreover, a report displays the students' readings, the machine's readings (computed by ISI), and images for students to check where their mistake was made. For the differential leveling module, a similar approach was described by Garbanzo and Lara (2018) but the module was extended to include the report. Figure 2 and 3 show the ISI's differential leveling and optical-mechanical theodolite modules respectively. ISI is currently being used by the School of Surveying Engineering of the University of Costa Rica for teaching early stages of surveying engineering and it has been well received by students and instructors (see Garbanzo and Lara (2017)).
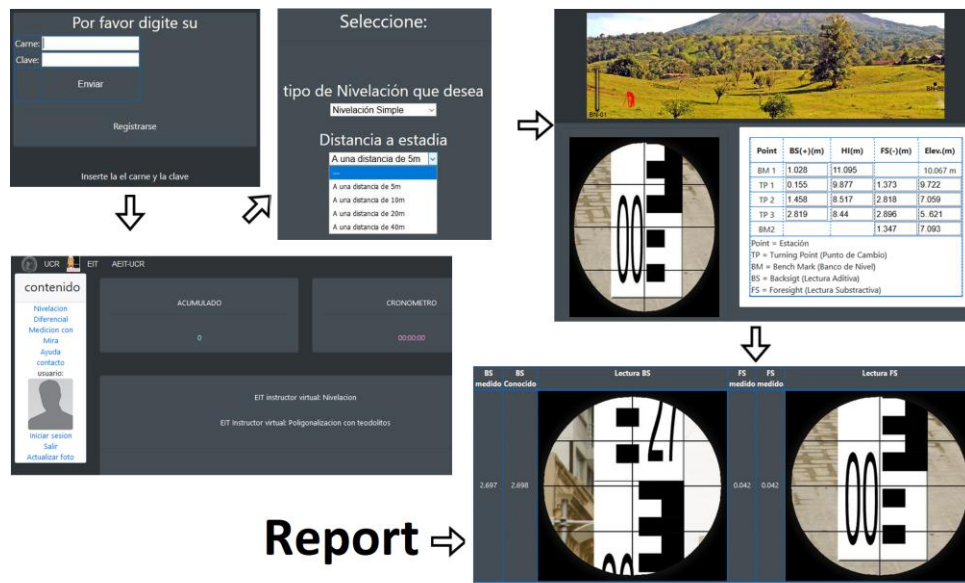

Figure 2. The process of setting up, filling up the practice and reviewing in the simple leveling module

Figure 3. This traverse module is based on a Pentax Fx-1 theodolite. The readings are shown in the righthand side of the image while the report is shown in the lower left part of the image

3.1 Teaching Strategy and Contribution

As stated before, instructors teach how to read surveying equipment on the field and to one student at the time. This situation is not convenient for instructors and students because the teaching time is limited. ISI allows instructors to teach a theoretical class in a computer lab and, right afterwards, all students to practice at the same time with the supervision of instructors. Also, the final report gives students the opportunity to clarify doubts about the reading or computation process. Figure 4 shows ow ISI interacts with the teaching process. Therefore, the good field work practices can be emphasized when the real surveying equipment is used.
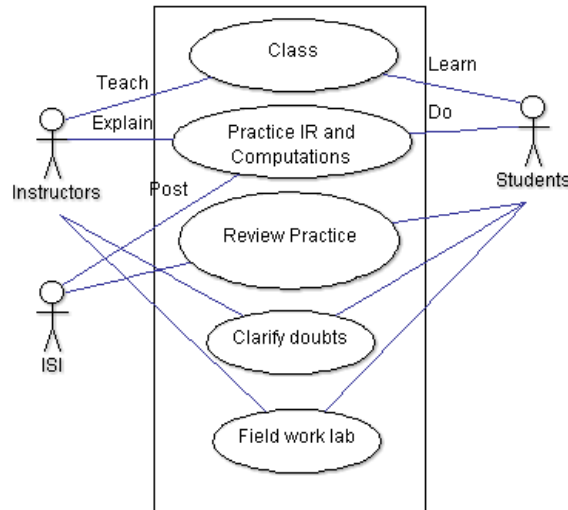

Figure 4. Images of the differential leveling module are presented above the black line while the traversing module is presented below this line

Two main contributions can be highlighted: we are presenting a way to adapt traditional teaching in surveying to new web technologies and a design that smooth the process of learning the use optical-mechanical surveying equipment. Finally, a value is added for the situation that surveying equipment nowadays is high-tech and eventually these methods of surveying will not be taught anymore; we consider that ISI is still important to demonstrate how measurements were made with optical-mechanical equipment.

4. CONCLUSIONS

We presented the Interactive Survey Instructor (ISI) that is a web 2.0 app to teach early stages of surveying engineering. Currently, ISI contains 2 modules: differential leveling and traversing with an optical mechanical theodolite and rod. This web app is currently being used for the School of Surveying Engineering in the University of Costa Rica. We presented a way to include e-learning to the traditional surveying teaching process and designed a web interface that smooth the training of optical-mechanical surveying equipment. This type of application has also an added value of preserving traditional methods of field surveying for future generations. We are currently developing an android version which will allow to reach more students and to show them an easy and fun way to learn.

ACKNOWLEDGEMENT

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