

Development of a Skill Learning System using Sensors in a Smart Phone for Vocational Education

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Abstract: Generally speaking, learning or teaching requires time, particularly with physical movement. In this paper, we demonstrate an efficient way for students to learn skills by using sensors in a smartphone. Every smart phone has some type of sensors e.g. acceleration sensor, gyro sensor and so on. Our “Skill Self Learning System (SSLS)” can give feedback, results and evaluation of a student’s actual movement to his/her self immediately on the smart phone, which he/she is using. In this research we used SSLS for learning how to saw and plane. As a result of running simple tests, a group using SSLS could improve their skills as well as a group, which a teacher taught in person. According to the results, if students have learned the skills before an actual class, a teacher can teach skills in detail and support them interactively. Our method is beneficial for enhancing traditional vocational learning as well as for distance skill education, intelligent skill learning and teaching system.

1 INTRODUCTION

For efficient learning, it is considerably important for learners to have knowledge about the contents before their class. Flipped-learning is one typical approach. The flipped learning/teaching method is defined as follows, according to Wikipedia (2011):

“Flip teaching is a form of blended learning which encompasses any use of Internet technology to leverage the learning in a classroom, so the teacher can spend more time interacting with students instead of lecturing”.

Moreover, Berrett (2012) mentions the benefit of the learning style. As a background, the important point made is that time is too short to learn only in face to face class environment. Needless to say, this problem occurs in skill learning as well. It is a particularly serious problem for Japanese junior high school students who do not have real experience (Ando and Abiko, 2003). In this paper, we focus on vocational learning, and the subject is technology-education in Japan. In Technology-Education,

students learn to “make things” such as the craft arts (woods, plastics and metals), electricity, metal craft, materials, changing energy and Information Technology. In the Japanese education system, the subject is allocated only one class per week and is found only in Junior high school education curriculum. Therefore, not only have almost all students never tried to use craft tools e.g. a saw and a plane, but also they don’t have enough time to learn its skill. In spite of the fact that these are basic skills in Technology Education, a lot of students have never been good at making things (Yamamoto et al., 2007). Obviously, the unique circumstances around students are changing. Competently, most students don’t feel the need to make things in their life. However the experience of making useful products according to their own design affects not only national power, but also desired character formation (Ando et al., 2011). It is commonly known that learning skills to use tools requires the necessary equipment and right conditions. Unfortunately, such tools, i.e. a saw and plane, are not readily available in students’ home. Moreover,

most parents themselves aren't good at these skills, therefore the students cannot understand if their posture and movement are correct or not. MEXT (Ministry of Education, Culture, Sports, Science and Technology in Japan) (2011) says teachers should make students into well-learned citizens, however a concrete teaching program hasn't been developed to meet such a need.

On the other hand, there exists research regarding the usage of sensors to understand a user's state or action. For instance, Hattanda et al. (2008) has tried to develop new functions of a cell-phone in which the screen changes automatically in response to adapting to user actions. In this work, it required acceleration sensor hardware connected outside of the cell-phone. At around this time, sensor devices had been the focus of mobile devices. In the educational field, Kashiwagi et al. (2010) began to research the use of a few acceleration sensors and slant sensors attached to a students' head, both sides of wrists, both sides of ankles and waist. These sensors were hardware which could transmit data to a PC. Using this system, an observer could know how students behaved from a distant place.

The originality of our work is in using a smartphone instead of special devices. All smartphones are equipped with acceleration sensors, slant sensors and gyro sensors. Though it is possible that special sensors may be far more precise than sensors in a smartphone, we haven't found practical reports for the investigation of a user's condition by using a smartphone. Moreover, we haven't found any previous research that exists regarding an application of a smartphone to learn or improve a students' skill. Our research question is sensing data from sensors in a smartphone that can enhance the students' skills. As we described, there are serious problems in vocational education. If this approach is developed, students' are able to learn, practice and improve their skill without a teacher and special classroom. Former models of smartphones are less expensive and even an obsolete model can be used in this approach.

In this research, we aimed to develop a "skill self-learning system (SSLS)" and evaluate the approach for beginner subjects to improve their skill. We described a beginner's typical mistakes of sawing and planning. Then, we suggested the necessity of self-skill-learning and advantages of using a smartphone. Finally, the results of a simple experimentation by using our developed system were discussed.

2 TYPICAL FAILURE SITUATION FOR A BEGINNER

Sometimes, typical failure situations appear while beginner students practice their own skill without the aid of a teacher. Situations may be errors such as the wrong strength or incorrect movement. Japanese official textbook (2012) for technology and vocational education says "While sawing, set the blade as shown, like a straight line" and the other textbook says "to cut straight, place the blade underneath, between the eyes". In addition, the textbook says "the angle between a wood piece and a blade should be from fifteen to thirteen degrees". When sawing, a blade should be moved forward and backward repeatedly while keeping the blade vertical. According to practical experience, a beginner tends to fail to correctly do the three patterns as follows; first, a worker cannot set and keep the blade at the proper angle. The second, while moving the blade, it leans to the side and isn't kept vertically straight. The last, the blade is moved irregularly. Unfortunately, a beginner cannot be made aware of these typical failures unless someone tells them.

In the case of using a "plane" to flatten the surface of wood, it is difficult for a beginner to slide it at the proper speed. Moreover, at the beginning of sawing, the peculiar movement, which a plane is moved marginally to a backward direction, appears in the expert's movement. It is also hard for a beginner to understand how to coordinate his/her arms and his/her waist.

3 OUTLINE OF THE SYSTEM

3.1 Basic Function and Contrivance

Our original SSLS method is to use "smart-phone" instead of special sensors and analysing system. Every smart phone has some important features: LCD wide screen, gyro sensor, acceleration sensor, data storage and connection to the Internet. Our basic design allows students to attach a smart phone on a tool and assess their own skill without an expert by displaying feedback results. The SSLS works on devices installed with Android OS version 2.3 or greater. The SSLS is able to record and calculate data every ten micro seconds. This data represents the number of forward and backward motions, speed of moving, maximum speed, elapsed time, change of slant angle while moving, and the change of blur

while moving.

In the case of sawing, the acceleration of the y axis and z axis is calculated using the three axis acceleration sensor of the smart phone, in order to count the number of times the blade moves forward and backwards. Figure 1 shows the actual results of an expert worker's sawing.

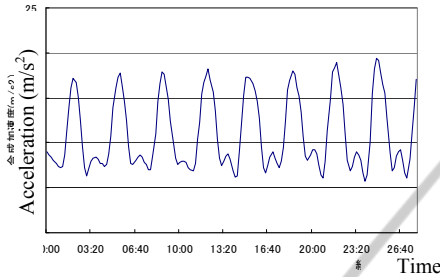


Figure 1: Change acceleration of an expert's sawing.

In this research, the threshold value for counting was fixed at $15(m/s^2)$. To record the slant angle of a blade, it uses values taken from the slanted sensors. After a few practice sessions, the application displays the initial results as feedback information to the student. By these results, a student can improve his/her own movement and skill (Figure 2). In the case of planning, the application shows the change of acceleration as a line graph comparing them with the results of an expert's movement, and feedback message regarding motion speed (Figure 3).

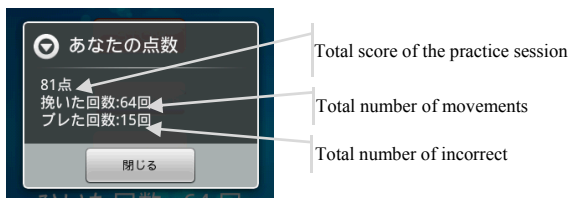


Figure 2: Result and advice for improving sawing.

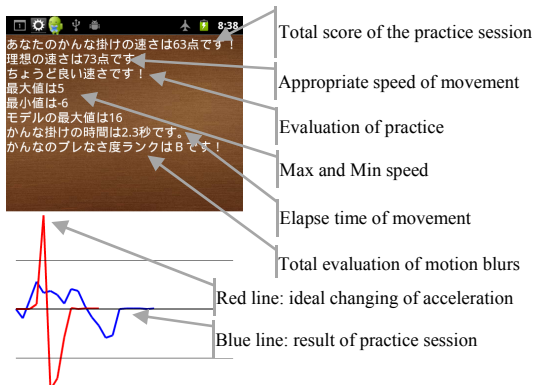


Figure 3: Result and advice for improving planning.

3.2 How to Set up and Practice

In the case of sawing, a smart phone, which was installed with our application, is put on a bar of a saw with an attachment (Figure 4, left). To minimize the weight of the whole saw, the attachment is made of foaming polystyrene. In the case of planning, the smart phone is put on a wooden piece, like the body of plane (Figure 4, right). In both cases, hook-and-loop fasteners secure the smart phone to the tool. Figure 5 shows a practice motion and Figure 6 shows actual scenes of sawing and planning.



Figure 4: A smart phone put on a bar of a covered saw (left) and a smart phone put on a wood piece like a plane (right).

To begin a practice session, tap to run SSLS application for sawing. Before sawing, the student must adjust the proper angle between the blade and wood. Then tapping the start button, SSLS begins to record and analyse the acceleration of the smart phone. During practice, if SSLS detects improper or irregular motion, the smart phone screen changes colour from blue to red and beeps to indicate incorrect movement. After sawing, SSLS shows a summary of the practice results. However, in order to practice planning, a student has to watch a recorded example of correct planning posture beforehand. To record proper examples, tap the "record button" on the menu screen. In this record mode, SSLS can record whole movements of planning. Figure 7 and Figure 8 show each algorithm of practice.



Figure 5: Actual scene of sawing with a smart phone.

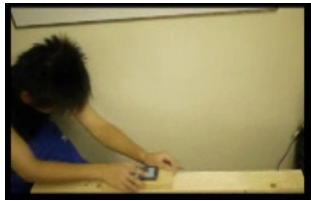


Figure 6: Actual scene of planning with a smart phone.

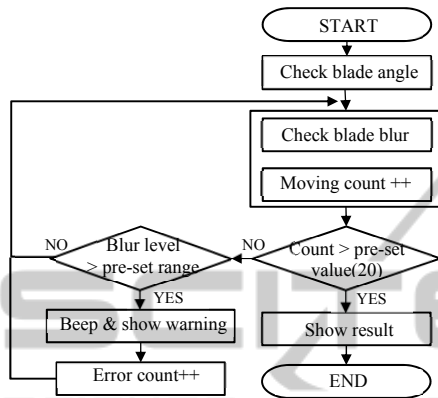


Figure 7: Algorithm in sawing practice.

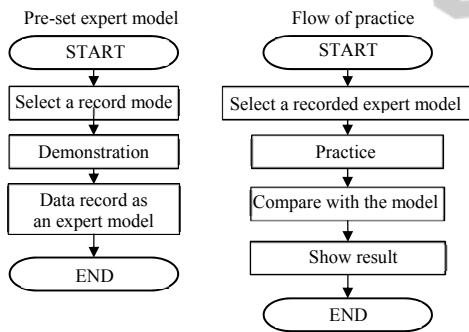


Figure 8: Algorithm in planning practice.

4 EXPERIMENTAL PROCEDURE

To evaluate our SSLS approach for improving students sawing skill experiment, we conducted test with seven university freshman subjects who were beginners, and we conducted test with six subjects who were high school students.

When sawing, the most important skill is to cut the wood straight and vertical. So, we compared changes of the blade's slant by using the SSLS and by a teacher's oral method (Oral teaching group). All subjects used a covered saw with the smart phone and practiced moving it forward and backward repeatedly twenty times. In the smart

phone group, subjects checked their own results and feedback information on the smart phone during every trial. In the other group, a teacher instructed subjects of the oral teaching group during every session. Subjects of both groups tried this repeatedly five times. We compared the average acceleration of the sideward motion of the first result with average acceleration of the fifth result.

Next, in the case of planning, we compared the first and fifth sessions' acceleration values change of the blur made by the body of the moving plane. In this case, all subjects were in separate SSLS groups; Oral teaching group as well as sawing. Both groups consisted of three subjects.

5 RESULT OF PRACTICE TEST

Figure 9 shows the result of sawing test. In first instance, average acceleration of the blade was 0.61 (m/s²) (SD=0.34) in SSLS group and 0.50 (m/s²) (SD=0.28) in the oral teaching group, and at the last time, it was 0.56 (m/s²) (SD=0.31). This result shows that only SSLS had significant differences ($t_{(603)} = 2.475, p < 0.05$). It means that subjects improved by using SSLS. The first time however, there were already apparent differences of skill between the SSLS group and the textbook group. Subjects of the oral teaching group were already good at sawing. Therefore, we could not conclude that using SSLS was better than the oral teaching methods according to only this result.

Likewise, Figure 10 shows the result of planning test. It was found that both groups improved in blur of planning ($p < 0.05$). There were no significance differences between the Oral teaching group and SSLS group in both the first trial and fifth trial.

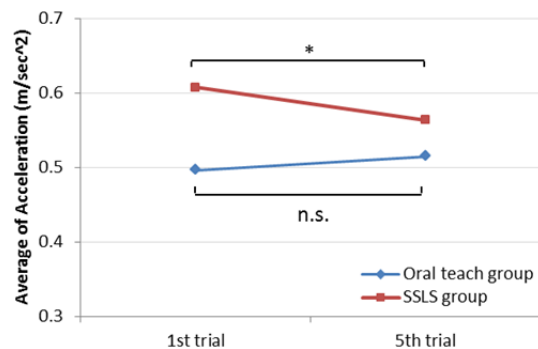


Figure 9: Effectiveness of practice sawing in proper slant.

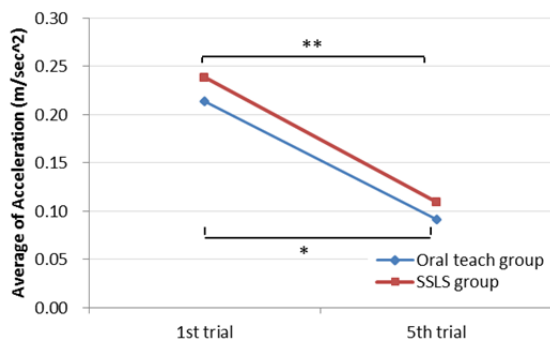


Figure 10: Effectiveness of practice in blur of planning.

6 DISCUSSION

According to these two tests, we found the students use of the smart phone while sawing and planning to be very effective in improving their skill. Though under the condition that subjects were beginners and the number of subjects was on a small-scale, it means that beginners can improve their skill of basic sawing and basic planning without the aid of a teacher. Even with such tentative results, we believe this to be meaningful even for distance learning and enhancing face to face classroom learning. Until now, e-learning has been used to acquire knowledge via text and visual aid e.g. videos and YouTube. As far as using a traditional method, students cannot understand and assess their skill without a teacher, i.e. they cannot avoid incorrect posture or improper movements without a teacher. Because of this problem, it is difficult for distance learning of skill based training. However using our method, students can understand how they should move their body or tools by themselves. Apparently, we have to validate our method using more subjects and improving the precision of data from the sensors. However, this method of using sensors on a smart phone and the resulting immediate feedback to students can enhance traditional learning not only in vocational education but also physical education and sports. Even though in this research, the number of subjects was low and limited, we could get appropriate results. Our research team has already applied the approach to about 80 actual junior high school students. We are going to report the effectiveness of the practice in detail in a next paper.

7 CONCLUSIONS

In this paper, we developed Self Skill Learning System (SSLM) using sensors in a smart phone. The

system works on smart phones using Android OS. In terms of a student's actual practice, it can indicate results visually and advise on how to improve. We conducted sawing and planning experiments that are basic skills in vocational education. As our results showed, a group using SSLS could improve both skills. However as far as this research, we could not clearly conclude that SSLS was better than a teacher's oral method. Currently, we are developing Skill Learning Management System (SLMS) that can record students' results of practice and can compare those results to other students. Using SLMS, a teacher will be able to know who is good at a skill or not before lectures and it will help a teacher to make a priority of whom he/she teaches to.

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