Geometry Learning Tool for Elementary School using Augmented Reality

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Abstract— Augmented Reality is a technology that overlay the virtual objects into the real world. With the capabilities of Augmented Reality in combining virtual and real world object in real time, it can be utilized to help education process for elementary students. There are numerous frameworks to build Augmented Reality based application. OpenCv is a computer library vision that implements various tools for processing images. The purpose of this research is to test whether OpenCv is capable to build Augmented Reality based application or not. With the capabilities of OpenCv in detecting color and registering the virtual object in real time, it supports the Augmented Reality based application creation. The research is done by creating the Augmented Reality Geometry Learning Tool prototype system based on OpenCv to help elementary students learning using protractor. The prototype system then is implemented in the elementary school to obtain the response from the students. The response from the student is satisfying and it proves OpenCv is capable to build Augmented Reality based application.

***Index Terms*—Augmented Reality, Mathematics, Geometry Application, OpenCV**

I. INTRODUCTION

Elementary school is the basic education for every person. In this stage, children receive the entire basic lesson that they need to continue their education to higher level. So elementary school needs to deliver good lesson to their student, so every student can have deep understanding in every lesson that they learned and not only know or remember.

There are many different ways to gain a deep understanding from the students, and one of the effective ways is by using visual study and also direct practice. After the student sees a live example, they can also practice the same thing and by doing this repeatedly, they will fully understand the lesson.

Augmented reality is the new technology that takes the visual based study into the next level. Augmented reality is the technology that augments virtual objects to the real world. This kind of technology can be used in education world to help student in gaining the deep understanding of the lesson and also to make them exciting in study. Augmented reality could be implemented for geometry lesson for elementary school student to help them understand the calculation of the geometry object.

There are numerous frameworks to build augmented reality based application. OpenCv is one of the computer vision library powered by Intel. OpenCv is used to process images and with the capabilities of OpenCv in processing image, it can be utilized to build augmented reality based application.

The primary goal of this research is to make an augmented reality based learning toolkit to measure 180 degree angle based on OpenCv as library. The second purpose is to measure whether OpenCv is capable as library for building augmented reality application in helping student in reading the angle by using protractor correctly or not. The dynamic changes of the lines position will make the learning process faster, because student or teacher doesn't need to redraw the lines every time they changes the angle [1].

By using augmented reality, the digital lines will be augmented in the real world and the teachers or students only need to move the marker to change the angle and it will make the learning process of the student in using protractor faster.

II. RELATED WORK

According to Giraldi [2] Augmented reality is live, combining real and virtual objects in a real environment, and runs interactively, in real time and can have a connection with each other. A user can interact with the object and observe the object in more details. Augmented reality can be utilized for education and lots of learning tools nowadays based on augmented reality. Augmented reality considered as the good way of teaching for small children because augmented reality use augmented live object as the tool for learning. [3]

Reference [4] learned that augmented reality provides rich contextual learning for individuals learning a skill. It also has it own appeal for the student where they can learn an own learning. And it also provides opportunities for more authentic learning and appeals to multiple learning styles.

There are some education applications that use augmented reality. Reference [5] discussed an application that utilizes augmented reality as the tools for kids to learn how to read and also help children in learning vocabulary. Another application utilizes augmented reality for learning geometry, but this application only shows the standard geometric object. This application can become the base of this project.

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There are several augmented reality frameworks that provide libraries for creating augmented reality applications. In this project, OpenCV is used to create the application. Even though OpenCV is not a pure augmented reality framework, it can be modified to augment the 2D objects into the real world, which is needed in this project [6].

III. RESEARCH METHODOLOGY

The proposed system is created to prove that OpenCv is capable as a library to build Augmented Reality application. There are three aspects that must be considered in designing Augmented Reality system:

1. Combination of real and virtual works
2. Interactivity in the real time
3. Registration in 2D or 3D object

To create the Augmented Reality based application, the application must meet those three aspects. The capability of OpenCv to meet the requirement will be tested through the Augmented Reality Geometry Learning Toolkit.

Another purpose of Augmented Reality Geometry Learning Toolkit is to help elementary school student to learn geometry lesson. This prototype system is focusing to help student learn using protractor to measure angle. The prototype system will be later implemented in the school to get the response from the student.

The response from the student can be used to find out whether the prototype system is helping them learning mathematic especially in learning using protractor to measure angle or not.

The prototype of Augmented Reality Geometry Learning Toolkit consists of two parts:

1. The device prototype
2. The augmented reality geometry learning toolkit application

A. The Prototype Device

The purposes of creating this device are:

1. To be able reflect the projection from projector to the table.
2. Increase the flexibility of the augmented reality geometry learning toolkit.

The picture of prototype device is shown in the Fig. 1.

Figure 1. The Prototype Device

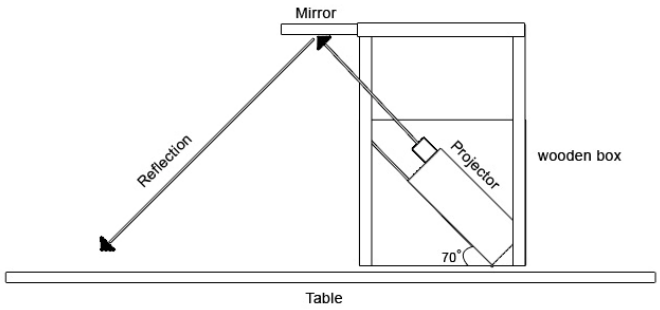


Figure 2. The Prototype Device Schema

The prototype device is made from the wood. The projector to display the augmented reality projection is placed inside the box. And then the mirror to reflect the projection of the projector is placed on top of the box. The projector then will be connected to the computer that runs the application. The prototype device works is described in the Fig. 2.

The projector is placed inside the wooden box with the slope of 70 degree. According to author experiment, the angle could be between 70 until 80 degree. The mirror is put on top of the projector and the mirror can be shifted forward and backward. This will make the adjustment of the reflection of projector to the table can be well positioned.

The projector that connected to the computer will run the geometry learning toolkit application. The application then will show the intersect line through the projector and with the projector inside the device, the lines projection will be shown on top of the table, so the student will be able to use their protractor to measure the angle directly on the table.

B. The Prototype Application

The purpose of augmented reality learning toolkit application is to help elementary student learning using protractor to measure angle. Hopefully with this application student will be able to learn faster, increase student capability of self-learning and also attract student to learn mathematic.

There are four cards that will be used as a marker, as illustrated in Fig 3. The red card (B) is used as the pivot point, the green and blue card will act as a target point and the lime card will be used to show how big the angle. Pivot point should not move because it will become the center point of the coordinate system.

The blue (A) and green markers (C) are used as target point. The target point marker is the marker that later will be moved to create the certain angle that want to be measured by using protractor.

The lime color marker (D) is used to show how big is the angle. Without showing the lime card color, the angle will not be shown, the students have to measure first with the protractor how big s the angle, and after they have measured the angle, they can check whether their answer is correct or wrong by showing the lime color marker.

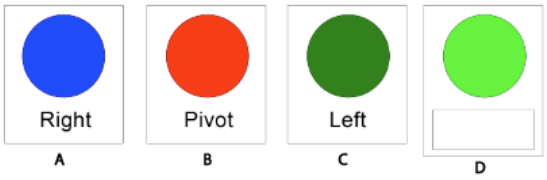


Figure 3 The Colored Markers

There are some steps for student to use the device:

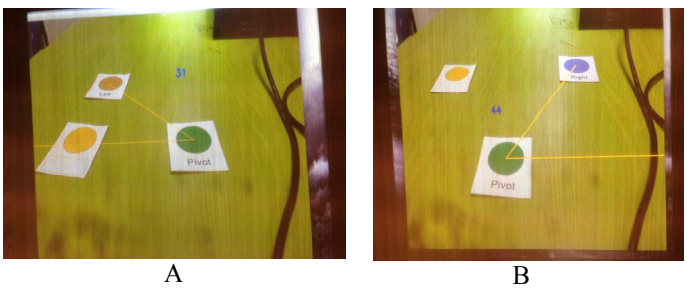
1. Students have to show the red marker (Pivot) first to the web cam. Without showing the red marker, the intersect lines will not be drawn.
2. After the red marker is detected by the web cam, the students can show between the blue(right) or green(left) marker to the web cam. If blue marker is shown, the intersect line will appear from the positive x coordinate. And if the green marker is shown, the intersect line will appear from the negative x coordinate. The students cannot show both of them at the same time.
3. After the intersect line is shown, now student can measure the angle between the intersect line with the protractor.
4. To check whether their answer is correct or wrong, they can show the lime marker. If the lime marker is shown, the marker will trigger the function to show how big is the angle on the screen.

The AR Geometry Learning Toolkit application is built based on OpenCv. According to the definition from the OpenCv reference manual, OpenCv is "a computer vision library that implements various tools for processing image" (1). The purpose of using OpenCv as a library to develop the application is because of the OpenCv capability to detect marker based on color differentiation and also for flexibility in drawing 2D object.

IV. Result and Analysis

A. The Prototype System Application Result

The Augmented Reality Geometry Learning Toolkit application is built using Python language and run on Mac OSx with Intel processor. The application result is described in the Fig. 4.



A B

Figure 4. The Prototype System Application Result

Figure 4 illutrates the application picture of the AR Geometry Learning Toolkit. The figure 4A shows the left angle measurement and the figure 4B shows the right angle measurement. When the student shows the green card, it will trigger the function to draw the intersect lines from the left coordinate and if the student shows the blue card, it will trigger the function to draw the intersect lines from the right coordinate. The lime card is used to display the angle.

B. Student's Response

The response from the students is satisfying. The test of this prototype is done in the 4th grade student in one class. The result is obtained from the questionnaire that is spread out among the student before and after using the prototype device.

Figure 5 shows that there is an increment in the learning process from student in learning using protractor. Before the students use the device for learning process, 17 % of them don't interest in mathematic lesson (see Fig. 5A) and 38% of the students having trouble in geometry lesson especially in learning using protractor (see Fig. 5B).

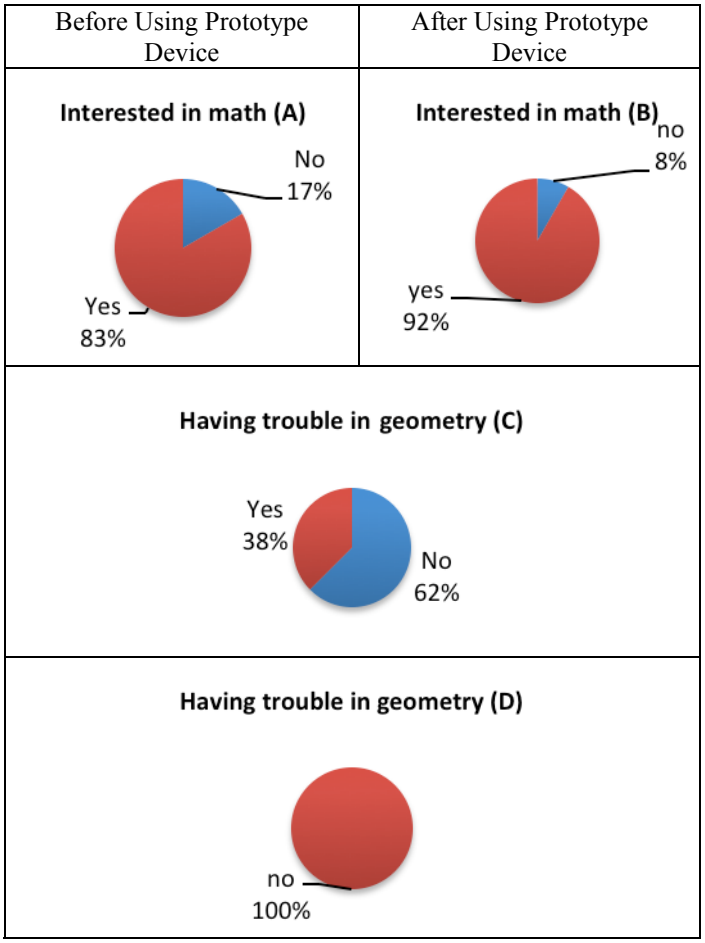


Figure 5. The Student's Response

Figure 5C shows that the students who interest in mathematic are increasing 9%. Figure 5D also shows that 100% of students feel they are helped in learning using protractor. These two factors are caused because the students are really interested with the Augmented Reality application. With the prototype Augmented Reality application, they can interact with the virtual object in real time.

V. CONCLUSION

The conclusion of this research is OpenCv is capable as the library to build Augmented Reality application. OpenCV meets the three aspects of Augmented Reality, there are:

[1] Combination of real and virtual work.

[2] Interactivity in real time

[3] Registration in 2D/3D

The three aspects are fulfilled by OpenCv through the Augmented Reality Geometry Learning Toolkit Prototype. The purpose of the prototype system is to help elementary student learn using protractor. By using the prototype system, students will be able to interact directly with the virtual object which is the intersect lines and they can change the angle of the intersect line in real time.

The student's response is really satisfying. They find the prototype system helping them in learning mathematic especially in using protractor. The prototype device also increases the student's interest in learning mathematic. According to the student's response, 92% of them find the prototype system makes the learning process faster than using conventional method.

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