Application of Augmented Reality Technology in the Study of Electrical Engineering

N.S. Rigenkov, V.N. Tulsky, S.V. Borisova
National Research University "Moscow Power Engineering Institute"
Moscow, Russia

Abstract — **The article deals with the technology of augmented reality in relation to the process of teaching students. The application of this approach in the development of manuals and methodical materials is shown on the example of studying of work of the transformer. Developed mobile application for smartphone with Android operating system that visualizes the operation of the transformer with the help of augmented reality. Physical processes are shown with the help of animation and 3D models.**

Keywords* — *augmented reality, transformer, electrical engineering, mobile application, 3D models

I. Introduction

Augmented reality is a technology by which real objects acquire new qualities. [1]. Technologies of augmented reality are used in various spheres of our life, for example, in medicine, military equipment, computer games, printing, aviation and automotive industries. So when using a smartphone and hovering it on the building the cost of rented housing can be displayed on the screen. There are applications that allow you to measure the size of objects. We know a variety of applications of augmented reality in the design case, etc.

Augmented reality is a promising trend in information technology, and it has already been implemented in modern smartphones. The technology of augmented reality is constantly being improved, adding more and more possibilities for a plausible representation of virtual objects.

At present, the application of Augmented Reality technology for the study of devices and phenomena is a new approach in teaching. The use of augmented reality in the learning process increases the level of perception and memorization of the material. In the long term, augmented reality can become one of the most effective ways of quickly and qualitatively training of professional staff.

The presented work is the result of cooperation between the Department of Computers, Systems and Networks and the Department of Electric Power Systems of the National Research University "Moscow Power Engineering Institute". The goal is to create a mobile application using augmented reality to increase the visibility while studying the work of the transformer for students of the direction "Power and Electrical Engineering".

In electrical engineering, there are a large number of objects, whose work can be shown using mobile application with the augmented reality. From a simple circuit containing a current source and resistance demonstrating Ohm's law, to complex devices such as a transformer.

It is especially important to revive schemes in books and manuals on electrical engineering. Student, having studied the text in the textbook, hovering a smartphone or tablet on the circuit in the corresponding paragraph, can observe how the directions and the value of currents and voltages change. Thus, the mobile application complements the textbook and helps the student to better understand the current process, to more fully represent the image of the ongoing process and completely build the model of the current process in his mind.

A typical diagram of the transformer is shown in Fig. 1. This diagram shows only the functional relationships between the components. When you move the smartphone (tablet) to a picture, which is a label for the program, a 3D model of the transformer appears on the device screen (Fig. 2).

Using the on-screen buttons, you can change the circuit parameters and observe on the model the changes taking place in the circuit.

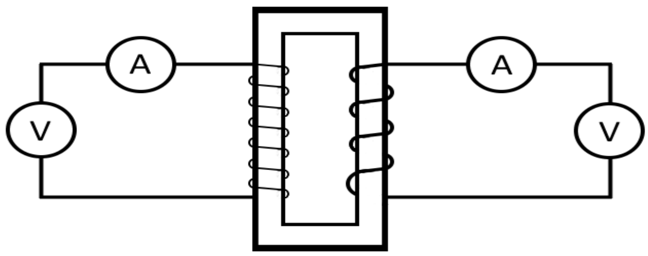

Fig. 1. A typical diagram of the transformer.

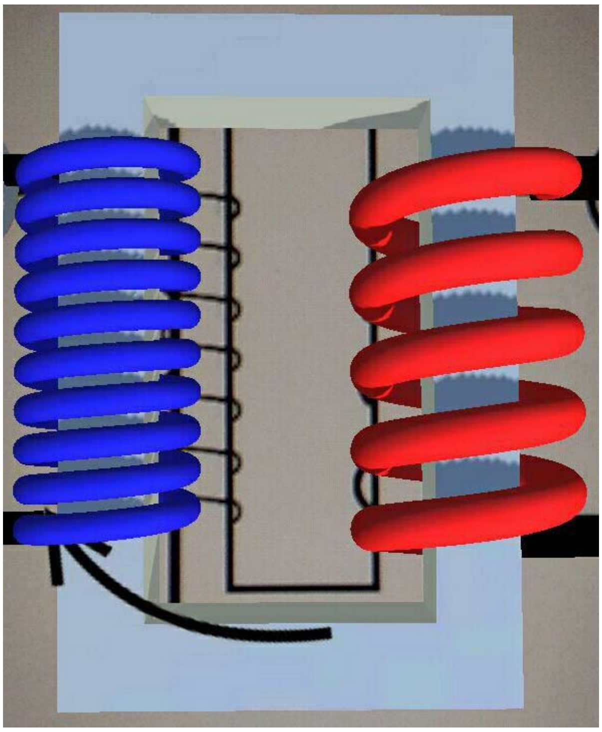

Fig. 2. 3D модель трансформатора

II. Choice of software tools for application development

At the first stage of the work, it was necessary to choose the operating system and software for augmented reality.

The market for mobile operating systems is dominated by two systems: Android and iOS. For these operating systems, there is a toolkit that allows you to develop applications with augmented reality. According to Statcounter statistics in Russia, the share of smartphone owners with the Android operating system is 70%. As a result, the Android operating system was chosen. In the future, it is planned to convert this application to iOS.

Currently, the choice of tools for augmented reality is large (ARCore, ARToolKit, EasyAR, Kudan, Maxst, Vuforia, Xzimg). Each of them meets its purpose. Let's dwell on two technologies: Vuforia and ARCore.

Vuforia (SD AR Vuforia) serves as a “digital eye” within an application that detects tags. Various images can serve as a label, for example, geometric shapes, QR codes, etc. Objects of augmented reality should be placed in such a way that their perception is realistic for the user [2].

ARCore can track traffic, recognize the environment and evaluate lighting, but this platform is suitable for a limited number of smartphones.

To develop the application, the Vuforia SDK was chosen, because its functionality is sufficient to implement the application. In addition, Vuforia is supported by a large number of mobile devices.

When choosing a development environment, Unity and Unreal Engine were compared.

Unity is a tool for developing two- and three-dimensional applications and games that runs under the operating systems Windows, Linux and OS X. Unity-based applications run under the operating systems Windows, OS X, Windows Phone, Android, Apple iOS, Linux [3]. The Unity editor has a simple Drag & Drop interface that is easy to configure. It consists of various windows, so you can debug the application directly in the editor. The engine supports two scripting languages: C #, JavaScript [4].

Unreal Engine - game engine, developed and supported by Epic Games. Written in C ++, the engine allows you to create games for most operating systems and platforms.

The determining factor in choosing the development environment was what development tools each of the considered environments supports.

Unity supports Vuforia SDK and ARcore, and Unreal Engine supports ARkit and ARcore. Due to the fact that Vuforia is used we chose Unity [5].

Blender was used for building a 3D model of the transformer. Blender is a powerful and multifunctional program for creating three-dimensional computer graphics, which is distributed free of charge [6].

A characteristic feature of the Blender package is its small size compared to other popular 3D modeling packages. The main functions of the package include support for a variety of geometric primitives, universal built-in rendering engines, animation tools, basic functions of nonlinear editing and video combining, and others.

To create a 3D model of the winding of the transformer (inductor), the circle primitive is used. Further with the help of the built in modifier Screw, the circle round a point scrolls - the torus turns out. After that, the screw turns the torus into one segment of the coil (Fig. 3).

To create a full coil, use the Iterations field. This field repeats the segment and puts it immediately after the previous one. The final result is shown in Fig. 4. A 3D model of the transformer core is shown in Fig. 5.

The developed application was tested on a smartphone with the Android operating system. Testing showed stable performance of the model, quick response to button pressing. The greatest impact on the quality of recognition and traceability is provided by the quality of the camera in the smartphone and the level of ambient lighting. The application is adapted to the different resolutions of smartphone screens.

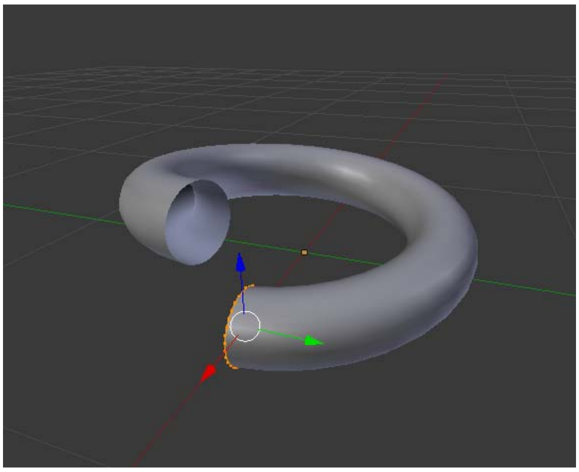

Fig. 3. One srgment of the coil

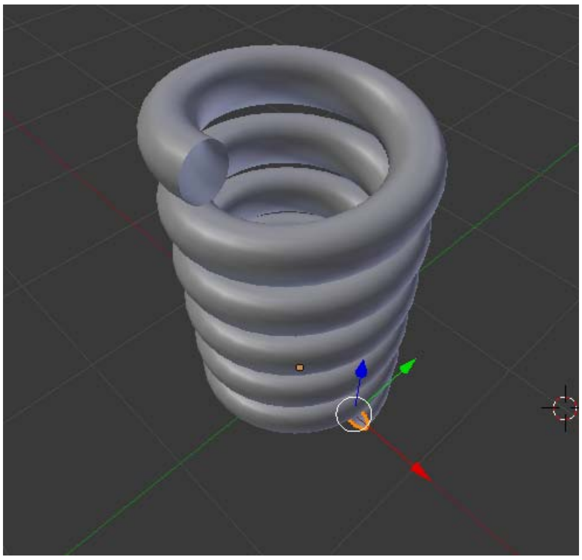

Fig. 4. 3D model of the transformer winding

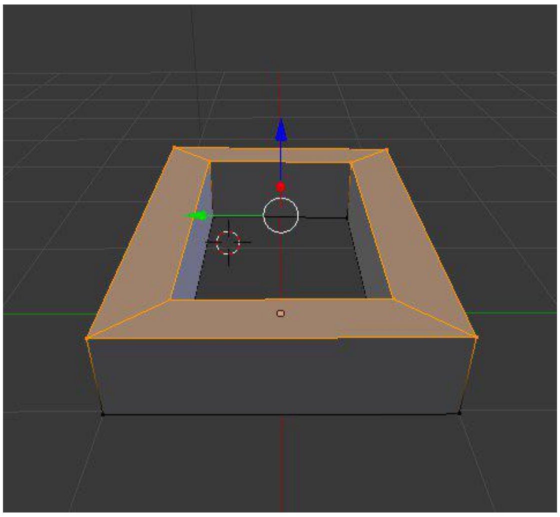

Fig. 5. 3D model of the transformer core.

III. DESCRIPTION OF THE WORT OF THE APPLICATION

It is known that a transformer is a static electromagnetic device having two or more inductively coupled windings and intended to convert an alternating current by electromagnetic induction [7].

The transformation depends on the ratio of the number of turns in the primary and secondary windings. For example, if the number of turns in the secondary winding is greater, then the voltage induced in it will be higher, but the current will be less by the same amount. Therefore, the power in the primary winding is equal to the power in the secondary winding. As a result, transmission costs are reduced [8].

The electromagnetic circuit of a single-phase transformer consists of two windings located on a closed magnetic circuit, which is made of a ferromagnetic material (Fig. 6).

When connected to the mains in the primary winding, an alternating current arises that creates an alternating magnetic flux that closes along the magnetic circuit. The flux induces variable EMF in both windings.

When you first point to the label (transformer diagram, Fig. 1), a 3D model of the transformer appears on the mobile device screen.

In the center is a quadrangular core. The core is wound two windings, one of which is dense and of a thin wire, and the other is loose and of a wire of a larger cross section. For greater clarity, the primary winding is highlighted in blue, and the secondary winding is red (Fig. 2).

Above the core is an arrow showing at each individual time the directions of the magnetic field lines, which depend on the direction of the current in the primary winding. Devices that show the direction of the current and voltage in the circuit are connected to the winding.

On the front side of the device the letter A or V, identifying the device, are at the top. In the lower part, the direction of the current is shown with the help of an elongated red rectangle. If it is on the right side, then the current flows to the right. A current generator is connected to the primary winding on the left side. The generator is represented by a button in the form of a cube with an arrow (Fig. 6).

The application allows you to consider in detail the individual parts of the scheme. If an alternating current flows in the circuit, a voltage with a phase shift is induced in the other side of the lying isolated circuit.

In the initial state, the current in the primary winding flows from left to right, and in the secondary from right to left. The arrow representing the directions of the lines of force of the magnetic field moves in this clockwise direction.

By pressing the button, conditionally simulating the current generator, the current direction in the primary winding reverses, while the arrow in the generator image also changes its direction. The new direction of the current in the secondary winding is opposite to the direction in the primary winding.

Using the animation, the screen displays the changes in the ammeter and voltmeter readings (the red rectangle moves from one part to the other). And the arrow that depicts the direction of the magnetic field lines in the windings, starts moving counter-clockwise (Fig. 6).

The readings of devices with the direction of magnetic lines counter-clockwise are shown in Fig. 7.

The logic of the program is that when a label is defined, the label recognition event occurs. The result of the processing is the display of the 3D model in the diagram.

For the generator button, a script that handles the event "pushing a button" is developed. In the handler, it is checked in which direction the arrow, which represents the flux of magnetic field lines, is moving. For each direction, it runs its own algorithm that triggers the corresponding animation. In Fig. 8 shows the code fragment of the algorithm that starts the corresponding animation.

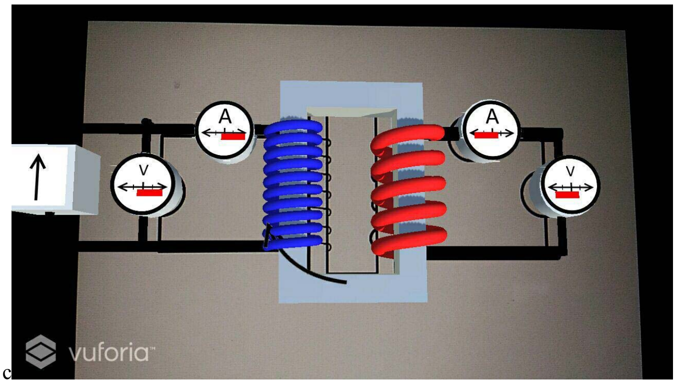

Fig. 6. The readings of devices with the direction of the magnetic lines clockwise

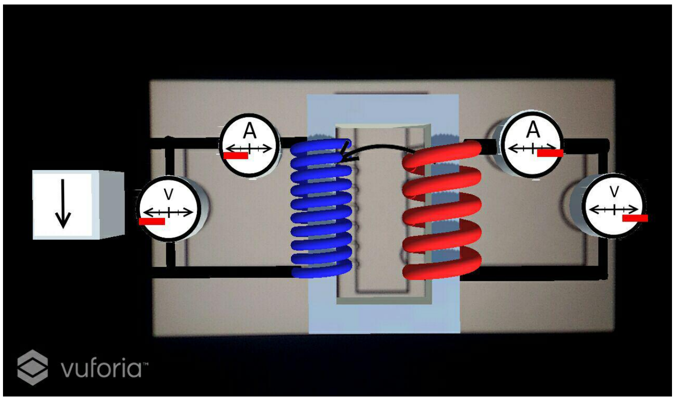

Fig. 7. Instrument readings for the direction of magnetic lines counter-clockwise

```
if (spriteRight.activeSelf) {

    arrowTransform.Rotate(0,180,0,Space.World);

    spriteRight.SetActive(false);
    spriteLeft.SetActive(true);

    leftIminObj.SetActive(false);
    leftUminObj.SetActive(false);
    rightImaxObj.SetActive(false);
    rightUmaxObj.SetActive(false);

    leftImaxObj.SetActive(true);
    leftUmaxObj.SetActive(true);
    rightIminObj.SetActive(true);
    rightUminObj.SetActive(true);

    moveLeftU = leftUmaxObj.GetComponent<Animation>();
    moveLeftI = leftImaxObj.GetComponent<Animation>();
    moveRightI = rightIminObj.GetComponent<Animation>();
    moveRightU = rightUminObj.GetComponent<Animation>();

    moveRightU.Play();
    moveRightI.Play();
    moveLeftU.Play();
    moveLeftI.Play();


}
else {
```

Fig. 8. Fragment of the code of the algorithm that starts the animation

IV. Conclusion

The developed mobile application using modern technology of augmented reality visually and simply demonstrates the work of the transformer. The testing of the application on a smartphone with Android OS showed a clear operation, rapid detection of the label (circuit) and the appearance of the transformer model on the screen of the mobile device. The main influence on the quality of the recognition of the mark is provided by the lighting and the characteristics of the camera.

The application can be used to study the course in electrical engineering. Visualization of the studied circuits (objects) leads to a more efficient delivery of material and promotes a better understanding operating principle of the devices. In the future, it is planned to develop the visualization of all drawings of a literary source at the rate of electrical engineering.

References

[1] D.Yu. Kalugin, Development of the elective course “Supplemented Reality”, Novosibirsk, 2014, p. 3

[2] Vuforia: the leader in the augmented reality market announced a new version of the platform [Electronic resource]. — Access mode: URL https://vrgeek.ru/vuforia/

[3] Unity 3D. [Electronic resource]. — Access mode: URL https://unity3d.com/en/

[4] Hawking J., “Unity in Action. Multiplatform development on C # ”, St. Petersburg, Peter, 2017, p. 20

[5] Eight best augmented reality SDK for AR development for iOS and Android in 2017. [Electronic resource]. — Access mode: URL https://thinkmobiles.com/blog/best-ar-sdk-review/

[6] Blender. [Electronic resource]. - Access mode: https://www.blender.org//

[7] Transformers. [Electronic resource]. — Access mode: URL: http://model.exponenta.ru/electro/0070.htm

[8] Halas I., “Principicon” Popular electrical engineering, Budapest, Terra, 1958, pp. 44-45