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Augmented Reality Application

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EXECUTIVE SUMMARY

The developed augmented reality application allows experiments on range and penetrating power of alpha, beta and gamma radiation. The aim is to provide further opportunities for experimentation in school. In contrast to hands-on experiments the application offers visualization features that aim to effectively convey the nature of ionizing radiation and its propagation. The visualization can enhance students' understanding of radiation.

Experiments can be set up with the help of image markers. The image markers are placed on a table and scanned with a mobile device. Each image marker represents a detector, a radiation source, or a shielding material. On the screen of the mobile device, further settings can be made after the experiment setup, such as the selection of the emitter or the election of the visualization mode.

The application is available for:

Android <https://seafle.projekt.uni-hannover.de/d/dd033aaaf5df4ec18362/> and,

iOS <https://apps.apple.com/us/app/arradiation/id1619335572> devices.

The application can be used flexibly in different ways in the classroom and has already been tested by 100 students. The feedback has been implemented in the form of improvements.

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1 INTRODUCTION

The main objective of the augmented reality application is the ease of use of experiments with ionizing radiation in educational institutions. Consequently, significant emphasis was placed on ensuring a user-friendly interface and providing easy to understand experimental setups. The aim is not to replace hands-on experiments, but to provide further opportunities for experimentation. For example, the application offers visualization features that aim to effectively convey the nature of ionizing radiation and its propagation, to enhance students' understanding of radiation. In addition, the augmented reality environment offers a welcome variation from the traditional classroom environment.

2 FUNCTION OF THE AUGMENTED REALITY APPLICATION

To enable the experiments on the range and penetrating power of ionizing radiation, three laboratory devices had to be programmed that can be moved using an image marker. The typical setup of these experiments consists of a radiation source, a shield and a counting tube. The setup is achieved by laying down and scanning the image markers individually and from a short distance with a mobile device (See Figure 1).

To develop the application for Android and iOS Unity Engine v2020.3 and the AR Foundation was used. ARCore (Android) and ARKit (iOS) are used to track the image markers.



Figure 1 General experimental set up to determine the range of beta radiation in the augmented reality application. In the background one can see the image markers on a table to set up the experiments.

2.1 The detector

A typical detector used in German schools is the GM counting tube. Therefore, this was implemented in the application first. The counting tube can measure either count rate (counts per minute) or the absolute number of counts for a predefined time interval, (e.g., 2 minutes). The measurement stops automatically after the selected time interval. Additionally, a dose rate meter was implemented, which gives the dose rate in micro-Sieverts per hour. The dose rate meter opens up further applications and familiarization with this measuring device and has therefore been integrated. You can switch between the three different types of measurements using a drop-down menu. The different detectors are shown in Figure 2.

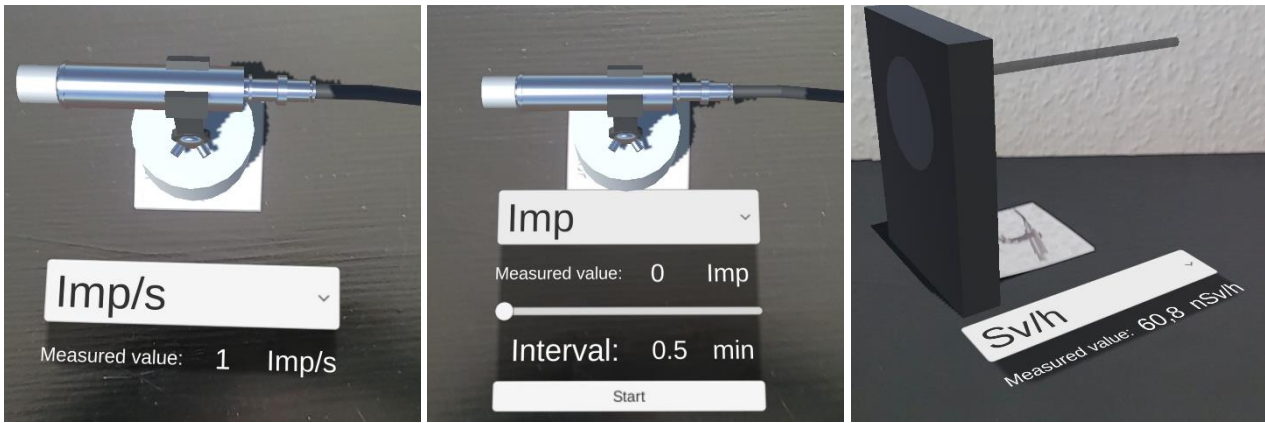


Figure 2 The different options for the detector. On the left is the GM counting tube, which measures counts per second. In the middle is the GM counting tube which detects counts for a predefined time interval. On the right is shown the dose rate meter.

2.2 The radiation sources and shielding materials

In order to carry out the intended experiments alpha, beta and gamma emitters needed to be implemented. To compare different sources by range or count rate, it was decided to include two alpha and two gamma sources. In total five sources were integrated. All sources are typically found in German school. This way, experiments in the application can be compared with real experiments if wished. The five sources can be switched via drop down menu (See Figure 3 on the left). Once a source is selected further information on the emitter is provided (See Figure 3 on the right).

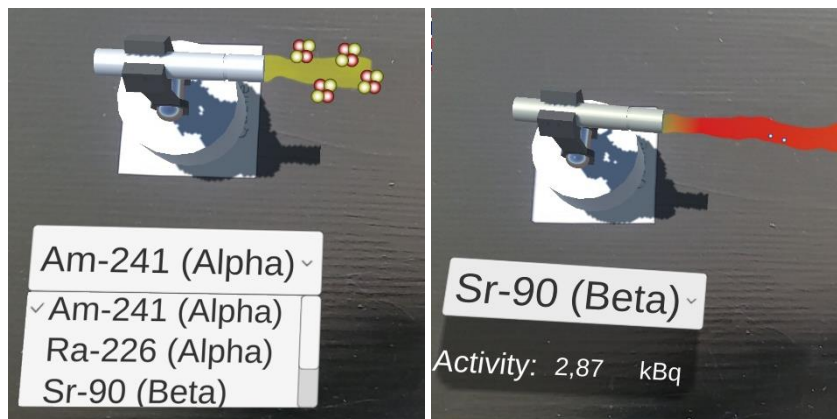


Figure 3 The radiation source drop-down menu with the different ionizing radiations on the left. The menu when a radiation source is selected on the right.

For the shielding, materials were chosen that are typically mentioned for shielding the respective types of radiation. The corresponding coefficients for the shielding of ionizing radiation were determined from available data such as hands-on experiments. The different materials can be selected via drop down menu (See Figure 4 on the left and in the middle). To measure entire series of measurements, the thickness of the respective materials can be changed via sliding bar (See Figure 4 on the right).

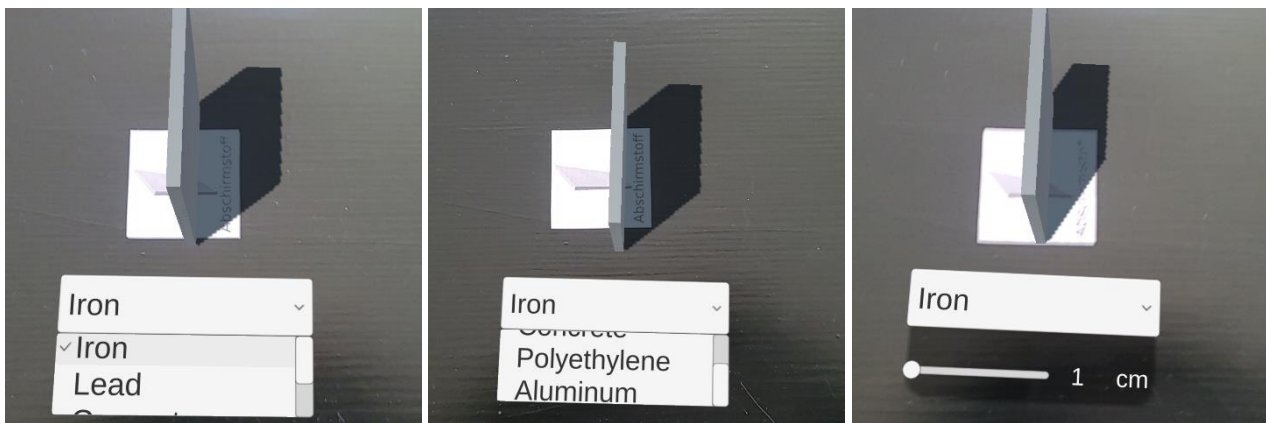


Figure 4 The shielding material drop-down menu with the different materials on the left and in the middle. On the right one can see how to change the thickness via sliding bar.

2.3 The visualization

The user can choose between four visualization modes (See Figure 5). It was decided to reflect both the propagation of radiation and the nature of radiation in the visualization. Thus, it is now possible to choose between flow and particle visualization. In addition, both can be displayed at the same time or no visualization can be shown. The ability to set the visualization independently allows students to find the best visualization for them.

The flow visualization was implemented using Shader Graph in Unity, which requires its own render pipeline. The Universal Render Pipeline (URP) was used for this purpose. For particle visualization, a particle system was used. Here, the particles are shot in one direction with a certain velocity and a certain lifetime.

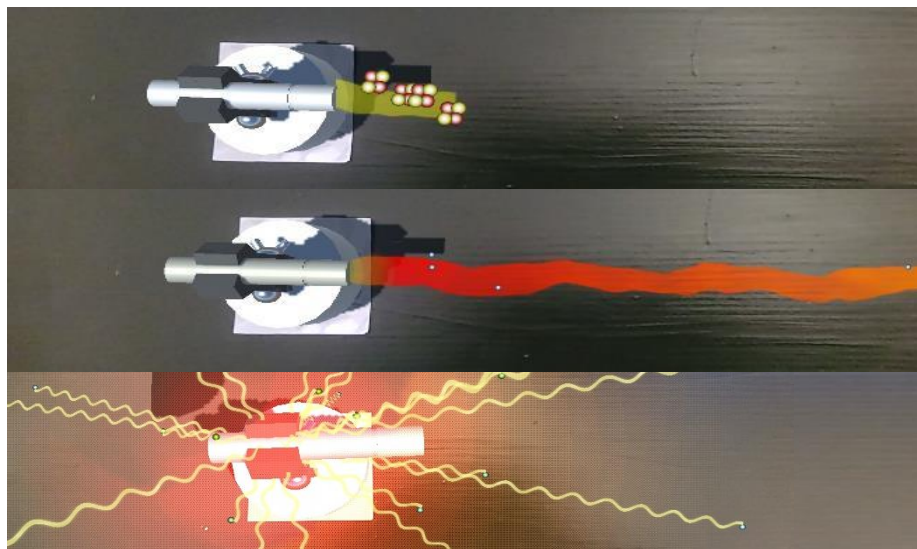


Figure 5 Flow and particle visualization for every ionizing radiation.

2.4 The layout

The layout of the application on the mobile device screen was kept as simple as possible. In the upper corners of the screen were placed more settings options for the functions of the application.

Towards the end of the project different languages were included. These can be selected in the top right hand corner (See Figure 6).

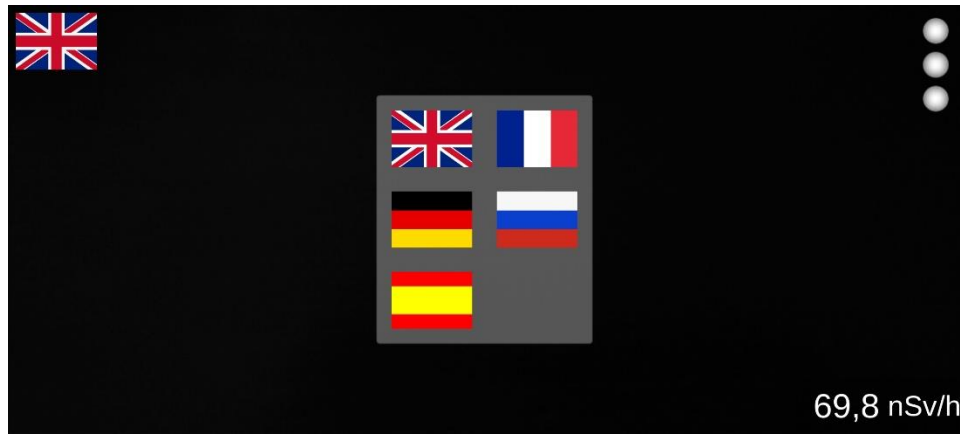


Figure 6 The different languages of the application.

Furthermore, the user can choose between different visualization settings. These can be found by clicking on the three dots in the upper right corner (See Figure 7). Furthermore, the names of the emitters can be turned off. This was integrated to cover further areas of implementation in the classroom (See 3 Areas of implementation). The first tests have shown that the application sometimes crashes or has problems loading, so it was added that the graphics resolution (quality) of the application can be adjusted. This is possible in the same menu as the visualization.

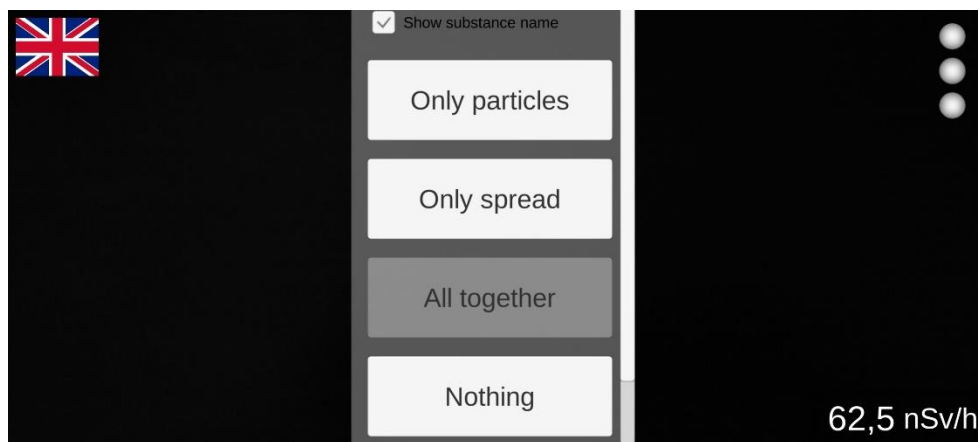


Figure 7 The different visualization settings.

There was a lot of discussion about the display in the lower right corner (See Figure 7). In the end, it was decided that a dose rate display at the position of the mobile device could be interesting. Among other things, this makes it clear that ionizing radiation is also reaching the mobile device. And thereby the necessity of protective measures can be made clear.

3 AREAS OF IMPLEMENTATION

3.1 The experiments

The following experiments can be performed in the application. For measurement of the background, the measurements are started at the detector without having previously scanned the image marker of a source.

The range of alpha radiation in air can be determined. Also, it can be confirmed that any shielding materials present shield alpha radiation by placing the image marker for the shielding material between the source and the detector and scanning it. Similarly, the range of beta and gamma radiation in air can be investigated. A fixed position for the source on the table can be chosen for this purpose. Then the detector is placed. After the measurement, the distance is changed by moving the image markers on the table and rescanning them. The distance can be measured with a ruler on the table (See Figure 8). The penetrating power can also be investigated. In the case of the beta emitter, polyethylene and aluminium of various thicknesses can be used for shielding. Gamma radiation penetration is measured by shielding with lead, iron or concrete.



Figure 8: Example setup for taking a series of measurements to investigate distance,, which beta radiation travels in air. Distance between image markers from source and detector: 7 cm (top left), 13 cm (top right), 18 cm (bottom left), 26 cm (bottom right).

3.2 The implementation in class

There are several ways to use the application in the classroom. The application can be used to discover the characteristics of ionizing radiation. For this purpose, the range and penetrating power of the individual types of ionizing radiation can be worked out one after another through several series of measurements. Another possibility is the repetition of the entire unit on radioactivity or part of it. In the application, the names of the emitters can be switched off. In this way, the characteristics of the existing emitters can be examined and then matched to the corresponding ionizing radiation using the known characteristics. A further possibility is offered for alpha and gamma radiation, where two emitters each are now available whose characteristics can be compared with each other. Another option is to use the application to prepare for more advanced practical experiments, for example, to illustrate the setup or procedure. In addition, the application can be used at any time for illustration, for instance for the distance-squared law.

4 TESTING AND EVALUATION

As part of a bachelor thesis at IRS Hanover, the application was tested by 100 students (age 14 to 17) in German schools. The feedback on the application was mostly positive. Most of the students agreed that the application was easy to use. Regarding the visualization, the majority stated that it helped them in understanding the radiation. From time to time help with handling was needed. Therefore, a short instruction manual for the application was written for easy familiarization with the application. Only 35% answered in the negatively to the question of whether the application could replace real experiments.

Furthermore, the students provided valuable feedback to further improve the application. For example, the radius in which the detector registers radiation was increased. This simplifies the setup and alignment of the measuring devices.

5 CONCLUSIONS

The augmented reality application is fully functional and can be used for various purposes in the classroom. The application was well received by the students surveyed, which means the application can be a positive addition to lessons. Above all, the application can be used in schools that cannot offer real experiments.

With the short instructions, the application's functions can be worked out independently by students and teachers, and the application can be used autonomously in class. Looking back at the COVID-19 pandemic, the application can also be used in home schooling, allowing students to conduct experiments at home.