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Innovative Approaches in Electromedical Education: Designing Low-Cost X-ray Stationary Simulations Using Camera from Concept to Implementation

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ABSTRACT In response to the pressing need for vocational students to acquire the requisite capacity and competence for gainful employment, this project addresses the demand for educational materials in vocational studies, particularly in the electromedical field. Focusing on radiology courses utilizing the X-ray stationery tool as a modality, the project aims to enhance the competency of graduates. The X-ray stationery tool, a medical imaging device utilizing X-rays for patient diagnosis, employs light beams from LEDs, and its system incorporates a camera to record the exposed region. The simulation utilizes the Arduino Uno as the controller, employing low-cost, effective, and readily available components, making it suitable for college-level students. This endeavor seeks to bridge the gap between theoretical knowledge and practical skills, providing students with a comprehensive learning experience in electromedical education.

INDEX TERMS X-ray Stationery, Arduino Uno, simulation, halogen lamp,

I. INTRODUCTION

After the Covid-19 pandemic, an amount of government and private sector entities turned their attention to ensuring the independence of the country's medical equipment. This consequently caused more professional electromedical workers to be placed in various healthcare facilities and equipment-related industries. Wellness. This increase is consistent with data from the Ministry of Health about Indonesia's medical imaging equipment population, which is growing annually in terms of the total number of devices in each hospital [1]. This is, therefore, consistent with the common public's interest in learning about electromedical engineering technology since many graduates work for companies that manufacture medical equipment. Therefore, a medical equipment learning method that all students can comprehend is required to generate competent graduates. In this study, we developed a low-cost simulation tool to develop an instrument prototype or demonstration that can explain the operation of a stationary X-ray tool. It is well known that radiology classes are included in the curriculum for electromedical education. These courses primarily include science using instruments connected to radiation, x-rays, radiography, and medical imaging modalities. The general goals of radiology courses are to teach students about the types of medical imaging diagnostic tools utilized, their operation, installation, maintenance, and repair techniques, as well as broad ideas about radiation-effects-related tool safety. The usage of X-rays is among the greatest scientific and technological achievements. X-rays are electromagnetic radiation with great resolution that can create images of an object's inside structure because of their ability to penetrate matter. In 1895, German scientist Wilhelm Conrad Roentgen made the discovery of these rays. When it comes to health, X-rays are very helpful to medical professionals in diagnosing patients and making recommendations for therapy or additional measures if needed. Our ability to model an X-ray scanner tool and understand its operation significantly advances our ability to develop simulations [2].

In previous research, there is much research about simulation studies. For example, simulation research can find the construction process [3]. A journal article covered the development of X-ray simulations on medical devices using Visual Basic [4]. Nevertheless, there was also discussion about developing simulations for health workers' lecture studies [5]. Research is being done on medical imaging instruments, including identifying risk factors for instruments like angiography, which are utilized in heart surgery [1]. However, in addition to the many medical imaging tool modalities, other tools serve as backup for network- and data-transfer-based radiology facility services, such as PACS [6]. Other than that one of the research about the development and validation of real-time simulation of X-ray with respiratory motion [7]

X-ray imaging, or radiography, is integral to medical diagnostics, involving X-ray machines to create two-dimensional images that capture tissue density variations within the body [8]. These images assist in detecting health issues and supporting medical interventions. The resulting X-ray image is displayed in terms of tissue density, represented by five shades from black to white. X-rays, with wavelengths ranging from 0.01 to 10 nanometers, penetrate the body to produce internal images, with varying tissue absorption levels creating the characteristic black-and-white contrasts. Simulating an X-ray device is crucial for understanding its operational principles and functionalities, providing insights into X-ray interaction with the body and image interpretation. This enhances comprehension of X-ray technology for effective medical diagnosis and treatment planning, deepening our understanding of its role in modern healthcare practices [9].

II. MATERIALS AND METHOD

Several foundational aspects warrant careful consideration in crafting a stationary X-ray simulation device. Firstly, material selection plays a pivotal role, necessitating the choice of components like tungsten filaments and halogen gas to accurately replicate real X-ray machine functionality. Understanding the operational principles of X-ray imaging, such as parameter settings and image processing techniques, is essential for designing a realistic simulation. Moreover, integrating technologies such as sensors and microcontrollers facilitates precise control and user interaction during simulation sessions. Safety considerations, including radiation shielding and fail-safe mechanisms, are paramount to ensure the well-being of users. By addressing these key aspects with meticulous attention to detail, an effective X-ray simulation device can be developed, offering a comprehensive educational tool for understanding X-ray technology and procedures

.A. Experiemental Setup

The study used an X-ray stationery device as the equipment sample to develop the prototype in the experimental setup. The choice of the X-ray stationery device as the sampling equipment was driven by its relevance to the research objectives, aiming to create a functional prototype for simulating X-ray procedures. By utilizing this specific equipment sample, researchers could closely replicate real X-ray machines' operational characteristics and functionalities, ensuring the prototype's accuracy and effectiveness in simulating X-ray imaging processes. This experimental setup allowed for comprehensive testing and validation of the prototype's performance, ultimately contributing to the advancement of X-ray simulation technology for educational and training purposes in radiography. [10]

1). X-ray Stationary

X-ray imaging is the most common and routinely used modality for diagnostic purposes around the globe. There are three different possible behaviors when X-rays penetrate an object. The X-ray photon may penetrate the patient or object without interaction, and this is commonly referred to as the primary X-ray. Alternatively, X-rays may interact with the patient or object, and the energy of the X-rays is totally absorbed, contributing to the absorption dose. Finally, the X-rays may interact with the object and then be scattered from its initial path.

B. ARDUINO UNNO

The Arduino Uno microcontroller has gained widespread usage across various fields. In previous research endeavors, Arduino has been employed for programming tasks in weighing systems as a controller in ultraviolet-C (UVC) [11] devices and also for weighing scales in medical equipment prototypes [12]. This study focuses on exploring the utilization of Arduino Uno as a controller for X-ray simulation. The Arduino Uno, renowned for its versatility and ease of use, presents a viable option for controlling simulated X-ray operations efficiently. By harnessing its capabilities, researchers aim to develop a cost-effective and accessible solution for simulating X-ray procedures. This entails programming the Arduino Uno to manage parameters such as kilovoltage (kV), milliampere (mA), exposure timing, and image capture. This research evaluates the potential of Arduino Uno as a versatile controller for X-ray simulation, paving the way for innovative educational tools and training platforms in radiography.

C. HALOGEN LAMP

A halogen lamp is a light bulb containing a tungsten filament enclosed in a small, transparent bulb filled with halogen gas like iodine or bromine. The halogen gas helps extend the bulb's life by preventing darkening of the bulb's surface. It does this by recycling tungsten vapor that evaporates from the filament back onto the filament, keeping it clean. They're also more energy-efficient, producing more light per watt than traditional incandescent bulbs. Additionally, the halogen cycle allows the lamp to operate at higher temperatures than standard incandescent lamps, thus increasing its efficiency. This characteristic makes halogen lamps particularly suitable for applications where a high-quality, intense light source is required, such as in photography, stage lighting, and automotive headlights. [13]

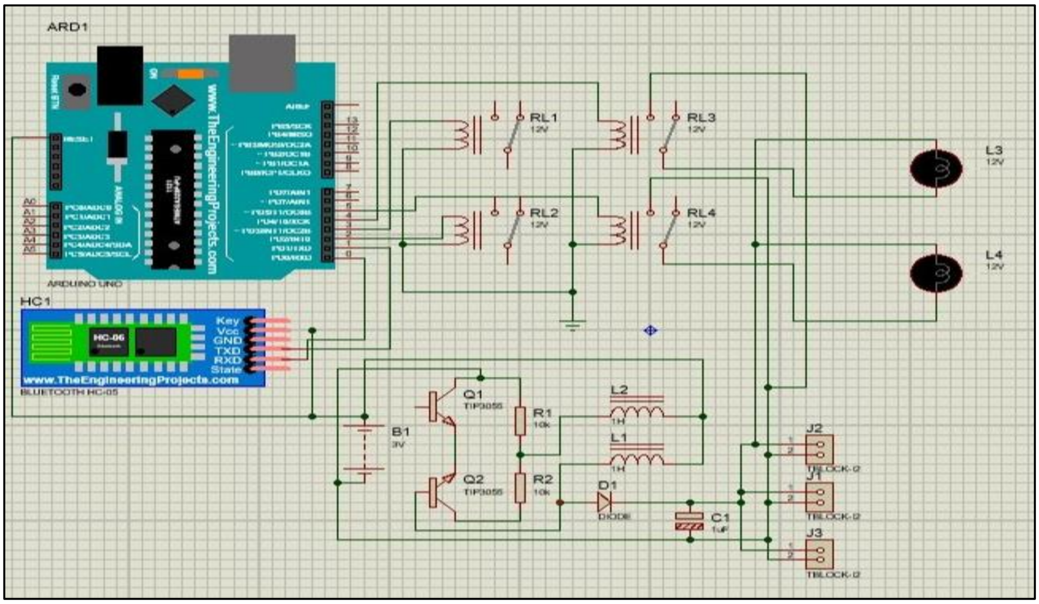

FIGURE 1. Diagram scheme of simulation xray stationary

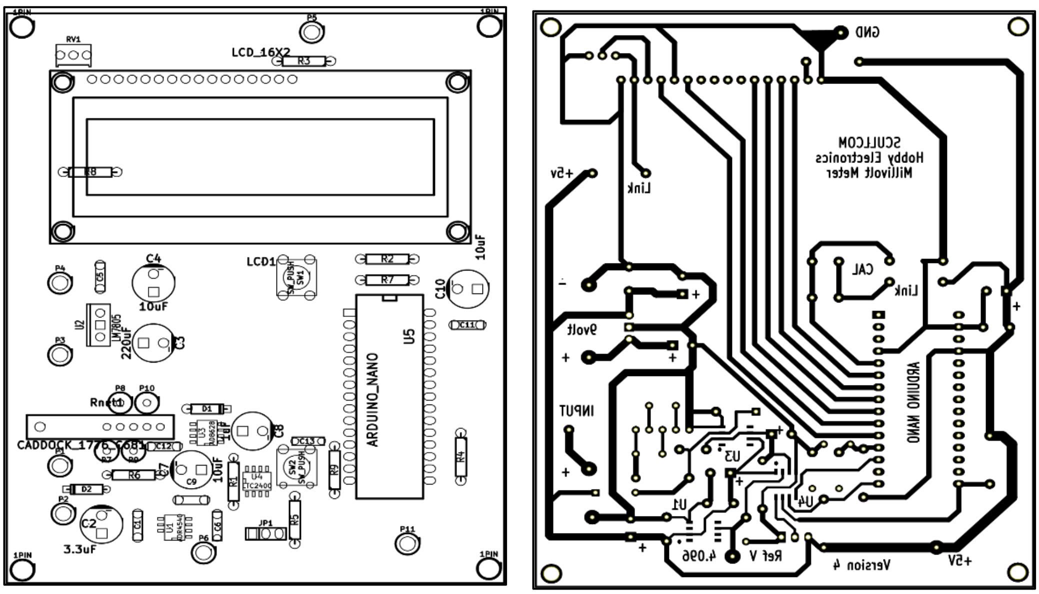

FIGURE 2. Wiring scheme for board simulation

III. EXPERIMENTAL DESIGN

A. SIMULATION PROTOTYPE

The design of the simulation tool used for this simulation adopts a simulation scheme within the Proteus Application, along with the corresponding circuit diagram, that shown in figure 1. Hopefully, these designs can be tried with many curious students about X-ray stationary studies. Proteus is software commonly used to design, simulate, and test digital and analog circuits. Engineers and electronic designers can visualize and analyze circuit performance before its physical implementation by leveraging Proteus. The simulation scheme within the Proteus Application enables users to create virtual representations of the circuits they intend to simulate. This involves selecting components, adjusting parameters, and establishing interconnections between components according to the simulation requirements. In this context, the simulation scheme will be structured based on the specifications of the device or system intended for simulation. Moreover, a circuit diagram is also necessary to define the interconnections between components within the simulated electronic circuit. This circuit diagram illustrates how electronic components, including signal paths and power lines, are interconnected. Using Proteus to design simulation schemes and circuit diagrams, users can test the performance of electronic devices or systems in a safe and controlled simulation environment before physical implementation. This helps to mitigate design errors, expedite product development processes, and optimize overall electronic system performance.

B. ASSYMBLY PROCESS

In the assembly process that shows the wiring scheme in Figure 2, the primary focus is on preparing the circuit board where the wiring has been inserted. This involves several crucial steps to ensure the integrity and functionality of the circuit. Firstly, the board must be carefully inspected to verify its quality and ensure it meets the specifications for the intended application. Any defects or discrepancies found during this inspection phase must be addressed promptly to avoid issues later. Once the board is deemed suitable, the next step involves placing and securing the components onto the board. This process requires precision and attention to detail to ensure each component is properly aligned and soldered onto the board. Special care must be taken to avoid overheating components during soldering, as excessive heat can damage sensitive electronic parts. After all components have been securely attached to the board, the wiring is carefully routed and connected according to the circuit diagram or layout. This step demands meticulousness to ensure each wire is correctly positioned and soldered to the appropriate terminals or pads on the board. Proper insulation and strain relief techniques should also be employed to prevent short circuits or mechanical failures due to stress on the wires. Throughout the assembly process, rigorous quality control measures should be implemented to promptly detect and rectify any potential issues. This may involve visual inspections, electrical testing, and functional testing to verify the integrity and performance of the assembled circuit board. Manufacturers can produce high-quality electronic assemblies that meet the desired specifications and performance requirements by preparing the board and managing the wiring insertion process.

IV. RESULT AND DISCUSSION

The X-ray simulation using a camera has been successfully developed, with the results in the image in Figure 3. The initial operation of this simulation tool involves several steps. First, the device must be connected to the mains electricity supply. Then, the desired kilovoltage (kV) needs to be set. Subsequently, the milliampere (mA) setting must be adjusted. After ensuring all necessary settings are in place, the "ready" button is pressed. Finally, the "expose" button is pressed to activate the X-ray exposure process. Upon pressing this button, the indicator light illuminates, and the image can be captured using the camera. The control panel of the simulation device contains various components to adjust the exposure factors. These include the kV control for setting the voltage, the mA selector for adjusting the current, and the timer selector for determining the duration of exposure. Additionally, there are indicators for kV and mA, which provide information on the magnitude of the settings and assist in determining the focus size. These components collectively enable precise control over the X-ray exposure parameters, ensuring accurate and consistent results during the simulation process.

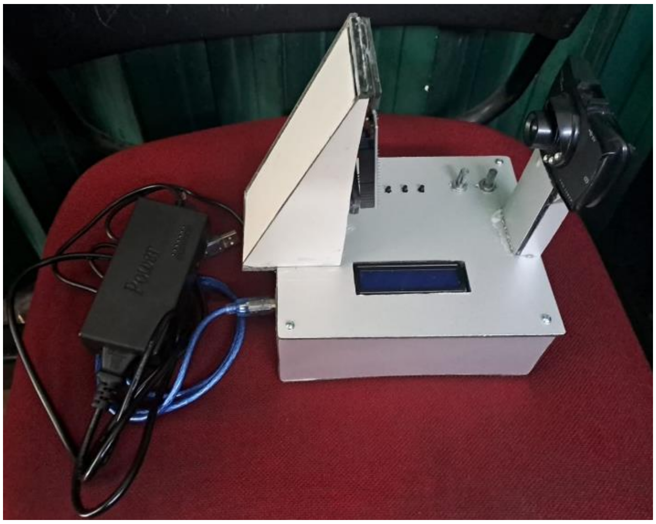

FIGURE 3. Diagram scheme of simulation xray stationary

V. CONCLUSSION

Based on the results obtained from the simulation, the following conclusions can be drawn. This simulation provides a comprehensive understanding of how X-rays work without radiation exposure. By utilizing the simulation, individuals can grasp the fundamental principles behind X-ray imaging techniques, including how X-rays penetrate materials and create images without posing any radiation risk. This hands-on experience fosters a deeper comprehension of X-ray technology and its applications in various fields such as medicine, industry, and security. The simulation demonstrates that cameras and halogen lamps can effectively replicate X-ray imaging processes. By incorporating a camera to capture images and a halogen lamp to emit light, the simulation emulates the essential components of an X-ray system. This approach enables users to visualize the simulated X-ray images without needing specialized X-ray equipment, making it accessible for educational purposes and training exercises. Additionally, readily available equipment enhances the practicality and affordability of conducting X-ray simulations, facilitating widespread learning and experimentation in radiography.

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