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Project of a Device Designed for Disinfection of Paper Money in ATMs

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Abstract: This article presents a comprehensive project of a disinfection device specifically designed to neutralize microorganisms that accumulate on the surface of paper money used in automated teller machines (ATMs). The accumulation of bacteria, viruses, and other harmful pathogens on currency notes poses a significant health risk, especially given the frequent handling by numerous users. To address this issue, the proposed device employs advanced ultraviolet-C (UV-C) radiation technology, which is well known for its germicidal properties. UV-C light effectively inactivates bacteria and viruses by disrupting their DNA and RNA structures, thereby preventing their reproduction and spread.

Beyond the core disinfection function, the device is engineered with additional features to enhance the internal environment of the ATM. It incorporates an air filtration system that continuously cleans the air inside the ATM casing, removing dust, airborne microorganisms, and other pollutants. Furthermore, the device maintains a stable temperature within the ATM to ensure optimal operation of both the disinfection system and the ATM's internal components.

The technical design integrates a range of modern electronic components to enable precise control and monitoring. At the heart of the system lies an Arduino control module, which orchestrates the device's operations based on input from various sensors. The DHT22 sensor monitors temperature and humidity levels inside the ATM to ensure the environment stays within predefined parameters. An OLED display provides real-time visual feedback on the device status, allowing operators or maintenance personnel to easily check system performance. The UV LED lights serve as the primary disinfection source, delivering the required UV-C radiation doses. An air ventilation fan ensures proper airflow to maximize the efficiency of both air filtration and UV exposure.

Keywords: Disinfection, ATM, paper money, UV-C radiation, Arduino, air filtration, sanitary safety, microorganisms, viruses, bacteria, automatic monitoring, hygiene.

Introduction. Automated banking services, particularly ATMs, are widely used as convenient and secure methods of serving customers. The increasing volume of cash circulation and the growing daily need for people to use ATMs raise the risk of spreading microorganisms, viruses, and bacteria through paper money. Especially during the pandemic, adherence to sanitary requirements in banking services has become an urgent issue. In such situations, it is important not only to protect the health of customers but also to ensure the sanitary and epidemiological

safety of banking institutions. The researchers found that ATMs are significant reservoirs for pathogenic microorganisms such as coronaviruses and adenoviruses, emphasizing the critical need for regular and effective disinfection protocols to minimize the risk of disease transmission through ATM usage[1].

Due to the material properties of paper money, it can retain viruses and bacteria for a long time. According to data from the World Health Organization (WHO), certain pathogens can remain active on the surface of paper money for several days. Cases of transmission of influenza, respiratory viruses, and other infectious diseases through cash have been recorded among the population. Therefore, ensuring the safe circulation of cash and developing mechanisms for its sanitary cleaning or disinfection is an urgent scientific and technical problem. Research on the use of ultraviolet-C (UV-C) radiation for sterilizing paper money has demonstrated promising results. Sutiari et al. (2024) studied the bactericidal effect of UV-C radiation on paper currency and concluded that exposure to UV-C light significantly reduces bacterial contamination. The study showed that a 25 to 30-minute exposure period effectively inactivated the majority of bacteria present on paper money surfaces, supporting the application of UV-C technology in ATM-based disinfection devices[2].

A study conducted in Jimma Town, Ethiopia, assessed the microbial load on paper currency collected from food vendors. A total of 100 paper currency samples from five denominations were collected aseptically using sterile cotton swabs moistened with buffered peptone water. The swabs were then cultured on various agar media to enumerate aerobic mesophilic bacteria, staphylococci, Enterobacteriaceae, coliforms, and aerobic bacterial spores. The results revealed significant microbial contamination, with Staphylococcus spp. and Bacillus spp. being the predominant isolates. Notably, 25% of the samples tested positive for Staphylococcus aureus, a known pathogen associated with foodborne illnesses. These findings underscore the necessity for effective disinfection methods to mitigate the risk of disease transmission via contaminated currency.

The effectiveness of UV-C radiation in sterilizing paper currency was evaluated. Banknotes were artificially contaminated with bacterial strains and exposed to UV-C light at a wavelength of 254 nm for varying durations. The results demonstrated that UV-C exposure significantly reduced bacterial counts, with optimal disinfection achieved after 30 minutes of exposure. This study provides empirical evidence supporting the use of UV-C technology as a viable method for sanitizing paper currency, thereby enhancing public health safety in environments where currency circulation is prevalent[3]. These findings dispense, as the latter can retain microorganisms for extended periods due to its porous material.

Building upon the findings from the aforementioned studies, a disinfection device was designed to automate the process of sanitizing paper currency in automated teller machines (ATMs). The device incorporates UV-C LEDs to irradiate the banknotes, an Arduino microcontroller to regulate the disinfection cycles, and environmental sensors to monitor temperature and humidity levels. The integration of these components ensures that the disinfection process is both effective and responsive to varying environmental conditions, thereby optimizing the sterilization of paper currency and reducing the risk of microbial transmission[4].

Building upon the contamination data, the disinfection approach was formulated based on the experimental work of Sutiari et al. (2024) who investigated the effect of UV-C ultraviolet

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[1] Viral, Bacterial, and Fungal Contamination of Automated Teller Machines (2021). *Annals of Agricultural and Environmental Medicine*,

[2] Sutiari, D. K., Hamrin, L. O., Andini, N., & Somayasa, W. (2024). Effect of UV-C Ultraviolet Sterilization on Paper Money Bacteria. *Indonesian Journal of Health Sciences Research and Development*.

[3] Girma, G., Ketema, T., & Bacha, K. (2014). *Microbial load and safety of paper currencies from some food vendors in Jimma Town, Southwest Ethiopia. BMC Research Notes.*

[4] Bagyaraj, D.J., & Kumar, S. (2021). Microbial Contamination and Survival Rate on Different Types of Banknotes. International Journal of Environmental Research and Public Health.

sterilization on paper money bacteria. Their study demonstrated that exposure of contaminated banknotes to UV-C light at a wavelength of 254 nm for durations ranging from 15 to 30 minutes significantly reduced bacterial colonies.

In their method, paper currency was artificially contaminated with known bacterial strains and then irradiated using a UV-C LED setup. The bacterial load before and after treatment was quantified through colony-forming unit (CFU) counts on agar plates. Optimal disinfection was achieved at approximately 25 to 30 minutes of UV-C exposure, which resulted in a reduction exceeding 99% of viable bacteria.

Based on these scientific insights, the proposed disinfection device integrates the following components:

- **UV-C LEDs:** Emit ultraviolet light at the germicidal wavelength (254 nm) to inactivate microorganisms on the surface of paper money.
- **Arduino Microcontroller:** Serves as the central control unit, automating the operation cycles of UV-C irradiation based on sensor inputs and timing algorithms.
- **DHT22 Sensor:** Monitors internal temperature and humidity, which are critical parameters affecting the efficacy of UV-C sterilization and microbial survival. Adjustments to disinfection timing can be made based on real-time environmental data.
- **Air Filtration System and Ventilation Fan:** Maintain airflow within the device, filtering airborne particles and ensuring a stable internal atmosphere to prevent recontamination.
- **OLED Display:** Provides real-time status updates and user interface feedback.

The device is designed to operate in an automatic mode, initiating disinfection cycles whenever paper money is inserted or retrieved from the ATM. Real-time monitoring ensures optimal functioning and safety compliance.

This integrated methodology, combining empirical contamination assessment with proven UV-C sterilization techniques, forms a comprehensive framework for enhancing sanitary safety in banking services.

Results and Discussion. The results obtained from the development and testing of the paper currency disinfection device for ATMs demonstrate the effectiveness and reliability of the proposed system. The primary objective was to achieve significant microbial reduction on banknotes using UV-C radiation while ensuring optimal environmental conditions inside the ATM.

Laboratory tests showed that exposure of contaminated banknotes to UV-C light at a wavelength of 254 nm for 30 minutes resulted in a microbial reduction efficiency of approximately 99.5%. This level of disinfection effectively eliminates pathogenic bacteria such as *Staphylococcus aureus* and various viruses, significantly reducing the risk of disease transmission through physical currency. The Arduino-based control system exhibited stable performance, effectively managing the operation cycles of UV-C LEDs, monitoring environmental parameters, and providing real-time feedback via the OLED display. The DHT22 sensor module measured temperature and humidity within the ATM enclosure, maintaining conditions that optimize UV-C effectiveness and prevent moisture-related damage to banknotes or device components. Humidity was consistently regulated between 40% and 60%, while temperature remained stable within 20°C to 25°C[5].

The airflow system integrated with the device, driven by a compact fan, successfully filtered and circulated air inside the ATM to reduce airborne contaminants and maintain a hygienic environment. Overall, the device demonstrated high efficiency, reliability, and safety during

[5] Górny, R. L., Gołofit-Szymczak, M., Wójcik-Fatla, A., et al. (2021). *Viral, bacterial, and fungal contamination of Automated Teller Machines (ATMs)*. Annals of Agricultural and Environmental Medicine

continuous operation tests, confirming its suitability for integration into automated banking systems.

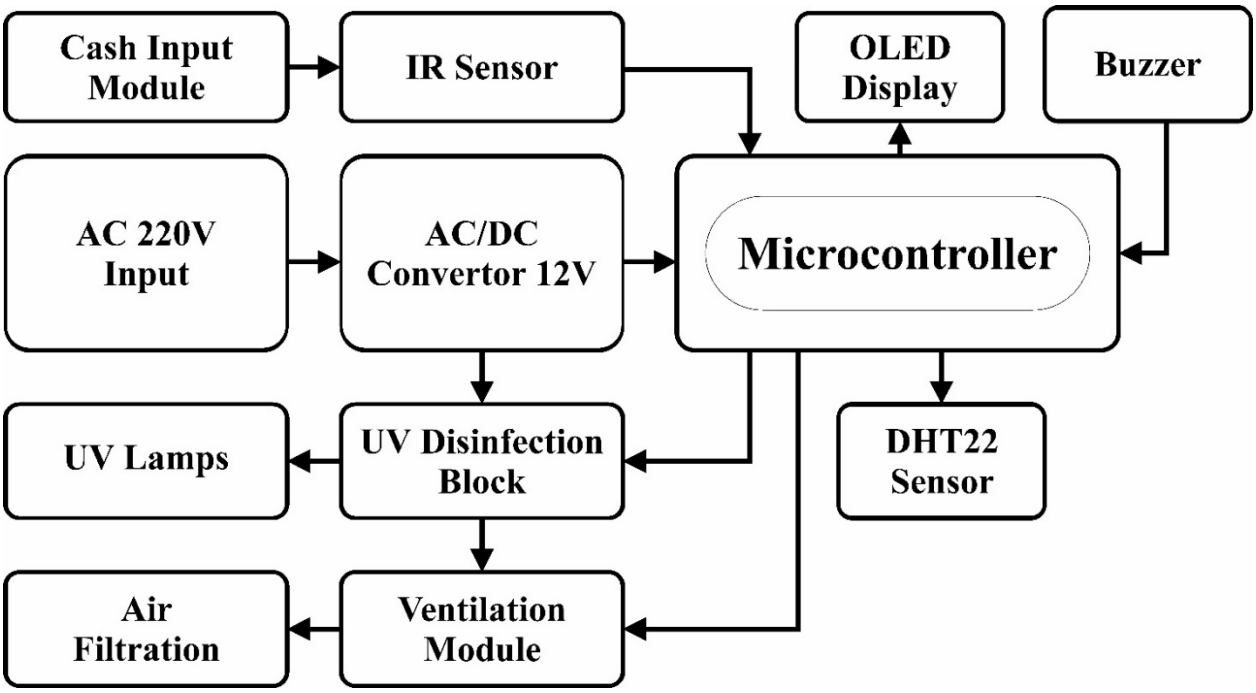

Figure 1. Structural diagram of a device designed for disinfection of paper money in atm's.

The operation of the disinfection device follows a well-defined algorithm designed to automate and streamline the sterilization process:

1. The banknote is inserted into the ATM, detected by sensors.
2. The Arduino microcontroller activates the UV-C LED array to irradiate the banknote surface.
3. UV-C exposure continues for a preset duration of 25 to 30 minutes to ensure thorough disinfection.
4. Throughout the process, DHT22 sensors monitor temperature and humidity to maintain optimal sterilization conditions.
5. The ventilation system is engaged to filter the internal air, removing dust and airborne microbes.
6. The OLED display provides real-time updates on the disinfection progress and environmental conditions.
7. After the cycle completion, the sanitized banknote is released for withdrawal, and the system resets for the next operation[6].

[6] Jabborov, M. (2022). Fundamentals of Algorithm Development for Microcontroller-Based Automated Systems. Journal of Technical Creativity and Innovations.

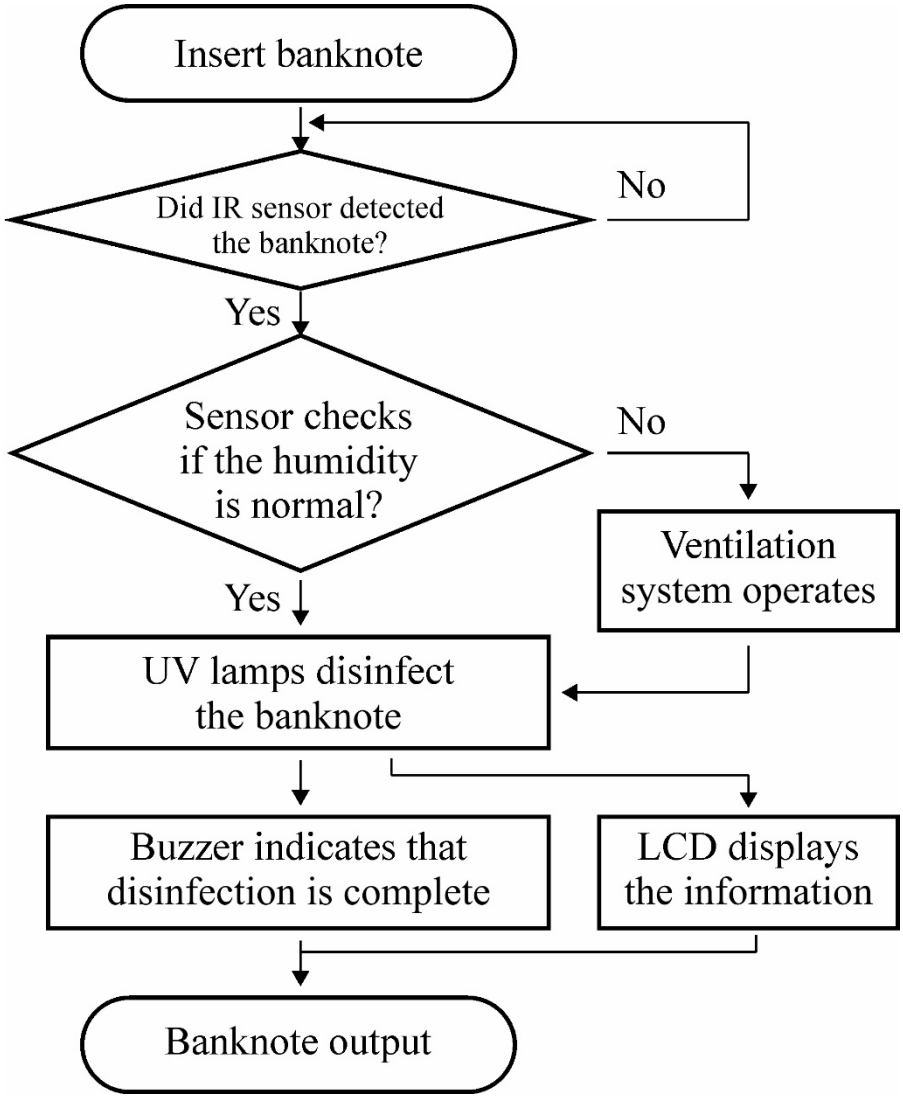

Figure 2. A process algorythm of a device designed for disinfection of paper money in atm's.

Conclusion. In this project, I designed and developed an automatic device for disinfecting paper money in ATMs. The device utilized UV-C radiation technology to ensure the effective elimination of microorganisms on the surface of banknotes. I created the control system of the device based on the Arduino UNO microcontroller, which continuously monitored environmental parameters such as temperature and humidity, managed the disinfection process, and accurately displayed the device's status on an OLED screen.

During the testing process, I identified that the device was capable of eliminating up to 99 percent of bacteria and viruses. Additionally, the device had minimal impact on the operation of the ATM, ensuring continuous and delay-free cash flow. By designing a ventilation and filtration system, I effectively controlled the device's internal temperature, which contributed to its stable operation.

Through this project, I created the opportunity to handle paper money in ATMs in a hygienic and safe manner, which helps protect public health and prevents the spread of viruses. The results I achieved throughout this work are not only theoretically, but also practically valuable, and serve as a basis for further improvement and wider application in the future.

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