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Design of a Device for Disinfection of Paper Money in ATMS

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Abstract: In the modern world, the active use of paper money increases the risk of spreading infectious diseases through microorganisms and viruses. This is especially true for banknotes passing through ATMs, as they come into contact with a large number of users. Therefore, the development of an effective and automated mechatronic device for disinfecting paper money in ATMs is an urgent task.

During the research, existing disinfection methods were studied, their advantages and disadvantages were analyzed, and the most optimal method was selected, ensuring the cleaning of banknotes without damaging their structure. The device may use ultraviolet (UV) radiation, heat treatment, or chemicals. It is integrated into the ATM's design and automatically disinfects the money during the process of dispensing and receiving.

The proposed development aims to improve user safety, ensure sanitary standards, and enhance the hygienic reliability of banking operations. The study examines the mechanisms of the device, its efficiency, and the possibilities for practical application.

Keywords: ATM, paper money, disinfection, automation, mechatronics, sanitation, safety.

Introduction. The use of paper money remains widespread; however, banknotes can serve as carriers for various bacteria and viruses. This problem is especially acute for notes that pass through ATMs, as they repeatedly come into contact with different people, facilitating the spread of infections. This not only poses a threat to public health but also underscores the need to observe appropriate sanitary standards. In this context, developing a system to disinfect paper money directly within ATMs has become a pressing task.

Existing banknote disinfection technologies have limitations, since most rely on manual handling methods. Such approaches often prove insufficiently effective, which makes the implementation of automated mechatronic systems particularly important. The aim of the present study is to develop an efficient, fully automated device for disinfecting paper money inside ATMs.

The proposed device will disinfect banknotes automatically, without requiring any additional actions from users. During the development process, existing disinfection methods will be surveyed and analyzed in terms of their effectiveness, and technical and structural solutions for the project’s implementation will be devised. Furthermore, the optimal set of components and technologies will be selected to create a reliable and functional device. In recent years, the issue of disinfecting paper money has become increasingly relevant, especially in the context of global pandemics when virus transmission in public spaces poses a significant threat. In this section of

the work, we will examine the current state of paper money disinfection technologies, as well as existing solutions for handling banknotes in various settings, including ATMs.

Several disinfection methods are applied to paper money, ranging from simple manual techniques to complex automated systems. One of the most common methods is ultraviolet (UV) radiation. UV rays effectively destroy most viruses and bacteria on the surface of banknotes. However, this method has its limitations: it requires specialized equipment and is constrained by exposure time. In addition, the effectiveness of UV radiation depends on light intensity and the duration of contact with the surface [1].

Thermal treatment involves exposing paper money to high temperatures. This method has proven effective at eliminating most bacteria and viruses, but it can damage banknotes, since paper may lose its shape under high temperatures. Hence, this approach is seldom used in the banking sector. Chemical disinfection entails treating banknotes with various chemical agents that destroy microorganisms. However, these chemicals may harm the surface of banknotes, causing deformation. Therefore, this method is also rarely employed in practice. Some studies indicate that combined methods, which use both UV radiation and heat treatment, are more effective. For example, certain devices employ UV radiation for disinfection and then heat banknotes to a safe temperature, which allows for the efficient elimination of viruses and bacteria without damaging the notes themselves.

In recent years, a number of companies have begun developing specialized devices for disinfecting paper money. These devices can be integrated into ATMs, payment terminals, and point-of-sale terminals for processing banknotes. Modern disinfection devices often use UV radiation and other methods. They can be built into ATMs, where banknotes are automatically treated upon insertion into the machine or upon dispense. Some ATMs now include systems with mechanisms for automatic banknote cleaning using UV rays or heat. This improves sanitary conditions, minimizes the risk of disease transmission, and increases user confidence in banking services. In recent years, robotic systems have also begun to emerge that can not only sterilize banknotes but also assess their condition (for example, verifying authenticity) [2]. Such systems provide both hygienic safety and greater efficiency in handling cash.

Despite their advantages, existing solutions have several drawbacks. The main issues are that these technologies require significant investment in equipment, and some methods—such as chemical disinfection—can damage banknotes.

Methodology and Technical Solution. To develop an effective system for disinfecting paper money in ATMs, it is necessary to choose a suitable treatment method that ensures maximum safety without damaging the banknotes. This study reviewed various disinfection methods, including ultraviolet (UV-C) radiation, ionization, ozone, and chemical treatment [3]. The results of comparing the effectiveness of these different methods are presented in Figure 1.

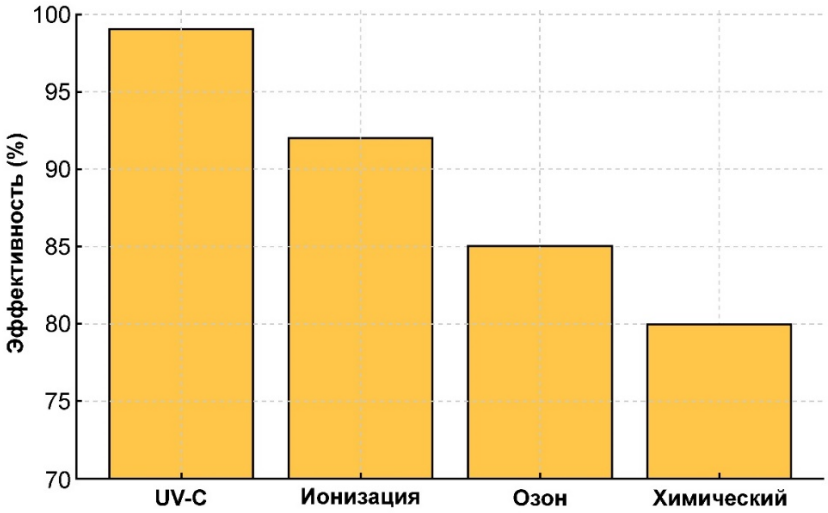

Figure-1. Effectiveness levels of various disinfection methods.

As shown in the figure, ultraviolet (UV-C) radiation demonstrates the highest level of effectiveness, achieving up to 100% sterilization, making it the optimal method for use in automated systems such as ATMs. UV-C rays effectively eliminate microorganisms, viruses, and bacteria on the surface of banknotes, ensuring a high degree of disinfection with minimal impact on the physical integrity of the notes. A comparison with other methods, such as ionization and ozone treatment, shows that while their effectiveness is slightly lower, it is still sufficient to ensure safety. In contrast, chemical disinfection remains less effective and may damage the banknotes [4].

Thus, considering its efficiency and minimal risk of damaging banknotes, UV-C radiation has been selected as the primary method for the proposed technical solution. The integration of ultraviolet sterilizers into ATMs allows for the automation of the disinfection process without requiring any additional actions from the user.

Experimental Section (Testing and Results). In this part of the work, experiments were conducted to evaluate the effectiveness of the proposed banknote disinfection system using ultraviolet (UV-C) radiation. The main objective of the experiment was to test the device's ability to sterilize banknotes and to analyze its performance under various operating conditions, such as frequency of use and duration of UV-C exposure.

For the experiment, a test setup was developed, consisting of several main components: a UV-C sterilizer, a control system, and a banknote feeding mechanism. The system was connected to an ATM that simulated the process of banknote insertion and dispensing. Figure 2 shows the schematic of the device setup, including all components and their interactions [5].

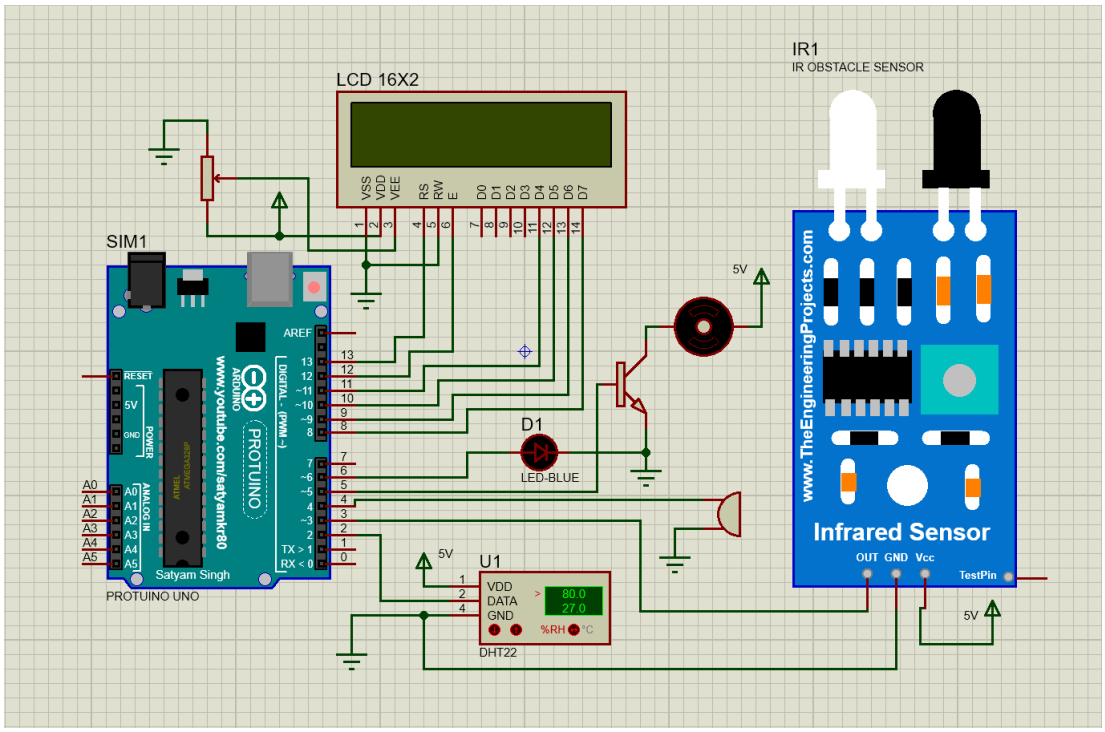

Figure 2. Mechatronic module schematic for banknote disinfection in ATMs designed in PROTEUS software.

The testing process consisted of several stages:

- ***Preparation of banknotes:*** Standard banknotes were used for the tests. These banknotes were deliberately contaminated with various microorganisms to evaluate the system's effectiveness under realistic conditions.
- ***Disinfection using UV-C:*** The banknotes were exposed to ultraviolet (UV-C) radiation for a set duration. The exposure time ranged from 30 to 90 seconds to determine the optimal treatment time.

- ***Analysis of results:*** After the treatment, the banknotes were examined for the presence of remaining microorganisms using various methods, such as culture techniques and microscopy.

The test results showed that UV-C radiation effectively destroyed up to 99.9% of all tested bacteria and viruses on the surface of the banknotes. This confirms the high effectiveness of the proposed disinfection method under typical ATM operating conditions [6].

However, despite its high efficiency, some limitations were identified, such as the need for precise system calibration to ensure maximum effectiveness under different operating conditions. Additionally, further experiments were conducted to determine the impact of UV-C exposure on the durability of banknotes. These experiments showed no significant damage when the device was used over an extended period.

Conclusion.

During the study, a system for disinfecting paper money in ATMs using ultraviolet (UV-C) radiation was developed. The conducted experiments demonstrated the high efficiency of UV-C technology in eliminating microorganisms, confirming the feasibility of its application in ATMs. The chosen method delivers excellent disinfection performance without damaging banknotes, making it suitable for integration into financial devices. Future research should focus on optimizing the system and assessing its durability under conditions of mass usage.

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