International Journal of Education and Social Science Research

ISSN 2581-5148

Vol. 5, Issue.3, May-June 2022, page no. 155-168

To cite this article: Uman Sukmada, Romie Oktovianus Bura, R. DJoko Andreas Navalino, and Ekanesti Ruswidia Sari (2022). DEVELOPMENT OF AUTOMATED BIOMETRICS SYSTEMS FOR STOCKPILE MANAGEMENT OF WEAPONS AND WEAPONS SAFETY, International Journal of Education and Social Science Research (IJESSR) 5 (3): 155-168

DEVELOPMENT OF AUTOMATED BIOMETRICS SYSTEMS FOR STOCKPILE MANAGEMENT OF WEAPONS AND WEAPONS SAFETY

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DOI: http://dx.doi.org/10.37500/IJESSR.2022.5310

ABSTRACT

The safe storage of weapons is crucial for the security of both civilians and security personnel. Storage security is especially precarious in areas suffering from weak governance. This research tries to enhance some aspects of storage security by relatively low-cost improvements in monitoring and the physical security of weapons by designing smart weapon storage system. Physical security measures are provided by the physical storage enclosure itself. Access to open the enclosure are strictly controlled by means of biometric access, specifically iris scan of authorized personnels. This type of biometric access control was chosen to add convenience and responsiveness of authorized personnels to retrieve weapons while maintaining security. To address inventory management and accounting control of weapons, proximity sensors are used to detect whether the weapons can be found inside a controlled environment, that is inside the designed storage enclosure. Specific software was then designed to manage combined use of those sensors and database of authorized personnels.

KEYWORDS: weapons; weapons storage management; access control; biometric; iris scan; proximity sensor

1. INTRODUCTION

Storage management of weapons is part of a wider term called stockpile management of weapons. Stockpile management of weapons involves accounting, storage, transportation and handling. Effective stockpile management requires comprehensive planning that includes issues such as the determination of stockpile size, types of stockpiles, location of stockpiles and the management of ammunition in service. [1]

The safe storage management of weapons is very important for a number of reasons. These include:

1. Security: The safe storage of weapons is crucial for the security of both civilians and security personnel. Poor storage security is a prime means through which arms and ammunition are

diverted from the legal to illegal or unlicensed owners. Storage security is especially precarious in areas suffering from weak governance.

2. Safety: Unsafe storage can result in the explosion that can kill and injure many people as well as destroy or damage costly facilities and equipment. If not stored properly, weapons can also be affected by environmental conditions such as moisture and temperature. This can significantly affect the stability of weapons to the degree that they become unsafe to handle. [2]
3. Accountability: By providing safe storage management, the exact number of weapons in stock become known. Registering the number of weapons and ammunition in stock can help identify when losses occur and prompt necessary actions.

This research tries to enhance some aspects of stockpile security by relatively low-cost improvements in monitoring and the physical security of weapons. Many researches have been conducted to prove that it is possible to do so. [1]

2. DESIGN CONSIDERATIONS

Security, safety, and accountability are aspects that need to be considered in this research. Each aspect will be addressed so that the results of this study answer all the problems that exist in each. These three aspects are basically interrelated and cannot be separated. But each has unique problems that need to be resolved individually.

A. Security Aspect

It is crucial that the storage of weapons follows the principle that it is held securely to prevent unauthorised access. Such storage system should involve the physical securing of the firearms, and the process to manage access control, such as security of keys. The keys should not be located so inaccessibly as to deter the authorized personnel from securing his or her guns after use.

Only authorised persons should have access to any of the keys for any cabinet containing firearms and ammunition. In case of physical keys, care needs to be taken in selecting locations for the storage of keys, particularly any spare sets, to avoid them being discovered and improperly used. Consideration could be given to using a key cabinet or secure storage (safe) to store keys and spare keys. In all cases primary and spare should be stored separately.

Safe-keeping of keys will certainly require more effort, in addition to increasing the time required for personnel to have direct access to weapons. Using physical keys will also increase the risk of human error and of course misuse. Therefore, the locking system that will be used to secure weaponry will use a non-physical lock.

There are several non-physical lock mechanisms that are commonly used, including personal identification numbers (PIN), passwords, and biometrics. Biometric identification technique was

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chosen because other conventional techniques such as passwords and PINs are prone to identity theft. Biometric identification addresses this fundamental problem, because an individual's biometric data is unique and cannot be transferred. Especially in this specific application of weapons access, biometric identification will be more suited because each weapon is assigned to specific personnel at a given time. The advantage of using biometric is that it cannot be lost or forgotten, as the person has to be physically present during at the point of identification process. [3]

Biometric features that are commonly used are speech, fingerprint, face, iris, voice, hand geometry, and retinal. [4] Among them, iris is a biometric feature found to be more reliable and accurate for authentication process compare to the others. The highly randomized appearance of the iris makes its use as a biometric to be exceptionally accurate. [5]

B. Safety Aspect

The safety aspect provided as a result of this study is the use of a locking mechanism that is integrated with the security aspects previously described. The safety of weapons can in most cases be achieved using cabinet made from steel sheet designed for this purpose. The locking mechanism will be linked to biometric identification in such that it provides auto-lcoking mechanism.

C. Accountability Aspect

The accountability aspect addressed is the availability of accountable documentation regarding the use of weapons. With the selection of a biometric identification system and an auto-locking mechanism that requires the presence of an electronic system, documentation of the use of weapons can be easily carried out.

3. PROPOSED SYSTEM DESIGN

The picture below shows the Smart Weapon Storage System workflow, as well as lists the components that make up the entire designed system.

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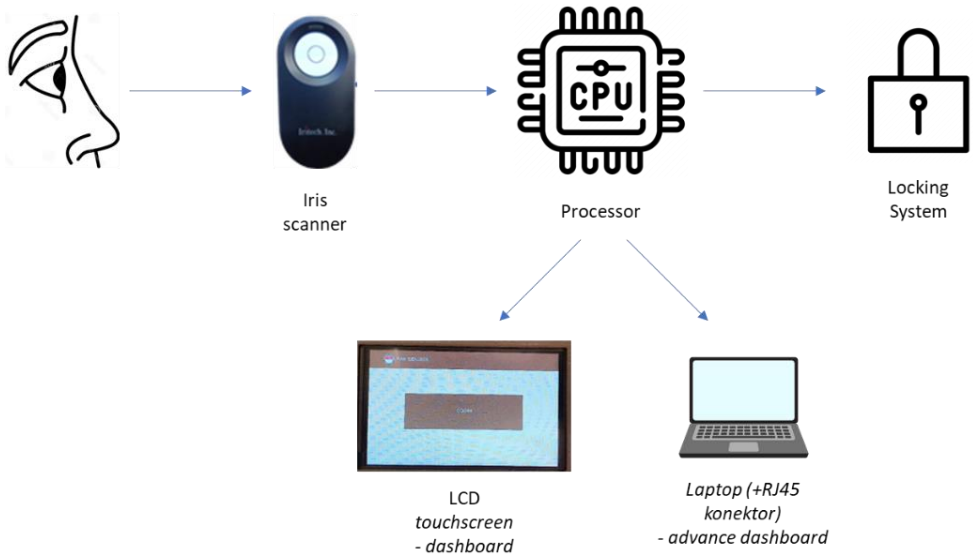

Figure 1. Workflow and components of the Smart Weapon Storage System

The system will automatically start to work when the scanner detects the somebody's eye. If the user is not authorized, then the system will reject the request to access weapons inside. Authenticated users will be recognized as having the role of either normal user or administrator.

Authenticated users will then be directed by processor on the system according to the roles they have. Normal users will be directed to specific page display showing options to unlock stored weapons. Locking mechanism was implemented to provide ten seconds of windows to physically access the weapons until it automatically locked again. On the other hand, administrators will be directed to a page where they can open any weapon slots.

In addition to dashboard showed on the screen of storage system, a more advance dashboard can be accessed via physical connection using RJ45 port at the back side of the product. From this advance dashboard, management of users can be performed, for example changing iris data, weapon slot data, and other user management functions.

On the hardware, we designed additional modules of emergency doors and deposit boxes. The emergency door module can be used in case there is no supply of electricity to the system. Thus, authorized personnels can manually open all weapon slots. The deposit box module located at the bottom is useful for storing other supporting equipment such as weapon magazines and other equipment.

4. HARDWARE SYSTEM DESIGN

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Main hardware modules of Smart Weapon Storage System are main controller board, motor controller, and mechanical locking system. Each module is specifically designed to work as a complete unit. The following sub-sections explains each of the modules and their design considerations.

A. Main Controller Board

This module is the main controller of the smart weapon storage system. This controller will be the link between the processor system, motor controller, and the sensor module.

The various functions performed by the controller board are sending signals to the motor module, receiving readings from the sensor module, controlling the opening or closing of the locking system, to regulating the switching on or off of the smart weapon storage system.

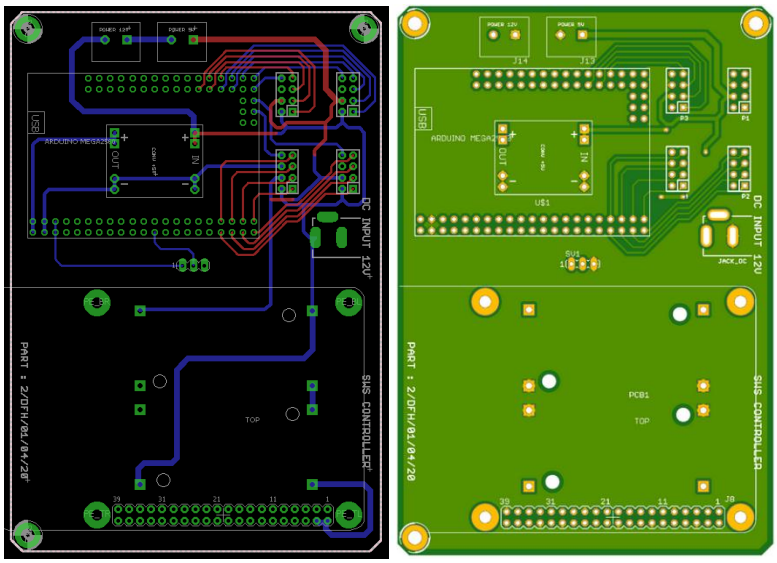

Figure 2. Main controller board design

B. Motor Controller

The motor controller module gets input in the form of a voltage signal sent from the controller board. If it gets a signal with a certain value, the motor will open or close according to the value obtained. Basically, the way the motor works in this smart weapon storage product is to raise and lower the cover / sleeve that is used as a locking system.

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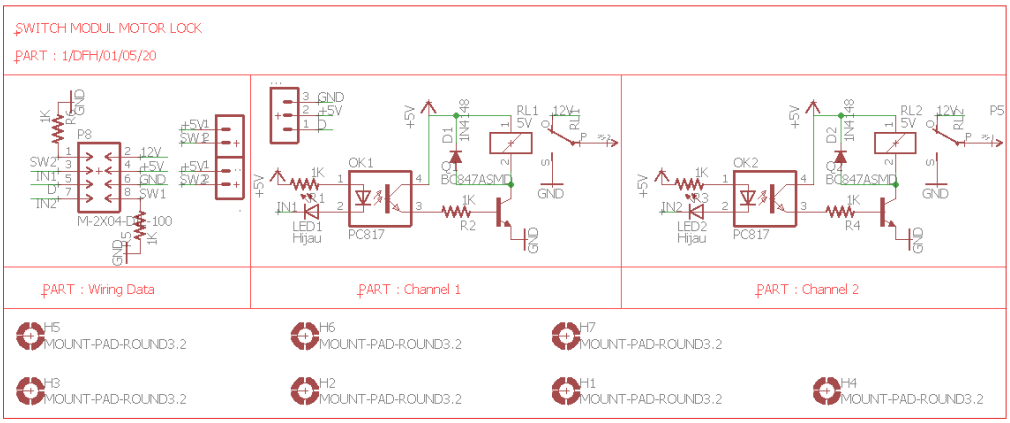

Figure 3. Schematic diagram of motor controller

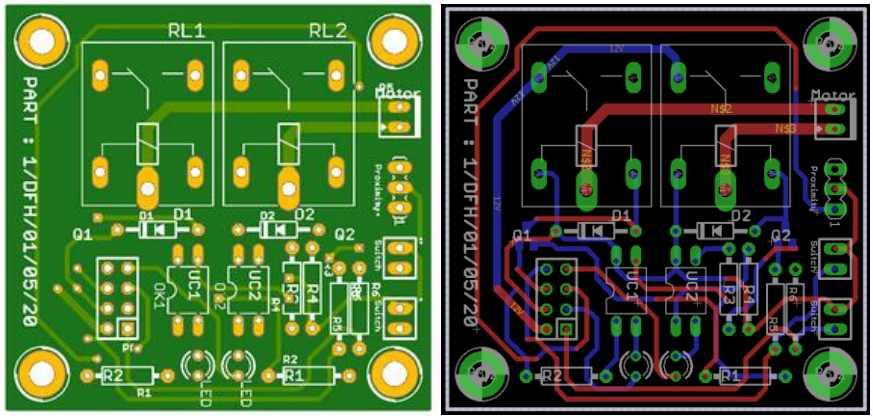

Figure 3. Motor controller board design

C. Cabinet

The design of this cabinet involves many mechanical aspects which are connected to the electrical system. The pictures below show the important components as part of the cabinet, they are the weapon locking and emergency opening mechanism. The emergency opening mechanism is designed as a backup mechanism and requires more human intervention.

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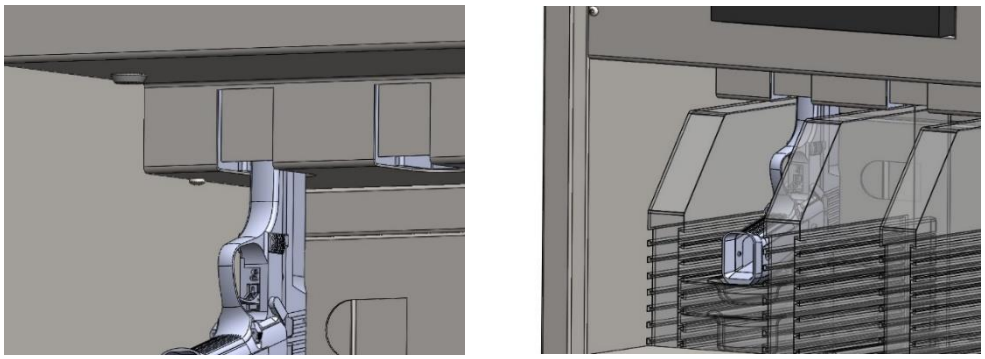

Figure 4. Weapon locking mechanism design

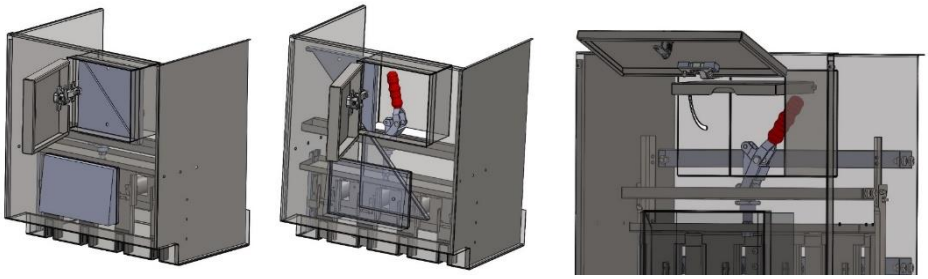

Figure 5. Emergency opening mechanism design

5. SOFTWARE SYSTEM DESIGN

Software is the interconnection between user interaction and hardware systems. The software system starts from the user's iris reading feature, user authorization, historical storage of user logs in the database, to integration of sensor readings whether weapons are taken or stored. User authorization includes granting access rights as an administrator, as a registered user, or as an unregistered user.

There are three main parts in the software system, namely database, front-end components, and back-end components. The database is a data storage system for user's iris data, activity dates record, and weapon slot positions record. The front-end components will show user interface display on the LCD touchscreen. Each button pressed or selected by the user on the user interface will trigger command to the back-end components. Processing is then carried out of every action performed by the user such as data storage, sending signals to the motor, turning on hardware and so on.

The figure below shows the main algorithm flow that is implemented into the software section of the Smart Weapon Storage System.

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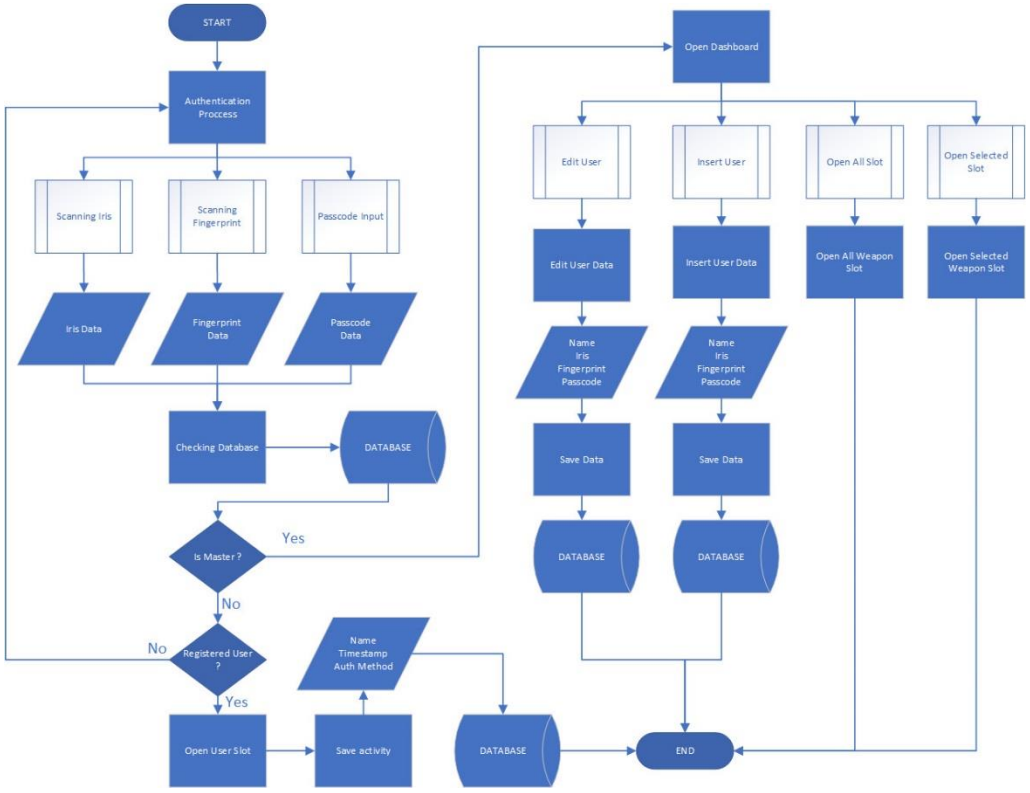

Figure 6. Algorithm flowchart of the software

A. Software Environment

This system uses NodeJS as the main platform to perform all its tasks. NodeJS is integrated with MySQL as a database to store data recaps on every Smart Weapon Storage System activity. Express JS will play a role as a server to run the Dashboard of Smart Weapon Storage System. NodeJS functions as an API that connects iris scanners, databases and also mechanical systems for the weapon locking process.

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Figure 7. Software environment of Smart Weapon Storage

B. Locking System Design

The locking system module works automatically after getting the results of reading the user's iris data and it has been declared that the user is authorized. The locking system will open according to the weapon slot that has been assigned to the user in question. After 10 seconds, the locking system will close again. The same mechanism is also applied, both when there is a weapon in the slot or when there is no weapon in the slot. The image below shows the algorithm of this locking system.

Figure 8. Algorithm flowchart of locking system

6. DESIGN RESULTS

A. Hardware System

The main hardware modules of the Smart Weapon Storage System are integrated in one cabinet. This cabinet consists of four parts, including: (1) Emergency access, which is located at the top of the cabinet; (2) Human interface panel, which is located in the middle of the cabinet; (3) Cabinet storage, including additional/multi-purpose storage, which are located at the middle to the bottom of the cabinet; and (4) Computer-interface panel and power switch, which are located at the back-side of the cabinet.

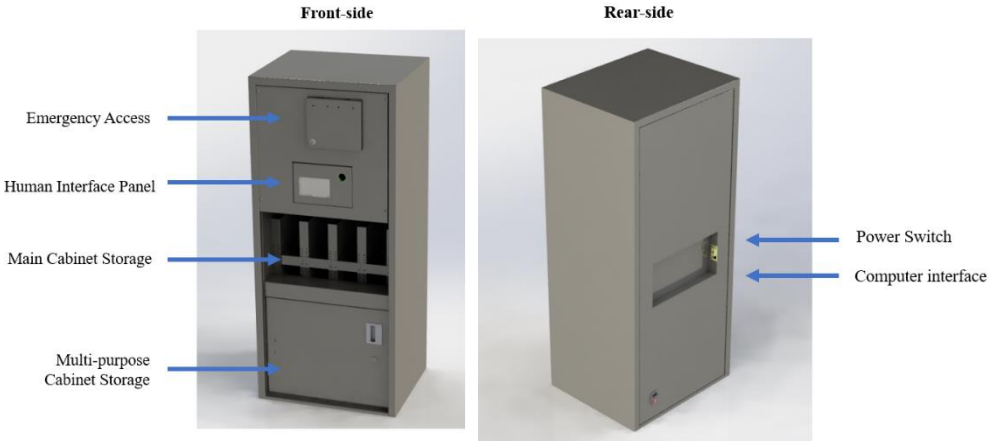

Figure 9. Design of Smart Weapon Storage System cabinet

The explanation for each of these parts is as follows:

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1. Emergency access.

This part is located at the top of the cabinet. This part will serve as a backup mechanism for access to the weapon, for example, when there is a power failure.

2. Human interface panel.

This part allows interaction between users and the Smart Weapon Storage System. It is located in the middle of the cabinet, consists of touchscreen display, iris scanner, and proximity sensor. The iris scanner serves as a gateway that authenticates the user. This scanner will read the user's identity in the form of a unique iris characteristic reading. Display with touchscreen capability will show a graphical user interface to guide users intuitively and to receive input / commands from users. While the proximity sensor functions to monitor the presence of weapons in their respective slot positions. All actions to retrieve or return the weapon will be recorded based on the proximity sensor reading. In the databse, it will be recorded whether a certain weapon has been taken, has been returned, or if there is no activity carried out.

3. Main storage and additional/multi-purpose storage.

These are parts that store weapons, located in the middle to the bottom of the cabinet. The main storage area will store weapons to be stored, while the additional storage area is multi-functional and can be used for various purposes, for example to store ammunition.

4. Computer interface panel and power switch.

These two parts are located on the back side of the cabinet. Interface to the computer is done by connecting the computer via the RJ-45 port. An interface to the computer is required to perform more advanced Smart Storage Weapon System management functions. The power switch itself functions to disconnect or connect the electrical power supply to the Smart Storage Weapon System.

B. Software System

The output of the system software will be visible from the graphical user interface displayed on the screen. Some of the main pages will be discussed in this subsection.

1. Login Page

The login page is the first page displayed to the user. On this page there is a button to login. Users who want to access weapons need to touch the login button, then scan their eyes on the available iris sensors.

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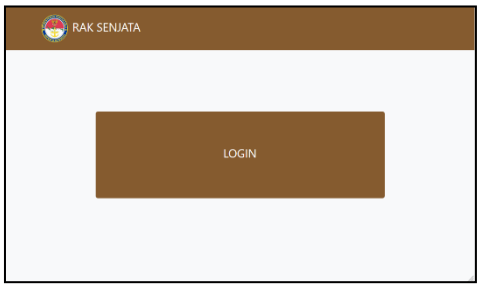

Figure 10. Login Page on Smart Weapon Storage System

After iris reading is complete, system will identify the user according to the predefined roles in the user's organization environment. The next page will adjust to the user's role. There are at least two pre-defined roles: Administrator or General User. If the user has an administrator role, then the next page is the Administrator Page. If the user has the role of a general user, the weapon slot will be opened for 10 seconds, after which the weapon slot will relock again.

2. Administrator Page

This page can only be accessed if the user is authorized as admin. On this page, the admin has the freedom to be able to open any weapon slot as desired, as in the following image. The Administrator page can only be accessed by users who have an administrator role. On this page, an administrator can have the privilege of opening any weapon slot he wants. The figure below shows how the Administrator Page looks like.

Figure 11. Administrator Page on Smart Weapon Storage System

After the administrator selects a weapon on which slot to access, the slot in question will open for 10 seconds and then lock again. This administrator activity will still be logged in the database.

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3. History Page

The History page displays all activities that occurred on the Smart Weapon Storage System, including the time of activity (date and time). The image below shows an example of how the History Page looks like.

Figure 12. History Page on Smart Weapon Storage System

The table below describes the data parameters displayed on the History Page.

Table 1. Parameters shown on History Page

No.	Column	Description
1	Slot	Shows the weapon storage slot number.
2	Name of user	Shows the name of the personnel assigned to the slot number.
3	Action	Information regarding actions taken by user and administrator for the slot. There are three type of actions: • Store: User/administrator stores weapon on the cabinet • Pick-up: User/administrator picks up weapon from the cabinet

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		• Scan only: Users/administrator only perform iris scans without picking up from or storing weapon on the cabinet.
4	Description	Information regarding the method used to store or retrieve weapon in the slot. There are two types of descriptions in this column: • Iris Scan: User performed an iris scan to access weapon • Administrator Accessed: Administrator accessed weapon (via dashboard)
5	Access date	Information regarding time the slot was accessed.

4. Advance Dashboard Page

The Advance Dashboard page can be accessed via a physical connection to the RJ-45 port located on the back of the cabinet. By accessing this Advance Dashboard page, users can control several important features that are not possible to access using the screen in the cabinet. These features include:

- Change the weapon assignment for a specific user.
- Modify iris biometric data record.

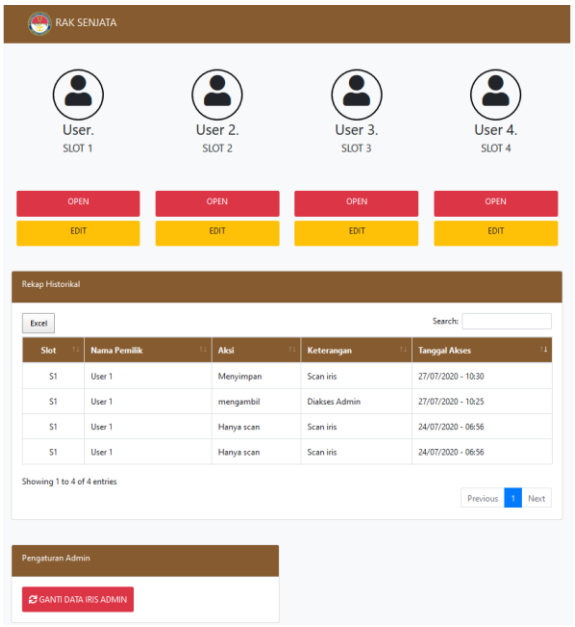

Figure 13. Advance Dashboard on Smart Weapon Storage System

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7. SUMMARY AND RECOMMENDATIONS

This research has resulted in a Smart Weapon Storage System design that answers the problems that exist in relation to stockpile management of weapons. Security, safety and accountability aspects are considered in the design of the Smart Weapon Storage System. The resulting Smart Weapon Storage System prototype has the main function as a weapon storage area with a high level of security but is still practically used by users, including in emergencies. The key components in this Smart Weapon Storage System are the use of biometric sensors, proximity sensors, weapon locking mechanical components, and an information system that integrates them all.

As input for the improvement of this research or continuation of research on the same topic, the following points can be recommended.

1. Create an online database system or put it as a cloud service. Thus, access to database changes can be done anytime and anywhere. This development must also be supported by increased security systems considering that the database is stored in the cloud, not physically attached to the product.
2. Creating a centralized database system and interface for operational handling of more than one Smart Weapon Storage System.
3. The addition of a customizable weapon holder so that various types of weapons can be placed in the available slot holders.

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