Weapon Zeroing and Warriors Range Analysis System of Small Arms for Bangladesh Army

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***Abstract*—**
Weapon Zeroing system is a software based zeroing tool which is designed only for Assault Rifle BD 08, the basic weapon of Bangladesh Army. In this system the the required correction is calculated by the algorithm which follow the zeroing technique prescribed by School of Infantry and tactics. In the range analysis part the basic fault of a firer is identified by analyzing the pattern of the impacts in the target. At the same time the sub-unit commander can see the progress of fire of his under-commands by visiting the website. For preparing the zeroing tool three stepper motors are used which can be utilized in any weapon of same specification. For the identification of the firing impact computer vision is used and the algorithms for calculation of the required correction are nothing but the standard system stated in SI&T precies as stated before. To simulate a sub-unit firing record in the website we uploaded fictitious data which does not have any similarity with any real military force.

***Index Terms*—Weapon Zeroing, Rifle Zeroing, Weapon Calibration, Range Analysis, Fire Analysis System**

I. Introduction

Weapon is the best friend of a soldier in the Battlefield. To achieve the ultimate goal of the Battlefield ”One Bullet, One Enemy” a soldier must have an accurate weapon. During the peace time a soldier is trained to make himself fit to fight during war. Zeroing of weapon means to adjust the line of sight of the weapon to the point of impact of fire, so that it can bring the fire accurately on the point of aim. The zeroing of weapon is suppose to be done every year and before going for a war. But due to lack of interest, accurate knowledge this is not done accordingly. At present in our army manual zeroing system is being followed. In this system the MPI is suppose to be calculated geometrically and the adjustment to be done by hand. If this zeroing can be done by an automatic system then the calculation of the MPI and required adjustment can be done more accurately.

In present system, after the fire the individual firer goes for target checking. Then he roughly identify the MPI of the impact. Thereafter the armourer does the adjustment of the Front Sight of the weapon. This process is not an accurate process. In our proposed system after the firing practice the firer will go to check the target and take a snapshot of the target paper. The system will identify the impacts by using computer vision.By using the impacts it will calculate the MPI. From the MPI and the bull it will calculate the required correction in the sight. If the required correction is accepted by the firer then the firer will set the zeroing tools on the front sight of the weapon and push a button. After that the tools will make the required correction by itself. The system will also suggest the firer the mistakes he is doing in firing and it will keep the record of all these in the database.

The automatic zeroing system will allow the firer to make a more accurate zeroing of the weapon. At the same time the analytic side of the system will help the firer to know his mistakes and required corrections in his firing.

The rest of the paper is organized as follows: Section II presents the related works in the relevant field while III describes the features, conceptual design and implementation along with the work flow of our proposed approach. Section IV talks about the process of implementing the system, Section V determines the accuracy and precision of the system based on the results of trails and testing, Section VII talks about the limitations of the system and way of getting rid of those limitations. Besides, this section also highlights the future planning of the developers regarding the system and their plan of expanding the system for better help of the firer. Finally Section VII terminates the paper.

II. Literature Review

In process of firing, the process of zeroing the weapon is mandatory. However this has been done till now following manual process. No machines or automation have not been made for it. Several papers are studied in this section to make this process of automation fruitful. Since the zeroing tools for different weapons are different from each other, therefore much of papers are not available on particularly on zeroing system. But these papers are on weapon calibration and weapon system which are also related to our project.

Larsson et al.[1] proposed a mount for mounting an accessory on a weapon comprises a base plate with an upper surface and a lower surface, to be connected with the accessory. The base plate is clamped to a rail on the weapon with the lower surface engaging the rail. Two aligned first grooves in the upper surface extend in the longitudinal direction of the rail and a third groove in the upper surface of the base plate, extends transversely of the first grooves. First protrusions on the lower surface of the accessory guiding engage the first grooves, and a third protrusion on the lower surface of the accessory located between the first protrusions engages the third groove to prevent displacement of the accessory along the first grooves.

Whereas Migliorini et al.[2] proposed a thermal silhouette target including a high emissivity surface, a conductive layer, a heating coil, an insulative layer and a direct voltage source. A thermal zeroing silhouette target device further includes a mask with a zeroing grid and a pair of contacts for electrical connection to a direct voltage current source.

Meyers et al.[3] presents an aiming system for a trajectory weapon such as a ground launcher, machine gun, mortar, or the like. The aiming system is attached to a conventional mount for the involved weapon. Also disclosed is a method of sighting in a weapon which employs the aiming system.

Randazzo et al.[4] in their paper talks a scope mounting system which includes a one or two-piece base and a plurality of scope support assemblies. Mating portions of the base and scope support assemblies have parallel v-notches engaged with parallel flat lands to set the position of each support assembly relative to the sighting direction of a weapon to which the base is attached.

O'brien et al.[5] had the invention which provides a method for zeroing an automotive power train torque sensor while a vehicle is moving during the zero torque condition. The invention relates to torque sensors or more particularly to automotive torque sensors which measure the torque transmitted at one or more positions within an automotive power train.

Quinn et al.[6] talks about a self-contained gimbaled weapon system (GWS) has a shared azimuth axis and two independent elevation axes for a sighting device and a weapon cradle. The GWS allows the weapon cradle to be elevated completely independent of the sighting device. The GWS can be stabilized and operated remotely.

Callegari et al.[7] proffered a weapon benchrest in combination with a vehicle receiver hitch. The benchrest includes a main support frame with one end received in and supported by the vehicle receiver hitch and the other end supporting a weapon support table. The benchrest may use either a bi-level weapon support table with rifle rests, or a flat table for use with an additional rifle bench, vice or rest.

Howard et al.[8] on their paper describes an efficient network architecture and a set of two hyper-parameters in order to build very small, low latency models that can be easily matched to the design requirements for mobile and embedded vision applications.

Apart from that Danti et al. [9] in their paper proposed a system where K-means clustering based algorithm is used to detect pot holes which can be the motivation for detecting holes in the firing target of this project.

The weapon in this system is zeroed with help of 3 stepper motors. Their accurate rotation is to be ensured to zero the weapon precisely. The stepper motor must be studied properly in order to work with it and get its best advantage. Markkanen et al.[10] in their paper have given a brief study on stepper motors and regarding its complete system. The position of stepper motor is a great concern here. Its position must be regulated here for proper functioning. Zribi et al.[11] has instructed here in this regard. The motors used here need to work on weapon which has hard body. The issue of proper torque and load attached to it comes here which is discussed by Howard et al.[12] in their paper.

The combination of Digital Image Processing and Computer Vision is applied to detect the holes from the target as pescribed in the paper by Schalkoff et al. [13] In this system, the image captured from target which contains the bullets holes must be analyzed to calculate the MPI. Digital Image Processing is used here. The concepts of this process of image processing are studied from Patin et al.[14], where they talked about all the basics required here.

Weapon zeroing system being a project for Military is full of security concern. Specially, the web server and data of firing is crucial which needs special attention for protection. In this regard Lambert et al.[15] brings forward a session processing module for a server is adapted to communicate across the Internet with a plurality of clients. Here in one embodiment the module relays encrypted request data for a session to a back-end server, and receives from the back-end server encrypted response data for the session for the client. Alternatively, the module itself decrypts input streams containing request data and processes the data to generate output streams containing encrypted response data for the client. In addition to that, Devine et al.[16] brings forward a double firewalled system is disclosed for protecting remote enterprise servers that provide communication services to telecommunication network customers from unauthorized third parties.

III. Methodology

Weapon Zeroing is the process of bringing accuracy and correction in weapon. The proposed system will automate the process of zeroing. The following features are included:

1) Target Analysis: The bullet pierced target's image will be collected using camera which will be processed using the mobile application incorporated in the system. The application will identify the bullet piercing holes in the target and calculate the MPI value for weapon zeroing. MPI is calculated from the firing impact created on target. The firer fires 5 bullets in the target.
2) Data Storage: The data collecting from image process will be storage in the web server which will be reference for analysis of performance of the soldiers. Besides, the data stored will be displayed to the commander to judge the performance of the soldiers.
3) Data Analysis: The data collected in server will be analyzed to determine the range efficiency of the soldier. This data will be also used to analyze the firing efficiency of the firer. That is error can be generated due to weapon or due to the inefficiency of firer. Here the analyzed data can find out whether the error is due to weapon or the firer.
4) Weapon Zeroing: The data(MPI) collected from image processing is used to zero the weapon. The weapon set at weapon zeroing tool will use its motors which will

rotate to zero the weapon. Once it is done, the firer will check the weapon by firing and testing it.

5) Firer Profile Management: The firers will have their individual profiles which will carry their own firing data. It will help them to determine their efficiency of firing based on the result analyzed by the system.

The complete process or system architecture is given in Figure 1. The work flow of the total system is given in the Figure 2

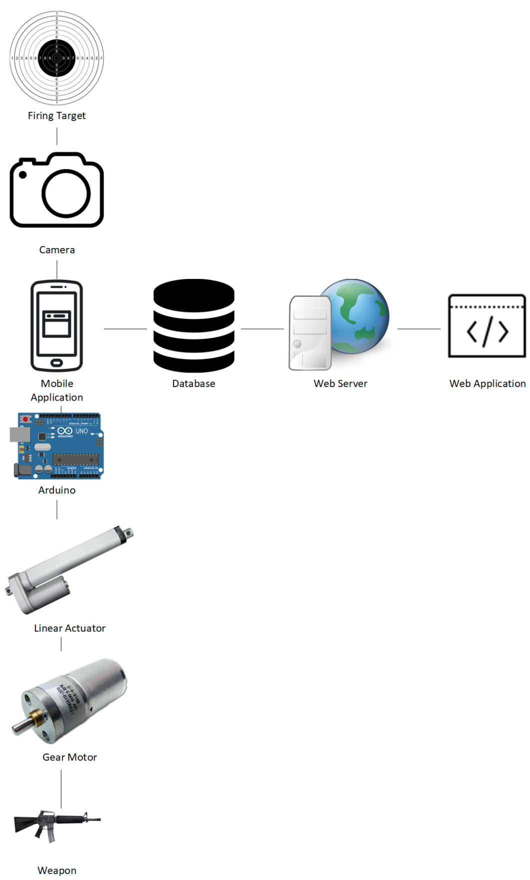

Fig. 1: System Architecture

IV. Implementation

The weapon zeroing system consists of two major parts: the hardware part that zeros the weapon and the software or the system which controls or operates the hardware section.

A. Hardware

A metal framework is designed for the hardware section which will contain the weapon where it will be zeroed. For zeroing purpose, a linear actuator and a gear motor will be attached in the framework. The linear correction of the weapon will be done by the linear actuator. Based on the values of the correction sent by mobile application using Bluetooth interface, the linear actuator will move forward and backward. Linear actuator movement is controlled on basis of time. Based on the calculation of linear correction, its movement zero the weapon linearly.

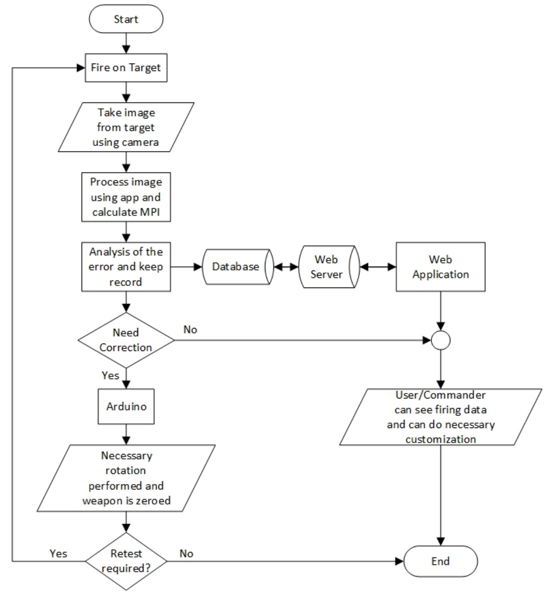

Fig. 2: Work Flow Diagram

The front side tip is corrected by gear motor. However, there arises the problem of number of rotations calculation since in gear motor the number of rotation calculation is not possible. To solve this problem, it is interfaced to rotation sensors through pinions. The pinions are interfaced with rotary encoder. It controls the number of rotations of the motor through the pinions as per command from the mobile application through arduino.

B. Software

The software part implementation is followed by a web application and an android application.

The database plays the main role before moving to software development. MySQL has been used to implement the database of the system. phpMyAdmin, a free and open source administration tool for MySQL is used here for operating the database. The Schema diagram for the database is in Figure 3.

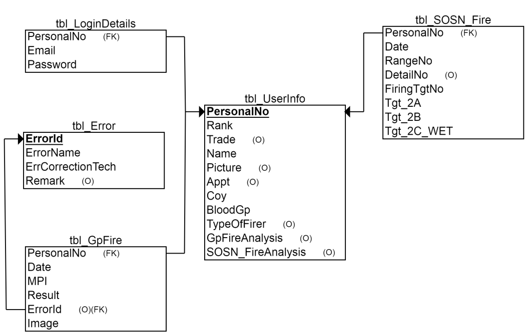

Fig. 3: Schema Diagram

The web application is built using basic languages like HTML, CSS, PHP. The user need to log in and complete their profile using this web application. Besides, the firer can observe the record of their performance in firing logging in his account. The sub unit commander will have the control to observe the overall performance of all the companies under him. The complete web system will be under control of the admin where he can create, update, delete, lock and unlock user.

The android application will use the same database used for web application through localhost. In computer networking, localhost is a hostname that means this computer. It is used to access the network services that are running on the host via the loopback network interface. Using the loopback interface bypasses any local network interface hardware. Records of all user information is stored in a mysql database which shares connection with all the devices through wifi/cable network. Therefore, a localhost server is required with web, php, mysql facilities. The mobile application will be mainly used for weapon correction value calculation. The firer logging into their profile will enter the weapon correction section. He will take photo of the target. The application will detect the holes pierced in the target by the bullets. OpenCV framework is used to detect the holes in the target. It will calculate the MPI value of the weapon. When the firer click for zero command, a Bluetooth interface sends the zeroing value directly to the arduino for zeroing the weapon.

The MPI value will be sent to the database at the same time, where at the back end the efficiency analysis of the firer is done. Based on the error generated, the quality of firer is determined and the firer's error type is generated.

C. Hardware and Software Communication

The hardware and software communication is a major task in the total project. Unless the data from software is sent to the hardware section, the components in that section can not work as desired. The exact value of rotation for motor and increment/decrement length for linear actuator must be sent from mobile application to arduino.

With this purpose in mind, the developers of the system have used bluetooth interface. The block diagram for bluetooth connection is in Figure 4.

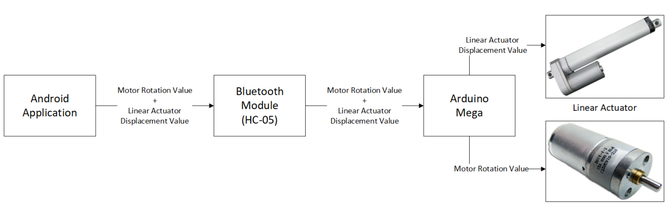

Fig. 4: Block Diagram for Bluetooth Connection

The mobile application detects bluetooth interface connected via bluetooth. It pairs with the device. The processed data from the target image will fetch the zeroing value for motor rotation and linear actuator displacement passing through algorithm for finding zeroing value. The motor rotation value and the linear actuator displacement value through the bluetooth interface finally to the arduino will be sent to the gear motor and linear actuator which will zero the front size and bring linear correction in the weapon respectively.

V. Experimental Result

The accuracy and precision of the system completely relies on the test and trails. The more test are done, the better will be the performance of the system. With this view in mind, the developer team went through several test in firing range. The result table I is to determine the accuracy of the image processing. Here the results of manual MPI and software generated MPI is compared.

Accuracy Test of Image Processing		
Manual MPI value	Software generated MPI value	Percentage of error

TABLE I: Accuracy test table for Image Processing

The next test is for correction of weapon. Here in Table II it is checked how accurately the designed machine can zero the weapon. Here value of MPI is taken before zeroing and right after zeroing which results in accuracy and precision scale of the designed machine.

Accuracy Test of Weapon Zeroing		
MPI value before zeroing	MPI value after zeroing	Percentage of error

TABLE II: Accuracy test table for Zeroing System

VI. Limitations and Future Expansion

A. Limitations

Though the developers broadened their scope while designing the system, however with few limitations they could complete almost all the available functions for smooth running of the system. The primary focus was to incorporate all the firing processes including grouping fire, SOSN etc. However, addition of all these firing features will provide versatility and help firers with greater options to choose from. Besides, present features of the system need massive improvement since random disruptions were found due to lack of proper test and trials. Apart from that working with processing of image of the target was another massive challenge for the developer team which is still under progressive development for better output.

Following recommendations may be implemented to overcome the present limitations.

- Inclusion of all available firing options in the system like group fire, SOSN etc.
- Auto detection of bullet holes in target with accuracy and preciseness.
- Auto cropping of the image of target on basis of target size which is currently done manually.

- Conciseness of the hardware section is great demand from the firer end. If it can be done, the hardware can be easily carried to all places even in times of war.

B. Future Expansion

- With the existing features of the system, few new features can be added for better assimilation with the user requirements and for providing one stop services. The initial set out plan was to keep it as a zeroing system. Later on with the upcoming user requirements the designers looked forward to merge image processing of the target image which will help to find the zeroing value directly without human or manual help. However, this part of the system is still under development where proper machine learning is to be applied to get accurate and precise values from the target.
- All the firing features are not incorporated in the system till now which will be added later after further development.
- Exact error of the firer can be predicted using the system. The system will find out whether the error is due to human or weapon problem based on error result.

VII. Conclusion

To build up a weapon zeroing system for Bangladesh Army is the main purpose of the project. The weapon zeroing done manually at field level is absolutely troublesome and full of error. This is because of lack of expert manpower. However to reduce the problem, a system has been developed which will bring automation in the process to a great extent. The zeroing will be done with help of machine and the value of MPI will be generated by the software. Apart from that, the error data will be analyzed to check the efficiency of the firer. Besides, it will also find out the reason of the error, whether it is due to firer or the weapon. However, the success of the project will be ensured when it will be implemented at field level. The developers side is continuously working to enhance the efficiency or the accuracy of the machine and the system. To accelerate the effectiveness of system, collaboration among the stake holders is massively required. Further development of the system is always encouraged to ease the weapon zeroing and warriors' efficiency analysis of Bangladesh Army.

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