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Design and Development of Reaction Timer Device based Visual Reaction Time (VRT) Scale Stimulant for Silat Athlete

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In this study, a reaction timer device has been developed with objectives to obtain the reaction time of silat athletes based on the specific stimulants. Nine male participants based on different weight categories were recruited to conduct the Simple Reaction Time Task (SRT) by performing Layang kick in the outdoor environment. The main sensors of the prototype consist of three LEDs (red, green, and yellow) and a vibration sensor was attached to the kick pad. From the findings, it can be deduced that 66.7 % of the participants reacted fastest towards green LED as compared to red and yellow LEDs. Also, the average collected reaction time for each LED associated with the SRT experiment revealed that the green LED produced the fastest reaction time (408.8 ± 15.8 ms). In the future, multiple experiments will be added to clarify the performance of the device towards a variety of experiments by adding Multiple-choice Reaction Time Task (MRT) and indoor setting environment, participants gender-based as well as from different combat sports branches.

Keywords: Arduino; reaction time; simple reaction time task (SRT); visual reaction time (VRT)

I. INTRODUCTION

A measurement of quick react and completed response is known as reaction time. Nevertheless, there are no reaction timer devices available to measure reaction time for silat athletes for physical and motor skills improvement. The reaction is a voluntary movement, whereas reflex action is an involuntary movement. These reactions or reflex actions are caused by sensory stimuli such as sight, smell audible, or nature (Atan & Akyol, 2014; Yadav *et al.*, 2013). The reaction time is the time taken between receiving the immediate and unexpected stimulus and reacting to it (Atan & Akyol, 2014; Yadav *et. al.*, 2013; Grigore *et al.*, 2015). However, reaction time changes based upon factors such as age, gender, condition, fatigue, high altitude, alcohol, nicotine, and use of psychotropic substances (Atan & Akyol, 2014; Prasad, 2013). An athlete who has an advantage in their physical and motor skill that are improved by training will give better performance. One of the parameters that enable an athlete to have such performance is reaction time. Athletes who perform better are said to have good reaction time than others (Atan & Akyol, 2014).

Silat requires coordination of eyes, hands, and feet simultaneously to execute the better performance. In the market, there are devices or tools that can be used to examine an individual's reaction time prior to a stimulus situation. Regrettably, there are no devices used to examine an individual's reaction time which helps to improve physical and motor skills for silat athletes. Therefore, developing a device that is able to display silat practitioners' reaction time associated with certain stimuli will provide important data for their coach to plan their training regime to improve their physical response and motor response.

The objectives of this research are first to develop a reaction timer device based on a simple reaction scale (using visual stimulation) and secondly, to evaluate the performance of the developed device on the silat athletes by performing Layang kick.

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To fulfill the objectives of the research, the scope of the research is divided into three phases. The first phase is the circuit design process, which involves the development of a reaction timer device circuit that is able to record the reaction time in milliseconds (ms). The main sensor of the circuit consists of a vibration sensor and there were three Light Emitting Diodes (LEDs) that serve as a visual stimulus. By using Proteus software, the designed circuit is simulated for testing the circuit operation. The reaction time is displayed on the Liquid Crystal Display (LCD) screen and can be saved in the SD card for later analysis. As for the second phase, which is the programming language phase, the Arduino software (IDE) is used to check its operation and to troubleshoot the programming coding.

The final phase of this research is data collection from the participants. This research was conducted on silat athletes and non-athletes for comparison purposes. The experiment was conducted in the outdoor environment. This was done because the selected subjects were trained in this environment setting. The prototype device was attached to a silat kicking pad and the participants were required to perform the Simple Reaction Time Task (SRT) based on the LEDs (red, yellow, and green) stimuli. The attached device must be able to withstand the force of the kicks from the participants. This was to ensure that the data was able to be collected and at the same time to avoid any damages to the device.

A. Visual Reaction Time

This section discussed the previous studies related to reaction time. Participated by 215 male athletes, a study was conducted to investigate the relationship between visual, auditory, and various parameters of the reaction time of athletes in various sports. Using LaFayette reaction time scale which costs more than 3000 USD (Reaction Timing, 2018), the athletes were required to press on the device that provided the stimulus immediately around 1 to 3 seconds after the 'ready' mode. This section was repeated 10 times to obtain the required information. The recorded information was analysed using a One-Way ANOVA test and correlation analysis test (Atan & Akyol, 2014).

Another study was conducted by researchers to investigate the effects of Daytime Running Lamps (DRL) on pedestrians' visual reaction time (Pena-Garcia *et al.*, 2014). The experiment was based on how 148 pedestrians reacted to the turn indicator activation in different situations. The DRL lights were placed in the holder and produced a state where the vehicle was at the height of 900 mm from the ground. The important results in this experiment were the changes of Visual Reaction Time (VRT) regarding the pedestrian's cognitive skills and gender when the turn indicator was activated during a state of bright lights DRL. These results were vital elements for carmakers, the safety of road vehicles, drivers, and pedestrians as it provides information about the probability of avoiding accidents.

There was another study that investigated the ability of a novel reaction time perimeter to detect a physiological blind spot. This survey was conducted on 11 healthy volunteers who had their blind spot location determined by using Octopus visual field blind and Saccade Triggering Stimuli (STS). The STS has time perimeter reaction at the designated location in the visual field to start saccades and followed by a Fixation Object (FO). Identification of FO was conducted by pressing the buttons provided on the left and right of the device. The time interval for pressing the buttons had been recorded and the reaction time to detect the STS with a blind spot area was compared to detect the STS at other positions in the field of vision (Knaapi *et al.*, 2015).

In addition, there was an experimental framework to run the simulator to study cognitive impairment in the driver for braking reaction time at different levels of simulation. The participants consisted of two men and a woman who asked to wear the Emotiv headset on their head. The participants could start the stimulation when the signal quality was received by the headset and each participant must perform twice the repetitive tasks. The braking response to each arousal state was recorded several times between 3 to 7 times for every driving simulation (Sena *et al.*, 2016).

Another literature study whose presented experimental design and initial results of measured reaction time using a wearable sensor. To investigate the functionality of the sensor, two different setups were designed to be tested on 5 subjects (2 females, 3 males). In the first half of the experiment (desktop-based), participants were required to respond to the visual stimulus by pressing the space bar on the keyboard while in the second half (wearable reaction time

test), they were instructed to react to visual stimulus through hand movement where the wearable sensor is attached to the dominant hand. The results showed that there is no difference in mean duration and variability of reaction times in both desktop-based and wearable reaction time tests (Cinaz *et al.*, 2011).

Lastly, a general reaction time test instrument based on jump motion was developed to measure general reaction time. In this study, the invented instrument can measure general simple reaction time, general choice reaction time, jump time, and maximum jump force. Three hundred college students were recruited to assist the experimental procedure. There are 4 groups of light that act as stimuli (arrow up, arrow left, arrow right, and circle). The subjects were required to stand on the footboard and perform jump motions in the right direction corresponding with the sign of the signal. The result obtained was sent to PC software for saving and data analysis. A time-force curve was generated to show the jump process which correlates with the general reaction time (Yue & Kefei, 2013).

II. DESIGN AND DEVELOPMENT OF REACTION TIMER DEVICE

Figure 1 shows the overall block diagram of the proposed reaction timer device. As depicted in Figure 1, the Arduino UNO was used as the main microcontroller to control the selection of the visual stimulants (red, yellow, or green LED) as well as to receive the input from the vibration sensor once it senses the kicking impact. When the stimulant is selected, the response counter starts to count time in ms and this information is displayed on the LCD screen. The reaction timer counter will stop counting when the input from the vibration sensor is received by the microcontroller. The reaction time will be saved in the SD card for later retrieval. The next trial can be done by pushing the reset button.

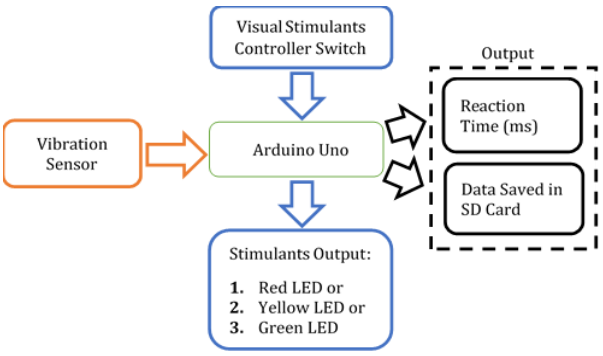

Figure 1. The block diagram of reaction timer device using Arduino UNO

A. Subject Consideration

Subject consideration is a vital aspect and hence, it was decided to collect the data from two subject categories; i) the silat performers and ii) non-athletes who did not practice silat. Table 1 shows the subject consideration based on the subjects and weight categories. Two persons were selected from each weight category as proposed by the sports center of UTHM. One of them was selected based on their best achievement in the tournament ("*") meanwhile the other one did not have any achievement yet. There were three persons from the non-athlete category that served as a control variable in which their weights fall within the same silat weight category.

Table 1. Subject consideration based on weight category

	Non-athlete person	**Silat athlete**
Subject category	Not active in sports (N)	A*, A, D*, D, F*and F
Weight category (kg)	NA (50-55) ND (65-70) NF (75-80)	A* (50-55) A (50-55) D* (65-70) D (65-70) F* (75-80) F (75-80)
Number of participants	One non-athlete subject for each weight category whom does not participate in any combat sport	Two subjects for each type of category. One with achievement in tournament ("*") and the one without any achievement
Skill to be assessed	Layang kick	

To ensure the collected data is constant and fair, the participants were required to perform a Layang kick and repeat the same kicking five times. The Layang kick is one type of silat skill usually performed during training and therefore has been selected to measure the speed of the kick using reaction time measurement.

B. Visual Stimulation Consideration

Visual stimulation is a visual scale that will be presented to subjects for the measurement of reaction time. For example, once the LED lights up, the subject must respond to the triggered stimuli as fast as possible. The user must focus on the visual stimulation and need to react as soon as possible so that the reaction time in ms can be obtained. As in a paper by Pena-Garcia *et al.* (2014), the VRT scale used the bright DRL which was made from a combination of bright LEDs or a white small bright light bulb. Meanwhile, in research by Prasad (2013) and Yanqun *et al.* (2013), the method for VRT consisted of different colors of LED namely red, yellow, and green.

By considering previous studies that have been done so far on VRT, it can be concluded that various types of light sources can be used with different colors, sizes, and brightness. In accordance with the previous study, the bright LEDs consisting of red, yellow and green have been chosen in this study to serve as the VRT scale stimulation. The LED is chosen not only because it is cheap but also very easy to get and provides reasonable complexity of reaction time measurement.

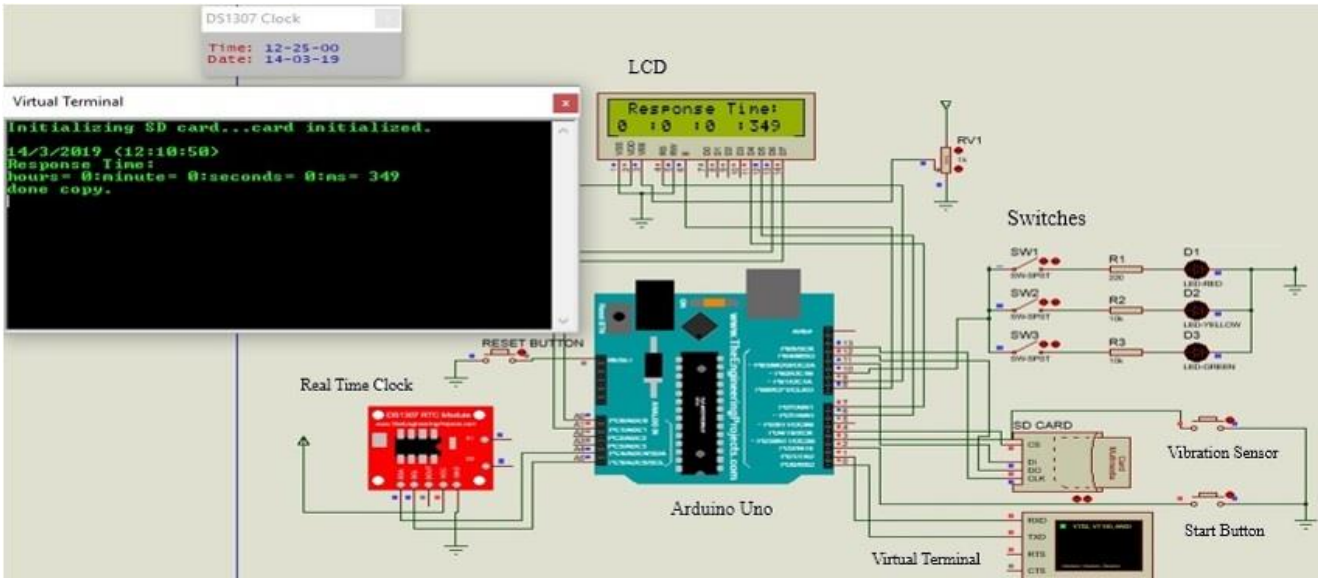

Figure 2. The Proteus simulations of reaction timer device

C. Development of Hardware and Software

Meanwhile, Figure 2 presents the circuit diagram drawn using Proteus which consists of main components such as Arduino UNO, real-time clock (RTC), liquid crystal display (LCD), SD card, start button, reset button, vibration sensor, and switches for controlling visual stimulants. The Arduino UNO had been used in this project since its pin (input/output) could support the overall circuit connection. The Real-Time Clock (RTC) was used to state the current time and date which was useful to clock in the time when the reaction time data were saved into the SD card memory. The SD card module was used to enable the retrieval of data from the SD card memory. Two pushbuttons' switches were used, one was for the start button and another one was for the reset button. The 9 VDC battery was used to power up the circuit. The LCD 16x2 was used in this project since it can fulfill the requirement for display purposes. Resistor 220 Ω was used to limit the current and voltage flow of the circuit that connected to certain components to provide a safety measure for the components. The silat kick pad was obtained from UTHM Sports Center and the three LEDs (red, yellow, and green) were used as the Visual Reaction Time (VRT) scale stimulant.

Figure 3 illustrates the flowchart of the reaction timer device. The user selects the stimulus by using visual

stimulants controller switch. Depending on the user's choice, one of the stimulus LEDs (LED 1 (red), LED 2 (yellow), or LED 3 (green)) will light up. The timer coding in the Arduino would start to count the response upon triggering the stimulus. The subjects were to respond to the stimulus by performing kicking action on the kick pad with the vibration sensor switch attached to it. The vibration sensor switch was used to detect the vibration when receiving the impact from the kicking force and stopped the counter-response. The reaction time of the subjects will be displayed on the LCD and saved into the SD card.

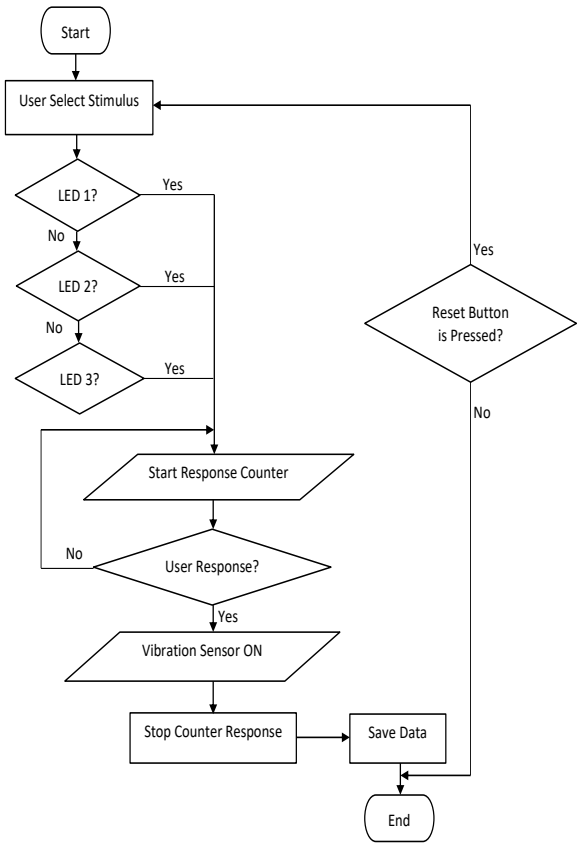

Figure 3. The flowchart of reaction timer device for data collection

D. Experiment Protocol for Simple Reaction Time Task (SRT)

Before conducting the experiment, the subjects were recruited, and the procedure of the research was explained in detail. Once they agreed, they were required to fill up the written consent form. The data provided by the participants were recorded in the SRT table in which the participants were required to execute the Layang kick on the kick pad based on the LED stimuli. Participants were informed to conduct five trials to obtain the average reaction time in ms. For example, participants were asked to kick the kick pad when the red LED light was turned on and this process was repeated five times. Then, other responses for yellow and green LEDs would be recorded too for assessment purposes. The subject was required to take 1-minute rest after each kicking action.

III. RESULTS AND DISCUSSIONS

This section provides evaluation and discussion on the developed prototype and the data obtained from the reaction timer prototype. The data were obtained from nine participants of which six participants were from silat background while remaining were from non-athlete background.

A. Reaction Timer Device

Figure 4 shows the front view of the silat kick pad with the attachment of the hardware prototype. The designed hardware was placed in between the two layers of leather to prevent impact on it when the Layang kick was performed. Hence, the PCB and the wiring were covered inside the layer. The vibration sensor switch had been soldered at the stripboard and was layered with the sponge between the surface of the silat kick pad and the leather. The elastic strap (hook style) was used to hook the leather of the prototype. Table 2 summarised the functions of each numbering item corresponding to Figure 4.

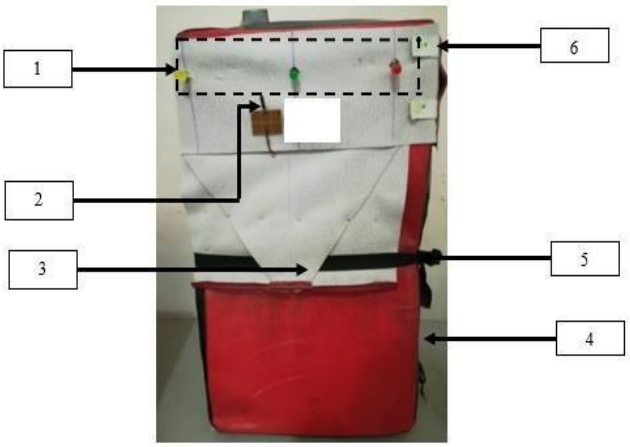

Figure 4. Front view of hardware prototype attached on the kick pad

Table 2. Function for each numbering based on Figure 4

No.	Name	Descriptions
1.	VRT scale	Contain red, yellow and green LEDs
2.	Vibration sensor switch	Used as a triggering switch to detect vibration to stop the reaction counting time
3.	Aim or target	Used as a target for silat athlete to kick at that part. The aim has vibration sensor switch that attached behind the layer covered with sponge and leather.
4.	Silat kick pad	A kick pad that used by silat athlete during training.
5.	Leather strap	Used to tie the Aim onto the silat kick pad body.
6.	Elastic strap (hook style)	Used to tie the body of prototype appropriately onto the silat kick pad body.

Figure 5 shows the back view of the silat kick pad that contained all processing components. The back view of the silat kick pad had an arm holder designed to enable the coach or trainer to firmly hold the pad. There was the 9V battery with its cover and a Real-Time Clock (RTC) used to provide the current date and time. Meanwhile, the SD card module was used to store the reaction time data from the LCD display. The switching buttons were used to trigger starting and resetting, whereas the user selection was controlled by the slide switch. The LCD screen, which is used to display the reaction time was connected to a variable resistor for adjusting the brightness of the LCD screen. Table 3 summarises the function for each numbering item corresponding to Figure 5.

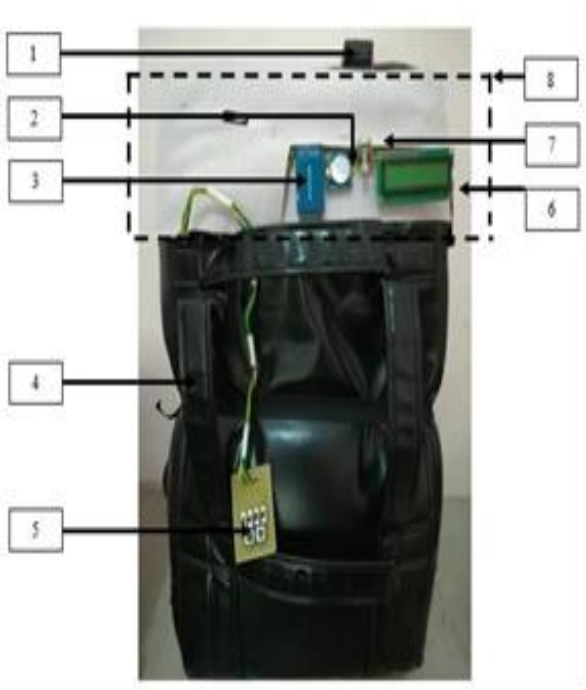

Figure 5. Back view of silat pad

Table 3. Function for each numbering based on Figure 5

No.	Name	Descriptions
1.	9V battery with cover	Supplied the voltage into Arduino. Containing switch on/off cover.
2.	Real Time Clock (RTC)	Provide current time and date.
3.	SD card module	Occupied with SD card memory to save the response time data
4.	Arm holder	Used to hold the kick pad
5.	Multiple-choice reaction scale switching	Used to control the switch button for LEDs and at the same contain start and reset button switch
6.	LCD screen	Display the response time counter
7.	Variable resistor	Used to adjust the LCD screen contrast
8.	Processing unit	The processing unit that contains Arduino UNO, RTC, SD card, LCD screen, and variable resistor

B. Assessment on Reaction Time

As mentioned previously, the participants came from two different backgrounds. The first one is silat athlete which can be categorised as A* (50-55 kg), A (50-55 kg), D* (65-70 kg), D (65-70 kg), F* (75-80 kg) and F (75-80 kg) meanwhile non-athlete who was not actively in sport has been categorised as NA (50-55 kg), ND (65-70 kg) and NF (75-80 kg). There were in total of nine participants whom six of them were silat athletes whereas the remaining were non-athlete participants. In this study, a small sample size of subjects was used due to the shortage of silat athletes available during the study being conducted. Moreover, the number of subjects was sufficient in this study because they were intended only to test whether the device could be performed as expected. The athletes were required to observe the stimulation and they need to respond after receiving the VRT scale signal. The trainer must control the switching and at the same time holding the silat kick pad. For the evaluation of the subject's average reaction time, the participants must perform their kicking for five trials. The average reaction time (in ms ± standard deviation) was calculated by adding all the time and dividing it by five (number of trials). Figure 6 shows the average reaction time of visual stimulation for the red LED. It can be concluded that the best average reaction time was from D (65-70 kg) subject which was 443.8 ± 14.3 ms meanwhile the worst came from ND (65-70 kg) subject that is 774 ± 129.6 ms.

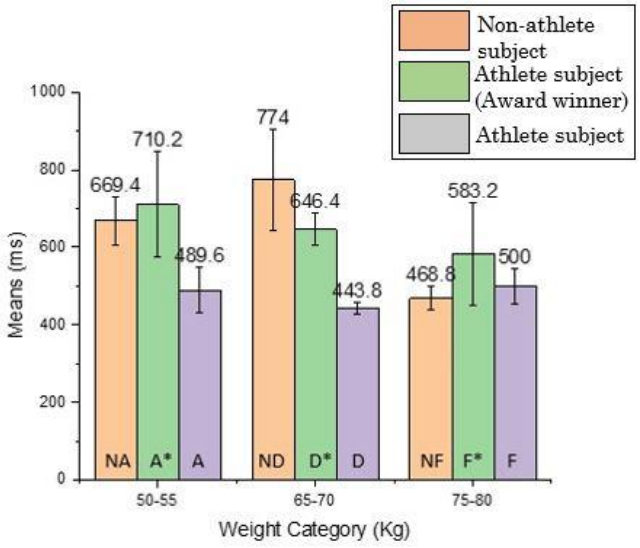

Figure 6. Average reaction time (ms) for red LED

Figure 7 shows the summary of the average reaction time of visual stimulation for yellow LED. It can be concluded that the best average reaction time was from NF (75-80 kg) subject (417.4 ± 11.5 ms) whereas the worst came from ND (65-70 kg) subject which was 700.4 ± 52.9 ms.

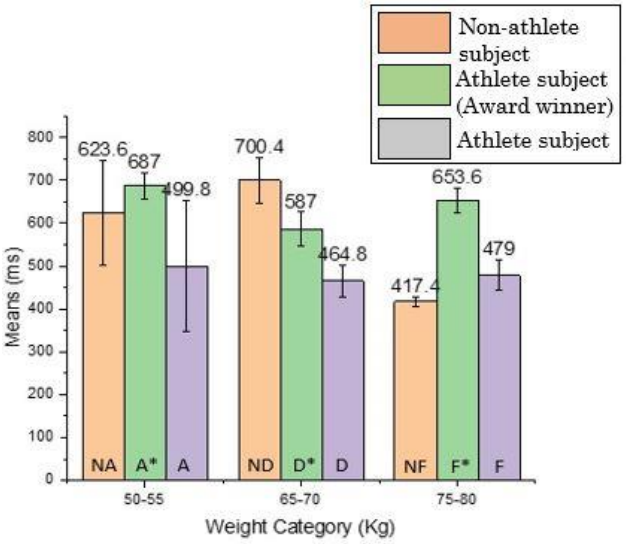

Figure 7. Average reaction time (ms) for yellow LED

Figure 8 shows the average reaction time on visual stimulation for the green LED. Based on the figure, the best average reaction time had been achieved by candidate NF (75-80 kg) which was 408.8 ± 15.8 ms and the worst one came from candidate ND (65-70 kg) which was 725.6 ± 115 ms.

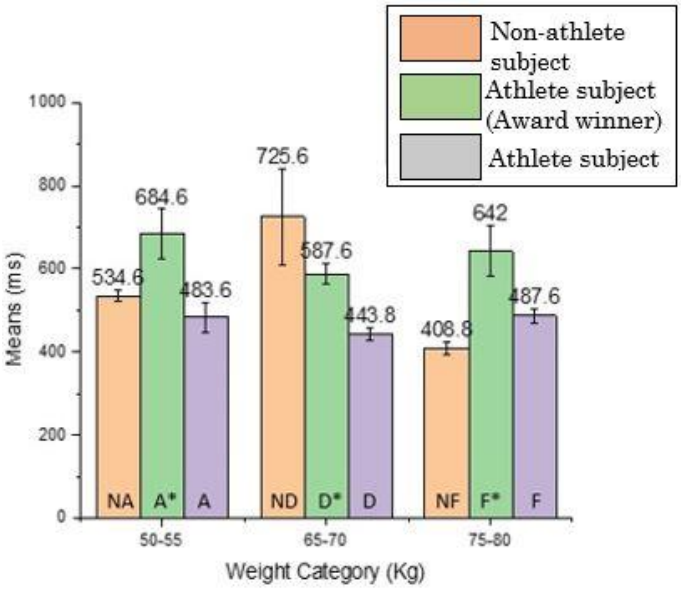

Figure 8. Average reaction time (ms) for green LED

Table 4 shows the means and standard deviation for all LEDs (red, yellow, and green). Based on this table, it can be deduced that 66.7 % of the participants reacted fastest towards green LED as compared to red and yellow LEDs. The exact reason for this is unknown, but it is speculated that the green color is more preferable by the subjects to other tested colors. In contrast, only two participants reacted fastest in response to red and yellow LEDs, however, given that subject D (65-70kg) recorded the shortest reaction time in response to both, red and green LEDs. The standard deviation provides the measure of how to spread out the data for five trials conducted in this experiment. For example, participant NF (75-80 kg) recorded a reaction time of 417.4 ± 11.5 ms, which was the lowest standard deviation value as compared to others. A smaller standard deviation value indicated that within the five trials, the participant manages to record the reaction time not so much different than the mean value of the reaction time. Thus, the reaction time of participant NF (75-80 kg) was quite consistent throughout the five trials, which contributes to its smaller standard deviation value.

Further analysis on benchmarking the reaction time measurement with the existing system or approach could not be carried out because to the authors' knowledge, the existing system has not being used yet by any silat community or other combat sports communities.

Table 4. Means and standard deviation of reaction time corresponding to LEDs

Weight Category (Kg)	LEDs		
	Red LED (ms)	Yellow LED (ms)	Green LED (ms)
NA (50-55)	669.4± 62.9	623.6± 123.3	**534.6± 13.4**
A* (50-55)	710.2± 136.2	687±31.3	**684.6± 59.3**
A (50-55)	489.6± 59.6	499.8±153.6	**483.6± 35.7**
ND (65-70)	774± 129.6	**700.4± 52.9**	725.6± 115
D* (65-70)	646.4± 41.6	587± 38.6	**587.6± 24.7**
D (65-70)	**443.8± 14.3**	464.8± 36.3	**443.8± 14.3**
NF (75-80)	468.8± 29.9	417.4± 11.5	**408.8± 15.8**
F* (75-80)	**583.2± 133.3**	653.6± 29.1	642± 61
F (75-80)	500± 45.5	**479± 35.6**	487.6± 16.5

IV. CONCLUSION

This research was conducted with the aim to investigate the reaction time of athletes based on visual stimulation so that their physical and motor skills can be improved. The designed device was able to measure the reaction time of each subject and the data was successfully saved in the SD card for further analysis. There are some limitations that cause the results obtained to be inconclusive. Firstly, the physical and mental conditions of the subject may affect the reaction time recorded. Secondly, the study is constituted by a small sample of subjects. Nevertheless, this sample was sufficient since the subjects were used only for testing the performance of the prototype. It can be seen that obtaining the reaction time from each participant will provide useful information to the coaches so that the training strategies can be adjusted to improve the reaction time. Silat practitioners need a faster reaction time to cope with their opponent's attack and to counter at the same time. Hence, the designed device will indirectly help them to focus on visual stimuli, as they need to be alerted on the incoming attack from their opponent during the tournament. Lastly, it can be concluded that the visual cognitive of 66.7 % of participants are more responsive towards green LED as compared to red and yellow LEDs. The exact reason is unknown, but it is speculated that the green color is more preferable by the subjects to other tested colors.

For future works, there are several recommendations that can be done. Firstly, it is strongly suggested to improve the

design of the hardware in terms of circuitry and better housing for the hardware. For instance, a new mechanism to prevent the LCD screen from receiving the impact from the kicking force of the subjects that will contribute to unknown values and words appearing on the LCD screen. Secondly, it is highly recommended to add audio stimulation to investigate changes in reaction time. Thirdly, a multiple-choice reaction time task (MRT) can be experimented with by combining audio and visual stimulants. Fourthly, the collected data was focused only on male participants from silat backgrounds. It is recommended to consider the measurement of reaction time for female participants as well as from other branches of combat sports. Finally, a study on the difference in reaction time using SRT and MRT experiments can be conducted in the indoor setting environment to investigate any differences in reaction time value when conducting at the different setting environments.

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