COMPARISON OF EXECUTION TIMES OF *KAEDAH A* FOR DIFFERENT MOVEMENT TRAJECTORIES USING VIRTUAL SENSEI LITE

Mohd Firdaus Abdul Razak[1,5*], Mohd Saiful Aizat Mohd Shafie[2,5], Muhamad Sharafee Shamsudin[3,5], Muhamad Faris Che Aminudin[4,5],

[1]School of Civil Engineering, Universiti Sains Malaysia, Nibong Tebal, Penang
[2]School of Mechanical Engineering, Universiti Sains Malaysia, Nibong Tebal, Penang
[3]School of Chemical Engineering, Universiti Sains Malaysia, Nibong Tebal, Penang
[4]School of Electrical and Electronic Engineering, Universiti Sains Malaysia Nibong Tebal, Penang
[5]Persatuan Seni Silat Cekak Malaysia

[*]Email: firdausrazak86@gmail.com
(Received 26 March 2019; accepted 13 May 2019; published online 1 January 2020)

To cite this article: *Abdul Razak, M. F., Mohd Shafie, M. S. A., Shamsudin, M. S., Che Aminudin, M. F. (2020). Comparison of execution times of Kaedah A for different movement trajectories using Virtual Sensei Lite. Malaysian Journal of Movement, Health & Exercise, 9(1), 9-17.* *https://doi.org/10.15282/mohe.v9i1.385*
Link to this article: *https://doi.org/10.15282/mohe.v9i1.385*

Abstract

The main objective of this study is to compare the execution times produced by fending off techniques of Seni Silat Cekak Malaysia (SSCM), *Kaedah A* for different movement trajectories. Three kind of movement trajectories for *Kaedah A* were carried out, which were Trajectory A (normal path), Trajectory B (curve path) and Trajectory C (starting by pulling the hand to the back and continue as Trajectory A). The experiments were conducted using a motion capture system. The movement position of the left hand during the execution of *Kaedah A* were recorded by a Kinect sensor, prior to storing and processing via Virtual Sensei (VS) Lite software. A total of four (4) experienced practitioners from SSCM were selected to perform *Kaedah A* techniques. The data acquired were further analyzed to determine their kinematic characteristics. The results showed that the execution of *Kaedah A* using Trajectory A produced the shortest time and highest velocity with averages of 0.071±0.007s and 6.438±0.863ms^{-1} respectively, compared to Trajectory B (0.087±0.011s, 5.230±0.578 ms^{-1}) and Trajectory C (0.149±0.015s, 2.903±0.273ms^{-1}). Therefore, Trajectory A is considered to be more efficient than Trajectory B and Trajectory C in terms of execution times and maximum velocity produced by *Kaedah A.*

Keywords: Kaedah A, Execution Time, Martial Art, Motion Capture, Seni Silat Cekak Malaysia

Introduction

Kaedah A is one of the fend off technique~~s~~ from *Seni Silat Cekak Malaysia* (SSCM) (Traditional Malay martial art) specifically for self-defense. This technique has been inspired by the act of *'Doa'* in Muslim *Solah*, and is executed to avert an attack such as punch within the thorax abdomen area (PSSCM, 2018; Mustapha et al. 2014a). According to Mustapha et al (2014a), the average execution time of *Kaedah A* was determined to be less than 0.1s, which is an effective reaction towards a punch.

In addition to the standard trajectory of *Kaedah A*, there are another two types of trajectories often executed, especially by the beginners during training in the class (Shahdan, 2019; Johari, 2019). Such trajectories can be differentiated as follows (see Figure 2): (a) Trajectory A: normal/standard path; (b) Trajectory B: curve path; and (c) Trajectory C: started by pulling the hand to the back and continue as Trajectory A. The execution time of less than 0.1s mentioned earlier was measured for Trajectory A. It was expected that the execution times for Trajectories B and C would be longer than Trajectory A due to its additional pathway. In addition to fitness, experience, skill, and performance (Thomas & Thomas, 1994; Mohammed Shapie et al., 2018), execution time appears to be a key element in any martial arts technique to counter the opponent (Falco et al. 2011; Vieten et al. 2007). In SSCM, the shortest execution time gives an advantage to the practitioners to avert an attack, thus preventing any injuries. Nonetheless, the actual execution times for the trajectories mentioned have not been measured and compared systematically. Such measurement is crucial, as it determines the best and most effective trajectory for *Kaedah A* fend-off technique, which eventually would determine whether this technique could save the practitioner in real fighting situation. Furthermore, the output data together with practitioner's understanding of the technique used would boost confidence during training session and enhance their performance (Mustapha et al. 2014b). Therefore, the aim of the study is to compare the execution times produced by *Kaedah A* with three (3) different movement trajectories while averting an incoming attack. Virtual Sensei (VS) Lite incorporated with Kinect sensor were utilized in acquiring raw data and further analyzed using MATLAB.

Over the past few years, motion analysis system has become ~~a~~ widely used research tool specifically in martial art study (Polak et al., 2016; Mustapha et al. 2016). Availability and low cost features of VS Lite which was developed by Alesandro Timmi makes it interesting and suitable to be utilized in current study, in addition to having high reliability and being markerless (Virtual Sensei, 2018; Mustapha et al. 2014c). This motion capture system can facilitate the task by tracking and providing three-dimensional positioning data of human body motion. By further post-processing and analyzing the data, kinematics characteristics including execution time can be generated (Mustapha et al. 2014a)

Methodology

Subject and Equipment

Four (4) healthy and experienced male practitioners (more than five years) from SSCM provided informed consent and were chosen as the subjects for this experiment. Their physical characteristics are presented in Table 1.

Table 1: Descriptive statistics of physical characteristics of subjects (N=4)

Physical Characteristics	Mean ± SD
Age (years)	29.25 ± 1.64
Height (cm)	170.75 ± 4.02
Mass (kg)	73.50 ± 11.41

*cm = centimeter, kg = kilogram

The equipment used in the study consists of a Kinect sensor for capturing and recording whole body movement, and VS Lite software for data processing. Kinect sensor utilized in current study have the capability to record body motion in 3-D position (x, y, and z-axis) at the speed of 30 frame per second (fps), before VS lite reproduced the movement at 100 fps. VS lite can track fifteen (15) skeleton points of the human body, but the current study only considers the points on the left hand for further analysis.

Experimental Setup

The experiment was arranged as illustrated in Figure 1. Subject stands 2.5 meters away facing the Kinect sensor which is the optimum distance for the whole body to be recorded. To optimize the capability of the Kinect sensor, experiments were conducted in an empty room with good lighting source and the subjects were required to wear tight outfits to reduce measurement error.

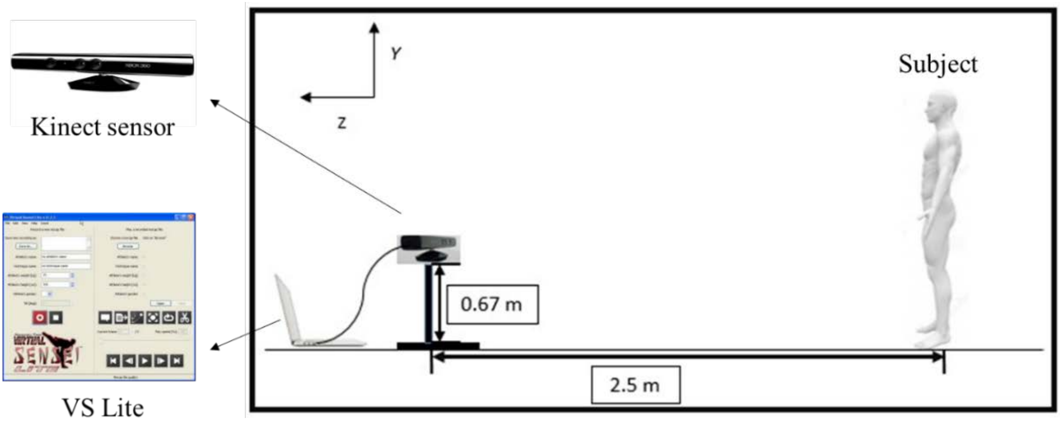
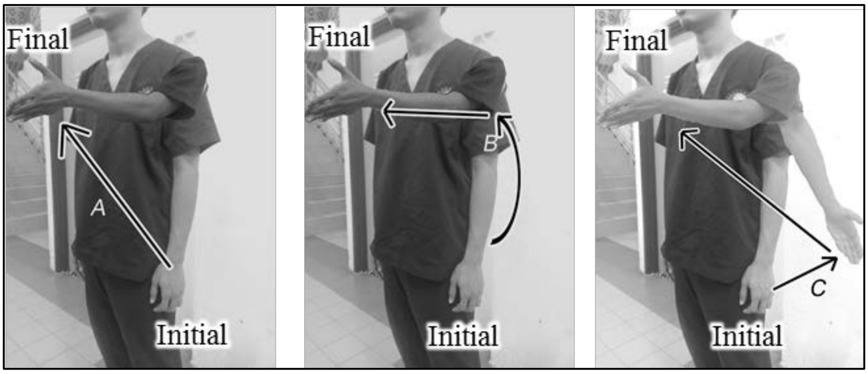


Figure 1: Schematic diagram of experimental setup.

Each subject was required to perform *Kaedah A* technique using left hand for three types of movement trajectories (three-time repetition each) as follows (refer Figure 2):

i. Trajectory A: normal path for the execution of *Kaedah A*, where the left hand moves from initial to final position with straight line as if 45° from vertical axis
ii. Trajectory B: the left hand moves from initial to final position with a curved path
iii. Trajectory C: the left hand pulls at the back and continues to move forward as trajectory A

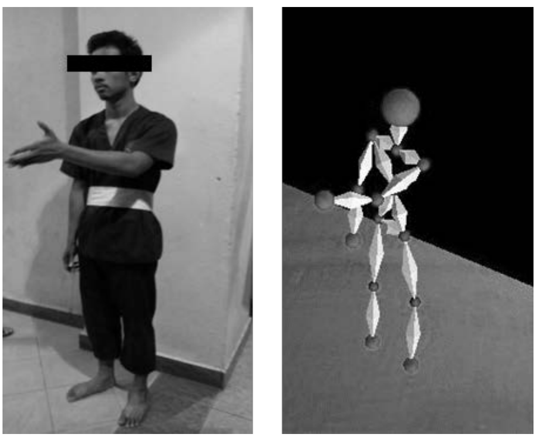


(a) Trajectory A (b) Trajectory B (c) Trajectory C

Figure 2: Three types of movement trajectories when executing *Kaedah A*

Data Visualizing and Analyzing

The body image as well as its motion was detected by the Kinect sensor, before it was transferred to VS Lite which visualized it as a skeleton image with 15 body landmarks (refer Figure 3). When performing *Kaedah A*, these 15 point positions (x, y, and z-axis coordinate) were recorded and saved into the Excel file format. Then, the left hand data point (y-axis) was extracted, and further calculation of their execution time and maximum velocity was performed using MATLAB.



(a) Practical (b) VS Lite

Figure 3: Skeleton views by VS Lite during execution of *Kaedah A*

The total time of the execution, t_e of *Kaedah A* can be defined as the interval between initial time, t_i and final time, t_f as indicated by equation [1]. t_i is the point where the hand starts to move while t_f is measured at the presumed intersection of the hand with the punch line of action.

$$t_e = t_f - t_i \qquad [1]$$

Maximum velocity, V_{max} (velocity at t_f) of the hand motion was calculated based on the kinematics equation as followed (Knudson, 2007).

$$V_{max} = \frac{\Delta d_y}{t_f} \qquad [2]$$

Δd_y = displacement in y-axis

Result and Discussion

Results of execution time and maximum velocity produced from three different trajectories of *Kaedah A* are shown in Table 2 and Figure 4. Trajectory A had the shortest execution time, with an average of 0.071±0.007s, followed by Trajectory B (0.087±0.011s) and Trajectory C (0.149±0.015s). Besides, the highest maximum velocity is produced by Trajectory A with average velocity of 6.438±0.863ms^{-1}, higher than Trajectory B and C by 18.76% and 54.91%, respectively. The results obtained were found to be consistent for each subject.

Results showed that Trajectory A gave the fastest execution time (0.071±0.007s) to perform *Kaedah A* due to the shortest distance to travel compared to both Trajectory B (0.087±0.011s) and C (0.149±0.015s). This also verifies the hypothesis by Razak et al (2017) which also claimed that Trajectory A is faster than Trajectory B. Shortest execution time taken for *Kaedah A* in SSCM is a very important factor towards fending off incoming attacks thus preventing any risks of possible injuries. This will give advantages to the practitioner to counterattack the opponent after repelling their attack (Ismail & Ahmad, 2017). In addition, it can also be concluded that execution time is inversely proportional to maximum velocity of *Kaedah A*. This indicates that *Kaedah A* can generate highest impulse force to the incoming attack compared to Trajectory B and C (Razak et al. 2017).

Table 2: Comparison of execution time and maximum velocity of three different *Kaedah A* trajectories for each subject

Path	Parameter	Subject 1	Subject 2	Subject 3	Subject 4	Average
Trajectory A	Execution Time, t_e (s)	0.080 ±0.013	0.064 ±0.006	0.068 ±0.010	0.070 ±0.000	0.071 ±0.007
	Max. Velocity, V_{max} (ms^{-1})	5.701 ±0.944	7.532 ±0.480	6.408 ±1.457	6.111 ±0.571	6.438 ±0.863
Trajectory B	Execution Time, t_e (s)	0.100 ±0.018	0.075 ±0.007	0.088 ±0.011	0.082 ±0.006	0.087 ±0.011
	Max. Velocity, V_{max} (ms^{-1})	4.634 ±0.636	6.254 ±0.735	4.599 ±0.279	5.435 ±0.663	5.230 ±0.578
Trajectory C	Execution Time, t_e (s)	0.149 ±0.017	0.149 ±0.013	0.154 ±0.009	0.146 ±0.022	0.149 ±0.015
	Max. Velocity, V_{max} (ms^{-1})	3.007 ±0.240	2.598 ±0.185	2.870 ±0.333	3.139 ±0.378	2.903 ±0.273

*s = second, ms^{-1} = meter/second

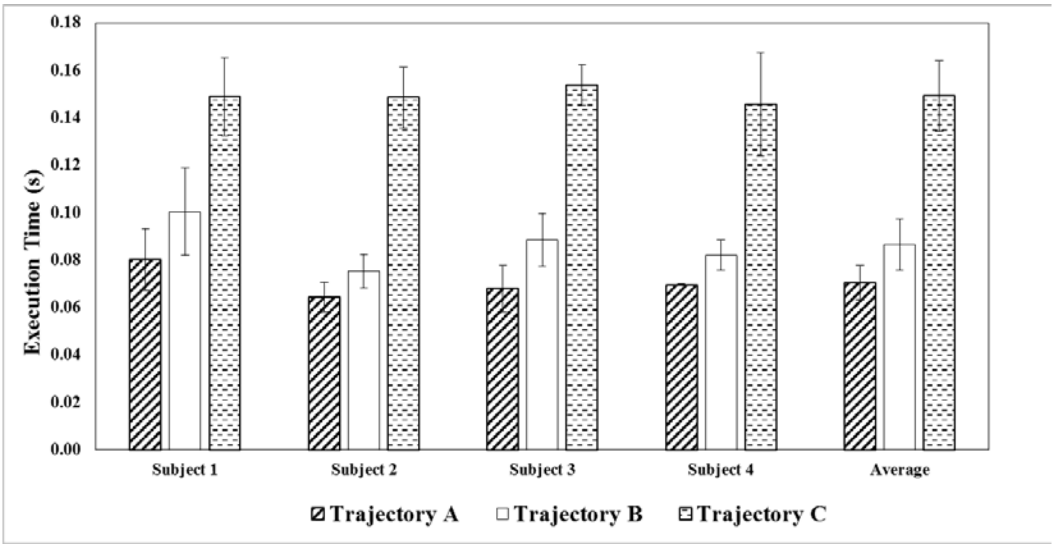


Figure 4: Execution time produced for different trajectories and subjects

Apart from that, the locus of *Kaedah A* itself also affected its execution time and maximum velocity. Having a linear locus facilitates Trajectory A to fend off the incoming attack quicker and more efficient since it has the shortest distance. On the other hand, Trajectory B has a curve locus which increased the travel distance hence increased execution time and reduced its velocity. The poorest performance of *Kaedah A* occurred while using Trajectory C. This was mainly caused by the negative locus (the hand move backward) during the initial stage of execution of *Kaedah A*. The effect of this infinitesimal negative locus caused Trajectory C to record 109.86% later execution time. It was slower by 54.91% compared to Trajectory A. These vast differences prove that Trajectory C is not suitable to be applied to *Kaedah A.* Thus, *Kaedah A* using Trajectory A was proved to be more efficient than Trajectory B and C in terms of execution times and maximum velocity.

Conclusion

The aim of this study has successfully determined and compared the kinematic characteristics of *Kaedah A* for three different trajectories using VS Lite. Trajectory A has been identified as the fastest pathway with average execution time of 0.071±0.007s and average maximum velocity of 6.438±0.863ms^{-1} during execution of *Kaedah A* compared to Trajectory B and C. Therefore, Trajectory A is considered the optimum path for *Kaedah A* to avert the incoming attack with regard to execution time taken and maximum velocity generated. Suggestions for further study include the determination of efficiency of Trajectory A in term of kinetic and potential energy, as well as the force produced by *Kaedah A.*

Acknowledgement

The authors would like to acknowledge Persatuan Seni Silat Cekak Malaysia (PSSCM) for providing research fund and equipment to facilitate the study.

Conflict of interest

There are no conflicts of interest to declare

References

Ismail, A. M. & Ahmad, S. (2017). 'Nilai seni dalam silat tempur: rujukan kes Seni Silat Cekak Malaysia', in Proceeding 7th International Conference on Local Knowledge 2017 (ICLK): Engaging Local Wisdom in the New Millenium, Sekretariat Kearifan Tempatan, Universiti Sains Malaysia, ms 170-178.

Falco, C. Estevan, I. and Vieten, M. (2011) 'Kinematical analysis of five different kicks in Taekwondo', *Portuguese Journal of Sport Sciences*, 11 (Suppl. 2) pp 219-222.

Johari, S. (2019). Interview with the author. Nibong Tebal, Penang. [En Nezam Shahdan is an experienced instructor of Persatuan Seni Silat Cekak Malaysia, having more than 25 years experience in teaching SSCM in Universiti Sains Malaysia].

Knudson, D. (2007). *Fundamentals of biomechanics*, 2nd Edition, New York: Springer

Mohamed Shapie, M. N., Oliver, J., O'Donoghue, P., and Tong, R. (2018). Effect of circuit training on fighting performance of young silat athletes - a case study. *Movement, Health & Exercise*, 7(1), 27-41. https://doi.org/10.15282/mohe.v6i2.157

Mustapha, G. Zakaria, M. Sulaiman, W. R. W. and Mahmud, J. (2014a) 'The Mechanical Aspects of Martial Arts: Total Time of Execution and Kinematics of Kaedah A', in Book Chapter, Proceedings of the International Colloquium on Sport Sciences, Exercise, Engineering and Technology 2014 (ICoSSEET 2014), Springer, pp 3-12. https://doi.org/10.1007/978-981-287-107-7_1

Mustapha, G. Sulaiman, W. R. W. Majeed, A. P. P. A. Yahya, N. H. M. and Mahmud, J. (2014b) 'Kinematics and Efficacy Analysis of the Seni Silat Cekak Malaysia (Kaedah A)', *Applied Mechanics and Materials*, 680, pp 267-270. https://doi.org/10.4028/www.scientific.net/AMM.680.267

Mustapha, G. Shafie, M. S. A. M. Yahaya, N. H. M and Mahmud, J. (2014c) 'Measurement system analysis of VS lite', *Applied Mechanics and Materials*, 680, p. 447-450. https://doi.org/10.4028/www.scientific.net/AMM.680.447

Mustapha, G. Razak, M. F. A. Hamzah, M. S. M. Yahya, N. H. M. and Mahmud, J. (2016) 'The development of a low cost motion analysis system: Cekak Visual 3D v1.0', *International Journal of GEOMATE*, 11(24), pp. 2248-2252. https://doi.org/10.21660/2016.24.1393

Polak, E. Kulasa, J, Vencesbrito, A. Castro, M. A. Fernandes, O. (2016) 'Motion analysis systems as optimization training tools in combat sports and martial arts', *Revista de Artes Marciales Asiaticas*, 10(2), pp. 105-123. https://doi.org/10.18002/rama.v10i2.1687

PSSCM, (2018) *Portal rasmi Persatuan Seni Silat Cekak Malaysia*, Available at: https://www.silatcekak.org.my (accessed: 11 February 2018).

Razak, M. F. A. Shafie, M. S. A. and Ahmad, N. (2017). '*Konsep hukum newton dalam Seni Silat Cekak Malaysia'* dalam Nazarudin Zainun & Mohamad Omar Bidin (edt.), Pelestarian Silat Melayu Antara Warisan dan Amalan, Universiti Sains Malaysia, pp. 108-120.

Shahdan, N. (2019). Interview with the author. Nibong Tebal, Penang. [En Nezam Shahdan is an experienced instructor of Persatuan Seni Silat Cekak Malaysia, having more than 25 years experience in teaching SSCM in Universiti Sains Malaysia].

Thomas K. T, Thomas J. R. (1994) Developing expertise in sport: the relation of knowledge and performance. *Int J Sports Psychol* 25(3): 295-312.

Vieten, M., Scholz, M., Kilani, H. and Kohloeffel, M. (2007). Reaction time in Taekwondo. In H.J. Menzel & M.H. Chagas (Eds.), Proceedings of the 25th International Symposium on Biomechanics in Sports (pp. 293-296). Ouro Preto: Brazil.

Virtual Sensei. (2018) *Virtual Sensei: discover you kinetic energy*^{TM}, Available at: http://www.virtualsensei.it/ (accessed: 11 February 2018).