กระบวนการระบุตัวตนโดยใช้ความสามารถในการรับรู้ภาพด้วยตาร่วมกับแบบรูปการเคาะแป้นพิมพ์

นางสาวกนกพร โนนศรีชัย

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย

บทคัดย่อและแฟ้มข้อมูลฉบับเต็มของวิทยานิพนธ์ตั้งแต่ปีการศึกษา 2554 ที่ให้บริการในคลังปัญญาจุฬาฯ (CUIR)
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AUTHENTICATION PROCESS USING EYE VISION WITH KEYSTROKE PATTERNS

Miss Kanogporn Nonsrichai

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Computer Science and Information Technology

Department of Mathematics and Computer Science

Faculty of Science

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กนกพร โนนศรีชัย : กระบวนการระบุตัวตนโดยใช้ความสามารถในการรับรู้ภาพด้วยตาร่วมกับแบบรูปการเคาะแป้นพิมพ์. (AUTHENTICATION PROCESS USING EYE VISION WITH KEYSTROKE PATTERNS) อ.ที่ปรึกษาวิทยานิพนธ์หลัก : ผศ.ดร.ภัทรสินี ภัทรโกศล, 103 หน้า.

ปัจจุบันการระบุตัวบุคคลด้วยข้อมูลทางชีวภาพนั้นเป็นเทคโนโลยีที่นำมาใช้ในการรักษาระบบความปลอดภัยของข้อมูลทางคอมพิวเตอร์อย่างกว้างขวาง เนื่องจากเป็นเทคโนโลยีที่ให้ผลลัพธ์ที่มีประสิทธิภาพและความแม่นยำสูง อย่างไรก็ตามส่วนใหญ่การระบุตัวบุคคลด้วยข้อมูลทางชีวภาพนั้นต้องอาศัยอุปกรณ์พิเศษเพิ่มเติมในการรับข้อมูล การระบุตัวบุคคลโดยอาศัยข้อมูลจังหวะในการพิมพ์ของแต่ละคนนั้นเป็นหนึ่งในวิธีในการระบุตัวบุคคลด้วยข้อมูลทางชีวภาพที่ไม่ต้องอาศัยอุปกรณ์พิเศษใดๆ เพิ่มเติมนอกจากแป้นพิมพ์ ดังนั้นเทคโนโลยีจึงมีประโยชน์อย่างมากในการเอามาประยุกต์ใช้กับระบบต่างๆ บนอินเทอร์เน็ต แต่น่าเสียดายที่ยังมีข้อบกพร่องของการระบุตัวบุคคลโดยใช้ข้อมูลจังหวะในการเคาะพิมพ์ของบุคคลอยู่ เมื่ออารมณ์ของบุคคลนั้นๆ เปลี่ยนไปผลลัพธ์ที่ได้ก็ไม่ถูกต้องสมบูรณ์ ดังนั้นความแม่นยำของการระบุตัวบุคคลด้วยข้อมูลจังหวะในการเคาะแป้นพิมพ์นี้สามารถเพิ่มขึ้นได้โดยการประยุกต์รวมใช้กับวิธีการระบุตัวบุคคลด้วยข้อมูลทางชีวภาพอื่นๆ อาทิ การสแกนลายนิ้วมือและม่านตา เป็นต้น แต่การนำเอาวิธีเหล่านี้มารวมกันก็ไม่เหมาะสมนักเนื่องจากเทคนิคเหล่านี้ล้วนต้องอาศัยอุปกรณ์พิเศษเพิ่มเติมในขั้นตอนการระบุตัวบุคคล ดังนั้นเพื่อเป็นการกำจัดความต้องการเหล่านั้น งานวิจัยนี้จึงนำเสนอการพัฒนาวิธีการระบุตัวบุคคลโดยอาศัยจังหวะในการเคาะแป้นพิมพ์ โดยปรับใช้ร่วมกับความสามารถในการมองเห็นของแต่ละบุคคลเพื่อเพิ่มความแม่นยำในการระบุตัวบุคคล โดยการแก้ปัญหานี้เสนอว่าขั้นตอนการระบุตัวบุคคลด้วยข้อมูลทางชีวภาพนั้นสามารถทำงานได้โดยอาศัยแค่อุปกรณ์ธรรมดาทั่วไปอย่างแป้นพิมพ์คอมพิวเตอร์

ภาควิชา คณิตศาสตร์และวิทยาการคอมพิวเตอร์ ลายมือชื่อนิสิต

สาขาวิชา วิทยาการคอมพิวเตอร์และเทคโนโลยีสารสนเทศ ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก

ปีการศึกษา 2555

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KEYWORDS : BIOMETRICS AUTHENTICATION/ MULTIBIOMETRICS/ KEYSTROKE DYNAMICS/ EYE VISION

KANOGPORN NONSRICHAI : AUTHENTICATION PROCESS USING EYE VISION WITH KEYSTROKE PATTERNS. ADVISOR: ASST. PROF. PATTARASINEE BHATTARAKOSOL, Ph.D., 103 pp.

Biometrics authentication is one of the powerful solutions that being used broadly in the Information Security due to its high effective and accurate results. Nevertheless, most of these methods require specific devices to gain input data. The keystroke dynamics authentication is a biometric technique that requires a common device which is a keyboard. Therefore, this biometric is a very useful technology that can be implemented on various systems over the Internet as long as those users use keyboards. Unfortunately, the defect of using the keystroke dynamics is that the authentication result is invalid when users have different tempers. Thus, the accuracy of the use of the keystroke dynamics can be increased when combining this technique with other biometrics, such as the fingerprint and the iris scan. The unsuitable for these combinations is that special devices are required in the authentication process. So, to eliminate such requirements, this research proposes the modification of keystroke dynamics biometric by adapting it with the speed of eyes vision in order to increase the higher accuracy of identifying legitimate users. The proposed solution presents that the authentication process can be performed on a basic device such as the keyboard.

Department : Mathematics and Computer Science Student's Signature ....
Field of Study : Computer Science and Information Technology Advisor's Signature ....
Academic Year : 2012

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CHAPTER I

INTRODUCTION

This chapter gives information about background and importance. Details in this chapter include the objective, the scope and constraint of the experiment and the expected outcome. Moreover, definitions of technical terms are clarified so readers will have the same understanding for each technical term followed by the structure of the entire thesis.

1.1 Background and importance

In the world of Computer Science, the authentication system is played as an important role in the Information Security since there is the advent of the Internet and the number of the Internet population has growth rapidly. As a consequence, the large amount of information has been accessed and transmitted over the Internet. Much of information is sensitive data which are needed to be protected and accessed by authorized users only.

Generally, many websites rely on usernames and passwords as a tool to authenticate the users. This traditional authentication system has its vulnerabilities because passwords can be stolen easily by attackers. For example, it can be stolen by the dictionary attack or the guessing attack. Some systems utilize the combination of the authentication process using a token with a password in order to make it more secured. Unfortunately, this technique still has its limitations such as the token can be lost according to the user. Since this old-fashion password has its weakness but it is still the most popular authentication system due to ease of implementation and use. Thus, this original technique is needed to be improved in order to increase the reliability of the system.

Generally, there are three techniques that being used in the authentication system. The first one is verifying the legitimate users by asking something related to the user's knowledge. To illustrate, asking for the password before accessing to the system. For example, the current traditional authentication system that asks username and password of the user. The second one is verifying a user by something that a user is possessing such as asking for a token or the user's identification card. The last technique that being used in the authentication system is identifying users by something the user owns, such as fingerprint, signature, voice, and DNA sequence. This technique is known as the biometrics authentication.

Biometrics authentication is the most powerful technique comparing with other techniques that can be stolen or forgotten easily. Usually, it is much difficult to imitate the individual's characteristics or behaviors of other persons. This technology is utilized from the characteristics of individuals. It is a very effective and reliable technology because it is rarely possible that an imposter could steal or copy the identity of a legitimate user. Currently, many organizations that required a high security perform the authentication system using biometrics authentication. One advantage of this technique is users need not carry any special devices to authenticate themselves just show for what they have such as fingerprint and retina. The development of biometrics authentication is increased and much secured; then, the accuracy and reliability is very high. It would be a good solution if biometrics authentication can be applied on the authentication process on the current systems over the Internet. However, most of biometrics required some special devices to detect individual's trait. As a consequence, the implementation cost is quite expensive.

Nonetheless, each biometrics technology has its limitation. There are some problems which need to be improved, for instance, the scar on fingerprint and spoof attack. So, the multibiometrics is proposed to overcome the limitations of single biometric trait [1]. Multibiometrics refers to the combination of two or more biometrics in the authentication process to enhance the accuracy of identification and reliability of the security system. Furthermore, the multibiometrics system is difficult for imposters to illegally access the system because the intruders can hardly gain all biometrics from a legitimate user.

Although there are various techniques have been proposed and implemented, some techniques require a special device to capture biometric information. Additionally, some proposed techniques are proved under a specific environment; thus, it might not be possible for the real use. Therefore, this research will focus on the possibility of implementing biometric in the real usage under the low cost of implementation. The proposed technique is based on the use of basic keyboard and the human's eyes.

1.2 Objective

This research has aims to perform the following tasks

1. To determine the personality of person using multibiometrics from the keystroke dynamics with eye vision ability.
2. To implement a new authentication mechanism using multibiometrics from the keystroke dynamics with eye vision ability.
3. To determine the effect and accuracy of the proposed multibiometrics in the authentication process.

1.3 Scope of thesis and Constraint

There are many types of biometrics authentication methods. This research focuses on the behavioral biometrics, called as the keystroke dynamics because it is a biometrics which does not require any additional hardware and it can be applied on any system over the Internet. The study is based on the experiment on a group of samples. The following list is the scope and constraints of this research.

1. The sample size of this experiment is 15 persons who work daily with the computer.
2. The program is developed as a web-based application to collect the data.
3. The work focuses on the time that a sample consumes to type a password and responds to the displayed character.
4. All interesting time values are captured and stored in the database if and only if the typing password is correct.
5. The password that being used in this experiment is the assigned password which is the same to every sample.
6. The samples are asked to use the desktop or laptop computers with the QWERTY keyboard only.

1.4 Expected outcome

According to the defined objectives, the expected outcomes of this research are listed below.

1. The new mechanism of authentication process using keystroke dynamics biometric with eye vision ability of a person.
2. The high accuracy of the verification result.

1.5 Definition

In this research, the capturing data for keystroke dynamics includes the dwell time and interleave time, as shown in Figure 1.1. During the eye evaluations, the significant values are the typing time after the assigned character appears randomly in one of the nine areas of eye vision test, called as the vision time.

Dwell time: the time that a user used to press and release a key.

Interleave time: the time that a user used to move from a key to another consecutive key.

Vision time: the time that a user used to response with the displayed character on the eye vision test screen by pressing a key which matched with the appeared character.

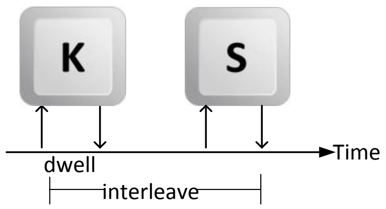


Figure 1.1 Measurement method of times

1.6 Thesis structure

The remaining parts of this thesis consist of four chapters as follows. Chapter 2 informs about the fundamental knowledge and literature review related to this study. In chapter 3, it describes the methodology of this thesis, including the proposed method. The results of this study will be demonstrated in Chapter 4 and the discussion and conclusion are presented in Chapter 5.

CHAPTER II

FUNDAMENTAL KNOWLEDGE AND LITERATURE REVIEW

This chapter provides the fundamental knowledge and literature review for this thesis. The background of the biometrics is demonstrated in Section 2.1. The fundamental knowledge of keystroke dynamics biometric is described in Section 2.2 and the literature review is stated in Section 2.3.

2.1 Background of Biometrics

"Biometrics" is a combination of Greek words, meaning "life measurement". In the information technology (IT), biometrics refers to the technologies which measures and analyzes human's characteristics or behaviors in order to identify a person. Generally, biometrics is used in the user identification and verification process. The identification is the process to determine who the person is. This process compares a biometric trait of an unknown person with the recorded templates in the database to search for a match record. In other word, the system can recognize an individual by searching in the database for a match template. The verification is the process of confirming or denying the claimed identity of a person to ensure that this is the same person by comparing that person's biometric data against a reference recorded data of a specific user [2][3]. Biometrics is also referred to automated method and techniques of user recognition based on the characteristics or traits of a person. Thus, this technology is especially used for the authentication purpose. Biometrics authentication is different from other authentication technique because it requires what a person is, so the problem of user has forgotten password or lost token will be solved. There are two major categories of biometrics; physiological and behavioral biometrics.

- Physiological biometrics: This biometrics is based on measurement of data which derived from a curtain part of human body. For example, the fingerprint, hand geometry and face recognition. This type of biometrics is usually more reliable and accurate comparing with behavioral biometrics because they are not influenced by mental conditions such as illness, stress or sadness [4].

- Behavioral biometrics: This biometrics is based on a habitual or behavioral of a person. Examples of this biometrics include signature dynamics, voice recognition, and keystroke dynamics. This biometrics provides some advantages over physiological biometrics. They can be collected without the knowledge of the user. Normally, gathering of this biometrics data does not require additional special device and the cost of implementation is low. Although, most behavioral biometrics are not unique enough comparing with the other type of biometrics, they still offer satisfactorily high accuracy of user verification. The element of time is essential to this biometrics because the behavioral biometrics may change when the time has passed [5], so the new data gathering process must be performed to improve the authentication result. Moreover, using the behavioral biometrics requires a large sample size of individuals when comparing with the physiological biometrics since larger samples provide higher accuracy. Moreover, behavioral biometrics use confidence measurement instead of pass or fail measurements that used in physiological biometrics [6].

Biometrics is mainly used in the authentication process. The results of verifying the identity of person based on the use of biometrics are quite accurate and reliable because it is difficult for an imposter to reproduce the identity of physical or behavior of a person.

2.2 Keystroke dynamics biometric

Since the use of username and password is ease of use to every user over the Internet, most of the verification mechanism of websites chooses to use this mechanism. Thus, this simple method is widely implemented as same as the aggregation of web's implementation. Unfortunately, this traditional authentication method is weak. So it can be attacked and stolen from the attackers easily.

The keystroke dynamics biometric is a promising technique that is proposed to apply with the traditional password authentication. It is the technology that used to discriminate individual among users based on his manner when typing on a keyboard, which is assumed that there is a characteristic way of person when types on a keyboard [7]. Keystroke dynamics is part of behavioral biometrics; the patterns or rhythm of typing are natural statistic [6]. Keystroke dynamics biometric is able to adapt with most of the current systems without any knowledge or extra actions from the user. Moreover, it does not require any special hardware to implement with. This technology is based on software solution which costs less comparing with other biometrics which requires both special hardware and software.

The original of keystroke dynamics is the telegraph system which is the communication technology emerged in the 80's. In the World War II, the military transmitted messages by using Morse code which is a method of transmitting message as a series of "dots" and "dashes". U.S. Military Intelligence specialist took the advantages of the methodology called "The Fist of the Sender" to identify the typing rhythm, pace and syncopation of the sender in order to determine whether the sender are ally or not [6]. In 1899, the study of Bryan and Hater who observed on telegraph operators demonstrated that each operator had a characteristic pattern when keying message. Moreover, the listening on the distinctive pattern of dot and dashes could simply make the operator recognize who transmitted the message [7].

The studies on keystroke dynamics in computer science have been proposed since the past few decades. In 1985, the experiment of Umphress et al. [8], which conducted with the group of seventeen people who were experienced programmers but the range of typing skills are from experienced touch-typists to those with no formal typing skills. This research's results indicated that the timing aspects and rhythm of typing can be used to identify a person in verification process. Moreover, several researchers have developed an authentication system based on keystroke dynamics to strengthening traditional password verification [9][10][11]. The studies on keystroke dynamics have not only focused on the adapting this biometric with the use of password but some studies also have focused on applying it with the long-text input [12].

The concept of keystroke dynamics biometrics is based on the measurement of individual's typing rhythm. It captures the interesting features of typing pattern from individual. The examples of features are the time of pressing and releasing a key, the total time when a user types a username and password, and the length of time when a user types successive keys. These pattern and features are believed to be presented the uniqueness of an individual and it should be very difficult for attackers to copy or duplicate [13]. Besides, this biometric is deployed easily and not easily forgotten or stolen [14].

2.3 Literature review

Presently, the authentication system is an important issue because most people use computers as a tool for their daily activities. Therefore, the authentication process and mechanisms are widely proposed by various researchers. One of the verifying techniques in the authentication process is the use of bioinformatics to identify a user. There are many biometric variables that are implemented and used over the electrical technologies, such as fingerprint, face, iris, and voice. However, these biometrics have some defects when the time passes and the device is expensive.

According to the need of the authentication system and the elimination of defects from the existing biometrics, the implementation of the keystroke dynamics was proposed [15]. The keystroke dynamic is identified as an identical measurement of each person since each person has a unique typing style and speed [16], including the typing pattern [17]. The main measurement parameters for evaluate the correctness of the verification system are False Acceptance Rate (FAR) and False Rejection Rate (FRR). FAR refers to the percentage that the intruders can access the system according to the false indication of the authentication mechanism while the FRR refers to the percentage that authenticated persons are identified as intruders.

Based on the study of Gaines et al.[16], characteristics of keystroke dynamics are similar to the personal signature. There is certainly a typing signature. Especially, with the skilled typists, they do have distinguishable typing styles. The study of Monrose et.al [18] reviewed the prior studies on keystroke dynamics and also presented classification techniques which based on matching of template and Bayesian likelihood models. The study also supported that use of behavioral trait in the traditional password provided more robust authentication systems than traditional password alone. Thus, in the year 2007, the use of keystroke dynamics was verified in the identification process to protect intruders [19]. Moreover, this study had pointed out that the use of keystroke dynamics is not practical when apply to the verification process over the network with the high delay because the biometrics value might be altered during the transferring period. Moreover, the identification process might fail according to the long latency and the high congestion situation.

In year 2009, the study of Shanmugapriya and Padmavathi [20] conducted to survey the keystroke dynamics authentication. This study shows that the basic methods and metrics that were used in the previous studies of keystroke dynamics biometrics can be summarized in the followings.

1. Analysis of typing patterns based on a known keyword or predetermined text. The captured typing pattern is compared against recorded typing patterns that stored during the enrollment of the system.
2. Analysis of dynamic keystroke based on typing of user during a logged session. The captured data in the period of the logged session is compared with an archived typing pattern to determine the deviations.
3. Analysis of keystroke in the entire duration of the logged session. This continuous keystroke analysis monitors the keystroke of user during the logged session. The captured data offers more significantly data compare with analysis keystroke on login process only.
4. Analysis of specific keyword during the logged process continuously or periodic. Including the monitoring and detecting on misuse of sensitive commands.

Moreover this study also concluded from the previously studies of keystroke dynamics biometrics; the metrics that were used in the studies are digraph latency which is the most general used. In addition, it normally measures the delay between events of key up, key down and trigraph latency. It extends the digraph latency to capture and consider timing for three successive keystrokes, keyword latency. It considers the overall latency for a completed word.

For the keystroke analysis approaches, there are two mainly used approaches; the statistical techniques, and neural networks techniques. Moreover, some studies used the combination of both approaches. Normally, the statistical method is conducted to compare a reference set of typing patterns of a user with a test set of that same user or test set of an imposter. On the other hand, the neural networks process first creates a prediction model from recorded data and uses the acquired model to classify a new coming record.

The approach to recognize authentic users from the extracted characteristics of keystroke dynamics can be performed using neural network or statistical method. Hurun et al. [21] studied on the use of time interval between the keystrokes as a feature of typing pattern of each person. They used the Multilayer Perceptron (MLP) neural network to train and validate the extracted features. Moreover, they also compared the results with the use of Radial Basis Function (RBF) neural network and some distance classifier method. This study showed that MLP provided greater results comparing with another method. The example of study of classification keystroke dynamics based on statistical method is the research of Cheng et al. [14]. This study applied a statistical method to extract the features of keystroke authentication to identify individuals. The results implied that using statistics to extract characteristic information in keystroke dynamics can be used and gave acceptable results with the low FRR and FAR.

Although the keystroke dynamics have been proved that it can be applied for the authentication process over the individual system, unfortunately, this biometric may be affected from many uncontrolled factors. These factors are such as human's tempers, the familiarity of the keyboard, etc. Therefore, the combination of the keystroke dynamics and another biometrics or methods has been applied.

As mentioned earlier, the personal emotion may affect to the typing style. This suspicious has been proved by Tsihrintzis et al. [22]. The results from this study indicated that the keystroke information support the correctness of facial recognition when the emotion is angry and happy. Nevertheless, the keystroke information has no impact when the emotion is neutral, or surprise.

Another work that integrates the keystroke value with another biometric, fingerprint, is the research of Yang et al. [23]. This work applied the keystroke pattern of users with the fingerprint checking to increase the accuracy in the verifying process of Point of Sales (POS) device. They showed that with the proposed innovative multibiometric; fingerprint and keystroke pattern recognition can strengthen the Personal Identification Number (PIN) authentication. Their results illustrated that this integrated biometrics authentication system provided more reliable verification. Moreover, they stated that using fuzzy logic with the keystroke dynamics will offer better performance because fuzzy logic is more suitable with the keystroke patterns since each individual's keystroke dynamics has uncertain pattern. Similar to the research of Sulong et al., the keystroke pressure-based biometrics authentication was developed with the typing patterns to obtain the higher accuracy of the authentication system. The experiment showed that combined technique can improve the accuracy [24].

Moreover, the combination between the keystroke dynamics and numbering input or password has been studied by Maxion and Killourhy in the year 2010 [25]. This research controls the external influencing by allowing every sample to type by one right-hand index finger, typing the same password, and the typing number is the fixed length for 10 characters long. The outcome of this research indicates that the use of these two factors is sufficient for the authentication system.

In the past decade, the detection of eye vision has been studied to support human abilities. According to the study in the year 2003, the vision-based face tracking system for cursor control by head movement had been adopted [26]. This research indicated that the eye vision is related to the movement of the head. Furthermore, the study of Hansen, et al. [27] had shown that the eye detection was affected from the dark and bright image. Moreover, the movement of head and the ability of eye vision are related to the light from the image. Then, there is an implementation of using hand and eye to replace the implementation of ordinary human interface, such as mouse [28]. Thus, one assumption from the research of [28] is the movement of the user's hand and eyes must be consistent.

CHAPTER III

METHODOLOGY

This chapter will described the experimental design by demonstrating the proposed system in the structure of overall system, use case diagrams, class diagrams, sequence diagrams and the designed database.

3.1 Experimental Design

This research focuses on presenting the results of individual's keystroke dynamics and speed of eye vision characteristics in order to introduce a new alternative of multibiometrics authentication by combining keystroke dynamics with the eye vision ability. The system is developed as a web-based application to record users' keystrokes and speed of the eye vision. The standard keyboard in this experiment is the QWERTY keyboard on desktop computers or laptops because most of computer users are familiar with it. The assumption of this research is that using the combination among keystroke dynamics and speed of eye detection in the authentication process may increase the accuracy of the personal identification.

The main idea for this authentication technique is that password time entering and the pressing times for presented characters can distinguish a user from others. All participants in this experiment are graduated students and they use a keyboard in their daily life. Each volunteer was assigned a username derived from their own e-mail, whereas an assigned password is 8 characters long which is a typical length of password. The assigned password is the same for every sample but it will be blinded from each other. So, each sample will understand that their passwords are unique. Thus, the bias from various passwords is under controlled.

In order to prove such assumption stated in the previous section, the suitable sample must be collected under the controlled conditions and they must be computer users. The sample size of this experiment is 15 volunteers whose age is in between 24-35 years old and they are daily computer users. The data collection was performed on the user's desktop or laptop with the standard QWERTY keyboard. Each person enters to the testing application by browsing to the web-based application that developed for recording all keystrokes as required. In this experiment, the participants were asked to login to the system and participate in the test of the eye vision section. The test of eye vision section is performed by divided the screen into nine segments as shown in Figure 3.1.

2	7	5
8	1	9
4	6	3

Figure 3.1 Screen pattern for eye testing

Referring to Figure 3.1, the appearance of each number is random. Thus, each time the sample runs the test, a character will be displayed in various positions. Although there are nine areas on the screen, only five areas will be displayed at each round. For each time of the test, the sample must be evaluated for their eye visions in three consecutive times. So, the bias from the sample knowing the displayed pattern is eliminated.

According to the separation of the display screen, the keyboard is divided into nine groups based on the fingers' locations when types. These nine groups are listed below.

1. q, w, e, r
2. t, y
3. u, i, o, p
4. a, s, d
5. f, g, h
6. j, k, l
7. z, x, c
8. v, b
9. n, m

3.2 Proposed method

The Keystroke Data Collector System (KDCS) is implemented to collect the data. The KDCS is composed of two main modules which are shown as list below.

1. *Profiling Module (PRM)*: This module responsible for collecting the basic information of the sample. The profile of each volunteer must be entered before the experiment begins. The profile information includes e-mail and age. All these values are stored in the Experimental Database (ExDB) when the sample registers to the KDCS.

2. *Time Capturing Module (TCM)*: This module responsible for capturing every interesting values in this research which are dwell time, the interleave time and the vision time of each sample. All these values are also stored in the ExDB.

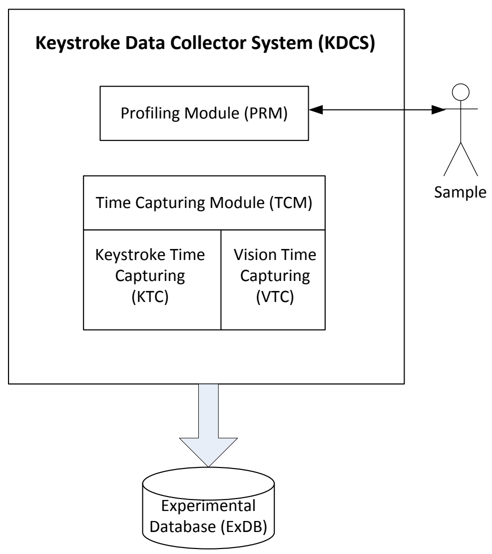


Figure 3.2 Keystroke Data Collector System (KDCS) Architecture

Referring to Figure 3.2 which illustrates the architecture of KDCS, it starts at the PRM which is an enrollment process. After the enrollment process, every sample will be informed for their username and password for logging in to the TCM. For time capturing, there are separated into two parts. The first part is the time of keystroke dynamics, and the second part is the time of the eye detection.

In the first part, the process of the TCM starts when users start keying the password. All time values defined previously are captured and stored in the ExDB if and only if the typing password is correct.

After passing the login process, the second part for vision time capturing starts. The process for time measurement begins when the sample clicks the button to start the test and the KDCS randomly chooses a character and its location on the display area. The time counts when a character is presented until the character on the keyboard are pressed.

The storing data from the second process of the TCM are the character's location and the vision time. The value of the vision time is the time interval of the appearing time and the typing time. For example, the time of presentation before typing is 1353902375221 and the time of typing is 1353902375326, so the recorded vision time is 95 milliseconds. Since there are five positions to be presented, there are five vision times to be stored.

Based on the scenarios described above, the data in the ExDB is presented in Figure 3.3. Referring to Figure 3.3, there are three tables in the ExDB: Users table, KeystrokeTime table, and VisionTime table. The users table stores the user's profile of the KDCS while the other two tables store the time values of all rounds of test.

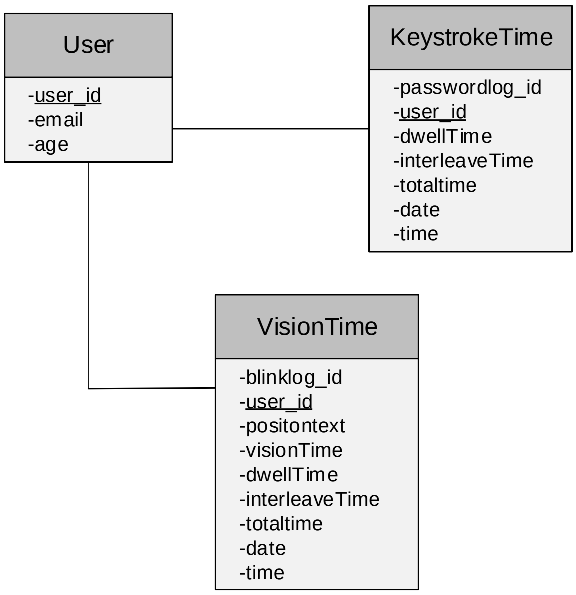


Figure 3.3 Tables and Attributes in ExDB

3.3 Use Case Diagram

As the structure of KDCS which is mentioned on the previous section, it can be illustrated as use case diagrams of two main modules bellows.

3.2.1 Use Case Diagram of Profiling Module (PRM) which responsible for the enrollment process.

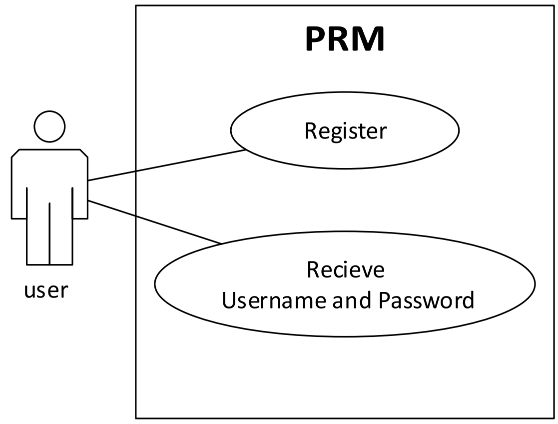


Figure 3.4 Use case diagram of the PRM

Use case diagram: Template

- *Use case name*: PRM
- *Participant actors*:
    1. User
- *Flow of events*
    1. The PRM asks user to register into the system.
    2. The information of user is stored into the database.
    3. The PRM sends a username and password to the user.
- *Exit condition*
    1. The user receives a username and password to log in to the experiment.

User case diagram: Scenarios

- *Scenario Name*: PRM
- *Participating actor*:
    1. Immily: User
- *Flow of events*
    1. The PRM asks Immily to register into the system.
    2. The information of Immily is stored into the database.
    3. The PRM sends a username and password to Immily.

- *Exit condition*
    1. Immily receives a username and password to log in to the experiment.

3.2.2 Use Case Diagram of Time Capturing Module (TCM) which responsible for the capturing interesting values in the logging in process and the speed of eye vision test.

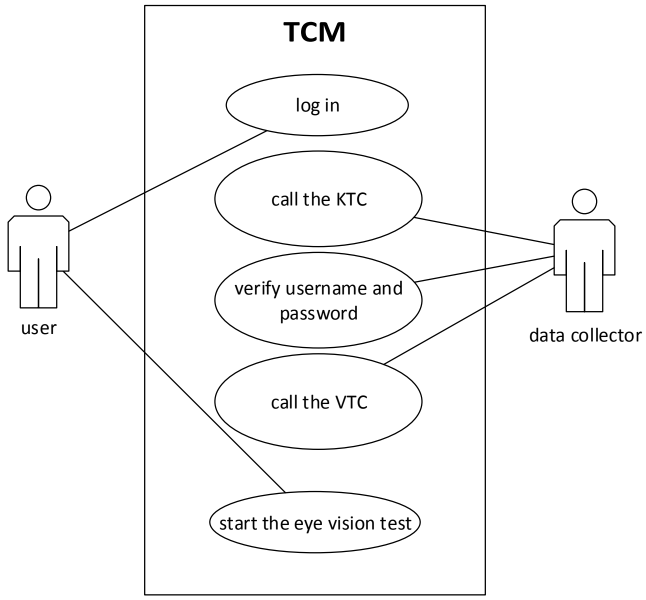


Figure 3.5 Use case diagram of the TCM

Use case diagram: Template

- *Use case name*: TCM
- *Participant actors*:
    1. User
    2. Data collector
- *Entry condition*:
    1. The user is already being the member of the KDCS.
- *Flow of events*
    1. The user logs in to the system.
    2. The data collector calls the KTC.
    3. The data collector verifies username and password of the user.
    4. The data collector calls the VTC.
    5. The user starts participating in the eye vision test.

Use case diagram: Scenarios

- *Use case name*: TCM
- *Participant actors*:
  1. Immily: User
  2. Data collector
- *Entry condition*:
  1. Immily is already being the member of the KDCS.
- *Flow of events*
  1. Immily logs in to the system.
  2. The data collector calls the KTC.
  3. The data collector verifies username and password of Immily.
  4. The data collector calls the VTC.
  5. Immily starts participating in the eye vision test.

Based on activities in Figure 3.5 there are two sub modules of TCM: KTC, and VTC. These sub-modules can be drawn as use case diagrams presented below.

3.2.2.1 Use Case Diagram of Keystroke Timing Capture (KTC) which responsible to capture all interesting data in the login process.

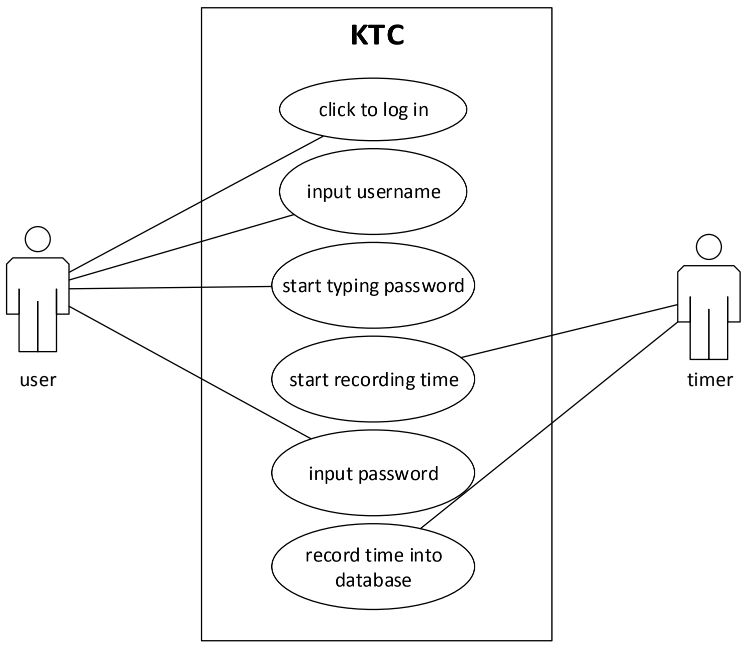


Figure 3.6 Use case diagram of the KTC

Use case diagram: Template

- *Use case name*: KTC
- *Participant actors*:
    1. User
    2. Timer
- *Entry condition*:
    1. The user is already registered into the system.
- *Flow of events*
    1. The user clicks to log into the experiment.
    2. The user input his/her username.
    3. The user starts typing on the password box.
    4. The timer starts to record all interesting time values when user is typing on a password box.
    5. The user inputs his/her password.
    6. The timer records all values and stores it into database.
- *Exit conditions*
    1. The user types username and password correctly and login successfully.

Use case diagram: Scenarios

- *Use case name*: KTC
- *Participant actors*:
    1. User: Immily
    2. Timer
- *Entry condition*
    1. Immily is already registered into KDCS.
- *Flow of events*
    1. Immily clicks to log into the experiment.
    2. Immily inputs her username.
    3. Immily starts typing on the password box.

4. The timer starts to record all interesting time values when Immily is typing on a password box.
5. Immily inputs her password.
6. The timer records all values and stores it into database.

- *Exit conditions*
    1. Immily types username and password correctly and login successfully.

3.2.2.2 Use Case Diagram of Vision Timing Capture (VTC) which responsible to capture all interesting data in the eye vision test.

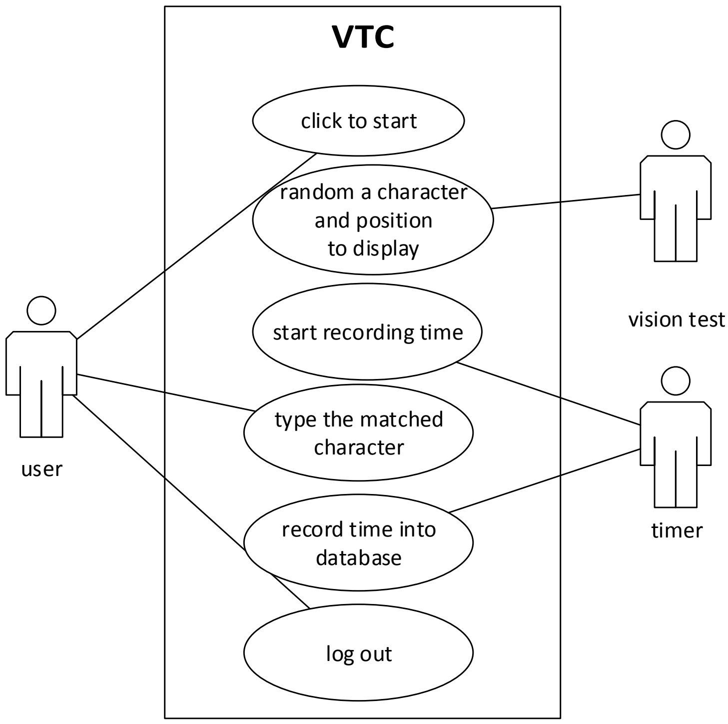


Figure 3.7 Use case diagram of the VTC

Use case diagram: Template

- *Use case name*: VTC
- *Participant actors*:
    2. User
    3. Vision test
    4. Timer
- *Entry condition*

1. The user is logged in to the KDCS successfully.

- *Flow of events*
  1. The user clicks to start the experiment on speed of eye vision.
  2. The vision test random a character and location to display on the screen test.
  3. The timer starts to record time.
  4. The user enters the matched character.
  5. The timer records the interesting values and stores it into databases.
  6. The user log out from the system.
- *Exit conditions*
  1. The user types matched characters correctly.

Use case diagram: Scenarios

- *Use case name*: VTC
- *Participant actors*:
  1. User: Immily
  2. Vision test
  3. Timer
- *Entry condition*
  1. Immily is logged in to the KDCS successfully.
- *Flow of events*
  1. Immily clicks to start the experiment on speed of eye vision.
  2. The vision test random a character and location to display on the screen test.
  3. The timer starts to record time.
  4. Immily enters the matched character.
  5. The timer records the interesting values and stores it into databases.
  6. Immily logs out from the system.
- *Exit conditions*
  1. Immily types matched characters correctly.

3.4 Class Diagram

The KDCS composes of four main classes: class User, class KTC, class Timer, and class VTC. The relationships among classes are shown as the Figure 3.8.

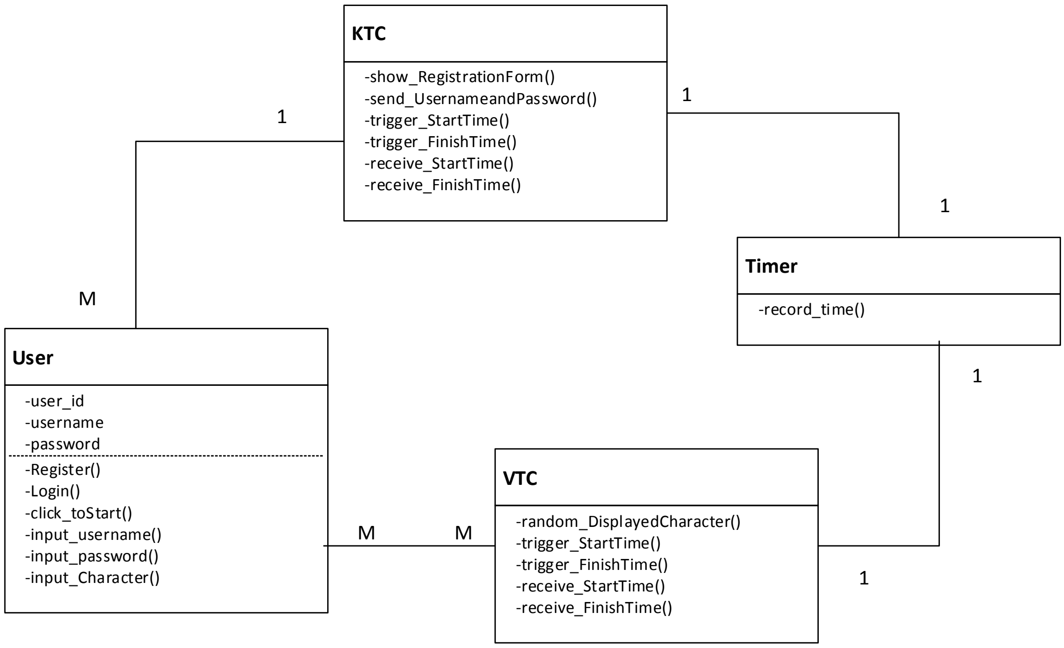


Figure 3.8 Class diagram of KDCS

Referring to the Figure 3.8, the relations among classes in the KDCS can be explained that each user registers to the system just one time. After registration, the user is able to login to the system which is responsible by the KTC. Each time the user accesses the system, the KTC will trigger the timer to record time. Then, if the user logs in successfully, the user will be asked to participate on the eye vision test of the VTC which requires user to do it three rounds for each time. Each time the user participates in the VTC, it will trigger the timer to record time.

3.5 Data Gathering Method

In order to capture data as needed, the data gathering mechanism must be determined as described as a sequence diagram in Figure 3.9.

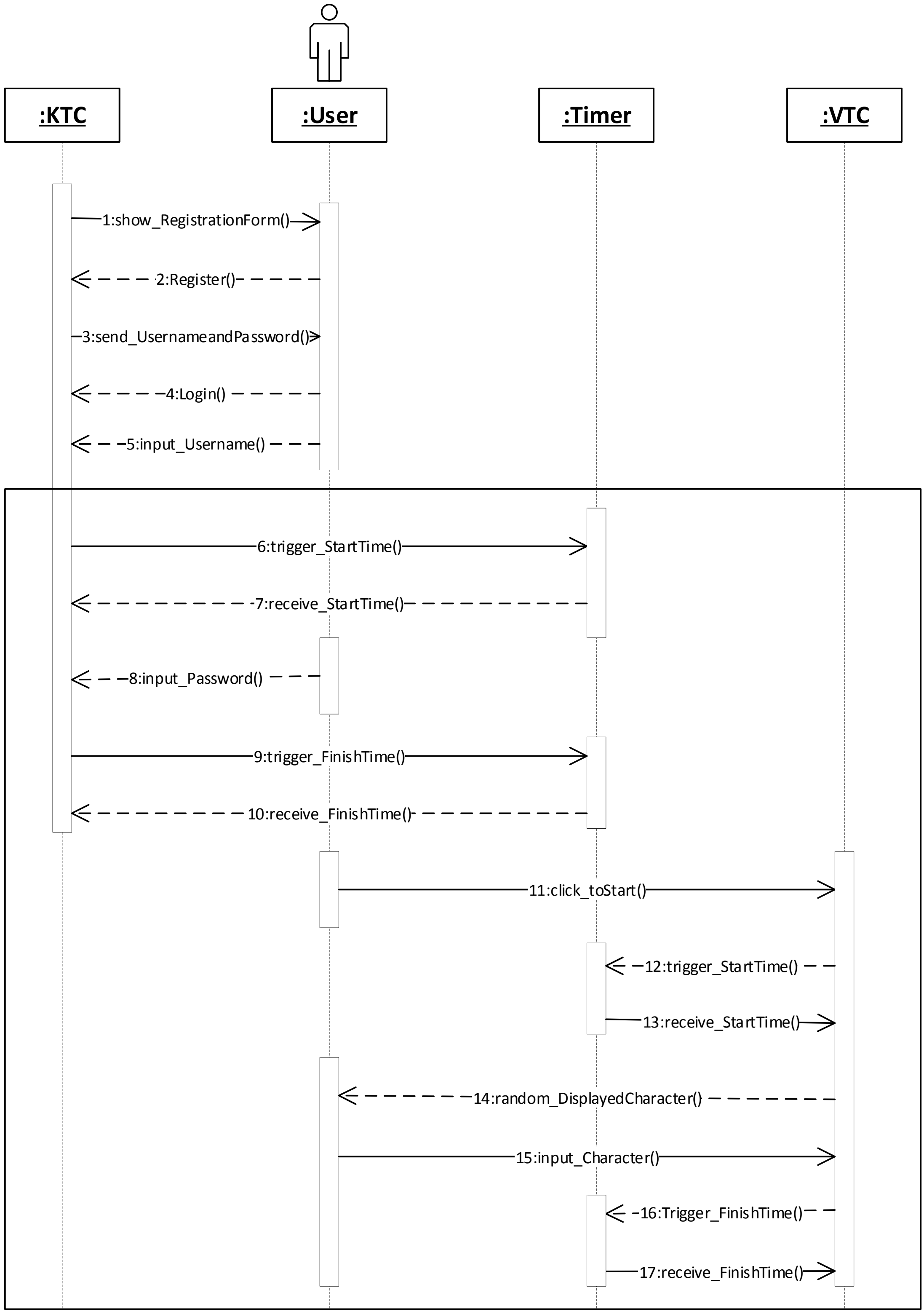


Figure 3.9 Sequences diagram of the KDCS

From Figure 3.9, the process to gather data in the experiment can be described as follow.

(1) When the user launches the website to participate in the experiment for the first time, KTC will show the registration form to the user.

(2) The user provides all personal information and register into the system.

(3) The KTC sends username and password to the user.

(4) The user clicks to log in to the system.

(5) The user inputs the given username.

(6) When the user starts typing in the password box. KTC will trigger the timer to record time.

(7) The KTC will record the start time when the user starts typing password.

(8) The user inputs the given password correctly.

(9) The KTC will trigger the timer to stop recording time.

(10) The KTC records all the interesting values of time into database.

(11) After the user has successfully logged in, there will be the eye vision test. The user clicks to start the experiment.

(12) The VTC will trigger the timer to record the time.

(13) The VTC will record the start time when the first character is displayed on the screen.

(14) The VTC randomizes the character and its location to display on the screen.

(15) The user inputs the matched character.

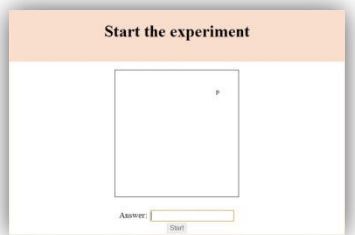
(16) The VTC will trigger the timer to stop recording time.

(17) The VTC records all the interesting values of times into the database.

The KDCS interfaces illustrates in Figure 3.10. As mentioned above, the KDCS was developed as a web-application using PHP, Javascript, HTML and Jquery. This web consists of three main pages. The first page is the registration. The second page is the login interface which is also has a recording keystroke function when the user starts typing in the password box. The last main page is evaluation of the eye vision ability, there is a displayed screen which randomizes the character to appear on each location.

(a) page 1, the registration interface

(b) page 2, the login interface



(c) page 3, the eye vision test interface

Figure 3.10 Screenshot of KDCS interfaces

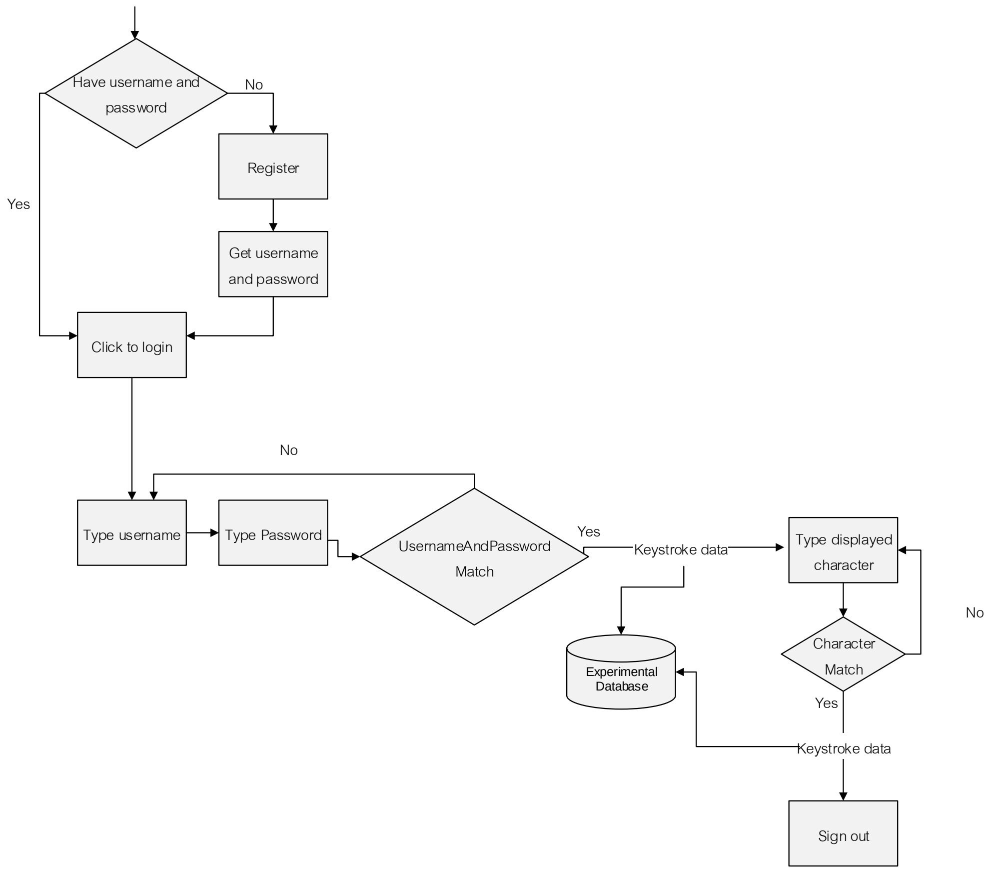


Figure 3.11 Flowchart of the KDCS

From the Figure 3.11, it concludes the workflow of the experiment procedures of the KDCS into a flowchart. The KDCS starts to work when a user browses to the website. If that user has not yet registered to the KDCS, the user will firstly be asked to register into the system. After registration, the user will be assigned a username and a password to log into the system. When the user already received the username and the password, the user is able to log into the system by typing correct username and password. After the user completes typing a password, the KDCS will collect the keystroke dynamics data and also check whether the user is typing the password correctly or not. If the user typed the incorrect password, the user must start the login process over again. In case user inputs the password correctly, the data of keystroke dynamics will be stored into the database then the eye vision test will be appeared to the user. The user must type a key that match with the displayed character on the eye vision test screen. If the user types the wrong key, user must start typing over again. After, the user typed correctly, all data of keystroke dynamics will be stored into the database; and the user signs out to finish the test.

3.6 Code implementation

The KDCS system was implemented as a web-based application that was mainly programmed in PHP, javascript, HTML, and Jquery language. The system consists of three main subsystems: the registration subsystem, the login subsystem and the eye vision evaluation subsystem.

3.6.1. The registration subsystem: This subsystem is responsible to collect the personal information of samples and provides the username and the password to the user after the user successfully registered.

3.6.2. The login subsystem: This subsystem is used to record the dwell time and interleave time of keystroke when the user starts interacting with the password box.

3.6.3. The eye vision evaluation subsystem: This subsystem is responsible for randomize a character and location to display on the screen, including records the vision time.

All recorded data during in the KTC will be stored in the database at the KeystrokeTime table. The example of recorded data in this table is shown in the Figure 3.12 below.

passwordlog_id	user_id	dwellTime	interleaveTime	totaltime	date	time
2	2	159,80,96,96,112,112,96,112	672,768,528,384,1040,320,784	7433	06/03/2013	08:42:45
3	2	224,144,128,95,207,128,96,160	1824,416,1792,785,817,352,480	8942	06/03/2013	08:47:02
24	2	80,79,64,80,80,80,112,96	656,1696,1440,1792,1360,960,272	22559	07/03/2013	08:27:39
444	2	126,112,145,144,160,160,79,128	224,240,239,1104,720,304,337	5496	23/03/2013	20:42:29
56	2	206,80,80,96,224,48,80,65	784,448,1537,576,1664,544,368	8508	07/03/2013	16:34:17
66	2	159,96,144,128,80,112,144,144	288,432,448,1232,304,288,1456	6563	08/03/2013	10:08:59
77	2	165,205,185,210,185,171,130,191	1392,851,531,2367,285,450,485	33614	09/03/2013	11:17:09
80	2	188,180,214,230,180,181,155,190	735,1968,316,1026,330,1006,470	7918	09/03/2013	11:24:06
90	2	152,215,160,225,106,115,110,125	891,431,596,1401,1586,626,516	9826	10/03/2013	08:58:07
96	2	79,128,64,112,80,112,80,80	656,832,656,1376,880,528,592	7620	11/03/2013	09:04:16

Figure 3.12 Records of a user in the KeystrokeTime table

Figure 3.12 shows some parts of the recorded data in the KeystrokeTime Table from the phpMyadmin that is a software tool used in this research to manage the database. As seen from this figure, the KeystrokeTime table consists of 7 attributes; passwordlog_id, user_id, dwellTime, interleaveTime, totaltime, date and time. Each time the user interacts with the password box in the login process. The dwell time and the interleave time that the user used to type a password will be recorded into the table, including the total time that user consumed to complete typing the password, date and time that user logged into the system. The unit of the dwell time, the interleave time and the total time is millisecond.

For the recorded data during the eye vision test will be stored in the VisionTime Table in the database. Figure 3.13 illustrates an example of records in the VisionTime Table of a user.

blinklog_id	user_id	positiontext	visionTime	dwellTime	interleaveTime	totalTime	date	time
7	2	7,5,3,4,8	2095,1279,1599,975,1119	207,112,160,128,80	1280,1600,976,1120,	7761	06/03/2013	08:47:29
8	2	4,1,2,6,0	1156,993,1360,1279,1167	176,144,127,176,176	993,1360,1280,1168,	9057	06/03/2013	08:47:29
9	2	1,0,7,5,8	1252,1119,1103,1055,1040	192,160,176,176,144	1120,1104,1056,1040,	8512	06/03/2013	08:47:29
61	2	0,7,8,3,6	1176,1519,1232,1072,1407	176,96,96,95,80	1520,1232,1072,1408,	6954	07/03/2013	08:28:24
62	2	8,6,2,4,5	1710,1103,1168,1055,1551	80,80,80,80,96	1104,1169,1056,1552,	9105	07/03/2013	08:28:24
63	2	4,3,7,6,1	1135,1024,1040,1119,1136	80,96,80,80,96	1024,1040,1120,1136,	7072	07/03/2013	08:28:24
151	2	5,1,4,2,7	1296,1087,1248,1135,1023	144,96,80,112,144	1088,1248,1135,1024,	6371	07/03/2013	16:34:43
152	2	4,7,8,0,3	1584,1215,1455,1599,1279	128,128,128,112,176	1216,1456,1600,1280,	8624	07/03/2013	16:34:43

Figure 3.13 Records of a user in the VisionTime table

As seen from the Figure 3.13, there are nine attributes in the VisionTime table: blinklog_id, user_id, positiontext, visionTime, dwellTime, interleaveTime, totalTime, date and time. The positiontext attribute collected the location that each character appeared on the test. Since there are nine areas on the eye vision test, only five locations will be presented each time. Thus, each record of positiontext attribute has five displayed positions. Similarly to the the positiontext attribute, the visionTime and dwellTime attributes record the vision time and dwell time respectively. Each round of eye vision test, there are five records of time stored in the attributes. For the interleaveTime, there are only four values because only four key pair of each round of test. The totalTime attribute collected the total time that user used to complete the eye vision test of each round. The other attributes, date and time records the date and time that the user participated in the eye vision test. The vision time, the dwell time, the interleave time, and the total time are recorded in millisecond unit.

3.7 Data analysis

As mentioned above, all data are collected from the developed website. These data are gathered from 15 participants who volunteers in this experiment. The data are analyzed using SPSS v.17 for the statistical results. Moreover, these data are also analyzed using Weka 3.6.9 for the neural network analysis. The objective of this analysis is to present the personality of person, keystroke dynamics and the eye vision ability.

CHAPTER IV

EXPERIMENTAL RESULTS

This chapter demonstrates the experimental results from the gathered data of the proposed method. The statistical results that are shown in this chapter were processed by SPSS v.17 will be described in Section 4.1 Furthermore, the neural network analysis results will be illustrated in Section 4.2.

4.1 Statistical analysis results

Based on the data collected from all 15 persons, the mean dwell time and interleave time for each person when typing a password in the login process can be plotted as shown in Figure 4.1, and Figure 4.2 respectively. From Figure 4.1 and Figure 4.2 it can be seen that each sample has a different mean dwell time pattern, as well as a different mean interleave time from typing a password.

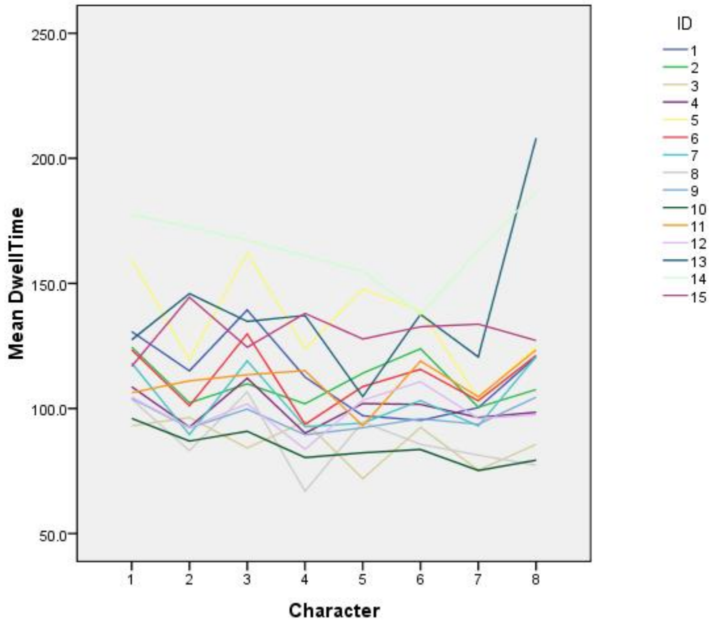


Figure 4.1 Mean time of dwell time in the login process

Each line graph above shows the mean dwell time for each person when typed on each character of the password. The horizontal axis refers to each character of the password since the length of password is 8. For example, 1 means the first character of password and 8 refers to the last character of password. The vertical axis refers to the mean time of dwell time that users used to enter each character of password. As seen from the Figure 4.1, each person has different time of pressing and releasing each character on the keyboard when typing a password.

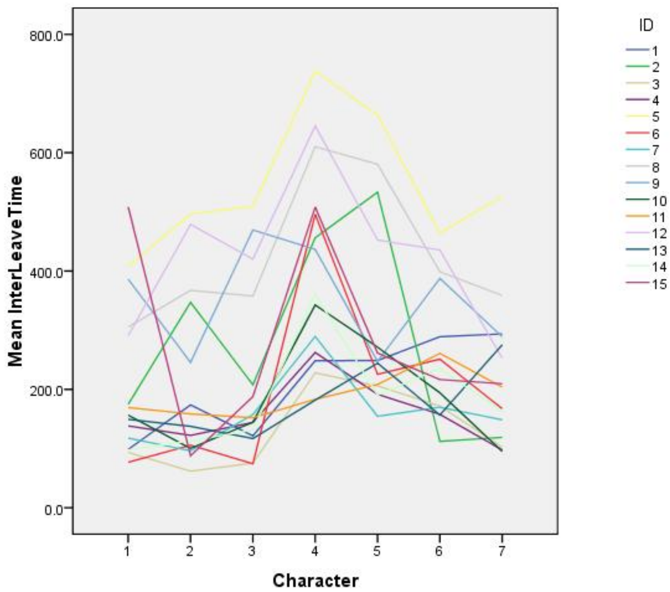


Figure 4.2 Mean time of interleave time in the login process

Each line graph above shows the mean time of interleave time when each person typed on consecutive keys to enter the password. The horizontal axis refers to each pair of the characters. The length of password is 8, so the total pair of characters is seven. For example, 1 means the first character and the second character of password which is called one pair. The vertical axis refers to the mean time of the interleave time that users used to type a consecutive character of the password. From Figure 4.2, it indicated that each person has different time of keying consecutive keys on the keyboard when entering a password.

Moreover, the mean time of the dwell time and the interleave time in the eye vision test phase also show that each sample has different pattern of typing when keying the displayed characters. The mean time of the dwell time and the interleave time of each person in this phase can be plotted as shown in Figure 4.3 and Figure 4.4 respectively. As seen from the figures below, it is obvious that each sample has different typing rhythm.

The following graph illustrated the mean time of the dwell time when each person inserted a character on keyboard to match with the displayed character on screen. The horizontal axis refers to the position of displayed character. There are nine possible positions as mentioned in the Chapter 3. The vertical axis refers to the mean time of the dwell time that users used to press and release the key. Figure 4.3 can be interpreted that each person has different pattern of the dwell time in the eye vision test.

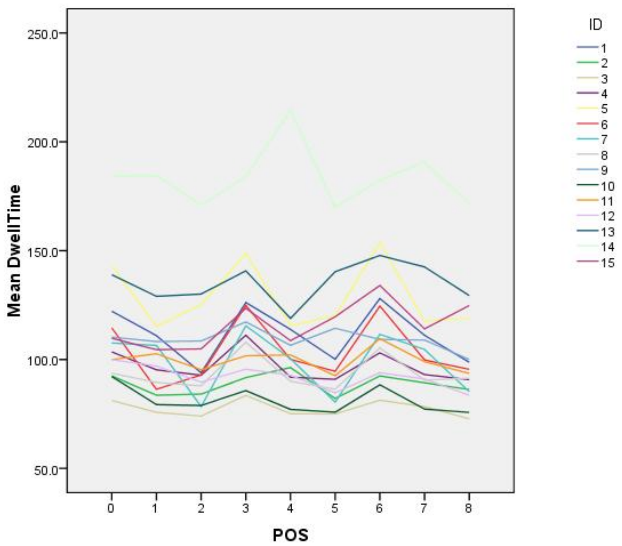


Figure 4.3 Mean time of dwell time in the eye vision test

As well as the mean time of the interleave time in the eye vision test that is shown as multiple line graph in Figure 4.4 below. It indicates that each person used different of interleave time when keying a displayed character. The vertical axis refers to the mean time of the interleave time that users used to entered a consecutive key. The horizontal axis refers to the displayed position.

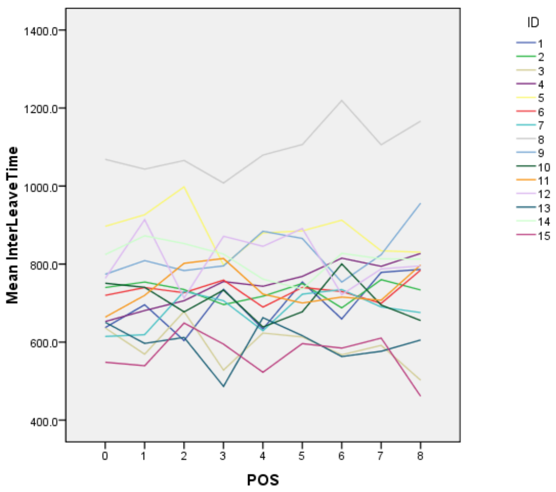


Figure 4.4 Mean time of interleave time in the eye vision test

After passing the password entering, the display of characters on each area is performed; and the vision times are recorded. With these data, the multiple line graph can be plotted as same as Figure 4.3 and Figure 4.4. The results from the graph in Figure 4.5 can be interpreted that each sample also has unique vision time since the pattern of each individual line is dissimilar.

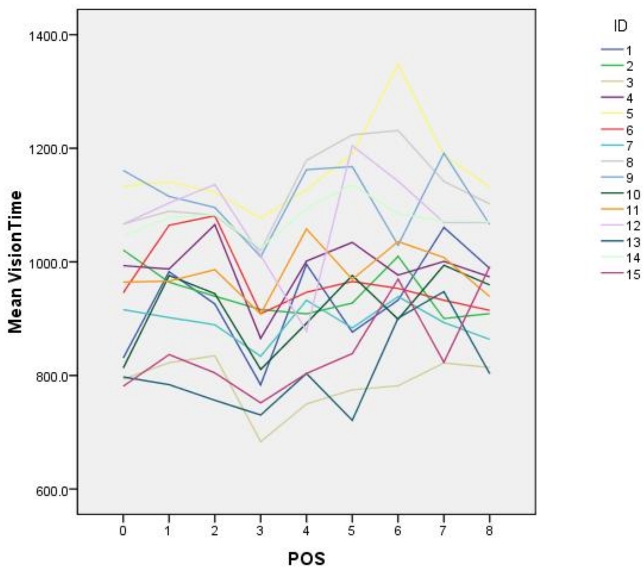


Figure 4.5 Mean time of vision time in the eye vision test

As the presented ling graph presented above, it is clear that the patterns of lines in the multiple line graphs of the dwell time and the interleave time in login process, including the dwell time, the interleave time and the vision time in the eye vision test, are unlikely the same. Therefore, the outcomes of this experiment must be analyzed to confirm the hypothesis. According to the experiment's outcomes, the analysis method for these outcomes is the multivariate method, where all subjects are determined at the same time. The results of the login process that have been obtained are shown in Table 4.1. Under this analysis method, there are two dependent variables, DwellTime and InterLeaveTime where two independent variables are ID (user's identification) and Character (password).

Table 4.1 Tests of Between-Subjects Effects (login process)

Source	Dependent Variable	F	Sig.
Corrected Model	DwellTime	50.268	.000
	InterLeaveTime	12.343	.000
Intercept	DwellTime	119069.208	.000
	InterLeaveTime	3785.660	.000
ID	DwellTime	286.562	.000
	InterLeaveTime	51.618	.000
Character	DwellTime	64.216	.000
	InterLeaveTime	40.600	.000
ID * Character	DwellTime	10.019	.000
	InterLeaveTime	3.907	.000

Referring to the analysis results in Table 4.1, various conclusions can be drawn as follow.

H_0: There is no significant different between mean values of DwellTime within the sample group.

H_1: There is at least one mean value of DwellTime within the sample group that has a significant different from other mean values.

The analysis result has shown that the alternative hypothesis is accepted with sig.=0.00 < 0.05(α). So, there is at least one mean value of DwellTime within the sample group that has a significant different from other mean values.

H_0: There is no significant different between mean values of InterLeaveTime within the sample group.

H_1: There is at least one mean value of InterLeaveTime within the sample group that has a significant different from other mean values.

The analysis result has shown that the alternative hypothesis is accepted with sig.=0.00 < 0.05(α). So, there is at least one mean value of InterLeaveTime within the sample group that has a significant different from other mean values.

According to the two results above, this can conclude that at least one individual sample has different mean times with others in the same group.

The next evaluation is to determine the results obtained with each character of password.

H_0: There is no significant different between mean values of DwellTime with each character of password.

H_1: There is at least one mean value of DwellTime with each character of password that has a significant different from other mean values.

The analysis result has shown that the alternative hypothesis is accepted with sig.=0.00 < 0.05(α). So, there is at least one mean value of DwellTime with each character of password that has a significant different from other mean values.

H_0: There is no significant different between mean values of InterLeaveTime with each character of password.

H_1: There is at least one mean value of InterLeaveTime with each character of password that has a significant different from other mean values.

The analysis result has shown that the null hypothesis is accepted with sig.=0.00 < 0.05(α). So, there is at least one mean value of InterLeaveTime with each character of password that has a significant different from other mean values.

The last analysis results are the determination of the interaction between the individual samples when typed each character of password. The results from Table 4.1 confirm that there is one mean different of DwellTime when both individual sample and characters in a password are considered together, sig.= 0.00 < 0.05(α). Moreover, there is one mean different of InterLeaveTime when both individual sample and the characters of the password are considered together, sig.= 0.00 < 0.05(α).

The next outcomes to confirm the hypothesis are based on analysis of data in the eye vision test. As same as the analysis data of login process, the method is also multivariate. The dependent variables are DwellTime, InterLeaveTime, and VisionTime where two independent variables are ID (user's identification) and POS (displayed position). The results are shown in the Table 4.2. In this analysis, the interaction among independents is applied because one assumption of this research is that there is a significant difference between means of all dependent variables when the ID and POS are interacted.

Table 4.2 Tests of Between-Subjects Effects (The eye vision test)

Source	Dependent Variable	F	Sig.
Corrected Model	DwellTime	42.380	.000
	InterLeaveTime	4.444	.000
	VisionTime	10.816	.000
Intercept	DwellTime	80643.001	.000
	InterLeaveTime	20802.494	.000
	VisionTime	89009.019	.000
ID	DwellTime	357.301	.000
	InterLeaveTime	34.944	.000
	VisionTime	76.887	.000
POS	DwellTime	35.016	.000
	InterLeaveTime	.501	.857
	VisionTime	14.498	.000
ID * POS	DwellTime	2.906	.000
	InterLeaveTime	.877	.820
	VisionTime	2.324	.000

Referring to the analysis results in Table 4.2, various conclusions can be drawn as follow.

H_0: There is no significant different between mean values of DwellTime within the sample group.

H_1: There is at least one mean value of DwellTime within the sample group that has a significant different from other mean values.

The analysis result has shown that the alternative hypothesis is accepted with sig.=0.00 < 0.05(α). So, there is at least one mean value of DwellTime within the sample group that has a significant different from other mean values.

H_0: There is no significant different between mean values of InterLeaveTime within the sample group.

H_1: There is at least one mean value of InterLeaveTime within the sample group that has a significant different from other mean values.

The analysis result has shown that the alternative hypothesis is accepted with sig.=0.00 < 0.05(α). So, there is at least one mean value of InterLeaveTime within the sample group that has a significant different from other mean values.

H_0: There is no significant different between mean values of VisionTime within the sample group.

H_1: There is at least one mean value of VisionTime within the sample group that has a significant different from other mean values.

The analysis result has shown that the alternative hypothesis is accepted with sig.=0.00 < 0.05(α). So, there is at least one mean value of VisionTime within the sample group that has a significant different from other mean values.

Related to these three results, this can summarize that at least one individual sample has different mean times with others in the same group.

The next evaluation is to determine the results obtained for different display positions.

H_0: There is no significant different between mean values of DwellTime within different display positions.

H_1: There is at least one mean value of DwellTime within different display positions that has a significant different from other mean values.

The analysis result has shown that the alternative hypothesis is accepted with sig.=0.00 < 0.05(α). So, there is at least one mean value of DwellTime within different display positions that has a significant different from other mean values.

H_0: There is no significant different between mean values of InterLeaveTime within different display positions.

H_1: There is at least one mean value of InterLeaveTime within different display positions that has a significant different from other mean values.

The analysis result has shown that the null hypothesis is accepted with sig.=0.857 > 0.05(α). So, there is no significant different between mean values of InterLeaveTime within different display positions.

H_0: There is no significant different between mean values of VisionTime within different display positions.

H_1: There is at least one mean value of VisionTime within different display positions that has a significant different from other mean values.

The analysis result has shown that the alternative hypothesis is accepted with sig.=0.00 < 0.05(α). So, there is at least one mean value of VisionTime within different display positions that has a significant different from other mean values.

The last analysis outcomes are the determination of the interaction between the individual sample and the display positions. The results from Table 4.2 affirm that there is one mean different of DwellTime when both individual sample and the display positions are considered together, sig.= 0.00 < 0.05(α). Moreover, there is one mean different of VisionTime when both individual sample and the display positions are considered together, sig.= 0.00 < 0.05(α). Nonetheless, there is no significant different of mean values of the InterLeaveTime when both individual sample and the display positions are considered, sig.= 0.820 > 0.05(α).

4.2 Neural network analysis results

Referring to the results from the statistical analysis, there is at least one mean different among other mean values under individual sample and the display positions consideration. Thus to confirm the use of keystroke dynamics and the eye vision ability in the authentication process can that can identify the individual with the better result of classification, the neural network analysis must be performed. From the results of data analysis in the eye vision test, it showed that the mean values of interleave time does not provided significant difference. So, the interleave time values which were collected in this phase will be excluded in the neural network analysis.

In this research, the neural network analysis was performed using Weka 3.6.9. The analysis is based on Multilayer Perceptron (MLP) network. MLP neural network is one of the network architecture that being used widely in the pattern classification and provides the promising performance for keystroke analysis [21]. MLP uses back-propagation to classify the instances.

The data that used as the training set are the merged data from the login process and the eye vision test phase where the interleave time are excluded. Below is the result using the MultilayerPerceptron function which is provided by Weka using the default parameters to classify the instances, see Figure 4.6.

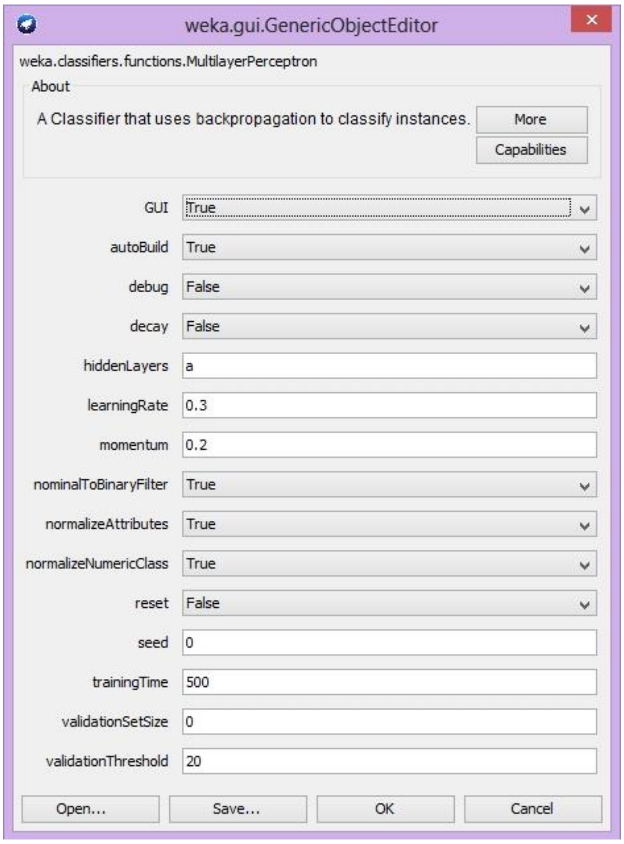


Figure 4.6 Default parameters in Weka

Table 4.3 Classification results using data from login process with eye vision test

Correctly Classified Instances	548	97.5089 %
Incorrectly Classified Instances	14	2.4911 %
Kappa statistic	0.9731	
Mean absolute error	0.0064	
Root mean squared error	0.0479	
Relative absolute error	5.1559 %	
Root relative squared error	19.2555 %	
Total Number of Instances	562	

Referring to Table 4.3, the result above can be interpreted that if applying this classifier model which is constructed from the combined data which derived from the login process and eye vision test, it can classify the instance correctly at 97.5089%.

The table below shows the result of classification using all keystroke values from the login process. It shows that the correctly classified instances at 87.2792% as shown in Table 4.4. Comparing with combined data that uses keystroke data and vision time in the login process and the eye test vision, the result shows that it provides less performance of the classification.

Table 4.4 Classification results using data from login process only

Correctly Classified Instances	494	87.2792 %
Incorrectly Classified Instances	72	12.7208 %
Kappa statistic	0.8627	
Mean absolute error	0.0286	
Root mean squared error	0.1185	
Relative absolute error	23.1096 %	
Root relative squared error	47.6523 %	
Total Number of Instances	566	

CHAPTER V

DISCUSSION AND CONCLUSION

In this chapter, the discussion will be discussed in Section 5.1, and the conclusions of this study will be stated in Section 5.2. Lastly, the future work for this thesis is drawn in Section 5.3.

5.1 Discussion

Since the Internet is widely used around the world, people can access their information from any places. Thus, the authentication system can be counted as a significant issue for every organization. Although many authentication techniques were announced and implemented, they still remain some defect that fails the authentication process. One interesting method is the application from the use of biometrics, such as face scan, fingerprint, keystroke dynamic, and iris scan. However, the measurement value for these metrics can be altered according to time change, medical surgery, and aging. As a consequence, the combination among biometrics or the combination between a biometric and password have been proposed for a new authentication mechanism. This combination increases the accuracy of the authentication system under the values of FRR and FAR.

Since the combination among biometrics and password increase the performance of the identification process, this research proposed a new combination of an interesting biometric, keystroke dynamic, with the sensitive eye vision of users. According that there is relation between eye vision and head movement [26] and the movement of users' hands is consistent with the eye vision [28], thus, the ability of eye vision should related to the keystroke value. Moreover, the value of keystroke dynamics and the time count for eye vision of each person are unique. Then, the outcome from the proposed mechanism can be trusted. In addition, the use of keystroke dynamics and eye vision has low potential to alter when the time passes because of the existing of the consistency of eye vision and hand movement.

From the experimental results on previous chapters clearly presented that keystroke dynamics and the eye vision ability can be used in the authentication system. In the login process, there is one mean different of the dwell time and the interleave time when individual sample and characters of a password are considered together. The results of classification based on the neural network analysis using Multilayer perceptron network showed that the instances could be classify correctly at 87.2792 %. In the eye vision test, there is one mean different of the dwell time and the vision time when both individual sample and the displayed positions are considered at the same time. Then, when applied the data from the login process with the data from eye vision test to identify a person, it provided more accuracy of correctly classification which improved up to 97.5089 %.

5.2 Conclusion

The Internet is a huge source that people can gain access easily every time they need. One important issue for these accesses is the security of the available data over the network. Thus, user identification mechanism is required when the system is requested. Biometrics authentication is one of powerful tools that being used in the Information Security. This kind of authentication system provides the high performance of security because the bioinformation of each person is unique so it can represent the identity of a person. Nevertheless, there is still weakness of the unibiometric authentication, such as eye damaged (for iris scan) and scar on the finger (for fingerprint scan). Then, the multibiometrics authentication is proposed to overcome this defect, including increases the performance of security in the authentication system.

This research proposed a user detection mechanism based on the value of keystroke dynamics and the eye vision ability based on the relation of hand movement and the image detection of eyes. The results which are shown in the previous chapter indicated that this combination of biometrics can be used to enhance the performance of the authentication system. The results presented the higher accuracy of the user classification when merged the dwell time and the interleave time of keystroke dynamics biometric with the vision time of the eye vision test when comparing with using just single value of biometric; keystroke dynamics showed less accuracy of classification result. Moreover, the experimental results in the statistical analysis also express that the mean dwell time, interleave time and vision time of each person is difference. So, using all these values to determine the identity of the user must provide the high effective and an accurate result. Therefore, the identification result from this proposed method can be trusted according to the classification result from the keystroke that can affect from the sensitivity of eye detection.

5.3 Future work

This research performed the initial study of multi-behavioral biometrics: keystroke dynamics and eye vision ability. Consequently, the real implementation of mechanism to identify the authenticated person using this technique should be developed to test the real usage. Moreover, the future work may be tested on subjects who has different of eyesight such as myopic, hyperopic or normal eyesight. The displayed character may be changed to different font and tilt.

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APPENDIX

APPENDIX

EXPERIMENTAL ADDITIONAL RESULTS

Table A1: Tests of Between-Subjects Effects (KTC)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square
Corrected Model	DwellTime	1.976E6	104	18997.766
	InterLeaveTime	8.483E7	104	815714.480
Intercept	DwellTime	4.500E7	1	4.500E7
	InterLeaveTime	2.502E8	1	2.502E8
ID	DwellTime	1516203.503	14	108300.250
	InterLeaveTime	4.776E7	14	3411325.389
Character	DwellTime	145614.790	6	24269.132
	InterLeaveTime	1.610E7	6	2683164.054
ID * Character	DwellTime	318060.684	84	3786.437
	InterLeaveTime	2.169E7	84	258187.983
Error	DwellTime	1457296.929	3856	377.930
	InterLeaveTime	2.548E8	3856	66087.286
Total	DwellTime	5.168E7	3961	
	InterLeaveTime	6.003E8	3961	
Corrected Total	DwellTime	3433064.573	3960	
	InterLeaveTime	3.397E8	3960	

a. R Squared = .576 (Adjusted R Squared = .564)

b. R Squared = .250 (Adjusted R Squared = .230)

Post Hoc Tests

ID

Table A2: Multiple Comparisons (Dwell time with id 1 and 2 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
DwellTime	1	2	1.908	1.6075	.998	-3.547	7.363
		3	26.021*	1.8396	.000	19.779	32.264
		4	12.400*	1.7703	.000	6.393	18.408
		5	-23.651*	1.8200	.000	-29.828	-17.475
		6	2.134	1.6749	.995	-3.549	7.818
		7	11.508*	1.6983	.000	5.745	17.271
		8	24.054*	1.9318	.000	17.498	30.609
		9	17.552*	1.5916	.000	12.151	22.953
		10	27.851*	1.6863	.000	22.128	33.573
		11	3.946	1.4609	.304	-1.011	8.904
		12	13.986*	1.5994	.000	8.558	19.413
		13	-16.839*	1.8017	.000	-22.953	-10.725
		14	-49.114*	1.6749	.000	-54.798	-43.430
		15	-18.224*	1.7844	.000	-24.279	-12.169
	2	1	-1.908	1.6075	.998	-7.363	3.547
		3	24.113*	1.7887	.000	18.043	30.183
		4	10.492*	1.7174	.000	4.664	16.320
		5	-25.559*	1.7686	.000	-31.561	-19.558
		6	.226	1.6188	1.000	-5.267	5.720
		7	9.600*	1.6430	.000	4.024	15.176
		8	22.146*	1.8834	.000	15.755	28.537
		9	15.644*	1.5325	.000	10.444	20.845
		10	25.943*	1.6306	.000	20.409	31.476
		11	2.038	1.3963	.981	-2.700	6.777
		12	12.078*	1.5406	.000	6.850	17.306
		13	-18.747*	1.7497	.000	-24.685	-12.809
		14	-51.022*	1.6188	.000	-56.515	-45.529
		15	-20.132*	1.7319	.000	-26.009	-14.255

Post Hoc Tests

ID

Table A3: Multiple Comparisons (Dwell time with id 3 and 4 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	3	1	-26.021*	1.8396	.000	-32.264	-19.779
		2	-24.113*	1.7887	.000	-30.183	-18.043
		4	-13.621*	1.9363	.000	-20.192	-7.050
		5	-49.673*	1.9819	.000	-56.398	-42.947
		6	-23.887*	1.8494	.000	-30.163	-17.611
		7	-14.513*	1.8707	.000	-20.861	-8.165
		8	-1.967	2.0850	1.000	-9.043	5.108
		9	-8.469*	1.7744	.000	-14.490	-2.448
		10	1.830	1.8598	1.000	-4.482	8.141
		11	-22.075*	1.6582	.000	-27.702	-16.448
		12	-12.036*	1.7814	.000	-18.081	-5.991
		13	-42.860*	1.9650	.000	-49.529	-36.192
		14	-75.135*	1.8494	.000	-81.411	-68.859
		15	-44.245*	1.9492	.000	-50.859	-37.631
	4	1	-12.400*	1.7703	.000	-18.408	-6.393
		2	-10.492*	1.7174	.000	-16.320	-4.664
		3	13.621*	1.9363	.000	7.050	20.192
		5	-36.051*	1.9178	.000	-42.559	-29.544
		6	-10.266*	1.7806	.000	-16.308	-4.224
		7	-.892	1.8026	1.000	-7.009	5.225
		8	11.654*	2.0241	.000	4.785	18.522
		9	5.152	1.7025	.144	-.625	10.929
		10	15.451*	1.7913	.000	9.372	21.529
		11	-8.454*	1.5810	.000	-13.819	-3.089
		12	1.585	1.7098	1.000	-4.217	7.387
		13	-29.239*	1.9004	.000	-35.688	-22.790
		14	-61.514*	1.7806	.000	-67.556	-55.472
		15	-30.624*	1.8840	.000	-37.017	-24.231

Post Hoc Tests

ID

Table A4: Multiple Comparisons (Dwell time with id 5 and 6 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	5	1	23.651*	1.8200	.000	17.475	29.828
		2	25.559*	1.7686	.000	19.558	31.561
		3	49.673*	1.9819	.000	42.947	56.398
		4	36.051*	1.9178	.000	29.544	42.559
		6	25.785*	1.8300	.000	19.575	31.996
		7	35.159*	1.8515	.000	28.876	41.442
		8	47.705*	2.0678	.000	40.688	54.722
		9	41.204*	1.7541	.000	35.251	47.156
		10	51.502*	1.8405	.000	45.256	57.748
		11	27.598*	1.6365	.000	22.044	33.151
		12	37.637*	1.7612	.000	31.660	43.614
		13	6.812*	1.9468	.036	.206	13.419
		14	-25.463*	1.8300	.000	-31.673	-19.253
		15	5.428	1.9308	.241	-1.124	11.980
	6	1	-2.134	1.6749	.995	-7.818	3.549
		2	-.226	1.6188	1.000	-5.720	5.267
		3	23.887*	1.8494	.000	17.611	30.163
		4	10.266*	1.7806	.000	4.224	16.308
		5	-25.785*	1.8300	.000	-31.996	-19.575
		7	9.374*	1.7089	.000	3.575	15.173
		8	21.920*	1.9412	.000	15.332	28.507
		9	15.418*	1.6030	.000	9.978	20.858
		10	25.717*	1.6970	.000	19.958	31.475
		11	1.812	1.4733	.997	-3.187	6.812
		12	11.851*	1.6107	.000	6.385	17.317
		13	-18.973*	1.8118	.000	-25.121	-12.825
		14	-51.248*	1.6857	.000	-56.968	-45.528
		15	-20.358*	1.7946	.000	-26.448	-14.268

Post Hoc Tests

ID

Table A5: Multiple Comparisons (Dwell time with id 7 and 8 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
DwellTime	7	1	-11.508*	1.6983	.000	-17.271	-5.745
		2	-9.600*	1.6430	.000	-15.176	-4.024
		3	14.513*	1.8707	.000	8.165	20.861
		4	.892	1.8026	1.000	-5.225	7.009
		5	-35.159*	1.8515	.000	-41.442	-28.876
		6	-9.374*	1.7089	.000	-15.173	-3.575
		8	12.546*	1.9614	.000	5.890	19.202
		9	6.044*	1.6274	.017	.522	11.567
		10	16.343*	1.7201	.000	10.506	22.180
		11	-7.562*	1.4999	.000	-12.651	-2.472
		12	2.478	1.6351	.974	-3.071	8.026
		13	-28.347*	1.8334	.000	-34.569	-22.125
		14	-60.622*	1.7089	.000	-66.421	-54.823
		15	-29.732*	1.8164	.000	-35.896	-23.568
	8	1	-24.054*	1.9318	.000	-30.609	-17.498
		2	-22.146*	1.8834	.000	-28.537	-15.755
		3	1.967	2.0850	1.000	-5.108	9.043
		4	-11.654*	2.0241	.000	-18.522	-4.785
		5	-47.705*	2.0678	.000	-54.722	-40.688
		6	-21.920*	1.9412	.000	-28.507	-15.332
		7	-12.546*	1.9614	.000	-19.202	-5.890
		9	-6.502*	1.8698	.038	-12.847	-.157
		10	3.797	1.9510	.829	-2.824	10.418
		11	-20.107*	1.7599	.000	-26.080	-14.135
		12	-10.068*	1.8765	.000	-16.436	-3.701
		13	-40.893*	2.0516	.000	-47.855	-33.931
		14	-73.168*	1.9412	.000	-79.755	-66.581
		15	-42.278*	2.0364	.000	-49.188	-35.367

Post Hoc Tests

ID

Table A6: Multiple Comparisons (Dwell time with id 9 and 10 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	9	1	-17.552*	1.5916	.000	-22.953	-12.151
		2	-15.644*	1.5325	.000	-20.845	-10.444
		3	8.469*	1.7744	.000	2.448	14.490
		4	-5.152	1.7025	.144	-10.929	.625
		5	-41.204*	1.7541	.000	-47.156	-35.251
		6	-15.418*	1.6030	.000	-20.858	-9.978
		7	-6.044*	1.6274	.017	-11.567	-.522
		8	6.502*	1.8698	.038	.157	12.847
		10	10.299*	1.6149	.000	4.818	15.779
		11	-13.606*	1.3779	.000	-18.282	-8.930
		12	-3.567	1.5239	.560	-8.738	1.605
		13	-34.391*	1.7351	.000	-40.279	-28.503
		14	-66.666*	1.6030	.000	-72.106	-61.227
		15	-35.776*	1.7171	.000	-41.603	-29.949
	10	1	-27.851*	1.6863	.000	-33.573	-22.128
		2	-25.943*	1.6306	.000	-31.476	-20.409
		3	-1.830	1.8598	1.000	-8.141	4.482
		4	-15.451*	1.7913	.000	-21.529	-9.372
		5	-51.502*	1.8405	.000	-57.748	-45.256
		6	-25.717*	1.6970	.000	-31.475	-19.958
		7	-16.343*	1.7201	.000	-22.180	-10.506
		8	-3.797	1.9510	.829	-10.418	2.824
		9	-10.299*	1.6149	.000	-15.779	-4.818
		11	-23.904*	1.4863	.000	-28.948	-18.861
		12	-13.865*	1.6226	.000	-19.371	-8.359
		13	-44.690*	1.8223	.000	-50.874	-38.506
		14	-76.965*	1.6970	.000	-82.724	-71.206
		15	-46.075*	1.8052	.000	-52.200	-39.949

Post Hoc Tests

ID

Table A7: Multiple Comparisons (Dwell time with id 11 and 12 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	11	1	-3.946	1.4609	.304	-8.904	1.011
		2	-2.038	1.3963	.981	-6.777	2.700
		3	22.075*	1.6582	.000	16.448	27.702
		4	8.454*	1.5810	.000	3.089	13.819
		5	-27.598*	1.6365	.000	-33.151	-22.044
		6	-1.812	1.4733	.997	-6.812	3.187
		7	7.562*	1.4999	.000	2.472	12.651
		8	20.107*	1.7599	.000	14.135	26.080
		9	13.606*	1.3779	.000	8.930	18.282
		10	23.904*	1.4863	.000	18.861	28.948
		12	10.039*	1.3869	.000	5.333	14.746
		13	-20.786*	1.6160	.000	-26.269	-15.302
		14	-53.060*	1.4733	.000	-58.060	-48.061
		15	-22.170*	1.5967	.000	-27.589	-16.752
	12	1	-13.986*	1.5994	.000	-19.413	-8.558
		2	-12.078*	1.5406	.000	-17.306	-6.850
		3	12.036*	1.7814	.000	5.991	18.081
		4	-1.585	1.7098	1.000	-7.387	4.217
		5	-37.637*	1.7612	.000	-43.614	-31.660
		6	-11.851*	1.6107	.000	-17.317	-6.385
		7	-2.478	1.6351	.974	-8.026	3.071
		8	10.068*	1.8765	.000	3.701	16.436
		9	3.567	1.5239	.560	-1.605	8.738
		10	13.865*	1.6226	.000	8.359	19.371
		11	-10.039*	1.3869	.000	-14.746	-5.333
		13	-30.825*	1.7422	.000	-36.737	-24.912
		14	-63.100*	1.6107	.000	-68.566	-57.634
		15	-32.209*	1.7243	.000	-38.061	-26.358

Post Hoc Tests

ID

Table A8: Multiple Comparisons (Dwell time with id 13 and 14 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	13	1	16.839*	1.8017	.000	10.725	22.953
		2	18.747*	1.7497	.000	12.809	24.685
		3	42.860*	1.9650	.000	36.192	49.529
		4	29.239*	1.9004	.000	22.790	35.688
		5	-6.812*	1.9468	.036	-13.419	-.206
		6	18.973*	1.8118	.000	12.825	25.121
		7	28.347*	1.8334	.000	22.125	34.569
		8	40.893*	2.0516	.000	33.931	47.855
		9	34.391*	1.7351	.000	28.503	40.279
		10	44.690*	1.8223	.000	38.506	50.874
		11	20.786*	1.6160	.000	15.302	26.269
		12	30.825*	1.7422	.000	24.912	36.737
		14	-32.275*	1.8118	.000	-38.423	-26.127
		15	-1.385	1.9135	1.000	-7.878	5.109
	14	1	49.114*	1.6749	.000	43.430	54.798
		2	51.022*	1.6188	.000	45.529	56.515
		3	75.135*	1.8494	.000	68.859	81.411
		4	61.514*	1.7806	.000	55.472	67.556
		5	25.463*	1.8300	.000	19.253	31.673
		6	51.248*	1.6857	.000	45.528	56.968
		7	60.622*	1.7089	.000	54.823	66.421
		8	73.168*	1.9412	.000	66.581	79.755
		9	66.666*	1.6030	.000	61.227	72.106
		10	76.965*	1.6970	.000	71.206	82.724
		11	53.060*	1.4733	.000	48.061	58.060
		12	63.100*	1.6107	.000	57.634	68.566
		13	32.275*	1.8118	.000	26.127	38.423
		15	30.890*	1.7946	.000	24.800	36.980

Post Hoc Tests

ID

Table A9: Multiple Comparisons (Dwell time with id 15 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
DwellTime	15	1	18.224*	1.7844	.000	12.169	24.279
		2	20.132*	1.7319	.000	14.255	26.009
		3	44.245*	1.9492	.000	37.631	50.859
		4	30.624*	1.8840	.000	24.231	37.017
		5	-5.428	1.9308	.241	-11.980	1.124
		6	20.358*	1.7946	.000	14.268	26.448
		7	29.732*	1.8164	.000	23.568	35.896
		8	42.278*	2.0364	.000	35.367	49.188
		9	35.776*	1.7171	.000	29.949	41.603
		10	46.075*	1.8052	.000	39.949	52.200
		11	22.170*	1.5967	.000	16.752	27.589
		12	32.209*	1.7243	.000	26.358	38.061
		13	1.385	1.9135	1.000	-5.109	7.878
		14	-30.890*	1.7946	.000	-36.980	-24.800

Post Hoc Tests

ID

Table A10: Multiple Comparisons (Interleave time with id 1 and 2 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	1	2	-68.056	21.2574	.089	-140.192	4.080
		3	76.456	24.3258	.105	-6.093	159.005
		4	51.065	23.4102	.678	-28.377	130.506
		5	-333.088*	24.0678	.000	-414.761	-251.415
		6	11.032	22.1478	1.000	-64.126	86.190
		7	48.577	22.4573	.692	-27.631	124.784
		8	-214.988*	25.5452	.000	-301.674	-128.301
		9	-141.138*	21.0464	.000	-212.558	-69.718
		10	24.154	22.2989	.999	-51.517	99.824
		11	19.644	19.3185	1.000	-45.912	85.201
		12	-214.525*	21.1499	.000	-286.296	-142.754
		13	30.223	23.8250	.995	-50.626	111.073
		14	26.084	22.1478	.998	-49.073	101.242
		15	-72.243	23.5962	.131	-152.316	7.829
	2	1	68.056	21.2574	.089	-4.080	140.192
		3	144.512*	23.6531	.000	64.246	224.778
		4	119.121*	22.7104	.000	42.054	196.187
		5	-265.032*	23.3876	.000	-344.397	-185.667
		6	79.088*	21.4068	.018	6.445	151.731
		7	116.633*	21.7268	.000	42.904	190.361
		8	-146.932*	24.9054	.000	-231.447	-62.416
		9	-73.082*	20.2651	.025	-141.851	-4.314
		10	92.210*	21.5630	.002	19.037	165.383
		11	87.700*	18.4642	.000	25.042	150.358
		12	-146.469*	20.3726	.000	-215.603	-77.336
		13	98.279*	23.1377	.002	19.762	176.796
		14	94.140*	21.4068	.001	21.497	166.783
		15	-4.187	22.9020	1.000	-81.904	73.530

Post Hoc Tests

ID

Table A11: Multiple Comparisons (Interleave time with id 3 and 4 in KTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	3	1	-76.456	24.3258	.105	-159.005	6.093
		2	-144.512*	23.6531	.000	-224.778	-64.246
		4	-25.392	25.6052	1.000	-112.282	61.499
		5	-409.544*	26.2078	.000	-498.479	-320.609
		6	-65.425	24.4564	.321	-148.416	17.567
		7	-27.880	24.7370	.999	-111.824	56.064
		8	-291.444*	27.5708	.000	-385.004	-197.884
		9	-217.595*	23.4636	.000	-297.217	-137.972
		10	-52.302	24.5933	.717	-135.759	31.154
		11	-56.812	21.9270	.376	-131.221	17.596
		12	-290.981*	23.5565	.000	-370.919	-211.043
		13	-46.233	25.9850	.907	-134.412	41.946
		14	-50.372	24.4564	.762	-133.364	32.620
		15	-148.699*	25.7754	.000	-236.167	-61.232
	4	1	-51.065	23.4102	.678	-130.506	28.377
		2	-119.121*	22.7104	.000	-196.187	-42.054
		3	25.392	25.6052	1.000	-61.499	112.282
		5	-384.152*	25.3602	.000	-470.211	-298.094
		6	-40.033	23.5459	.933	-119.935	39.869
		7	-2.488	23.8372	1.000	-83.379	78.402
		8	-266.052*	26.7664	.000	-356.883	-175.222
		9	-192.203*	22.5129	.000	-268.600	-115.806
		10	-26.911	23.6880	.999	-107.295	53.474
		11	-31.421	20.9066	.976	-102.366	39.525
		12	-265.590*	22.6097	.000	-342.315	-188.864
		13	-20.841	25.1299	1.000	-106.119	64.436
		14	-24.980	23.5459	.999	-104.882	54.922
		15	-123.308*	24.9131	.000	-207.849	-38.766

Post Hoc Tests

ID

Table A12: Multiple Comparisons (Interleave time with id 5 and 6 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	5	1	333.088*	24.0678	.000	251.415	414.761
		2	265.032*	23.3876	.000	185.667	344.397
		3	409.544*	26.2078	.000	320.609	498.479
		4	384.152*	25.3602	.000	298.094	470.211
		6	344.119*	24.1998	.000	261.999	426.240
		7	381.664*	24.4833	.000	298.581	464.747
		8	118.100*	27.3434	.002	25.311	210.889
		9	191.950*	23.1960	.000	113.235	270.664
		10	357.242*	24.3381	.000	274.651	439.832
		11	352.732*	21.6404	.000	279.296	426.168
		12	118.563*	23.2899	.000	39.529	197.596
		13	363.311*	25.7436	.000	275.951	450.671
		14	359.172*	24.1998	.000	277.051	441.293
		15	260.845*	25.5320	.000	174.203	347.486
	6	1	-11.032	22.1478	1.000	-86.190	64.126
		2	-79.088*	21.4068	.018	-151.731	-6.445
		3	65.425	24.4564	.321	-17.567	148.416
		4	40.033	23.5459	.933	-39.869	119.935
		5	-344.119*	24.1998	.000	-426.240	-261.999
		7	37.545	22.5987	.944	-39.143	114.233
		8	-226.019*	25.6696	.000	-313.128	-138.911
		9	-152.170*	21.1972	.000	-224.102	-80.238
		10	13.122	22.4413	1.000	-63.031	89.276
		11	8.612	19.4827	1.000	-57.501	74.726
		12	-225.557*	21.3000	.000	-297.837	-153.276
		13	19.192	23.9583	1.000	-62.110	100.493
		14	15.053	22.2912	1.000	-60.592	90.697
		15	-83.275*	23.7308	.034	-163.804	-2.745

Post Hoc Tests

ID

Table A13: Multiple Comparisons (Interleave time with id 7 and 8 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	7	1	-48.577	22.4573	.692	-124.784	27.631
		2	-116.633*	21.7268	.000	-190.361	-42.904
		3	27.880	24.7370	.999	-56.064	111.824
		4	2.488	23.8372	1.000	-78.402	83.379
		5	-381.664*	24.4833	.000	-464.747	-298.581
		6	-37.545	22.5987	.944	-114.233	39.143
		8	-263.564*	25.9371	.000	-351.581	-175.548
		9	-189.715*	21.5203	.000	-262.743	-116.686
		10	-24.423	22.7467	.999	-101.613	52.768
		11	-28.933	19.8337	.982	-96.238	38.372
		12	-263.102*	21.6215	.000	-336.473	-189.730
		13	-18.353	24.2447	1.000	-100.627	63.920
		14	-22.492	22.5987	1.000	-99.180	54.195
		15	-120.820*	24.0198	.000	-202.330	-39.309
	8	1	214.988*	25.5452	.000	128.301	301.674
		2	146.932*	24.9054	.000	62.416	231.447
		3	291.444*	27.5708	.000	197.884	385.004
		4	266.052*	26.7664	.000	175.222	356.883
		5	-118.100*	27.3434	.002	-210.889	-25.311
		6	226.019*	25.6696	.000	138.911	313.128
		7	263.564*	25.9371	.000	175.548	351.581
		9	73.849	24.7256	.159	-10.056	157.755
		10	239.142*	25.8001	.000	151.590	326.693
		11	234.632*	23.2724	.000	155.658	313.606
		12	.463	24.8137	1.000	-83.742	84.667
		13	245.211*	27.1299	.000	153.147	337.276
		14	241.072*	25.6696	.000	153.963	328.181
		15	142.745*	26.9292	.000	51.361	234.128

Post Hoc Tests

ID

Table A14: Multiple Comparisons (Interleave time with id 9 and 10 in KTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	9	1	141.138*	21.0464	.000	69.718	212.558
		2	73.082*	20.2651	.025	4.314	141.851
		3	217.595*	23.4636	.000	137.972	297.217
		4	192.203*	22.5129	.000	115.806	268.600
		5	-191.950*	23.1960	.000	-270.664	-113.235
		6	152.170*	21.1972	.000	80.238	224.102
		7	189.715*	21.5203	.000	116.686	262.743
		8	-73.849	24.7256	.159	-157.755	10.056
		10	165.292*	21.3550	.000	92.825	237.760
		11	160.782*	18.2208	.000	98.951	222.614
		12	-73.387*	20.1523	.022	-141.773	-5.001
		13	171.362*	22.9440	.000	93.502	249.221
		14	167.223*	21.1972	.000	95.291	239.155
		15	68.895	22.7063	.141	-8.158	145.948
	10	1	-24.154	22.2989	.999	-99.824	51.517
		2	-92.210*	21.5630	.002	-165.383	-19.037
		3	52.302	24.5933	.717	-31.154	135.759
		4	26.911	23.6880	.999	-53.474	107.295
		5	-357.242*	24.3381	.000	-439.832	-274.651
		6	-13.122	22.4413	1.000	-89.276	63.031
		7	24.423	22.7467	.999	-52.768	101.613
		8	-239.142*	25.8001	.000	-326.693	-151.590
		9	-165.292*	21.3550	.000	-237.760	-92.825
		11	-4.510	19.6542	1.000	-71.206	62.186
		12	-238.679*	21.4570	.000	-311.492	-165.865
		13	6.069	24.0981	1.000	-75.706	87.845
		14	1.930	22.4413	1.000	-74.223	78.084
		15	-96.397*	23.8718	.005	-177.405	-15.389

Post Hoc Tests

ID

Table A15: Multiple Comparisons (Interleave time with id 11 and 12 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	11	1	-19.644	19.3185	1.000	-85.201	45.912
		2	-87.700*	18.4642	.000	-150.358	-25.042
		3	56.812	21.9270	.376	-17.596	131.221
		4	31.421	20.9066	.976	-39.525	102.366
		5	-352.732*	21.6404	.000	-426.168	-279.296
		6	-8.612	19.4827	1.000	-74.726	57.501
		7	28.933	19.8337	.982	-38.372	96.238
		8	-234.632*	23.2724	.000	-313.606	-155.658
		9	-160.782*	18.2208	.000	-222.614	-98.951
		10	4.510	19.6542	1.000	-62.186	71.206
		12	-234.169*	18.3403	.000	-296.406	-171.932
		13	10.579	21.3700	1.000	-61.939	83.098
		14	6.440	19.4827	1.000	-59.673	72.554
		15	-91.887*	21.1146	.001	-163.539	-20.236
	12	1	214.525*	21.1499	.000	142.754	286.296
		2	146.469*	20.3726	.000	77.336	215.603
		3	290.981*	23.5565	.000	211.043	370.919
		4	265.590*	22.6097	.000	188.864	342.315
		5	-118.563*	23.2899	.000	-197.596	-39.529
		6	225.557*	21.3000	.000	153.276	297.837
		7	263.102*	21.6215	.000	189.730	336.473
		8	-.463	24.8137	1.000	-84.667	83.742
		9	73.387*	20.1523	.022	5.001	141.773
		10	238.679*	21.4570	.000	165.865	311.492
		11	234.169*	18.3403	.000	171.932	296.406
		13	244.748*	23.0389	.000	166.567	322.930
		14	240.609*	21.3000	.000	168.329	312.890
		15	142.282*	22.8022	.000	64.903	219.660

Post Hoc Tests

ID

Table A16: Multiple Comparisons (Interleave time with id 13 and 14 in KTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	13	1	-30.223	23.8250	.995	-111.073	50.626
		2	-98.279*	23.1377	.002	-176.796	-19.762
		3	46.233	25.9850	.907	-41.946	134.412
		4	20.841	25.1299	1.000	-64.436	106.119
		5	-363.311*	25.7436	.000	-450.671	-275.951
		6	-19.192	23.9583	1.000	-100.493	62.110
		7	18.353	24.2447	1.000	-63.920	100.627
		8	-245.211*	27.1299	.000	-337.276	-153.147
		9	-171.362*	22.9440	.000	-249.221	-93.502
		10	-6.069	24.0981	1.000	-87.845	75.706
		11	-10.579	21.3700	1.000	-83.098	61.939
		12	-244.748*	23.0389	.000	-322.930	-166.567
		14	-4.139	23.9583	1.000	-85.441	77.163
		15	-102.467*	25.3033	.005	-188.332	-16.601
	14	1	-26.084	22.1478	.998	-101.242	49.073
		2	-94.140*	21.4068	.001	-166.783	-21.497
		3	50.372	24.4564	.762	-32.620	133.364
		4	24.980	23.5459	.999	-54.922	104.882
		5	-359.172*	24.1998	.000	-441.293	-277.051
		6	-15.053	22.2912	1.000	-90.697	60.592
		7	22.492	22.5987	1.000	-54.195	99.180
		8	-241.072*	25.6696	.000	-328.181	-153.963
		9	-167.223*	21.1972	.000	-239.155	-95.291
		10	-1.930	22.4413	1.000	-78.084	74.223
		11	-6.440	19.4827	1.000	-72.554	59.673
		12	-240.609*	21.3000	.000	-312.890	-168.329
		13	4.139	23.9583	1.000	-77.163	85.441
		15	-98.328*	23.7308	.003	-178.857	-17.798

Post Hoc Tests

ID

Table A17: Multiple Comparisons (Interleave time with id 15 in KTC)

Tukey HSD							
						95% Confidence Interval	
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
InterLeave Time	15	1	72.243	23.5962	.131	-7.829	152.316
		2	4.187	22.9020	1.000	-73.530	81.904
		3	148.699*	25.7754	.000	61.232	236.167
		4	123.308*	24.9131	.000	38.766	207.849
		5	-260.845*	25.5320	.000	-347.486	-174.203
		6	83.275*	23.7308	.034	2.745	163.804
		7	120.820*	24.0198	.000	39.309	202.330
		8	-142.745*	26.9292	.000	-234.128	-51.361
		9	-68.895	22.7063	.141	-145.948	8.158
		10	96.397*	23.8718	.005	15.389	177.405
		11	91.887*	21.1146	.001	20.236	163.539
		12	-142.282*	22.8022	.000	-219.660	-64.903
		13	102.467*	25.3033	.005	16.601	188.332
		14	98.328*	23.7308	.003	17.798	178.857

Post Hoc Tests

Character

Table A18: Multiple Comparisons (Dwell time with Character 1-5 in KTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	1	2	9.617*	1.1556	.000	6.208	13.026
		3	-.002	1.1556	1.000	-3.411	3.407
		4	13.173*	1.1556	.000	9.764	16.582
		5	13.779*	1.1556	.000	10.370	17.188
		6	6.845*	1.1556	.000	3.436	10.253
		7	15.696*	1.1561	.000	12.285	19.106
	2	1	-9.617*	1.1556	.000	-13.026	-6.208
		3	-9.618*	1.1556	.000	-13.027	-6.209
		4	3.557*	1.1556	.034	.148	6.965
		5	4.163*	1.1556	.006	.754	7.571
		6	-2.772	1.1556	.199	-6.181	.637
		7	6.079*	1.1561	.000	2.669	9.490
	3	1	.002	1.1556	1.000	-3.407	3.411
		2	9.618*	1.1556	.000	6.209	13.027
		4	13.175*	1.1556	.000	9.766	16.584
		5	13.781*	1.1556	.000	10.372	17.190
		6	6.846*	1.1556	.000	3.437	10.255
		7	15.698*	1.1561	.000	12.287	19.108
	4	1	-13.173*	1.1556	.000	-16.582	-9.764
		2	-3.557*	1.1556	.034	-6.965	-.148
		3	-13.175*	1.1556	.000	-16.584	-9.766
		5	.606	1.1556	.999	-2.803	4.015
		6	-6.329*	1.1556	.000	-9.738	-2.920
		7	2.523	1.1561	.305	-.888	5.933
	5	1	-13.779*	1.1556	.000	-17.188	-10.370
		2	-4.163*	1.1556	.006	-7.571	-.754
		3	-13.781*	1.1556	.000	-17.190	-10.372
		4	-.606	1.1556	.999	-4.015	2.803
		6	-6.935*	1.1556	.000	-10.344	-3.526
		7	1.917	1.1561	.644	-1.494	5.327

Post Hoc Tests

Character

Table A19: Multiple Comparisons (Dwell time with Character 6 and 7 in KTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
DwellTime	6	1	-6.845*	1.1556	.000	-10.253	-3.436
		2	2.772	1.1556	.199	-.637	6.181
		3	-6.846*	1.1556	.000	-10.255	-3.437
		4	6.329*	1.1556	.000	2.920	9.738
		5	6.935*	1.1556	.000	3.526	10.344
		7	8.851*	1.1561	.000	5.441	12.262
	7	1	-15.696*	1.1561	.000	-19.106	-12.285
		2	-6.079*	1.1561	.000	-9.490	-2.669
		3	-15.698*	1.1561	.000	-19.108	-12.287
		4	-2.523	1.1561	.305	-5.933	.888
		5	-1.917	1.1561	.644	-5.327	1.494
		6	-8.851*	1.1561	.000	-12.262	-5.441

Post Hoc Tests

Character

Table A20: Multiple Comparisons (Interleave time with Character 1-5 in KTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
InterLeave Time	1	2	-.716	15.2815	1.000	-45.794	44.363
		3	-11.270	15.2815	.990	-56.349	33.808
		4	-179.975*	15.2815	.000	-225.054	-134.897
		5	-95.429*	15.2815	.000	-140.508	-50.351
		6	-54.760*	15.2815	.006	-99.838	-9.681
		7	-7.721	15.2883	.999	-52.820	37.377
	2	1	.716	15.2815	1.000	-44.363	45.794
		3	-10.555	15.2815	.993	-55.633	34.524
		4	-179.260*	15.2815	.000	-224.338	-134.181
		5	-94.714*	15.2815	.000	-139.792	-49.635
		6	-54.044*	15.2815	.007	-99.123	-8.966
		7	-7.006	15.2883	.999	-52.104	38.093
	3	1	11.270	15.2815	.990	-33.808	56.349
		2	10.555	15.2815	.993	-34.524	55.633
		4	-168.705*	15.2815	.000	-213.784	-123.626
		5	-84.159*	15.2815	.000	-129.238	-39.080
		6	-43.489	15.2815	.067	-88.568	1.589
		7	3.549	15.2883	1.000	-41.549	48.648
	4	1	179.975*	15.2815	.000	134.897	225.054
		2	179.260*	15.2815	.000	134.181	224.338
		3	168.705*	15.2815	.000	123.626	213.784
		5	84.546*	15.2815	.000	39.467	129.625
		6	125.216*	15.2815	.000	80.137	170.294
		7	172.254*	15.2883	.000	127.155	217.353
	5	1	95.429*	15.2815	.000	50.351	140.508
		2	94.714*	15.2815	.000	49.635	139.792
		3	84.159*	15.2815	.000	39.080	129.238
		4	-84.546*	15.2815	.000	-129.625	-39.467
		6	40.670	15.2815	.109	-4.409	85.748
		7	87.708*	15.2883	.000	42.610	132.807

Post Hoc Tests

Character

Table A21: Multiple Comparisons (Interleave time with Character 6 and 7 in KTC)

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
InterLeave Time	6	1	54.760*	15.2815	.006	9.681	99.838
		2	54.044*	15.2815	.007	8.966	99.123
		3	43.489	15.2815	.067	-1.589	88.568
		4	-125.216*	15.2815	.000	-170.294	-80.137
		5	-40.670	15.2815	.109	-85.748	4.409
		7	47.038*	15.2883	.034	1.940	92.137
	7	1	7.721	15.2883	.999	-37.377	52.820
		2	7.006	15.2883	.999	-38.093	52.104
		3	-3.549	15.2883	1.000	-48.648	41.549
		4	-172.254*	15.2883	.000	-217.353	-127.155
		5	-87.708*	15.2883	.000	-132.807	-42.610
		6	-47.038*	15.2883	.034	-92.137	-1.940

Table A22: Tests of Between-Subjects Effects (VTC)

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	DwellTime	6622057.235[a]	134	49418.338	42.380	0.000
	InterLeaveTime	129765573.994[b]	134	968399.806	4.444	.000
	VisionTime	125113188.712[c]	134	933680.513	10.816	.000
Intercept	DwellTime	94036052.977	1	94036052.977	80643.001	0.000
	InterLeaveTime	4533017169.583	1	4533017169.583	20802.494	0.000
	VisionTime	7683943780.254	1	7683943780.254	89009.019	0.000
ID	DwellTime	5832977.306	14	416641.236	357.301	0.000
	InterLeaveTime	106604892.183	14	7614635.156	34.944	.000
	VisionTime	92924245.882	14	6637446.134	76.887	.000
POS	DwellTime	326653.554	8	40831.694	35.016	.000
	InterLeaveTime	872631.482	8	109078.935	.501	.857
	VisionTime	10012420.105	8	1251552.513	14.498	.000
ID * POS	DwellTime	379516.683	112	3388.542	2.906	.000
	InterLeaveTime	21394909.387	112	191025.977	.877	.820
	VisionTime	22471561.274	112	200638.940	2.324	.000
Error	DwellTime	10242831.671	8784	1166.078		
	InterLeaveTime	1914098521.721	8784	217907.391		
	VisionTime	758302507.063	8784	86327.699		
Total	DwellTime	119822346.000	8919			
	InterLeaveTime	6975856240.000	8919			
	VisionTime	9311283661.000	8919			
Corrected Total	DwellTime	16864888.906	8918			
	InterLeaveTime	2043864095.714	8918			
	VisionTime	883415695.774	8918			

Post Hoc Tests

ID

Table A23: Multiple Comparisons (Dwell time with id 1 and 2 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	1	2	23.779*	1.8335	.000	17.559	29.998
		3	34.860*	2.2447	.000	27.245	42.474
		4	15.017*	2.1193	.000	7.828	22.206
		5	-17.054*	2.2447	.000	-24.668	-9.439
		6	9.133*	2.0138	.001	2.302	15.965
		7	13.469*	1.9815	.000	6.747	20.190
		8	18.349*	2.2307	.000	10.782	25.916
		9	3.059	2.0782	.980	-3.990	10.109
		10	31.334*	2.0641	.000	24.332	38.336
		11	12.833*	1.8127	.000	6.683	18.982
		12	20.195*	1.9918	.000	13.439	26.952
		13	-23.453*	1.9918	.000	-30.209	-16.696
		14	-71.283*	2.0026	.000	-78.077	-64.490
		15	-3.672	2.3235	.963	-11.554	4.209
	2	1	-23.779*	1.8335	.000	-29.998	-17.559
		3	11.081*	2.0202	.000	4.228	17.934
		4	-8.762*	1.8800	.000	-15.139	-2.384
		5	-40.832*	2.0202	.000	-47.685	-33.979
		6	-14.645*	1.7602	.000	-20.616	-8.674
		7	-10.310*	1.7231	.000	-16.155	-4.465
		8	-5.430	2.0047	.300	-12.230	1.371
		9	-20.719*	1.8335	.000	-26.939	-14.500
		10	7.555*	1.8175	.003	1.390	13.721
		11	-10.946*	1.5260	.000	-16.123	-5.769
		12	-3.583	1.7349	.758	-9.469	2.302
		13	-47.231*	1.7349	.000	-53.117	-41.346
		14	-95.062*	1.7473	.000	-100.989	-89.135
		15	-27.451*	2.1074	.000	-34.600	-20.302

Post Hoc Tests

ID

Table A24: Multiple Comparisons (Dwell time with id 3 and 4 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	3	1	-34.860*	2.2447	.000	-42.474	-27.245
		2	-11.081*	2.0202	.000	-17.934	-4.228
		4	-19.843*	2.2828	.000	-27.587	-12.099
		5	-51.914*	2.3997	.000	-60.054	-43.773
		6	-25.726*	2.1852	.000	-33.139	-18.314
		7	-21.391*	2.1555	.000	-28.703	-14.079
		8	-16.511*	2.3866	.000	-24.607	-8.415
		9	-31.801*	2.2447	.000	-39.415	-24.186
		10	-3.526	2.2316	.963	-11.096	4.044
		11	-22.027*	2.0015	.000	-28.817	-15.238
		12	-14.665*	2.1650	.000	-22.009	-7.321
		13	-58.313*	2.1650	.000	-65.657	-50.969
		14	-106.143*	2.1749	.000	-113.521	-98.766
		15	-38.532*	2.4735	.000	-46.923	-30.141
	4	1	-15.017*	2.1193	.000	-22.206	-7.828
		2	8.762*	1.8800	.000	2.384	15.139
		3	19.843*	2.2828	.000	12.099	27.587
		5	-32.071*	2.2828	.000	-39.815	-24.327
		6	-5.884	2.0563	.215	-12.859	1.092
		7	-1.548	2.0246	1.000	-8.416	5.319
		8	3.332	2.2691	.981	-4.365	11.029
		9	-11.958*	2.1193	.000	-19.147	-4.769
		10	16.317*	2.1055	.000	9.175	23.459
		11	-2.185	1.8598	.998	-8.493	4.124
		12	5.178	2.0347	.408	-1.724	12.080
		13	-38.470*	2.0347	.000	-45.372	-31.568
		14	-86.300*	2.0453	.000	-93.238	-79.363
		15	-18.689*	2.3604	.000	-26.696	-10.683

Post Hoc Tests

ID

Table A25: Multiple Comparisons (Dwell time with id 5 and 6 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	5	1	17.054*	2.2447	.000	9.439	24.668
		2	40.832*	2.0202	.000	33.979	47.685
		3	51.914*	2.3997	.000	43.773	60.054
		4	32.071*	2.2828	.000	24.327	39.815
		6	26.187*	2.1852	.000	18.774	33.600
		7	30.522*	2.1555	.000	23.211	37.834
		8	35.403*	2.3866	.000	27.307	43.499
		9	20.113*	2.2447	.000	12.499	27.727
		10	48.388*	2.2316	.000	40.818	55.958
		11	29.886*	2.0015	.000	23.097	36.676
		12	37.249*	2.1650	.000	29.905	44.593
		13	-6.399	2.1650	.171	-13.743	.945
		14	-54.230*	2.1749	.000	-61.607	-46.852
		15	13.381*	2.4735	.000	4.991	21.772
	6	1	-9.133*	2.0138	.001	-15.965	-2.302
		2	14.645*	1.7602	.000	8.674	20.616
		3	25.726*	2.1852	.000	18.314	33.139
		4	5.884	2.0563	.215	-1.092	12.859
		5	-26.187*	2.1852	.000	-33.600	-18.774
		7	4.335	1.9139	.617	-2.157	10.827
		8	9.216*	2.1709	.002	1.852	16.580
		9	-6.074	2.0138	.147	-12.906	.757
		10	22.201*	1.9993	.000	15.419	28.983
		11	3.699	1.7386	.716	-2.199	9.597
		12	11.062*	1.9246	.000	4.533	17.590
		13	-32.586*	1.9246	.000	-39.115	-26.058
		14	-80.417*	1.9357	.000	-86.983	-73.850
		15	-12.806*	2.2661	.000	-20.493	-5.119

Post Hoc Tests

ID

Table A26: Multiple Comparisons (Dwell time with id 7 and 8 in VTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	7	1	-13.469*	1.9815	.000	-20.190	-6.747
		2	10.310*	1.7231	.000	4.465	16.155
		3	21.391*	2.1555	.000	14.079	28.703
		4	1.548	2.0246	1.000	-5.319	8.416
		5	-30.522*	2.1555	.000	-37.834	-23.211
		6	-4.335	1.9139	.617	-10.827	2.157
		8	4.880	2.1409	.606	-2.382	12.143
		9	-10.409*	1.9815	.000	-17.131	-3.688
		10	17.865*	1.9667	.000	11.194	24.537
		11	-.636	1.7010	1.000	-6.406	5.134
		12	6.727*	1.8907	.029	.313	13.140
		13	-36.922*	1.8907	.000	-43.335	-30.508
		14	-84.752*	1.9020	.000	-91.204	-78.300
		15	-17.141*	2.2374	.000	-24.731	-9.551
	8	1	-18.349*	2.2307	.000	-25.916	-10.782
		2	5.430	2.0047	.300	-1.371	12.230
		3	16.511*	2.3866	.000	8.415	24.607
		4	-3.332	2.2691	.981	-11.029	4.365
		5	-35.403*	2.3866	.000	-43.499	-27.307
		6	-9.216*	2.1709	.002	-16.580	-1.852
		7	-4.880	2.1409	.606	-12.143	2.382
		9	-15.290*	2.2307	.000	-22.857	-7.723
		10	12.985*	2.2176	.000	5.463	20.508
		11	-5.516	1.9858	.259	-12.253	1.220
		12	1.846	2.1505	1.000	-5.449	9.141
		13	-41.802*	2.1505	.000	-49.097	-34.507
		14	-89.632*	2.1604	.000	-96.961	-82.304
		15	-22.021*	2.4608	.000	-30.369	-13.674

Post Hoc Tests

ID

Table A27: Multiple Comparisons (Dwell time with id 9 and 10 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
DwellTime	9	1	-3.059	2.0782	.980	-10.109	3.990
		2	20.719*	1.8335	.000	14.500	26.939
		3	31.801*	2.2447	.000	24.186	39.415
		4	11.958*	2.1193	.000	4.769	19.147
		5	-20.113*	2.2447	.000	-27.727	-12.499
		6	6.074	2.0138	.147	-.757	12.906
		7	10.409*	1.9815	.000	3.688	17.131
		8	15.290*	2.2307	.000	7.723	22.857
		10	28.275*	2.0641	.000	21.273	35.277
		11	9.773*	1.8127	.000	3.624	15.923
		12	17.136*	1.9918	.000	10.379	23.893
		13	-26.512*	1.9918	.000	-33.269	-19.755
		14	-74.343*	2.0026	.000	-81.136	-67.549
		15	-6.731	2.3235	.198	-14.613	1.150
	10	1	-31.334*	2.0641	.000	-38.336	-24.332
		2	-7.555*	1.8175	.003	-13.721	-1.390
		3	3.526	2.2316	.963	-4.044	11.096
		4	-16.317*	2.1055	.000	-23.459	-9.175
		5	-48.388*	2.2316	.000	-55.958	-40.818
		6	-22.201*	1.9993	.000	-28.983	-15.419
		7	-17.865*	1.9667	.000	-24.537	-11.194
		8	-12.985*	2.2176	.000	-20.508	-5.463
		9	-28.275*	2.0641	.000	-35.277	-21.273
		11	-18.501*	1.7966	.000	-24.596	-12.407
		12	-11.139*	1.9771	.000	-17.846	-4.432
		13	-54.787*	1.9771	.000	-61.494	-48.080
		14	-102.617*	1.9880	.000	-109.361	-95.874
		15	-35.006*	2.3109	.000	-42.845	-27.167

Post Hoc Tests

ID

Table A28: Multiple Comparisons (Dwell time with id 11 and 12 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	11	1	-12.833*	1.8127	.000	-18.982	-6.683
		2	10.946*	1.5260	.000	5.769	16.123
		3	22.027*	2.0015	.000	15.238	28.817
		4	2.185	1.8598	.998	-4.124	8.493
		5	-29.886*	2.0015	.000	-36.676	-23.097
		6	-3.699	1.7386	.716	-9.597	2.199
		7	.636	1.7010	1.000	-5.134	6.406
		8	5.516	1.9858	.259	-1.220	12.253
		9	-9.773*	1.8127	.000	-15.923	-3.624
		10	18.501*	1.7966	.000	12.407	24.596
		12	7.363*	1.7130	.002	1.552	13.174
		13	-36.285*	1.7130	.000	-42.096	-30.474
		14	-84.116*	1.7256	.000	-89.969	-78.262
		15	-16.505*	2.0894	.000	-23.593	-9.417
	12	1	-20.195*	1.9918	.000	-26.952	-13.439
		2	3.583	1.7349	.758	-2.302	9.469
		3	14.665*	2.1650	.000	7.321	22.009
		4	-5.178	2.0347	.408	-12.080	1.724
		5	-37.249*	2.1650	.000	-44.593	-29.905
		6	-11.062*	1.9246	.000	-17.590	-4.533
		7	-6.727*	1.8907	.029	-13.140	-.313
		8	-1.846	2.1505	1.000	-9.141	5.449
		9	-17.136*	1.9918	.000	-23.893	-10.379
		10	11.139*	1.9771	.000	4.432	17.846
		11	-7.363*	1.7130	.002	-13.174	-1.552
		13	-43.648*	1.9015	.000	-50.098	-37.198
		14	-91.479*	1.9128	.000	-97.967	-84.990
		15	-23.867*	2.2465	.000	-31.488	-16.247

Post Hoc Tests

ID

Table A29: Multiple Comparisons (Dwell time with id 13 and 14 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
DwellTime	13	1	23.453*	1.9918	.000	16.696	30.209
		2	47.231*	1.7349	.000	41.346	53.117
		3	58.313*	2.1650	.000	50.969	65.657
		4	38.470*	2.0347	.000	31.568	45.372
		5	6.399	2.1650	.171	-.945	13.743
		6	32.586*	1.9246	.000	26.058	39.115
		7	36.922*	1.8907	.000	30.508	43.335
		8	41.802*	2.1505	.000	34.507	49.097
		9	26.512*	1.9918	.000	19.755	33.269
		10	54.787*	1.9771	.000	48.080	61.494
		11	36.285*	1.7130	.000	30.474	42.096
		12	43.648*	1.9015	.000	37.198	50.098
		14	-47.830*	1.9128	.000	-54.319	-41.342
		15	19.781*	2.2465	.000	12.160	27.401
	14	1	71.283*	2.0026	.000	64.490	78.077
		2	95.062*	1.7473	.000	89.135	100.989
		3	106.143*	2.1749	.000	98.766	113.521
		4	86.300*	2.0453	.000	79.363	93.238
		5	54.230*	2.1749	.000	46.852	61.607
		6	80.417*	1.9357	.000	73.850	86.983
		7	84.752*	1.9020	.000	78.300	91.204
		8	89.632*	2.1604	.000	82.304	96.961
		9	74.343*	2.0026	.000	67.549	81.136
		10	102.617*	1.9880	.000	95.874	109.361
		11	84.116*	1.7256	.000	78.262	89.969
		12	91.479*	1.9128	.000	84.990	97.967
		13	47.830*	1.9128	.000	41.342	54.319
		15	67.611*	2.2561	.000	59.958	75.264

Post Hoc Tests

ID

Table A30: Multiple Comparisons (Dwell time with id 15 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	15	1	3.672	2.3235	.963	-4.209	11.554
		2	27.451*	2.1074	.000	20.302	34.600
		3	38.532*	2.4735	.000	30.141	46.923
		4	18.689*	2.3604	.000	10.683	26.696
		5	-13.381*	2.4735	.000	-21.772	-4.991
		6	12.806*	2.2661	.000	5.119	20.493
		7	17.141*	2.2374	.000	9.551	24.731
		8	22.021*	2.4608	.000	13.674	30.369
		9	6.731	2.3235	.198	-1.150	14.613
		10	35.006*	2.3109	.000	27.167	42.845
		11	16.505*	2.0894	.000	9.417	23.593
		12	23.867*	2.2465	.000	16.247	31.488
		13	-19.781*	2.2465	.000	-27.401	-12.160
		14	-67.611*	2.2561	.000	-75.264	-59.958

Post Hoc Tests

ID

Table A31: Multiple Comparisons (Interleave time with id 1 and 2 in VTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
InterLeave Time	1	2	-36.407	25.0635	.982	-121.427	48.614
		3	105.679*	30.6851	.042	1.589	209.769
		4	-56.519	28.9715	.827	-154.797	41.758
		5	-187.326*	30.6851	.000	-291.416	-83.236
		6	-36.639	27.5291	.992	-130.024	56.746
		7	13.030	27.0868	1.000	-78.854	104.914
		8	-398.567*	30.4939	.000	-502.009	-295.125
		9	-129.476*	28.4089	.001	-225.845	-33.107
		10	-11.333	28.2163	1.000	-107.049	84.382
		11	-43.933	24.7805	.909	-127.994	40.127
		12	-115.735*	27.2282	.002	-208.099	-23.371
		13	97.997*	27.2282	.025	5.633	190.361
		14	-118.984*	27.3755	.001	-211.847	-26.121
		15	125.639*	31.7621	.007	17.895	233.383
	2	1	36.407	25.0635	.982	-48.614	121.427
		3	142.086*	27.6168	.000	48.403	235.768
		4	-20.113	25.6994	1.000	-107.291	67.065
		5	-150.919*	27.6168	.000	-244.601	-57.237
		6	-.232	24.0617	1.000	-81.855	81.390
		7	49.437	23.5544	.736	-30.465	129.338
		8	-362.161*	27.4043	.000	-455.122	-269.200
		9	-93.069*	25.0635	.017	-178.090	-8.049
		10	25.073	24.8450	1.000	-59.206	109.353
		11	-7.527	20.8611	1.000	-78.292	63.238
		12	-79.328	23.7168	.058	-159.781	1.124
		13	134.403*	23.7168	.000	53.951	214.856
		14	-82.578*	23.8858	.041	-163.603	-1.552
		15	162.045*	28.8088	.000	64.320	259.771

Post Hoc Tests

ID

Table A32: Multiple Comparisons (Interleave time with id 3 and 4 in VTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	3	1	-105.679*	30.6851	.042	-209.769	-1.589
		2	-142.086*	27.6168	.000	-235.768	-48.403
		4	-162.198*	31.2067	.000	-268.058	-56.339
		5	-293.005*	32.8037	.000	-404.282	-181.728
		6	-142.318*	29.8725	.000	-243.652	-40.984
		7	-92.649	29.4653	.104	-192.601	7.304
		8	-504.246*	32.6250	.000	-614.917	-393.575
		9	-235.155*	30.6851	.000	-339.245	-131.065
		10	-117.012*	30.5069	.011	-220.498	-13.527
		11	-149.612*	27.3602	.000	-242.424	-56.801
		12	-221.414*	29.5953	.000	-321.807	-121.020
		13	-7.682	29.5953	1.000	-108.076	92.711
		14	-224.663*	29.7309	.000	-325.517	-123.810
		15	19.960	33.8133	1.000	-94.742	134.662
	4	1	56.519	28.9715	.827	-41.758	154.797
		2	20.113	25.6994	1.000	-67.065	107.291
		3	162.198*	31.2067	.000	56.339	268.058
		5	-130.807*	31.2067	.003	-236.666	-24.947
		6	19.880	28.1094	1.000	-75.473	115.233
		7	69.550	27.6763	.431	-24.334	163.433
		8	-342.048*	31.0187	.000	-447.270	-236.826
		9	-72.957	28.9715	.427	-171.234	25.321
		10	45.186	28.7826	.965	-52.451	142.823
		11	12.586	25.4235	1.000	-73.656	98.828
		12	-59.216	27.8147	.715	-153.569	35.138
		13	154.516*	27.8147	.000	60.163	248.869
		14	-62.465	27.9589	.640	-157.307	32.378
		15	182.158*	32.2663	.000	72.704	291.612

Post Hoc Tests

ID

Table A33: Multiple Comparisons (Interleave time with id 5 and 6 in VTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
InterLeave Time	5	1	187.326*	30.6851	.000	83.236	291.416
		2	150.919*	27.6168	.000	57.237	244.601
		3	293.005*	32.8037	.000	181.728	404.282
		4	130.807*	31.2067	.003	24.947	236.666
		6	150.687*	29.8725	.000	49.353	252.021
		7	200.356*	29.4653	.000	100.404	300.309
		8	-211.241*	32.6250	.000	-321.912	-100.570
		9	57.850	30.6851	.861	-46.240	161.940
		10	175.993*	30.5069	.000	72.507	279.478
		11	143.393*	27.3602	.000	50.581	236.204
		12	71.591	29.5953	.500	-28.803	171.985
		13	285.323*	29.5953	.000	184.929	385.716
		14	68.342	29.7309	.592	-32.512	169.195
		15	312.965*	33.8133	.000	198.263	427.667
	6	1	36.639	27.5291	.992	-56.746	130.024
		2	.232	24.0617	1.000	-81.390	81.855
		3	142.318*	29.8725	.000	40.984	243.652
		4	-19.880	28.1094	1.000	-115.233	75.473
		5	-150.687*	29.8725	.000	-252.021	-49.353
		7	49.669	26.1626	.854	-39.080	138.418
		8	-361.928*	29.6760	.000	-462.595	-261.261
		9	-92.837	27.5291	.053	-186.221	.548
		10	25.306	27.3303	1.000	-67.405	118.016
		11	-7.294	23.7668	1.000	-87.916	73.328
		12	-79.096	26.3090	.151	-168.341	10.150
		13	134.636*	26.3090	.000	45.390	223.881
		14	-82.345	26.4614	.114	-172.108	7.418
		15	162.278*	30.9777	.000	57.195	267.361

Post Hoc Tests

ID

Table A34: Multiple Comparisons (Interleave time with id 7 and 8 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
InterLeave Time	7	1	-13.030	27.0868	1.000	-104.914	78.854
		2	-49.437	23.5544	.736	-129.338	30.465
		3	92.649	29.4653	.104	-7.304	192.601
		4	-69.550	27.6763	.431	-163.433	24.334
		5	-200.356*	29.4653	.000	-300.309	-100.404
		6	-49.669	26.1626	.854	-138.418	39.080
		8	-411.597*	29.2662	.000	-510.874	-312.320
		9	-142.506*	27.0868	.000	-234.390	-50.622
		10	-24.364	26.8847	1.000	-115.562	66.835
		11	-56.964	23.2530	.477	-135.843	21.915
		12	-128.765*	25.8458	.000	-216.439	-41.091
		13	84.967	25.8458	.069	-2.708	172.641
		14	-132.014*	26.0009	.000	-220.215	-43.814
		15	112.609*	30.5853	.019	8.857	216.360
	8	1	398.567*	30.4939	.000	295.125	502.009
		2	362.161*	27.4043	.000	269.200	455.122
		3	504.246*	32.6250	.000	393.575	614.917
		4	342.048*	31.0187	.000	236.826	447.270
		5	211.241*	32.6250	.000	100.570	321.912
		6	361.928*	29.6760	.000	261.261	462.595
		7	411.597*	29.2662	.000	312.320	510.874
		9	269.091*	30.4939	.000	165.649	372.533
		10	387.234*	30.3146	.000	284.400	490.067
		11	354.634*	27.1456	.000	262.550	446.717
		12	282.832*	29.3971	.000	183.111	382.553
		13	496.564*	29.3971	.000	396.843	596.285
		14	279.583*	29.5336	.000	179.399	379.767
		15	524.206*	33.6399	.000	410.092	638.320

Post Hoc Tests

ID

Table A35: Multiple Comparisons (Interleave time with id 9 and 10 in VTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	9	1	129.476*	28.4089	.001	33.107	225.845
		2	93.069*	25.0635	.017	8.049	178.090
		3	235.155*	30.6851	.000	131.065	339.245
		4	72.957	28.9715	.427	-25.321	171.234
		5	-57.850	30.6851	.861	-161.940	46.240
		6	92.837	27.5291	.053	-.548	186.221
		7	142.506*	27.0868	.000	50.622	234.390
		8	-269.091*	30.4939	.000	-372.533	-165.649
		10	118.143*	28.2163	.003	22.427	213.858
		11	85.543*	24.7805	.041	1.482	169.603
		12	13.741	27.2282	1.000	-78.623	106.105
		13	227.473*	27.2282	.000	135.109	319.836
		14	10.492	27.3755	1.000	-82.372	103.355
		15	255.115*	31.7621	.000	147.371	362.858
	10	1	11.333	28.2163	1.000	-84.382	107.049
		2	-25.073	24.8450	1.000	-109.353	59.206
		3	117.012*	30.5069	.011	13.527	220.498
		4	-45.186	28.7826	.965	-142.823	52.451
		5	-175.993*	30.5069	.000	-279.478	-72.507
		6	-25.306	27.3303	1.000	-118.016	67.405
		7	24.364	26.8847	1.000	-66.835	115.562
		8	-387.234*	30.3146	.000	-490.067	-284.400
		9	-118.143*	28.2163	.003	-213.858	-22.427
		11	-32.600	24.5594	.993	-115.911	50.711
		12	-104.402*	27.0272	.010	-196.083	-12.720
		13	109.330*	27.0272	.005	17.648	201.012
		14	-107.651*	27.1756	.007	-199.836	-15.466
		15	136.972*	31.5899	.001	29.813	244.132

Post Hoc Tests

ID

Table A36: Multiple Comparisons (Interleave time with id 11 and 12 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	11	1	43.933	24.7805	.909	-40.127	127.994
		2	7.527	20.8611	1.000	-63.238	78.292
		3	149.612*	27.3602	.000	56.801	242.424
		4	-12.586	25.4235	1.000	-98.828	73.656
		5	-143.393*	27.3602	.000	-236.204	-50.581
		6	7.294	23.7668	1.000	-73.328	87.916
		7	56.964	23.2530	.477	-21.915	135.843
		8	-354.634*	27.1456	.000	-446.717	-262.550
		9	-85.543*	24.7805	.041	-169.603	-1.482
		10	32.600	24.5594	.993	-50.711	115.911
		12	-71.802	23.4175	.129	-151.239	7.636
		13	141.930*	23.4175	.000	62.493	221.367
		14	-75.051	23.5886	.094	-155.068	4.967
		15	169.572*	28.5629	.000	72.681	266.463
	12	1	115.735*	27.2282	.002	23.371	208.099
		2	79.328	23.7168	.058	-1.124	159.781
		3	221.414*	29.5953	.000	121.020	321.807
		4	59.216	27.8147	.715	-35.138	153.569
		5	-71.591	29.5953	.500	-171.985	28.803
		6	79.096	26.3090	.151	-10.150	168.341
		7	128.765*	25.8458	.000	41.091	216.439
		8	-282.832*	29.3971	.000	-382.553	-183.111
		9	-13.741	27.2282	1.000	-106.105	78.623
		10	104.402*	27.0272	.010	12.720	196.083
		11	71.802	23.4175	.129	-7.636	151.239
		13	213.732*	25.9939	.000	125.555	301.908
		14	-3.249	26.1481	1.000	-91.949	85.451
		15	241.374*	30.7106	.000	137.197	345.550

Post Hoc Tests

ID

Table A37: Multiple Comparisons (Interleave time with id 13 and 14 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	13	1	-97.997*	27.2282	.025	-190.361	-5.633
		2	-134.403*	23.7168	.000	-214.856	-53.951
		3	7.682	29.5953	1.000	-92.711	108.076
		4	-154.516*	27.8147	.000	-248.869	-60.163
		5	-285.323*	29.5953	.000	-385.716	-184.929
		6	-134.636*	26.3090	.000	-223.881	-45.390
		7	-84.967	25.8458	.069	-172.641	2.708
		8	-496.564*	29.3971	.000	-596.285	-396.843
		9	-227.473*	27.2282	.000	-319.836	-135.109
		10	-109.330*	27.0272	.005	-201.012	-17.648
		11	-141.930*	23.4175	.000	-221.367	-62.493
		12	-213.732*	25.9939	.000	-301.908	-125.555
		14	-216.981*	26.1481	.000	-305.681	-128.281
		15	27.642	30.7106	1.000	-76.535	131.819
	14	1	118.984*	27.3755	.001	26.121	211.847
		2	82.578*	23.8858	.041	1.552	163.603
		3	224.663*	29.7309	.000	123.810	325.517
		4	62.465	27.9589	.640	-32.378	157.307
		5	-68.342	29.7309	.592	-169.195	32.512
		6	82.345	26.4614	.114	-7.418	172.108
		7	132.014*	26.0009	.000	43.814	220.215
		8	-279.583*	29.5336	.000	-379.767	-179.399
		9	-10.492	27.3755	1.000	-103.355	82.372
		10	107.651*	27.1756	.007	15.466	199.836
		11	75.051	23.5886	.094	-4.967	155.068
		12	3.249	26.1481	1.000	-85.451	91.949
		13	216.981*	26.1481	.000	128.281	305.681
		15	244.623*	30.8413	.000	140.003	349.243

Post Hoc Tests

ID

Table A38: Multiple Comparisons (Interleave time with id 15 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
InterLeave Time	15	1	-125.639*	31.7621	.007	-233.383	-17.895
		2	-162.045*	28.8088	.000	-259.771	-64.320
		3	-19.960	33.8133	1.000	-134.662	94.742
		4	-182.158*	32.2663	.000	-291.612	-72.704
		5	-312.965*	33.8133	.000	-427.667	-198.263
		6	-162.278*	30.9777	.000	-267.361	-57.195
		7	-112.609*	30.5853	.019	-216.360	-8.857
		8	-524.206*	33.6399	.000	-638.320	-410.092
		9	-255.115*	31.7621	.000	-362.858	-147.371
		10	-136.972*	31.5899	.001	-244.132	-29.813
		11	-169.572*	28.5629	.000	-266.463	-72.681
		12	-241.374*	30.7106	.000	-345.550	-137.197
		13	-27.642	30.7106	1.000	-131.819	76.535
		14	-244.623*	30.8413	.000	-349.243	-140.003

Post Hoc Tests

ID

Table A39: Multiple Comparisons (Vision time with id 1 and 2 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Vision Time	1	2	-16.346	15.7754	.999	-69.859	37.168
		3	141.808*	19.3137	.000	76.292	207.324
		4	-59.393	18.2352	.076	-121.250	2.465
		5	-234.948*	19.3137	.000	-300.464	-169.431
		6	-40.332	17.3273	.570	-99.110	18.446
		7	32.741	17.0489	.843	-25.093	90.574
		8	-196.667*	19.1934	.000	-261.775	-131.559
		9	-180.763*	17.8811	.000	-241.419	-120.107
		10	7.989	17.7598	1.000	-52.256	68.234
		11	-53.836*	15.5973	.041	-106.745	-.927
		12	-148.702*	17.1379	.000	-206.837	-90.567
		13	119.469*	17.1379	.000	61.333	177.604
		14	-150.174*	17.2306	.000	-208.624	-91.724
		15	82.897*	19.9916	.003	15.081	150.713
	2	1	16.346	15.7754	.999	-37.168	69.859
		3	158.154*	17.3825	.000	99.188	217.119
		4	-43.047	16.1757	.329	-97.918	11.824
		5	-218.602*	17.3825	.000	-277.567	-159.637
		6	-23.987	15.1449	.962	-75.361	27.388
		7	49.086	14.8256	.064	-1.205	99.378
		8	-180.321*	17.2487	.000	-238.833	-121.810
		9	-164.417*	15.7754	.000	-217.931	-110.904
		10	24.334	15.6379	.968	-28.713	77.381
		11	-37.490	13.1303	.218	-82.031	7.050
		12	-132.356*	14.9278	.000	-182.995	-81.718
		13	135.814*	14.9278	.000	85.176	186.452
		14	-133.828*	15.0342	.000	-184.827	-82.829
		15	99.243*	18.1328	.000	37.733	160.753

Post Hoc Tests

ID

Table A40: Multiple Comparisons (Vision time with id 3 and 4 in VTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Vision Time	3	1	-141.808*	19.3137	.000	-207.324	-76.292
		2	-158.154*	17.3825	.000	-217.119	-99.188
		4	-201.201*	19.6421	.000	-267.831	-134.571
		5	-376.756*	20.6473	.000	-446.795	-306.716
		6	-182.140*	18.8023	.000	-245.921	-118.359
		7	-109.067*	18.5460	.000	-171.979	-46.155
		8	-338.475*	20.5347	.000	-408.133	-268.817
		9	-322.571*	19.3137	.000	-388.087	-257.055
		10	-133.819*	19.2016	.000	-198.955	-68.684
		11	-195.644*	17.2210	.000	-254.061	-137.227
		12	-290.510*	18.6278	.000	-353.699	-227.320
		13	-22.339	18.6278	.997	-85.529	40.850
		14	-291.982*	18.7132	.000	-355.461	-228.503
		15	-58.911	21.2827	.264	-131.106	13.285
	4	1	59.393	18.2352	.076	-2.465	121.250
		2	43.047	16.1757	.329	-11.824	97.918
		3	201.201*	19.6421	.000	134.571	267.831
		5	-175.555*	19.6421	.000	-242.185	-108.925
		6	19.061	17.6925	.999	-40.956	79.077
		7	92.134*	17.4200	.000	33.041	151.226
		8	-137.274*	19.5237	.000	-203.503	-71.046
		9	-121.370*	18.2352	.000	-183.228	-59.513
		10	67.381*	18.1163	.016	5.927	128.836
		11	5.557	16.0020	1.000	-48.725	59.839
		12	-89.309*	17.5070	.000	-148.697	-29.922
		13	178.861*	17.5070	.000	119.474	238.249
		14	-90.781*	17.5978	.000	-150.477	-31.086
		15	142.290*	20.3090	.000	73.398	211.182

Post Hoc Tests

ID

Table A41: Multiple Comparisons (Vision time with id 5 and 6 in VTC)

Tukey HSD

Dependent Variable	(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Vision Time	5	1	234.948*	19.3137	.000	169.431	300.464
		2	218.602*	17.3825	.000	159.637	277.567
		3	376.756*	20.6473	.000	306.716	446.795
		4	175.555*	19.6421	.000	108.925	242.185
		6	194.615*	18.8023	.000	130.834	258.397
		7	267.688*	18.5460	.000	204.777	330.600
		8	38.281	20.5347	.871	-31.378	107.939
		9	54.185	19.3137	.244	-11.332	119.701
		10	242.936*	19.2016	.000	177.801	308.072
		11	181.112*	17.2210	.000	122.694	239.529
		12	86.246*	18.6278	.000	23.056	149.435
		13	354.416*	18.6278	.000	291.227	417.606
		14	84.774*	18.7132	.001	21.295	148.253
		15	317.845*	21.2827	.000	245.649	390.040
	6	1	40.332	17.3273	.570	-18.446	99.110
		2	23.987	15.1449	.962	-27.388	75.361
		3	182.140*	18.8023	.000	118.359	245.921
		4	-19.061	17.6925	.999	-79.077	40.956
		5	-194.615*	18.8023	.000	-258.397	-130.834
		7	73.073*	16.4672	.001	17.213	128.933
		8	-156.335*	18.6786	.000	-219.697	-92.973
		9	-140.431*	17.3273	.000	-199.209	-81.653
		10	48.321	17.2022	.242	-10.033	106.674
		11	-13.504	14.9592	1.000	-64.249	37.241
		12	-108.370*	16.5593	.000	-164.543	-52.197
		13	159.801*	16.5593	.000	103.628	215.973
		14	-109.842*	16.6553	.000	-166.340	-53.344
		15	123.229*	19.4979	.000	57.088	189.370

Post Hoc Tests

ID

Table A42: Multiple Comparisons (Vision time with id 7 and 8 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Vision Time	7	1	-32.741	17.0489	.843	-90.574	25.093
		2	-49.086	14.8256	.064	-99.378	1.205
		3	109.067*	18.5460	.000	46.155	171.979
		4	-92.134*	17.4200	.000	-151.226	-33.041
		5	-267.688*	18.5460	.000	-330.600	-204.777
		6	-73.073*	16.4672	.001	-128.933	-17.213
		8	-229.408*	18.4207	.000	-291.895	-166.921
		9	-213.504*	17.0489	.000	-271.337	-155.670
		10	-24.752	16.9217	.981	-82.154	32.650
		11	-86.577*	14.6358	.000	-136.225	-36.929
		12	-181.443*	16.2678	.000	-236.627	-126.259
		13	86.728*	16.2678	.000	31.544	141.911
		14	-182.915*	16.3654	.000	-238.430	-127.400
		15	50.156	19.2509	.366	-15.147	115.460
	8	1	196.667*	19.1934	.000	131.559	261.775
		2	180.321*	17.2487	.000	121.810	238.833
		3	338.475*	20.5347	.000	268.817	408.133
		4	137.274*	19.5237	.000	71.046	203.503
		5	-38.281	20.5347	.871	-107.939	31.378
		6	156.335*	18.6786	.000	92.973	219.697
		7	229.408*	18.4207	.000	166.921	291.895
		9	15.904	19.1934	1.000	-49.204	81.012
		10	204.656*	19.0805	.000	139.931	269.381
		11	142.831*	17.0859	.000	84.872	200.790
		12	47.965	18.5030	.375	-14.801	110.731
		13	316.136*	18.5030	.000	253.369	378.902
		14	46.493	18.5890	.440	-16.565	109.551
		15	279.564*	21.1736	.000	207.739	351.389

Post Hoc Tests

ID

Table A43: Multiple Comparisons (Vision time with id 9 and 10 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Vision Time	9	1	180.763*	17.8811	.000	120.107	241.419
		2	164.417*	15.7754	.000	110.904	217.931
		3	322.571*	19.3137	.000	257.055	388.087
		4	121.370*	18.2352	.000	59.513	183.228
		5	-54.185	19.3137	.244	-119.701	11.332
		6	140.431*	17.3273	.000	81.653	199.209
		7	213.504*	17.0489	.000	155.670	271.337
		8	-15.904	19.1934	1.000	-81.012	49.204
		10	188.752*	17.7598	.000	128.507	248.997
		11	126.927*	15.5973	.000	74.018	179.836
		12	32.061	17.1379	.868	-26.074	90.196
		13	300.232*	17.1379	.000	242.096	358.367
		14	30.589	17.2306	.908	-27.861	89.039
		15	263.660*	19.9916	.000	195.844	331.476
	10	1	-7.989	17.7598	1.000	-68.234	52.256
		2	-24.334	15.6379	.968	-77.381	28.713
		3	133.819*	19.2016	.000	68.684	198.955
		4	-67.381*	18.1163	.016	-128.836	-5.927
		5	-242.936*	19.2016	.000	-308.072	-177.801
		6	-48.321	17.2022	.242	-106.674	10.033
		7	24.752	16.9217	.981	-32.650	82.154
		8	-204.656*	19.0805	.000	-269.381	-139.931
		9	-188.752*	17.7598	.000	-248.997	-128.507
		11	-61.825*	15.4581	.006	-114.262	-9.388
		12	-156.691*	17.0114	.000	-214.397	-98.985
		13	111.480*	17.0114	.000	53.774	169.186
		14	-158.163*	17.1048	.000	-216.186	-100.140
		15	74.908*	19.8833	.014	7.460	142.357

Post Hoc Tests

ID

Table A44: Multiple Comparisons (Vision time with id 11 and 12 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Vision Time	11	1	53.836*	15.5973	.041	.927	106.745
		2	37.490	13.1303	.218	-7.050	82.031
		3	195.644*	17.2210	.000	137.227	254.061
		4	-5.557	16.0020	1.000	-59.839	48.725
		5	-181.112*	17.2210	.000	-239.529	-122.694
		6	13.504	14.9592	1.000	-37.241	64.249
		7	86.577*	14.6358	.000	36.929	136.225
		8	-142.831*	17.0859	.000	-200.790	-84.872
		9	-126.927*	15.5973	.000	-179.836	-74.018
		10	61.825*	15.4581	.006	9.388	114.262
		12	-94.866*	14.7394	.000	-144.865	-44.867
		13	173.305*	14.7394	.000	123.305	223.304
		14	-96.338*	14.8471	.000	-146.702	-45.973
		15	136.733*	17.9780	.000	75.748	197.718
	12	1	148.702*	17.1379	.000	90.567	206.837
		2	132.356*	14.9278	.000	81.718	182.995
		3	290.510*	18.6278	.000	227.320	353.699
		4	89.309*	17.5070	.000	29.922	148.697
		5	-86.246*	18.6278	.000	-149.435	-23.056
		6	108.370*	16.5593	.000	52.197	164.543
		7	181.443*	16.2678	.000	126.259	236.627
		8	-47.965	18.5030	.375	-110.731	14.801
		9	-32.061	17.1379	.868	-90.196	26.074
		10	156.691*	17.0114	.000	98.985	214.397
		11	94.866*	14.7394	.000	44.867	144.865
		13	268.171*	16.3610	.000	212.671	323.671
		14	-1.472	16.4581	1.000	-57.301	54.357
		15	231.599*	19.3298	.000	166.028	297.170

Post Hoc Tests

Table A45: Multiple Comparisons (Vision time with id 13 and 14 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Vision Time	13	1	-119.469*	17.1379	.000	-177.604	-61.333
		2	-135.814*	14.9278	.000	-186.452	-85.176
		3	22.339	18.6278	.997	-40.850	85.529
		4	-178.861*	17.5070	.000	-238.249	-119.474
		5	-354.416*	18.6278	.000	-417.606	-291.227
		6	-159.801*	16.5593	.000	-215.973	-103.628
		7	-86.728*	16.2678	.000	-141.911	-31.544
		8	-316.136*	18.5030	.000	-378.902	-253.369
		9	-300.232*	17.1379	.000	-358.367	-242.096
		10	-111.480*	17.0114	.000	-169.186	-53.774
		11	-173.305*	14.7394	.000	-223.304	-123.305
		12	-268.171*	16.3610	.000	-323.671	-212.671
		14	-269.642*	16.4581	.000	-325.472	-213.813
		15	-36.571	19.3298	.858	-102.142	28.999
	14	1	150.174*	17.2306	.000	91.724	208.624
		2	133.828*	15.0342	.000	82.829	184.827
		3	291.982*	18.7132	.000	228.503	355.461
		4	90.781*	17.5978	.000	31.086	150.477
		5	-84.774*	18.7132	.001	-148.253	-21.295
		6	109.842*	16.6553	.000	53.344	166.340
		7	182.915*	16.3654	.000	127.400	238.430
		8	-46.493	18.5890	.440	-109.551	16.565
		9	-30.589	17.2306	.908	-89.039	27.861
		10	158.163*	17.1048	.000	100.140	216.186
		11	96.338*	14.8471	.000	45.973	146.702
		12	1.472	16.4581	1.000	-54.357	57.301
		13	269.642*	16.4581	.000	213.813	325.472
		15	233.071*	19.4120	.000	167.221	298.921

Post Hoc Tests

ID

Table A46: Multiple Comparisons (Vision time with id 15 in VTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Vision Time	15	1	-82.897*	19.9916	.003	-150.713	-15.081
		2	-99.243*	18.1328	.000	-160.753	-37.733
		3	58.911	21.2827	.264	-13.285	131.106
		4	-142.290*	20.3090	.000	-211.182	-73.398
		5	-317.845*	21.2827	.000	-390.040	-245.649
		6	-123.229*	19.4979	.000	-189.370	-57.088
		7	-50.156	19.2509	.366	-115.460	15.147
		8	-279.564*	21.1736	.000	-351.389	-207.739
		9	-263.660*	19.9916	.000	-331.476	-195.844
		10	-74.908*	19.8833	.014	-142.357	-7.460
		11	-136.733*	17.9780	.000	-197.718	-75.748
		12	-231.599*	19.3298	.000	-297.170	-166.028
		13	36.571	19.3298	.858	-28.999	102.142
		14	-233.071*	19.4120	.000	-298.921	-167.221

Post Hoc Tests

POS

Table A47: Multiple Comparisons (Dwell time with displayed position 0-3 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DwellTime	0	1	7.372*	1.5412	.000	2.590	12.153
		2	11.313*	1.5162	.000	6.609	16.018
		3	-3.660	1.5241	.283	-8.389	1.068
		4	3.587	1.5375	.322	-1.183	8.357
		5	10.972*	1.5343	.000	6.212	15.732
		6	-5.916*	1.5253	.003	-10.648	-1.184
		7	5.247*	1.5237	.017	.520	9.975
		8	11.621*	1.5260	.000	6.887	16.356
	1	0	-7.372*	1.5412	.000	-12.153	-2.590
		2	3.942	1.5364	.201	-.825	8.709
		3	-11.032*	1.5442	.000	-15.823	-6.241
		4	-3.785	1.5574	.268	-8.617	1.047
		5	3.600	1.5542	.332	-1.222	8.422
		6	-13.288*	1.5453	.000	-18.082	-8.493
		7	-2.124	1.5438	.907	-6.914	2.665
		8	4.249	1.5461	.131	-.547	9.046
	2	0	-11.313*	1.5162	.000	-16.018	-6.609
		1	-3.942	1.5364	.201	-8.709	.825
		3	-14.974*	1.5193	.000	-19.687	-10.260
		4	-7.726*	1.5327	.000	-12.482	-2.971
		5	-.342	1.5295	1.000	-5.087	4.403
		6	-17.229*	1.5204	.000	-21.947	-12.512
		7	-6.066*	1.5189	.002	-10.779	-1.354
		8	.308	1.5212	1.000	-4.412	5.027
	3	0	3.660	1.5241	.283	-1.068	8.389
		1	11.032*	1.5442	.000	6.241	15.823
		2	14.974*	1.5193	.000	10.260	19.687
		4	7.247*	1.5405	.000	2.468	12.027
		5	14.632*	1.5373	.000	9.863	19.402
		6	-2.256	1.5283	.867	-6.997	2.486
		7	8.908*	1.5268	.000	4.171	13.644
		8	15.281*	1.5291	.000	10.538	20.025

Post Hoc Tests

POS

Table A48: Multiple Comparisons (Dwell time with displayed position 4-7 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
DwellTime	4	0	-3.587	1.5375	.322	-8.357	1.183
		1	3.785	1.5574	.268	-1.047	8.617
		2	7.726*	1.5327	.000	2.971	12.482
		3	-7.247*	1.5405	.000	-12.027	-2.468
		5	7.385*	1.5506	.000	2.574	12.195
		6	-9.503*	1.5417	.000	-14.286	-4.720
		7	1.660	1.5401	.977	-3.118	6.439
		8	8.034*	1.5424	.000	3.249	12.819
	5	0	-10.972*	1.5343	.000	-15.732	-6.212
		1	-3.600	1.5542	.332	-8.422	1.222
		2	.342	1.5295	1.000	-4.403	5.087
		3	-14.632*	1.5373	.000	-19.402	-9.863
		4	-7.385*	1.5506	.000	-12.195	-2.574
		6	-16.888*	1.5384	.000	-21.661	-12.115
		7	-5.724*	1.5369	.006	-10.493	-.956
		8	.649	1.5392	1.000	-4.126	5.425
	6	0	5.916*	1.5253	.003	1.184	10.648
		1	13.288*	1.5453	.000	8.493	18.082
		2	17.229*	1.5204	.000	12.512	21.947
		3	2.256	1.5283	.867	-2.486	6.997
		4	9.503*	1.5417	.000	4.720	14.286
		5	16.888*	1.5384	.000	12.115	21.661
		7	11.163*	1.5279	.000	6.423	15.904
		8	17.537*	1.5302	.000	12.790	22.284
	7	0	-5.247*	1.5237	.017	-9.975	-.520
		1	2.124	1.5438	.907	-2.665	6.914
		2	6.066*	1.5189	.002	1.354	10.779
		3	-8.908*	1.5268	.000	-13.644	-4.171
		4	-1.660	1.5401	.977	-6.439	3.118
		5	5.724*	1.5369	.006	.956	10.493
		6	-11.163*	1.5279	.000	-15.904	-6.423
		8	6.374*	1.5287	.001	1.631	11.117

Post Hoc Tests

POS

Table A49: Multiple Comparisons (Dwell time with displayed position 8 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
DwellTime	8	0	-11.621*	1.5260	.000	-16.356	-6.887
		1	-4.249	1.5461	.131	-9.046	.547
		2	-.308	1.5212	1.000	-5.027	4.412
		3	-15.281*	1.5291	.000	-20.025	-10.538
		4	-8.034*	1.5424	.000	-12.819	-3.249
		5	-.649	1.5392	1.000	-5.425	4.126
		6	-17.537*	1.5302	.000	-22.284	-12.790
		7	-6.374*	1.5287	.001	-11.117	-1.631

Post Hoc Tests

POS

Table A50: Multiple Comparisons (Interleave time with displayed position 0-1 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
InterLeave Time	0	1	-16.300	21.0684	.998	-81.665	49.065
		2	-19.657	20.7269	.990	-83.962	44.648
		3	-22.404	20.8347	.978	-87.044	42.236
		4	-7.532	21.0180	1.000	-72.740	57.677
		5	-32.048	20.9738	.843	-97.120	33.023
		6	-13.594	20.8504	.999	-78.282	51.095
		7	-21.086	20.8295	.985	-85.710	43.537
		8	-34.308	20.8610	.780	-99.029	30.414
	1	0	16.300	21.0684	.998	-49.065	81.665
		2	-3.357	21.0029	1.000	-68.519	61.805
		3	-6.104	21.1094	1.000	-71.596	59.389
		4	8.769	21.2903	1.000	-57.285	74.822
		5	-15.748	21.2467	.998	-81.666	50.170
		6	2.706	21.1249	1.000	-62.834	68.247
		7	-4.786	21.1042	1.000	-70.262	60.690
		8	-18.007	21.1353	.995	-83.580	47.565

Post Hoc Tests

POS

Table A51: Multiple Comparisons (Interleave time with displayed position 2-5 in VTC)

Tukey HSD

Dependent Variable		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
2	0	19.657	20.7269	.990	-44.648	83.962
	1	3.357	21.0029	1.000	-61.805	68.519
	3	-2.747	20.7686	1.000	-67.181	61.688
	4	12.126	20.9524	1.000	-52.879	77.131
	5	-12.391	20.9081	1.000	-77.259	52.477
	6	6.063	20.7843	1.000	-58.420	70.547
	7	-1.429	20.7633	1.000	-65.848	62.989
	8	-14.651	20.7949	.999	-79.167	49.866
3	0	22.404	20.8347	.978	-42.236	87.044
	1	6.104	21.1094	1.000	-59.389	71.596
	2	2.747	20.7686	1.000	-61.688	67.181
	4	14.872	21.0591	.999	-50.464	80.208
	5	-9.644	21.0150	1.000	-74.844	55.555
	6	8.810	20.8919	1.000	-56.007	73.627
	7	1.317	20.8710	1.000	-63.435	66.070
	8	-11.904	20.9024	1.000	-76.754	52.946
4	0	7.532	21.0180	1.000	-57.677	72.740
	1	-8.769	21.2903	1.000	-74.822	57.285
	2	-12.126	20.9524	1.000	-77.131	52.879
	3	-14.872	21.0591	.999	-80.208	50.464
	5	-24.517	21.1967	.965	-90.280	41.247
	6	-6.062	21.0746	1.000	-71.446	59.322
	7	-13.555	21.0539	.999	-78.875	51.765
	8	-26.776	21.0851	.940	-92.193	38.641
5	0	32.048	20.9738	.843	-33.023	97.120
	1	15.748	21.2467	.998	-50.170	81.666
	2	12.391	20.9081	1.000	-52.477	77.259
	3	9.644	21.0150	1.000	-55.555	74.844
	4	24.517	21.1967	.965	-41.247	90.280
	6	18.454	21.0306	.994	-46.793	83.702
	7	10.962	21.0099	1.000	-54.222	76.145
	8	-2.260	21.0411	1.000	-67.540	63.021

Post Hoc Tests

POS

Table A52: Multiple Comparisons (Interleave time with displayed position 6-8 in VTC)

Tukey HSD

Dependent Variable	(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
InterLeave Time	6	0	13.594	20.8504	.999	-51.095	78.282
		1	-2.706	21.1249	1.000	-68.247	62.834
		2	-6.063	20.7843	1.000	-70.547	58.420
		3	-8.810	20.8919	1.000	-73.627	56.007
		4	6.062	21.0746	1.000	-59.322	71.446
		5	-18.454	21.0306	.994	-83.702	46.793
		7	-7.493	20.8867	1.000	-72.294	57.308
		8	-20.714	20.9181	.987	-85.612	44.185
	7	0	21.086	20.8295	.985	-43.537	85.710
		1	4.786	21.1042	1.000	-60.690	70.262
		2	1.429	20.7633	1.000	-62.989	65.848
		3	-1.317	20.8710	1.000	-66.070	63.435
		4	13.555	21.0539	.999	-51.765	78.875
		5	-10.962	21.0099	1.000	-76.145	54.222
		6	7.493	20.8867	1.000	-57.308	72.294
		8	-13.221	20.8972	.999	-78.055	51.613
	8	0	34.308	20.8610	.780	-30.414	99.029
		1	18.007	21.1353	.995	-47.565	83.580
		2	14.651	20.7949	.999	-49.866	79.167
		3	11.904	20.9024	1.000	-52.946	76.754
		4	26.776	21.0851	.940	-38.641	92.193
		5	2.260	21.0411	1.000	-63.021	67.540
		6	20.714	20.9181	.987	-44.185	85.612
		7	13.221	20.8972	.999	-51.613	78.055

Post Hoc Tests

POS

Table A53: Multiple Comparisons (Vision time with displayed position 0-3 in VTC)

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
VisionTime	0	1	-23.303	13.2608	.710	-64.445	17.838
		2	-21.899	13.0459	.760	-62.374	18.576
		3	64.744*	13.1137	.000	24.059	105.430
		4	-12.246	13.2291	.992	-53.290	28.797
		5	-28.333	13.2013	.442	-69.290	12.625
		6	-51.450*	13.1236	.003	-92.166	-10.734
		7	-36.260	13.1105	.126	-76.936	4.415
		8	-5.278	13.1303	1.000	-46.015	35.459
	1	0	23.303	13.2608	.710	-17.838	64.445
		2	1.405	13.2196	1.000	-39.609	42.419
		3	88.048*	13.2866	.000	46.826	129.269
		4	11.057	13.4005	.996	-30.518	52.632
		5	-5.029	13.3731	1.000	-46.519	36.461
		6	-28.146	13.2964	.462	-69.399	13.106
		7	-12.957	13.2834	.988	-54.169	28.255
		8	18.026	13.3029	.914	-23.247	59.298
	2	0	21.899	13.0459	.760	-18.576	62.374
		1	-1.405	13.2196	1.000	-42.419	39.609
		3	86.643*	13.0721	.000	46.086	127.199
		4	9.652	13.1878	.998	-31.263	50.568
		5	-6.434	13.1599	1.000	-47.263	34.395
		6	-29.551	13.0820	.368	-70.138	11.036
		7	-14.362	13.0688	.975	-54.908	26.184
		8	16.621	13.0887	.940	-23.987	57.229
	3	0	-64.744*	13.1137	.000	-105.430	-24.059
		1	-88.048*	13.2866	.000	-129.269	-46.826
		2	-86.643*	13.0721	.000	-127.199	-46.086
		4	-76.990*	13.2550	.000	-118.114	-35.867
		5	-93.077*	13.2272	.000	-134.114	-52.039
		6	-116.194*	13.1497	.000	-156.991	-75.397
		7	-101.004*	13.1366	.000	-141.761	-60.248
		8	-70.022*	13.1563	.000	-110.840	-29.204

Post Hoc Tests

POS

Table A54: Multiple Comparisons (Vision time with displayed position 4-7 in VTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
VisionTime	4	0	12.246	13.2291	.992	-28.797	53.290
		1	-11.057	13.4005	.996	-52.632	30.518
		2	-9.652	13.1878	.998	-50.568	31.263
		3	76.990*	13.2550	.000	35.867	118.114
		5	-16.086	13.3416	.956	-57.479	25.306
		6	-39.204	13.2648	.076	-80.358	1.951
		7	-24.014	13.2517	.674	-65.127	17.100
		8	6.968	13.2713	1.000	-34.206	48.143
	5	0	28.333	13.2013	.442	-12.625	69.290
		1	5.029	13.3731	1.000	-36.461	46.519
		2	6.434	13.1599	1.000	-34.395	47.263
		3	93.077*	13.2272	.000	52.039	134.114
		4	16.086	13.3416	.956	-25.306	57.479
		6	-23.117	13.2371	.718	-64.185	17.951
		7	-7.928	13.2240	1.000	-48.955	33.100
		8	23.055	13.2436	.721	-18.034	64.143
	6	0	51.450*	13.1236	.003	10.734	92.166
		1	28.146	13.2964	.462	-13.106	69.399
		2	29.551	13.0820	.368	-11.036	70.138
		3	116.194*	13.1497	.000	75.397	156.991
		4	39.204	13.2648	.076	-1.951	80.358
		5	23.117	13.2371	.718	-17.951	64.185
		7	15.190	13.1464	.965	-25.597	55.977
		8	46.172*	13.1662	.014	5.324	87.020
	7	0	36.260	13.1105	.126	-4.415	76.936
		1	12.957	13.2834	.988	-28.255	54.169
		2	14.362	13.0688	.975	-26.184	54.908
		3	101.004*	13.1366	.000	60.248	141.761
		4	24.014	13.2517	.674	-17.100	65.127
		5	7.928	13.2240	1.000	-33.100	48.955
		6	-15.190	13.1464	.965	-55.977	25.597
		8	30.982	13.1531	.309	-9.825	71.790

Post Hoc Tests

POS

Table A55: Multiple Comparisons (Vision time with displayed position 8 in VTC)

Tukey HSD							
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
VisionTime	8	0	5.278	13.1303	1.000	-35.459	46.015
		1	-18.026	13.3029	.914	-59.298	23.247
		2	-16.621	13.0887	.940	-57.229	23.987
		3	70.022*	13.1563	.000	29.204	110.840
		4	-6.968	13.2713	1.000	-48.143	34.206
		5	-23.055	13.2436	.721	-64.143	18.034
		6	-46.172*	13.1662	.014	-87.020	-5.324
		7	-30.982	13.1531	.309	-71.790	9.825

Table A56: Results of classification data from KTC

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area	Class
	0.704	0	1	0.704	0.826	0.987	id3
	0.821	0.006	0.914	0.821	0.865	0.945	id1
	0.742	0	1	0.742	0.852	0.995	id4
	0.964	0.007	0.871	0.964	0.915	0.997	id5
	0.978	0.013	0.863	0.978	0.917	0.988	id2
	0.895	0.006	0.919	0.895	0.907	0.968	id6
	0.917	0.032	0.66	0.917	0.767	0.935	id7
	0.826	0.002	0.95	0.826	0.884	0.974	id8
	0.915	0.025	0.768	0.915	0.835	0.985	id9
	0.919	0.021	0.756	0.919	0.829	0.989	id10
	0.903	0.01	0.929	0.903	0.915	0.991	id11
	0.674	0.004	0.939	0.674	0.785	0.946	id12
	0.862	0.002	0.962	0.862	0.909	0.947	id13
	1	0.004	0.95	1	0.974	1	id14
	0.9	0.006	0.9	0.9	0.9	0.978	id15
Weighted Avg.	0.873	0.01	0.888	0.873	0.873	0.975	

=== Confusion Matrix ===

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	<-- classified as
19	0	0	0	0	0	1	0	1	6	0	0	0	0	0	a = id3
0	32	0	1	0	0	1	0	1	0	2	1	1	0	0	b = id1
0	0	23	0	0	1	7	0	0	0	0	0	0	0	0	c = id4
0	0	0	27	0	0	0	0	1	0	0	0	0	0	0	d = id5
0	0	0	0	44	0	0	0	1	0	0	0	0	0	0	e = id2
0	1	0	0	0	34	1	0	0	0	1	0	0	0	1	f = id6
0	0	0	0	2	0	33	0	0	1	0	0	0	0	0	g = id7
0	0	0	0	0	0	1	19	2	0	0	1	0	0	0	h = id8
0	0	0	0	1	1	0	0	43	0	2	0	0	0	0	i = id9
0	0	0	0	0	0	0	0	3	34	0	0	0	0	0	j = id10
0	1	0	0	0	0	3	0	2	0	65	0	0	0	1	k = id11
0	0	0	2	3	1	2	1	2	4	0	31	0	0	0	l = id12
0	1	0	0	1	0	1	0	0	0	0	0	25	0	1	m = id13
0	0	0	0	0	0	0	0	0	0	0	0	0	38	0	n = id14
0	0	0	1	0	0	0	0	0	0	0	0	0	2	27	o = id15

Table A57: Results of classification data from KTC and VTC

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area	Class
	1	0.002	0.976	1	0.988	1	id3
	0.955	0.002	0.955	0.955	0.955	1	id1
	0.871	0.002	0.964	0.871	0.915	0.938	id4
	1	0.002	0.966	1	0.982	1	id5
	1	0.004	0.957	1	0.978	1	id2
	0.974	0	1	0.974	0.987	0.988	id6
	0.889	0	1	0.889	0.941	0.935	id7
	1	0	1	1	1	1	id8
	0.979	0	1	0.979	0.989	0.982	id9
	0.973	0	1	0.973	0.986	0.994	id10
	0.986	0.008	0.947	0.986	0.966	0.995	id11
	1	0.004	0.958	1	0.979	1	id12
	1	0	1	1	1	1	id13
	1	0	1	1	1	1	id14
	0.967	0.004	0.935	0.967	0.951	0.994	id15
Weighted Avg.	0.975	0.002	0.976	0.975	0.975	0.989	

=== Confusion Matrix ===

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	<-- classified as
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	a = id3
0	21	0	0	0	0	0	0	0	0	0	0	0	0	1	b = id1
0	1	27	0	1	0	0	0	0	0	2	0	0	0	0	c = id4
0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	d = id5
0	0	0	0	45	0	0	0	0	0	0	0	0	0	0	e = id2
0	0	0	0	0	37	0	0	0	0	1	0	0	0	0	f = id6
1	0	1	0	0	0	32	0	0	0	0	1	0	0	1	g = id7
0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	h = id8
0	0	0	1	0	0	0	0	46	0	0	0	0	0	0	i = id9
0	0	0	0	0	0	0	0	0	36	0	1	0	0	0	j = id10
0	0	0	0	1	0	0	0	0	0	71	0	0	0	0	k = id11
0	0	0	0	0	0	0	0	0	0	0	46	0	0	0	l = id12
0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	m = id13
0	0	0	0	0	0	0	0	0	0	0	0	0	38	0	n = id14
0	0	0	0	0	0	0	0	0	0	1	0	0	0	29	o = id15

BIOGRAPHY

Miss Kanogporn Nonsrichai was born on December 6^{th}, 1988 in Kalasin. She attended in the department of Mathematics at Chulalongkorn University for her undergraduate degree in the year of 2007 and graduated with her Bachelors of Science in Computer Science in March 2010. She continued her education in June 2011 and received her Master's degree in Computer Science and Information Technology from Chulalongkorn University in 2012 under the scholarship of Centre of Excellent Mathematics (CEM), Thailand. Her research focused on keystroke dynamics biometric.

Publication paper:

- Nonsrichai, K., and Bhattarakosol, P. A New Alternative of an Authentication System Using the Eye Vision Ability, Proceedings on 7^{th} ICCCT International Conference on Computing and Convergence Technology. Seoul, 2012, pp.561-565, Seoul: IEEE, 2012.