Available online at www.sciencedirect.com
ScienceDirect
IERI Procedia 10 (2014) 51 – 56
Procedia IERI
www.elsevier.com/locate/procedia

2014 International Conference on Future Information Engineering

Path Mapping of Shape Drawings Using Double Integration Technique

Ching Yee Yong*, Rubita Sudirman, Nasrul Humaimi Mahmood, Kim Mey Chew

Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.

Abstract

A preliminary path tracking experiment was done and a mapping system was developed in this study. Data collection of human activities in this study was focused on different shape of hand drawings. Five subjects were required to draw three types of shapes (circle, square and triangle) according to their convenience pace. A sensor consists of accelerometer, gyroscope and compass was attached firmly on subject's wrist with special designed holder. PCA and double integration technique were used to process and analyze the data. The tracking path was mapped and presented in GUI developed by MATLAB. The developed GUI is capable to display the tracking with animation starting from the first stroke until the end. The GUI is managed to trace the upper-limbs tiny motion accurately and presented well in graphic form.

Selection and peer review under responsibility of Information Engineering Research Institute

Keywords: Human motion, Double integration, Heading, Mapping

1. Introduction

Human motion analysis especially path mapping requires lot of data and computation algorithms. Kalman filter is among the famous operator used to track and trace a path. This algorithm combine the accelerometer data with angular matrix with multiplication for a real world coordinates (Ching Yee Yong et al., 2011).

* Corresponding author. Tel.: +6-014-913-7896;
E-mail address: chiyong@fkegraduate.utm.my.

Selection and peer review under responsibility of Information Engineering Research Institute
doi:10.1016/j.ieri.2014.09.090

Double integration technique was proposed to determine the real path of a drawing shape from subject by mapping out the tracks. Accelerations from sensor were double integrated for distance data. Gyroscope data were used to determine the heading and direction of the following steps.

The proposed technique aims to investigate and trace the consequences path of the drawing. A tracing and mapping system was developed using MATLAB software. A user-friendly GUI was developed to increase the availability of the system to other types of data analysis.

2. Project review

2.1. Distance

Distance or called as farness is a term to describe how far apart both objects are in numerical approach. In physics, distance refers to estimation length from an origin. In a 2D plane with x and y axes, distance is calculated using Euclidean theorem. The formula is derived by square root and adding the difference square of both x and y coordinates (Deza et al., 2006; Blumenthal, 1953).

2.2. Heading

Heading or generally called direction facing is a technique needed for path mapping. The direction of a heading is normally written as an arrow. For example, forward motion is indicated by an upward arrow and backward motion is indicated by an downward arrow. Heading is determined and specified by rotational angle (Federal Aviation Administration, 2009; Ching Yee Yong et al., 2013a).

2.3. Double Integration

Integration together with its inverse, differentiation in mathematics is fundamental concept of calculus operations. Double integral is a positive function of two variables over a region (Thong et al., 2004; Kudryavtsev, 2001).

3. Methodology

Five persons were selected randomly in campus for taking part in this gait motion study. Three male and two female students with right hand as dominant limb for performing normal life activities were requested to perform a gait motion according the circle, square and triangle shapes as shown in Figure 1.

A 3-space sensor integrated with accelerometer, gyroscope and compass was attached on the right upper-limb of the subjects for data collection. A special holder was designed to attach the sensor firmly to the skin to avoid jolting as shown in Figure 2.

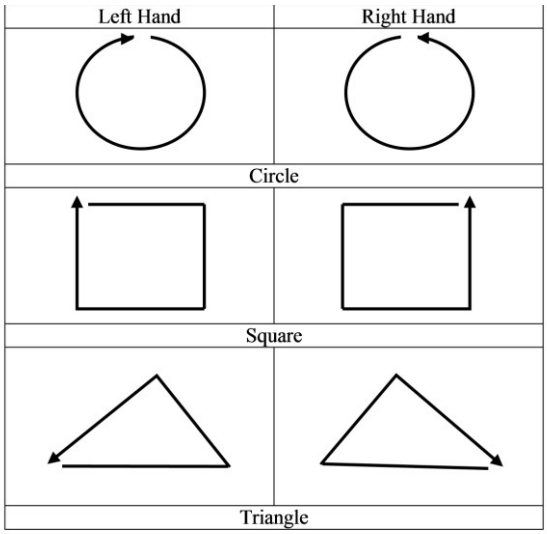


Fig. 1. Directions of shape drawing by both hands

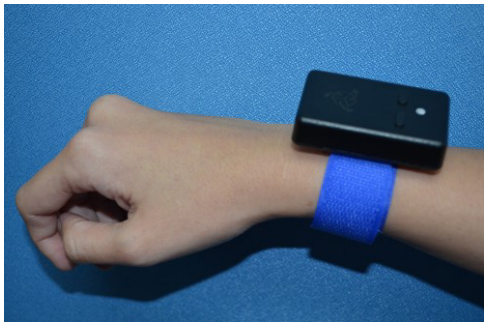


Fig. 2. Attachment of sensor on subject's skin

Subjects were required to draw the shapes using their index finger on a plain paper according their speed. The task was performed using left hand then follow by right hand. Sensor was calibrated before every single experiment was started to avoid zero error. Every movement of the subjects' limb was sensed and data were transmitted to laptop in text file format.

A system was developed according to the specificity of the study. The layout of the system was consist of three data plots, an animated gait plot, four press buttons and a file listing box. The system is ease to control for user with low or even no MATLAB experience. User may analyze any type of data by adding file through list box and performing the gait by clicking gait button. Data of accelerometer, gyroscope and compass were scattered in the data plots in two dimensions view. A 2D perspective view of motion gait was plotted with animated style showing the beginning until the end of the path drawing. User may save all the plots in a larger view by right click on the plot. This function is very useful for plots analysis.

Double integration was used in the study to investigate and discover the mapping path of the shape drawing by subjects. Accelerations data from accelerometer are collected for every single movement during

drawing. Integration was applied to the data for velocity data. Then, the data were integrated again for distance.

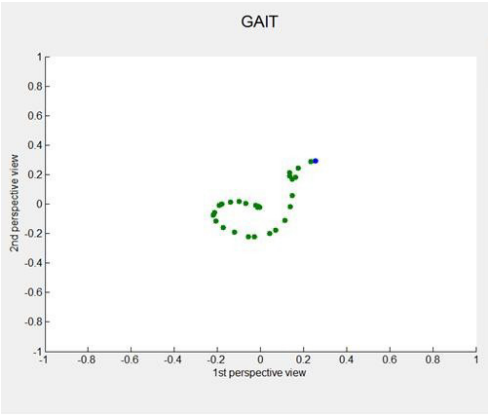
Principle Component Analysis (PCA) was used to reduce the data variables from complexity. PCA aims to realign the accelerometer data, gyroscope data and compass data for a best view in order for correct mapping and tracking (Ching Yee Yong et al., 2013b).

4. Result

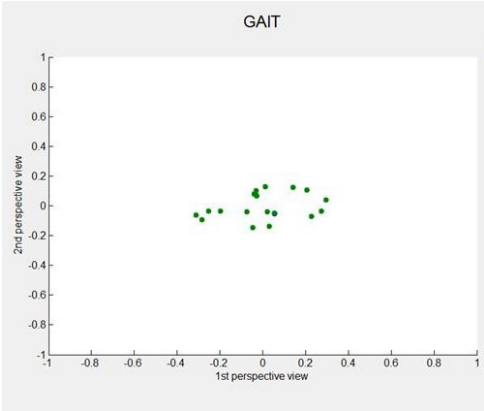
For the preliminary testing measurement, three types of shape are considered for analysis and they are circle, square and triangle. A gait system was developed using MATLAB software to trace the motion path back and present it in animated visualization form.

Results were shown in Figure 3, 3(a), 3(c) and 3(e) is circle, square and triangle shape mapping by left hand motion while 3(b), 3(d) and 3(f) is for right hand motion. From observation, shapes drawn by right hand are well presented and neat compared with left hand. Subjects from the study are all right-handed and therefore, every single movement performed by right hand is agile and lively. The animation of the tracking for path mapping is presented starting from the first stroke until the end, thus every sequence or order of a drawing from movement is delivered by the GUI.

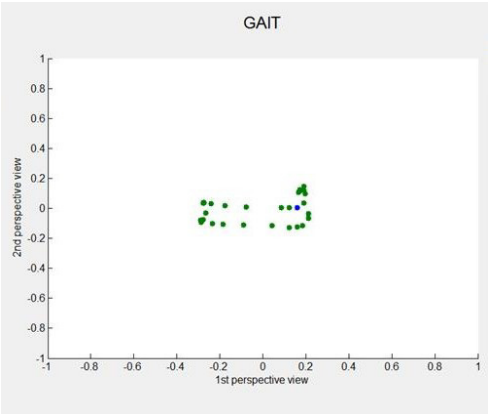
Accelerometer, gyroscope and compass data of the experiments were plotted in best 2D view. Principle component analysis (PCA) was used to process and realign the plotting to a best 2D view. PCA is able to reduce the number of variables in order to reduce the complexity of processing.



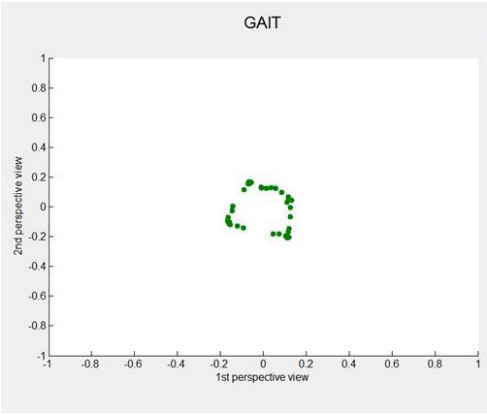
(a)



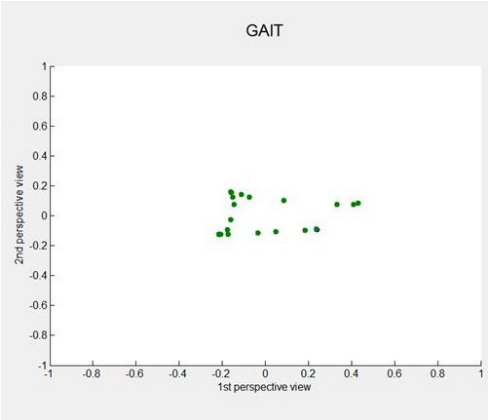
(b)



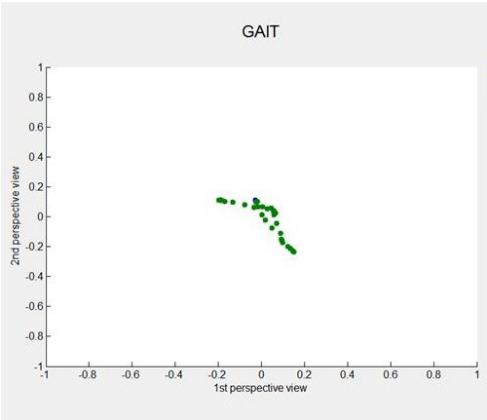
(c)



(d)



(e)



(f)

Fig. 3. (a) Circle by left hand, (b) circle by right hand, (c) square by left hand, (d) square by right hand, (e) triangle by left hand and (f) triangle by right hand

5. Discussion

The results have shown success at the beginning of the study. In order to enhance and increase the accuracy of the system, filtering should be added into the methodology. Filtering technique is able to reduce noise and distortion of the raw data.

The aim of the gait motion analysis system is to discover and analysis the gait and movement of every action. The system is able to track the path of drawing gait from the beginning of the movement until the last stop. For example, the system can trace back a particular subject with his nature habit of drawing a circle by clockwise rather than the majority of most people with anti-clockwise drawing.

6. Conclusion

The study is still in a preliminary stage of research. However, the results from the system are managed to bring an impact to the motion analysis area. The system was proposed to be useful to rehabilitation center for patient who is undergoing physiotherapy treatment. Practitioner may record and chart the patient's progress from time to time.

The system was eligible for Parkinson Disease (PD) patient. Professional doctor might use the system for PD screening. Patient verified suffering with PD is encouraged to do the testing everyday for charting objective and the main purpose is to reduce the seriousness of the disease.

Furthermore, child who suffers with dyslexia is encouraged for training according to the system. Parent or kindergarten instructor is able to screen the ability of the children in listening, writing and verbally speaking skills. Moreover, the system is able to discipline and exercise children with the correct writing sequences and strokes.

In future, the system is upgraded into a wireless device for better mobility. Filter is applied and other techniques are premeditated to produce a more accurate and precise result.

Acknowledgements

The authors would like to express our gratitude to the Universiti Teknologi Malaysia for supporting and funding this study under Research University Grant (Q.J130000.2523.05H37) and MyPhD Scholarship Scheme from Ministry of Education.

References

[1] Ching Yee Yong, Rubita Sudirman, Kim Mey Chew. Motion Detection and Analysis with Four Different Detectors. Computational Intelligence, Modelling and Simulation (CIMSiM), IEEE 2011:46-50.
[2] Deza MM, Deza, E. Dictionary of distances. Elsevier Science; 2006.
[3] Blumenthal LM. Distance geometry. In A study of the development of abstract metrics. With an introduction by Karl Menger, Univ. of Missouri Studies 1953;13(2).
[4] Federal Aviation Administration. Pilot's Handbook Of Aeronautical Knowledge. Skyhorse Publishing Inc; 2009.
[5] Ching Yee Yong, Rubita Sudirman, Nasrul Humaimi Mahmood and Kim Mey Chew. Comparison of Human Jogging andWalking Patterns Using Statistical Tabular, Scatter Distribution and Artificial Classifiers. Advances Technologies in Nano Materials and Electric Devices, Advanced Materials Research, Trans Tech Publication Inc, Switzerland 2013a;646:126-133.
[6] Thong YK, Woolfson MS, Crowe JA, Hayes-Gill BR, Jones DA. Numerical double integration of acceleration measurements in noise. Measurement 2004;36(1): 73–92.
[7] Kudryavtsev LD. Asymptotics of solutions to differential equations near singular points. Trudy Matematicheskogo Instituta im. VA Steklova 2001;232:194-217.
[8] Ching Yee Yong, Rubita Sudirman, Nasrul Humaimi Mahmood and Kim Mey Chew. Human Body and Body Part Movement Analysis Using Gyroscope, Accelerometer and Compass. Applied Mechanics and Materials, Trans Tech Publication Inc, Switzerland 2013b;284-287:3120-3125.