# Left and Right Hand Gesture Classification Using Scatter Diagram and Principle Component Analysis

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*Abstract*— **This study investigates and acts as a trial clinical outcome for human motion and hand behaviour analysis in consensus of subject's habit related quality of life. It was developed to analyse and access the quality of human hands motion that can be used in hospitals, clinics and human motion researches. It aims to establish how widespread the quality of life effects of human motion. An experiment was set up in a laboratory environment with conjunction of analysing human hand motion and its habit. Sensors are attached on both wrists. The instruments demonstrate adequate internal consistency of findings: 1. it is hard for subject to draw a perfect circle whether using left or right hand and this is supported by descriptive statistical data and scatter diagram. 2. Subject's left hand unable to draw a perfect circle or square. These two drawings are looks alike and it is supported by PCA analysis. A simple and informative representation for statistical data, scatter diagram and PCA plot were developed to demonstrate the results.**

***Keywords- accelerometer; motion; scattergram; PCA***

## I. Introduction

This study focuses on investigating the human hands motion and movement habit through analyzing their drawing hand patterns, to come out with a better solution for habit recognition and nature behavior analysis. The methodology of research is to get the three shapes drawing patterns through two sensors attachment on skin for further processing and analysis. The literature reviews from previous research on the requirement of experiment design and the current trend of analysis method will guide us to develop a good research framework.

The objective of this study is to investigate the human both hands motion and movement habit in order to establish how widespread the hand habit effects of drawing motion are by quantifying them. The expected results in terms of the stability, design, efficient control for mobility will help researchers to consider the outcomes of a human hands motion and movement. This paper presents a novel hands motion signal processing technique, and presents ideas for further development, to give researchers ideas of how they can use human movement in related field for product development.

## II. Existing Techniques

Accelerometer, gyroscope and compass sensors are the most commonly devices used in movement detection and analysis system [1]. Introduction of human actions into digital domain is a primary driver for innovation of motion functionality. Human motion signal processing technique, which combines inertial measurement units with digital signal processing, enables people readily incorporate motion [2, 3]. Description below shows provides readers with understanding of the sensors combinations used in motion detection and analysis field [4, 5].

Scatter plot or scatter diagram is a representation values for two variables for a set of data using mathematical diagram. The mathematical diagram is called Cartesian coordinates. The data is displayed as a collection of points, each having the value of one variable determining the position on the horizontal axis and the value of the other variable determining the position on the vertical axis [6]. This kind of plot is also called a scatter chart, scattergram, scatter diagram or scatter graph.

Principle Component Analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. It is an easy way of identifying patterns in data and to express the data in such a way as to highlight the similarity and differences. Since some of patterns from data are difficult to express and present in such a luxury of graphical diagram, especially of high dimension data, PCA is a powerful tool for that [7].

## III. Methodologies

The research framework and methodology complies with the below model. The five phases—Sensor attachment, Data transmission, Data acquisition unit, Back end data processing, and Evaluation — represent a dynamic, flexible guideline for building effective human motion analysis and movement performance detection support tools [8, 9, 10].

### A. Study Sample

A healthy volunteer was selected inside university campus for taking part in this study. His age is around 20 years old with normal limbs movement and significant mobility in everyday routine independent of any walking aid and with no athletic background. The subject is a right-handed and right hand is his main and frequently moving limb.

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### *B. Experimental Setup*

For this preliminary study, experimental setup was done with using a wireless 3-axis accelerometer. This device employs a YEI 3-Space Sensor breakout board for the tri-axial gyroscope, accelerometer, and compass sensors in conjunction with advanced processing and on-board quaternion-based Kalman filtering algorithms to determine orientation relative to an absolute reference in real-time in an enclosure measuring 60mm x 35mm x 15mm.

The subject wore a wearable sensor on above both left wrist and right wrist which employed of 3 sensors (gyroscope, accelerometer and compass) inside the package. These sensors were attached firmly on subject's skin with a special designed holder

### *C. Data Collection and Management*

In the initial phase of the trial study, experiment was conducted for three tasks; there is drawing circle, square and triangle from both hands. Subject was asked to perform a normal drawing in air for the three shapes. This activity was performed in a supervised and comfortable environment with presence of researcher for time-stamping the start and end time of activity period.

Subject was encouraged to perform the drawing activity at his own pace and convenience. The whole experiment setup place was ensuring a relaxing and natural mood for the sake of subject for reflective of real world conditions.

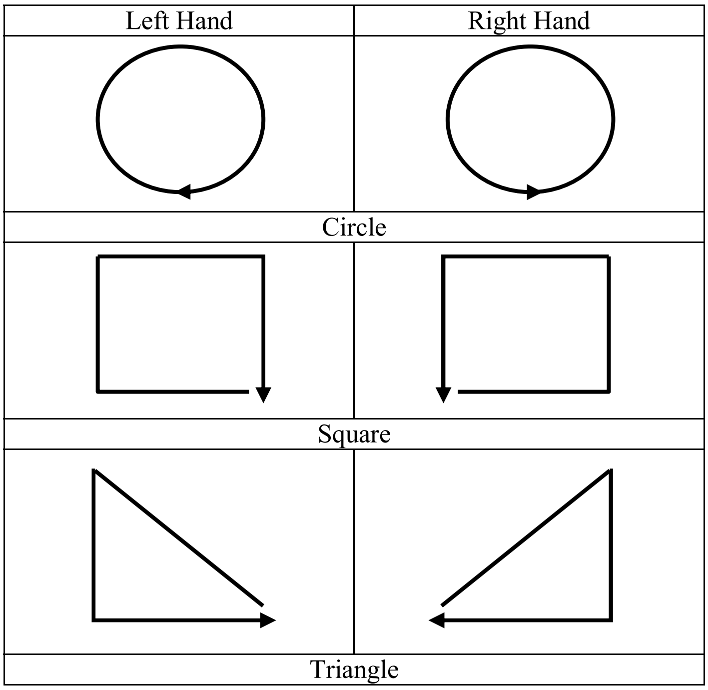


Figure 1. Three hand gestures performed by left and right hand.

The subject needs to perform three main hand gesture activities by using left and right hand according to Figure 1. The ending points of the drawing are represented by arrow. The subject needs to follow the instructions fully in order to produce significant readings.

The data was transmitted from sensors to the laptop for processing later.

### *D. Data Analysis*

Data collected through transmission from sensor to laptop through wireless dongle. The data then transferred into MATLAB for processing.

Raw data were firstly presented in descriptive statistical tabulated table, and then the data were processed using Principle Component Analysis (PCA). Scatter diagrams were plotted according the standard deviation distribution. Descriptive statistical data includes minimum values, maximum values, mean and standard deviation.

All the processing algorithms and methods were coding in MATLAB signal processing toolbox platform and results were showed in GUI.

### *E. Instrument Revision*

The preliminary set of outcome measures was shown in Table 1, Figure 2 and Figure 3. There are 3 sensors used in this experimental setup: gyroscope, accelerometer and compass. The ability of the sensors in differentiating both left and right hand for drawing circle, square and triangle. In this study, only accelerometer data are used for analysis.

Accelerations due to jolting of the sensors if loosely attached may add noise to the signal. The special designed of sensor holder capable attached firmly to the subject's skin to avoid any disturbance.

## IV. RESULT

The study is still in a preliminary stage and yet we had conducted this pilot test on data collecting and analyzing and therefore significant preliminary results had been generated. A descriptive statistical data from tri-axial accelerometer, gyroscope and compass signals from the kinematic sensors for both hands gesture movement activities are tabulated in Table 1. It can be seen the dynamic activity can be identified by the orientation of the accelerometers, simple threshold, scatter diagram and PCA analysis. Sample data were varied depending the time used to complete every gesture. For LHSAY (Left Hand Square Accelerometer Y-axis), the standard deviation is 0.0593, and it means that there is an ease for a left hand to draw a square with little deviation while on opposition, LHCAX (Left Hand Circle Accelerometer X-axis) has recorded standard deviation of 0.1646 and it is the highest value for all the gestures drawing by both hands.

In Figure 2, the scatter diagram is divided into two sections from a straight line. Drawings performed by left hand are mostly located at the right side of the diagram while drawings from right hand are located both side equally. Left hand circle drawings are plotted the most right side while right hand circle drawings are distributed along the left side of the straight line on the diagram.

In Figure 3 for PCA plot, the left hand and right hand circle drawings are difficult to be classified due to the distribution of the data. The left hand circle drawings are overlapped with left hand square drawings. The other shapes of drawings are classified normally.

In order to obtain a clearer and cleaner approximation plot, data received from the sensors was pre-processing using averaging filter to eliminate DC noise. Then the data was post-processing for plotting scatter plot.

## V. Discussion

As the initial, the study took place in a laboratory environment, it was considered appropriate for the initial phase of the quantitative study to be conducted in a similar environment. Further work is planned to widen the sample and to encompass different environments in both the dynamic and transition activities.

Based on standard deviation from Table 1, it is very hard to draw a circle whether using left hand or right hand since both of the value recorded are the highest among. On the other hand, the readings collected show that left hand can draw a square and a triangle better.

In Figure 2, an amazing finding that support the descriptive statistical data is that both circle drawings are scatters the whole diagram: left hand drawings scatter mainly at the most right side of the diagram, while right hand circle drawings scatter and distributed evenly along the left side of the diagram. Due to the scattering effect, scatter diagram once again support and agree the result form descriptive data showing drawing a circle is very hard for both left hand and right hand than drawing other shapes.

In Figure 3, the PCA classification for hand gestures are focus on circle drawings and square drawings for left hand. Due to the overlapping of both of the patterns, PCA is difficult to classify both of the gesture. In conclusion, the system is confused with the drawings from left hand for drawing square and circle due to the high similarity of both of the shape.

There is a lot to do with this study depending on the imagination. One but not the only one straight forward application for this research is motion recognition. It also can be applied on the incredible thing likes gesture recognition, behavioural analysis and gait analysis.

## VI. Conclusion

An accelerometer was proved to be a highly effective motion sensor for physical activity assessment. The sensor is capable to filter and normalized data using Kalman filter. Results presenting in descriptive statistical data, scatter plot and PCA analysis are successful reveal information needed. The study aims to investigate both hands movement during drawing shapes. Results show that it is not an easy job to perform a task to draw a circle neither left nor right hand. This finding can be proved by referring the statistical data and scatter plot.

Another finding is that human left hand may draws a square likes a circle or draw a circle likes a square. Due to the high similarity of both shapes, PCA is difficult to classify both shapes from the left hand motion. In order to reduce the errors and increase the classification rate, every motion from both hands should be performed perfectly according the needs.

In order to fully realize this study, there are few things that could be considered, the main feature of interest is the data processing unit. All data are process under the same platform without bias. Further approach need to be taken in order to achieve a higher aim in this research.

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TABLE I. DESCRIPTIVE STATISTICS FOR LEFT HAND AND RIGHT HAND MOVEMENT

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| LHCAX | 31 | -.1490 | .3499 | .114189 | .1646070 |
| LHCAY | 31 | -.9875 | -.7092 | -.887524 | .0723113 |
| RHCAX | 21 | -.4023 | .1027 | -.130782 | .1556531 |
| RHCAY | 21 | -.9360 | -.7103 | -.848615 | .0756072 |
| LHSAX | 39 | -.1217 | .1592 | -.001099 | .0663870 |
| LHSAY | 39 | -.9833 | -.8212 | -.917062 | .0593172 |
| RHSAX | 31 | -.2962 | .1976 | -.007111 | .1450436 |
| RHSAY | 31 | -.9445 | -.7229 | -.871922 | .0634924 |
| LHTAX | 33 | -.0566 | .1674 | .048522 | .0598865 |
| LHTAY | 33 | -.9377 | -.7099 | -.882762 | .0653275 |
| RHTAX | 21 | -.2365 | .1574 | -.056536 | .1202520 |
| RHTAY | 21 | -.9848 | -.7498 | -.891433 | .0765893 |

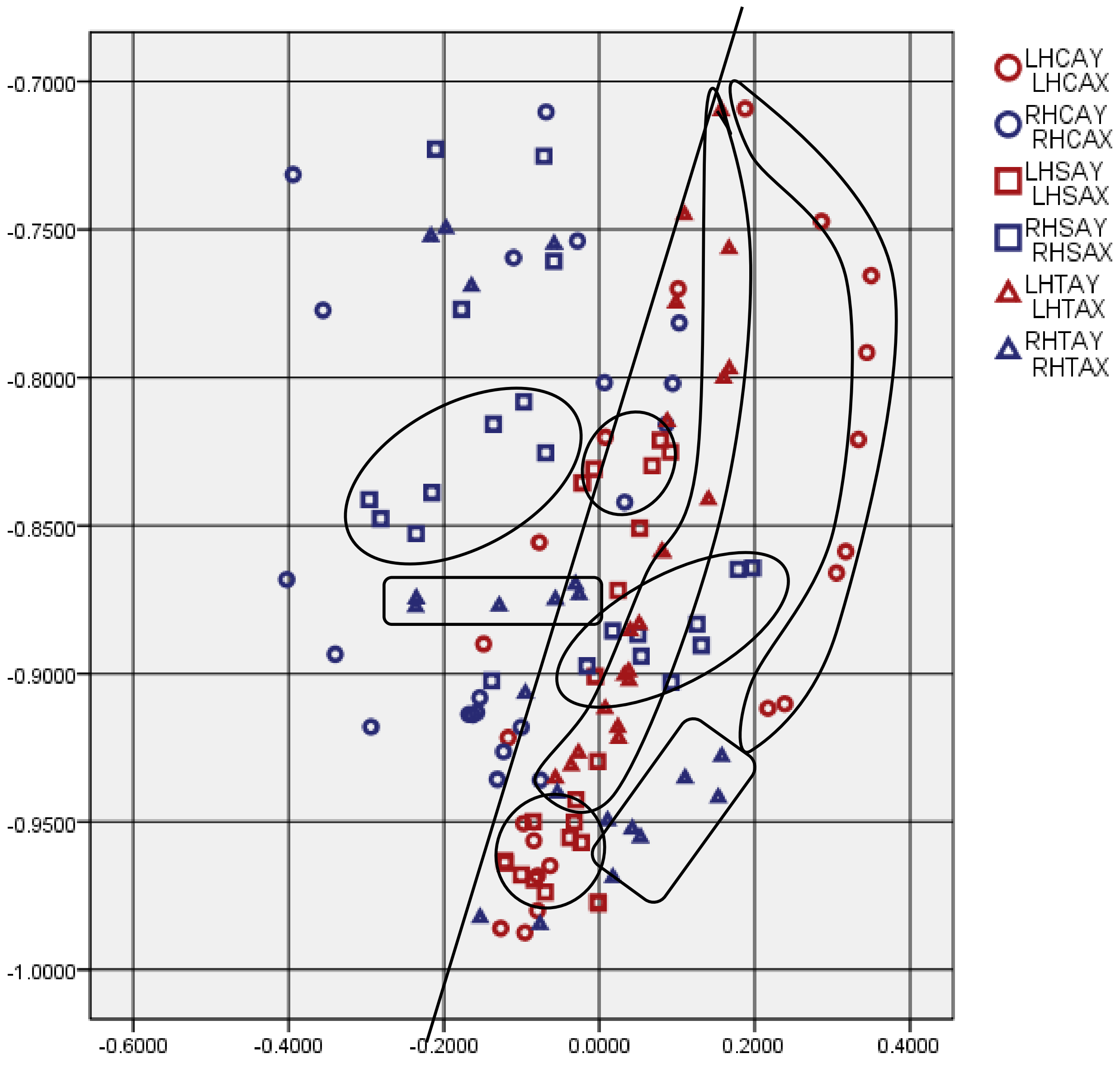


Figure 2. Scatter diagram of left hand and right hand movement.

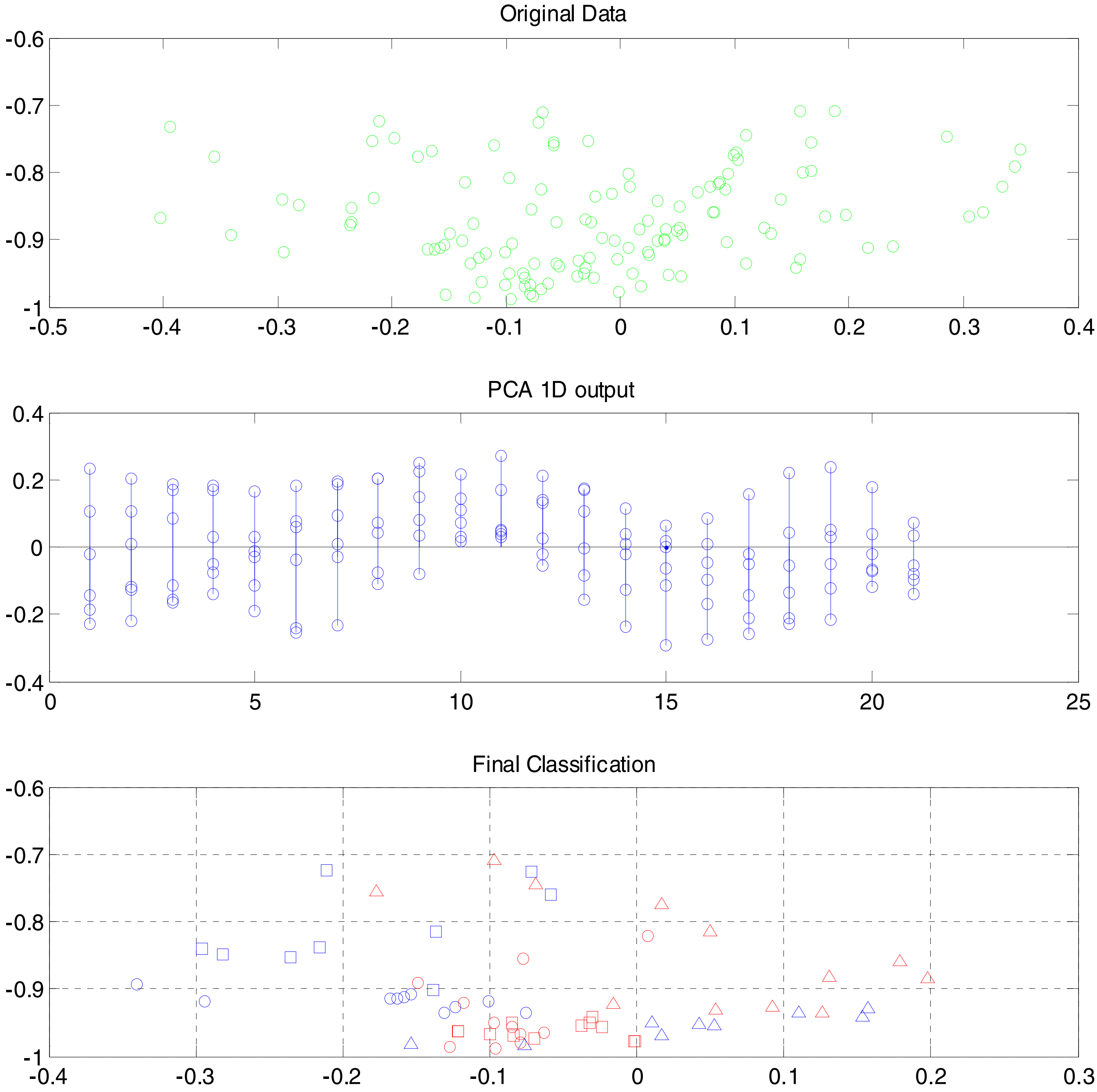


Figure 3. PCA plot of left hand and right hand movement.