e-Bangi Faculty of Social Sciences and Humanities Universiti Kebangsaan Malaysia
Journal of Social Sciences and Humanities
Vol. 16. No.3 (1-10), ISSN: 1823-884x

POSITION AND SHAPE ESTIMATION USING DOUBLE INTEGRATION OF ACCELERATION

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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 simulation of drawings. 2. Subject's left hand (right handed) unable to draw a perfect circle or square. These two drawings are looks alike and it is supported by double integration technique. A simple and informative representation for statistical data, simulation of drawings were developed to demonstrate the results.

Keywords: Accelerometer, motion, scattergram, double integration, statistical data.

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.

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REVIEW OF LITERATURE

If something starts moving it displacement from its original position depends on the velocity that is moving and the time that it has been moving (velocity is distance moved in a given time) so velocity is the rate of change of distance. However, when this velocity is not a constant and keeps changing, the rate of change of velocity is acceleration. In other words, a position is in meters from a particular spot of location, velocity is meters per second and acceleration is meters per second per second. This process is called differentiation. The inverse of this process is integration.

The effect of a moving human that can be interpreted as wave motion which detected by sensors is something starts at rest, accelerates, moves a bit, comes to rest and move back again. This involves continually varying, position, velocity and acceleration (Migueles et al. 2017).

Accelerometer, gyroscope and compass sensors are the most commonly devices used in movement detection and analysis system (Kateraas & Pedro 2015). 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 (Yong et al. 2012). Description below shows provides readers with understanding of the sensors combinations used in motion detection and analysis field (Cairns 2017, Nalma 2009 and Godfrey et al. 2015).

Double integral or double integration is the integration of fuctions of two variable in $f(x, y)$. Most of the physical structures and quantities that vary in two and three dimensions can be calculated, such as mass, area, volume, moments, centre of mass, gravity, flight and artillery paths, maps and etc (Dumitriu et al. 2016). There are five general areas of use, namely, information processing (to create statistic solvers, probability and simulations and generally used in the processing information process), binary (it is a number system comprised of only zeros and ones that the computer uses to follow instructions and save data), code (basic formula is generated for derivative, integral and probability applications), applications to solve problems (such as simulation and physics engines, in fact, a calculator was the first simple computer programs) and graphing and visuals (to create graphs and charts). Double integrals play a more prominent role than single integrals due to the domain of the function (Kowalczuk & Tomasz 2015).

MATERIALS AND METHODS

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 (Yong et al. 2011 and Godfrey et al. 2006).

Study Sample

A healthy volunteer was selected in 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. The subject is a right-handed and right hand is his main and frequently moving limb.

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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 60 mm × 35 mm × 15 mm. 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.

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.

The subject needs to perform three main hand gesture activities by using left and right hand. The subject needs to follow the instructions fully in order to produce significant readings. The subject was requested to draw all three types of shapes on a blank paper and repeated the drawings by 10 times per day for 5 days period. The data was transmitted from sensors to the laptop for processing later.

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 double integration technique. Descriptive statistical data includes minimum values, maximum values, mean and standard deviation. The subject's drawing was simulated with 3D dimensions.

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

Instrument Revision

The preliminary set of outcome measures was shown in Table 1, Figure 1 and Figure 2. 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.

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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.

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 as in Table 1.

Table 1: Descriptive Statistics for Left and Right Hand Movement

Drawing	Mean	Standard Deviation
Left hand circle drawing	-0.3866675	0.11845915
Right hand circle drawing	-0.4896985	0.11563015
Left hand square drawing	-0.4590805	0.0628521
Right hand square drawing	-0.4395165	0.104268
Left hand triangle drawing	-0.41712	0.33209625
Right hand triangle drawing	-0.4739845	0.09842065

In Figure 1, it can be seen the dynamic activity was recorded in three axes with acceleration as measurement unit against time. According to the signal recorded, the finding extracted from the time domain graphs is the appearance of a couples of peaks in square and triangle drawing. The result is not significant since the peaks are able to indicate the drastic changing of direction of the motion. Therefore, double integration technique was used to analyze the peaks and thereby a simulation of the motion of drawings was developed to re-present the movement of the drawing in 3D.

Figure 2 shows the three shapes drawings plotted in 1D and 3D form for x, y and z axes. The drawings were performed by the subject (right handed) using left hand.

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 in 3D form.

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.

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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, the double integration result for hand gestures are focus on circle drawings and square drawings for left hand. Due to the overlapping of both of the patterns, double integration is difficult to differentiate 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 and classification. It also can be applied on the incredible thing likes gesture recognition, behavioural analysis and gait analysis.

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, time domain plot and double integration technique are successful reveal the 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 time domain plot and 3D double integration 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, double integration technique is difficult to differentiate both shapes from the left hand motion. In order to reduce the errors and increase the shape drawings rate, a classification approach is introduced into the system for further work.

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.

ACKNOWLEDGEMENT

A project of this magnitude depends on the hard work and commitment of many professionals, and we are pleased to acknowledge their contributions. The authors are deeply indebted and would like to express our gratitude to the University College of Technology Sarawak for supporting and funding this study under University Research Grant (UCTS/RESEARCH/4/2016/14).

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Figure 1a: Circle Left Hand Drawing Acceleration Data

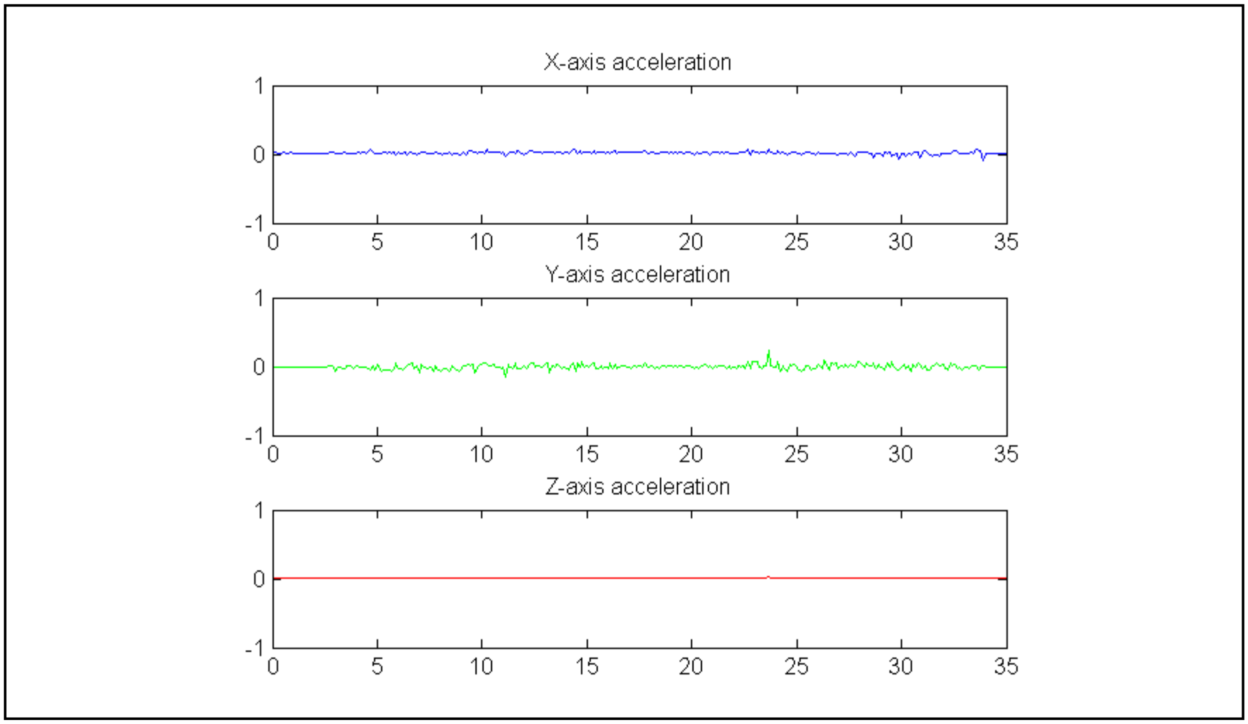

Figure 1b: Square Left Hand Drawing Acceleration Data

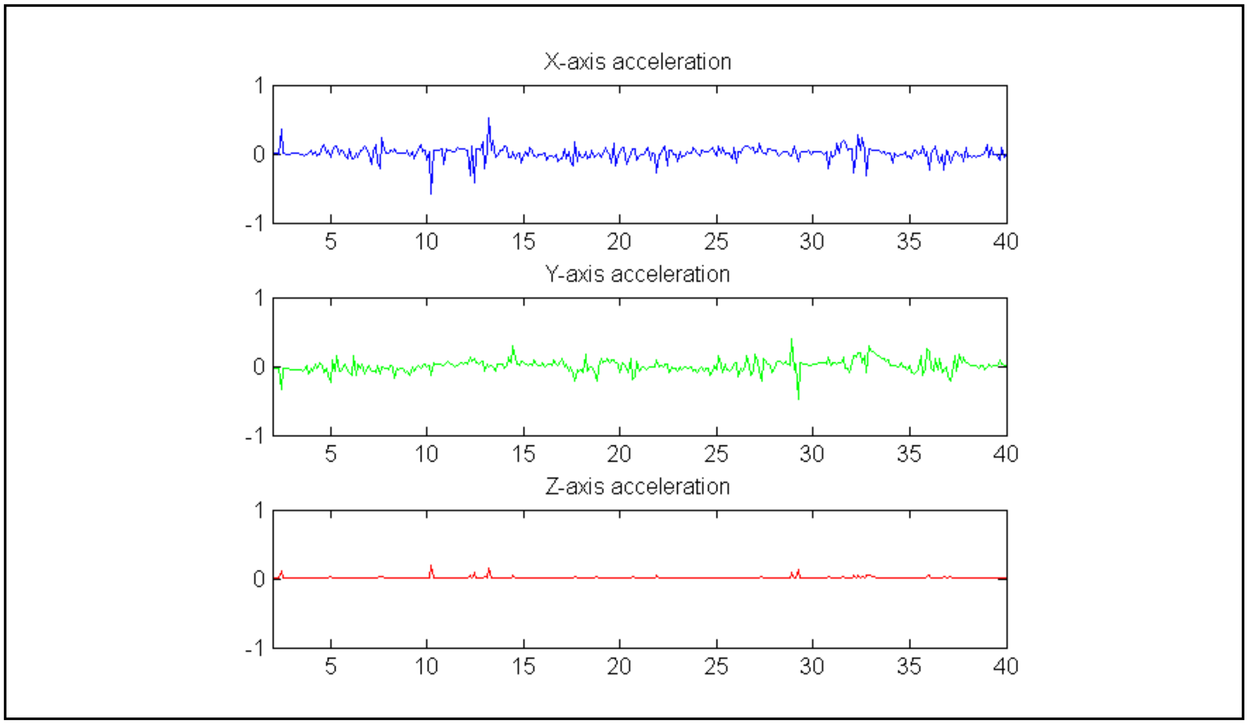

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Figure 1c: Triangle Left Hand Drawing Acceleration Data

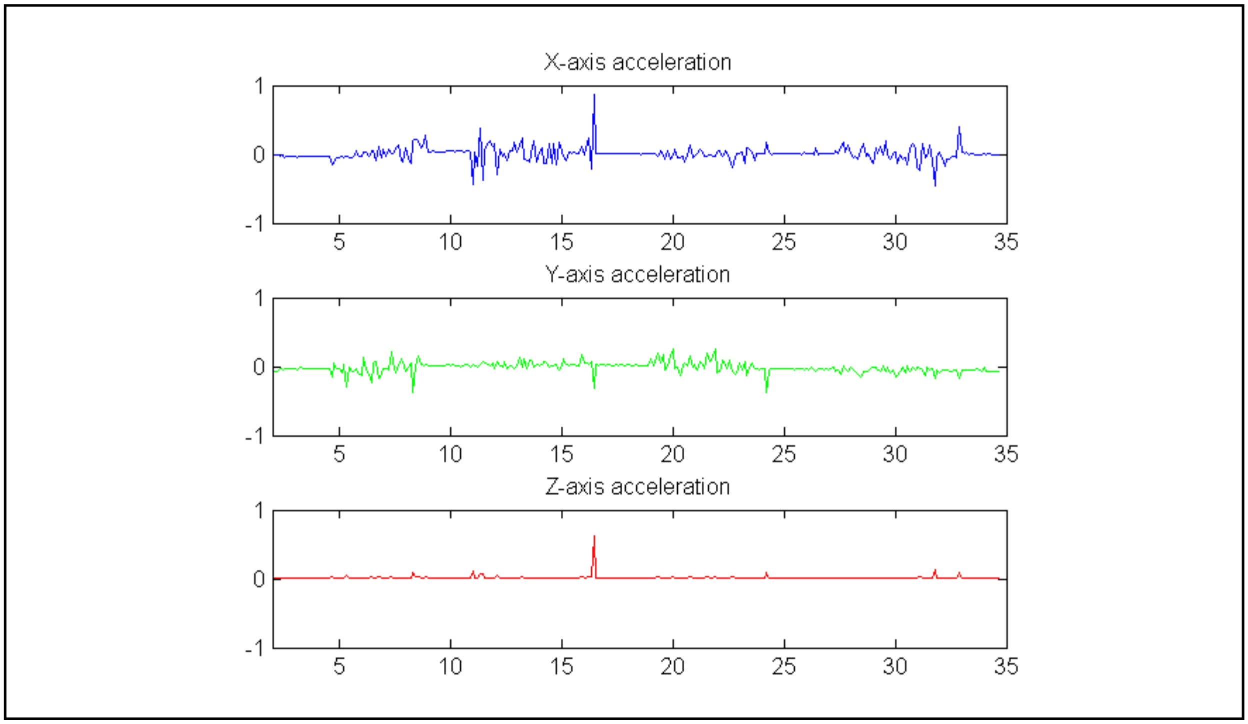

Figure 2a: Circle Left Hand Drawing

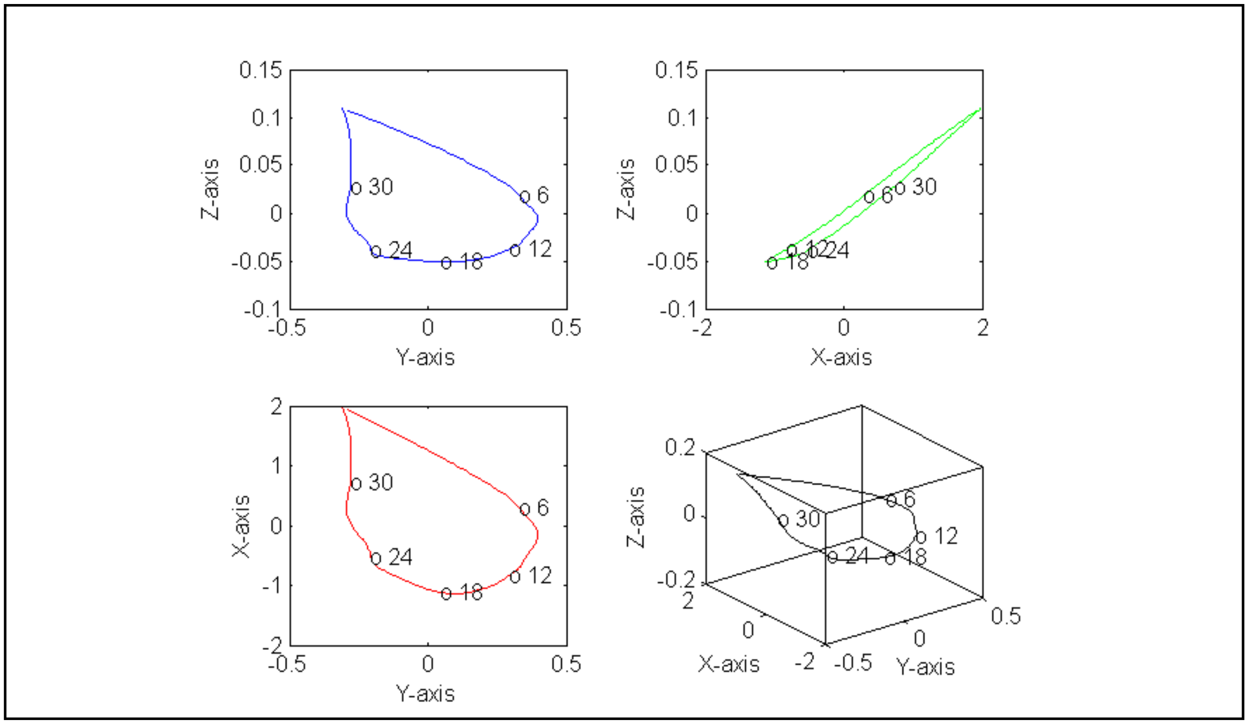

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Figure 2b: Square Left Hand Drawing

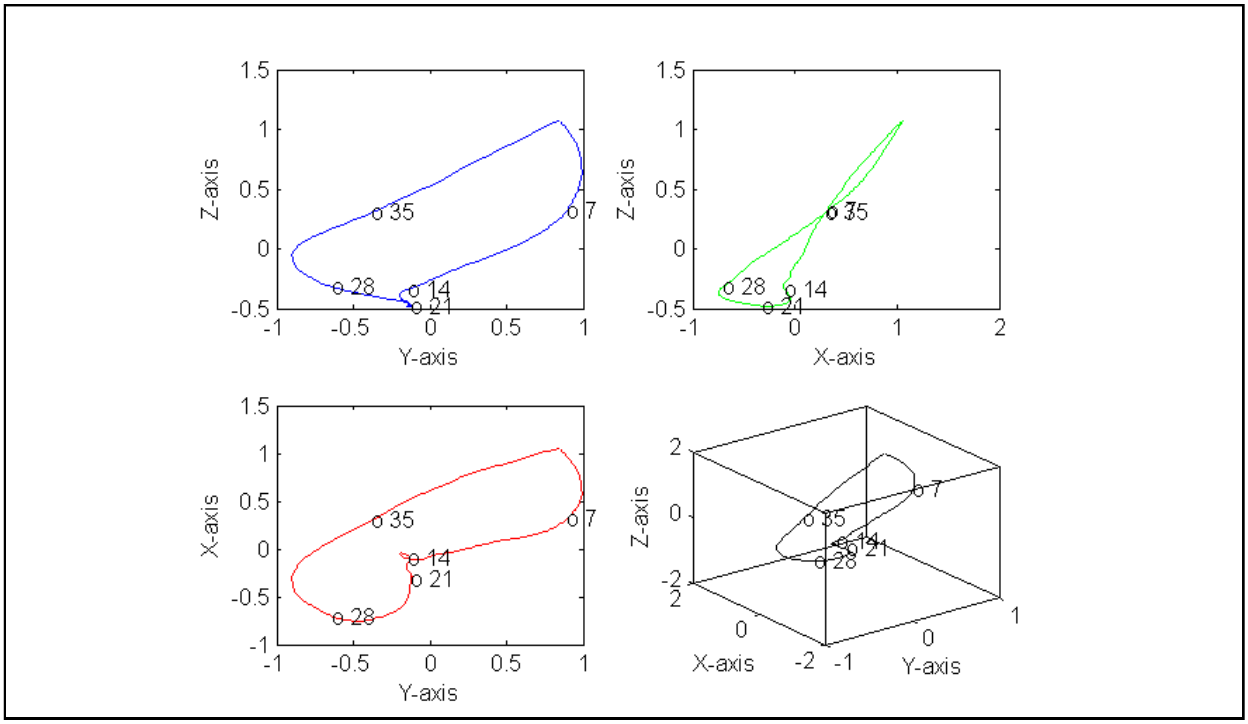
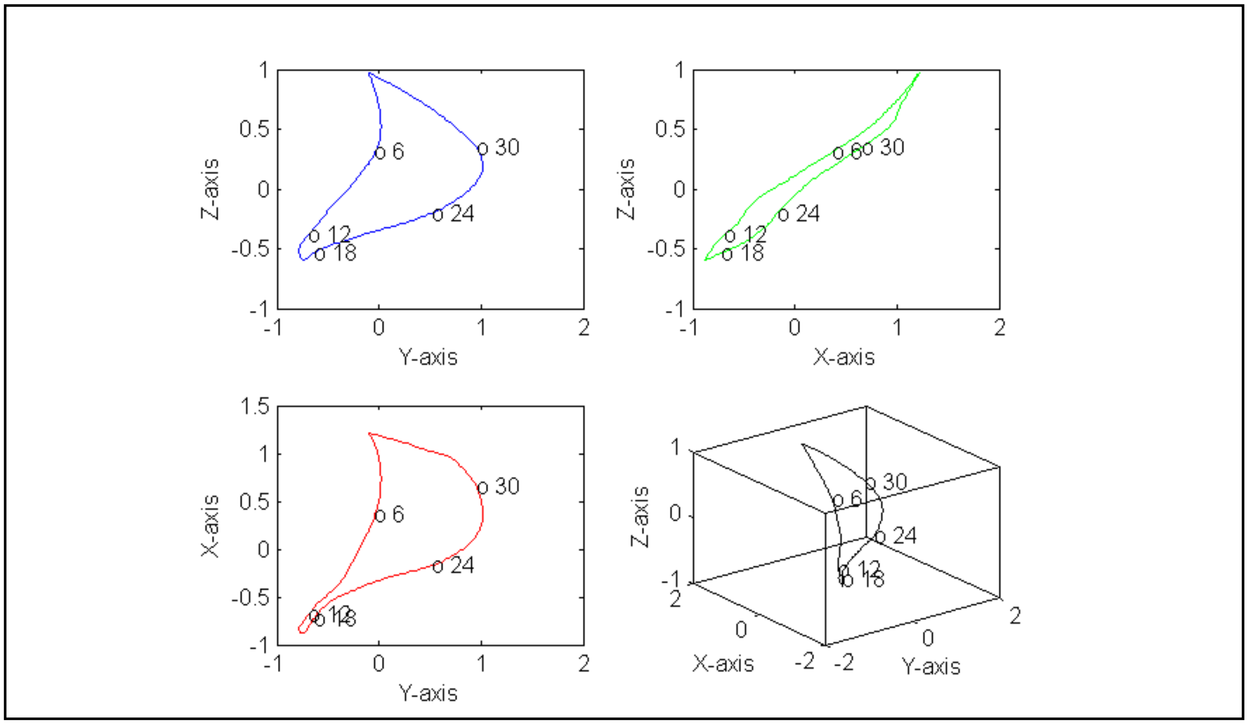


Figure 2c: Triangle Left Hand Drawing



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