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Analysis of *GloveMAP* Feature Extraction Using the Polynomial Regression Method

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ABSTRACT

Glove based device has outstandingly archive successfully in nowadays especially in industries, virtual reality, and medical. *GloveMAP* are recent DataGlove prototype aimed at obtaining signal information of finger movements. The cubic polynomial regression method is used to convert the original *GloveMAP* voltage output into angle since the information more user approachable. In this paper, we propose a continuation of the polynomial regression method to extract features from angle information. The preliminary results of experiment exhibit the result of using quadratic polynomial regression method for extracting *GloveMAP* features.

INTRODUCTION

Human-Computer Interaction (HCI) is a term used to refer an understanding and designing of differences relationship between people and computer (Richard Harper *et al*., 2008). HCI is a discipline concerned with the design, evaluation and implementation of interactive computing system for human use and with the study of major phenomena surrounding them. DataGlove is one of HCI example, capable to transmit via Bluetooth of each finger flexion of the user's hand (Tomasz P Bednarz *et al*., 2010). DataGlove often use in Virtual Reality (S. Sayeed, N. S. Kamel, and R. Besar, 2007) and hand gesture applications (M. Ishikaws and H. Matsumnra, 1999; S. Saengsri, V. Niennattrakul and C. A. Ratanamahatana, 2012; Wu jiangqin *et al*., 1998; T. T. Swee *et al*., 2007).

This research paper investigates on pattern recognition of the *GloveMAP* output signals to transform a set of data into a feature. Beforehand, a lengthy voltage signal data produced by the movement of finger while wearing *GloveMAP* is translated into angle by polynomial regression method (M.Hazwan Ali *et al*., 2013). Afterward, the meaningful data result from finger movement will be applied with polynomial regression over again to extract key information that will represent entire angle data. Polynomial Regression is a form of linear regression in which the relationship between variable x and dependent variable y is modeled as an *nth* order polynomial. The polynomial fitting curve will follow as closely as possible to angle curve data and consequential will construct a mathematical equation where the polynomial coefficient will be used as feature extraction.

This research paper is organized as follows; Section 2 assessing the literature reviews of the approach in acquiring finger data, related research field and difficulty. Section 3 presents the methodology of applied system. Section 4 is divided into two sections, first are about the experiment setup done while the second section demonstrated the result of the experiments. Finally, section 5 will express the overall conclusions over the current research.

2. Literature Review:

Feature extraction is required to decreasing computation power especially on a large set of data, Mohamed A. Mohandes has developed a recognition of Two-handed Arabic Signs using the CyberGlove in 2010 (Mohamed A. Mohandes, 2013). In this paper, the duration of the sign is divided into 10 segments where the signals from the 56 sensors will be represented by 1120 values. Principal Components Analysis (PCA) is used as feature extraction to reduce the dimensionality of data.

Aleem Khalid Alvi *et al*. has research a sign language recognition using DataGlove to recognize Pakistan Sign Language (PSL) using statistical template matching (Aleem Khalid Alvi *et al*., 2004). His work proposes a Boltay Haath approach by calculating the mean and standard deviation of all sensors and then limit bounded those

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input samples by an integral multiple standard deviation.

The polynomial equation is applied to GloveMAP angle data in order to extract feature. GloveMAP otherwise is a form of wired glove construct via strain gauge sensor aimed to acquire finger flexion data (Nazrul H. ADNAN *et al*., 2012). Through excellent GloveMAP data manipulation and programming skill, a promising outcome can be archived as instance waveform produce by GloveMAP is displayed into virtual reality (Nazrul H. ADNAN *et al*., 2012) as an alternative by means of regular Graphical User Interface (GUI) (Y. A. A. Refaat, and A. A. Ahmed, 2004). Furthermore through GloveMAP, PCA-based finger movement and grasping classification development (Nazrul H. ADNAN *et al*., 2013) has been conducted successfully.

MATERIALS AND METHODS

A. Flow chart of the proposed works:

The flow chart of the proposed works shown in Fig.1 provides an overview of the proposed works. The design system starts with data acquisition from *GloveMAP*, which is the voltage signal. The acquired voltage signals then are converted to the finger's bending angle by using polynomial regression method (M.Hazwan Ali *et al*., 2013). The output angle resulted from polynomial regression method will be applied to extract polynomial coefficient, which represent features of the bending's signal.

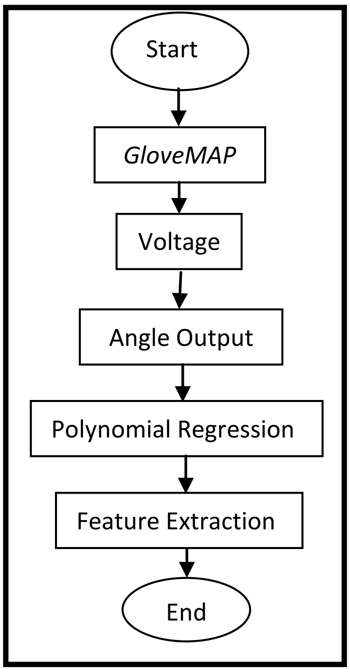

Fig. 1: Process flow of feature extraction.

B. GloveMAP:

GloveMAP shown in Fig. 2 is adopted flexible bend sensors in the construction of DataGlove. The resistivity of the sensor corresponds to the increasing distance between each of carbon element inside the thin strip of flexible bend sensor. With the change of the resistance values, the voltage outputs can be calculated referring to voltage the divider equation, where V_{in} is the flexible bend sensor supply voltage, *R* refer as the resistance of flexible bend sensors, whereas V_{out} is the voltage output resulting by referring to Eq. (1). By analyzing voltage data into Matlab, waveform as shown in Fig. 3 is obtained.

$$V_{out} = \frac{R_2}{R_1 + R_2} . V_{in} \quad (1)$$

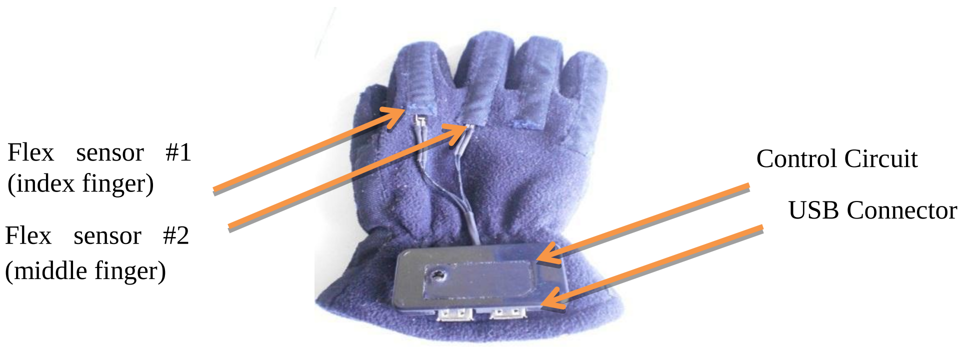

Fig. 2: GloveMAP.

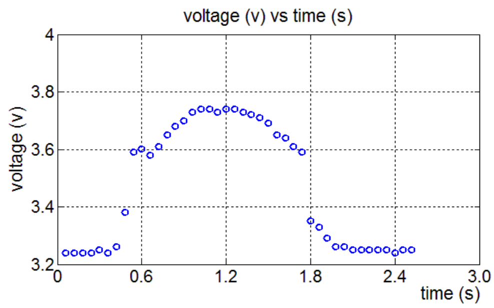

Fig. 3: Voltage data resulted from *GloveMAP*.

C. Polynomial Regression:

Polynomial regression method has been used attentively to nonlinear functions for modeling real-life phenomena and usually used in mathematical model to correlate the dependent variable y on the independent variable x. First degree of regression analysis (non-constant linear function) can be used in constructing best fit straight line in scatter plot data. Second degree polynomial is a quadratic polynomial, with better data fit than first degree polynomial. A polynomial regression equation is given in Eq. (2). Fig. 4 demonstrates the result of using polynomial into voltage data.

$$f(x) = ax^2 + bx + c \quad (2)$$

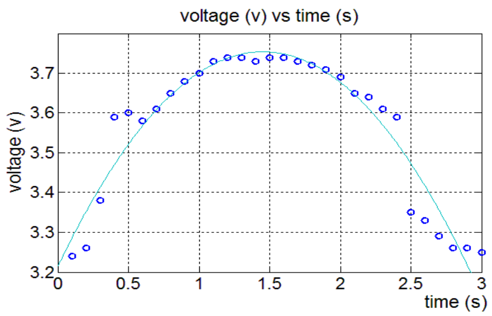

Fig. 4: Quadratic polynomial used into voltage data.

Results:

1. Experimental Setup:

The experiment were conducted from the initial hand position before holding an object then grasp and release it with the total time 3 second as Fig. 6. The grasp and release sequence produce 30~40 angle data in 3 second. The objects are selected based on its shape and diameter which were round and 4.5cm respectively as Fig. 5. The experiment was conducted by repetition of five trials. The signal was resample to discard low value signal as shown in Fig.7.

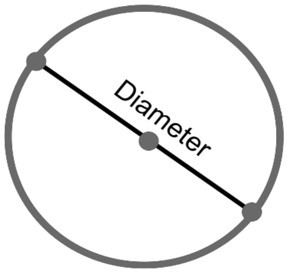

Fig. 5: Diameter of selected object.

Fig. 6: *GloveMAP* grasping an object.

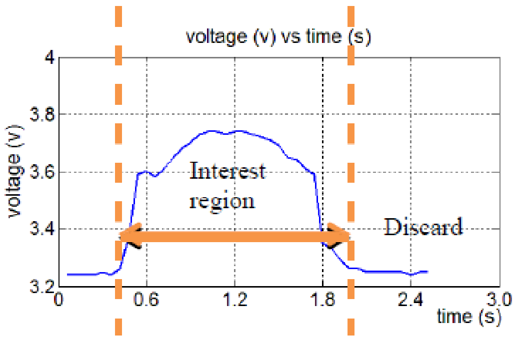

Fig. 7: The selected voltage signal.

2. Experimental Result:

For the experiment result, the signals of five trials as in Fig.8 were plotted into single graph to demonstrate the similarity of signal while holding the object. Even through the signal contain a lot of noise resulted from bending sensor and circuit, the polynomial regression technique nullified the noise and represent the signal in the polynomial form. Polynomial method estimate the best fit curve of nonlinear model which represent the angle signal. Quadratic polynomial regression method was also tested into angle signal. Fig. 9 (a), (b), and (c) demonstrate angle signal after applying quadratic polynomial regression. Table 1 shows the obtained coefficients in the experiments.

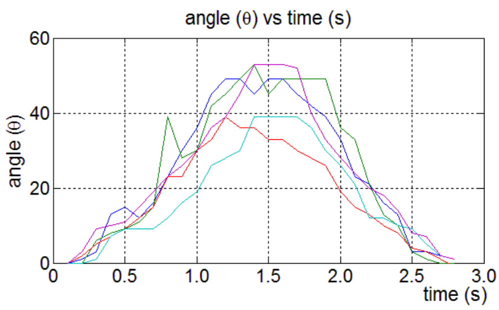

Fig. 8: Signal of five trial of same object.

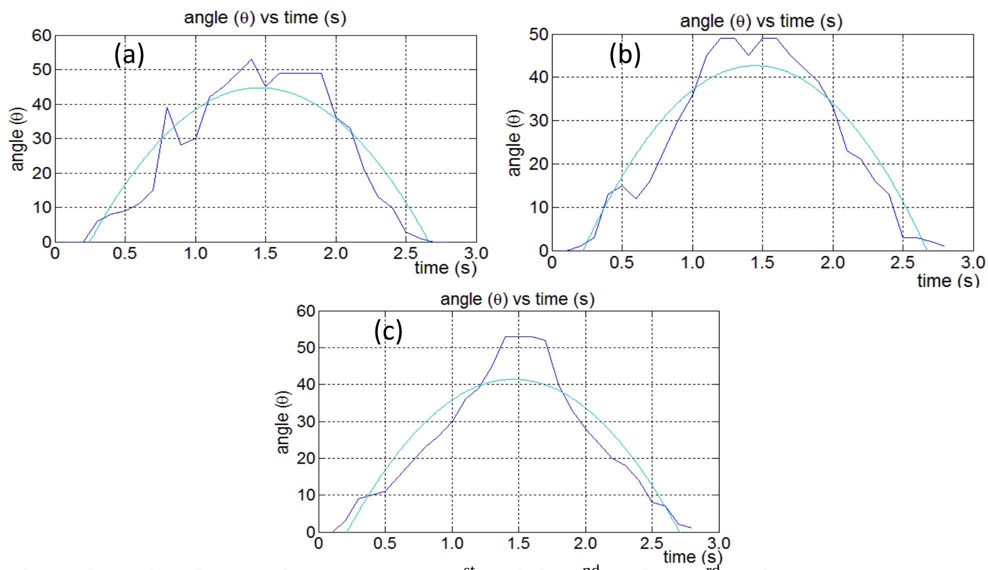

Fig. 9: Angle apply with polynomial regression (a) 1st trial (b) 2nd trial (c) 3rd trial.

Table 1: Polynomial coefficients.

Trial	Polynomial coefficients		
	(a)	*(b)*	*(c)*
#1	-0.28424	8.2348	-16.958
#2	-0.3061	8.9221	-20.29
#3	-0.26639	7.7844	-15.484

By referring to Table 1, the coefficient of *a*, *b*, and *c* of each trial were selected as the features of small bottle. In the future, polynomial coefficient could be employed as the feature to represent grasping of the object. With knowledge of original signal range which was from 1 to 28 data as shown in Fig.9 (c) and the polynomial equation refers to Eq. (3), it can be reproduced as shown in Fig.10.

$$y = -0.26639x^2 + 7.7844x - 15.484 \quad (3)$$

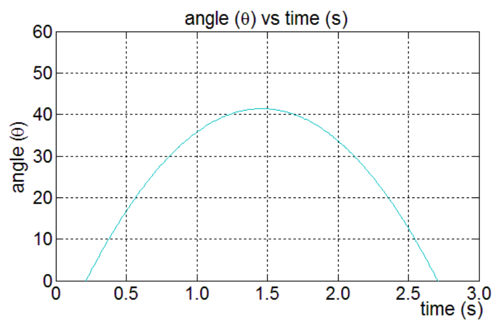

Fig. 10: Signal reproduces from polynomial equation.

Conclusions:

The research works proposed the polynomial regression coefficient produced by angle information in the feature extraction process. The combination of higher order polynomial and with other parameters likes confident level of the distribution curve, standard derivation, and angle of the distribution slope could be used as the features in order to increase accuracy of the computer to learn grasping activities. In the future, the experiments will be conducted to train the computer to know various grasping patterns based on the shape and diameter of the object.

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