DEVELOPMENT OF GESTURE DATABASE FOR AN ADAPTIVE GESTURE RECOGNITION SYSTEM

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Development of Gesture Database for an Adaptive Gesture Recognition System

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TABLE OF CONTENTS

CHAPTER 3 SYSTEM DEVELOPMENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

PCA	Principal Component Analysis
NN	Neural Networks
MOCAP	Motion Capture System
UAV	Unmanned Aerial Vehicles
HCI	Human-computer Interaction
MFDT	Multivariate Fuzzy Decision Tree
HRI	Human Robot Interaction
LMNN	Large Margin Nearest Neighbour
MLP	Multilayer Perceptron
WER	Word Error Rate
LMT	Line Measure Technique
kNN	k-Nearest Neighbour
LMFW	Large Margin Feature Weighing Method
ART	Adaptive Resonance Theory
ROI	Region of Interest
AKF	Adaptive Kalman Filter
KUG	Korean University Gesture
SVM	Support Vector Machines
ANN	Artificial Neural Network
SAS	Statistical Analysis System
DTW	Dynamic Time Warping
FPS	Frames Per Second
BMI	Body Mass Index

Pembangunan Pengkalan Data Gerak Isyarat untuk Sistem Pengecaman Gerak Isyarat Mudah Suai

ABSTRAK

Ciri-ciri pergerakan manusia adalah salah satu daripada cabang penyelidikan terhadap perwatakan manusia tanpa mengira kebolehan fizikal dan daya intelek setiap individu. Di dalam penyelidikan ini, fokus utama adalah untuk mengkaji ciri-ciri fizikal manusia yang mana menyumbang kepada penyampaian pergerakan gerak isyarat. Tambahan pula, setiap manusia mempunyai struktur badan dan fizikal yang berbeza dan boleh ditentukan melalui kiraan indeks jisim badan (BMI) dan ukuran saiz melalui berat dan tinggi badan seseorang individu. Di dalam projek ini, subjek yang berlainan saiz badan (berat dan tinggi) dipilih untuk melaksanakan lima gerak isyarat geometri. Gerak isyarat geometri telah dipilih dan pangkalan data gerak isyarat geometri dibina berdasarkan ciri-ciri badan manusia. Pangkalan data gerak isyarat ini digunakan untuk mengenal pasti gerak isyarat yang tidak diketahui daripada pengumpulan maklumat berkenaan ciri-ciri manusia untuk kajian di masa hadapan. Sistem penangkapan pergerakan digunakan untuk mendapatkan pergerakan gerak isyarat dari setiap subjek. Data tiga dimensi diperoleh daripada sistem penangkapan pergerakan, dianalisa, dibezakan mengikut kelas dan disimpan di dalam pengkalan data gerak isyarat. Algoritma persampelan semula dibina untuk mengurangkan lebihan maklumat pergerakan untuk dipamerkan semula. Prinsip Analisis Komponen (PCA) adalah teknik yang digunakan untuk mengurangkan dimensi data dan mengkelaskan data gerak isyarat. PCA akan membahagikan data kepada tiga kumpulan manusia berdasarkan struktur badan. Untuk penjelasan seterusnya, data di dalam pangkalan data diuji kiraan persamaan dan perbezaan menggunakan 'Jaccard Similarity Measure' yang mana memberikan keputusan nilai purata keseluruhan 90.8% perbezaan daripada kesemua lima isyarat geometri antara kumpulan #1, kumpulan #2 dan kumpulan #3 untuk kesemua tiga paksi, paksi X, paksi Y dan paksi Z. Selain daripada itu, satu pengecaman gerak isyarat mudah suai diperkenalkan yang ia digunakan utuk memilih pangkalan data yang sesuai bagi secara khususnya mengenalpasti gerak isyarat asing yang dimasukkan ke dalam sistem. Keputusan daripada proses pengecaman ini menunjukkan pengecaman pangkalan data individu adalah 86.5%, pangkalan data kumpulan 83.7% dan paling rendah adalah pengecaman pangkalan data 'universal' sebanyak 82.8%. Daripada keputusan eksperimen yang diperolehi, pengkalan data kumpulan adalah lebih sesuai digunakan untuk mengcam gerak isyarat mudah suai.

Development of Gesture Database for an Adaptive Gesture Recognition System

ABSTRACT

Human gestural motion is one of the areas in studying human behaviour regardless the physical capability and intellectuality of each individual. In this research, the focus is to investigate human physical characteristics which contribute to the performance of gestural motions. Every person has different body structure and physical distinctive that can be determined by calculating the person's body mass index (BMI) and measuring the size represented by the weight and height of individual body. Subjects with different body size (weight and height) are selected for this research to perform five geometrical gestures. The geometrical gesture databases are developed based on human body characteristic features. These gesture databases are utilized to recognize and identify an unknown gesture by gathering some information of human features for further analysis. A motion capture system was used to capture gestural motions. Three dimensional data obtained from motion capture system are analysed, classified and stored in the gesture database. The resampling algorithm is developed to diminish the excessive movement information which to be used in the represented form. Principal Component Analysis (PCA) is used to reduce dimension of data and classify the gesture data. PCA classifies three groups of people based on gestural motions of subjects. For further clarification, data inside the group database were tested for similarity and dissimilarity measured using Jaccard Similarity Measure; the result of total average is 90.8% dissimilarity of all five geometrical gestures between group #1, group #2 and group #3 for all the three axes: X-axis, Y-axis and Z-axis. Consequently, adaptive gesture recognition is introduced to select the suitable database especially for identifying unknown gestures inserted into the system. The result of recognition shows that recognition of individual database is 86.5%, group database 83.7% and the lowest is recognition of universal database which is 82.8%. The experimental result shows that the group database is preferable for an adaptive gesture recognition system.

CHAPTER 1

INTRODUCTION

1.1 Research Overview

A gesture is a movement that a person makes with his hands, head or face to show a particular meaning and convey particular messages. In general, any movement of the human body parts which signifies a message can be considered as a gesture. The human body can be divided into two parts, namely the upper body and the lower body (Khairunizam & Sawada, 2008). In this research, only the upper body part is considered as the gesture database being developed is focused solely on arm gestures. Arm gestures consider the movement of the elbow to fingertips. The aim is to develop a gesture database based on different body structures of human for adaptive gesture recognition system.

In recent gesture database, researchers only one aspect of the database to recognize an unknown input gesture (Gunes & Piccardi, 2007). This research also considers other aspects, namely the physical characteristics of subjects performing the gestures. The proposed method is to develop a gesture database that recognizes an input gesture based on human features classification, specifically for gestures of the arms and hands. The geometrical gesture motion is developed based on different human appearances as a gesture database. An optical motion capture system (MOCAP) is used

to capture the motion and extract the motion features from hand trajectories which consist of wrist position, the movement and the velocity of hands. Several of the geometrical motion patterns are simplified by applying a new algorithm. At the end of this study, a gesture database is developed based on classification of a group of people by considering human physical appearances. With the database, an adaptive system will be able to recognize unknown gestures introduced into the system and taken for further analysis.

1.2 Motivation

A gesture recognition system is a system that can identify the motions of a human body part which could interact with machines, for instance to control mobile robots, robotic arms and humanoid robots. This system has been used in many applications including unmanned aerial vehicles (UAV) control, human-computer interaction (HCI) and also in audio/video (AV) devices such as Samsung Smart Interaction TV (Zhao, Naguib, & Lee, 2014). The medical field also sees an increasing necessity for HCI and gestures. Currently, many studies on recognizing human gestures have been reported, using numerous parts of the body such as the hands, head and face. Hand gesture plays an important role in transmitting non-verbal information due to the flexibility of hand movement. Several attributes can be used to classify hand gestures such as the hand shape, palm orientation, hand location and arm motion. The focus of this research is on the movement and characteristics of projectile motion of the human arm.

On the other hand, the development of database is based on the differentiation of human, specifically to physical body characteristics. Previous research on human

gesture database were related to a universal dataset and full body movement database (Hwang, Kim, & Lee, 2006) and neither concentrate on individualistic part of the gesture performer. Hwang (2006) showed some examples of database developed for full body orientation. With the database development, recognition of parts had become more accurate, hence improved the recognition rates. Human gestures are genetically affected by the human body structure which relates to the physical attribute of the human body. Human body is constructed with highly complex features, with genetic structures that differentiate from one another. These differences make human unique and matters in the gesture performances. Movements made by different persons may induce some differences in the results, whether huge or small. These differences could increase the accuracy of the recognition process; errors can be reduced or eliminated and processing time can be shortened. It is useful in many applications and data processing. Thus, several researchers suggested numerous types of methods to improve the precision of recognition results, classification of data and features extraction.

Motion capture and image capture are utilized in order to obtain gestures that are usually using a lot of equipment and sensors; some researchers even use multiple orientation sensors (Phadtare, Kushalnagar, & Cahill, 2012). Arm gesture recognition can be achieved using active or passive sensors, or a combination of both. An active sensor would include gloves with bend sensors, while the other category users wear sensors such as Data Glove (Nazrul., Khairunizam, & Shahriman, 2014). Aside from sensors, cameras play an important role in capturing the image. Gesture recognition system can also operate on video stream. The extraction of head and hand region images are obtained by stereo cameras. For the purpose of improving the interaction between human with machines, optical motion capture is used (Metcalf, Robinson & Malpass, 2013). Figure 1.1 shows examples of gesture recognition. In University of Tsukuba

Japan, researchers utilized a digital camera that integrated with a software that allows the photographer to pan or tilt the frame before taking the shot.

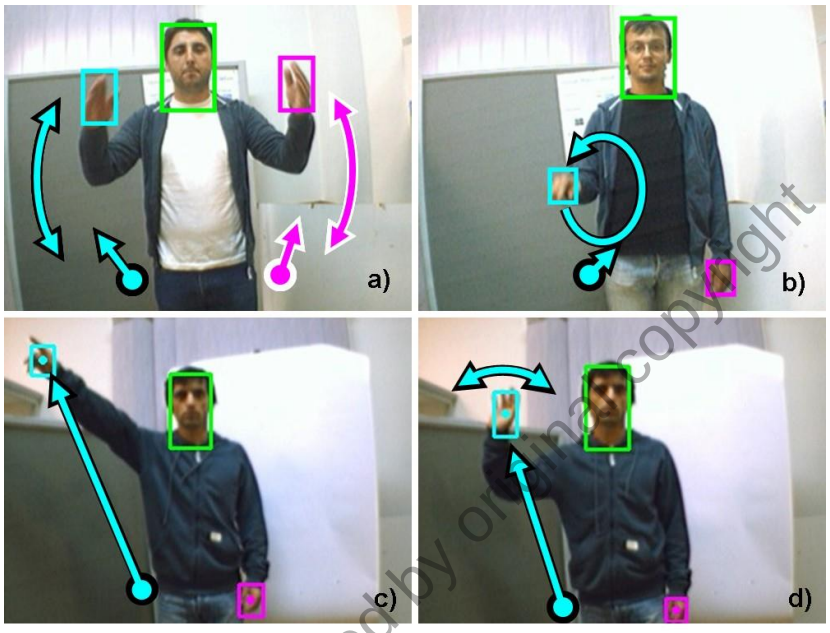

Figure 1.1: Examples of gesture recognition.
(https://mgitecetech.wordpress.com/tag/gesture-recognition/)

In analysing human gestures, several algorithms were introduced. Dynamic gesture recognition by using a human upper body model and fuzzy algorithm approach was discussed (Khairunizam et al., 2008). Some of the method is simultaneously used with other human robot interaction (HRI) approaches such as speech recognition and face recognition. Seungsu, Kim and Park (2006) proposes multivariate fuzzy decision tree (MFDT) learning and classification algorithm for hand gesture recognition. It has smaller number of node then general fuzzy decision tree.

In recent years, a lot of research has been conducted in order to recognize human gestures which include various parts of human body such as the hand, head and face. Among the body parts, hand gestures are the important gesture to transmit non-verbal

information between human with computer. However, most of the work on hand gestures recognition has been concentrated on the classification of the shapes and locations of hands (Phadtare et al., 2012), and relatively a few works have been done on the classification of dynamic arm motions. Arm motion is the movements of arm to represent the expression of human without saying a word. Different arm motion could be used to differentiate the semantics of hand gestures that have similar shapes and locations of hands.

1.3 Problem Statement

Human gesture contains movement of body structure and can be called body language. Humans have numerous body structures in terms of body size, which contribute to different gesture performance of every subject's gesture. Moreover, even though each subject performs the same gesture repetitively, the trajectories could be different due to physical physiognomies factor of the subject; this factor signifies the importance of body structure information presented in human gestures which can influence gesture recognition. Moreover, the emotional state of the subject also gives to the differences in gesture performance (Khairunizam et al., 2008).

For the past few years, researchers have developed databases based on human characteristics but not depending on body size (Khairunizam et al., 2008; Gunes et al., 2007). It is also known that body size affects the motion of gesture. Therefore, in this project, gesture will be classified according to body size. However, several difficulties need to be tackled such as the difficulty in determining the start and end points of a gesture, the difficulty in dealing with a sequence of body posture and hand shape (Elmezain, Al-Hamadi, & Michaelis, 2009). Moreover, the comparison of data to

recognize gestures also faces difficulties which are referred to the gesture database. In designing the database, difficulty occurs because of different subjects have different body structures. Thus, a new system is required to overcome this limitation.

1.4 Objective

The objectives of this project are:

1) To investigate the characteristics of motion of arm movements for the representation of the gesture.
2) To classify humans based on the arm gesture and the physical body structure.
3) To design a gesture database that can be used as reference in gesture recognition process.
4) To analyse the recognition performance of the proposed adaptive gesture recognition system.

In this study, a resampling algorithm is introduced for the recognition of dynamic hand gesture, which is based on dynamic movement of arm trajectories. An investigation is conducted to classify the group of human based on gestural information of the arm and their physical body structures. Three types of gesture databases are introduced which are the individual gesture database, group gesture database and a universal gesture database. These gesture databases are used to develop an adaptive gesture recognition system. In this study, the system will choose the types of gesture database based on the subject's body structure.

1.5 Scope of Research

In the process of achieving the objectives of this research, there are a number of constraints that need to be decided on the practice for obtaining more rigorous result.

1. The selection of experiment's subjects is based on different body size, different ages and also different gender then running an experiment on their gesture performance. The age of the subjects range between 20 to 45 years old. Data collection process is using an optical motion capture system that generates discrete and floating values. The experiment is conducted in a laboratory space condition with the specific location of subject during performing gesture. Geometrical shape gestures are selected as gesture performance and using arm to draw a gesture.
2. Monitoring the distribution of gesture motion data and classification process are done by using resampling data approach and classification method such as Principle Component Analysis (PCA), and justified by Jaccard similarity approach.
3. From classification of human based on gestural motion, the development of gesture database was conducted. The gesture database is defined based on individual database, group database and universal database.
4. For recognition purposes, template matching method is used. This method using comparison technique which unknown input data entered to the system will be compared to the data inside the database. The value of the accuracy in matching the data is considered to be recognition rate. Several software that will be used in this research is Lab View software, Matlab software and JMP software.

1.6 Project Expectation

The main objective of this research is to develop a gesture database for improving gesture recognition performance. At the end of this research, it is expected that the human can be classified into several groups based on human gesture by referring to the human physical characteristics. The proposed grouping approaches could be used to develop an adaptive gesture recognition system that can increase the performance of the gesture recognition systems.

1.7 Report Organization

Chapter 1 explains on overview of the thesis, problem statement, scope of research and the goal for this project. From this chapter, the direction of the research is briefly discussed.

Chapter 2 presents the related research, different gesture recognition approaches and application of human gesture. The methodology, result and conclusion from some related research are the reviewed to serve as a foundation and steering point for this research.

Chapter 3 discusses the methodologies including data collection, method of elimination error in data, pre-processing and also describes the classification method. The proposed Principal Component Analysis (PCA) algorithm are utilized in the implementation stages.

Chapter 4 presents the result and discussion of the project, which apparently encompasses the important part of this research. Aside from elaborating the classification and recognition result, this chapter also describes the experimental set up,