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* *Cut where unnecessary*

DESIGN AND ANALYSIS OF MECHANICAL HAND USING COMPUTER AIDED MECHANISM DESIGN (CAMD) TECHNIQUE

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MAY 2009

"I confess that this work is the result of my own investigations. All sections of the text and results, which have been obtained from other workers/sources, are fully referenced"

Signature :.....

Name : **Muhamad Khalis bin Ramli**

Date : **18th May 2009**

I dedicate this thesis to my beloved family

ACKNOWLEDGEMENT

"In The Name of Allah, The Merciful, The Beneficent"

Glory to Allah S.W.T, The Most Gracious, The Most Merciful, and peace is upon His messenger Holy Prophet Muhammad S.A.W. All the worship belongs to only Allah. We seek refuge with Allah from the wickedness within and from the evil deeds. We also praised to Allah S.W.T for giving us courage, time, and knowledge in completing this thesis for my bachelor project.

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ABSTRACT

Robotic hands are still long way from matching the grasping and manipulation capability of their human counterparts. One way to push the research further along is to use computer modeling and simulation to learn more about human and robotic grasping. This project have used LEGO MINDSTORMS model to construct the robotic hand for replace robotics that present nowadays. This project also analyzed by using three software to design, simulating something and analysis for this model. Among them is, COSMOSMotion, Lego Digital Designer, and SolidWorks 2007. All software that has been used provides the convenience type of design hand from the various aspects. It can accommodate a wide variety of hand designs, and it can evaluate grasps formed by these hands, as well as perform full dynamic simulation of the grasping process. In this research, it presents the various components of the systems, and describes the projects which use it as an integral part of larger grasp planning systems. This project also discusses the development of a human hand model that uses accurate geometry and kinematics derived from experimental measurements. This is part of current project to create a biomechanically realistic human hand model to better understand what features are most important to mimic in the designs of robotic hands by using this LEGO MINDSTORMS model.

ABSTRAK

Keupayaan tangan robotik masih lagi jauh untuk dibandingkan dengan keupayaan genggaman dan manipulasi daripada tangan manusia. Salah satu cara untuk membawa kajian ini lebih jauh ialah dengan menggunakan pembentukan dan simulasi komputer untuk mempelajari dengan lebih lanjut berkenaan dengan genggaman manusia dan robotik. Projek ini telah menggunakan model "LEGO MINDSTORMS" untuk membina model tangan berkenaan bagi menggantikan robotik yang sedia ada. Projek ini juga dianalisis dengan menggunakan tiga perisian untuk mereka bentuk, membuat sesuatu simulasi dan analisis terhadap model berkenaan. Antara perisian yang dimaksudkan adalah "*COSMOSMotion*", *"Lego Digital Designer",* dan "*SolidWorks 2007*". Semua perisian yang digunakan ini memberikan kemudahan dari segi pelbagai jenis reka bentuk tangan, serta menjalankan simulasi dinamik penuh tentang proses menggenggam. Kajian ini juga memperkenalkan pelbagai komponen untuk sistem ini dan menerangkan segala projek yang menggunakan komponen tersebut sebagai bahagian penting untuk sistem genggaman yang lebih besar. Projek ini juga membincangkan tentang pembangunan sebuah model tangan manusia yang menggunakan geometri yang tepat dan kinematik yang diterbitkan daripada pengukuran eksperimen. Ini adalah sebahagian daripada projek terkini untuk menghasilkan sebuah model tangan manusia realistik biomekanikal untuk memahami dengan lebih baik tentang apakah ciri-ciri yang penting untuk ditiru dalam rekabentuk tangan robotik dengan menggunakan model "LEGO MINDSTORMS" ini.

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CHAPTER I

INTRODUCTION

Grasping is one of the primary ways for a robot to interact with objects in its environment. Assembly line robots use simple end-effectors such as suction cups or parallel jaw grippers to accomplish pick and place tasks with a high degree of reliability. However, the factory environment is highly structured, and each robot usually only grasps one type of object until it is reprogrammed to handle another object type. This reprogramming is done simply using operator knowledge or more recently using software to automatically pick the contact points (Smith *et al*., 1999). As robots are being required to work in more unstructured environments, such as service robots in the home, bomb disposal robots, and robots used in space missions, more general purpose hands are being designed that are capable of grasping and manipulating a much wider range of objects. Hence, in these projects, one model of mechanical hands will be constructing by using LEGO MINDSTORMS model to study the movement mechanism by grasp any objects. This project also can put something more clearly about the mechanical hand in diurnal life.

1.1 Objective

The objective of this project is to design and analyze a mechanical hand that can grasp object using CAMD (Computer Aided Mechanism Design) Technique, which is building the mechanical hand by using LEGO MINDSTORMS NXT. With

using the touch sensor to trace object, the touch sensor will work to take the object and move it from one place to another place.

1.2 Scope

Following are the scope of the projects to make sure this project is successful:

i. Design mechanical hand by using 3D CAD software, such as SolidWorks 2007 and Lego Digital Designer.
ii. Study the mechanism of mechanical hand by using CAMD techniques, likes COSMOSMotion.
iii. Then, use the COSMOSMotion to do the analysis about the acceleration and the velocity. To do the simulation by using the same software to investigate the mechanical hand when grasp object.
iv. Also, use COSMOSMotion to make the animation how it works.
v. Analyze and suggest improvement of mechanical hand mechanism so that the model must be in the best condition and able to function in a long period of time.

1.3 Problem Statement

Nowadays, LEGO MINDSTORMS NXT becomes smartest, strongest, and most advanced in many ways. Even the LEGO MINDSTORMS NXT becomes the next generation of robots, in Malaysia doesn't have any platforms for the society to develop any idea to make the new robot. The best design of the mechanical hand model to be developed using LEGO MINDSTORMS. The designs are limited to the components which are provided with the set of the LEGO MINDSTORMS, or better known as bricks. In other words, the model needs to be designed with taking into account on the limited amount of bricks provided.

Apart from that is to determine which software can give the accurate value when do the analysis. For example, between SolidWorks and ADAMS, which software can give the actual value with the origin condition?

Other than that is how to identify the limitation factors of the model, such as the types of objects that can be grasped, the object's minimum and maximum weight, and other factors. For example, the simulation data taken from COSMOSWorks Designer and COSMOSMotion, which can give the accurate data with the real condition when grasp the object.

Lastly, the software which is files that saved can it moves from the SolidWorks to ADAMS? Which software that can use to draw the bricks (small) part of LEGO MINDSTORMS to make the mechanical hand? Which software that can use to do the animation? All this are the problem statement.

CHAPTER II

LITERATURE REVIEW

2.1 Related Work

Because of the versatility of the human hand, there has been a great deal of research devoted to studying the hand and to building robotic hands that can mimic some of its functionality. This thesis focuses on grasp analysis as well as simulation, and this chapter reviews the significant body of work in these areas. A clear division of approach in grasping was illustrated by Mishra and Silver, (1989) who separated the previous work into higher level of physiological studies of the human hand and lower level studies of the mechanics of contact. While this thesis is primarily concerned with simulating and analyzing the grasping mechanics, the synthesis techniques of the higher level approach cannot be ignored. This chapter begins by reviewing these techniques, and then it presents the large body of previous work concerned with the mechanics of grasping which is further divided into several sub-areas. Finally, the chapter concludes by reviewing research in the area of general robotic simulation.

2.2 High Level Grasp Synthesis

One difficulty in synthesizing grasps in the large number of degrees of freedom possessed by typical robotic hands. This flexibility gives rise to an

enormous set of possible hand configurations. However, in choosing their own grasps, humans unconsciously simplify the task to selecting one of the only a few different prehensile postures appropriate for the object and for the task to be performed. Medical literature has attempted to classify these postures into grasp taxonomies as seen in McBride (1942), Griffiths (1943), and Slocum and Pratt (1946), but the most well known grasp taxonomy was proposed by Napier (1956). His work establishes the fundamental differences between power grips, which envelop the object and offer maximum manipulability. Cutkosky and Wright (1986) extended this classification to the types of grips needed a manufacturing environment and examined how the task and object geometry affect the choice of grasp. Their tree-like classification can be seen in Figure 2.1.

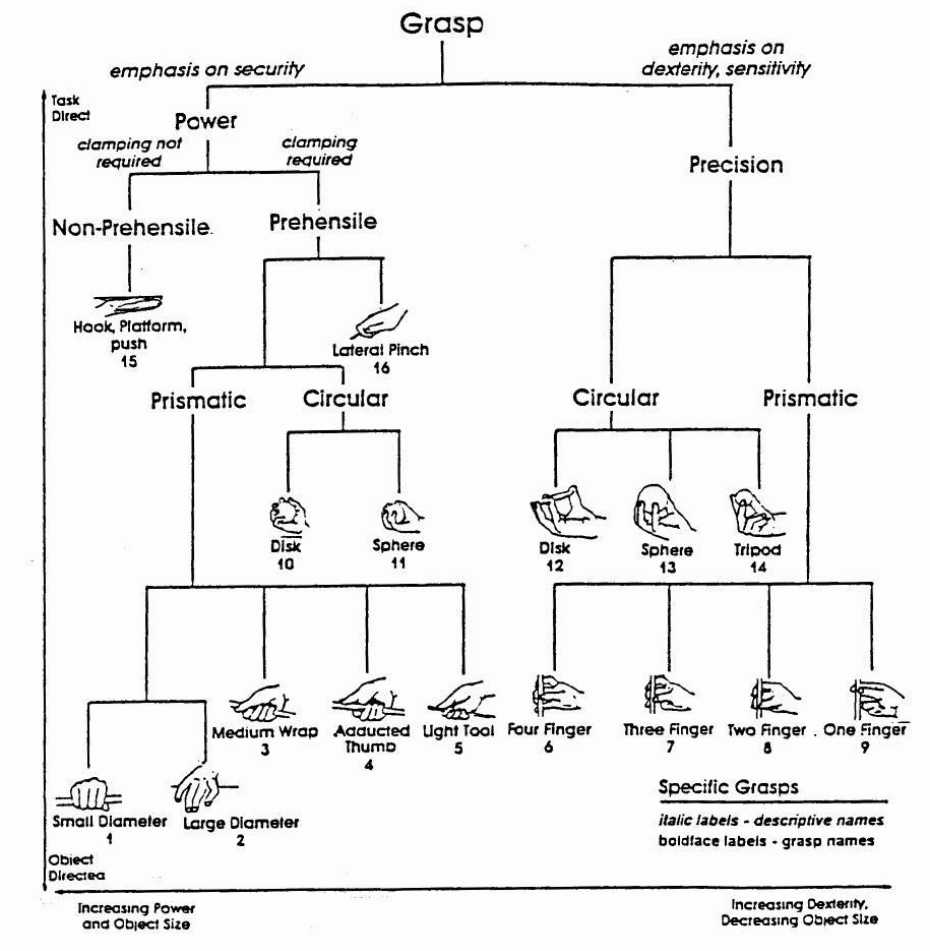

Figure 2.1: Taxonomy of human grasps by Cutkosky and Wright's, (1986)

Iberall (1987) saw this classification as too rigid, since in practice, the human hand often uses a combination of grasps to accomplish a task. She defined grasps

with respect to two virtual fingers which apply opposing forces on the objects, and only later maps these virtual fingers onto physical fingers based on object characteristics. The basic oppositions of the virtual fingers are divided into pad opposition, which is between the thumb and finger pads and used for precision type grasps, palm opposition, which is between the palm and the digits and used for power type of grasps, and side opposition, which is between the thumb and the side of the index finger and is compromise between the flexibility of the pad opposition grasps and the stability of the palm opposition grasps. Lyons (1985) uses the concept of the virtual fingers in his development of a grasp index that that selects a grasp on the basis of two object characteristics, shape, and size, whether the grasp should be firm or not and whether the grasp should be precise or not. Unfortunately, his categories are quite broad and make it difficult to create a grasp tailored to specific objects.

Stansfield (1991) built these classifications into a rule based system that, when given a simplified object description from a vision subsystem, will provide a set of possible hand preshapes and reach directions for the pre-contact stage of grasping. However, many problems are left unsolved. She only examines five possible approach directions, she does not try to choose the best grasp from this set of possibilities, and for any grasp that is chosen, the hand simply closes its fingers; no attempt is made to optimize the grasp for stability.

Pao and Speeter (1989) developed a method of solving for a transform that maps human hand poses to poses of the robotic hand, and using a Data Glove to measure the joint angles of a human hand, they were able to recreate a variety of poses with the robotic hand. Speeter (1991) later created HPL, Hand Programming Language that simplifies the problem of coding robotic grasps and dexterous manipulation tasks. The language consists of a number of motion primitives that are related to common human grasps and manipulation motions, providing a high-level abstraction of the grasping process.