DEVELOPMENT AND REAL TIME CONTROL OF AN ARM FOR PATIENT ASSISTANCE FOR LIFTING MOBILITY ROBOT (PALMBOT)

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DECLARATION

This thesis is the result of my own work with the exception of quotations, excerpts, summaries and references, the sources which have been duly acknowledged.

17 July 2008

MURALINDRAN MARIAPPAN
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CERTIFICATION

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ABSTRACT

DEVELOPMENT AND REAL TIME CONTROL OF AN ARM FOR PATIENT ASSISTANCE FOR LIFTING MOBILITY ROBOT (PALMBOT)

The dawn of medical robots for hospital applications has enormously enhanced the services rendered to the patients. The medical robots, spanning from surgical to rehabilitation, provide their support not only to the doctors but to the patients as well. In spite of such advancement, some major health hazards still exist for the hospital nurses. Lifting and moving the patients in hospitals are the usual duties of nurses. Injuries and backache occur while they frequently lift the unconscious, un-cooperating or immobile patients. This research highlights on the development of a single prototype arm of a Patient Assistance for Lifting Mobility Robot (PALMBOT) as an effort in order to resolve this problem. Fieldwork conducted in Queen Elizabeth Hospital and Nursing Training College, Kota Kinabalu reveals that 83.9% of nurses have backache and back injuries due to patient handling. Observations on lifting techniques and hospital specifications were used to conceive the PALMBOT. The PALMBOT is a semi-automatic robot designed especially to assist nurses to perform lifting and transferring patients to different locations, thereby reducing the chances of nurses getting injured during these tasks. The three arms of the PALMBOT, which perform the automatic patient loading and unloading process, use a set of open end conveyor systems. Since safety is a primary concern of the PALMBOT, Artificial Intelligence (AI) was incorporated in developing various sensing and control modules. Neural network was employed for the detection and execution systems which consist of Patient Position Tracking System (PPTS), Danger Monitoring System (DMS), Automatic Procedure Sequencing System (APSS) and Fail Safe and Automatic Recovery System (FSARS). The intricacy faced in maintaining the tension of the conveyor was resolved by using fuzzy logic in the Conveyor Tension Control System. A prototype single PALMBOT arm was fabricated. All the hardware and software modules are interconnected by using several tools such as MATLAB, EPOS Position Control and MPLAB® IDE PIC C working on the LABVIEW V8.0 as a common platform. The PALMBOT system is tested by a set of experiments and by simulated studies and found to be demonstrating an acceptable performance. It is envisaged that the PALMBOT is a very useful addition to the modern hospital facilities.

ABSTRAK

Robot perubatan bagi aplikasi hospital telah banyak meningkatkan perkhidmatan yang diberikan kepada pesakit. Robot perubatan bukan sahaja memberikan bantuan kepada para doktor malah kepada para pesakit juga iaitu dari segi pembedahan hingga pemulihan. Walaupun maju, masalah kesihatan yang penting masih wujud bagi jururawat hospital. Mengangkat dan mengalihkan pesakit di hospital adalah tugas seharian bagi jururawat tetapi kecederaan dan sakit belakang wujud semasa kerap mengangkat pesakit yang tidak sedar, tidak bekerjasama dan pesakit yang tidak boleh bergerak. Penyelidikan ini menonjolkan perkembangan satu lengan prototaip bagi robot bantuan mengangkat pesakit kuramg upaya pergerakan (PALMBOT) bagi menyelesaikan masalah ini. Kerja lapangan yang telah dilakukan di Hospital Queen Elizabeth dan di Kolej Latihan Kejururawatan, Kota Kinabalu menunjukkan bahawa 83.9% daripada jururawat mengalami sakit belakang serta kecederaan yang disebabkan oleh pengendalian pesakit. Pemerhatian pelbagai teknik mengangkat pesakit dan spesifikasi hospital digunakan bagi merekacipta PALMBOT. PALMBOT adalah robot semi-automatik yang direkacipta khas untuk membantu jururawat mengangkat dan memindahkan pesakit ke lokasi yang lain, secara langsung mengurangkan kebarangkalian jururawat mendapat kecederaan semasa melakukan tugas tersebut. Tiga lengan PALMBOT yang melakukan proses memuat dan memunggah pesakit secara automatik menggunakan satu set sistem konveyor terbuka. Oleh kerana keselamatan adalah kebimbangan utama bagi PALMBOT, kecerdikan buatan (AI) telah disertakan dalam pembangunan pelbagai modul pengesan dan kawalan. Rangkaian neural telah digunakan bagi mengesan dan mengendalikan sistem yang mengandungi sistem pengesan posisi pesakit, sistem memantau bahaya, sistem procedur urutan otomatik dan sistem gagal selamat dan pemulihan otomatik. Masalah rumit dalam mengekalkan ketengangan pada konveyor diselesaikan dengan menggunakan logik fuzzy dalam sistem kawalan ketegangan konveyor. Satu lengan prototaip PALMBOT telah dihasilkan. Semua modul perkakasan dan perisian disatukan dengan menggunakan pelbagai alat perisian seperti MATLAB, EPOS Position Control dan MPLAB® IDE PIC C yang bekerja diatas pentas umum LABVIEW V8.0. Data simulasi dan eksperimen telah diuji pada sistem PALMBOT dan prestasinya adalah memuaskan. Adalah dibayangkan bahawa PALMBOT akan menjadi sangat berguna sebagai kemudahan hospital moden.

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LIST OF ABBREVIATIONS

AGV	Automated Guided Vehicles
AI	Artificial Intelligence
APSS	Automatic Procedure Sequencing System
CALL	Communication Aid for Language and Learning
CAN	Control Area Network
Conv.	Conveyor
CS	Conveyor Sequence
CTCS	Conveyor Tension Control System
DARPA	Defense Advance Research Projects Agency
DMS	Danger Monitoring System
DOF	Degree of Freedom
EP	Electronic Personality
FL	Fuzzy Logic
FR	Fail Recovery
FSARS	Fail Safe and Automatic Recovery System
GUI	Graphical User Interface
HEX	Hexadecimal
HMI	Human Machine Interface
I/O	Input Output
KS	Korean Industrial Standards
L	Load / Loading
LABVIEW	Laboratory Virtual Engineering Workbench
MAid	Mobility Aid for Elderly and Disabled People
MEL	Mechanical Engineering Laboratory
MSE	Mean-Square Error
NEDO	New Energy & Industrial Technology Development Organization
NGI	Next Generation Internet
NIOSH	National Institute for Occupational Safety and Health
NN	Neural Networks
PALMBOT	Patience Assistance for Lifting Mobility Robot

PIC	Peripheral Interface Controller
PPTS	Patient Position Tracking System
RPM	Revolution Per Minute
Seq.	Sequence
SIU	Spinal Injury Unit
SPSS	Statistical Package for Social Science
STRIPS	Stanford Research Institute Problem Solver
U	Unload / Unloading
VIs	Virtual Instruments

LIST OF SYMBOLS

Kgf	Kilogram Force
N	Number of Samples
u(.)	Net value
f(.)	Activation function / Threshold function

CHAPTER 1

INTRODUCTION

1.1 ROBOTS

The first robot, Ternstedt Unimate used by General Motors is a programmable machine that operated totally independent of human presence appeared in 1961 four decades after Karl Cepek coined the word 'robot' (Steven, 2002). Since then, these robots were effectively seen as a potential solution in any work settings of "3D": Dirty, Dangerous and Dull. This definition changed along time as the application flourished due to the technological advancement. From its industrial origin, robots have now spanned into many areas from sea to space. Figure 1.1 and Figure 1.2 show a planet terrain exploratory robot and humanoid robot respectively. A significant contributing factor to this increased use is the robot's ability to dynamically interact with its environment in a precise manner (Preising *et al.,* 1991).

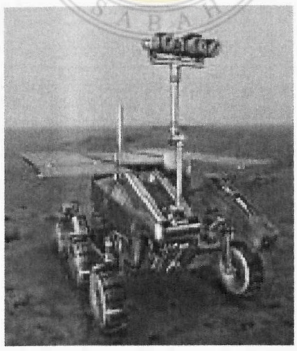

Figure 1.1: Terrain Exploratory Robot

Figure 1.2: ASIMO – Humanoid Robot

Although Capek introduced the term 'robot', the word 'robotics' was pioneered by Isaac Asimov in 1942 (James, 1999). He underlined three fundamental laws of robotics to ensure that robots are built with safety measures in mind to assist human beings. These laws have been further added and made clear that in any basic engineering design, the robot should obey the laws in order to preserve mankind and