AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

MECHATRONICS ENGINEERING

Design and Control of a Multi-grasping Bionic Transradial Prosthesis

A Thesis submitted in partial fulfillment of the requirements of the

M.Sc. in Mechanical Engineering

By

Mohamed Hamed ElSaied Zarzoura

B.Sc. of Mechanical Engineering, Mechatronics Engineering Department. Ain Shams University, 2006

Supervised by

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Statement

This thesis is submitted as a partial fulfillment of M.Sc. degree in Mechanical engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis and no part of it has been submitted for a degree or qualification at any other scientific entity.

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Abstract

The high number of degrees of freedom (DoFs) of human hand introduces difficulty to design an effective prosthetic hand that enables its user to perform the regular activities of daily living. In that sense, the aim of this research is to investigate the minimum number of actuators required to design and control prosthetic hand. Such problems involve dimensionality reduction of human hand kinematics. Recent studies have used quantitative or qualitative techniques either (a) to reduce the number of hand DoFs only or (b) to suggest actuating strategies for prosthetic hand. However, movements coordination that involving several hand joints have not been investigated yet. In that sense, this study tries to group hand joints by investigating each joint movement coordination during performing different grasp tasks. To accomplish this, multi linear regression (MLR) models are constructed to describe the movement coordination for each hand joint during performing each grasp task. Then, hand joints are clustered into different groups by analyzing the similarities between joints' movement coordination across grasp tasks using hierarchical cluster analysis (HCA) technique. Finally, the reduced number of DoFs are assigned to each group. The hand dimensionality is reduced by using Principal Component Analysis (PCA). The results suggest that (a) hand joints can be either grouped into six groups that can be derived by thirteen actuators or all joints are grouped into one group and be driven by eight actuators , (b) prosthetic hand may need to utilize fingers abduction/adduction movements, (c) coupling of joints strategy need to be based on joints topology, and (d) insights on hand joint movements' coordination.

Key words: Kinematic Reduction, Degrees of Freedom, Prosthetic Hand.

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List of Abbreviations

ABD	abduction/adduction
ADLs	Activities of Daily Living
DIP	Distal Interphalangeal Joints
DoAs	Degrees of Actuation
DoC	Degrees of Coupling
DoFs	Degrees of Freedoms
HCA	Hierarchical Cluster Analysis
iDIP	Distal interphalangeal of index finger
iMCP	Metacarpal phalangeal Joint of index finger
iPIP	Proximal interphalangeall Joint of index finger
lDIP	Distal interphalangeal Joint of little finger
lMCP	Metacarpal phalangeal Joint of little finger
lPIP	Proximal interphalangeall Joint of little finger
MCP	Metacarpal phalangeal Joints
mDIP	Distal interphalangeal Joint of middle finger
MLR	Multiple Linear Regression
mMCP	Metacarpal phalangeal Joint of middle finger

mPIP	Proximal interphalangeall Joint of middle finger
PCA	Principal Component Analysis
PCs	Principal Components
PIP	Proximal interphalangeall Joints
rDIP	Distal interphalangeal Joint of ring finger
rMCP	Metacarpal phalangeal Joint of ring finger
rPIP	Proximal interphalangeall Joint of ring finger
SVD	Singular value decomposition
tCMC	metacarpal joint of the thumb
tIP	Interphalangeal joint of the thumb
tMCP	Metacarpal phalangeal Joint of thumb