UNIVERSITY OF CALIFORNIA

SANTA CRUZ

Controlling a 7-DOF Upper Limb Exoskeleton Towards the Improved Human-Robot Interface

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in

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by

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Table of Contents

List of Figures	**iv**
List of Tables	**v**
Abstract	**vi**
Dedication	**vii**
Acknowledgments	**viii**
1 Introduction	**1**
2 Related Work	**2**
3 Method	**2**
4 Experiments	**2**
5 Results	**2**
6 Discussion	**2**
7 Test Figure/Table	**4**
References	**4**

List of Figures

1 mass-spring with relative damping model for the elbow movement of the human arm 3
2 Outside of the BSOE. 4

List of Tables

1 A simple table. 4
2 Some Result 4

Abstract

Controlling a 7-DOF Upper Limb Exoskeleton Towards the Improved Human-Robot Interface

by

Jay Ryan U. Roldan

1. State the problem briefly.
2. Describe the methodology.
3. Summarize the findings.

ProQuest recommends that the Abstract be no longer than 350 words, as it may be posted to sites with limited file size

DEDICATION!

ACKNOWLEDGMENTS!

1 Introduction

For decades, there has been a lot of research on redundant robot manipulators. Kinematically redundant robot manipulators enable various joint configurations for the given end effector position and orientation and allow for obstacle avoidance, singularity avoidance[2], joint limit control[3], torque optimization, dexterity optimization and much more. proposed an improved motion planning scheme which provides proper joint configuration at key path points in the velocity level. However, unlike the conventional robotic manipulator, a robot such as an exoskeleton robot, which requires human robot interaction, has to provide natural arm movement at the human robot interface so the operator feels as if the robot is a natural extension of their body. The control algorithms introduced so far provide proper joint configuration to the robotic manipulator when it interacts with the work space. However due to the lack of knowledge about the human motion planning mechanism, it is important to find the proper control mechanism providing synchronized movement with the human. Since grabbing and reaching tasks make up the majority of arm movements during daily life, we focus on a control mechanism that supports a natural human-robot arm interface for these types of motions. These motions raises a significant inverse kinematic issues. One line of research focuses on posture-based motion control on a kinematic level based on Donders' law, originally proposed for eye movements. Most of this work assumes the kinematic constraint is the target location. Another line of research focuses on dynamic constraints such as the amount of work and energy[1]. In this context, Soechting and his colleagues proposed that the final arm posture is made by minimizing the amount of work required to move the hand from a starting to an ending position. The minimum-torque-change model is presented in [1]. More recently in[3], it is shown that the arm posture at a particular target location is affected by both the kinematics and dynamics, and their portion changes depending on the task complexity. Tao et al.[3] presented an inverse kinematic solution which defines the natural elbow position by minimizing the total work done by joint torques. All the criteria introduced so far are important from an engineering point of view and partially explain the human arm inverse kinematics.

However due to fundamental differences between robots and humans, it is hard to fully model human arm movement without conflict among all criteria. In addition to this, most of the inverse kinematic solutions require iterative algorithm or well known optimization techniques, which are computationally demanding and prone to instability from the nature of ill-posed inverse problems. It is important to meet the precision, complexity and stability criteria for use in real-time control. In this paper, we present an inverse kinematic solution for natural arm movement based on a new kinematic constraint. The proposed algorithm focuses on the functional difference between a robot and a human manipulator by closely observing the human's behavior. As a result, it is shown that natural hand posture for reaching activities is made to bring the hand efficiently back to the head region. Based on this constraint, a stable and precise real-time control algorithm is formulated.

2 Related Work

Related work information will go in here...

3 Method

Method information will go in here...

4 Experiments

Experiments information will go in here...

5 Results

Results information will go in here...

6 Discussion

Discussion information will go in here...

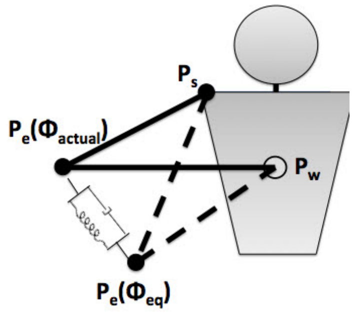

Figure 1: mass-spring with relative damping model for the elbow movement of the human arm

Some not so simple table is in Table 2.

Here's an equation for Fig. 1.

$$\phi = \dot{\phi}_{est} t + \phi_{est0} - \frac{\tau_1}{(\tau_1 - \tau_2)}[(\dot{\phi}_{est} - \dot{\phi}_0)\tau_2 + \phi_{est0} - \phi_0] \\ \exp{(\frac{-t}{\tau_1})} + \frac{\tau_1}{(\tau_1 - \tau_2)}((\dot{\phi}_{est} - \dot{\phi}_0)\tau_1 + \phi_{est0} - \phi_0)\exp{(\frac{-t}{\tau_2})} \tag{1}$$

7 Test Figure/Table

Below are a test figure and a test table to show usage, and that they actually populate the automatically generated lists at the beginning of the document.

Figure 2: Outside of the BSOE.

1	2	3
4	5	6
7	8	9

Table 1: A simple table.

Table 2: Some Result

Case	Method#1	Method#2
1	12	9.2
2	.47	8.01
3	32.1	7.88
4	54	3.56
5	.012	.3

Here's a link to my soe web page.

References

[1] Norman I. Badler and Deepak Tolani. Real-time inverse kinematics of the human arm. *IEEE Trans Syst Man, Cybernetics SMC-13*, 5.

[2] Marc H.E. de Lussanet, Jeroen B.J. Smeets, and Eli Brenner. Relative damping improves linear mass-spring models of goal-directed movements. *Human Movement Science*, pages 85–100, 2002.

[3] C.A. Klein and C. Huang. Review of pseudoinverse control for use with kinematically redundant manipulators. *IEEE Trans Syst Man, Cybernetics SMC-13*, pages 245–250, 1983.