



HAL
open science

Proposition of an algorithm for simulating natural variability in arm grasping posture when rotating a spherical object

Julien Lardy, Thomas Robert, Xuguang Wang

► **To cite this version:**

Julien Lardy, Thomas Robert, Xuguang Wang. Proposition of an algorithm for simulating natural variability in arm grasping posture when rotating a spherical object. 25th congress of the International Society of Biomechanics, Jul 2015, GLASGOW, France. 2 p. hal-01857650

HAL Id: hal-01857650

<https://hal.science/hal-01857650>

Submitted on 20 Sep 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Proposition of an algorithm for simulating natural variability in arm grasping posture when rotating a spherical object

LARDY, Julien, ROBERT, Thomas, WANG, Xuguang

Introduction

Digital human models are being more and more used in early phase of a product/workplace design. However, human motion simulation still faces the well-known problem of motor redundancy, implying that humans have more degrees of freedom than necessary to perform a given task. As a consequence, humans have an infinite number of possibilities to do one task. Solutions used nowadays in motion simulation are mainly based on optimization trying to find a unique solution that satisfies a set of constraints while minimizing an objective function (see [1] for review). Nevertheless, some authors suggest that redundancy should be considered as an advantage rather than a problem to be solved. Indeed, Latash considers the human redundancy as an ability to adapt to the environment [2]. Moreover, studies showed that different ways to perform a task can coexist, questioning the pertinence of looking for a unique solution. Then, natural motion variability should also be simulated. Grasping and manipulating an object with the hand is one of the routine tasks of human beings and is frequently encountered in workplace evaluation and product design. In case of rotating a spherical object, a recent study showed a large variation in arm posture when grasping the object for a given rotation amplitude [3]. The work presented here aims at proposing a stochastic algorithm to predict the grasping posture as a function of the intended manipulation.

Methods

The rotation task consists in grasping and rotating a sphere. Rotation amplitudes range from -315° in counter-clockwise direction (CCW) to 270° in clockwise direction (CW). Actual subjects performed this task in order to compare our simulation results to real data.. Experimental results and details of the protocol have been published in [3].

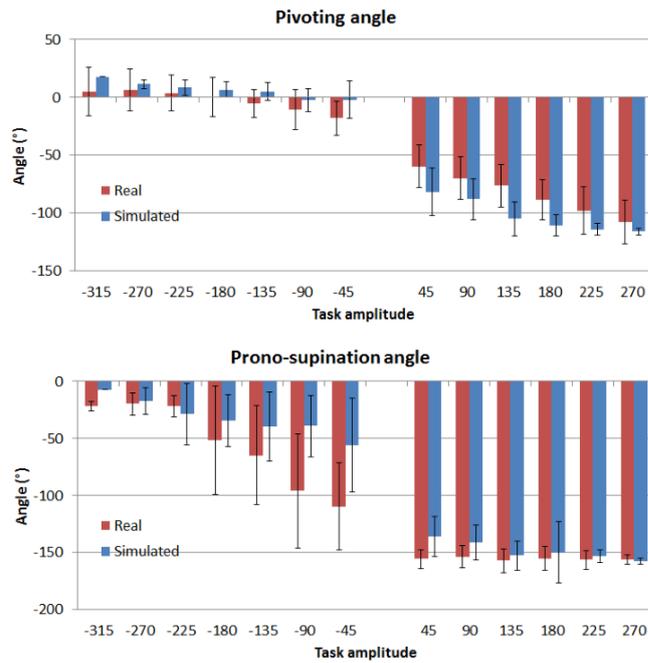
Hand palm is considered as a rigid plan formed by the head of the second metacarpal bone and the wrist styloids. Although there are multiple contact points between the palm and the sphere, we choose to limit our analysis to a unique contact point on the sphere, where the sphere and the palm share the same normal vector. From the shoulder to the palm, seven degrees of freedom are defined (3 for the shoulder, 2 for the elbow and 2 for the wrist).

Joint limits avoidance is based on Wang's work [4] which takes into account coupling effect of joint axes allowing us to have more natural simulated postures. Shoulder and wrist circumduction cones are based on data from the literature ([4] for the wrist and [6] for the shoulder), while axial limits of the upper arm are from [5].

The definition of the grasping posture is done as follow: 1- estimation of all the possible grasping points allowing an amplitude of rotation required by task; 2- a uniform probability distribution is attributed to these admissible points; 3- a grasping point is selected randomly; 4- the palm orientation around the selected grasping point is defined in order to maximize the shoulder-wrist pivoting angle margin at the beginning of the rotation, given the constraint that it must be inferior or equal to the pivoting margin at the end of the rotation; 4bis- if this constraint cannot be satisfied, another point is selected (step 3); 5- the elbow position is compute in the middle of the pivoting margin once the palm orientation is determined.

Results

Simulations were based on one subject's anthropometric data. Due to simulation constraints (rigid hand and no shoulder motion), we were only able to simulate grasping postures for the rotation amplitudes from -315° to 270° . Twenty simulations were performed for each amplitude. Figure represents the forearm (prono-supination) and shoulder-wrist (pivoting) angles for simulated and real postures. Globally, one can observe a similar evolution between the simulated and actual angles. Also, we have to note a tendency to have higher values for simulated pivoting angle in counter-clockwise rotations, i.e. a lower elbow position. Finally, as for the real data, simulated pivoting margins at the beginning and end of rotation show same behavior described in one of our previous work [3].



Conclusion

First conclusion of this work is the ability of our algorithm to simulate arm grasping postures in agreement with experimental data. Moreover, despite a quite simple probability distribution, simulations show interesting results in term motion of variability. Nevertheless this model could be improved taking into account individual joint limits. Finally, other probability distributions should also be tested.

Biblio

- [1]Gielen et al., Hum. Movement Sci., 14: 487-509, 1995
- [2]Latash, Fundamentals of Motor Control, Academic Press, 2012
- [3]Lardy et al., Ergonomics, 55 (12): 1524-1534, 2012
- [4]Wang, J. Biomech. 32: 453-460, 1999
- [5] Wang et al., J. Biomech. 31: 899-908, 1998
- [6]Engin et al., J Biomech. Eng. 108: 215-227, 1986