Grasps of real objects - jointangles for the Hand Corpus Repository

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1 Introduction

This PDF file contains the description of the joint angle data that is contributed by DLR to the Hand Corpus Database, which is maintained by the The Hand Embodied EU project. The main idea is to compute postural synergies from grasps of objects. The objects grasped are a subset of the objects used by Santello et al. [1]. In contrast to [1], here *real* objects instead of imagined objects are grasped, meaning that the contact forces between the fingers and the object can induce deformations to the hand posture. Each object is associated with a certain use scenario, because this strongly influences the location of the grasp. Seven subjects took part in the measurements; the number of objects is 23.

2 Markerisation

Each subject's right hand is fitted with 25 retro-reflective markers. Their position is measured with a seven-camera Vicon MX3+ tracking system. The marker placement is shown in Figure 1.

3 Grasps

The list of grasped objects is shown in Table 1. Each object is grasped twice. First, it is picked up from a table. Second, it held up in the air by the other hand and grasped by the markerised hand according to the use scenario. Each grasp is started with the hand flat on the table.

no.	object	use
1	apple	prepare to bite in side of apple
2	bottle	prepare to open lid
3	chalk	prepare to write
4	cigarette	prepare to smoke
5	comb	prepare to comb
6	CD	grasp at the edge
7	dictionary	prepare to open
8	egg	prepare to crack
9	frisbee	prepare to throw
10	hammer	prepare to hit a nail
11	knife	prepare to cut
12	light bulb	prepare to screw in
13	milk carton	prepare to open
14	pencil	prepare to write
15	playing card	look at it
16	umbrella	hold
17	toothpick	prepare to use
18	toothbrush	prepare to use
19	mug	prepare to drink
20	bottle cap	prepare to unscrew
21	tea cup	prepare to drink
22	cherry	prepare to eat
23	cream jar	prepare to open

Table 1: Grasped objects and associated uses.

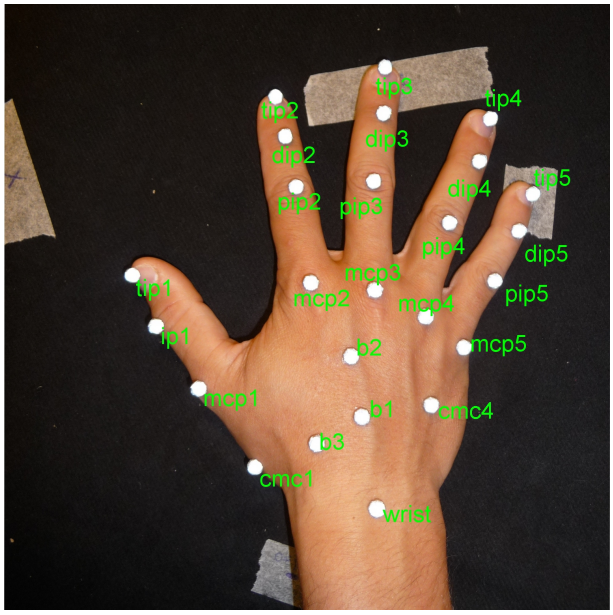

Figure 1: Marker placement

4 Simple approach to extract joint angles

The joint angles currently contained in our data set were extracted with a simple approach that uses lines between marker positions and one plane fitted a set of marker positions. A 20-DoF kinematic model is assumed, see Table 2.

1. A **palm plane** is defined by a least-squares fit of a plane to the following points: **b1, b2, b3, cmc4, mcp2, mcp3, mcp4, mcp5**.

2. For measuring the **ab-/adduction** angle of the index finger, the line between **b1** and **b2** and the line between **mcp2** and **pip2** are projected onto the **palm plane**. The ab-/adduction angle is the angle
between the projected lines. Angles to the radial side are counted positive, to the ulnar side negative. The ab-/adduction angle for middle, ring and little finger is calculated analogously.

3. The **MCP flexion** angle for the index finger is the angle between the **palm plane** and the line connecting **mcp2** and **pip2**. The MCP flexion angle for middle, ring and

little finger is calculated analogously.

4. The **PIP** angle of the index finger is the angle between the line connecting **mcp2** and **pip2** and the line connecting **pip2** and **dip2**. Angles towards the palm are counted positive, towards the back of the hand negative. Middle, ring and little analogously.

5. The **DIP** angle of the index finger is the angle between the line connecting **pip2** and **dip2** and the line connecting **dip2** and **tip2**. Angles towards the palm are counted positive, towards the back of the hand negative. Middle, ring and little analogously.

6. The **thumb anteversion/retroversion** angle is the angle between the line connecting **cmc1** and **mcp1** and the palm plane. Anteversion (angle towards the palm) is counted positive, retroversion (angle towards the back of the hand) is counted negative.

7. For the **thumb abduction** angle, the line between **b1** and **b2** and the line between **cmc1** and **mcp1** are projected onto the **palm plane**. The abduction angle is the angle between the projected lines.

The whole grasping action from the starting posture (flat hand on the table) to the final posture (hand at the object) is stored. The marker positions were sampled at 100 Hz. Due to measurement noise, the jointangles also exhibit a noise of around 1 degree. This was removed with an 11-point moving average filter (cf. Figure 2).

5 Data format

The jointangles (in radians) are stored in $n_\mathrm{f} \times n_\mathrm{a}$-matrices, where n_f is the number of time frames measured and $n_\mathrm{a} = 20$ is the number of joint axes. These matrices are stored in ASCII text files.

6 Discussion of the simple approach

The approach has a few drawbacks. It will not work with hyperextension in the PIP and DIP and MCP1 and IP1 joints, i.e. extending the joints beyond the streched-out position. However, hyperextension of PIP and DIP is functionally not so important and hardly occurs in the grasps. The hand posture cannot be precisely reconstructed

no.	axis
1	CMC1 radial abduction
2	CMC1 anteversion
3	MCP1
4	IP1
5	MCP2 radial abduction
6	MCP2 flexion
7	PIP2
8	DIP2
9	MCP3 radial abduction
10	MCP3 radial abduction
11	PIP3
12	DIP3
13	MCP4 radial abduction
14	MCP4 flexion
15	PIP4
16	DIP4
17	MCP5 radial abduction
18	MCP5 flexion
19	PIP5
20	DIP5

Table 2: Joint axes of the 20-DoF kinematic model.

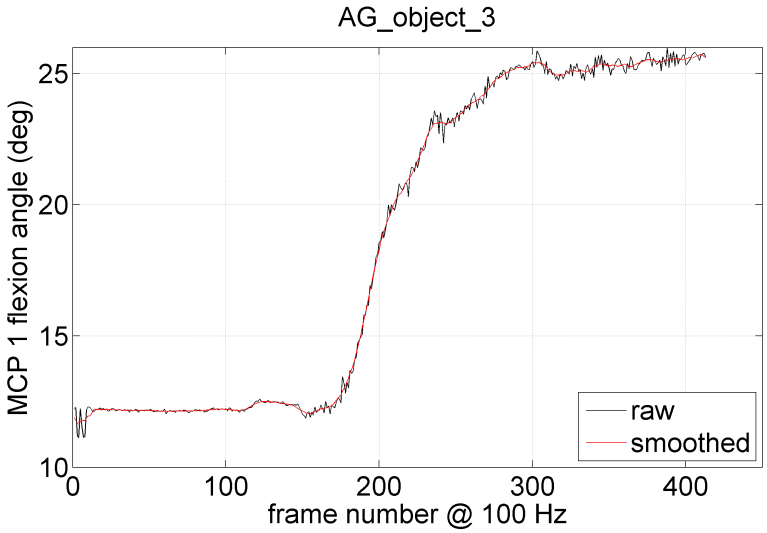

Figure 2: An example of the change of a joint angle during the grasp approach. The data is smoothed with a moving average filter.

from the jointangles, because the axis orientations are not known. For an analysis of the correlation of the joint angles, however, the data should be useful. Still, we plan to make a refined analysis of the data as soon as the software for extracting the kinematic model is available.

References

[1] M. Santello, M. Flanders, and J. F. Soechting, "Postural Hand Synergies for Tool Use," *The Journal of Neuroscience*, vol. 18, no. 23, pp. 10 105–10 115, Dec. 1998. [Online]. Available: http://www.jneurosci.org/content/18/23/10105.abstract