VALIDATION OF A DATA GLOVE CALIBRATION PROTOCOL IN HAND OSTEOARTHRITIS PATIENTS

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Introduction

Data gloves are one of the most popular hand motion capture systems for manipulation tasks, providing accurate data when properly calibrated [1]. Although manufacturers specify that the glove has to be calibrated for each subject, an across-subject calibration protocol was developed in [1] to speed up the capture process. The protocol requires: (i) obtaining subject-specific (SS) gauge gains and cross-coupling correction factors to a set of subjects with varied hand size, and (ii) computing across-subject (AS) gains/correction factors as the average of the SS ones. Using the AS gains, motion capture for each new subject only needs recording a reference posture to compute anatomical angles. This protocol was validated for healthy participants by comparing results with a videogrammetric technique as a gold standard. Here, its validity for subjects with pathologies causing joint deformities, such as hand osteoarthritis (HOA), will be studied by means of comparing the joint angles obtained from using the AS gains obtained from healthy hands against those from using the SS gains of the HOA patients.

Methods

Two HOA patients volunteered to participate in the experiment, approved by the university ethics committee. The participants wore a CyberGlove data glove recording 16 degrees of freedom (DoFs) at 100Hz while following the glove calibration protocol [1], which consists in 44 recordings: static postures (to obtain gauge gains) and controlled movements (to apply kinematic cross coupling corrections). Furthermore, 5 additional static postures (Fig. 1) were recorded in order to study biases in joint angles.

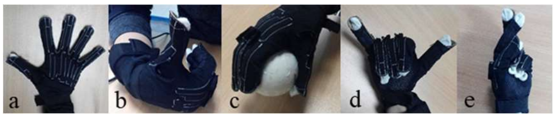

Figure 1: Postures for validation: (a) Fingers max. abduction; (b) 90º fingers metacarpophalangeal flexion and thumb max. extension; (c) Grasping a ball; (d) 'Y' from American Sign Language (ASL); (e) 'R' from ASL.

SS gains were obtained for each HOA patient and joint angles in postures of Fig. 1 were computed both with SS and with the healthy AS gains. Mean bias and standard deviation (SD) when computing joint angles using both sets of gains were computed for each DoF (using healthy AS gains – using HOA SS gains). These biases were compared with the ones obtained for healthy participants when performing the same procedure in [1].

Results

Mean biases and SD obtained for each DoF in HOA patients are presented in Fig. 2, along with biases obtained for healthy participants in [1]. Mean biases were higher for HOA patients in almost all DoFs, being all of them < 10º, except for CMC1_F (11.77º). Furthermore, patients reported difficulties for performing one of the calibration trials consisting of closed loop motions made between index finger and the thumb, repeatedly flexing and extending both digits while maintaining tip contact, used for thumb carpometacarpal calibration.

JOINT	BIAS IN HOA		BIAS IN HEALTHY	
	MEAN	SD	MEAN	SD
CMC1_A	-3.93º	1.49º	2.18º	10.39º
CMC1_F	-11.77º	9.21º	1.78º	10.26º
IP1_F	0.65º	5.20º	-0.03º	1.72º
MCP1_F	2.95º	6.02º	0.84º	4.90º
MCP2_A	-5.61º	6.69º	0.20º	5.34º
MCP2_F	0.24º	1.35º	-0.23º	2.10º
MCP3_F	1.44º	2.59º	2.26º	3.00º
MCP4_A	3.09º	7.31º	-0.40º	8.19º
MCP4_F	-2.77º	4.41º	0.19º	1.44º
MCP5_A	3.61º	5.74º	4.86º	10.16º
MCP5_F	-4.47º	7.36º	-1.51º	1.91º
PalmArch	6.87º	7.02º	-0.18º	4.85º
PIP2_F	-1.61º	4.16º	0.04º	2.47º
PIP3_F	2.83º	2.26º	-0.41º	1.34º
PIP4_F	2.00º	3.24º	0.72º	1.70º
PIP5_F	3.53º	3.48º	-0.35º	1.48º

Figure 2: Bias values. Nomenclature: flexion (_F) & abduction (_A), thumb to little (1-5), carpometacarpal (CMC), metacarpophalangeal (MCP), proximal inter-phalangeal (PIP) and palmar arch (PalmArch).

Discussion and conclusions

The obtained biases in HOA patients are acceptable despite the joint deformity and swelling. Moreover, the higher bias in CMC1_F is hypothesised to be due to patient difficulties in performing one of the calibration trials, which reinforces the suitability of the AS calibration in HOA patients, since it avoids the recording of difficult controlled movements whilst providing good accuracy.

References

1. Gracia-Ibáñez, V. et al. Comput. Methods Biomech. Biomed. Eng. 20:587-597, 2017.

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