Evaluation of 3D marker-less motion capture accuracy in upper limb children movement

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Summary

This study aims to quantify the precision of three pose detection models on the assessment of upper limb movements in children, an underexplored population. A database called ARGOS, currently made up of 5 asymptomatic participants (aged 2-12) performing 6 bimanual tasks has been created. Children movements were recorded using 8 RGB and 10 optoelectronic cameras. The pose detection algorithms HRNet, PoseResnet, RTMPose were evaluated against reference optoelectronic data. The results show a median difference between 10 and 20 mm with a maximum difference of 40 mm. The perspectives are to further enhance the ARGOS database with 15 supplementary participants performing 20 tasks.

Introduction

Assessing upper limb movements in children with cerebral palsy (CP) can greatly benefit from automated approaches like markerless motion analysis using RGB cameras. Indeed, this data collection is faster than marker-based approaches and less likely to distract children attention. Thus, it could advantageously allow to quantify performance in daily activities as in the Assisting Hand Assessment [1]. Multiview markerless methods employ computer vision algorithms to detect anatomical points in 2D and triangulate them in 3D. Due to the limited availability of reference data, their accuracy remains unknown for upper limbs in pediatric populations. Thus, our objectives are to create an upper-body pediatric database combining markerless and marker-based data, and to assess the accuracy of existing markerless algorithms.

Methods

The ARGOS database is intended to include 20 asymptomatic participants aged from 2 to 12 years, performing 20 different tasks. Six bimanual everyday-tasks (drawing, playing with modeling clay, cutting food, eating yogurt, combing hair, and simulating wiping their buttocks) performed by 5 children (3 ♀/2 ♂, average age 5 years) are already included. Tasks were recorded by 8 RGB cameras (60 Hz) and 10 opto-electronic cameras (120 Hz), all calibrated. Twenty-five markers (∅1 mm), almost invisible on RGB images, were used to reconstruct the kinematics of the torso, arm, forearm, and hand [2]. The glenohumeral joint center was defined using Rab's regression [3], the elbow center as the epicondyles' midpoint, and the wrist center as the midpoint of the styloid process of the ulna and radius. The hand joint center was defined as the middle of the 2nd and 5th metacarpal head. Three pose detection algorithms were compared to the marker-based reference: HRNet, PoseResnet, and RTMPose trained on the COCO whole-body dataset (133 keypoints on 200K images containing some children images) [4]. The 3D difference distribution after triangulation of the joint center 3D positions (shoulders, elbows, wrists and hands) was quantified.

Results and Discussion

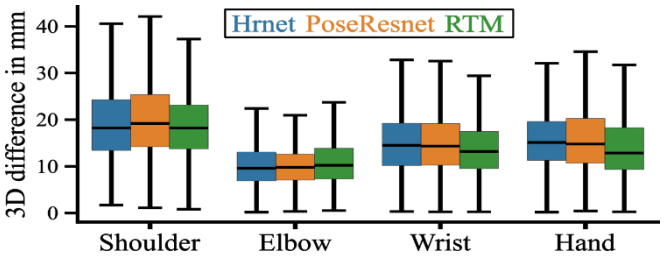

Figure 1: Difference distribution (median and quartiles) for 3D joint locations in mm for different pose detection algorithms.

All models exhibited similar accuracy with medians differences between 10 and 20 mm (Fig. 1), RTMPose showing slightly lower median differences for all joints but the elbow. The differences found in our study are slightly lower than the ones found by Lahkar et al. [5] using Theia Markerless (Kingston, Ontario) on adult boxing motions (23, 31, and 18 mm for the shoulder, elbow, and wrist, respectively). This seems consistent with children vs adults' size. ARGOS database will also allow us studying the effect of each step of the markerless processing from the 2D point detection to joint kinematics and relevant biomarkers, such as straightness or smoothness, for assessing performance in pediatric population especially those with CP.

Conclusions

Based on our preliminary results, RTMPose would be the most suitable algorithm for estimating upper limb kinematics in children. Once completed, the ARGOS database will be shared with the community to train models, further validate upper limb kinematics in children, or optimize camera's setup.

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