POSE ESTIMATION METHODS FOR GENERAL MOVEMENTS ASSESSMENT IN INFANTS: OPEN METHODOLOGICAL ISSUES

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Introduction

General Movements Assessment (GMA) is a non-invasive reliable assessment for identifying risk of neurological impairment in infants [1]. General Movements (GMs) are spontaneous movement patterns evident up to 20 weeks of age; they involve the whole body in a variable sequence of arm, leg, neck and trunk movements. GMA is performed through direct or video observation by a licensed operator, resulting in a qualitative description of motor performance of the infants. These aspects limit widespread objective and quantitative evaluations [1].

Recently, technological approaches aiming at automated or technology-assisted GMA have surfaced [2]. Video-based approaches remain authentic to the non-intrusive character of the classic GMA and guarantee potential easy and widespread clinical applications [2].

Video-based automatic GMA generally consists of i) automatic tracking of body segment kinematics, ii) metrics extraction, and iii) performance classification. The proper initial tracking of segmental kinematics is the prerequisite for reliable metrics extraction and resulting classification; unfortunately, when comparing the few available studies [2], exploiting mainly state-of-the-art open source software for automated tracking [2], no standard can be identified for video acquisition and processing.

The present work aims to fill this gap, investigating the influence of video acquisition settings (i.e. frame rate and resolution) and processing (e.g. reconstruction model, accuracy thresholding, filtering, and interpolation) on resulting kinematics, as well as on a set of assessment metrics from previous studies [3].

Methods

Experimental protocol: As part of an ongoing research study, 81 infants at risk of neurodevelopmental impairment (preterm newborns with gestational age <32 weeks and/or birth weight <1500 g) were recruited at the Neonatal Unit of IRCCS AOU Bologna (ethical approval n° EM1229-2020_76/2013/U/Sper/AOUBo). Videos of GMs were collected at term equivalent age, using, ease of use in a clinical setting by clinical staff, a commercial video camera (GoPRO Hero 9), at 240fps, and 1920x1080p resolution. Video collection was performed following GMA guidelines [1].

Data analysis: Kinematics of body segments was extracted using OpenPose [2] (predefined Body25, 25 landmark5, and MPI, 15 landmarks, models) and DeepLabCut [2] (ad-hoc defined 14 landmark model), having been used in previous studies. For the implementation of DeepLabCut *ad-hoc* model, influence of the number of training iterations was tested for 200k, 400k, 600k, 800k, and 1M iterations.

Computational time and percentage of missing reconstructed points were analysed for basic performance assessment.

Percentage of points with confidence above 95%, distance of marker trajectories for increasing number of training iterations, and spectral analysis were performed to assess influence of video resolution and sampling frequency, and model training iterations on trajectory reconstruction.

Influence of model training iterations, filtering, and interpolation on resulting evaluation metrics (i.e. range, covered distance, velocity and jerk mediated over 1s windows) was tested for processing assessment.

Results

Due to double processing time and low performance in trajectory reconstruction Open-Pose was excluded from further analysis after basic performance assessment.

After 400K iterations reconstructed trajectories resulted to reach a plateau in terms of stability, completeness, and number of values above 95% confidence.

Both filtering and interpolation resulted to critically affect evaluation metrics.

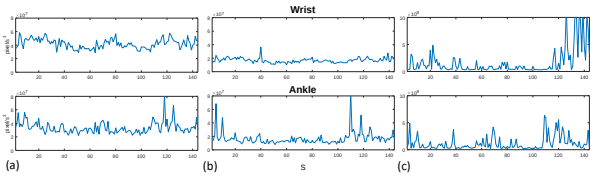

Figure 1: trajectory jerk mediated over 1s window over time: a) for raw trajectory over 95% confidence; b) 60Hz filtered trajectory over 95% confidence; c) linearly interpolated trajectory over 95% confidence.

Discussion

Preliminary analysis highlighted the critical role of video acquisition settings and processing on reconstructed kinematics and, even more, on the resulting evaluation metrics. The finalization of the analysis will provide evidence-based criteria for the definition of a reliable methodologic approach for the automatic assessment of GMs.

References

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