Automated video-based General Movement Analysis: sensitivity analysis of metrics in a population of very preterm infants

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Summary

General Movement Assessment (GMA) is a key tool for early detection of neurodevelopmental disorders. Numerous automated, video-based approaches have been proposed, yet their standardization is lacking, and reliability remains critical. This study aims to analyze the sensitivity of 15 video-based GMA metrics to acquisition and preprocessing settings (i.e. interpolation, down-sampling, filtering). Anatomical landmark trajectories were extracted using DeepLabCut and processed in MATLAB. Results exhibit high variability, highlighting the need for rigorous acquisition and processing protocols to ensure metric reliability that is essential for clinical implementation.

Introduction

GMA is a non-invasive method for early detection neuro-developmental disorders from observation and scoring of infants' spontaneous motions [1]. GMA widespread use is limited by the need for licensed evaluators, subjectivity, and time constraints [2]. Several methods have been proposed for automated, video-based GMA, exploiting anatomical landmark tracking and different evaluation metrics [3]. Still, lack of standardization and of reliability prevent clinical applicability. This work aims at comparing the reliability of 15 metrics, and at analyzing their sensitivity to acquisition and preprocessing specifications (i.e. frame-rate, track interpolation, filtering) in a population of very preterm infants.

Methods

Clinical staff recorded GM videos (GoPro Hero 9, 240fps, 1920x1080p) from 33 very preterm infants (gestational age <32 weeks and/or weight at birth <1500g) at 40 weeks and 3 months of corrected age.

Anatomical landmark trajectories were extracted using DeepLabCut (14-point model) and processed in MATLAB. 15 GMA metrics (Table 1), from a literature review, were implemented and calculated on raw data with: linear interpolation over 120, 240, and 1200 frames; down-sampling at 30 and 60 Hz; filtering at 5 and 10 Hz. Percentage variation relative to raw data was calculated.

Results and Discussion

Unlabeled frames per video averaged 17.89% (median = 14.00%, IQR = 15.53%). Missing frames were 7.15% (median = 0.96%, IQR = 4.07%) due to infants being on their side, 0.31% (median = 0.00%, IQR = 0.14%) to body parts out of frame, and 1.06% (median = 0.61%, IQR = 0.81%) to hidden body parts.

Mean COM coordinates (x, y) exhibited the lowest variation over the analyzed factors. All other metrics showed mean or IQR percentage variations >10% for at least one factor. Specifically, Lateral Mobility Index, Area Out of Standard Deviation, and Periodicity were the least reliable, being highly dependent on all factors. The results for each metric are detailed in Table 1.

Conclusions

Results highlight the need for a better definition of acquisition and processing protocols to ensure metrics' reliability. Future work will extend the analysis to a large cohort of infants.

References

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Table 1: Extracted metrics and relative median and IQR percentage variation (%) with Interpolation, Down-sampling and Filtering.

Extracted Matrix	Interpolation		Down-sampling		Filtering	
	Median	IQR	Median	IQR	Median	IQR
Mean of centroid of motion (COM) x coordinate	0.23	1.05	0.09	0.47	0.24	1.28
Mean of COM y coordinate	-0.11	1.09	-0.07	0.68	-0.19	1.16
Standard deviation of COM velocity	-1.90	5.44	47.08	99.19	-75.31	16.54
Mean of COM velocity	-5.81	6.47	-13.04	48.41	-88.29	5.28
Minimum of COM velocity	0.00	0.00	-1.30	41.33	-46.85	33.07
Standard deviation of COM acceleration	0.08	6.75	43.03	101.71	-83.93	12.42
Lateral mobility index	-96.89	209.95	-78.47	184.06	-103.33	291.75
Mean hull area percentage	-1.82	3.18	-3.93	13.63	-13.26	18.05
Mean orientation	-1.17	16.64	-1.97	14.22	-1.50	21.58
Area out of standard deviation	-85.06	13.41	10.10	101.39	-85.28	12.08
Periodicity	-80.95	20.38	-44.37	61.15	-84.83	13.80
Correlation coefficient	-3.83	39.97	0.09	33.53	-2.86	44.08
Mean of power spectral density	0.00	122.93	-62.50	65.16	95.82	226.72
Standard deviation of power spectral density	24.83	129.07	-68.27	61.02	95.65	247.89