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Low Cost stereophotogrammetric camera system for gait assessment analysis using a single marker

Félix Marcellin^{a*}, Khalil Ben Mansour^a, and Frédéric Marin^a

^a Université de Technologie de Compiègne, Alliance Sorbonne Université, UMR CNRS 7338 Biomécanique et Bioingénierie (BMBI), Centre of Excellence for Movement Biomechanics (CoEMoB), Compiègne (France)

Keywords: Velocity; Deviation; Step Length; Motion Capture; Gait Disorder

1. Introduction

Gait disorder still a challenging problem in the medical field. These disorders are present in many neurological pathologies. Today, based on motion capture technologies, clinicians use a clinical scale to quantify these disorders (Chastan et al. 2016). However, one of the best and well-used motion capture solution is based on optoelectronic technology which is expensive, cumbersome and needs high expertise. Thus, one alternative is to use stereophotogrammetric technology which is also a marker-based optical motion capture system but represents an affordable cost. Furthermore, to simplify the analysis, only one marker could be used to estimate subject velocity, horizontal deviation, lateral deviation and step length (Chan et al. 1996, Latorre et al. 2018).

This study aims to compare the performance of a stereophotogrammetric system versus one gold standard system for gait assessment using only one marker to validate this technology and using it to estimate gait disorders and predict neurological pathology.

2. Methods

Sixteen asymptomatic subjects (12 female, 20±1 years and four male, 23± 2 years) performed four meters walk test. This distance was chosen following the constructor's instructions and was tested in several studies (Unver et al. 2016, Munoz Mendoza et al. 2011). The stereophotogrammetric camera system (moKam, Kinesthesia, France) has been located in front of the walkway at 2.7m of the ending recording line. As shown in Figure 1, the walkway was constituted of one meter of acceleration, four meters of record and one meter of deceleration. Acceleration and deceleration were not recorded. A gold standard motion capture system, 37 cameras (Vicon, Oxford Metrics, UK) were placed all around the walking line. Each subject realised a single trial with the instruction to walk at their normal speed from the starting line to the finish line.

Every subject was equipped with a 14mm reflective spherical marker stuck on a 50mm square high-coloured plane marker placed on the sternum.

Based on the 3D coordinates markers tracked simultaneously by the two systems, we calculate the mean velocity of the point, lateral and horizontal deviation from the starting coordinates. To estimate the footstep length and cycle length, we used the "findpeaks" function of Matlab (r 2017a) to detect the vertical minimum values of the sinusoidal trajectory of the sternum.

Finally, a Bland Altman analysis and correlation coefficient was used to compare results of the two systems (Bland et Al. 2010).

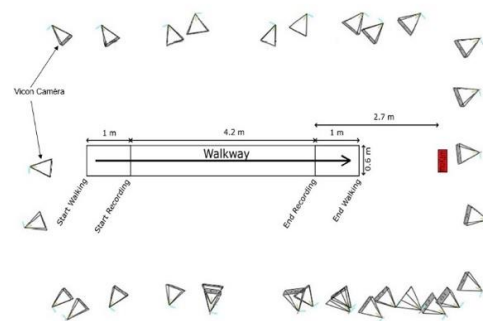


Figure 1: Experimental setup with walk line detail and mocap systems placement

3. Results and discussion

Figure 2 shows Bland-Altman graph for average velocity estimated by moKam versus Vicon system. We can see then that Limits of Agreement (LOA) are included between -0.07 m/s and 0.03 m/s with a bias of -0.02 m/s. To complete this first result, we can see a correlation coefficient (r) of 0.98 which presents a significant correlation at the 0.01 level.

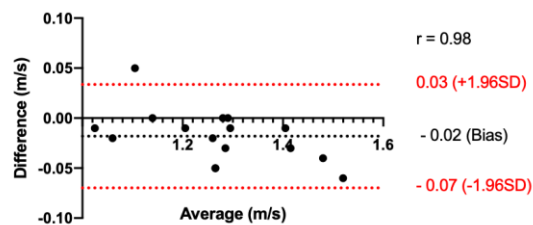


Figure 2 : Bland Altman graph for average velocity parameter

Table 1 presents Bland Altman and correlation coefficient results for the five analysed parameters. Bias are about -0,02m/s for the average velocity. Regarding vertical deviation, lateral deviation, cycle length and step length the bias range from 1.18 and -11.11mm. Correlation Coefficients are included between 0.75 and 0.98 and are all significant.

	Bias	LOA	r
Velocity (m/s)	-0.02	-0.07, 0.03	0.98*
Lat. Deviation (mm)	-10.63	-31.35, 10.10	0.83*
Vert. Deviation (mm)	1.18	-16.69, 19.06	0.75*
Cycle Length (mm)	-11.11	-91.67, 69.46	0.92*
Step Length (mm)	-8.63	-75.87, 58.62	0.78*

*Denotes a significant correlation at the 0.01 level.

Table 1: Bland-Altman bias, 95% limits of agreement (LOA) and correlation coefficient (r) between moKam and Vicon estimates of gait parameters

4. Conclusions

This study highlights that a lowcost stereophotogrammetric system offers the possibility to

quantify gait parameters based on a single marker trajectory.

To sustain this preliminary study, an asymptotic database is under construction to build a graphic method as a radar chart.

Furthermore, we project to study the sensitivity of this method for pathologic diagnosis due to neurological pathologies.

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