ESMAC 2020 abstract

Title

The feasibility of automated detection of the aligned trunk in sitting directly from raw video using a depth camera

Acknowledgement

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Abstract

Introduction

Maintenance of an upright head and trunk ('trunk') posture is mandatory for effective performance of everyday activities. Poor trunk control is commonly seen in children with neuromotor or neuromuscular disorders, (e.g. cerebral palsy or muscular dystrophy), and in adults with neurological conditions (e.g. stroke): this leads to functional limitations, such as compromised ability to sit independently [1-3].

Detailed and reliable evaluation of trunk control status is essential when planning therapeutic interventions for these patients [2-5]. The Segmental Assessment of Trunk Control (SATCo) [4] evaluates sitting control at seven separate trunk segments, judging each segment's position in space relative to a defined, neutral aligned posture. SATCo is a validated test that is in regular clinical and research use but it remains a subjective assessment. Generating objective, automated tools that are feasible for use in a clinical environment, will positively impact the planning and delivery of therapeutic interventions for both children and adults.

Research Question

This study tests the feasibility of deep convolutional neural network (DCNN) analysis of raw high definition and depth (HD+D) video to identify those video frames containing the aligned, reference trunk posture.

Methods

Ethical approval was obtained from the Manchester Metropolitan University Ethics Committee. A SATCo was conducted on sixteen healthy male adults (mean±SD age 31.39 ±5.21) and recorded using a Kinect V2. For each of seven segments tested, two different trials were collected (control and no-control) to simulate a range of alignment configurations. For all images, classification of alignment obtained from a trained and validated DCNN was compared to expert clinician's labelling.

Results

Using leave-one-out testing, the DCNN correctly classified individual images alignment (positive classes) v misaligned (negative classes), with average precision of 92.7±16% (mean±SD) (Table 1).

Discussion

This study tested the feasibility of a neural network methodology to provide automated identification of SATCo video frames that contained the aligned trunk posture in sitting. The main requirement of automated SATCo is that frames identified as aligned, are indeed aligned. Average Precision (AP) is the measure of performance reporting this requirement and the encouraging results (Table 1) confirm the feasibility of the method.

Previous studies used a 2D video-based semi-automated method to track markers in the sagittal plane [6, 7]; participants' movement in planes other than the sagittal generated movement artefacts reducing the accuracy of the method. The present method overcame this problem by using the depth information in the images.

The promising level of success of this feasibility study suggests that a fully powered study on clinical populations would be likely to result in a successful system: the resulting fully automated SATCo would provide reliable and objective evaluation of trunk control status in children and adults, enhancing both research and clinical interventions.

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Table 1 Summary of results.

This table presents comprehensive results for each participant, calculated over all trials, and a summary of results calculated over all participants and trials. For each participant, the number of positively classified (*aligned*) and negatively classified (*misaligned*) images are given for the clinical expert and for the automated system, followed by measures of agreement between the clinical expert and the neural network (ANN), in the form of accuracy, precision, recall, F_1 score (harmonic mean of precision and recall), and average precision. Values are calculated using LooCV.

Participant #	# Positive classes (labels)	# Negative classes (labels)	Precision (%)	F_1 (%)	Average Precision (AP)
1	693	257	93.4	93.4	93.5
2	894	73	62.5	1.1	94.3
3	441	186	94.1	48.5	93.1
4	671	22	100.0	100.0	100.0
5	767	68	100.0	26.5	100.0
6	591	240	100.0	11.2	100.0
7	734	309	100.0	8.9	100.0
8	612	177	100.0	27.8	100.0
9	196	406	48.1	64.5	36.3
10	493	80	100.0	64.0	100.0
11	557	35	100.0	100.0	100.0
12	688	179	88.2	84.6	98.8
13	729	91	100.0	25.8	100.0
14	383	105	74.7	50.9	80.5
15	782	199	72.2	6.4	100.0
16	332	126	91.5	91.1	86.2
Mean	**598**	**160**	**89.1**	**50.3**	**92.7**
SD	187	106	16.1	35.9	16.1
Median	**401**	**36**	**96.8**	**92.3**	**99.2**