Detecting Arm Flapping in Children with Autism Spectrum Disorder Using Human Pose Estimation and Skeletal Representation Algorithms

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Abstract— Stereotypical behaviour such as arm flapping is among the prominent early signs for young children with Autism Spectrum Disorder (ASD). Diagnosis of arm flapping requires clinicians to use the standard Repetitive Behaviour Scale-Revised (RBSR) which is a structured questionnaire with the caregivers to detect the arm flapping behavioural patterns or cues. This method involves clinicians in multiple long sessions, risking a delay in diagnosis and usually an expensive process. Moreover, trained clinicians may not be available in some areas. The focus of this work is to propose a development of a computational framework to automate the diagnosis process of arm flapping. Here, we show how the human action recognition (HAR) techniques, namely, the pose estimation and the skeletal representation are utilized simultaneously to segment parts of the human body (head, neck, elbows and shoulders) into stickman model. We show how the stickman model allows us to estimate arm asymmetry (during arm flapping) which indicates quantitatively possible sign of autism. The framework developed has been tested against data taken from a public database and has shown a high accuracy in detecting the repetitive behavioural pattern among young children. The results show that our method can provide efficient results in clinical assessment.

Keywords: Pose estimation, skeletal representation, stickman model, arm flapping, autism spectrum disorder

I. INTRODUCTION

Arm flapping is one of the most prominent repetitive behavior that is frequently referred to in an early autism spectrum disorder (ASD) diagnosis. From the repetitive behavior scale revised (RBSR) noted in Lam et al. (2007), the criteria for arm flapping include an approximate 45 degree angle from shoulder to elbow (upper arm) and elbow to wrist (fore arm) respectively and at least 20 flapping motion detected in an hour. Depending on the child’s level of functioning, these highly individualized, self–stimulatory (“stimming”) behaviors can be disruptive and socially awkward. In low functioning cases, most often caregivers do not even realize the children is showing arm flapping pattern until proper clinical assessment is done. However, many are reluctant to visit clinicians which normally include multiple long sessions and a high expense, risking a delay in diagnosis and prevent early detection of a prominent ASD symptom among young children. The odyssey to take a child diagnosed for arm flapping sometimes led to caregivers waiting for other signs of impairments particularly cognitive and communication deficits before taking action. This severely affect the chances for early and intensive prevention for children with autistic tendency.

II. MOTIVATION

The time for ASD diagnosis is long due to (a) lack of availability specialists in many areas and (b) the diagnosis involving the observation taken over a period of time. Human action recognition approach can assists in analysis of videos to determine the children behaviors and to summarize the videos for the specialists may help to reduce the long session for the diagnosis and provide better access to clinicians. Furthermore, this provides an alerts to parents by analyzing unconstrained videos, such as videos taken in normal day-to-day play activities of a children, this can go a long way towards early intervention. Hence, this work aims to take a step towards this goal. Advancements in this field lead to the next stage of analyzing children behaviors.

III. RELATED WORK

In autism traits behavioral pattern or cues detection, the human action recognition approach is rapidly gaining popularity. Westeyn et al. (2005) used accelerometers and pattern recognition algorithms in a pilot work to detect stereotypical motor movements among children. While 69% of hand flapping events was automatically and accurately detected in this work using the Hidden Markov Models, the data were acquired from individuals mimicking the actual behaviors which means the work did not observe children with ASD actually performing the behaviors. Bao and Intille (2004) recently compared several sensor positions and methods for recognizing full-body activities. Results showed the use of two accelerometers positioned at the waist and upper arm were sufficient to recognize 20 distinct activities using the C4.5 decision tree learning algorithm, with overall accuracy rates of 84%. Hashemi et al. (2012) recently achieved the human body segmentation and methods for recognizing gait pattern in autistic. Results showed the method of human pose estimation were sufficient to detect arm symmetry with the score of accuracy 45 degree. However, as noted in the RBSR (Lam et al., 2007), arm flapping is the more favored symptoms to show autistic tendency in clinical assessments. In this paper, we are interested to propose a new framework using HAR techniques to automate the diagnosis process of arm flapping among young children (Figure 1). We show how we coupled