Detecting Arm and Hand Flapping Movement Disorder in Children using Human Pose Estimation and Skeletal Representation Algorithms

Zati Azizul *, Nurliyana Mut

Department of Artificial Intelligence, Faculty of Computer Science and IT
University of Malaya, 50603 Kuala Lumpur, Malaysia

Abstract

Increased frequency and extended duration of repetitive movements such as the arm and hand flapping is among prominent early signs for children with Autism Spectrum Disorder (ASD). While repetitive behaviour occurs in all children, like finger-tapping and body-rocking, the repetitions are limited and often considered as an expression to help with anxiety or adapting to the environment the children is associating with. However, in the case where the repetition has become incessant to the point of impairing a child’s daily routine, it makes the patterned behaviour a movement disorder. In diagnosing ASD, clinicians often refer to the standard Repetitive Behaviour Scale-Revised (RBSR) where caregivers are interviewed and risked children are observed for movement disorders. In the case of arm and hand flapping, clinicians must score (1) the asymmetrical pose of shoulder-to-elbow (upperarm) and elbow-to-wrist (forearm) to determine if it is an occurrence, and (2) score the frequency of such occurrence. If the pose is confirmed and at least 10 occurrences recorded in 1 hour, the arm and hand flapping disorder is diagnosed on the observed child. In this paper, we show a novel approach to semi-automate the process of detecting arm and hand flapping among children. We show how techniques under the human action recognition (HAR), namely, the pose estimation and the skeletal representation are utilised simultaneously to segment parts of the human body (head, neck, shoulders and elbows) onto a stickman model where a child’s arm asymmetrical pose is estimated and the occurrences recorded. We have tested against 5 subjects; males and females of age 8-10 years old and our results shown a high accuracy in positive and negative detection of the movement disorder among the subjects.

Keywords: human pose estimation, skeletal representation, stickman model, arm and hand flapping, autism spectrum disorder (ASD)

1. Introduction

Arm and hand 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) [1], the criteria for arm and hand 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. These highly individualized, self-stimulatory or stimming behaviors may disrupt a child’s daily life and led them to be socially awkward [2]. While in high functioning cases the pattern are obvious and alarming to caregivers which led them to immediate clinical attention, it is in low functioning cases that most often caregivers do not even realized the children is showing a pattern until proper clinical assessment is done. In time where caregivers are mostly working adults leading successful high-paced lifestyle, many are guilty of denial and often succumbed to waiting for other signs of movement disorders and/or more severe impairments particularly the cognitive and communication deficits before taking action. In cases of concerned caregivers, sometimes the odyssey to get a child diagnosed for movement disorders like the arm and hand flapping make them reluctant to book an appointment with the clinicians. Very often the prospective of getting involved in multiple long sessions at the clinic and bearing the kind of expense over such sessions especially if such specialists are not available within the area prevent caregivers from getting the child a proper clinical diagnosis. Risking a delay in diagnosis for something as prominent as arm and hand flapping can affect the chances for early detection of a serious ASD symptom and interfere with giving immediate attention, care and treatment autistic risked children.

Simulating criteria of the RBSR to detect the arm and hand flapping disorder and making the technology available has its appeal to caregivers. The freedom to analyze unconstrained videos, such as videos taken in normal day-to-day play activities of a child, and compare them against selected RBSR criteria can be a highly useful and powerful tool in early detection of one of the red-