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Augmented Reality Analytics to Investigate Motor Skills for Crossing the Midline

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Abstract: This study investigates the use of Augmented Reality (AR) generated analytics to measure the number of times a child can perform the action of crossing the midline by a drumming action. Using a prototype Drum AR App with gamification techniques to motivate the drumming actions with a drumstick, we can capture and log key metrics which measure the physical drumming actions such as the timings and the quality of crossing of the midline through game play. This study is still work in progress where further research on the uses and effectiveness of AR generated analytics can give insights to the development of perceptual motor skills in young children. Generating 2D and 3D plots from the AR generated analytics gives evidence to further identify novel metrics to capture, analyse and give insights to user interactions while using AR apps in learning.

Keywords: Augmented Reality, crossing the midline, analytics, motor Skills

1. Introduction

Perceptual motor skills such as “crossing the midline” are critical for young children's development, learning and growth to utilise senses, motor skills to interact with the environment. Inferring that either the hand or foot can spontaneously move over to the opposite side of the body to perform an action, such as the use of drum and a drumstick to hit alternatively. It is important that we can measure and qualify such body and limbs movements. Augmented Reality (AR) is an advanced emerging technology which has the capability to provide quantifiable measurements to in complex immersive interactions. We have developed a prototype Drum AR app which engages young children to learn colours.

Figure 1. Learning Red & Blue colours by hitting virtual 3D mushrooms (representing Drums) using a virtual drumstick. The drums and drumstick are triggered by AR Markers when viewed through a mobile device or tablet. The virtual drumstick is triggered by a third AR marker. The drumming instructions starts, and the child is to hit the relevant coloured drum (mushrooms) according to the audio instructions. This action of hitting the left drum (Red mushroom) or the right drum (Blue mushroom) with the virtual drumstick enables the movement of crossing the midline. As the child uses the AR app, analytics are simultaneously logged in a JSON file.

2. Literature Review

From a review of research studying young children's ability to cross the midline, it was observed that many have used clinical observational approaches (Benton, 1955, Stilwell, 1987, Screws, et al., 1987) and occupational therapy driven sensory testings (Cermak, et al., 1980, Mitchell et al., 1999). These tests and observations provide expert-based evaluations and recommendation of interventions and exercises. In a recent study (Jacobs, et al., 2018) used Virtual Reality (VR) tools to assists occupational therapists treating a child that has difficulty crossing the midline using sensors to detect movement in accordance with the desired outcome - crossing the midline. The finding concluded that through the integration of technology, innovation and creativity a method of using an interactive game to treat children would serve as a beneficial method of mitigating the problem of crossing the midline. It was that the interactive game would create a less boring and more stimulating treatment process allowing the child to have more fun than the conventional methods of treatment for crossing the midline.

3. AR Analytics in Drum AR App

A Drum AR app with analytics capture capability was designed to be used in this study which investigates the use of AR enhanced analytics which are captured through the mobile device, analysed and presented visually to detect crossing the midline action. To elaborate, this is when the right hand holding the drumstick hits the drum on the left-side of the child's midline body. In this pilot, we are using a mobile device which is being held by the non-drum hand, hence only one hand is involved in the drum actions. Table 1 shows the relationships gathered from the Drum AR Analytics for the measured metrics, properties referencing the action on data and the attributes to crossing the midline from a user experience perspective. In next stages, we intend to use wearable AR devices which will be head-mounted, allowing both hands to freely use both virtual drumsticks in either hand to play the virtual drums. The Drum AR app is developed using Unity3D as the game engines and Vuforia's computer vision tools to enable AR marker recognition in the environment.

3.1 Visualising the AR Experience Analytics with a Dashboard

To further analyse the JSON file data, a prototype "Analytics Plots Dashboard" was developed using Python programming language together with Streamlit; which is an open-source python library to build data science driven web applications. The Drumming AR experience analytics can now be generated and analyse on a web browser with an intuitive presentation of the JSON data. The total of 10 moves are recorded and as shown in the plot, individual moves can be analysed by selecting the move on the slider.

3.2 AR Analytics Distance Plots 2D & 3D

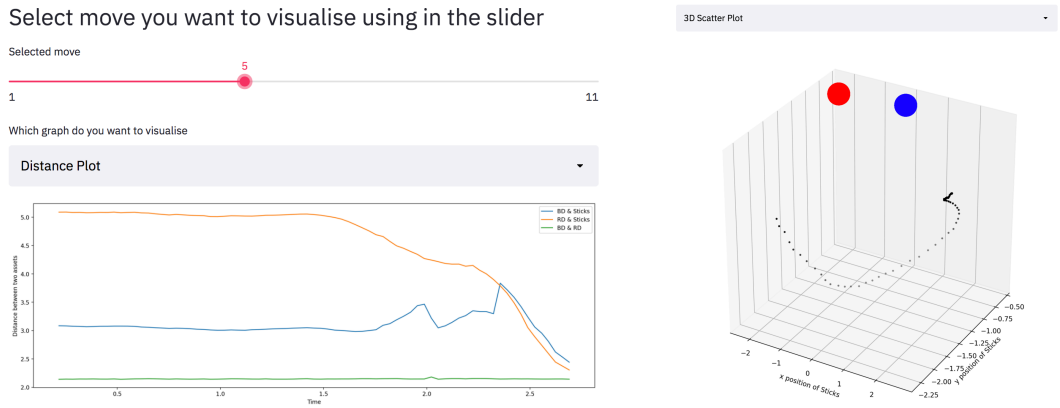

Figure 2 (Left): Single Move Analysis (Move No.5) - Distance Plot vs time positions for DrumStick, RedDrum and BlueDrum. SUCCESS in crossing the midline - 2 lines DO intersect. (Right) Single Move Analysis (Move No.5) - Distance Plot vs time positions for DrumStick, RedDrum and BlueDrum. SUCCESS in crossing the midline - 2 lines DO intersect.

Table 1. *Drum AR Analytics for Metrics, Properties and Attributes*

AR Data/Metrics	Actions on Data (Properties)	Attributes
Username & Userid	Input text box to capture child's name. Unique userid is assigned	Engagement
Correct Hit to Coloured Drum	Audio instructions to hit the Red or Blue drum with the drum stick	Engagement
Wrong Hit to Coloured Drum	Audio instructions to hit the Red or Blue drum with the drum stick	Engagement
User Feedback	Feedback via Emoji smileys (Like, Don't Like and Neutral).	Enjoyment
Number of Correct Moves	Drumstick is hitting one of the drums	Engagement
Number of Wrong Moves	Drumstick is hitting one of the drums	Engagement
AR Marker Events	Marker (found / lost) for blue drum, red drum and drumstick,	Attention
Hit Rate Timing	Time for drumstick to hit virtual drums (correct / wrong)	Speed / Control
Blue Drum (Bx, By, Bz)	Distance: drumstick to Red drum < drumstick to Blue drum	Cross Over Success
Red Drum (Rx, Ry, Rz)	Distance: drumstick to Red drum < drumstick to Blue drum	Cross Over Success
Stick Positions (Sx, Sy, Sz)	Drumstick positions	Cross Over Success
Stick Orientation (P1, P2)	Drumstick orientation	Control / Attention
Camera Position (Cx, Cy, Cz)	Camera positions	Initialisation
Video recording (30sec)	Front-facing camera (audio, facial semantics analysis)	Enjoyment

4. Conclusion and Future Work

We presented a Drum AR prototype to evaluate the effectiveness of capturing real-time analytics on crossing the midline performances a mobile. Future work comprises an evaluation in classrooms to capture real-time analytics as children use the app and subsequently to validate these analytics with observational feedback. The evaluation will give insights to the acceptance of the analytics gathered and presented to teachers and early childhood therapist in visual dashboards to gather feedback and identify improvements to task performances and user experiences.

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