Head Orientation Monitoring with Wearable RFID for Detection of Lateral Glance of Children with Autism Spectrum Disorder

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Background and Purpose Children with Autism Spectrum Disorder (ASD) show typical associated symptoms such as averted gaze, toe walking, excessive sensitivity to light, high interest in one particular object while being indifferent to human interaction, and social cues (Coulter, 2009). Among them is lateral glance, which means looking at objects out of corner of eye by turning head. It has assumed that this behavior is an attempt to reduce the amount of visual information that can be overwhelming and uncomfortable when it comes through the central vision (Mottron et al., 2007). Gaze of those with ASD is one of the main obstacles in their social communication and physiological well-being as well. Noris, Nadel, Barker, Hadjikhani, and Billard (2012) confirmed that children with ASD use more lateral vision than typically developing children using an eye-tracking device.

However, current devices to monitor this symptom are mostly too expensive and movement-restrictive to use in a daily basis. It arouses a possible adoption of RFID technology for development of a lightweight, portable, soft and low-price gear. RFID has been widely adopted in the fashion industry from product inventory management to tag-based payment. Without any battery, passive RFID tag uses RF signal from a reader as its energy source to send a back-scattered signal to the reader, so that the reader can recognize and identify the tag. Received Signal Strength Indicator (RSSI) shows the strength of the back-scattered signal, which depends on distance or angle between the reader and the tag. Since the tag can be easily integrated into a garment through embroidery, patchwork or just stitch and the cost per tag is very low, RFID has a great potential in wearable technology.

Sensor Design The newly developed wearable device in this pilot study uses the RSSI of the tags to detect the lateral glance of the children with ASD by monitoring their head orientation, based on the observations that the lateral glance occurs with turning the head while fixating on an object. A situation that a child is watching an educational media with a tablet or a smartphone connected with a portable RFID reader is set up for the possible use of this product. Four RFID tags (EPC GEN2 Adhesive Passive Monza R6 UHF RFID Tag, 73*17mm) are attached in two rows on a cap, which will be one of the easiest way for the children to wear a device. The tags are attached on the back of the cap so that the visor of the cap should not block the signal when a child wears it backwards. The difference of RSSI between the two tags (left – right) in each row represents the orientation of the head.

Method Impinj Speedway Revolution R220 reader and Rfmax S9028PCR Indoor RFID Antenna are used for the evaluation of the sensor. The distance between the antenna and the tags is set as 40cm considering the situation in use. A smartphone is also mounted on the top of the cap, to measure the angle between the antenna and the head orientation using Compass application. The angle of the head orientation was manually recorded at every seconds while the reader kept collecting RSSI of the tags.

As Wang et al. (2008) used a water bag to simulate a human body for RF signal, an organic object with enough amount of water, a melon, was chosen for this pilot study instead of the actual child's head. The cap was put on the object and the height of the object was adjusted to match the tags on the cap to the center of the antenna. One of the researchers rotated the object randomly only on the transverse plane within -45° (left) ~ 45° (right) range for 60 seconds. While rotating the object on the transverse plane, the other two plane kept the default state (0°). Since the reader sometimes miss the RSSI value if the angle of the head orientation goes high (mostly >40°), the missing values were replaced with the mean of its before/after values under the assumption the RSSI is continuously changing. Total six trials were conducted for this experiment, and R is used for the statistical analysis.

Result Mean of the correlation coefficient (r^2) of the angle of the simulated head orientation and the difference of RSSI between the tags is above 0.93 in both lower and upper row of the tags (Table 1). Figure 1 shows the data trend of first trial, which shows high correlation of RSSI with the head orientation, both above .93.

Trial	1	2	3	4	5	6	Mean	SE
Correlation (lower row)	0.939	0.922	0.914	0.916	0.968	0.942	0.934	0.008
Correlation (upper row)	0.982	0.977	0.945	0.945	0.980	0.981	0.968	0.007

Table 1. Correlation coefficient (r^2) between the head orientation and the difference of RSSI of the tags in each row

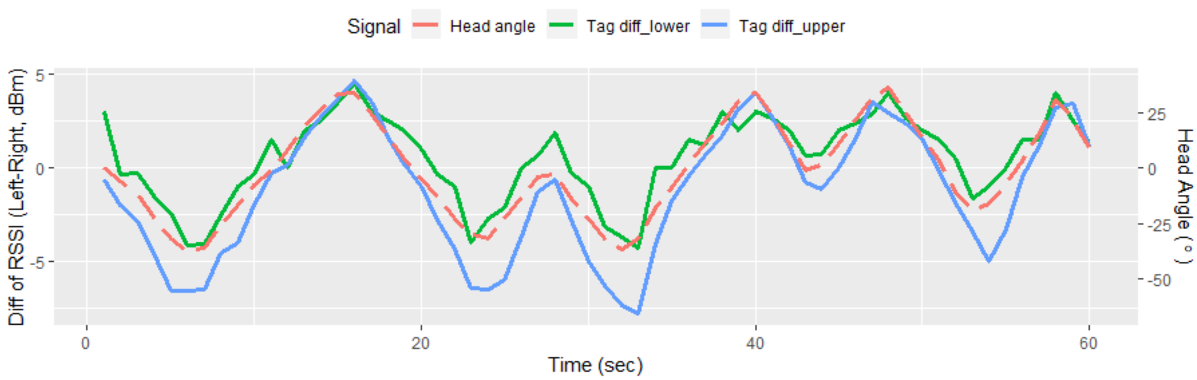

Figure 1. Trend of Head orientation and Difference of RSSI of the tags in each row by time

Discussion RFID tags mounted on a cap represented the simulated head orientation well, which can contribute to the detection and correction of lateral glance of the children with ASD. Even though the RFID tag gives the convenience of battery-less-ness, it requires a reader to be around the tags. Data trends from this preliminary study shows promising potential of RFID technology to be used for monitoring and correction of lateral glance found in children with ASD. Future studies need to verify effectiveness of the developed prototype through a large number of target population who have symptoms of lateral glance in a more realistic setting.

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