Test Protocol: Wearable Technology for Design and Safety Evaluation of Rider Acceleration Exposure on Aerial Adventure Attractions

Shelly Sicat[1], Kathryn Woodcock[2], and Alex Ferworn[3]

[1]Ryerson University, Digital Media

[2]Ryerson University, School of Occupational and Public Health, THRILL Laboratory

[3]Ryerson University, Computer Science, Digital Media, N-CART Laboratory

Abstract: Aerial adventure attractions are intended to produce exhilarating sensations at significant elevation, speed, and acceleration, all while maintaining the safety of the participant. While zipline designers and owners can refer to international standards addressing many safety requirements, the measurement and assessment of acceleration exposures of the zipline rider has not been standardized. This paper considers the design and validation protocol for wearable sensor technology to collect acceleration and g-force exposure of a zipline rider.

Introducing the combination of systematic design and quantitative analysis to wearable technology architectures requires considerable thought taking into account existing ride standards, biomechanics, ergonomics and the need for data accuracy. We first evaluate our state of knowledge and determine where there are gaps in safety standards. We then determine a design requirement outline for measuring acceleration utilizing wearable architecture. With the combination of complex processing requirements, the necessity of placing sensors and input/output modules at different locations on the rider's body, and stringent limits on size, weight, and sensor signal, the design of such systems is an inherently challenging problem. We contribute a test protocol that will evaluate the reliability and validity of the proposed system.

Keywords: design evaluation; wearable technology; computational public safety; aerial adventures; ziplines; accelerometers; requirements; test protocol.

1. Description

As noted in *Sicat, S., Woodcock, K., & Ferworn, A. (2018). Wearable technology for design and safety evaluation of rider acceleration exposure on aerial adventure attractions. Proceedings of the 30th Annual International Occupational Ergonomics and Safety Conference 2018. Pittsburgh 2018.* The following procedure will be followed:

1.1 Venue description

Since the dynamic characteristics may be affected by local attributes of the venue, descriptive data will be collected about the structures and operational practices. Each zipline resort has unique features and structures. Obtaining the specifications of the rides, information about current safety inspection processes and understanding the challenges faced during said processes should be noted as shown in Table 1.

Table 1. Venue description data

Topic	Data to be collected
Customers	Attendance and seasonality of operation
Zipline(s) at venue	Tabulation of each zipline and its parameters: elevation, length, intended speed and duration of transit.
Safety procedures, general	Description of nature and frequency of safety inspection
Safety procedures, specific to acceleration	Description of current process/practice/equipment used, if any, to measure acceleration.
Subjective assessment of acceleration	Operator perception of circumstances of variation in acceleration, if any, for each zipline.
Objective assessment of acceleration (if available)	Typical and maximum acceleration recorded, if available, for each zipline.

1.2 Procedure for data capture, filters and analysis

The test procedure is described in the next paragraph. When we refer to the "test participant" we mean either human rider or a stimulant. We refer to a "test administrator" who is a qualified individual who is responsible for conducting a safe, effective and meaningful test using the instruments previously described.

The test participant will be fitted with the instrumented garment and typical harness and helmet involved for safety protection. The garment will be tested to ensure that its' instruments are in order. Subjects will don the garment before the beginning of the ride. A check for sensor placement will be conducted once the garment is being worn. The test administrator will prepare the test participant to ride the zipline, latching the harness onto the trolley. Before departing, the test administrator will take note of the initial position of the test participant and the tri-axial accelerometers. More specifically, addressing the direction of the three axes involved. Two cameras placed at the starting position of the ride will capture the test participant's initial position for additional reference. The test participant will then ride the zipline, approach the end of the ride, encounter the zipline braking system and stop. The test administrator will observe the final position of sensors before unlatching the test participant. Two cameras at the end of the ride will capture the final position of the test participant for additional reference. Data will be filtered and analyzed following the recommended procedure noted in ASTM F2137.

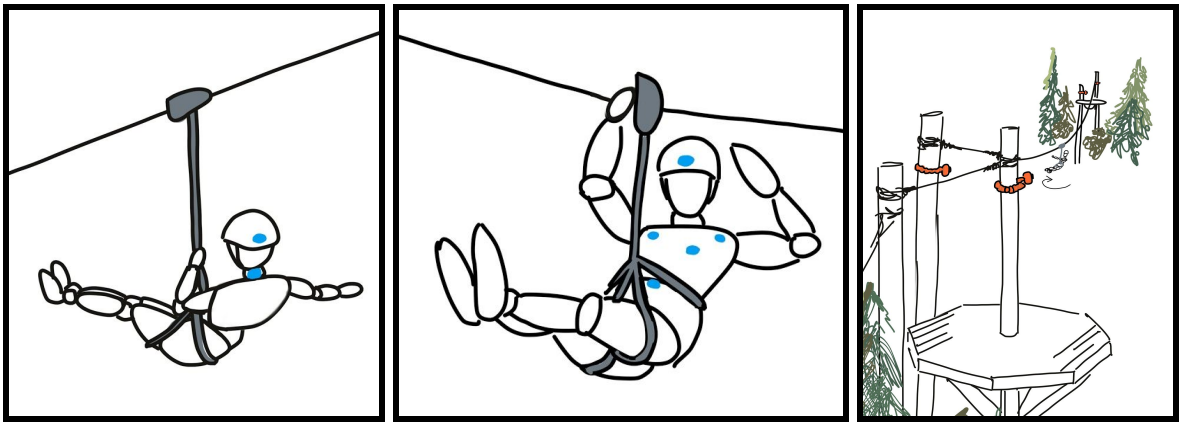

Figure 1. Wearable architecture setup. Blue indicates accelerometer placement. Orange indicates camera placement.