*******START OF ACTUAL PAPER*******

ABSTRACT (Writing this one last as it is a summary of the entire paper)

Does the Abstract concisely describe the content of this paper?

ABSTRACT The abstract should be a short summary of the overall project and should not exceed 8 lines (less than 150 words).

KEYWORDS List 1-5 keywords that would be detectable by a search function. Example: seating; pressure ulcers; communication rate; eye tracking; outcomes

Keywords

Obstacle detection; haptic feedback; ……3,4,5

INTRODUCTION/BACKGROUND

Does the background information support the need for this study/development?

Is the device design and application within the interest areas of the RESNA audience? Does the design reflect a new solution, has the design process adequately considered existing solutions?

[What is the motivation for this project / why did the PRP writers want this – from MSD, not SDC]

Visually impaired individuals face daily challenges in regards to interacting with and navigating through their environments. While some support systems exist in the form of assistive devices, most of these solutions provide audio feedback to the user to alert them of obstacles in their surroundings. This solution does not offer support for deaf-blind users or for hard-of-hearing users trying to navigate through obstacle-ridden environments.

The "Smart Cane" designed by this senior design team is an advanced assistive device that improves a deaf-blind user's ability to detect obstacles and navigate more safely. In contrast to the auditory design, the Smart Cane relies on tactile signals to guide the user. Current canes on the market that provide haptic feedback are upwards of 600 USD and our customer base is seeking a more affordable option that can be used for up to eight hours without the need for charging, is comfortable to use, and has accurate feedback signals that are intuitive or easy to learn.

Commented [KMC1]: Are we calling this a Smart Cane still or should we convert the team to using a new name for copyright sake?

PROBLEM STATEMENT

Is the Statement of the Problem or Objective clear? Is reference to previous work delineated clearly (if appropriate)?

The team needs to design and develop a working cane prototype for deaf-blind users that is competitive in the market with a low manufacturing cost. It must be able to detect obstacles, provide users with haptic feedback from the cane handle, is rechargeable for user convenience, is lightweight to avoid strain, and can be easily collapsed into segments for portability.

METHODOLOGY/APPROACH

Are the Methods/Approach clearly described and appropriate for achieving the stated objective? Is the device design appropriate and does it respond to the stated needs? Are the solutions considered consistent with current clinical practice?

Handle frame
The shell of this handle is composed entirely of polylactic acid [PLA] material with a 50 percent infill. Its purpose is to provide a lightweight solution that has a good layer bond to provide strength. The choice of PLA also provides a solution that is weather-resistant as the material is insoluble in water. A user will be able to comfortably grip this cane handle while sweeping the cane side-to-side. Per the current cane standard, one side of the cane handle will be a straightedge to ensure that a user holds the cane in the proper orientation.

*******PHOTO OF HANDLE INCLUDED*******

Power
To power-on the cane, a user moves a horizontal switch from left to right. Based on the final battery selected, the cane is expected to function for at least 8 consecutive hours and it is fully rechargeable.

Signal Detection
The selected sensor provides an obstacle detection range that goes as far as 9.25 feet from the sensor mount point of the cane, thus making the total detection range larger than ten feet. It provides a desirable vertical detection range of 4 feet and will be able to detect objects within a 180 degree radius as the user sweeps the cane from side-to-side. When an object is detected, the accelerometer indicates whether the obstacle is on the left or right side of the user. A signal is then sent from the electrical components to the two motors.

*******PHOTO OF ENTIRE CANE INCLUDED – MAKE A POINT OF WHERE THE SENSOR WILL BE & THE RANGE IN WHICH IT WILL BE ABLE TO DETECT OBJECTS*******

Motors/bearings
Each of the motors serves to rotate the bearing side-to-side on one side of the cane handle. One bearing contacts the palm of the hand while the other touches the user's fingers. Such placement ensures that, while the user holds the SmartCane in a way that mimics the traditional cane-handling technique, the haptic feedback can be easily felt. When users feel a bearing move in

Commented [KC(S2]: Need to change this once we know the new cane name

their hand, they intuitively know whether the obstacle is on the right-hand or the left-hand side as feedback side is identical to obstacle location side (i.e. Either to the left or right of the user).

*******PHOTO OF BEARING AT LEAST ON ONE SIDE OF THE CANE HANDLE INCLUDED*******

RESULTS/RESOLUTION

- Are results well-documented, valid and reliable? Are the conclusions/implications reasonable? Does the resolution presented appear to be consistent with problem originally stated?
- Device – test plans to evaluate…..brief description of each and what the outcomes were
- Briefly mention that the initial design iterations were reviewed multiple times by cane usage subject matter experts, mechanical, electrical engineers and industrial engineering professionals, other engineering students, …anyone else?
- Using input from others along with internal team critique, the design was finalized

DISCUSSION/OUTCOMES/PERFORMANCE

Does the discussion demonstrate how the solution addresses the issue? Is the discussion relevant to the RESNA Student Design Competition Instructions – Page 3 needs described in the Problem Statement/Objective? Was an evaluation attempted? [we can use our test plans results] Was it relevant to the needs of potential system users?[Yes – more cost-effective, works for deaf-blind users,

- Met / did not meet our goals (from problem statement)
- List what it has and how that meets the goals (i.e. lightweight – we chose parts that would not add unnecessary weight to the product)
- Outcomes – I.e. The cane will now….. be available for use by ABVI and they will have the opportunity to manufacture the product
- A little bit on the process of getting to the final design (i.e. something we tried one way and then ended up changing for the final design – material for the cane handle? Bearing setup?)
- May note any unique safety features the team added to improve user experience
- Conclusion – device is …good? Bad? Meets requirements? Exceeds requirements?... explain

Device Specifications	
Dimensions (H x W x D)	(240 x 53 x 32) mm
Grip Height	190 mm
Maximum Grip Diameter	32.5 mm
Sensor-angle Settings	3 Settings (0°, 17.8° and 35.6°)
Device Weight with Battery	136 grams
White Cane Diameter Range	12.8 mm to 13.04 mm
SmartCane Material	Polycarbonate
Electrical Protection	Class II, Type BF
Operating Temperature	-10° to +50° C
Storage Temperature	-25° to +70° C
Relative Humidity Range	15% to 93% (RH)
Storage Humidity Range	0% to 95% (RH)
Barometric Pressure Range	700 to 1060 hPa
Storage Pressure Range	00 to 1060 hPa
Ingress protection	IP22
Average Vibration Intensity	0.8 m/sec2
Minimum Vibration Intensity	0.6 m/sec2
Maximum Vibration Intensity	2.3 m/sec2
Audible Alarms	> 65 dB(A)
White Cane Length	100cms

****Maybe our team should include a device specifications table for our paper**

COST/IMPLICATIONS

Design for manufacturability was taken into account when finalizing cane design decisions. The cane's handle is a 3D printout on our prototype, but it will be injection molded when it is goes into production. The proposed design has a total bulk manufacturing cost of $136.05 [ADD G&A AND THE OVERHEAD AMOUNT AND THE INJECTION MOLDING VALUE TO GET THE CORRECT MANUFACTURING COST OF THE CANE]*****. Ordering in bulk is presumed to require 500 pieces and all values are quotes from external vendors. All costing includes a general and administrative expense along with expected overhead costs.

Commented [KC(S3]: Need to update this with our bulk coting work and then we can include the full estimate for injection molding of the cane handle from our external supplier (NY) – Lindsay's section

Market potential is great for this product as it is a lower-cost option than others on the market and it has the unique ability to be used by deaf-blind users. Our product was designed with the market in mind and we have ensured that its specifications meet current industry standards. Since all components are currently available from vendors, there is no additional work required from a sourcing perspective.

ACKNOWLEDGEMENTS

Design teams are encouraged to provide appropriate acknowledgements for support, including mentorship received from faculty or staff, and funding provided supporting design materials.

The team greatly appreciates the help of Dr. Iglesias for her assistance with design support and purchasing, Tom Oh and Carlos Barrios for their electrical design insights, and Gary Behm for patenting this idea and encouraging us to make his dream a reality. We would also like to thank our guide Charlie Tabb for his mentorship throughout this 32 week journey and Joe Kells and Nikki Llewellyn from ABVI for providing us with prototype test personnel, subject matter expert support on low-vision user needs, and financial support for the project. Denis Cormier had an integral role in providing design for manufacturability and design for assembly insights. We would like to thank both Denis and Mike Bufflin for their 3D printing knowledge and for helping us create a great prototype of the cane handle shell. Lastly, we are happy to have the help of our university's senior design staff who gave us guidance throughout the project.

*******END OF ACTUAL PAPER*******