Hygienic Public Interfaces for Autonomous Vehicles

Leave Authors Anonymous
for Submission
City, Country
e-mail address

Leave Authors Anonymous
for Submission
City, Country
e-mail address

Leave Authors Anonymous
for Submission
City, Country
e-mail address

Leave Authors Anonymous
for Submission
City, Country
e-mail address

ABSTRACT
If automated vehicles are to become widely used for urban transit, they must overcome potential hygienic stigmas associated with shared public spaces. Any municipal space used by the public has to contend with sanitation problems associated with heavy, continuous use. A touch screen interface has been seen as a convenience for its ease of use, but in a public health emergency, such as covid-19, it is a liability. Gesture control offers a safer, more hygienic alternative for public interfaces within autonomous vehicles.

Author Keywords
Autonomous vehicle; interface; gesture control; covid-19; Leap Motion;

CSS Concepts
•Human-centered computing~Interaction design

INTRODUCTION

Self-driving, autonomous and semi-autonomous vehicles will have an advantage within urban areas by combining the mobility of cars with the accessibility of public transportation. Indeed, a great deal of work is being done to bring this future market into existence [1].

In a study by Monash University of bacteria within public transportations systems a "sampling taken in New York's subway found that of the human bacterial DNA identified, 32 per cent was associated with the gastrointestinal tract and 29 per cent skin. Another 20 per cent was associated with the genital area, largely a result of people not washing their hands properly after going to the bathroom…" [2]. Such a bacterial load can be anticipated for autonomous vehicles used for public transit.

CHI 2020, April 25–30, 2020, Honolulu, HI, USA.

ACM ISBN 978-1-4503-6708-0/20/04...$15.00.
DOI: https://doi.org/10.1145/3313831.XXXXXXX
*update the above block and DOI per your rightsreview confirmation (provided after acceptance)

Pre-covid-19, it took around three hours to clean a bus from start to finish with a deep clean being performed every 45 days. [3] In a future where there could be thousands of autonomous vehicles in daily service in place of, or complimentary to, public transportation the time and labor required to maintain cleanliness within these spaces becomes impractical.

Autonomous public transportation would likely require an interface for direct interaction with the vehicle to access information, climate control, entertainment, destination tracking, and accessibility for anyone without a phone. A touch-screen would offer the most familiarity to passengers, flexibility, and ease of use. However, touch-screens have repeatedly been found to harbor harmful pathogens [4]

"Even though touchscreen technology is providing consumers with the convenience they want, it is undeniable that many touchscreens are dirty and unhygienic. Tests conducted by the Microbiology department at London Metropolitan University in 2018 found that touchscreens in McDonald's restaurants in London and Birmingham all carried traces of feces. More often than not customers eat immediately after placing their order not stopping to wash off the germs they have just picked up." [5] In a public health crisis like covid-19 this becomes a huge problem for safety in a difficult to clean autonomous public transportation system.

A voice interface would alleviate the need for a screen at all, however "adding speech to a device suggests agency, making it more likely that we will anthropomorphize the technology and feel safe revealing sensitive information." [6] among other potential ethical and social bias issues. The confined environment of car would be less than ideal for sound detection and differentiation. A voice interface also lacks the adaptability of a touch-screen and the accessibility needs of all passengers.

"Although various gesture implementations exist in the market, a notable percentage of them are based on embedded vision algorithms that use cameras to detect and interpret finger, hand and body movements." [7] A gesture-controlled screen that afforded the same functionality of familiar touch-screens without the need to actually touch the screen would be the best approach.

ENVISIONING A PUBLIC GESTURE INTERFACE

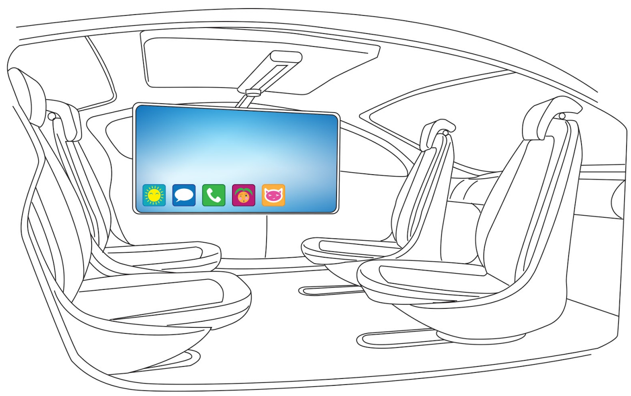

Figure 1 – Shared Interface for Public Autonomous Transport based on a stock image [8]

Most proposed autonomous vehicles intended for public use have similar dimensions as existing vehicles either because they are adapted from mass-production fleets [9] or are able to fit into established vehicle regulations and infrastructure [10].

With this in mind we imagined a gesture-controlled interface within the public setting of an autonomous ride-sharing vehicle (Figure 1).

About the challenges presented by Covid-19

Our original project vision was to use a combination of AR markers, gesture, and projection mapping to simulate a curved vehicle dashboard touch-screen. The project was to create methods for complex car interfaces to be simulated with cheap materials so that prototyping could become more rapid. Our project was forced to scale back after covid-19 forced a shelter-in-place statewide initiative.

We pivoted our project to meet the challenge of a public health crisis and adapted one of the core features, the gesture interaction, into a format that was more relevant to the present needs. All work for this project was completed remotely.

GESTURE INTERFACE DEVELOPMENT

Gesture Controlled APIs (Application Programming Interface)

We initially investigated open source Gesture Control programs that used ordinary cameras; however, this was short lived because they were not mature enough to meet our project requirements. We went instead with a commercially available, easily accessible product called *Leap Motion*.

Figure 2 – Leap Motion Controller Product Marketing Image [11]

About the Leap Motion Controller

"The Leap Motion controller is a small USB peripheral device which is designed to be placed on a physical desktop, facing upward. It can also be mounted onto a virtual reality headset. Using two monochromatic IR cameras and three infrared LEDs, the device observes a roughly hemispherical area, to a distance of about 1 meter." [12]

The Leap Motion has a highly useful proprietary development library [13] that greatly shortened our development time when creating our initial prototype. Using inexpensive off-the-shelf technology was a core goal in enabling automobile manufacturers a quick and cheap method for prototyping complicated technologies.

Creating the Graphical User Interface (GUI)

Since our focus was gesture interaction within vehicles, we first investigated common practices for vehicle occupants. While phone app interfaces offered the most familiarity with gesture-controlled usage, we tried to instead replicate the functionality of physical controls that would most likely be found in a vehicle and be accessible in a public manner that would not interfere with autonomous operations.

Climate and Radio were already shared between vehicle occupants and it seemed likely they would also be shared in a future autonomous vehicle for passenger comfort. We modeled our Scalable Vector Graphics (SVGs) to match this scenario using modern touchscreen Climate and Radio car interfaces as reference (Figure 3) within a simulated environment (Figure 4).

The Graphical User Interface was created using Adobe Illustrator, and common web tools including: HTML, JavaScript and CSS. HTML and CSS were used to display the SVG's and style them accordingly. JavaScript was used for the interaction with the SVG's. Keyboard key presses were used as the default GUI testing method to confirm functionality before integrating the Leap Motion device's gesture abilities.

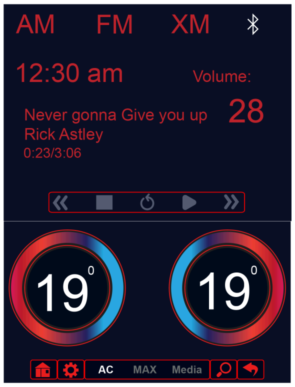

Figure 3 – The final exported SVG from Illustrator.

Figure 4 – Background .jpg image of Tesla Model X that we placed affectable SVG over.

The Gesture Controlled GUI Implementation

There are two main gestures to change values these being rotating your index finger clockwise to increase numbers and counterclockwise to decrease the numbers. Depending on which value a user is affecting the color of the number changes to yellow (Figure 5).

Figure 5 – Here, the right-side Climate number is selected as indicated by the yellow highlight.

To control how quickly the numbers would be changed a modulo [14] of five or two equaling 0 was implemented. There are four gestures to navigate the interface. By swiping with a full hand to the left or right moves between the two climate numbers. By raising an entire hand, a user can navigate to the volume on the radio. Alternatively, lowering your hand in a gesture motion will return a user to climate values.

The background image is saved as an .jpg that is stored in its own file, and the two SVG's are exported together for a single inline use. CSS was used to change the proportions and positions of the two independent objects. This meant positioning and scaling the affectable SVG on top of the image.

To alter any of the three affectable SVG's a call of Number (value) was implemented, and once the change was implemented a call String (value) is called, which meant having to transfer the values into integers from the inline html.

To store the variables that needed to be affected we used a Map data structure. Our map data structure uses a key value from the keyboard and an array made up of three values that include the SVG, the tag of the affectable part, and a Boolean. This map data structure is passed in as parameters to a function affect the code.

There are two main functions that affect the SVG using the leap motion. The first is to highlight the value that is currently being affected and the second to change the value.

To affect the SVG's with the leap motion a check is done on whether or not a finger is rotating and if it is clockwise or counterclockwise. If clockwise the call to the same alterSVG function as the key presses are called with the value changing mapped to go upward. Conversely, if counterclockwise the function is called to move the selected number downward.

To highlight the number that a user can affect several checks were implemented to on whether a person is swiping left, right, up or down. A user can swipe up to affect the radio, and down to affect either of the climate values. To get between the climate values a user can swipe left and right. Depending on where a user is with the interface the color of the value changes to yellow while all other numbers stay white.

Known Issues

The most difficult front-end issue was exporting the SVG's correctly to be used inline within the website. There are several ways to access the code created from an illustrator SVG. The best method for us was exporting using the save as method [15]. This method worked because the amount of code that was exported was manageable for inline work and was organized in a way that would be easy to add tags to affect using the leap motion.

Once the SVG's were exported correctly another difficulty was learning how to affect specific parts of the SVG using JavaScript. We prototyped with this issue and used one main resource as our foundation for affecting SVG's [16]. This taught us how to isolate variables that we want to be affected by the keyboard and the leap motion.

It was surprisingly difficult to be able to resize the SVG to fit within the image. To accomplish this goal, we used CSS to affect the image and the SVG to get it to look good on the website [17].

FINAL GESTURE CONTROLLED GUI

Figure 6 – Prototype Gesture enabled Radio and Climate interface

Using Leap Motion, we were able to create a gesture-controlled screen interface. Hand movements could change the volume of the radio and the temperature settings. A hand swipe up or down would toggle between radio and climate controls with a yellow highlight indicating what was currently selected. Similarly, a hand swipe left or right while using the climate interface would toggle between the left and right temperature controls.

CONCLUSION

While subject of public health and autonomous vehicles has often been focused on its replacement of exercise and non-communicable diseases, such as diabetes, [18] we believe that following the experiences of covid-19 the public will be hyper-aware of any interface that requires physical contact especially those in public spaces. The space within a car is already confining and the future need to create not only a comfortable environment, but a sanitary one will likely be at the forefront of the public's interest. Gesture control offers one path toward introducing a hygienic interface. Our current interface prototype represents a small part of our project original vision. We hope that one the covid-19 health crisis has passed to continue with our intention of building a simulated touch screen that can facilitate rapid prototyping of car interfaces. As easy to use and familiar as touch screens are, they have long been known to collect bacteria, and we hope that in simulating a touch screen we may also be advocating a potential alternative to it.

Future Research

Our original goal was scaled back due to the Covid-19 event; however, we chose what we could accomplish remotely with the idea of continuing our project at a later date. By developing this section of technology, we have built ourselves a foundation from which we can move forward.

ACKNOWLEDGMENTS

We'd like the thank Ellen for her help and support, and for buying us materials that we left in the lab unused.

REFERENCES

1. https://www.apta.com/research-technical-resources/mobility-innovation-hub/autonomous-vehicles/
2. https://www.smh.com.au/healthcare/the-disgusting-truth-about-germs-on-public-transport-20160627-gpsw2x.html
3. https://www.metrotransit.org/good-question-how-are-buses-and-trains-cleaned
4. https://www.ajicjournal.org/article/S0196-6553(15)01068-8/pdf
5. https://info.debgroup.com/blog/touchscreens-vectors-of-infectious-disease
6. https://hbr.org/2019/05/the-ethics-of-smart-devices-that-analyze-how-we-speak
7. https://www.eetimes.com/the-gesture-interface-a-compelling-competitive-advantage-in-the-technology-race/#
8. https://www.alamy.com/stock-photo-autonomous-car-interior-concept-ceiling-mounted-monitor-help-business-104824942.html

9. https://waymo.com/
10. https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety
11. https://www.ultraleap.com/
12. https://en.wikipedia.org/wiki/Leap_Motion
13. https://developer-archive.leapmotion.com/documentation/javascript/api/Leap.Gesture.html
14. https://en.wikipedia.org/wiki/Modulo_operation
15. https://css-tricks.com/illustrator-to-svg/
16. http://www.petercollingridge.co.uk/tutorials/svg/interactive/javascript/
17. https://www.w3schools.com/css/
18. https://www.sciencedirect.com/science/article/pii/S2214140517300014