Group 25: Tangible User Interface

Everett Brandt - brandte@oregonstate.edu
Lilian Chan - chanlil@oregonstate.edu
Hunter Cato - catoh@oregonstate.edu
Keana Kief - kiefk@oregonstate.edu

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Design Impact Statement

The tangible user interface (TUI) project is a wearable fidget habit tracker that measures people's fidget habits to be sent back to a computer real-time. Because of its data-collecting and wearable nature, it may have possible impacts on many areas. This paper covers the possible impacts of the tangible user interface projects on different areas. This information will be important for the project partner, users, and implementers of this project.

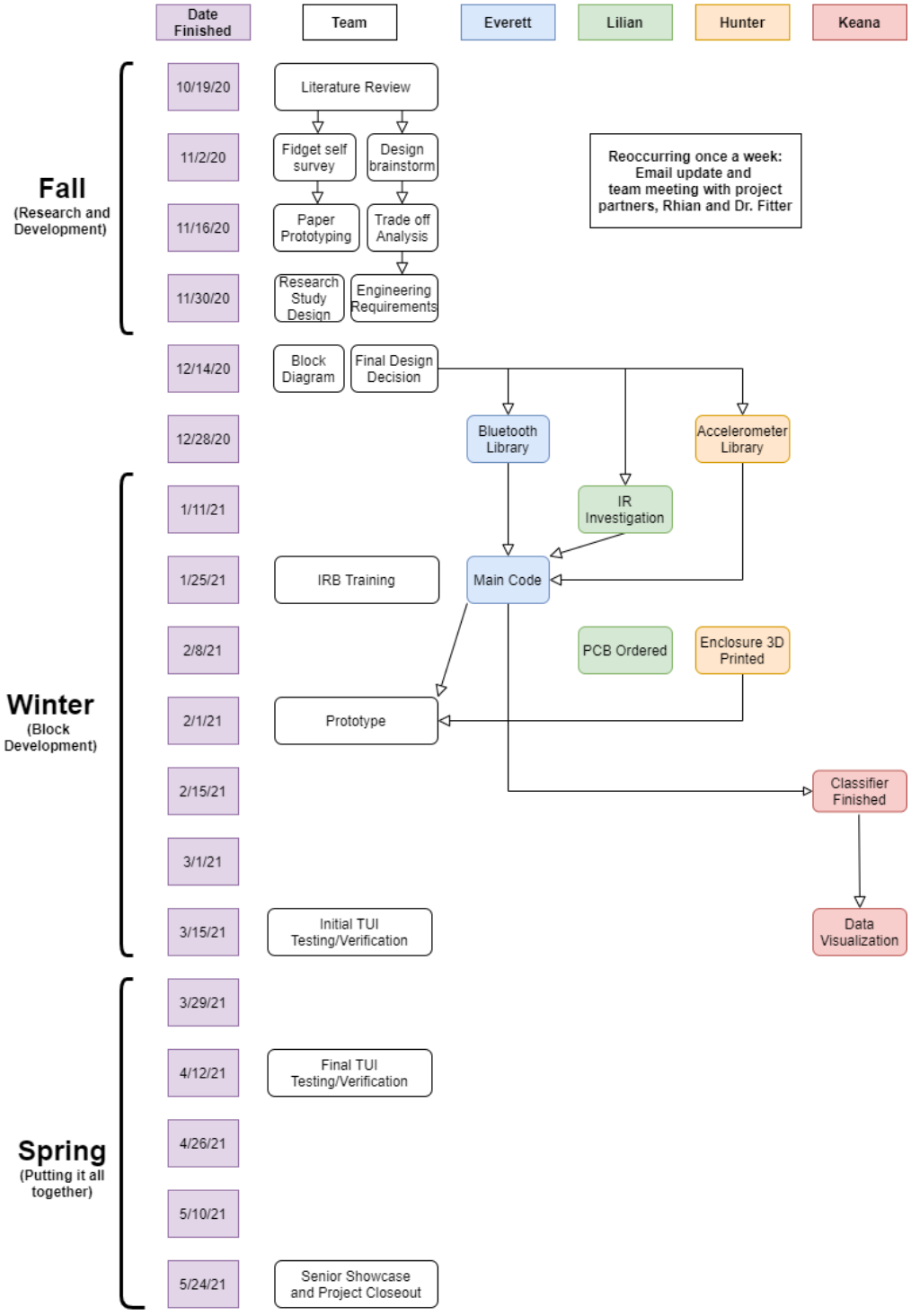
There are many impacts the tangible user interface project will have on public health, safety, and welfare. Because the TUI includes lithium ion and alkaline batteries, there are many possible safety hazards involved. These safety hazards include possible electric shock, burns, fire hazards, chemical reactions, and exposure to electromagnetic energy [1]. These safety hazards can be minimized with enough testing and cautious designing. There are also many positive public health impacts of this project. The data collected will be contributing to research projects that focus on improving public health and welfare projects at the Share Lab.

There are many possible cultural and social impacts of the tangible user interface system. The system collects information from users and sends it back real-time to a computer. This data collection is potentially dangerous because if the team is not careful with the data collected, someone's personal data might be compromised. The data must be handled carefully, which includes getting "explicit consent for each and every new usage of their personal data [2]." Because this is a wearable device, another stakeholder concern would be if the wearable device discriminates against certain groups of people. An example of how machines could discriminate would be how some soap dispensers have a hard time recognizing black skin colors [3]. To avoid the same pitfalls, this design has to account for all shapes and sizes. Our system also has many potential positive impacts socially. The Share Lab does research studies on helping disorders such as ADHD and autism through assistive robotics. Through collecting data, the TUI can assist that research by collecting relevant data to analyze.

There are also many possible environmental impacts of the tangible user interface project. A positive environmental impact is that the TUI uses rechargeable batteries, which use up to 23 times less resources than the non rechargeable batteries [4]. Additionally, the rest of the system as a whole is designed to be durable and multiuse, which means they will conserve resources and limit the amount of plastic being thrown away. However, this project is made of plastic and electronic materials, which can have negative impacts on the environment. "Plastic pollution has become one of the most pressing environmental issues, as rapidly increasing production of disposable plastic products overwhelms the world's ability to deal with them. [5]" Therefore, there can be more research done in future iterations to include more biodegradable materials into the design in order to deal with the environmental impacts of this project.

Impacts on economic factors are also relevant for this project. One positive economic impact is that this project is cost-saving over time because it is reusable and durable. This is an economic benefit to the Share Lab and other people who would like to utilize the system. It also utilizes rechargeable batteries, which can be used hundreds or even thousands of times, they can save hundreds of dollars over the course of its lifespan [4]. However, there are also negative economic impacts. The initial cost of the rechargeable batteries for my blocks are higher than disposable batteries [4], so it may be an economic deterrent for people who only want to use the system short-term. In order to reduce this cost in the future, more research can be done into making it more affordable.

Project Timeline



Throughout the whole project, we had enough resources, support, and interaction from our project partners. Whenever we needed anything, our project partners were able to provide them or help us locate them.

Scope and Engineering Requirements Summary

Category	Engineering Requirement
Battery Life	The System will collect data and transmit it periodically for 16 hours without replacing the battery or charging it so that the system can be used for a full day of work.
Classification	The System will be able to classify sensor data into either foot wiggles or upper leg swinging with 80% accuracy.
Durability	The system must be able to withstand 15 consecutive 4 foot drops and a 16 hours of continuous wear while attached to a subject's leg and be fully functional afterwards.
Ease of Use	The System will be reported as easy to use by 9/10 people who receive the TUI with instructions and each TUI module will be under 75 in^3.
Literature Review	A literature review paper totaling 4 pages in length will be written and approved by the project partner to summarize the different fidgets devices used in academic research and their applications.
Safety	The system will have rounded edges and corners with radiuses larger than .25 inches as well as no exposed wiring. The temperature on the exterior of the enclosure will also not exceed 20 degrees Fahrenheit higher than the ambient temperature.
System Justification	A system justification document will be written which includes a brainstorm and trade off analysis subsections that will be approved by the project partner.
Wireless Data Transfer	The system will communicate with an existing base station wirelessly and transmit accelerometer and positional data 5 times a second with a range of 10 meters.

Risk Register

Risk ID	Risk Description	Risk Category	Risk Probability	Risk Impact	Performance Indicator	Responsible Party*	Action Plan
R1	Vendor delay	Timeline	25%	M	Estimated shipping times	Everett Brandt	Retain
R2	3D-printing delay	Timeline	50%	M	Estimated wait times	Hunter Cato	Retain
R3	TUI may not integrate well into users fidgeting habits	Technical	25%	L	User interaction time	Lilian Chan	Transfer
R4	TUI may not collect sufficient data	Technical	25%	L	Collected data	Hunter Cato	Transfer
R5	Repurchasing components/not enough spares	Cost	40%	L	Rate of mistakes	Keana Kief	Reduce
R6	Not finding enough beta-testers in-time	Timeline	50%	M	Number of respondents	Everett Brandt	Reduce
R7	Not meeting deadlines	Timeline	10%	L	How well we follow plans	Lilian Chan	Reduce

*The emails of all the responsible parties/watchpeople are given above in the cover page.

Figure 1: An unexpected risk that almost occurred was not finding enough beta testers for checking off our engineering requirements. Another risk that we did not anticipate at first that almost occurred was not meeting deadlines due to the troubles of remote collaboration. We also learned many lessons throughout this project such as communicating often and planning beforehand to avoid conflicts and missing deadlines. We also learned to work closely with our project partner to solve problems easier when they are able to help.

Future Recommendations

1. **Increase Battery Life to 24 hours**
    a. Reason: Right now, the system can run for 16 hours, however the original plan was 24 hours in order to be able to measure for multiple work days. This will be able to reduce the amount of times the battery needs to be changed out. Therefore, there can be less interference with the research subject. By changing the battery less, it will also eliminate some of the wear and tear of switching out the batteries. It will also eliminate the down time of the TUI that will be needed when recharging batteries.
    b. Starting Point: A starting point would be researching different battery types to see if some can hold more charges than the one we currently have. Another starting point would be researching other ways to charge the TUI, such as through USB. Research can also be done to reduce the overall battery consumption of the system. This can mean replacing the sensors for more-efficient ones or to implement a sleep mode.
2. **Decrease the size of the system**
    a. Reason: The size of the wearable part of the system is a little hard to wear and clunky right now. It is noticeable and can't be hidden under clothes. If the system was reduced in size in any dimension, that would be a huge improvement to the comfort of the user. It would also make it easier to maintain because then it wouldn't hit as many things and be damaged from such.
    b. Starting Point: One starting point would be finding ways to reduce the battery size because the battery takes up a lot of space. The sensors and PCBs also take up a lot of space, so alternative sensors and PCB designs should be found that take up less space. The enclosure can also be redesigned so that everything is consolidated into a smaller area.
3. **Make a corresponding arm sensor**
    a. Reason: Right now, our system only measures feet fidgets and leg fidgets. If we made a corresponding arm sensor and classifier for the arm fidgets, we would be able to measure a wider range of fidgets. This was an original stretch goal, but we did not have time to implement this idea. A larger range of fidgets collected would mean more pieces of data collected.
    b. Starting Point: A starting point would be to make another IR emitter and receiver system above the desk for the arms and make both the systems (both arm and feet sensors) send to the same computer to consolidate the data. Another classifier for the arm data would also need to be created.
4. **Upgrade the classifier**
    a. Reason: Our classifier is only able to recognize 2 different leg fidgets. It would be much more useful if it is able to recognize more because different fidgets correspond to different emotions and energy levels. Because our classifier only recognizes two fidgets, a lot of fidgets are being left out. It is also at risk of miscategorizing fidgets that it does not recognize yet, so adding more is better.
    b. Starting Point: To upgrade the classifier, more research should be done through both trials and research papers to find more fidgets that are popular. After a list is

made, efforts should be made to implement this list of popular fidgets. This process can be a continual one to gradually add on more and more fidgets as data is discovered. Additionally, this might eventually expand into hand, arm, and body fidgets as the range of the TUI expands.

5. **Create more team meetings to discuss progress**
    a. Reason: The meetings have been very useful to communicate work, progress, and updates with the rest of the team members, especially since we are not able to meet in person because of current world situations. Having more meetings will help keep people accountable and up-to-date on what the rest of the team members are doing. They are also useful for building communication, teamwork, and camaraderie among the team members.
    b. Starting Point: There should be effort put in to try to have an extra meeting every other week with all the team members present. This does not need to include the project partner and can include simple project-sharing and project discussions. There should also be a person put in charge of this so that it is more organized.
6. **Better time management/Plan to turn assignments in a few days before the deadline**
    a. Reason: Because of current world situations and remote learning, it is harder to turn things in on-time than other years especially because unexpected things can come up due to remote learning. If people plan to turn in assignments a few days before the deadline, this will help eliminate the risk of being late with assignments and make the deadlines less stressful.
    b. Starting Point: There should be a universal calendar that the whole team can refer to with the earlier deadlines. One team member should be in charge of updating it and reminding people of their deadlines. There should also be extra resources to help people who have trouble meeting deadlines.
7. **Include more team building activities**
    a. Reason: The remote learning situation has eliminated a lot of the human interaction that usually occurs in group projects. Therefore, a few team building activities would have been useful to build camaraderie. Knowing each other more personally would have increased the teamwork of the team members. Additionally, it would have made the project more enjoyable.
    b. Starting Point: These team building activities can include movies, games, or just talking about each other's interests once a term. This would allow people to know each other more personally. If people were comfortable enough, this could also include in-person meetings with masks. However, any form of personal interaction a few more times a term would suffice.
8. **Start on a research study using the TUI**
    a. Reason: Our original plan was to start on a research study using the TUI, but because of time constraints, we were unable to conduct a full study. This would be a great future recommendation because a research study could fully explore the capabilities of the tangible user interface project. It would also collect useful data for the Share Lab on the emotional state of its research participants. Additionally, it would give ideas on how to improve the TUI.

b. Starting Point: A starting point would be to research past research projects so the research project will be more solid and thought-out. Another starting point would be talking the idea through with the research partners on what they would like in the research study because the research study would be conducting data for them. Additionally, there should also be test trials to eliminate problems and mistakes during the actual study.

References

[1] “Testing Battery Systems Designed for Wearable Technologies.” ul.com. https://www.ul.com/sites/g/files/qbfpbp251/files/2019-01/WP_TestingBatterySystemsDesignedForWearableTechnologies_15.pdf (accessed 16 April, 2021).

[2] A. Carpenter. “The Ethics of Data Collection.” towardsdatascience.com. https://towardsdatascience.com/the-ethics-of-data-collection-9573dc0ae240 (accessed 21 Jan, 2021].

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[5] L. Parker. “The world's plastic pollution crisis explained.” nationalgeographic.com. https://www.nationalgeographic.com/environment/article/plastic-pollution (accessed 16 April, 2021).