April 14/15 Results and Discussion, Conclusion, Prescreening, Report Mechanics and Structure Checklist: (section 10 of https://www.oacett.org/getmedia/9f9623ac-73ab-4f99-acca-0d78dee161ab/TR_GUIDELINES_Final.pdf.aspx)

your repository/Documentation/GroupNameConclusionandChecklists.pdf

Prescreening Checklist

1. Has a Proposal for a Technology Report been submitted and accepted and a copy of the approved proposal included in the Technology Report?

Yes, we had submitted a proposal in the previous semester, approved by professor Austin Tian who was our previous instructor for the first half of the project in Fall 2019. (CENG 319,317). Yes, a copy of the approved proposal is included in the report.

2. Has the Technology Report been submitted within one year since the proposal was approved?

Yes.

3. Is the Technology Report consistent with the Proposal (as approved and with the comments and suggestions made by the proposal reviewer)?

Yes.

4. Is the Technology Report typed, double-spaced and justified left?

Yes.

5. Has a 12 point Arial, Univers, or similar Sans Serif font been used?

Yes, and font type used is Arial.

6. Is the body of the report a minimum of 3,000 words?

Yes.

7. Are the components included and in the following order: Title Page; Declaration of Authorship; Approved Proposal; Abstract/Executive Summary; Table of Contents; Lists of Illustrations/Diagrams; Body of the TR; Conclusion(s), and if applicable Recommendation(s); Bibliography/Technical References; and Appendices?

Yes.

8. Is there a signed Declaration of Authorship?

No, because our group decided to not upload private signatures for security purposes to our repository as it is public to everyone.

9. Is the report dated?

Yes, date of April 15th,2020 to coincide with the final report submission.

10. Is the Technology Report current? (The Technology Report should be less than 5 years old.)

Yes.

11. Is there a Title Page?

Yes.

12. Is there a Table of Contents?

Yes.

13. Does the Table of Contents correctly reflect the Components: Headings, Illustrations/Diagrams and Appendices?

Yes.

14. Are the pages numbered with appropriate page breaks?

Yes, correctly numbered with odd page breaks for the start of each next section of the report.

15. Is there an Abstract/Executive Summary and Introduction?

Yes.

16. Does the body of the report contain Section Headings?

Yes.

17. Are there Conclusion(s), and if applicable, Recommendation(s)?

Yes.

18. Is there a Bibliography with appropriately cited Technical References?

Yes, there is a References section with properly cited references used for the project in APA format.

<u>Report Mechanics and Structure Checklist:</u>

1. Does the Title, in ten words or less, inform readers of the precise subject matter contained in the TR? A title should be concise and include key words for indexing.

Yes.

2. Does the Abstract or Executive Summary provide a brief overview of the report in approximately 75 to 100 words?

Yes.

3. Does the Abstract or Executive Summary summarize the Conclusion(s), and if applicable, the Recommendation(s)?

Yes.

4. Does the Introduction state the reason the work was undertaken? What is the industry, organization or context? What is the problem?

Yes.

5. Does the Introduction cover the scope of the report? What is included and /or admitted, and what procedures are used?

Yes.

6. Do the headings and subheadings in the Body adequately and accurately describe the section or subsection content?

Yes.

7. Does the Body include information regarding the methodology? Does it indicate materials, equipment and procedures used and why they were selected over alternatives? Is there sufficient detail so that that the methodology can be duplicated by others?

Yes.

8. Does the Body include recent research findings?

Yes.

9. Does the Body include results/data from the study?

Yes.

10. Are illustrations, tables, diagrams and charts clearly drawn, labelled and numbered?

Yes.

11. Is each Conclusion, and if applicable, each Recommendation, stated in a separate paragraph and in a positive way? Conclusions should not be qualified with “it seems”, “probably”, “it may be”, or other words that dilute the strength of the conclusion.

Yes.

12. Are the References/Bibliography complete? All materials referenced in the TR should be represented in the list of References/Bibliography.

Yes.

13. Do the Appendices support the study? Do the Appendices include substantiating data and calculations? Extraneous material should not be included.

Yes.

14. Is the spelling correct? Has either the Canadian or USA spelling system been used consistently through the TR.

Yes, modified and fixed based on feedback from previous submissions and returned work.

15. Is the language free of jargon? Are acronyms properly introduced? Are abbreviations appropriate and correct? Can someone without specific expertise in the field read and understand the TR?

Yes.

16. Is the same voice (I, one, person, etc.) used consistently throughout the Technology Report? There should not be any switching from third person to first person or vice versa.

Yes.

17. Do the grammar and punctuation follow normally accepted rules of use? Use Ron Blicq’s text Technically Write or a similar grammar reference as a guide.

Yes, fixed based on returned submission feedback received by the professor.

18. Are thoughts and illustrations/diagrams/charts that do not belong to the writer properly identified and footnoted in the text? Are quotations indicated correctly? Are the authors referenced in footnotes and/or reference list? Do they include the author’s name, the title of the article/book, the date of publication, and the publisher?

Yes.

Report Content:

This section evaluates the quality of the work completed when addressing the problem statement/hypothesis. Fulfillment of these criteria leads to a TR that makes a contribution to the field under study.

1. Are the Problem Statement and Hypothesis significant to the current state of the field/industry?

Yes.

2. Is the Methodology scientifically sound?

Yes.

3. Are the engineering technology and applied science principles used in the Methodology and Analysis appropriate to the subject area?

Yes.

4. Are the Data and/or Results complete?

Yes.

5. Have the Mathematical formulae been applied appropriately?

Yes.

6. Are the Mathematical calculations done correctly and accurately?

Yes.

7. Are the Illustrations/Diagrams/Charts technically correct?

Yes.

8. Is the Analysis of the results correct?

Yes.

9. Is the Analysis complete?

Yes.

10. Are the Conclusion(s), and if applicable the Recommendation(s), free of discussion, explanation and opinion?

Yes, expressed only in facts.

11. Do the Conclusion(s), and if applicable the Recommendation(s), relate to and resolve the Problem Statement and/or Hypothesis?

Yes.

12. Are the Conclusion(s), and if applicable the Recommendation(s), logical?

Yes, and next-steps are considered for marketing/client purchase, ways to improve the final product, and build on existing features for a wider consumption of the public and move the product into purchasing.

13. Does the report make a contribution to the industry/field of study?

Yes.

4.0 Results and Discussions

Our SMART parking assist platform, acts as an alternative method to support everyday consumer occurrences and provide the tools necessary to make parking easier, and more portable through forms of digital appeal by a mobile application for handy pocket pick-up use, and by offering parking data monitoring functionalities all bundled in one location. We have developed a parking lot prototype which works as a small-scale model to mirror our parking application with interactivities to offer to the consumer demographic/audiences worldwide. This application is developed with the consumer in mind, with ideas centered around the types of features a user may desire and crave from a business standpoint, as well as figuring out ways of how to present parking through a much more advanced, modern day approach in return making consumer/driver lives easier and more manageable. In terms of the end outcome of our prototype, we believe we have tackled our planned objectives for the project in a suitable and manageable manner for what is possible with the tools, services we have access to during development, and the final integration of all hardware/software components.

Due to the circumstances, we were faced with many challenges in overcoming how we would be able to meet the end requirements, including having all planned parts functioning and working in the end. There is always room for further improvement, after any kind of deployment and we believe collectively in terms of the hardware side/footprint of the prototype there can be much needed changes, modifications and further improvements to the existing software infrastructure. This will be further discussed in the Conclusion section under the “Recommendations/Future Steps” branch. We believe if given the opportunity to complete the project in its entirety we would have a much more efficient, and working product with all pieces brought to life and physically assembled. This was because, in the end we were unable to have our parking lot prototype designs come to life, and physically assembled with the other hardware pieces such as the enclosure design and sensors/effectors. Thus, due to the situation we focused mainly on completing all aspects of the project and parking application, without the physical assembly but give our full attention to refining the mobile application, testing the hardware sensors/effectors and adding the planned functionality which would have been showcased with a connected parking lot prototype. Although, in the end we are proud of what we set out to do from the initial development in the previous Fall 2019 semester, and what we were able to accomplish during this final Winter 2020 semester. As mentioned, there is always room for improvement in any type of project or application and we believe as with anything nothing can be in-stone perfect.

Future directions can lead to a much stabilized and finished product with having the physical assembly also potentially completed with lead way to time and integrated for demonstration and showcase purposes. The work accomplished on the software end we believe is outstanding from both the firmware and mobile application sides. In the end, we were able to include all functionalities of each sensor into the firmware code and build upon features for the mobile application, refine the work done for testing and deployment down the line. Due to time limitations and limited access to vital services, we were forced to work with the tools we had at our disposal near the end of the term and focused on providing a finished end product with all working features from the hardware/software side. Although, being unable to demonstrate our accomplishments with the hardware sensors/effectors functioning intact with the mobile application and active database setup in person but virtually.

This project taught us a variety of essential skills and tactical strategies to utilize from both industrial and technical standpoints, many of our hurdles along the way allowed our group to remain patient and face any challenges and overcome them. This includes, working in a team environment, which in the future for each of us would be important and informative to being able to share ideas, bounce off design choices or development strategies working together as opposed to individually. This project taught us how to be vigilant with our work, and put in the most effort by making sure the work is divided evenly and each member along the journey contributes an equal amount in the end. This skill as well as experience would be an ideal choice to consider when building a resume, as we were able to cooperate as a team and be active in doing so.

From an employer's standpoint, this would be an outstanding achievement and would help showcase our skills we learned from this capstone project environment. We learned how to schedule events, manage our time wisely using management tools such as the Gantt chart, being able to track our status based on planned milestones from the start of development. We learned how to take a schematic design, and transfer the circuit to a breadboard and then finally create individual PCB's, followed up with a combined unit holding each respective sensor/effector with use of the Fritzing software, and having access to services from campus such as the prototype lab. This also taught us how to design enclosures, PCB's in the most effective way and correctly with avoiding major mistakes down the line in production, which may be costly to us in the future for testing purposes. We learned how to use development tools/graphic applications such as CorelDraw and Inkscape to create 2D enclosure/parking lot prototype designs and use the tools provided to build a 3D representation of what was required from our parking application. Through this, we learned how the laser-cutting machines function and produce an acyclic design and have that come to life with safety measures taken and considerations taken for the types of acrylic material being available at our disposal in the prototype lab.

In this process, we remained patient in getting the work done, with having in mind there may be the need of multiple print-outs of the enclosure to fit the dimensions of the parking lot platform, or make enough space to hold the Raspberry Pi/PCB and the sensors/effectors attached to these hardware units. For the most part, we had to go through multiple designs, re-adjust and test which designs fit our hardware and work with those designs. We did not get the chance to take our case designs and physically assemble one, but we had the correct measurements taking into consideration each side and hardware piece. We learned how to work with an online database and figure out ways to communicate with a mobile application, and work with a development platform. We learned how to take individual hardware projects/units and re-design these units into a single, compact unit holding all sensors/effectors taking into consideration the hardware requirements for each sensor/effector, and any hardware limitations. Throughout this process, we learned it is not always possible to have planned objectives work out in the end, and there should always be backup plans or alternative ways put into place to achieve a goal. For example, facing the problem with the

VCNL4010 device and being unable to support all 4 spots on the prototype due to hardware limitations on the I2C device end.

Collectively, we really enjoyed working on this project as through the ups and downs we remained loyal and continued developing and moving forward with the pieces needed to assemble the final project. There were some doubts from the previous semester, which may have derailed the project due to a former member leaving the group but fortunately allowed us to put in even more effort, and complete the project whether individually as from last semester, or in the end as a three-member team. We are proud with what we had set out to accomplish and the end outcome, as we completed the project in a finished fashion with a majority of the planned features along with some minor adjustments along the way. In the end, our parking lot prototype was able to achieve and perform its overall purpose for the consumer, and we believe we have demonstrated this efficiently to help create a parking lot prototype that mirrors our software as well as helps in visualizing a SMART parking assist platform. As mentioned, there is always room for improvement in the case of our prototype as it is not perfect, but this product accomplishes our key goals and requirements for the project which was our target in the end. We will be actively monitoring our current prototype, and continue to update the hardware if needed through further advancements based on the technology world. Our SMART parking system targets consumer lives in support of everyday parking occurrences, and helps provide the gateway to parking from a global perspective.

A sincere thank you to professor’s Kristian Medri and Austin Tian, for helping shape this project and providing active feedback to further improve on key topics in support with the overall development and final integration.

5.0 Conclusions

The WatechPark IoT capstone project was developed to address the consumer demographic by determining an alternative method in regards to payment for parking, capacity management, and real-time information gathering. During the course of fifteen weeks, we have worked extensively on designing, developing, and integrating hardware/software components in preparation of unit testing, mass production testing phases, and overall refinement. Therefore, through the combined effort of all team members, we have successfully achieved our proposed objective by creating an alternative parking lot management system, to assist with everyday consumer occurrences and parking situations.

Recommendations/Future Steps

Future steps may include, a more compact PCB design to accompany the use of the two servo motors. Thus, reducing the overall footprint size of the project by a more considerable amount and allowing further room for improvement in terms of hardware use/capabilities. Other possible additions, may include adding support for each available parking spot on our prototype model. This would require the use of a I2C multiplexer to allow individual VCNL4010 proximity sensors to be positioned at each parking space, rather than the current single VCNL4010 device. Additionally, to appeal to the mass market a web application may be developed to allow a wide range of public users the ability to view advanced metrics/live parking lot data. The application would mirror the mobile application and allow the consumer to interact through a global reach.

Thus, in return gaining further popularity to contend as a major alternative SMART parking IoT platform from an investor's standpoint.

In regards to mass production of the project, including the parking lot prototype model we have each individual file associated to the hardware/software components of the project present in our project repository for replication purposes. This includes, the hardware designs of the PCB assembled in the end of the project, as well as the design files for the enclosure developed through CorelDraw, 3D printing pieces to accompany our small-scale parking lot model. This would also depend on the location the sensors/effectors are ordered from, and the ideal timeframe the parts can be delivered. Along with no major interruptions in the shipping and delivering of the parts, an individual can gather all parts in roughly 2 days and begin working on the PCB and electronic components. As all of the major development files are available on our repository, this includes the main code to run our mobile application an individual would only need to have access to an Android Studio development platform and run the software through an emulator, or a hardware device. Through the documentation files uploaded, it would be easier for anyone without a technical expertise to be able to replicate the project in due time with the mobile application, and using the files readily available without having the need to re-create from scratch.

Ideally, to mass produce between 1000 to 100,000 units of the prototype and hardware elements such as the PCB and enclosure, we would need to have access to a printing services for laser-cutting acrylic as well as help re-produce the PCB design through the Fritzing application and make use of the Gerber files for mass-production of these parts. In terms of overall production of the hardware prototype, an excess amount of acrylic/3D material would be needed to complete the enclosure, replicate the 3D printed components as well as the parking lot prototype in a small-scale atmosphere. An increased amount of tools/materials would be required for mass-production phases and extended marketing use with the sensors/effectors being in high demand and gathered through online access, including shipping/potential duty costs. The parking lot prototype would also require the use of a laser-cutting machine to be able to bring the model to life and replicate the project in its entirety. For testing procedures, access to a multimeter would be ideal to allow for testing of the sensors/effectors used in the project and test each sensors/effector thoroughly before beginning the next production phase for any upcoming units. This incudes, testing connections once soldering the sensors/effectors to the PCB, which we have also included documentation work/procedures to support any individual attempting to solder equipment, parts with an ideal temperature range to work with, without combining connections or a short in the process which can lead to possible of the hardware.

In the case, of production failure we would assess each part that may be causing the issue and have a backup plan for each hardware component. This can include, re-using some of the material such as the acrylic material for the enclosure or parking lot prototype. This would ensure, before mass-producing the project, that it would be capable to function as originally designed and developed following the steps provided through our main project repository and cut-down on excess waste for manufacturing purposes in the future. Other fundamentals required, would be making use of the firmware code available to run each sensor appropriately and have each part perform its necessary functionalities though the code and for the purpose of our parking application. Through these considerations, it would be ideal for the project to potentially be replicated over the course of two weekends. This includes, having access to the parts/materials laser-cutting/3D printing services and a soldering station that can used for completing the hardware, and testing the code for each sensor. Due to this, for commercialization purposes the product itself would require the cost of shipping, duty and taxes which as mentioned would include an excess amount of printing material, accumulated costs through designing, producing and manufacturing would also be included when considering an ideal marketable cost for a complete project with all working parts for the potential of 1000 or more units being readily available for consumer purchase.