High Concrete Group LLC, d/b/a
StructureCare: Site Inspection Automation

StructureCare Engineering + Restoration + Predictive Maintenance

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Executive Summary

Structure care is a small division of the High Concrete Group and only consists of about 14 employees. This means that each person's time is valuable. Currently, they only have one Field Engineer to do all of their field inspections. StructureCare is looking to send a non Field Engineer to sites to conduct the inspections and generate the inspection reports. As of now, a Field Engineer brings a tablet, a chain, and a hammer with him to a parking garage inspection. Our proposal consists of three major parts. The first is an application for the tablet that is used to record information during the site inspections. This application would allow the operator to automate the process of manually writing down conditions seen in the inspection. The second part is a mobile robot to drive through the parking garage dragging a chain to check for concrete delamination and defects. The last part of our proposal is the web application tool used on the computer. This application tool would speed up the report generation process and streamline the necessary steps to creating an effective and organized report.

Statement of Problem

StructureCare is currently a small division of the High Concrete Group. StructureCare focuses on concrete site inspections for parking garages. They rely heavily on their man power to complete daily tasks. Some of these tasks are very time consuming because a very small percentage of their processes are automated. The main issue that StructureCare faces is that their Field Engineer is busy and has limited time to inspect sites and work on the inspection reports that are created afterwards. The time for the Field Engineer to finish the report is about three to four weeks in duration which includes the time he is working on other tasks that have a higher priority. StructureCare would like the inspections and inspection reports to be automated and save the Field Engineer time. Their goal is to have a non Field Engineer conduct the inspections and have most of the inspection report finished before the Field Engineer has to look over it.

Patent & Literature Review

We performed a preliminary patent search to ensure that we are not in violation of any proprietary technologies. No potential conflicts were found, however we will be able to use off-the-shelf technology to help develop the robot, microphone, and chain device if needed.

Project Objectives

1. Cut the report generation time in half
2. Automate the report generation
3. Automate the site inspection process

Technical Approach

Identifying Needs of Customers

StructureCare is our customer and they have specific needs. They would like the inspection process at the site to take less time than it does now as well as the inspection report generation.They would also like us to come up with innovative ideas to incorporate into their needs.

Identifying Target Specifications

Our target is to cut down the inspection report generation time to one week. We will automate the inspection process and report generation as much as possible.

Generating Design Concepts

In order to generate design concepts our team had multiple meetings where we discussed possible solutions to StructureCare's problems. To generalize the most common problems encountered, we met with our sponsors on multiple occasions and had them walk us through the inspection process. After we obtained these common problems, we all generated possible solutions to each problem, analyzing each solution in turn and discussing the positive and negatives of each.

Selecting Design Concepts

The process of selecting our ideas involved talking amongst ourselves and getting advice from our sponsor. We talked to a variety of people at StructureCare to understand what was most important to them. Ultimately our group was able to eliminate one of our main ideas and focus on the other ideas. Our team will further eliminate parts of our ideas to tailor the solution as best as possible to our sponsor's needs.

Project Management

The project, tasks, meetings and important milestones are being accounted for in a Gantt chart that we have created. This Gantt chart allows us to stay organized and on top of meeting deadlines. It is also a great way to get an idea of how much the project has been completed. The full scope of the project can be seen in our Gantt chart in Figure 1.

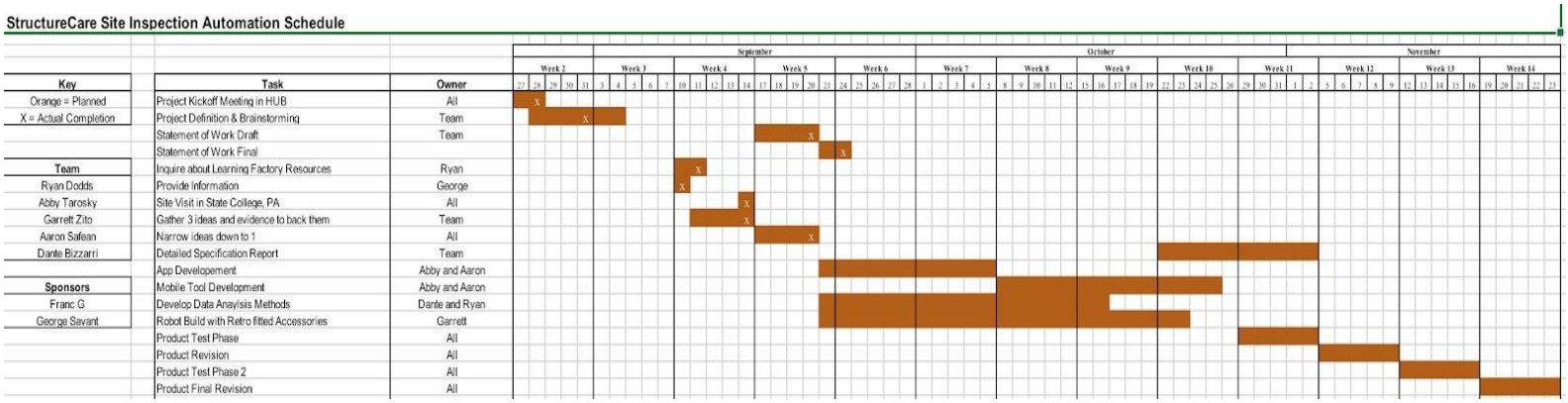

Figure 1: Gantt chart for the project. The solid bars indicate the portions of the tasks that have been scheduled while the white X's represent actual completion dates.

Deliverables

To fulfill the requirements our team will deliver three products which will all interact together. The first two products are a mobile application and a small robot which will automate the site inspection. The last product is a web based tool which will take information provided by the application and turn it into a report, automating the report process.

The first product our team will produce is an application. This application will allow the field agents to take images, select what type of problem is displayed in the image, rate the intensity of the problem, and mark the location of the image on the blueprint. The field agent will also have the capabilities to delete, edit, and sort images in the application. To develop this app, our team will be using Android Studio. To enable data to be shared between this mobile app and the web based tool our team will be implementing a database using PythonAnywhere or Firebase. This application should be completed by the 5th of October. In order to complete this application Aaron and Abby will be meeting to do work in the Davey Library. Once the application is complete, multiple parking garages downtown will then visited in order to test the features.

The next product is a robot that drags a chain around to decipher pitch changes in concrete. The robot will need to have multiple functionalities. First and foremost, it will be obviously required to drive or navigate the parking garage whether autonomous or

manually operated. Crumbled or raised concrete should not be an issue to navigate over or across. Secondly, the robot will need to be able to secure and drag the chain around the garage in a suitable orientation. The chain cannot become tangled or interfere with the functionality of the robot. Furthermore, there will need to be a some sort of sensor to detect and record the pitch. The most straightforward approach for this would be a microphone, but this will need to be tested. If the robot detects a pitch change then it will mark out the area where the change occurs either physically via spray paint or electronically onto the blueprint. The field agent can then come take pictures of these markings using the mobile application. This device should be completed by the 23rd of October.

The last product our team will be producing is a web based tool. This tool will use the tags given to the images in the mobile application to automatically generate the report and layout images and problems due to StructureCare templates. This tool will also enable drag and drop capabilities to allow the engineer to easily customize the report based on specific customer needs. This tool will either be developed in Javascript using a word or pdf API key or in XML through word add-ins. In order automate the description for each problem Dante and Ryan will be working with the database to analyze past reports and supply descriptions given in the past for similar problems. After this analysis is performed the tool will pull the results and insert them into the report. This tool will be completed by the 23rd of October. To develop this tool Aaron and Abby will be meeting in the Davey Library. To test our product from mobile application to web based tool, our team will meet with our sponsors on zoom and have them try out all the different features of both the mobile application and the web based tool.

Budget

Item	Cost	Justification / Description
Samsung Tablet	0 to group 150 to project	Bought by StructureCare
Robot	200	Rough estimate -- research pending
Long Chain	40	Locally sourced & inexpensive
Microphone	30	High quality microphone needed if possible
Bluetooth Connection Device	42	Needed to connect to the robot remotely
Database Hosting	20 / month	To ensure reliable data storage and enable more in-depth projects in the future
Poster for Showcase	62.24	Poster to display our project in a professional manner
TOTAL	**$374.24 + 20/month**	

Bill of Materials

- Samsung Tablet
- Long Chain
- Microphone
- Bluetooth connection device
- Robot
- Database Hosting
- Poster Board

Communication and Coordination with Sponsor

Our team's communication with the sponsor will interact at one video call conference meeting per week. This meeting should contain all of our team's thoughts, questions, concerns and new project ideas. By holding a weekly video conference call with the sponsor, it allows us to fully understand the project and eliminate possible confusion and miscommunication. Prior to video conference meetings, our team gathers our thoughts in a structured way so that the meeting is organized and efficient.

Aside from the weekly video conference, we are also given permission to contact our sponsor via call, text and email. Ryan Dodds has taken the responsibility of being the sole team member to contact our sponsor with questions and concerns. This is beneficial because it reduces confusion for our sponsor so we are all not contacting him at different times.

Team Qualifications

Abagail Tarosky is a senior Computer Engineer at Penn State. Abagail's experience both inside of and outside of the classroom has prepared her with valuable skills needed for this project. She has taken classes in application development and object oriented programming, which will enhance the mobile application and web based tool that will be developed. Abagail has also had multiple internships that coincide with either web based development or automation based tools, which gave her experience in producing industry level code.

Dante Bizzarri is currently a senior Industrial Engineer at Penn State. Dante's coursework is the foundation for most of his Industrial Engineering knowledge and qualifications. This can be seen under the "Relevant Course Work" section in his resume located in Appendix A. Aside from a strong background of data analytics and operations research, Dante is also proficient in interpreting blueprints, 3D modeling and understanding technical specifications in manufacturing. He is also certified to operate the HAAS VMC and CNC for machining purposes.

Garrett Zito is a senior Mechanical Engineer at Penn State. Garrett's experience in and out of the classroom have shaped his engineering thought process and given him valuable skills. Garrett has done both hands on machining and computer based 3D models in his internships. He has encountered a wide range of issues and worked with a wide variety of people. Garrett has a good knowledge of fundamental engineering principles. In terms of his strong suit for this project, he will be heavily involved with the oversight and design of the robot implementation.

Ryan Dodds is a senior in the Schreyer Honors College at The Pennsylvania State University studying Industrial Engineering and pursuing a minor in Supply Chain Management. He has supplemented his coursework with a study abroad experience in Pforzheim, Germany in addition to obtaining two process improvement focused

internships. In these internships he gained exposure to a Lowe's distribution center and an Owens Corning insulation manufacturing plant and he was able to provide impressive results in both roles. As the site inspection automation task is similar to a process improvement role, he believes he can offer innovative ideas and help the team excel on the final solution. Furthermore, his involvement in consulting organizations has taught him the soft skills required to be an effective communicator and ensure a customer is involved at every step of the process which is another useful skill for this project. In terms of relevant technical abilities, he has extensive experience at his most recent internship using VBA macros to manipulate data, which could play a key role in the report generation.

Aaron Safran is a senior in Computer Engineering at Penn State. His coursework, personal projects, and work experience make him a great fit for this project. While at Penn State, Aaron has already had experience working with outside companies to develop solutions for their problems. Also Aaron is proficient in object-oriented programming in several languages including C#, Java, and Python and he has solid experience with unit testing as well. With these skills and his passion for problem solving, Aaron will be major contributor to the development and testing of the mobile application and web tool.

Conclusion

Overall, our goal is to make the inspection process more efficient and streamline the inspection report. Currently, most of the inspection and report generation are manually completed. StructureCare would like us to automate as much of the process as possible. Each piece of our solution is aimed at making the inspection process easier, faster, and more accurate. The application, web based tool, and robot will all assist in automating the entire inspection process. The Team's qualities give us a well rounded knowledge base with extended industry experience, which will help provide the best solution possible to StructureCare.

References

Budget

Long Chain: www.walmart.com

Microphone: www.rakuten.com

Robot: www.robotshop.com

Data Housing: www.pythonanywhere.com

Bluetooth Connection Device:

https://www.amazon.com/LewanSoul-Controller-High-Capacity-Over-Current-Protection/dp/B073PZKLD2/ref=sr_1_5?ie=UTF8&qid=1537744518&sr=8-5&keywords=wireless+rc+controller

Research

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Computerized Hammer Sounding Interpretation for Concrete Assessment with Online Machine Learning. *Sensors* **2018**, *18*, 833.

Appendix A

(Résumés deleted)