CS 426: Software Engineering

Project Assignment 1

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Abstract
The project proposal will encompass a museum guidance robot with the focus on accessibility for participants through remote services or guided interactivity in place of human guides. The main purpose of this project is to address the current concerns regarding COVID-19 with the limit to the amount of participants and employees in the space. ADA museum guidelines will also be addressed to accommodate visual and auditory needs. This project intends to develop a functioning general use guidance robot to assist in various museum information delivery with web user interfaces for museums in the Reno-Tahoe area with a focus on those in the University of Nevada, Reno.

Project Description

The main goal of the project is to allow museum directors and curator personnel to have a hands-off approach in engaging with museum attendees in the perspective of tours. Our project utilizes a robot to autonomously guide museum goers and provide information and interactivity similar to a tour guide or docent. The intended audience for this project is mainly catered to the museum directors as it will offload their workload as well as provide an avenue to achieve tours during the pandemic and in the future allow for more interest in visiting the museum with the robot appeal. The project also hopes to help museum goers in terms of accessibility for certain ADA concerns to make the museum experience more inclusive for all people. Our team plans to focus on an interactive robot guide with object detection and routing alongside mobile interfaces for attendees to interact through questions with the addition of a web application to allow the curators to modify specific information for different exhibits within the museum via a map editor application. In terms of the physical robot technologies, ROS will be used for navigation and object detection and React will be a framework used for the mobile interface. The web application will utilize React as well for login credentials and the map editor pages. As for the backend, Python Flask is used to create schemas and routes for integrating the PostgreSQL database. For hardware components, we are currently awaiting the status of possible grants to obtain the Quori robot, but we intend to utilize the university's Pioneer's for testing. We are continuously ensuring that reliability, security, and safety is a top priority in our project through evaluating the structure of our databases. We are focusing on a login credential page to ensure only certain museum personnel can access the map editor page while the robot will also take into account collision prevention during testing.

Significance

The robotic docent project allows the team to grow as rising developers while establishing the basis for a large open-source project that enhances the social experience of museum touring. This project's goals align with our interests, so it is a natural fit for our team. Our senior project will further our professional growth as we will have to structure and design the system, learn the essentials of robotics, master new technologies, and work within an interdisciplinary team where some members have no experience with computer science. We will learn the technical and soft skills required to become a professional.

Applications of service robots are not relatively new; different industries have implemented mobile robotics with the goals of saving money, introducing novelty, and enabling telepresence. In the advent of COVID-19, few museums have focused on alternative methods to broadcast their exhibits; one museum in England has initiated robotic tours (Robot brings Hastings gallery art, 2020). The Hastings Contemporary museum essentially has a Segway with an iPad attached to it at the cost of 4000 U.S. dollars. Museum-goers can control the robot and cruise through the museum to examine every portion of the museum; however, it is possible to bump into tables. A digital tour also comes with a guidebook, access to a remote curator, and pre-recorded videos. Two indirect but similar robots include Penny—an autonomous food server robot—and Hilton's hospitality robot (Albrecht, 2020). Penny maps the restaurant and can deliver customer's orders in a timely and clean manner; the robot navigates tight spaces just like ours. The Hilton hotel worked with IBM to create the world's first hotel concierge with IBM's Watson software (Scott, 2017). The hospitality robot's goal is to personalize people's experience at the hotel.

From this, it is clear to see that the market for robots is on the rise. In 2019, the service robotics market was valued at 14.39 billion U.S. dollars with a compound annual growth rate of 25.34% over the next five years (Service Robotics Market). Furthermore, this rate is likely to be undervalued as the outbreak of COVID-19 has increased the adoption of service robotics such as robotics driven by contactless delivery. Quarantine and social distancing have also promoted the importance of telepresence. Our project will be open-source, so there is no concern about entering the market. Moreover, the open-source robotics technology will advance museums' ability to provide realistic digital tours and enhance the current state of museum touring.

Our technology will use an advanced robot body that is capable of more than moving around in a museum and broadcasting what it sees. Since our robot has more hardware capabilities than other museum robots, we can add additional features such as guest personalization along with pristine detection to avoid collisions. Moreover, we will provide a web application that allows guests to interact with the robot live. This project will continue after we graduate; our contribution provides a concrete starting point for future researchers to add more personality and customization to the robot's interactions with the public. Ultimately, our robot offers a clean and personalized way to go through a museum.

Legal and Ethical Aspects

As this is both a sponsored and open source project that will be continued to be worked on after our team is done, there are only a few potential legal challenges we have to address. We can’t rely on licensed solutions that would cost money or make it too difficult for other people to access. Also, the project will be given sensitive information from museum personnel, so we have to ensure that their data is properly secured.

Even with these legal challenges, we will still ensure a quality product to our sponsor. While this project is expected to develop after our team finishes, we are still working towards a fully functional project that people of multiple skill sets will be able to understand and add to. In order to do this, we are going to provide the robot, website, and mobile website fully functional and properly connected to each other. We are taking the necessary steps by doing daily stand-ups on weekdays, having proper communication between the robot and web development teams, and setting up realistic short-term and long-term goals. We are also regularly communicating with our sponsors to ensure that our progress is up to their standards and will be providing them documentation containing install instructions, general operational advice, and other important information.

Changes and Progress

Since starting our project in Fall Semester 2020, we have made substantial progress. So far, we have a simulated robot that is able to map and navigate a virtual environment and is able to communicate with our website to start a tour and query from its database. As our project is sponsored, many of our changes have been for the workflow and backend. We changed the structure of the database to be an easily accessible hierarchy (museum -> exhibit -> piece) with a separate part dedicated to tours. This allows the robot to now query portions of the database when needed instead of getting the whole thing all at once. Furthermore, we moved from developing a physical interface on the robot and instead are focusing on providing museum goers a mobile website separate from the main one. While a physical interface attached to the robot would be easiest, the purpose of the project is to accommodate museums during Covid-19, so the mobile website aligns closer with the project goal. As of now, we have no other planned major changes.

We have made several major developments coming into this semester. We have implemented the manual mapping system such that a user can operate the robot to generate an image of the map for both the user and the robot. Furthermore, we've implemented a navigation module in simulation and will only need some minor tweaking to be moved to the real robot. The website communicating with the robot can display the map of the robot, allow dynamic additions to the database, and has many of its frontend elements incorporated.

Project Responsibilities

We have split up our project into two main components: the web application and the robot. These two main components are managed by two team members each: Kyle Respicio and Sherman Lee manage the web application while Matthew Alighchi and Guillermo Del Valle manage the robot.

The two main components are further divided into two subsystems. The two subsystems for the web application are the front end and the server. The front end is being handled by Sherman Lee, while the server is being handled by Kyle Respicio. The two subsystems for the robot are the server that communicates with the web application and the application that is being used to communicate with museum goers. The server is being handled by Guillermo Del Valle while the interface for museum goers is being handled by Matthew Alighchi. These two subcomponents also tie into the general robot subsystem, which both Guillermo Del Valle and Matthew Alighchi are responsible for.

Sherman Lee is responsible for ensuring that the front end is responsive and displays all the information that is required while also communicating with the server. Kyle Respicio is responsible for setting up the database, creating the paths for the database and all functionality related to keeping the server up.

Guillermo Del Valle and Matthew Alighchi are both responsible for ensuring that the robot navigation system works properly. Guillermo Del Valle is responsible for the connections to the web application server and ensuring that the robot can query and display data properly. Matthew Alighchi is responsible for implementing the user interface that will allow museum goers to interact with the robot.

Project Monitoring and Risks

We plan to monitor the project's progress by adapting the scrum framework. We have daily standups where we update each other on the progress of our work and let each other know what we will work on. Additionally, we have set up an agile board which we update daily with new tasks and an overarching goal for the week.

We have also identified eight risks that might occur during development. The risks are as follows: accessibility to the robot and museum space, the museum space might be unfriendly to the robot, the robot software might have compatibility issues with available platforms, the robot might be limited in its actions, there might be issues troubleshooting erroneous behavior in action, manually fixing the robot's error state, communicating information to museum goers about how the robot operates and a reliance on web services and wireless internet.

For the first risk, accessibility to the robot and museum space, we are in constant communication with the museum team. Due to COVID-19, there are some difficulties in getting the team to work physically with the robot in the museum. We have developed a plan to minimize the amount of team members required to be with the robot at once and are planning to record our sessions with the robot so we can work on it in a COVID-19 safe environment.

For the second risk, the museum space being unfriendly to the robot, we are planning to develop a plan with the museum directors in order to have visual cues for the robot in order to help it navigate. Additionally, we plan on looking at ways to finetune the navigation in order to minimize the potential for the robot to bump into objects.

For the third risk, the robot software being incompatible with available platforms, we plan on talking with the museum directors and getting familiarized with the equipment and platforms that they have available, so we can develop the robot with a multiplatform approach in mind.

For the fourth risk, the robot being limited in its actions, we are planning on restricting the actions that the robot can do for now but leave the possibility to add more actions later on. While we would like to add as many actions as possible, it's important to restrict the actions that are implemented while leaving the option to add more.

For the fifth risk, there being troubleshooting issues with the robot, we plan on leaving extensive documentation with all of the issues that we believe might occur. We are planning on implementing an error state in the robot that asks for manual assistance from museum staff. This leads to the sixth risk which is the fixing of the error state. We will not be available to fix errors during runtime, so we have to train someone that can fix these errors as they occur.

For the seventh risk, communication with the museum goers about how to interact with the robot, we plan on creating easy ways to access the robot interface, including tools such as QR codes. We also plan on leaving documentation for museum personnel on how to guide museum goers on using the robot.

For the eighth risk, a reliance on web services and wireless internet, we are planning on having safety measures in case the robot loses connection to the internet. One of these safety measures is a "look ahead" cache, where the robot loads the information it needs for a tour a few pieces in advance. We are currently planning to add more safety nets just in case the robot can't reach the internet, but have not fully fleshed them out. Below is the risk register.

Risk Register											
Risk ID	Risks	Current Risk			Status	Owner	Raised	Mitigation Strategies	Residual Risk		
		Likelihood	Impact	Severity					Likelihood	Impact	Severity
Category 1: Project resources											
RP-01	Accessibility to robot and museum space	5	10	8	Open	Guillermo	08-feb	Coordinate with museum directors Make a strict schedule for robot	3	5	6
RP-02	Museum space unfriendly to robot	4	10	10	Open	Matthew	08-feb	Utilize a camera to stabilize navigation Fine tune navigation	3	6	6
RP-03	Robot software might have compatibility issues with available platforms	3	7	8	Open	Kyle	08-feb	Find the platforms the robot will run on Develop with a multi platform approach	2	5	5
RP-04	Robot might be limited in its actions	7	5	6	Open	Matthew	08-feb	Plan to make the software extendable to add more actions	7	4	4
Category 2: Infrastructure issues											
RP-05	Troubleshooting error behavior	10	10	10	Open	Kyle	08-feb	Create extensive documentation to help museum crew troubleshoot	10	4	4
RP-06	Manually fixing robot's error state	10	10	10	Open	Guillermo	08-feb	Train museum personnel on how to fix the robot in it's error states	10	4	4
RP-07	Communicating information to museum goers	6	8	8	Open	Sherman	08-feb	Include easily accessible tools, like QR codes, for museum goers and brief personnel on interactions	4	3	3
RP-08	Reliance on web services and wireless internet	10	10	10	Open	Sherman	08-feb	Create safety measures, such as caches, that the robot can rely on in case of internet failure	10	6	6

Fig. X: Risk register

Project Related Resources

Alighchi, M., Del Valle, G., Lee, S., & Respicio, K. (2020, October 19). *CS 425: Software Engineering Project Assignment 1* [Scholarly project]. Retrieved February 12, 2021.

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Service Robotics Market Valued at 14.39 Billion in 2019: Growth, Trends, Forecasts (2020-2025). (n.d.). Retrieved October 20, 2020, from https://www.mordorintelligence.com/industry-reports/service-robotics-market

Contribution Worked on Project Concept
Matthew worked a total of 1 hour and 30 minutes on the Legal and Ethical Aspects and Changes and Progress since the Initial Project Concept.
Guillermo worked a total of 2 hours and 30 minutes on Project Responsibilities and Project Monitoring and Risks
Sherman worked a total of 1 hour on the Cover Page, Abstract, Project Description, and formatting.
Kyle worked a total of 1 hour and 30 minutes on Significance.