Infrastructural Scanning Guide and Data Collection Tool

CSC 486: Human-Computer Interaction

Winter 2020

Professor Franz J. Kurfess

In collaboration with Digital Transformation Hub & World Bank

Team: H-C-Eye On The Prize
Sydney Nguyen, Matthew Patacsil, Andre Viloria, Gabriel Medina-Kim, Joshua King, Nathan Tu

Schedule

Week	Goals/Deadlines
Jan 21 (Tue)	Project Overview Due By class
Jan 23 (Thur)	NON PROJECT (A1 Due By class + Research Proposal Due by class)
Jan 28 (Tue)	Features, Requirement, Evaluation
Jan 30 (Thur)	NON PROJECT (A2 Due By class)
Feb 4 (Tue)	System Designs: Mockups, etc
Feb 6 (Thur)	NON PROJECT (RESEARCH: Extended Outline Due)
Feb 11 (Tue)	
Feb 13 (Thur)	Mid Project Display
Feb 18 (Tue)	Prototype 1 Due
Feb 20 (Thur)	NON PROJECT (A3 Due by class)
Feb 25(Tue)	Implementation Document Due
Feb 27	NON PROJECT (RESEARCH: Draft Version Due)
March 3(Tue)	User Feedback and Validation
March 5	Design Revisions
March 10(Tue)	Project Documentation Due + RESEARCH: Final Version Due
March 12	Final Project Display

Week 1 - Create teams and research topic ideas
Week 2 - Finalize topic and set specific tasks to evaluate
Week 3 - Project Overview and Schedule Document
Week 4 - Features, Requirements, and Evaluation Document
Week 5 - Complete System Design and Architecture
Week 6 - Begin collecting user feedback
Week 7 - Finish Implementation Document
Week 8 - Revise or expand Experimental Setup if needed, Continue study
Week 9 - Carry out design revisions if needed, Finalize Conclusions
Week 10 - Finish Project Documentation and create Final Project Display

Project Overview

The World Bank's Global Program for Safer Schools (GPSS) aims to design and implement large-scale investments to improve the safety and resilience of school infrastructure in developing schools. The process of collecting data about building infrastructure is costly due to specialized engineers, public safety, and the lack of geographical proximity of schools. This research proposes a mobile camera-based application to guide non-technical users in collecting the necessary photo-documentation for infrastructural assessment. By integrating human-computer interaction design principles, such as mental models, user interfaces, and sensory behavior, this research explores creating an intuitive user interface that informs non-technical user's mental models with the expert knowledge of structural engineers, architects, and similar related fields.

Background and Related Work

Disasters have profound impacts on schools and, in turn, on children's education and lives. With an estimated 875 million children exposed to earthquake hazard worldwide, there is an urgent need to provide safer and resilient school infrastructure for children. To address this issue, the Global Program for Safer Schools (GPSS) of the World Bank is supporting developing countries to design and implement large-scale investments to improve the safety and resilience of school infrastructure and the quality of learning environments.

One of the biggest challenges of this program in developing countries is the lack of high-quality data about school building inventory, and the absence of efficient mechanisms to update and manage this information. The data collection process to assess school infrastructure is commonly done through field inspections conducted by engineers, which are usually costly and time-consuming. Therefore, innovative and more efficient approaches to collect baseline data are essential to strengthen the capacity of developing countries to scale up safe school activities.

To facilitate the development of high-quality school infrastructure baseline at scale, the GPSS has developed a tool --Global liberty of School Infrastructure (GLOSI). It provides a global catalog of classified structural typologies of school buildings with vulnerability curves and salable vulnerability reduction solutions. This classification is at a building level and consists of parameters such as the structural system, number of stories, irregularities of the building, among other structural parameters that influence the performance of the building under an earthquake.

Difficulty

The services widely used today are field inspection, that require mobilizing and building under and training teams of experienced engineers to collect key information about building structure for each building of each school facility at a national level. Several limitations include:

- A nationwide field inspection can be costly and time-consuming, reducing the outcome that can be achieved with limited resources
- School buildings tend to have more standard designs, and therefore can be grouped into clusters (i.e. structural typologies) with similar vulnerability based on similar visual features. Given this fact, there is no need to have engineers inspect every school building countrywide; instead, detailed inspection on a representative sample
- There could be bias and inconsistency in classification of structural typologies performed by engineers. This requires quality control every time when field inspection is conducted, which reduces the efficiency with uncertainty of the data processed.

The technical challenges for this project will be working together with the clients from the Cal Poly Digital Transformations Hub to integrate a focus on human-computer interaction to assist them in solving real world problems. Though the problem presented to us does not directly involve human-computer interaction, this research will explore the development of a possible tool to assist the collection of data with a focus on accessibility and user experience design. The goal is to create an intuitive tool for anyone to use, regardless of their education or knowledge of the subject matter.

Relevance

Mental Models

Our proposed application will be creating a mental model to help users understand potential defects and problems within school infrastructure. The application's capabilities will depend on the expertise of those who are able to troubleshoot these problems in order to transfer knowledge to our users. By interacting with our system, non-technical users will be able to better understand how their school infrastructure functions while also being able to detect potential problems before they happen.

Interaction with Mobile Devices

Since we're emphasizing an app where anyone from an adult to a kid can use, our app will heavily incorporate HCI themes to ensure an intuitive and easy to use experience for the users. Users will interact with the camera and screen to take pictures of potential damage of buildings.

Users will also interact with the program and follow the directions in order to take quality damage control pictures to send to the database.

With mobile devices being a common form of technology across the world, we believe that this will provide an easy learning curve for all of our users. Since the main functionality of our application is based on picture taking and data collection, the only variance we will need to have across the world is the type of language in the tutorials.

UX/UI Design

This app will feature an interactive design with intuitive navigation and screen organization. By utilizing affordances to indicate how the user can interact with the application, the users will be guided in capturing the necessary data. By experimenting with different UX design choices such as supporting swipe controls to navigate or using auditory feedback, we can determine what works best for the purposes of our application.

Through several iterations and testing, the application utilizes UX practices that would be most beneficial to the users. The expected users will vary in technical background so pinpointing an exact demographic reamined difficult. Therefore, the app caters to many of the usability heuristics accepted in the UX/UI community in order to stay flexible for those of all skill levels and experience.

Features

The purpose of this project is to develop a tool that can be used to augment the collection of photos for the classification and detection of infrastructural vulnerabilities for the schools in areas where natural disasters are likely to occur. This tool will be used as a guide for the users to capture valuable photos to be uploaded for the detection of these vulnerabilities.

The main features of our tool will include:

- **F1** Inform the user about the purpose of the application.
- **F2** Retrieve the user’s location.
- **F3** Instruct the user to take photos of the infrastructure of the buildings.
  - **F3.1** Show example photos. (Good vs bad photos)
- **F4** Allow users to take photos.
- **F5** Allow users to caption their photos with useful information (typology).
- **F6** Allow upload of the photos along with necessary data.
- **F7** Uploaded photos are categorized by analyst or machine learning algorithm.
- **F8** Application can work offline.

Requirements

In order to be effective, our application will require:

- **R1** The cost of distribution and use is less than sending a specialist out to take pictures/notes themselves.
- **R2** Give clear/concise instructions for user to take useful photos for data collection. (F3)
- **R3** Collect necessary metadata. (F2)
- **R4** Allow the user to input any extra data. (F5)
- **R5** Provide a database to consolidate uploaded photos. (F6)
    - **R5.1** Categorize photos by location, typology, etc.
    - **R5.2** Allow editing of categorization or removal of duplicate photos.
- **R6** Analyst or machine learning algorithm. (F7)
    - **R6.1** Determine the condition of the infrastructure given the provided data.
    - **R6.2** Report areas of danger.
- **R7** Allow users to take pictures in “offline mode.” (F8)

Evaluation Criteria

Evaluating this project involves studying how easily users of different education levels and technological experience can navigate the mobile application and if they can capture useful photos with little to no prior knowledge of what they are looking for.

In evaluating our tool, we will look at:

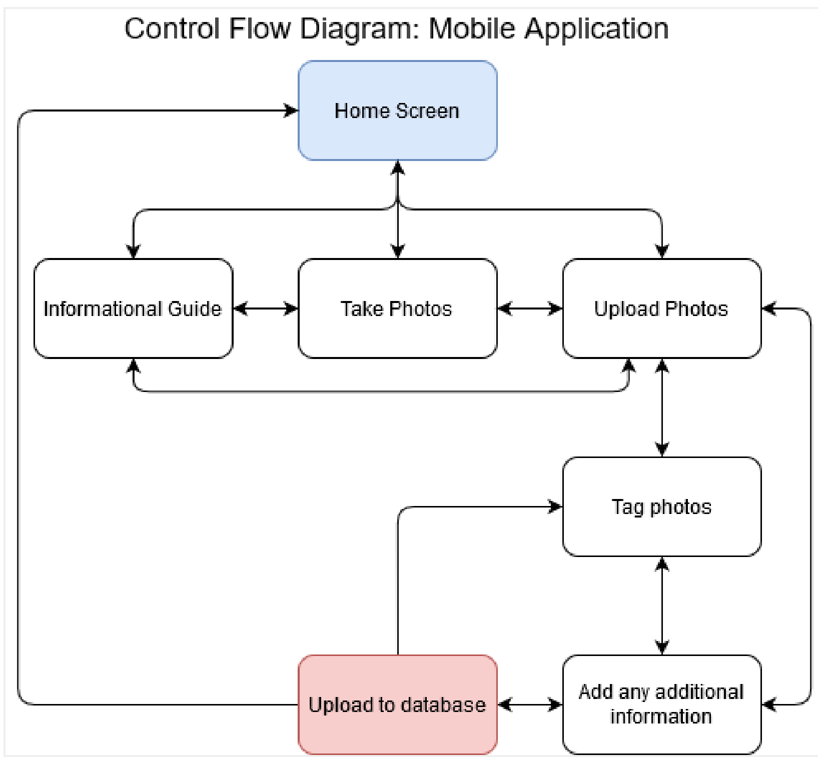
- **E1** Is the cost of the app development and use is minimal. (R1)
- **E2** Does the user understand what the application is used for? (R2)
- **E3** Can the user navigate the application intuitively?
- **E4** Can the user take valuable photos for data collection? (R2)
- **E5** Can the data be exported in a format that is usable to an analyst or engineer? (R6)
- **E6** Can the user label a picture for a given label? (R4)
- **E7** Can the user label a picture with a custom label? (R4)

System Design and Architecture

Overview

Our project involves creating a mobile phone app for the user to become primed and prepared to take photos of the buildings. The app will then instruct the user to take the photo and include any additional information that may be useful for the classification of the structures. These photos are then uploaded to a database to be analyzed and categorized into areas where vulnerabilities must be addressed.

The following diagram outlines the flow of user navigation through the various screens:



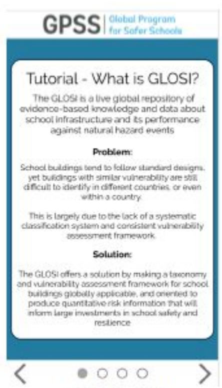
Implementation

Overview

We used the UI and UX design application Figma to prototype and provide a possible representation of what the final product of our app could look like using the flowchart we created in System Design. The schools that need structural review will be located in third world countries around the world. Taking this into account, we plan our app to not be too reliant on hardware since schools will most likely not have up to date phones with amazing cameras. To add to this, we also plan to provide different language options according to the schools under the World Bank's supervision. One implementation problem that may come up with providing multiple languages are the margins and how the app appears. Words in one area of our app that may appear easily visible in one language may appear too small, cluttered, or even cut off if we don't plan accordingly.

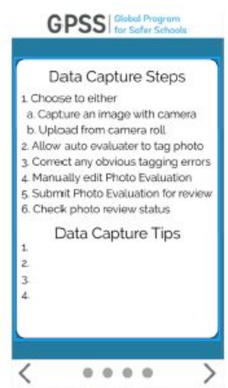
Initial Wireframes:

1. Home



1.1 Tutorial

1.2 Tutorial



2. Data Capture

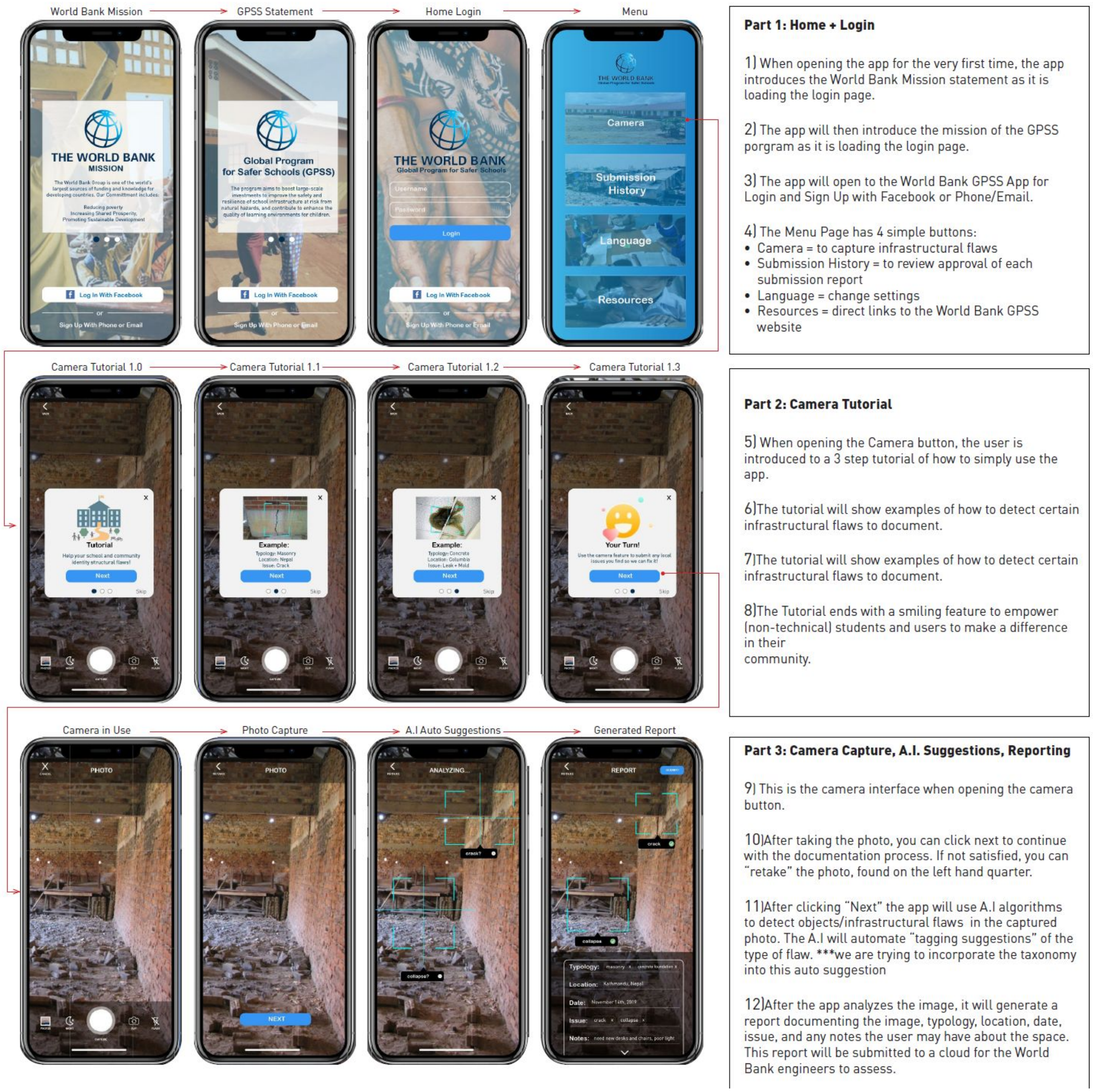
3. Data Collection

3.1 Camera

4. Taxonomy Analysis

4.1 Pop Up Description

Iteration 1: Wireframes and Mock-Ups



Validation and Evaluation

After creating our first iteration of our project, we constructed a Google Form survey to gather user feedback. This version of our mock-up only covers the home screen, login, camera tutorial, and photo submission, so our survey asks the participants to provide feedback on the actions that they can perform. The survey was posted online for other Cal Poly students to voluntarily answer questions that asked them about the mock-up after having them interact with it for a few minutes.

To make sure that we are in line with the previously described evaluation criteria, the participants were asked questions about what they believe the goal of the application was, what they believe the minimum age group that would be able to understand and navigate the app, and how they would make changes to the application to provide a better user interaction experience.

User Feedback

We obtained 10 responses for the application, with 50% of the participants in the 18-20 years old age group a 50% in the 21-23 years old age group. There was at least one representative from five of the six colleges at Cal Poly, with no response from the College of Architecture and Design.

The general consensus for the free-response question of what the participant believes the goal of the application is shows that the provided mock-up was successful in describing its purpose to the users without them needing any prior knowledge of the subject. The goal for our application was to provide an experience for school-age children to be able to understand and contribute to the data collection, and when asked what the minimum age group that would be able to understand and navigate the application, the majority of the answers were for the 11-14 years old group. When asked how to improve usability, the participants described that there may not be enough information to describe what exactly the user should be looking for when using the app and taking photos. The users also pointed out that because our mock-up was still a work in progress and did not include all the functionality, there was a lack of actions that they were able to perform.

This information shows us that there is a potential for the creation of a user-friendly, simple application that can be published for school children to use and send valuable data for the Global Program for Safer Schools to utilize in their efforts to keep buildings safe for the students.

Conclusion

The problem brought forward by the World Bank involved innovating methods related to the collection of data with the aim of creating a building infrastructure database to assist in disaster preparedness. Our team approached this issue with the focus of understanding how we can alleviate the costly process of sending specialized engineers out to schools with such great distance between them. By integrating human-computer interaction design principles, such as mental models, user interfaces, and sensory behavior, our research explored creating an intuitive user interface that informs non-technical user’s mental models with the expert knowledge of structural engineers, architects, and similar related fields. We found that our second attempt at creating a user friendly interface was much better than the first. Our second attempt also allowed us to flesh out a design that was easier on the eyes than the initial prototype wireframe. If our team had more time we would love to explore more ideas that would integrate camera scanning technologies, such as a 3D room scanner, AR/VR environment rebuilder, and using GAN algorithms to convert 2D images into a 3D model.