# 3  Design

## 3.1 Design Context

### 3.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address?

List relevant considerations related to your project in each of the following areas:

| Area | Description | Examples |
|---|---|---|
| Public health, safety, and welfare | How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or indirectly affected (e.g., the solution is implemented in their communities). | Increasing/reducing exposure to pollutants and other harmful substances, increasing/reducing safety risks, increasing/reducing job opportunities |
| Global, cultural, and social | How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures. | Development or operation of the solution would violate a profession's code of ethics, and implementation of the solution would require an undesired change in community practices |
| Environmental | What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable materials manufacture or procurement practices. | Increasing/decreasing energy usage from nonrenewable sources, increasing/decreasing usage/production of non-recyclable materials |
| Economic | What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups. | The product needs to remain affordable for target users, creates or diminishes opportunities for economic advancement, and high development cost creates risk for the organization. |

**Public health, safety, and welfare**

> The project does not have an immediate, crucial impact on our stakeholder's health and well-being aside from providing convenience in their current processes. The number one goal of the project is to improve the efficiency of the user's pumpkin tracking, which in return can eliminate or reduce their stress and frustration.

**Global, cultural, and social**

> The final web application product will potentially improve the work processes for the Reiman Gardens volunteer group. The hope is that volunteer practices geared toward the annual Halloween event will be more efficient and desirable.

**Environmental**

> The project does not have any major environmental impact. Users will just utilize the final project as a desktop or mobile web application, which does not directly contribute to environmental hazards.

**Economic**

> An economic concern that needs to be watched carefully is server cost. The project needs to use web resources in such a way that cost is as minimized as possible. As a result, the size and frequency of server requests should be carefully assessed during development.

## 3.1.2 User Needs

List each of your user groups. For each user group, list a needs statement in the form of

User group needs (a way to) do something (i.e., a task to accomplish, a practice to implement, a way to be) because of some insight or detail about the user group.

1. **Volunteer Admins** need to initiate a new event for the upcoming year, specify how many weeks the event will be, and enter, modify, and delete stencil information: to efficiently manage and organize the Spirits in the Gardens event. They need to select stencils for the upcoming event, print all stencils that were not brought back for cutting, search for any stencil by its code, and update stencil status: to ensure all stencils are available and ready for the event. They also need to view stencils' information and sort or categorize stencils: to maintain the quality of the event and ensure smooth operation.

2. **Volunteers** need to search for any stencil information by entering its code, submit a status update on the pumpkins showing whether they are traced or carved for the admins to approve, take a picture of the carved pumpkin, and get information about its stencil: to easily and effectively trace and carve pumpkins.

3. **Visitors** need to recognize the stencil that was carved on the pumpkin by using their cameras with AI, find more information about the stencil, including its title, category, source, etc., and vote for the most liked stencil/pumpkin: to enjoy and engage in the Spirits in the Gardens event.

## 3.1.3 Prior Work/Solutions

Include relevant background/literature review for the project

– If similar products exist in the market, describe what has already been done

– If you are following previous work, cite that and discuss the **advantages/shortcomings**

– Note that while you are not expected to "compete" with other existing products/research groups, you should be able to differentiate your project from what is available. Thus, list the pros and cons of your target solution compared to all other related products/systems.

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

Our project has been specifically designed to meet the needs of our customers, and currently, there is no similar software available in the market. While a previous group of computer science majors has attempted a similar project, they only completed a sample product with a low level of completion, and we have not considered reusing their ideas.

If our group completes this web application, we anticipate the following advantages and disadvantages:

- ❖ Advantages:
  - ➢ A visually appealing and user-friendly interface.
  - ➢ Fewer operational steps and time saved compared to using pure excel spreadsheets.
  - ➢ Comprehensive application where the admins can manage the event besides simply keeping track of the pumpkins.
  - ➢ Platform-independent solution for the volunteer side use, i.e. both iOS and Android users can access the app.
- ❖ Disadvantages:
  - ➢ The AI recognition system may not be completely accurate.
  - ➢ The server may require significant resources when there are many visitors.
  - ➢ Hosting the Spirits in the Gardens event may cost more than it did before.

## 3.1.4 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles  –AND–
2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

Our project is of sufficient technical complexity based on the following metrics:

The project's design consists of two main components: front and backend. The frontend handles user interactions and displays information, while the backend processes and stores information. Additionally, we plan to integrate AI to identify stencils engraved on the pumpkin, a complex problem requiring extensive research.

The problem scope contains challenging requirements that match or exceed current solutions or industry standards. The project aims to create a web application instead of a mobile app to reduce maintenance costs and increase user convenience. The system will allow volunteers to update information directly into the system by phone, reducing the time and effort required for manual updates. We will also classify which system functions are used by which users to simplify operations. Furthermore, the project prioritizes research to complete the system's main functions before integrating AI for stencil identification.

## 3.2 Design Exploration

### 3.2.1 Design Decisions

1. Using React with Next.js for frontend/backend development.
2. MySQL will be used as a database management system.
3. Extending the app's intended users to include volunteers.
4. Developing web application over Android or iOS native application

### 3.2.2 Ideation

Using React/Next.js for frontend/backend development:

1. React with Next.js: We chose this option because of its popularity and ease of use, especially for building server-rendered React applications. This option also allows for easy code sharing between the client and server.

2. Angular: Angular is a popular JavaScript framework that offers robust features for developing scalable and dynamic web applications. However, we opted not to use it due to its steep learning curve and the team's lack of experience with the framework.

3. Vue.js: Vue.js is another popular JavaScript framework known for its simplicity and performance. However, we felt its ecosystem and community were less mature than React's, making it less suitable for our project.

4. Django with Python: Django is a Python-based web framework that offers many built-in features for web development, such as authentication and routing. However, we felt this option would be less flexible than React with Next.js.

5. Ruby on Rails: Ruby on Rails is a web framework designed for rapid development and known for its convention over configuration approach. However, we did not choose this option because the team lacked experience with Ruby.

### 3.2.3 Decision-Making and Trade-Off

To identify the pros and cons of the ideated options for our project's frontend and backend development, we used a decision matrix, which helps compare different options based on their criteria.

We identified the following criteria for our decision matrix:

1. Popularity and community support
2. Ease of use and learning curve
3. Performance and scalability
4. Features and capabilities
5. Compatibility with other technologies used in the project
6. Team's Familiarity

We then assigned a weight to each criterion based on its importance to the project. The weight scale ranged from 1 to 5, with 5 being the most important. We assigned the following weights to the criteria:

1. Popularity and community support: 5
2. Ease of use and learning curve: 4
3. Performance and scalability: 4
4. Features and capabilities: 3
5. Compatibility with other technologies used in the project: 2
6. Team's Familiarity: 5

Here are the results of our decision matrix:

| Option | Popularity and Community Support | Ease of Use and Learning Curve | Performance and Scalability | Features and Capabilities | Compatibility with Other Technologies | Team's Familiarity | Total Score |
|---|---|---|---|---|---|---|---|
| React with Next.js | 5 | 4 | 4 | 5 | 5 | 4 | **102** |
| Angular | 4 | 3 | 3 | 4 | 4 | 2 | 74 |
| Vue.js | 4 | 4 | 3 | 4 | 5 | 3 | 85 |
| Django with Python | 3 | 4 | 4 | 3 | 4 | 2 | 74 |
| Ruby on Rails | 3 | 3 | 3 | 3 | 3 | 1 | 59 |

Based on the results of our decision matrix, we chose to use React with Next.js as the best option for our project. It had the highest score of **102**, indicating that it was the most suitable option based on our criteria.

## 3.3 Proposed Design

Discuss what you have done so far – what have you tried/implemented/tested?

Our team has made significant progress toward developing the web application. We began by creating a detailed Figma design for the volunteers and admin website, which helped us to visualize the different features and functionalities required for the system. We have also implemented a user-friendly UI for

volunteers and established a reliable connection to the database on the server. We are still in the design phase and discussing with customers, so we have not been able to test any functionality of the project.

## 3.3.1 Design Visual and Description
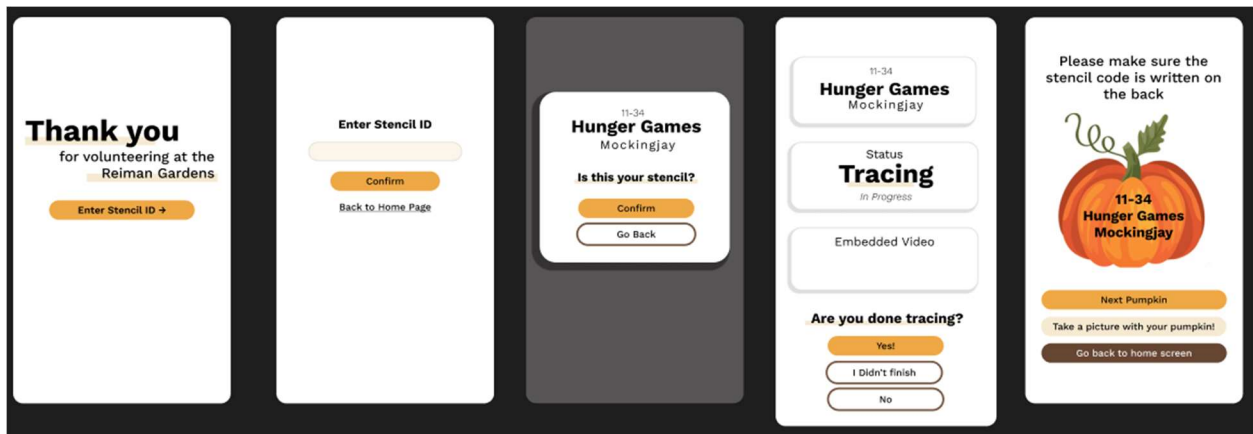
The image above is our current user interface design for our project's Volunteer Stencil Logging part. The first screen is the homepage. Volunteers will be given a URL to access during pumpkin tracing/carving days. Users can enter the stencil ID they have chosen to trace or carve. Then, they will be directed to a confirmation page. Then, the fourth screen will be shown. Here, users can see the current status of the stencil they are working on, and they can update the status of their stencils as they finish. Finally, if the volunteer has finished tracing or carving, they can move on to the next pumpkin, where they will enter a stencil ID again (second page).

This process is further detailed and/or visualized in the activity diagram below.
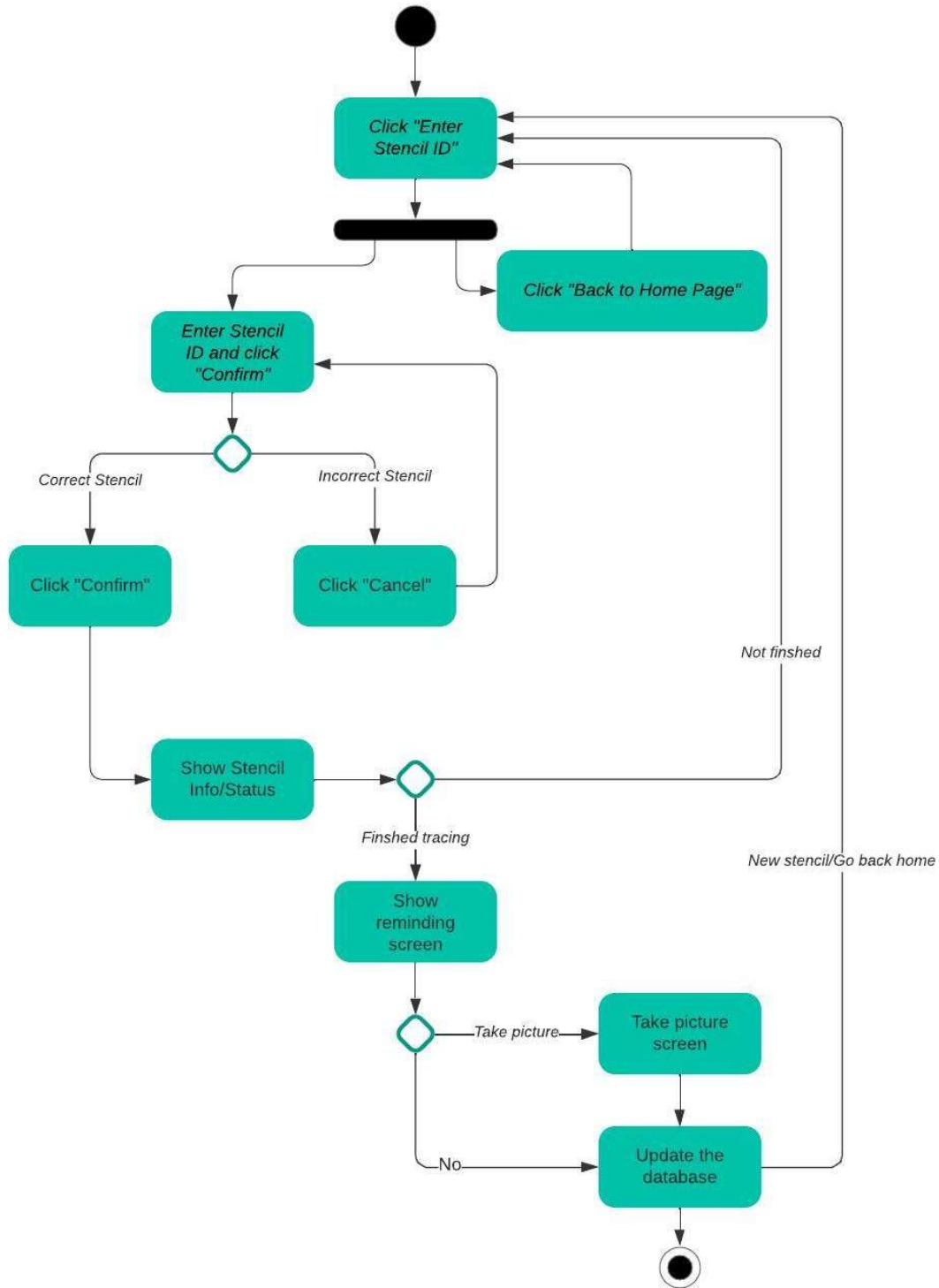
### 3.3.2 Functionality

Describe how your design is intended to operate in its user and/or real-world context. This description can be supplemented by a visual, such as a timeline, storyboard, or sketch.

The final project will be divided into three parts: stencil management for admins, stencil logging for volunteers, and stencil recognition for visitors.

- Admins will use the app during the event preparation. They will access the application through a web browser on their desktop. They will be able to add and edit stencil information as needed.
- Volunteers will use the app during the event preparation days for pumpkin tracing and carving. They will access the app using mobile browsers to update the status of their chosen stencils. If they don't have phones, the admins will update the pumpkin stencil status.
- Visitors will use the app during the Spirits of the Garden event. While strolling through the Jack-O-Lanterns, visitors can use their mobile browsers to access our site, where they can use their cameras to take a picture of a pumpkin, and they will be able to see information about which a jack-o-lantern utilizes a stencil.

## 3.3.3 Areas of Concern and Development

Based on your current design, what are your primary concerns for delivering a product/system that addresses requirements and meets user and client needs?

What are your immediate plans for developing the solution to address those concerns? What questions do you have for clients, TAs, and faculty advisers?

1. Primary concerns: Our main concern is the complexity of the UI for the admin website, as it requires significant effort to develop. In addition, we have doubts about the effectiveness of the AI camera feature, which may not be feasible to implement in the project.
2. Immediate plans to address the concern:
   a. Conduct user testing sessions with volunteer admins to gather feedback on the UI and identify areas that need improvement.
   b. Simplify the UI design to make it more user-friendly and intuitive.
   c. Integrate user feedback and make necessary adjustments to the UI.
   d. Explore alternative technologies to the AI camera, such as GPS location and mapping, and determine the feasibility of implementing them in the project.
   e. Research GPS mapping technologies and integrate them into the application, enabling visitors to see their location in the event and information about the pumpkins in the surrounding area.
3. Questions for clients, TAs, and faculty advisers:
   a. What are your thoughts on substituting the AI camera function with GPS location and mapping? Is this a feasible alternative?
   b. What alternative technologies or approaches could we consider to simplify the admin UI and make it more user-friendly?
   c. How can we ensure that the system meets the needs of all stakeholders, including admins, volunteers, and visitors?
   d. What features or functionalities should we prioritize to ensure the project's success?
   e. How can we effectively test and evaluate the system to ensure it meets all requirements and addresses user and client needs?

**NOTE: The following sections will be included in your final design document but do not need to be completed for the current assignment. They are included for your reference. If you have ideas for these sections, they can also be discussed with your TA and/or faculty adviser.**

## 3.4 Technology Considerations

Highlight the strengths, weaknesses, and trade-offs made in technology available.

Discuss possible solutions and design alternatives

## 3.5 Design Analysis

– Did your proposed design from 3.3 work? Why or why not?

– What are your observations, thoughts, and ideas to modify or iterate over the design?

## 3.6 Design Plan

Describe a design plan with respect to use cases within the context of requirements, modules in your design (dependency/concurrency of modules through a module diagram, interfaces, architectural overview), and module constraints tied to requirements.