4 Design

4.1 Design Context

4.1.1 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?

We are designing our product for use by local governments in combination with utility/energy companies.

The community that will use our product is limited to people with access to power grid information and the responsibility to perform maintenance on the power grid and prevent/restore outages.

The communities affected by our design are endless. Nearly everyone in the United States relies on electricity provided to them by the power grid, so any impact that our product can make on ensuring that the power grid stays healthy will impact millions of people.

Our project addresses the need for more oversight and visibility into the health of the power grid that is nearly non-existent right now. The more data you have to see how the grid is doing, the better you're able to address the issues and prevent them in the future.

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 may be indirectly affected (e.g., solution is implemented in their communities)* There are innumerable public safety benefits to ensuring normal power grid operation. While our project would not solve problems directly, early detection of developing issues in the grid could be the difference between a normal winter storm and the infamous 2021 Texas power crisis.	*Increasing/reducing exposure to pollutants and other harmful substances, increasing/reducing safety risks, increasing/reducing job opportunities* Hospitals and the patients within are dependent on the many systems within functioning correctly. While they have on-premises generators, these are only stop-gap solutions to short-term outages. Also, in the summer air conditioning units are critical for public safety, especially the elderly. Heat waves can be deadly, and badly-timed grid disruptions in the past have shown this.

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.* Our project reflects the values and practices of the cultural groups very well. It's not limited to nations, workplaces, etc because it touches everything. Our project would predict power outages, and stop it from happening, thus giving societies the freedom to carry on with their existing norms and practices.	*Development or operation of the solution would violate a profession's code of ethics, implementation of the solution would require an undesired change in community practices.* During the Chinese New Year celebrations, our project will help ensure abrupt power outages shan't occur thus allowing for this cultural tradition to go on.
Environmental	*What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.* This project will decrease energy usage from nonrenewable sources. Catching anomalies early can reduce the need for fossil fuels to fill energy gaps caused by them.	*Increasing/decreasing energy usage from nonrenewable sources, increasing/decreasing usage/production of non-recyclable materials.* For example, power disruptions may lead to businesses and organizations activating inefficient, diesel power generators host on-premises. Disruptions may also affect the ability of private solar power generators to provide excess power to the grid, negating any positive effects of these systems.
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.* This project will save energy companies and local governments money by preventing power outages and other grid issues as well as increasing the speed at which issues can be resolved. This could cause energy companies to downsize if the project is successful enough because they will need less technicians.	*Product needs to remain affordable for target users, product creates or diminishes opportunities for economic advancement, high development cost creates risk for organization* For example, if the power grid goes down, local coffee shops will not be able to process their credit card transactions. This is just a small example, but shows how many places are impacted economically by outages of the power grid.

4.1.2 Prior Work/Solutions

Include relevant background/literature review for the project

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

OpenDSS is currently a software used to provide insights to the power grid, but it is only available as a desktop application and is a very bulky program. It allows you to see the grid based off of existing datasets, toggle through different types of electricity(single phase vs three phase), and filter by types of users.

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

The previous work is a great start, but it's hard to access and inefficient. It is only available as a desktop application, so it can't be accessed remotely via any web browser, which is a goal of our project. A website that implements that kind of functionality would be a great asset to all utility companies and local governments. Second, since it's not web based, it requires a great amount of processing power and local machine usage to run. With a cloud based web application, it takes all of the load off of the user and puts it on the backend, making it easier to use for the end user.

– 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, provide a list of pros and cons of your target solution compared to all other related products/systems.

PROS

- Our project is sponsored by Iowa State University, and we have a powerful server (one of the best in the US) meant just for us. We also have great resources like Virtual Machines with 4TB space, GCP, an experienced client/professor, and many others.
- We have a solid team of senior software engineering students compared to other projects that might just have one programmer who only works in his/her free time
- We are building on a two year old working repository and thus not starting from scratch.

CONS

- We are students with limited expertise in this field, so other teams without such a problem are way ahead.
- Our motivation is slightly above or below meeting a class requirement. This might not be as high as someone who's motivated to do this so as to get a job, start a business or get income for his family. They thus have more reason to put in more effort than we do.
- We have a short timeframe to work on this project. As a senior design project, we have a year and after that are finished. This is a con as other (non senior design) teams could have many years to complete a project.

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.

There's work being done by Camus Energy, along with the Pacific Northwest National Laboratory and Kit Carson Electric Cooperative, that are building a machine learning model that will fix gaps in its grid data. They have received over $750, 000 in funds from the US Department of Energy (Camus, Feb. 14, 2022).

4.1.3 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*

1. Our design consists of multiple components/subsystems. We use APIs, hosts like firebase, GCP, environments in gitlab, webhooks for the google voice assistant, react framework for the frontend and neural networks for machine learning, and neo4j for the influx database.
2. Our project contains many challenging requirements including creating our own machine learning models. We will be from using neural networks instead of the old linear leaning machine learning models. Another challenging requirement of our project will be using GEOMap to display different layers in the map using the nodeID from the database.

4.2 Design Exploration

4.2.1 Design Decisions

List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc. Describe why these decisions are important to project success.

1. Neural network ML model. This choice gives us the performance and accuracy necessary for our anomaly detection.
2. Voice assistant. This feature will enable quicker and more natural interaction with our project for our users.
3. Use GEOMap to display node data to the front-end. This allows us to display data in different layers on a grid. This will allow users to filter unnecessary data.

4.2.2 Ideation

For at least one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). Describe at least five options that you considered.

1. Using neural networks instead of linear learning
2. Using our own code instead of integrating old code from the previous team
3. Setting up our own environment on gitlab instead of using the ones made by the previous team
4. We considered using the AI agent offered by Facebook to colleges for research purposes.
5. We considered switching some components to AWS to handle logins to use our website/frontend so that people can use/access our AI agent.

4.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish you include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

When deciding on a paradigm to use for machine learning, we decided to use a neural network rather than a linear learning model. When making a decision, we prioritized performance and accuracy over simplicity and ease of implementation. We decided on pursuing a neural network, as it gives better

performance and accuracy. Furthermore, as we are in this class to learn, we chose the option with more potential for growth and relevance in today's tech scene.

4.3 References

Overcoming Imperfect Grid Data with Machine Learning | Camus Energy.
https://www.camus.energy/blog/overcoming-imperfect-grid-data-with-machine-learning.
Accessed 21 Oct. 2022.