AI-VVO (Artificial Intelligence Volt-VAR Optimization)

DESIGN DOCUMENT

sdmay22-36
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Executive Summary

Acknowledgements

- This work is supported in part by the National Science Foundation under award number 2105269 (Physics-based Machine Learning Models and Algorithms for Attack-Resilient Smart Grid Infrastructure) and Iowa Energy Center Grant under award number 21-IEC-009 (Micro-DERMS: Distributed Energy Resource Management System (DERMS) for Real-time Monitoring & Control of Mobile Microgrids and DER Distribution Grid).

Development Standards & Practices Used

- IEEE 26514-2010 Requirements for Designers and Developers of User Documentation
- IEEE 1250-2018 IEEE Guide for Identifying and Improving Voltage Quality in Power Systems
- IEEE 1854-2019 IEEE Trial-Use Guide for Smart Distribution Applications -
- IEEE 1028-2008 IEEE Standard for Software Reviews and Audits
- IEEE 1547-2018 IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

Summary of Requirements

- ML: New machine learning algorithm with a higher test set accuracy
- ML: Ensure new deep learning model is not overfitting or underfitting the data
- ML: Segment data into training set, test set, and dev set
- Frontend: Algorithm selection on the UI screen
- Backend: Database powered by PostgreSQL
- Backend: ensure proper connection between backend and PostgreSQL
- Frontend: Map-based power grid display
- Frontend: Update UI to be more user friendly
- Frontend: Update output page to display data in a more readable format
- Frontend: Add voltage information of nodes to grid display page

Applicable Courses from Iowa State University Curriculum

- ENG 314: Technical Communication
- COM S 252: Linux Operating System Essentials
- COM S 309: Software Development Practices
- COM S 319: Construction of User Interfaces
- COM S 363: Introduction to Database Management Systems

- COM S 409: Software Requirements Engineering
- EE 455: Introduction to Distribution Systems
- EE 526: Deep Learning Theory and Practice
- SE 339: Software Architecture & Design

New Skills/Knowledge acquired that was not taught in courses

Our team learned several new technologies including:

- ReactJS
- React Leaflet
- PostgreSQL
- InfluxDB
- Django
- PyTorch
- Python
- Google Colab
- VMWare ESXi Vsphere

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List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Team

1.1 Team Members:

Demetrius Christou (DC)
Derrick Vang (DV)
Evan Dinnon (ED)
Jaden Alamsya (JA)
Megan Phinney (MP)
Rachel Owens (RO)
William Dulaney (WD)

1.2 Required Skill Sets for Your Project:

- Linux
- Programming Experience
- Deep Learning
- Power Systems Analysis

1.3 Skill Sets Covered by the Team:

Skill	Team Member
Linux	RO, DC, MP, WD, ED
Front-end app development	RO, DC, DV, ED, JA
Requirements derivation	RO, WD
Deep Learning	WD
Power Systems Analysis	WD

Programing Languages	Team Member
Java	RO, DC, DV, MP, WD, ED, JA
Javascript, HTML, CSS	RO, DC, DV
C	RO, WD, DC, DV, MP, ED, JA
Python	WD, MP, ED

1.4 Project Management Style Adopted by the Team:
Agile

1.5 Initial Project Management Roles: (enumerate which team member plays what role)
- Scrum Master - Jaden Alamsya
- Client Interaction - Derrick Vang
- Testing - Megan Phinney
- Team Organization - Rachel Owens
- Frontend Lead - Evan Dinnon
- Deep Learning Architect - William Dulaney
- Backend Lead - Demetrius Christou

2 Introduction
2.1 Problem Statement

Our project is trying to minimize waste in the power grid's transportation of energy. We are programming a smart device that monitors and minimizes losses in the power grid. The configuration of this system will be implemented in a webpage.

2.2 Requirements & Constraints

Requirements:
- ML: New machine learning algorithm with a higher test set accuracy
- ML: Ensure new deep learning model is not overfitting or underfitting the data
- ML: Segment data into training set, test set, and dev set
- Frontend: Algorithm selection on the UI screen
- Backend: Database powered by PostgreSQL
- Backend: ensure proper connection between backend and PostgreSQL
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- Frontend: Update output page to display data in a more readable format
- Frontend: Add voltage information of nodes to grid display page

Constraints:
- Using scripting to visualize data, plots and analytics and pulling data from the back end
    - Have many resources we can pull from
- Computing constraints for training the learning algorithms
- Must utilize existing codebase
- Memory constraints on the VMs

- Not real-time data. The data is all simulated. May not represent real-life scenarios as well as real-time data would.
    - Real-time data will be provided.

2.3 Engineering Standards

- IEEE 26514-2010 Requirements for Designers and Developers of User Documentation - This standard applies to our project as there will be a lot of programming done and a proper plan as to how we should design our project will be important. Documentation is also very important to our project since this project has been running for multiple semesters and proper documentation will help future groups improve upon our work.
- IEEE 1250-2018 IEEE Guide for Identifying and Improving Voltage Quality in Power Systems - This applies to us since we need to be sure that our simulated values for our voltages are realistic to use in the real world otherwise our simulation would not be very useful.
- IEEE 1854-2019 IEEE Trial-Use Guide for Smart Distribution Applications - These standards give our project a clear definition of the components and functions it needs to be successful.
- IEEE 1028-2008 IEEE Standard for Software Reviews and Audits - This will help us review and check code before it is pushed to try to limit the amount of bugs that get to the main branch of the code base.
- IEEE 1547-2018 IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

2.4 Intended Users & Uses

Our intended users are workers that manage distributed energy resources grids. They will be using it to help improve the overall quality of their grids. Iowa State students studying power could use this software to study power flow in distribution grids.

3 Project Plan

3.1 Project Management/Tracking Procedures

We will use Waterfall + Agile project management style, because the overhead for Agile is too much for the scale of this project. We will implement agile methodologies into our project without having all of the overhead for the agile process. The project deliverable is code, so using agile for code development will prove useful for developing bug-free, concise code, that can be prototyped early and often.

Gitlab will be used since its issues feature is extremely similar to trello and other progress tracking software and the team is already using it to host our project so it allows us to reduce the amount of apps we are using. We will also be using Google Colab for machine learning algorithm development. Once milestones are met on Google Colab, they will be pushed to the Gitlab repository. We are using Discord for day-to-day communications and progress monitoring.

3.2 Task Decomposition

Frontend:

- Add algorithm selection to the main page
- Add Map-based power grid display
- Update UI to be more user friendly
- Update output page to display data in a more readable format
- Add voltage information of nodes to grid display page
- Add user registration and store them in the database
- Increase readability for future teams

Backend:

- Fix issues related to PostgreSQL connection
    - Allow for easy connection for any stored data
    - The ability to store user information
- Integrate InfluxDB into application
- Increase readability for future teams
    - Update comments/refactor code to make current work clearer

Machine Learning:

- New machine learning algorithm with a higher test set accuracy
    - Research control mechanisms
    - Develop a convolutional neural network in PyTorch
    - Train convolutional neural network
    - 80% accuracy on test set is a good target
- Ensure new deep learning model is not overfitting or underfitting the data
    - Simplify or add layers to neural net as needed based on test set accuracy vs. training set accuracy
- Segment data into training set, test set, and dev set
    - Understand control mechanisms in order to decide how to segment this data

3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

Frontend:

- Add algorithm selection to the main page
    - Main page will display a drop-down list of algorithms to choose from. Selecting an algorithm will run the simulation with the selected algorithm
- Add Map-based power grid display
    - New page will be added for map-based power grid display. The display will overlay on a virtual representation of the selected grid area and will include relevant information such as street names and city names.
- Update UI to be more user friendly
    - The general user interface will be updated to be more clear and understandable
- Update output page to display data in a more readable format
    - The output page will display the data from the backend in a much clearer view
- Add voltage information of nodes to grid display page
    - The current grid display page will be updated so that when a user clicks on a node, voltage information for that node will be displayed above the node
- Add user registration and store them in the database
    - A user registration page will be added where new users may set up a profile page so that their data can be saved upon login. This will be implemented on the backend as well. Information stored will include name, email, password, and last session data
- Increase readability for future teams
    - Add good comments to code
    - Update the README to explain more of the structure, functionality, and why certain decisions were made
    - Include more comments to commits to show why decisions were made

Backend:

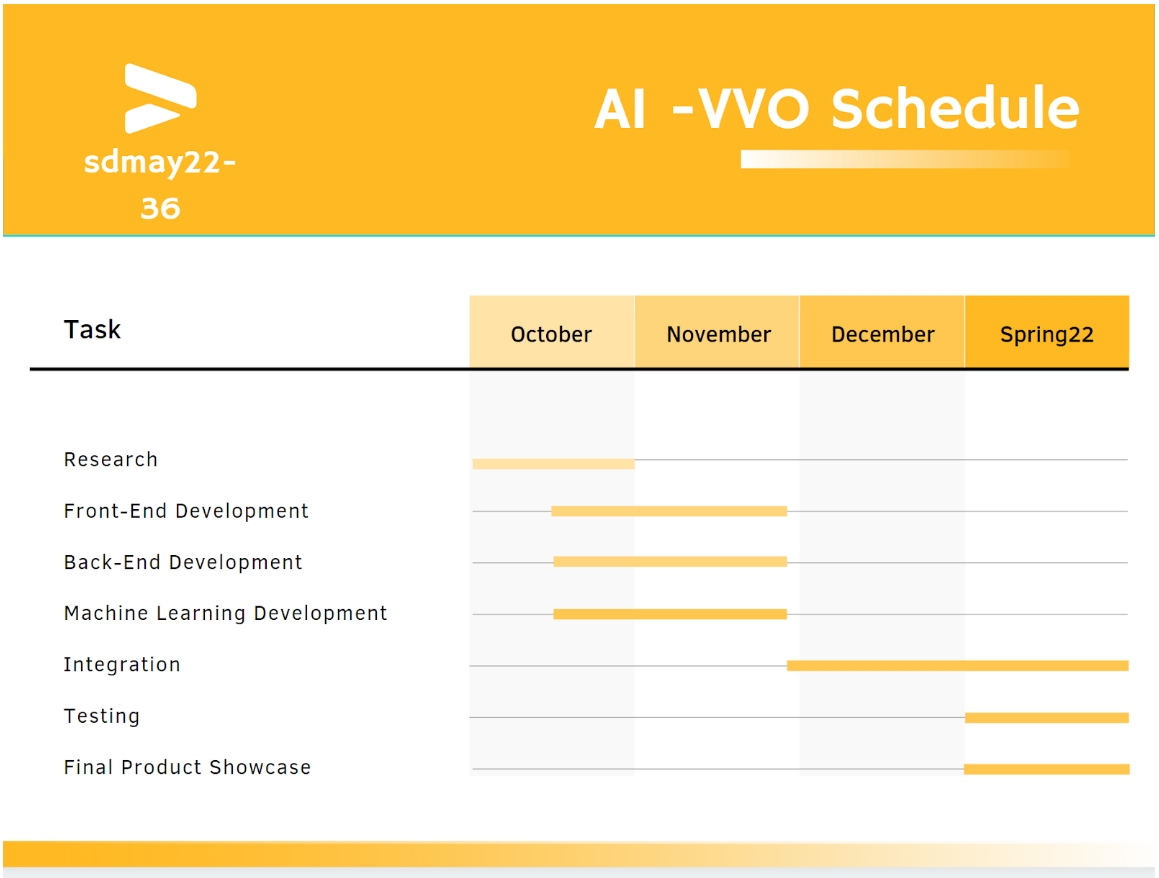
- Fix issues related to PostgreSQL
    - Backend should be able to easily fetch and update data that is currently on the server.
    - The data fetched should also be quickly transferred to wherever it is needed on the frontend
- Increase readability for future teams
    - Documentation and comments on the apis
    - Increase the amount of helper functions in the api to make code more readable
    - Rename variables to properly show what they represent

Machine Learning:

- New machine learning algorithm with a higher test set accuracy
    - Research control mechanisms.

        - Read all of the documentation provided by our faculty advisor regarding control systems and power delivery optimization.
    - Develop a convolutional neural network in PyTorch.
        - Develop a strong understanding of PyTorch.
        - Develop a simple convolutional neural network
        - Train the simple convolutional neural network to perform task of optimization
        - Observe the performance of the simple convolutional neural network on controlling the grid.
        - Add more algorithmic complexity to the simple convolutional neural network as needed. There will be an optimum complexity for the neural net that results in the best performance for the optimization of power distribution.
    - Train convolutional neural network
        - Use Google Colab GPU to train the simple convolutional neural network for a certain number of epochs. Number of epochs is to be determined. If the model is underfitting the data, we will add epochs and if the model is overfitting the data, we will remove epochs of training and will engage in early stopping of the training.
    - 80% accuracy on test set is a good target
- Ensure new deep learning model is not overfitting or underfitting the data
    - Simplify or add layers to neural net as needed based on test set accuracy vs. training set accuracy
        - We will observe the performance of each model and decide whether to add layers or remove layers from the neural net. When we achieve an 80% test set accuracy, we will consider our deep learning model to be of acceptable performance. If we can get better results than 80% test set accuracy and less than 90% test set accuracy, we will consider our deep learning model to be of great performance. Above 90% accuracy for the test set will be considered outstanding performance.
- Segment data into training set, test set, and dev set
    - Understand control mechanisms in order to decide how to segment this data
        - Data is sequential, so there is only one set of sequential data. Data shows the real and reactive powers for 3 feeders for every hour during a calendar year. Segmenting data may not be the optimum approach to this problem. Further research is needed into the control systems area of this project. We may decide to segment the data into 12 month trials that can then be used as the testing, training, and dev sets.

3.4 Project Timeline/Schedule



3.5 Risks And Risk Management/Mitigation

Agile project can associate risks and risk mitigation with each sprint.

- Our team is learning several new technologies including ReactJS, PyTorch, PostgreSQL and the learning curve could slow development down in the beginning. This will be mitigated by taking online tutorials and practicing with these environments before project development begins
- As all our work will be done virtually, including using Virtual Machines, any trouble connecting to the ISU network or the VM's could slow down progress. This will be mitigated as best possible by constantly pushing our work so our workspace is always up to date, and letting others know of connectivity issues.
- Previous team had issues integrating PostgreSQL into the backend. If that issue is still unresolved we may need to look into using a different database tool.

3.6 Personnel Effort Requirements

Frontend

Task	Explanation	Person-Hours
Add algorithm selection to the main page	Update main page to display a drop-down list of algorithms to choose from. Selecting an algorithm will run the simulation with the selected algorithm	30
Add Map-based power grid display	New page will be added for map-based power grid display. The display will overlay on a virtual representation of the selected grid area and will include relevant information such as street names and city names.	50
Update UI to be more user friendly	The general user interface will be updated to be more clear and understandable for users	20
Update output page to display data in a more readable format	The output page will display the data from the backend in a much clearer view	25
Add voltage information of nodes to grid display page	The current grid display page will be updated so that when a user clicks on a node, voltage information for that node will be displayed above the node	60
Add user registration and store them in the database	A user registration page will be added where new users may set up a profile page so that their data can be saved upon login. This will be implemented on the backend as well. Information stored will include name, email, password, and last session data	30

Increase readability for future teams	Add good comments to code. Update the README to explain more of the structure, functionality, and why certain decisions were made. Include more comments to commits to show why decisions were made	10
TOTAL		**225**

Backend

Task	Explanation	Person-Hours
Fix issues related to PostgreSQL connection	Backend should be able to easily fetch and update data that is currently on the server.The data fetched should also be quickly transferred to wherever it is needed on the frontend. Person hours on this task will also have to be spent on researching PostgreSQL and how it connects to Django.	65
Increase readability for future teams	Documentation and comments on the apis. Increase the amount of helper functions in the api to make code more readable. Rename variables to properly show what they represent. This time is variable depending on how the machine learning team rewrites the algorithms necessary for the ML api to work.	85
TOTAL		**150**

Machine Learning

Task	Explanation	Person-Hours
New Machine	Implement a deep learning	70

Learning Algorithm with a higher test set accuracy	convolutional neural network to control the power distribution system by finding the optimal step positions for the voltage regulators and optimal toggling of the shunt capacitor banks on and off. 80% is considered acceptable test set accuracy. 80-90% is considered great. Over 90% is considered outstanding.	
Ensure new deep learning model is not overfitting or underfitting the data	In order to find the optimum complexity for the deep convolutional neural network, we will need to observe the training set accuracy vs. the testing set accuracy and adjust the number of epochs the model is trained and adjust the number of layers in the model as needed.	60
Segment data into different sets	We will need to segment the data into a training set, tests set, and development sets. This will allow us to better organize our data to efficiently train our algorithm	20
TOTAL		**150**

3.7 Other Resource Requirements

Resources aside from financial (such as parts and materials) required to complete the project:

- PowerCyber workbench and virtual machines provided by client / advisor Dr. Ravikumar
- Google Cloud platform
- Real time data for the ML algorithms
- Documentation provided by sdmay21-24 and Dr. Ravikumar

4 Design

4.1 Design Context

4.1.1 Broader Context

We are designing for utility companies that manage distribution grids with distributed energy resources attached to their grid infrastructure. However, others will benefit from this technology as well. Consumers would see their energy bills go down, because if a utility has to pay less to distribute the energy to its customers, the customers will see these savings on their bill. Our project addresses economic, social, and environmental needs. This power distribution optimization application will allow utilities and power customers to save money and will allow less energy to be wasted.

Public health, safety, and welfare:

- This project will help deal with fluctuations in power. This will help make sure people utilizing power from these power grids will have continuous power with fewer outages. This can be a safety concern if people in rural areas are without power.

Global, cultural, and social:

- This project is meant to help workers who manage distributed energy resource grids, it allows them to see how a particular algorithm responds to different situations in the power grid which can improve voltage profiles for all end-use customers and achieve multiple objectives, such as real power losses and voltage deviation. This means that this project can help companies that manage power grids and their customers save money.

Environmental:

- This project's goal is to increase voltage stability and reduce energy loss in a distribution grid. This will keep the distribution grid running as efficiently as possible and reduce wasted resources.

Economic

- This project will help improve energy efficiency which should reduce over and under voltage conditions. This will help stabilize energy consumption and reduce energy loss. This will help save money in the long run for consumers and power companies.

4.1.2 User Needs

Consumers:

- Consumers want fewer power outages so they can continue running critical appliances.

- Consumers want more efficient power output to reduce their power costs.

Power Companies:

- Power companies want to reduce power outages to keep customers happy.
- Power companies want to reduce energy consumption to abide by environmental requirements set out by the government.

Power Grid Managers (Distributed Energy Resources grids) / Utility operators:

- Grid managers want to more easily interact with their systems.
- Grid managers want an easy way to determine how to run the system efficiently.

4.1.3 Prior Work/Solutions

- Our project is an extension of previous group, sdmay21-24.
    - Reference: https://sdmay21-24.sd.ece.iastate.edu/
- The biggest shortcoming from the previous project is lack of readability. It is difficult to understand their code as they have limited documentation in the code and not very detailed overall documentation. They also had some issues with backend code, specifically with the database.
- The biggest advantage is that they already got pretty far in the project and have a good starting point. We will be adding more detailed functionality and cleaning up their code.
- Current VVCs are slow and use a lot of power. Our project aims to improve the operation of VVCs by implementing Machine-Learning.

4.1.4 Technical Complexity

The design of our project consists of three main components. These components are the front-end, back-end, and machine learning application.

Front-end: The frontend will consist of ReactJS components which will communicate with the backend Django service. It will also need to communicate with the PostgreSQL database to handle user profile information and store data. A map based power grid display will also show the power grid overlaid on a map, showing the user important location and voltage information.

Back-end: The backend will consist of using Django as our web server. We will also use ReactJS and PostgreSQL. We will also use a Docker image to run the project in the cloud.

Machine Learning Application: The Machine Learning application will run on PyTorch, be trained on Google Colab, and will be a deep convolutional neural network to approximate the Q function of the power system. This machine learning model will optimize the distribution system in order to minimize power losses in the grid.

Requirements from our project that match or exceed current industry standards include the map based power grid display and the machine learning model.

4.2 Design Exploration

4.2.1 Design Decisions

1. ReactJS for frontend development
2. Map based power grid display using react-leaflet
3. Pytorch based ML algorithm to simulate power grid
4. Page displaying simulated data in a readable format

4.2.2 Ideation

1. ReactJS for frontend development
    - We had to decide between using ReactJS or Angular for frontend development. The previous team used ReactJS and the current frontend team is not familiar with either framework.
    - We decided to use ReactJS:
        - To maintain consistency with the previous codebase
        - It utilizes Javascript which several members of the frontend team are familiar with
        - It has a larger user base that has more documentation and answers to frequently asked questions.
        - It is more lightweight than Angular
2. Map based power grid display:
    - We decided to create a map based power grid display based on the client's request. They would like the option to see the power grid overlaid on a map showing city and street names so that the web application user can orient themselves.
    - We decided to use Google Maps because it is a widely used and documented library that will work well with ReactJS and should be fairly simple to implement. It has many features that would help us pull in necessary information.
3. Pytorch based ML algorithm
    - Had to decide between TensorFlow and other options. But, chose on Pytorch for a few reasons
        - Team experience with pytorch
        - Pytorch offers better speeds
        - Pytorch is much more modern
        - Pytorch has an easy to use API

4. Page displaying simulated data in a readable format:

    - We decided to update the current data output page because it is difficult to read and follow the output data points. The current output is just a dump of data all on one page, but it would be simpler to read and understand if it were in a table format.

4.2.3 Decision-Making and Trade-Off

For our decision making process, we identified the pros and cons and compared the number of pros to the number of cons for each option.

We had to decide between using ReactJS or Angular for frontend development. The previous team used ReactJS and the current frontend team is not familiar with either framework. Our client offered the option to use whichever we wanted to use. We researched both ReactJS and Angular and ultimately decided to stick with using ReactJS. Several things went into our consideration including, the cost of overhauling the current system for use with Angular, ease of use, and documentation and tutorials. Since our team is not very familiar with either option, we needed something that would be fairly easy to learn and well documented. Angular has many benefits, but ReactJS is easier to "plug-and-play" and has a lot of user-contributed, as well as official, documentation making it easier for us to research. As we are not familiar with either, it also meant overhauling the entire current codebase to work with Angular would have been a significant effort without many advantages over the current system.

Our client asked to include a requirement for creating a map-based power grid display. Currently, there is a grid display, but it has no landmarks, so it is not clear where the nodes are in relation to each other or in a real world setting. It is hard for the user to orient themselves unless they already know the system. We decided to implement Google Maps and D3-graph data visualization libraries for this function. The previous team used the D3-graph library which worked well for displaying the information so we will continue to use it in our future development. Google Maps is widely used for map applications and will provide a lot of good functionality that is frequently updated. There are some other map applications out there, but Google maps has a wide user base and frequently updates their documentation. They also make it fairly easy to implement.

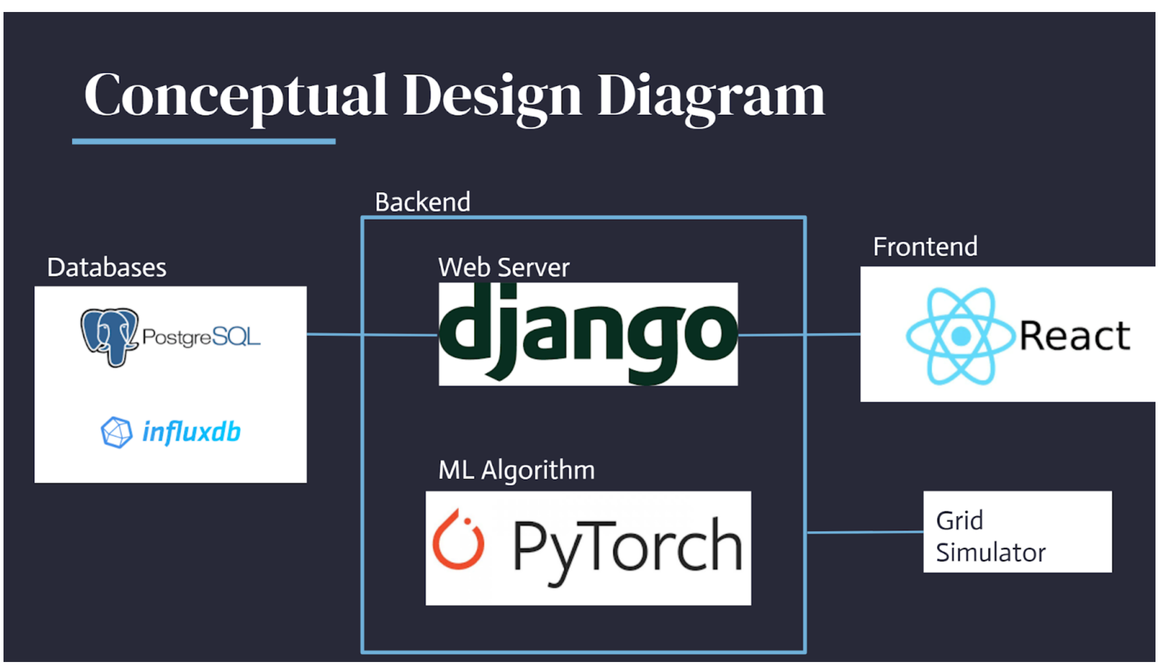
We decided to choose Pytorch over TensorFlow and other tools by doing research and writing down the pros and cons of each tool. The Machine Learning team chose Pytorch due to the team's previous experience with it along with some of the greater features that Pytorch offers like better speeds and a modern api. The only real con to the use of Pytorch was that the previous team wrote some algorithms in TensorFlow already so we would have to redo some of the work they did to translate the algorithm into Pytorch. There were some Pros to TensorFlow as well since it is an industry standard for Machine Learning and has plenty of resources to help solve problems we may face. But, it also has a major con of slowly being replaced in industry by technologies like Pytorch. These pros and cons were found by looking deeply into each technology and what they offered compared to what we actually needed in order to create an accurate algorithm to simulate the grid.

We had few options in what to do regarding the page currently displaying simulated output since it is an important part of the project. The only options were to leave the page as is with all the data spit out onto a single page or to redo the page in a way that can clearly show the data gathered from the simulation. We decided to redo the page completely as the pros of having data that is easily readable by the user greatly outweighs the cons of having to redo some of the work that the previous team had to do. Plus the addition of an improved output page will make our project much more useful to any potential users in the future.

4.3 Proposed Design

- So far, we have formulated the design for a map-based display for the distribution system by implementing latitude and longitude data of each node in the distribution system into a Google Maps overlay.
- We have started researching and designing a convolutional neural network to approximate the Q function of the system. This convolutional neural network will enable the system to take actions on its environment in the form of modifying the tap position of 3 voltage regulators and the on/off switch of a shunt capacitor bank. From the actions, the agent, in this case, the controller, will receive a signal that indicates how successful that action was in completing the task. In this project, we will use a cost function where the cost function is proportional to the reactive power on the feeders. We want the reactive powers to go to zero in order to maximize the real power delivered, so we will use this convolutional neural network to minimize this cost function.

4.3.1 Design Visual and Description



- The system works as follows:
  - The real-time real and reactive power data for all buses is fed into a database powered by PostgreSQL.
  - This data can then be sent through the backend, powered by Django and PyTorch, to be displayed on the front-end, powered by ReactJS.
  - The PyTorch machine learning model will make modifications to the control mechanisms in the system in order to push the reactive power on all feeders to zero to maximize the real power delivered by the system.
  - The functionality of our application will be tested with commercial grid simulators, such as GridApps-d, OpenDSS, and Opal-RT.

4.3.2 Functionality

- Our design is intended to give users the ability to optimize their distribution grid. It is intended to give both novice and advanced users a seamless experience in optimizing the power delivery in their grid.
- The current design satisfies the functional and non-functional requirements of the project well. The functional requirements of the project are significantly easier to implement than the non-functional requirements. The non-functional requirements are more based on the aesthetics of the project and we will continue to consult our faculty advisor, client, and TA to make sure these non-functional aesthetic requirements are met.

4.3.3 Areas of Concern and Development

- Our primary concern is creating an application that is both user-friendly and accessible to advanced users. We are striving to create an application that is easy to use and difficult to master. Another primary concern of ours is to create a visually appealing application that users will want to use. Aesthetics are an important part of any application and they are often more difficult to define than functional requirements.
- Our immediate plan for developing the solution to address these concerns is to create lots of prototypes early and often so that we can get user feedback.
- We will present the prototypes to our client, faculty advisor, and TA in order to get feedback as often as possible to direct our project in the right direction.

4.4 Technology Considerations

There are definitely some trade-offs with the technology we have chosen for implementing this project. We decided between using Django and React for the frontend, PostgreSql and MySql for the backend, and between PyTorch and Tensorflow for the machine learning algorithm. The main advantage to using Django is that it has direct integration with PostgreSql. The disadvantage to Django is it's not as new of a framework as React. PyTorch is more user friendly and is more concise than Tensorflow. Django has direct integration with PostgreSql, so PostgreSql has some definite advantages over using MySql or another database.

4.5 Design Analysis

Our proposed design worked, because it met the functional requirements while meeting the aesthetic requirements as well. By implementing OpenStreetMaps into the application, the application is far more user friendly and aesthetically pleasing.

4.6 Design Plan

The design plan is to check the interconnections between the backend, frontend, and the machine learning application. We will develop a series of tests to make sure that communication is working between all components of the project.

5 Testing

For our project, we plan on implementing testing schemes to test both the functional and non-functional components of the project. The functional requirements are easier to test because there are software packages available that allow unit testing of functional components of the project. The non-functional requirements are difficult to test with software packages, so we will be providing prototypes often to our client, faculty advisor, and TA in order to ensure our project is meeting non-functional requirements such as aesthetics. The functional components that we will be testing are the backend server, the machine learning application and algorithm, and the front-end UI components.

5.1 Unit Testing

There would be many different units that we could unit test in our project. One unit would be API communication another could be creation of the downloadable output. We could have tests on both the backend and frontend that would make sure that the proper thing happens when the API gives an expected response and that the proper error handling. In our case the API would handle the ML algorithm that simulates the power grid so common areas to test on the backend would be if incorrect parameters are given we would have to notice that and send an error message to the frontend instead of data. And on the front end we would need to have unit tests to ensure that we are sending correct parameters and to check that our data is valid and that the information is being sent to the correct locations in the application to be displayed. For the frontend tests for the downloadable output we could run a test with hardcoded outputs to make sure that output looks correct when it is downloaded. Tools that can be used would vary based on where the tests are run but, on the frontend Jest or a similar framework would be used to simulate the cases and check the results. On the backend Django has support for built in unit testing and that could be used for most cases. There are other frameworks like Pytest that could be used too if we feel that Django doesn't offer all the features that we want. For the machine learning application, we will use Python's assert statements for error checking and we will use PyTest for more in-depth error checking.

5.2 Interface Testing

In our design, the interfaces in our project include the data and results that are stored in the PostgreSQL database. It will need to be connected to our front-end interface so that way the information can be displayed on our application. We will need to make sure that our back-end and front-end interfaces have established a connection and then move on from there. We will be adding more user interfaces into our application such as the map based grid simulator and algorithm selection, that way users will be able to see a visual of the map and be able to change between algorithms. For our tools we can use Jest or React-testing-library or other similar frameworks to test components and user behavior.

5.3 Integration Testing

We have designed our overall high-level architecture designing our larger components including our database, web-server, ML program, and the frontend architecture. These will be tested individually throughout development, and through interface testing described above. We have also designed a frontend specific high-level design which indicates what components must interact with each other. These will be tested as part of the integration testing to ensure that new components we add such as the MapGrid and MLSelection work with the existing system.

We will use an incremental top-down approach testing the higher level Application module, then the Layout and URL components. The URL component connects to all of the other components such as login screen, home page, ML selection, and data output pages. These will be tested sequentially all the way down to the final lowest level which we are implementing as part of this second phase of this project. We will make sure that all components connect successfully. That low level calls to higher level components are successful and vice versa. We will use stubs as needed throughout by using Jest or Mockito to test components that aren't built yet.

5.4 System Testing

We will use API communication to test the system. We will develop a set of inputs that would typically be entered by the user into the system and test the system's response to this set of inputs. This strategy will ensure that our application is working as intended for a wide range of inputs. We will come up with a set of communication tests to make sure that each part of the project is properly communicating with the other components of the project.

5.5 Regression Testing

For our project with regression testing, we want to make sure that when we add new functionality, we don't break other parts of the code. We will use a combination of all the different testing methods above using the most important test cases. It is driven by the requirement that the new functionality doesn't break the old functionality. We may need to update some of the tests before regression testing but it wouldn't be a complete overhaul of the already created test cases.

5.6 Acceptance Testing

To ensure that our functional and non-functional requirements are being met, we will use a combination of unit testing, prototypes, and demos with our client. This should ensure that our project is behaving as intended and is acceptable in terms of the functionality that it provides. Our client will be heavily involved in these demos and will not only be relied on for feedback on functionality, but also for usability and aesthetics.

5.7 Security Testing (if applicable)

For this project, it is important that all grid data is private and not available to the public. Having grid data publicly accessible could allow for exploits to be carried out against the grid. We will ensure that we use secure programming practices to protect against SQL injection and other vulnerabilities common in applications. In order to test the security of our application, we will test to see if a user can inject code into the application. We will test to see if SQL commands can be passed into the system by an application user. We must ensure that all user input is sanitized to prevent common vulnerabilities from occurring.

5.8 Results

Based on our project plan, we will have results of testing after implementation is further along in the design process.

6 Implementation

Describe any (preliminary) implementation plan for the next semester for your proposed design in 3.3. If your project has inseparable activities between design and implementation, you can list them either in the Design section or this section.

Features:

- Map based Grid Simulator
  - Custom icons, route highlighting, node selection, etc.
  - Display voltage information
- User Registration
  - Profile page
- Algorithm Selection
  - ML Output
  - Download output option
- Update GUI
  - More user friendly
- Convolutional neural network model for grid control and Volt/VAR optimization
- AIVVONet class
- GridController class

- Main learning loop class for training the machine learning system to minimize the reactive power at all buses
- Functional data transfer between the different components of the system: backend, frontend, and machine learning application
- Updates to database technologies used to make sure every type of data that is used by our project is properly handled.

7 Professionalism

This discussion is with respect to the paper titled "Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

7.1 Areas of Responsibility

We have chosen the IEEE code of ethics for the following discussion on professionalism.

Area of Responsibility	Definition	NSPE Canon	IEEE Code of Ethics
Work Competence	Perform work of high quality, integrity, timeliness, and professional compete	Perform services only in areas of their competence; Avoid deceptive acts	From the IEEE code of ethics, "6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;" This tenet of the IEEE code of ethics applies to the area of responsibility of work competence. This is because this tenet of the IEEE code of ethics states

			that you should only do something if you are competent at that task. If you are an electrical engineer, you shouldn't be in charge of processes that a chemical engineer would have the proper training for. Only if an engineer has the proper training and experience for a task, should an engineer do that task.
Financial Responsibility	Deliver products and services of realizable value and at reasonal costs.	Act for each employer or client as faithful agents or trustees	From the IEEE code of ethics, "4. reject bribery in all its forms;". As an engineer, it is important to act in their client's best interests before their own. Rejecting bribery and corruption is important to carry out your financial responsibility as an engineer. This differs from the NSPE Canon only by semantics. It is the same tenet by meaning.
Communication Honesty	Report work truthfull without deception, ar understandable to stakeholders	Issue public statements only in an objective and truthful manner; Avoid deceptive	From the IEEE code ethics, "3. To be hone and realistic in statin claims or estimates based on available da

		acts.	This states that you should be honest and truthful when communicating and make realistic claims that are understandable and can be seen as possib
Health,Safety, Well-Being	Minimize risks to safe health, and well-bein stakeholders.	Hold paramount the safety, health, and welfare of the public.	From IEEE code of ethics: "1. To accept responsibility in making decisions consistent with the safety, health and welfare of the public." It states that the builder of the technology is responsible for the health, safety and well-being of the public.
Property Ownership	Respect property, ideas, and information of clients and others.	Act for each employer or client as faithful agents or trustees	From IEEE code of ethics: "7. ... to credit properly the contributions of others" It states the importance of giving the proper credit.
Sustainability	Protect environment and natural resources locally and globally	(Not included in author's original Table 1)	From IEEE code of ethics, "5. To improve the understanding of technology; its appropriate application, and potential

			consequences.” This states that it is important to improve the understanding of technology while also keeping in mind the appropriateness and possible consequences that come with technology to help protect the environment.
Social Responsibility	Produce products and services that benefit society and communities	Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.	From IEEE code of ethics: “8. To treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression.” It states that no one should be discriminated against which is an important part of social responsibility.

7.2 Project Specific Professional Responsibility Areas

Work competence - Work competence relates to our project’s professional context because it is essential that our team performs work of high quality. This project has the potential to impact many people and must be executed by those with the right skills to ensure it is done properly. Our team is performing at a Medium level. We are all currently being trained in areas related to the project work including Frontend development, Backend development, and Machine Learning. None of us has specific power grid knowledge or a significant amount of training related to Machine Learning, but are each learning as much as possible while performing to the best of our abilities**.**

Financial Responsibility - Financial responsibility relates to our project's professional context because it is important to create an application that is affordable to develop and maintain. This application could be used by research departments and hopefully, power companies in the future. If they are to adopt this application, it should be affordable. We are currently performing at a High level in this area as we are working as part of school training so our time is free. We are also using as many free software products as possible. We are using open source software where possible to keep future costs low.

Communication, Honesty - Communication and honesty relates to our project's professional context because it is important that we are communicating the details of our project development to our client / faculty advisor for future development efforts. We were not the first team, and will not be the last team to work on this project, so good communication and documentation is key to future success. Honesty about expectations and our abilities as well as current status is important so that our client can have a realistic understanding of the status and what yet needs to be done. Our team is performing at a high level in this area as we regularly communicate with our client / faculty advisor about the work we have done and will be doing. We provide weekly status updates in the form of a slide deck presentation. We are also each working within our technical areas to update documentation and make sure there are detailed notes on included libraries, current functionality and how-to's.

Health,Safety, Well-Being - Health, Safety, and Well-being also directly correlates to our project since our product will involve electrical grid simulation which if used in the real world could lead to major issues if we implement incorrectly. If another company uses our service when implementing a real electrical grid and due to a mistake on our part the simulation is incorrect we could lead to major power outages which would affect many people and depending on what is impacted could lead to serious injury or even death in some cases. Our team is operating at a high level in this regard since we must make sure we have a high level of testing to ensure that our product gives accurate results. We have also taken many steps in the production of our application to make sure we are creating the best application possible which helps to reduce the risk that our stakeholders (professor) is taking.

Property Ownership - Property ownership relates to our project's professional context because working with power grids will both directly and indirectly affect those who rely on it for power. Working on this project we will need to take into account the effects that our optimizations could have on the users of the power grid. If the grid is rendered nonfunctional many users could be without power. We also need to be careful of the intellectual property involved with this project. There are many research articles available on the topic of our project, it will be important to give credit when utilizing knowledge and resources from these sources. So far, our team has made sure to include sources to all the information we have gathered when giving our presentation. We have shared all papers and videos used in our research as well. Our project also does not work directly on a power grid. We make use of simulations to avoid possible mishaps causing trouble for those utilizing the power grid. Because of this our team has been high performing for this responsibility.

Sustainability - Sustainability is an important part of our project because we are dealing directly with power grid optimizations. These optimizations not only should improve efficiency in the power grid but also improve the effect the system has on the environment. By creating an optimized power grid we are also creating a power grid that more effectively utilizes the natural resources needed. In this area, our team's use of simulations rather than actual power grid information helps reduce the resources we need for the project. We also are designing an algorithm that will maximize the efficiency of the power grid in question. Because of this, our team has been high performing on following this responsibility.

Social Responsibility - This applies to our project because it is essential that our product is actually useful to people and can benefit various groups in society. I would say that our team is working at a high level in this regard since if we are able to successfully complete this project our service will be wildly useful to many people of various backgrounds since the simulation of the grid could help to reduce energy transportation costs which will end up saving people money. The reduction of energy loss on transportation would also have a good effect on the environment since less energy will need to be produced.

7.3 Most Applicable Professional Responsibility Area

Our team has demonstrated a high level of proficiency in the area of communication and honesty in the context of this project. We are the second team to work on this project and have first hand experience of the difficulties of interpreting a development project that was not documented well. The code base we all are working with had some documentation, but it was difficult to find or did not contain critical information that would save us time in setting up the project. However, there were specific pieces of documentation or resources that our faculty advisor, also our client, was able to provide from the previous team that greatly helped us in our initial assessment and design. Good communication and honesty about where the project is currently at has a big impact on future development and the potential success of the project.

We are all working to maintain good communication with each other and with our client and faculty advisor so that the project may be successful in the future since we are not the last team that will be working on this project. We provide weekly status updates to our faculty advisor. In these meetings we review the work we have completed and ensure that we are meeting his expectations and that the project is moving in a direction aligned with his vision. Additionally, we are updating all current documentation to make it more readable, and include pertinent information. Code bases are being updated with helpful comments. README files are being updated to include information about tutorials, helpful libraries, and how-to's for getting the current implementation running.

We have observed that good communication between team members and having the right information makes the development process run more smoothly and impacts faculty impression of the project and perception of future concepts.

8 Closing Material

8.1 Discussion

Our current design for the AI-VVO project takes into account all of the requirements that have been currently given to our team. In our design we made sure to estimate the amount of time needed to give our Front-End, Back-End, and Machine Learning team enough time to finish the requirements that their parts of the project need to complete while staying within the given constraints of our project.

8.2 Conclusion

Thus far our team has made progress on many of the requirements that have been specified on our project. We have begun to implement a new Machine Learning algorithm that will use a deep learning model that properly fits the given data that will guarantee a higher test set accuracy. The Backend team has taken steps to improve the current database design using PostgreSQL as well as adding on other database frameworks like InfluxDB that work better with the other types of data that our project needs to handle. The Frontend team has also worked to improve the current map based power grid display by using React-Leaflet to show a map of where the grid is located along with custom images that will represent the various symbols that the electrical grid uses. The overall goals of our project are to finish the implementation of these new features as well as complete the features that we have specified within the requirements section of this document. Our main constraint that slowed down the development of our project has been the lack of documentation of the previous team's work. As it made it difficult to add on to their existing code base. This problem will be fixed as we have added onto the existing documentation and the future and current code have an increased amount of documentation to make it extremely easy to add onto and will make it easy for any future team to add onto.

8.3 References

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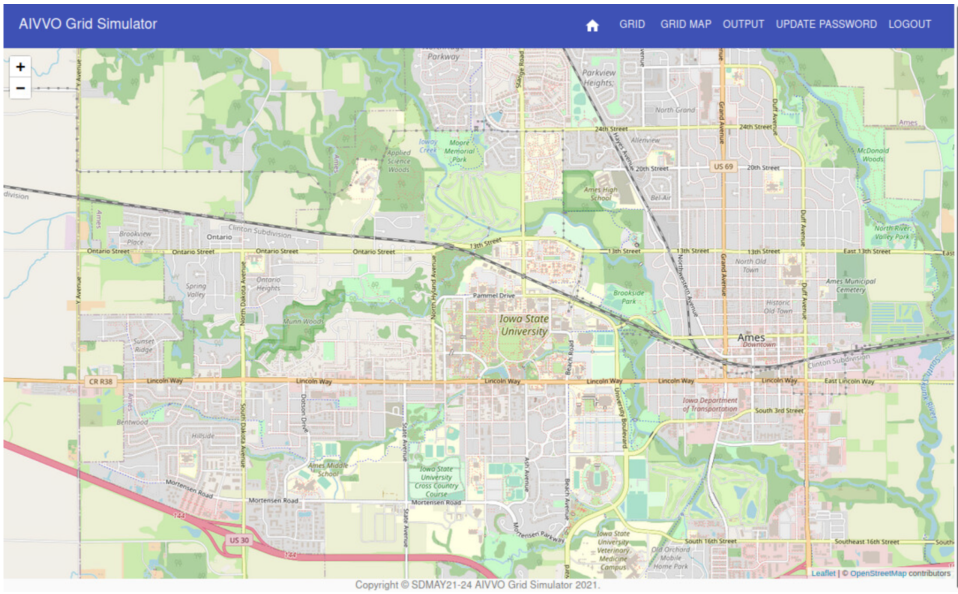
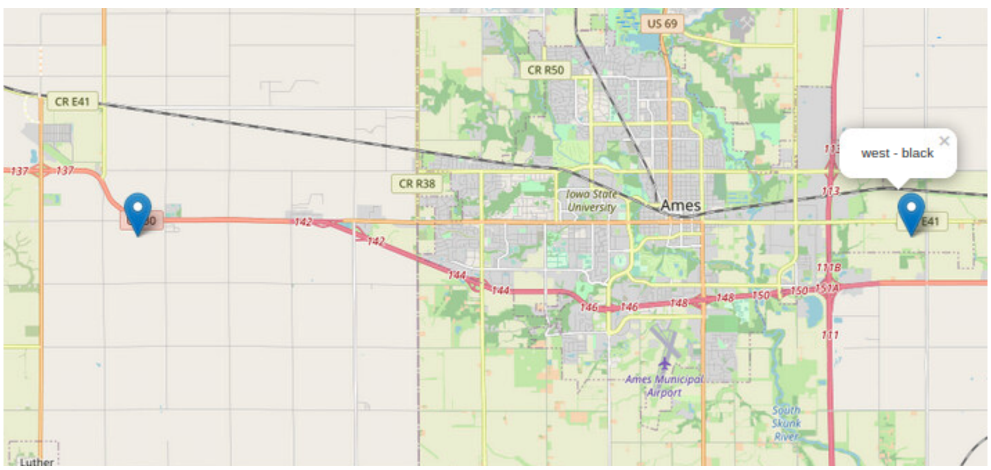
Y. Zhang, X. Wang, J. Wang, Y. Zhang, "Deep Reinforcement Learning Based Volt-VAR Optimization in Smart Distribution Systems," *IEEE Transactions on Smart Grid,* pp. 1-11, 2020.

8.4 Appendices

Demo Images


AIVVO Grid Simulator
GRID
GRID MAP
OUTPUT
UPDATE PASSWORD
LOGOUT
Iowa State University
Ames
Lincoln Way
Copyright © SDMAY21-24 AIVVO Grid Simulator 2021.


west - black
Ames
Iowa State University
Ames Municipal Airport

List of relations

Schema	Name	Type	Owner
public	auth_group	table	postgres_user
public	auth_group_permissions	table	postgres_user
public	auth_permission	table	postgres_user
public	auth_user	table	postgres_user
public	auth_user_groups	table	postgres_user
public	auth_user_user_permissions	table	postgres_user
public	authtoken_token	table	postgres_user
public	django_admin_log	table	postgres_user
public	django_content_type	table	postgres_user
public	django_migrations	table	postgres_user
public	django_session	table	postgres_user
public	prediction_feeder_ap_data	table	postgres_user
public	prediction_feeder_aq_data	table	postgres_user

(13 rows)

id	date_time	bus_1	bus_2	bus_3	bus_4	bus_5	bus_6	bus_7	bus_8	bus_9	bus_10	bus_11	bus_12	bus_13	bus_14	bus_15	bus_16	bus_17
0	1/1/2017 1:00	0.0000000	0.0000000	15.2900000	6.8920000	4.9160000	5.0400000	4.1630000	14.0960000	17.0810000	7.1360000	3.1250000	3.0830000	1.5370000	0.4580000	0.7930000	3.0830000	2.1310000
1	1/1/2017 2:00	0.0000000	0.0000000	14.9010000	6.6720000	5.3350000	4.7600000	3.0700000	14.9370000	12.7860000	7.0780000	2.7580000	2.0320000	2.3780000	0.3360000	0.8360000	2.0320000	1.9140000
2	1/1/2017 3:00	0.0000000	0.0000000	15.7720000	7.0130000	4.5630000	5.0400000	3.5070000	14.7890000	10.2090000	5.9910000	3.0960000	1.5970000	1.6150000	0.3260000	0.8030000	1.5970000	2.4460000
3	1/1/2017 4:00	0.0000000	0.0000000	15.7570000	6.4520000	4.7820000	4.8000000	3.1430000	14.7610000	10.0400000	7.0300000	3.3170000	1.2280000	1.5360000	0.4220000	0.7780000	1.2280000	6.0410000
4	1/1/2017 5:00	0.0000000	0.0000000	15.2920000	6.3560000	4.4820000	5.0000000	3.1470000	15.1560000	10.1470000	6.0430000	2.8320000	1.1620000	1.7730000	0.4040000	0.8740000	1.1620000	4.8800000
5	1/1/2017 6:00	0.0000000	0.0000000	15.8140000	6.8610000	4.9630000	4.3600000	3.3360000	11.1450000	9.6780000	6.0750000	4.4330000	1.7980000	1.6460000	0.3500000	0.8170000	1.7980000	3.6560000
6	1/1/2017 7:00	0.0000000	0.0000000	16.0440000	8.4220000	4.7000000	5.2400000	3.3200000	9.6230000	9.3270000	5.7060000	4.3310000	1.0500000	1.5880000	0.4150000	0.8540000	1.0500000	2.0050000
7	1/1/2017 8:00	0.0000000	0.0000000	15.3370000	8.2010000	4.6640000	4.1200000	3.5720000	9.3930000	9.5300000	5.8090000	7.2480000	1.6700000	1.7150000	0.8280000	1.0100000	1.6700000	2.3810000

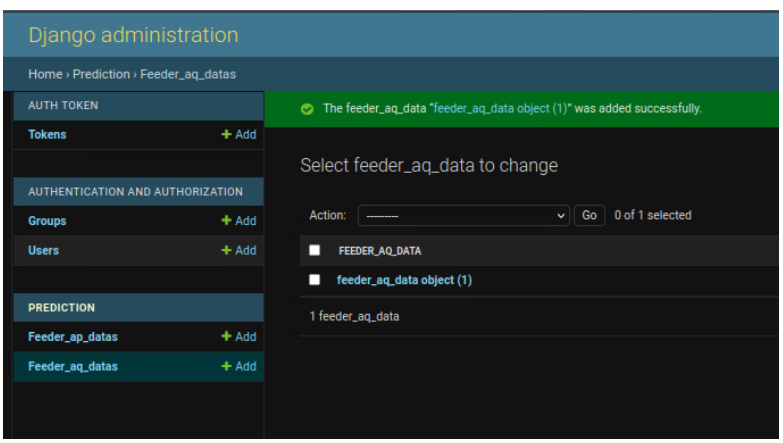
id	date_time	bus_1	bus_2	bus_3	bus_4	bus_5	bus_6	bus_7	bus_8	bus_9	bus_10	bus_11	bus_12	bus_13	bus_14	bus_15	bus_16	bus_17
0	1/1/17 1:00 AM	0.0000000	0.0000000	3.8320352	3.3379479	1.9429275	2.2962918	2.0162329	6.4223273	6.7508432	2.8203277	1.0271378	1.1189796	0.4482917	0.1951072	0.1610255	1.4931650	0.6215417
1	1/1/17 2:00 AM	0.0000000	0.0000000	4.8977219	3.0398530	2.4306978	0.9665592	0.4374513	5.9034801	3.7292500	1.4372492	0.5600358	0.9841425	1.1517180	0.1530861	0.1697570	0.9841425	0.6946892
2	1/1/17 3:00 AM	0.0000000	0.0000000	5.1840057	2.0454583	1.8034130	1.4700000	0.7121267	7.1626396	2.5586166	0.8536713	0.7759307	0.6803192	0.4047572	0.1485300	0.2914501	0.2275602	1.0419916
3	1/1/17 4:00 AM	0.0000000	0.0000000	7.1791013	3.1248462	1.3947500	2.0447914	1.3389124	5.3575276	4.8625939	2.3106493	1.5112698	0.4036241	0.4480000	0.1922689	0.2823763	0.3581667	2.1925902
4	1/1/17 5:00 AM	0.0000000	0.0000000	5.0262373	1.8538333	1.4731622	0.7124614	1.0343689	2.1596130	4.6231098	2.7532721	0.5750621	0.4592518	0.8078027	0.0575669	0.3454269	0.2912247	1.2230433
5	1/1/17 6:00 AM	0.0000000	0.0000000	4.6124167	1.7195287	1.9615031	1.8573522	0.6774037	4.0450948	1.3790403	1.7718750	1.2929583	0.8191930	0.2345423	0.1270330	0.2685349	0.6525869	1.5574495
6	1/1/17 7:00 AM	0.0000000	0.0000000	5.2734078	4.0789608	1.3708333	2.0709805	1.0912312	1.9540335	3.6862663	0.8130610	1.2632083	0.5085382	0.2262777	0.1210417	0.1216884	0.4783941	0.9135050
7	1/1/17 8:00 AM	0.0000000	0.0000000	4.4732917	3.9719256	1.1689086	1.0325693	0.5089824	2.3541077	4.3419963	2.8134271	3.5103666	0.8088179	0.7305869	0.1681326	0.3319709	0.5489025	0.4834827

```python
class feeder_ap_data(models.Model):
    date_time = models.TextField()
    bus_1 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_2 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_3 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_4 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_5 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_6 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_7 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_8 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_9 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_10 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_11 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_12 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_13 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_14 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_15 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_16 = models.DecimalField(max_digits=11, decimal_places=7)
    bus_17 = models.DecimalField(max_digits=11, decimal_places=7)
```

```python
print('input path of csv file to add:')
csvFileToAdd = input()

print('input database table name:')
databaseTableName = input()

#create column names that match django
columnNames = ('date_time', )
for i in range(1, 18):
    columnNames += ('bus_' + str(i), )

#read csv file skip 1st line rename columns to columnNames
dataframe = pd.read_csv(csvFileToAdd, header=0, names=columnNames)
print(dataframe)

print('does this data look correct?(y/n)')
confirmAddition = input()

if confirmAddition == 'n':
    quit()

#connect to db
engine = sqlalchemy.create_engine('postgresql://postgres_user:postgres_password@l

#transfer data to sql
dataframe.to_sql(databaseTableName, engine, index_label='id', if_exists='append')

print('table added successfully')
```

```python
import os
import numpy as np
import torch
import torch.nn as nn
import torch.optim as optimizer

class AIVVONet(nn.Module):
    def __init__(self):
        super(AIVVONet, self).__init__()
        #In_channels = 478, because there are 478 values on the grid at a given time step
        self.conv1 = nn.Conv2d(in_channels = 478, out_channels = 239)
        self.conv2 = nn.Conv2d(in_channels = 239, out_channels = 120)
        self.conv3 = nn.Conv2d(in_channels = 120, out_channels = 60)
        self.conv4 = nn.Conv2d(in_channels = 60, out_channels = 30)
        self.conv5 = nn.Conv2d(in_channels = 30, out_channels = 15)
        self.conv6 = nn.Conv2d(in_channels = 15, out_channels = 8)
        #Out_channels = 4, because there are 4 control mechanisms present on the grid.
        self.conv7 = nn.Conv2d(in_channels = 8, out_channels = 4)

    def forward(self,x):
        x = nn.functional.relu(self.conv1(x))
        x = nn.functional.relu(self.conv2(x))
        x = nn.functional.relu(self.conv3(x))
        x = nn.functional.relu(self.conv4(x))
        x = nn.functional.relu(self.conv5(x))
        x = nn.functional.relu(self.conv6(x))
        x = nn.functional.relu(self.conv7(x))
        return x
```

```
root@ubuntu-vm:/home/ubuntu# pip3 install torch torchvision torchaudio
Collecting torch
  Downloading torch-1.10.0-cp38-cp38-manylinux1_x86_64.whl (881.9 MB)
     |████████████████████████████████| 881.9 MB 3.5 kB/s
Collecting torchvision
  Downloading torchvision-0.11.1-cp38-cp38-manylinux1_x86_64.whl (23.3 MB)
     |████████████████████████████████| 23.3 MB 64.8 MB/s
Collecting torchaudio
  Downloading torchaudio-0.10.0-cp38-cp38-manylinux1_x86_64.whl (2.9 MB)
     |████████████████████████████████| 2.9 MB 49.2 MB/s
Collecting typing-extensions
  Downloading typing_extensions-4.0.0-py3-none-any.whl (22 kB)
Requirement already satisfied: pillow!=8.3.0,>=5.3.0 in /usr/lib/python3/dist-pa
ckages (from torchvision) (7.0.0)
Collecting numpy
  Downloading numpy-1.21.4-cp38-cp38-manylinux_2_12_x86_64.manylinux2010_x86_64.
whl (15.7 MB)
     |████████████████████████████████| 15.7 MB 19.2 MB/s
Installing collected packages: typing-extensions, torch, numpy, torchvision, tor
chaudio
Successfully installed numpy-1.21.4 torch-1.10.0 torchaudio-0.10.0 torchvision-0
.11.1 typing-extensions-4.0.0
root@ubuntu-vm:/home/ubuntu#
```



```python
# Retreive Data
def Pull_Data_Test(request):

    #Get data as an Object for Feeder AP
    ap_list = feeder_data.feeder_ap_data.objects

    #Get data as an Object for Feeder AQ
    aq_list = feeder_data.feeder_aq_data.objects

    #Utilize the render shortcut to display data
    return render(request, "tests.html", {'ap' : ap_list,'aq':aq_list})
```

```html
<p > Feeder AP </p>
{% for ap_data in ap.all %}
    <p > {{ap_data.date_time}}</p>
    <br>
    <p > {{ap_data.bus_1}}</p>
    <hr>
{% endfor %}
<br>
<p > Feeder AQ </p>
<br>
{% for aq_data in aq.all %}
    <p > {{aq_data.date_time}}</p>
    <br>
    <p > {{aq_data.bus_1}}</p>
    <hr>
{% endfor %}
```

```javascript
import icon from 'leaflet/dist/images/marker-icon.png';
import iconShadow from 'leaflet/dist/images/marker-shadow.png';

let DefaultIcon = L.icon({
    iconUrl: icon,
    shadowUrl: iconShadow
});

L.Marker.prototype.options.icon=DefaultIcon;
```

```
<MapContainer className="map"
    center={position}
    zoom={10}
    style={{ height: 750, width: "100%" }}
>
<TileLayer
    attribution='&amp;copy <a href="http:/
    url="https://{s}.tile.openstreetmap.or
/>
</MapContainer>
```

8.4.1 Team Contract

Team Members:

1) William Dulaney
2) Demetrius Christou
3) Derrick Vang
4) Rachel Owens
5) Jaden Alamsya
6) Megan Phinney
7) Evan Dinnon

Team Procedures

1. Day, time, and location (face-to-face or virtual) for regular team meetings:
    - Mondays at 3:00 pm on Discord
2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):
    - Discord
3. Decision-making policy (e.g., consensus, majority vote):
    - Majority vote
4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):
    - The Team Organization lead will take minutes and post to Discord "meeting-minutes" channel

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:
    - All meetings should be attended.

    - Communicate in advance if you will not be able to attend a meeting.
2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:
    - Make sure things that you are assigned are completed on schedule.
    - Communicate with the Technical Lead of your group if you need help or more time to complete scheduled tasks.
3. Expected level of communication with other team members:
    - Weekly status updates
    - Communicate directly with technical lead on a regular basis or with any questions
4. Expected level of commitment to team decisions and tasks:
    - Full commitment to project tasks as assigned and team decisions. If you have concerns see *Collaboration & Inclusion #3* below

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):
    - Scrum Master - Jaden Alamsya
    - Client Interaction - Derrick Vang
    - Testing - Megan Phinney
    - Team Organization - Rachel Owens
    - Frontend Lead - Evan Dinnon
    - Deep Learning Architect - William Dulaney
    - Backend Lead - Demetrius Christou
2. Strategies for supporting and guiding the work of all team members:
    - Technical Leads will rotate throughout the semester and will be the point of contact for all members of their group. They will provide support by meeting as needed with their group members to discuss strategies and make design decisions.
    - Technical leads will meet with their group members to assign tasks
    - If technical leads are not able to answer questions, members will work with professor or TA as needed
3. Strategies for recognizing the contributions of all team members:
    - When a sprint is finished we will review accomplishments and goals met
    - We will be encouraging to each team member and recognize good ideas and good work during weekly meetings and with technical groups

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.

Jaden Alamsya : I am a Software Engineering student with the majority of my experience being in frontend development. I mainly have experience using Java and C. I have used HTML, CSS, and Javascript, but at a much lower level.
Derrick Vang: I am a Software Engineering student with experience in frontend development, general user interface design and some backend development. I have worked on managing database systems and creating user interfaces in languages such as HTML, CSS , Javascript and Java.
Rachel Owens: I am a Software Engineering student with experience in GUI and Frontend development, and working in Linux environments. I have experience working with database systems for Frontend applications. The programming languages I have worked with are Java, C, C++, HTML and Javascript, as well as shell scripting languages.
Demetrius Christou: I am a Computer Engineering student with a focus on software. I have experience on both front and backend development. I have used C, Java, Javascript, html, css and have experience using Linux.
William Dulaney: I'm an EE focusing in power systems and machine learning systems. I have a background in programming in C, Java, and Python. I also have some background in secure computing and cybersecurity. I will bring hardware knowledge, controls knowledge, deep learning, and Jupyter Notebook experience to the group.
Evan Dinnon: I am a Computer Engineering student with a focus area in VLSI design and I primarily focus on Computer Hardware. I have done some work in Front End development including design and coding. I also have quite a bit of Linux experience, and backend server work.
Megan Phinney: I'm a Computer Engineering student with a research focus in high performance computing, specifically cloud-based containers. I have experience using C, Java, python and Linux.

2. Strategies for encouraging and supporting contributions and ideas from all team members:
    - Encouraging feedback from each team member on ideas and decisions during weekly team meetings.
    - Technical Leads will work to encourage new ideas and open discussion from members in their specialty group.
    - We will do brainstorming sessions and whiteboarding to encourage idea generation from all team members
3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)
    - Inform all team members of the grievance in the Discord chat or during weekly team meetings.
    - A meeting will be scheduled with the whole team to resolve the issue.

Goal-Setting, Planning, and Execution

1. Team goals for this semester:

- Design a usable architecture to solve the problem
- Minimize power losses in the smart grid by optimizing the reactive power delivery
- Implement the front-end side of the project
- Complete the technical project report through the Design phase

2. Strategies for planning and assigning individual and team work:
   - Trello
   - Assign manageable tasks for 2-week sprints
   - Individual channels for each sub-specialty
3. Strategies for keeping on task:
   - Weekly meetings/check-ups with group
   - Weekly meetings with Dr. Ravikumar
   - Weekly meetings with TA, Xinyao

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?
   - Initially communicate with the individual to help solve any issues, figure out why there is a continued problem.
2. What will your team do if the infractions continue?
   - If the problem persists, slowly escalate by speaking with the TA, and then the professor if needed.

****

a) I participated in formulating the standards, roles, and procedures as stated in this contract.
b) I understand that I am obligated to abide by these terms and conditions.
c) I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.

1) William Dulaney, DATE : 9/13/2021
2) Evan Dinnon, DATE: 9/13/2021
3) Demetrius Christou, DATE: 9/13/2021
4) Derrick Vang, DATE: 9/13/2021
5) Jaden Alamsya, DATE: 9/15/2021
6) Rachel Owens, DATE: 09/12/2021
7) Megan Phinney, DATE: 9/13/2021