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BP Wind Sim Team

Proposal/Statement of Work

September 18, 2022

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☑ Intellectual Property Rights Agreement Applies
☑ Non-Disclosure Agreement Applies

Executive Summary

The objective of this report is to present what the team plans to do to complete this project. The problem this project aims to solve is being able to optimize the output of a wind farm by turning each wind turbine slightly using a process called wake steering. The features that BP want in this simulation is a model that takes in various inputs and can output the power generation of the wind farm and using a graphical user interface the user will be able to run an optimization algorithm to find the optimal yaw angle to run each wind turbine at.

The external search that was completed provided several useful tools that could be used for the simulation. There were five different pieces of software that were looked into, them being OpenFast, Floris, PyWake, QBlade, and Ashes. All of them gave a good insight into the various ways a wind farm simulation could be modeled, and, in the end, the final product will likely use a combination of these models.

The engineering specifications of this software include the inputs of the software being things like wind speed, wind direction, and location of turbines and the outputs being the power production of the wind farm, the life of the turbine and the optimized wind farm after the wake steering optimization is applied. The interface that this software will be interacted with is through a GUI that the user will be able to modify inputs and see the corresponding outputs.

The concept generation section goes into detail about the various functions and inputs will work together to get the desired output. Then in the level design section it goes through how the concepts discussed in the concept generation section will be implemented. In the final section each team member goes through their skills and how they will be able to benefit this project. As well as the future plans for this project including the estimated budget, various risks that are involved in this project, and our communication with our sponsor.

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1.0 Introduction (Times New Roman 16, Bold, left)

1.1 Initial Problem Statement

A push to switch from fossil fuels to renewable energy sources is sweeping the energy industry. Wind energy is a source of renewable energy that BP is working on incorporating into their business model. The wind energy industry is monopolized by a few companies that use proprietary processes for designing, optimizing, installing, monitoring, and maintaining their wind turbine and wind farms. BP would like to develop a simulation application that uses several wind turbine and wind farm models that adequately matches their wind farm operations. This simulation will allow perturbation of several inputs as happens in the real world and allow visualization and data collection for the simulation inputs and on a variety of important outputs.

Wind turbines are most efficient when angled directly into the oncoming wind. Blades on a wind turbine act as air foils to create a pressure difference along the blades, driving motion. As the turbine spins, it generates a wake of turbulent air behind the turbine. This wake of air of the leading turbine can pose mechanical risks to turbines in the wake, as well as deplete the efficiency of their functioning. Operating wind turbines at a different angle of attack with respect to the oncoming wind will modify the wake impact of the leading turbine, potentially allowing for more optimal efficiency and energy output of the downwind turbines and as a result the overall wind farm.

The goal of the simulation would be to use models available from BP, open source and in industry to adequately simulate the operation of a wind turbine and by extension a wind farm. Then use actual site layout and operational data from BP to validate the outputs from the different models where possible, it is expected the outputs from some models will be more detailed or give different parameters when compared to others.

This will be a steppingstone that BP can use to as a training tool to make engineers more familiar with design and operations of wind turbines, wind farms. Eventually this model will be extended to perform monitoring where the models can be run in parallel with actual operations to detect abnormalities where significant deviations between the model and actual operations occur. It is expected this simulation can then be scaled up to develop a cloud based online optimizer which can be used for closed loop control to minimize the wake impact at a wind farm and generate increased energy from BP on shore and planned offshore wind farms.

1.2 Objectives

Modelling the wake in a wind field in an important step to optimizing the energy output of the wind field. There are various programs that allow for the input of wind field data and the simulation of wakes off turbines. Some of these programs do not have their own graphical user interface (GUI), thus another program may have to be run in addition to initially processing the data. The simulation should reflect the closed-loop controllers which are implemented by the wind turbine vendor's controller. This will allow any optimization that is explored later to be compared to the energy generated by the OEM's controller. This simulation needs to model and display the critical moments and forces on a wind turbine, allow for the adjusting of angle of attack, as well as wind conditions such as speed, direction, and density. The simulation will model and give a visual interface for the wake generated by each turbine as we change the angle of attack offset from the oncoming wind, as well as the resulting forces on the body of the turbine when operating it with different settings. The initial simulation will be for a wind farm with the stretch goal to use multiple wind farm layouts and data from conditions as well as energy generated over a period of operations to test, validate, and

evaluate the many models to see which models execute faster and better represent the actual operations.

There are many limitations in the scope of this project that will alter the possible outcomes of the solution. An important limitation to consider in any model is error from the simulation. Free vortex wake (FVW) and low-fidelity blade-element momentum (BEM) simulation models are used in most simulation tools to process wind field data and provide analytical outputs (Harrison, 2018). Differences in simulation output for various parameters (inflow, shear and yaw misalignment) vary based on what simulation method is being used. FVW methods tend to yield much lower percent error than BEM models do, so we must consider these differences when comparing programs (Shaler, 2022). Regardless of what modelling software is used, it needs to be documented that results from the simulation will not be exactly that of real life. Another important detail to consider when modelling and predicting for the set up of a new wind field is that using existing wind data will never be an accurate model for how wind will move through the field once the turbines are built in their own unique alignment on a unique landscape. There are a lot of variables at play, and all models must be considered in parallel with other simulations to get the best predictions.

Processing power is another major limitation of most software projects. Modelling a single wind turbine is a doable task. However, due to the resources available to us, multiplying that simulation and scaling it up in powers of ten will prove computationally difficult. CFD models demand a lot of processing power from a computer, as well as being graphically demanding displaying fluid wakes in a GUI. Using the CPU power of the computers we have access to through PSU, we will not be able to model a full wind farm Rather, we will be able to provide proof of concept that open source modelling and tools from BP can be used to model critical information regarding the layout and energy output of wind farms.

Another limitation to be considered in the allotted time for the project. Our modelling solutions must yield useful simulation results in 12-15 weeks. This accelerated project deadline eliminates the use of more complex modelling software, as the time it takes to learn how to use these programs would be too time consuming in comparison to the time we have for the project. When doing a software comparison for ease of use, Floris and PyWake have preferable user interfaces over programs like OpenFAST and Ashes. Floris and PyWake will likely be used for the majority of our modelling predictions and will be supplemented with CFD models for wake.

2.0 Customer Needs Assessment

2.1 Gathering Customer Input

The needs of the customer were initially gathered from a document and presentation presented by the sponsor at the beginning of the project. The client wants us to provide a simulated wind farm that can model how the wake of one wind turbine can affect the power production of the rest of the wind farm. This simulated wind farm will be built on already existing models that take in inputs that BP is able to provide and the produces the outputs that the team is looking for. We then take the simulated wind farm and apply a wake steering optimization algorithm to find out the optimal yaw angle to operate each wind turbine at to maximize the power output of the farm. Included in this simulation will be an output that says how running the wind turbine at an angle that is not directly facing the wind will affect the life of the wind turbine

The client wants this simulation to be presented in a graphical user interface where the user will be able to input wind speed, wind direction, number of turbines, and location of turbines. Included in this GUI will be the outputs such as the power generation of the wind farm, the estimated life of the wind turbine, and various strains and forces applied to the structure of the wind turbine. The GUI should

also allow the user to be able move the wind turbines within a grid and scale the number of wind turbines from 1-100

This simulation also needs to be able to run fast and efficiently. Since this will be used in real time to improve the power generation of a real wind farm the simulation needs to be able to output the optimal yaw angles in a relatively quick manner so that the wind farm can react to the constantly changing wind conditions

The stakeholders of this project plan to use this as the first phase of a larger project. This first phase is aimed at optimizing the power generation of the wind farm by using wake steering and adjusting for the various wind conditions. Then in the future they will use this project to complete phase 2 which is aimed at maximizing the life if the wind turbine by comparing the power output gained by applying the wake steering optimization compared to how much life of the wind turbine is lost by running certain wind turbines sub optimally.

2.2 Weighting of Customer Needs

Our sponsor has several goals for us to complete during this project. The first task is to implement the simulation of a single turbine. I am giving this a weight of one because this is the most important task that everything else is built upon so we won't be able to complete the other goals without the single turbine simulation. After that scaling the single turbine up to a whole wind farm would get a weight of 0.8 This is because we can't run and wake optimization on just a single turbine so the whole simulation would be pointless without multiple wind turbines. The wake steering optimization would get a weight of 0.7 This weight was assigned because one of the main goals is to optimize the power output of a wind farm, so we need the wake optimization algorithm to be able to do that. The only reason it is lower than the other is because the other two tasks are needed for the wake steering optimization to be possible. The GUI displaying the inputs and outputs has a weight of 0.5 This is because while it would be very nice to display the information in a nice and neat GUI it isn't absolutely necessary for the product to function. The lowest weighting is being able to move the wind turbines on a grid. This has a weighting of 0.3 This is because it won't really change much about the product it will just make testing different wind farm layouts a bit easier.

2.2.1 Needs and Wants

1. The simulation of one wind turbine
    - The simulation of one wind turbine requires us to model the wake produced by the turbine. This also requires the power generation of the turbine to be outputted depending on the various wind conditions like wind speed and direction. In addition it will also produce an estimate life of the wind turbine depending on the forces being applied to it
2. Scale the single turbine simulation up to a whole wind farm
    - This takes the simulation of a single turbine and scales it up to that of an entire wind farm.
3. Applying the wake steering optimization
    - The wake steering optimization will produce the optimal angle to run each wind turbine at to maximize the power generation of the entire farm/
4. A GUI to take in inputs and display outputs
    - This GUI will display the wind turbines on a grid and the user will be able to enter various parameters like wind speed, wind direction, and wind density. Based on the inputs the simulation will display the power generated from the wind farm and other outputs like the life of the turbine.
5. Ability to move the wind turbines on a grid

- This allows the user to move individual wind turbines around on a grid to test various layouts of a wind farm

The cut-off points for making this a minimal viable product would be everything at the wake steering optimization and above

2.2.2 Constraints

1. Speed of the simulation
2. Accuracy of the simulated wind farm

While both constraints are important, it would be sufficient to sacrifice a bit of accuracy to improve the speed and allow the simulation to function better in real time.

3.0 External Search

3.1 SCALA International | Researched by Bert Yan

3.1.1 Software Solution

- SCADA International's One View SCADA
  - Utility Constrained Maintenance Based Optimization
  - SCADA monitoring for Vestas wind turbines
- SCADA International's OneView Universal Park Controller
  - Intermediate Historian

3.1.2 Description

- OneView® Park SCADA solution allows for asset management at all levels.
  - As a mature product that had been developed for years, working with the industry, we can learn many things from their software.
- Provides extensive feedback data to customers.
  - The eventual simulation we will develop will likely allow for providing quite a bit of outputs that can be beneficial to subsequent studies, we can also learn what typical data they output are looked at most.
- Enables customers to run the system on own hardware or explore hosted solution
  - The project will likely be run locally at this stage, BP's Azure services will likely be introduced to next semester's team.
- Get a flexible pricing module and choose the way you pay
  - Not relevant to the project.

3.1.3 Project Relevance

SCALA's products are focused on end-users, providing detailed control over all levels of the wind farms, and providing necessary information via the extensive GUI the company had developed (*Intelligent scada solutions* 2022). This product can be a useful resource providing insights to top-level interfacing GUI design. As the current project is asking for wake steering manipulation simulation, one of the deliverables could be developing such a GUI to work with the steering simulation for simulated end-user controlling. For this purpose, we can develop such interface using React.JS for this application.

3.1.4 Legal & Financial

Currently, BP company uses the SCADA International software products to maintain the wind farm parks, in-land and off-shore. The attempt in researching in the SCADA International software is to

understand how BP uses SCADA OneView in their systems of control, SCALA as itself is an extensive learning subject for this 12-week project. BP has included examples of how they have utilized this software as potential resources for the team.

3.1.5 Utilization

As the sponsors at BP intends to have our final deliverable to have the ability to be further developed into a training tool, then as the primary control software BP uses, there is a lot to learn from the product. Given that the nature of this project is an academic study, we will not be using the product, but we can ask the sponsors of what features they interact most with the software that they would like to see on our simulation GUI.

3.2 OpenFAST | Researched by Bert Yan

3.2.1 Software Solution

OpenFAST V8

3.2.2 Description

OpenFAST is an open-source wind turbine simulation tool that was established with the FAST v8 code as its starting point ("OpenFAST v3.2.0 Documentation").

- Open-source wind turbine simulation tool
- Used in accordance with NREL, can be considered the top choice for simulation construction. Bert can research more into this.
- Well-documented GitHub Repository
- A new API has been added that provides a high-level interface to run OpenFAST through a C++ driver code helping to interface OpenFAST with external programs like CFD solvers written in C++
- Might be easier to program
- Licensed under apache

3.2.3 Project Relevance

Since OpenFAST has vast learning tutorials and excellent documentation, we are considering this simulation tool as one of the potential candidates for this project. While C and C++ do provide a more complex challenge as compared to Python-written simulation tools, its capability far outweighs the liability, meaning that the framework OpenFAST composed of couples computational modules for aerodynamics, hydrodynamics for offshore structures, control and electrical system (servo) dynamics, and structural dynamics to enable coupled nonlinear aero-hydro-servo-elastic simulation in the time domain, many of which are what the project sponsor at BP are looking for as project deliverables. We will do further research to make comparison among the software listed, specifically looking at what inputs and outputs will each simulation tool offer and what BP would like to see as well.

3.2.4 Legal & Financial

There will not be potential legal issues as OpenFAST is a recognized open-source software maintained by groups at NREL, the National Renewable Energy Laboratory, which allows for use in academic studies. The OpenFAST software, including its underlying modules, are licensed under Apache License Version 2.0 open-source license.

3.2.5 Utilization

As a potential candidate to building the simulation on, we will need to investigate the differences in the modeling parameters each potential tools have. According to a study led by Sebastian Perez-Becker, “OpenFAST and QBlade are set up so that their only difference is the implemented aerodynamic model. OpenFAST uses AeroDyn – an implementation of the BEM method – and QBlade uses an implementation of the LLFVW method” (Perez-Becker et al., 2020). In their conclusion, the different choices of the aerodynamic models led to some quite drastic outputs. We will need to consult on our sponsors at BP to know which one is more closely related to their data, or to say, a more accurate simulation.

3.3 Floris |Researched by David Rohrbaugh

3.3.1 Software Solution

The software is called FLORIS and it stands for Flow Redirection and Induction in Steady State. Floris is an open-source software developed by the National Renewable Energy Laboratory (NREL).

3.3.2 Description

Floris is a python program that implements a steady state engineering wake model with a focus on performance (*Floris: Flow redirection and induction in Steady State*). Floris takes in many inputs including the wind speed, wind direction, x and y coordinates of the wind turbines, wake deflection parameters, wake velocity parameters, and wake turbulence parameters. After these inputs are provided the simulation can provide the power output of each of the wind turbines for the specified wind speed and wind direction. The simulation also allows for the user to manually change the yaw of individual wind turbines as well as the ability to perform wake steering on the wind farm and it provides the optimal yaw angles for the wind turbines. Floris also has other output options like calculating the annual energy production. It calculates this by having the user input possible wind speeds and wind directions and the simulation assumes that all wind speeds and directions are equally likely to occur. One more output Floris has is it can output a 2d visualization of the modeled wake for the wind farm.

3.3.3 Project Relevance

Floris lays the groundwork for a lot of the project as it provides several models that can be used for simulating a wind farm. It also provides a lot of the outputs we are looking for like the annual energy production and the visualization of the wake. One component that Floris does not have that we may be looking for is that there is no graphical user interface where someone could modify the values in real time and see how that affects the simulation. So, if we choose to move forward with this simulation that would be something we would need to implement ourselves. Although another advantage it has is that because it is built in python it will likely be easier for us to use and develop with compared to some other software out there.

3.3.4 Legal & Financial

There will not be any legal or financial concerns with this software. Floris has an Apache license which means we can use the software for any purpose without the need for any financial obligation.

3.3.5 Utilization

At this time, we are not sure if this will be used but it certainly is a contender for use within our project.

3.4 Ashes |Researched by Seyilayo Olagbami and Nelloe Anonyuo

3.4.1 Software Solution

Ashes which stand for aero-servo-hydro-elastic simulation is a Wind turbine simulation software developed by Simis is a spin-off company from the Norwegian University of Science and Technology (NTNU) established in 2013 (Simis as - Wind turbine design software, *What is Ashes?*).

3.4.2 Description

Ashes is a software that performs integrated analyses of onshore and offshore wind turbines. The script for the software is written in Python.

Ashes provides a set of built-in templates that enables you to quickly create a wind turbine model which can be further customized. Airfoil data for a set of commonly used airfoils is integrated into Ashes, and these can be used when defining the blades on the turbine.

A fully integrated simulation of a wind turbine in Ashes includes loads such as wind loads, sea waves, gravity, buoyancy, and generator loads. Arbitrarily large motions of the full structure can be simulated accurately, which is especially important in the design of floaters. Ashes is capable of modeling flexible blades, thus including effects that are becoming increasingly important in today's larger and more slender designs. Both the built-in control system or an external one can be used to control the generator and pitch/yaw actuators.

3.4.3 Project Relevance

Ashes visualizes wind and wave loads and the resulting response of the wind turbine in a live, real-time manner during simulations. At any time, the simulation speed can be increased or decreased, and different parts can be studied close-up.

Data generated during the simulation is gathered in a collection of sensors, where each individual time series can be viewed live in graphs.

3.4.5 Legal & Financial

A 2-week evaluation is required by the developers for the full version of the application to be acquired. We would need to send the developers an email detailing what we plan to use the software for. It may also need a more powerful device to run on for optimal results

3.4.6 Utilization

Although the application is very well suited to our end goal it may be too detailed and complicated for us to consider using at this time. However, we are still considering our options.

3.5 PyWake | Researched by Shuaipeng Dong

3.5.1 Software Solution

The name of the software is PyWake

Developed by MIT for DTU wind energy

3.5.2 Description

PyWake is an open-source library in Python that can simulate wind turbines and wind farms. It can calculate flow fields, power generation, and AEP (Annual energy production) of wind farms. It provides a unified interface and well-established APIs to create different wind turbine models.

PyWake also provides predefined wake models such as NOJ, Fuga, BastankhahGaussian; Wind farm models like EllipSys Model (*Welcome to PyWake*).

PyWake also utilizes vectorization and numerical libraries as well as parallel processing to increase computation speed. PyWake supports three gradient computation methods: Finite Difference, Complex Step, and Automatic differentiation. PyWake has extensive built-in methods for gradient optimization, supports all wind turbine and wind farm classes.

PyWake also models change of operation due to reduced inflow speed, misalignment between thrust and downwind direction, and wake deflection die to traversal thrust component reaction. It also supports validation for wake and momentum deficit.

3.5.3 Project Relevance

PyWake library is relevant to the project because it provides modeling abilities to create wind turbines and wind farms with user defined parameters. It provides multiple wind farm base classes, that can handle blockage effects, and able to automatically achieve effective wind speed coverage, iterates until the effective wind speed coverage is achieved.

3.5.4 Legal & Financial

There are no legal or financial issues for this library because it is open-sourced, with Open-source MIT Licensing. Available for commercial use and modification of any kind, without liability and warranty.

3.5.5 Utilization

We are still considering which software to use.

3.6 QBlade | Researched by David, Shuaipeng, and Bert

3.6.1 Software Solution

QBlade v2.0 (*QBlade - Next Generation Wind Turbine Simulation* 2022)

3.6.2 Description

QBlade uses Blade Element Momentum method (BEM) for its mathematical formulation (Mustafa et al, 2019)

- In a study led by Mustafa at University of Baghdad, they have concluded that the obtained simulation results using QBlade were of high accuracy, and it was proved that the QBlade software is reliable to analyze the blades of wind turbine (Alaskari et al., 2019).
- The software lists “Windfarm Simulations / Wake Interaction Studies” as one of its prominent use case/features, which can prove useful to this project.
- A highly advanced multi-physics code that covers the complete range of aspects required for the aero-servo-hydro-elastic design, prototyping, simulation, and certification of wind turbines.
- Allows you to run highly detailed simulations of any wind turbine design, with superior physics models more than 20x faster than real-time
- Easy to use GUI
- Dual Licensing – QBlade Community Edition, QBlade Enterprise Edition
    - Under the academic (Community) licensing, functionality of the platform is extremely limited as compared to the Enterprise edition.

3.6.3 Project Relevance

- QBlade implements very complex models for a wind turbine simulation that will be useful for this project. These complex models will allow us to generate accurate information regarding the power output of a wind farm.
- The GUI will allow for the user to change variables in real time to see how the change will affect the simulation, which is something that will be included in the software our team develops so this could provide a baseline on how we implement the GUI.
- The wake interaction feature from QBlade will be useful for this project as the main goal with this project is to optimize the wake steering to maximize the power output.

3.6.4 Legal & Financial

This may encounter Legal/Financial issues for commercial use of this software, including consulting activities, design of commercial hardware or software networking products. Where we need to contact the author for appropriate licensing.

3.6.5 Utilization

QBlade would be a convenient software to use for research purposes. Since the software allows for wake interaction studies, it would be a great asset for us as that is the intended simulation scenario we want. As the software was suggested by the sponsors at BP, we will do more research on whether this is the platform we can build our project on or if QBlade has already done the necessary work we are supposed to do for this project. On the legal side of things, we will need to contact Cindy to find out if we can use this software as is or we will need to purchase the Enterprise license.

4.0 Engineering Specifications

4.1 Establishing Target Specifications

4.1.1 Inputs to the system

As we have worked with our sponsor, it has become evident that they have the information to run a simulation, they just do not have the simulation itself. Therefore, they can supply data that can be run through the simulation that we develop. This data includes the location of turbines, wind speed, and wind directions. The sponsor would also like to run a simulation with values that are input manually, without using data that they already had, so the aforementioned inputs of location, wind speed, and wind direction all need to be separate inputs in case there is no data already. The simulation also needs to have the ability for the user to input angle values that change the direction the wind turbine is facing relative to the direction of wind.

4.1.2 Outputs from the system

Our sponsor has a few specific goals for our project to output. The first main goal is to create a wind turbine simulation that can output the forces on the turbine, and the efficiency of the wind turbine. From this single turbine simulation, a multiple turbine wind farm simulation is to be created. The users for this simulation should be able to interact with each individual wind turbine and see the previously mentioned data, or they should be able to see the energy outputs of the entire farm and the efficiency of the entire farm. The ultimate goal of the project would be to create an optimization function of the wind farm simulation, that would take into account the wake of a single turbine and turn individual windmills in order to make the wind farm as a whole more efficient. The outputs for

this goal would be to have a comparison of efficiencies of pre and post optimization in order to show the effectiveness of wake optimization.

4.1.3 Features and functions

The features of this simulation include a GUI that is able to take in various inputs and produce the required outputs. This GUI will also allow for the user to move the wind turbines around in a grid. The simulation will be able to have any number of wind turbines from 1-100. On this simulation the user will be able to run a wake steering optimization algorithm that will produce the optimal yaw angle to run each wind turbine at to maximize the power output of the farm. Along with the wake optimization an output of the expected life of the wind turbine will be produced based on the various forces applied to the wind turbine due to being run not as it was intended.

4.1.4 Physical environment

Our sponsor hope that the Physical environment that the software will run on will be desktop or laptop computers inside BP's company, accessible to BP employees who needs this software for simulation or optimization for offshore wind farms. The overall environment should be focusing on web page development.

4.1.5 Interfaces to other systems

Depend on the type of data we output, there might be a need for databases to store the data or output a txt or csv file containing the data

4.1.6 HCI

For this project, the interface will be a web interface that uses will be able to input variables that specify from a single wind turbine to at most 100 wind turbines to simulate a working wind farm. Textural and graphic interface will be provided for representation of the data.

4.1.7 Security

In terms of security, because BP has its own security measures that we are not able to access or input, we will be providing the source code to BP that they will implement their security that will allow the software to run in their environment securely.

4.2 Relating Specifications to Customer Needs

4.2.1 Inputs to the system

The inputs to the system follow closely to the needs of the customer. The simulation of the one wind turbine and the simulation of the entire wind farm both require the inputs specified in 4.1.1 for the simulation to function.

4.2.2 Outputs from the system

The outputs of the simulation match the customer needs as to what they want to be displayed on the GUI

4.2.3 Features and functions

All the features and functions match what BP wants for both the GUI and simulation of the multiple wind turbines.

4.2.4 Physical environments
The physical environment relates to how they want us to use just a GUI to display the information so that it can be ran on any standard computer.

4.2.5 Interface to other systems
The Interface to other systems relates to the need of the simulation model because we will likely be using their Internal data and importing that into out model to produce the simulation of a wind turbine.

4.2.6 HCI
The HCI relates to the Implementation of the GUI as that is how the user will be interacting with the software.

4.2.7 Security
None of BP's needs or wants mention security as that is not something that we need to focus on.

5.0 Concept Generation

5.1 Problem Clarification

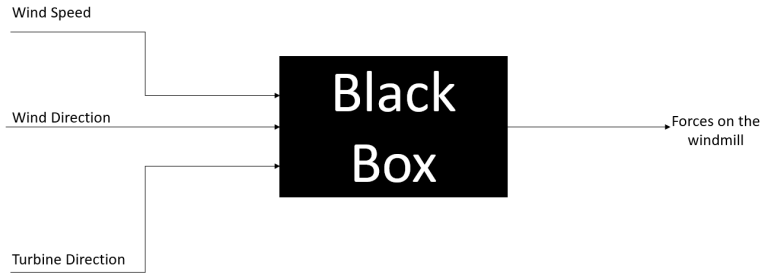

Figure 1. Black Box Model for Forces on a Windmill

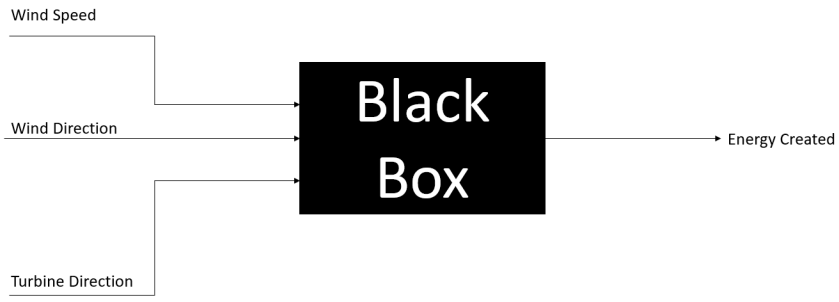

Figure 2. Black Box Model for Energy Output of a Windmill

Figure 3. Black Box Model for the Efficiency of a Wind Farm

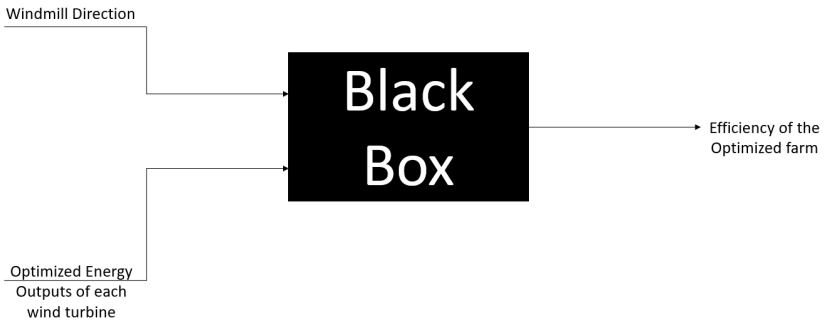

Figure 4. Black Box Model for the Efficiency of an Optimized Wind Farm

5.2 Concept Generation

Currently, the team has researched five simulation platforms, they are OpenFAST, QBlade, PyWake, Floris, Ashes. These platforms use languages ranging from Python interfaces for efficient deployment to C++ for utmost performance.

5.2.1 Inputs

Amongst the many models that are being considered at this moment, OpenFAST features the most research heavy tool bench. As OpenFAST is a modulated platform, for the simulation to function as close as possible to approximate real-world wind farms, multiple input files are required. Each input file represents a module being deployed for computation, for example, InflowFile allows us to adjust and modify inflow wind input parameters. However, amongst the modules being present in Figure 1, we do not necessarily have to deploy all of them, a change of the Boolean value in the input files allows us turn on/off a featured module.

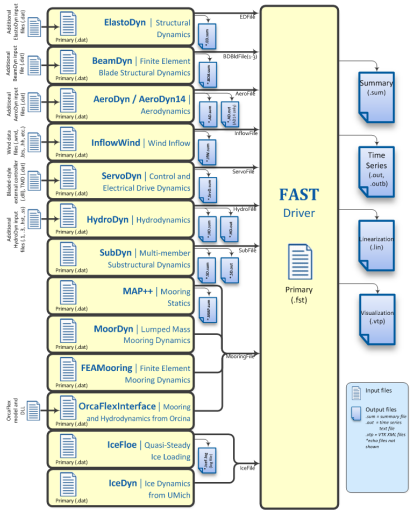

Figure 5*5.* OpenFast Inputs Example

5.2.2 Outputs

Output for this project will be in textual and graphical form, we will most likely obtain graphical output using Matplotlib in python as most of our research libraries are in python and NP array. A sample output form is shown in Figure 3 from PyWake. User can extract output into an output file as well, the format of the file will most likely be a CSV or Excel file.

5.2.3 Features and functions

For implementation of features and functions the software will be able to optimize wind farm power generation through wake steering. We will be implementing this feature by using existing wind simulation libraries such as OpenFAST, PyWake, Qblade etc. and customize to our input provided by BP.

Users will also be able to add, remove and move up to 100 wind turbines through a GUI interface that we will be building in React JS as shown in Figure 2.

5.2.4 Physical environment

Per BP's request, the physical environment will be a web interface on laptops and desktops inside BP's company, we will be using React JS for GUI system as it will allow us to develop a web interface will python or C++ (depending on libraries) running in background.

5.2.5 Interfaces to other systems

We will most likely be providing file interface since BP sent their data in a excel file, or CSV. And outputs will likely be in this format as well. An interface where users can drop input files will be built by GUI and read in through file stream and output can be packaged into a single output file too.

5.2.6 HCI

The following Figures 6 and & are a sample interface provided by BP, and a sample graph output from Pywake. Primary input interface of the software will be similar as shown figure 2, user is able to insert wind turbine in a 10 by 10 grid and real time output will be provided in textual and graphical format similar to figure 3.

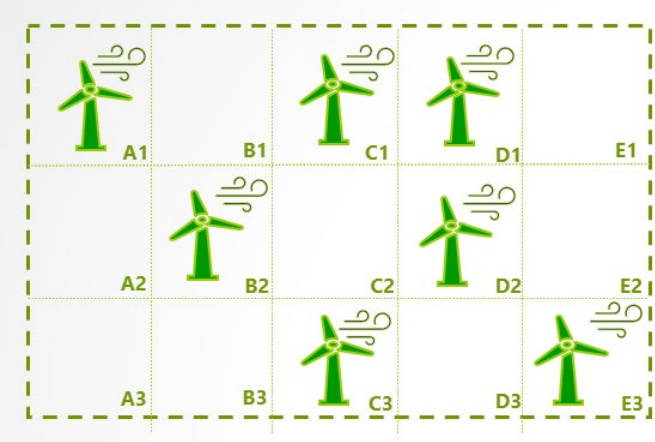

Figure 6. UI Example From BP

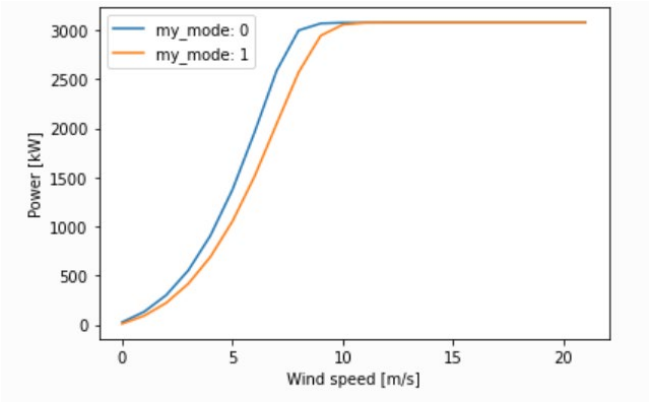

Figure 7. Example Graph from PyWake

5.2.7 Security

Security is not a concern on our side of the project because BP has their own internal security measures that we cannot access, thus this is not something we are going to implement.

6.0 System Level Design

The physical environment we will be designing for the wind simulation project will be the GUI intended to show the user the wakes of the turbines in the wind field as a result of yaw misalignment. This interface will have the ability to input all the desired inputs and stated by BP, displayed in a variety of features such as numerical input boxes, a file drop interface, as well as grid layout for moving around turbines on a simulated landscape. With all the inputs stated by the user, the program will then process the data using appropriate mathematical models and display the resulting data in list or visual format depending on the data type. Wake models will be represented visually for best comprehension. Scalar data values such as wind energy output and efficiency will be presented in list view for ease of access. All inputs and outputs of the user interface will be represented by features and

functions that produce an easy-to-use platform that will be used to train new engineers on the details of wind farm optimization in a user-friendly interface.

7.0 Special Topics

7.1 Budget and Vendor Purchase Information

At this current state in project, we will not be making use of any funds as the software we will be using is free open source and therefore we will not require any funds to make purchases at this time.

7.2 Project Management

The following Gantt chart provides a visual representation of the tasks we need to accomplish over the scope of the project.

GANTT CHART

PROJECT TITLE	BP Wind Turbine Project	COMPANY NAME	BP
PROJECT MANAGER	Ian Alleyne	DATE	09/18/2022

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
1	Project Conception and Initiation					
2	Team Introduction	All	8/23/22	8/23/22	0	100%
3	Project Introduction	All	8/23/22	8/23/22	0	100%
4	Stakeholder Introduction	All	8/25/22	8/25/22	0	90%
5	Status Report Week 1	Marissa	8/28/22	8/28/22	1	100%
6	Research	All	8/29/2022	9/11/22	12	90%
7	Deliverables Agreement	Bert	9/1/22	9/4/22	3	100%
8	Literature Review	Marissa	9/1/22	9/11/22	10	100%
9	Project Definition and Planning					
10	Status Report Week 2	Marissa	9/1/22	9/4/22	3	100%
11	Communication Plan	All	8/30/22	8/30/22	3	16%
12	Weekly Sponsor Meeting	All	8/30/2022	8/30/2022	1	100%
13	Status Report Week 3	All	09/11/2022	09/11/2022	2	100%
14	Weekly Sponsor Meeting	All	09/13/2022	09/13/2022	2	100%
15	Status Report Week 4	Seyilayo	09/11/2022	09/18/2022	2	100%
16	Statement of Work	Bert	09/11/2022	09/18/2022	7	80%
17	Design Specification Report	TBD	TBD	09/25/2022		
	Status Report Week 5	TBD	TBD	09/25/2022		
	Weekly Sponsor Meeting	All	TBD			
18	Status Report Week 6	TBD	TBD	10/02/2022		
19	Project Presentation	TBD	TBD	10/02/2022		
20	Weekly Sponsor Meeting	All	TBD			
21	Status Report Week 7	TBD	TBD	10/09/2022		
22	Weekly Sponsor Meeting	All	TBD			
23	Status Report Week 8	TBD	TBD	10/23/2022		
24	Weekly Sponsor Meeting	All	TBD			
25	Project Launch & Execution					
26	TBD				0	0%
27	Implementation(TBD)				0	0%
28	Project Performance/Monitoring					
29	Reflection(TBD)				0	0%
30	TBD				0	0%

PHASE ONE: WEEK 1 (M T W R F), WEEK 2 (M T W R F), WEEK 3 (M T W R F)
PHASE TWO: WEEK 4 (M T W R F), WEEK 5 (M T W R F), WEEK 6 (M T W R F)

Figure 8: Gantt Chart Showcasing Scope of the Project

7.2 Summary of Team Skills

Reference appendices A-G for team member resumes.

7.2.1 Nelloe Anonyuo

Nelloe's skills cross over at the intersection of technology and management. She has knowledge of multiple coding languages such as Python, Java, C++ and ABAP, a database programming language. In her experience as an AI/ML Technical Program Manager with Meta, she was able to learn more about the industry implementations of Artificial Intelligence and Machine Learning as well as manage a large project, working cross functionally with customers, engineers and other TPMs.

Along with her strong technical skills, Nelloe also served as the Program Coordinator for the Multicultural Engineering Program Orientation in which she worked for over a year to plan a weeklong orientation for incoming first year engineering student. Currently, Nelloe serves as President of the National Society of Black Engineers overseeing a chapter of over 100 members and managing an executive board of 18. These experiences have not only helped her grow as a leader but develop useful organization and time management skills.

7.2.2 Seyilayo Olagbami

Seyilayo is familiar with many of the applications within the Adobe Creative Cloud and has a background in programming languages such as Java, Python, SQL, HTML and C++. She has had the privilege of working for Penn State World Campus and Libraries as a Virtual reality content creator in her free time, where she learned valuable professional skills such as UI design, database design, and web design. As well as obtained an advanced knowledge of 3D modelling and VR applications. She also has the privilege of working as a Technical Assistant for Penn State Information Technology, where she assists faculty, staff, and students with all the technological concerns they may have. In both her academic and professional life, she has been consistently praised as adaptable, creative and intuitive by my professors, supervisors and peers. Whether working on academic, extracurricular, or professional projects, Seyilayo applies a proven combination of writing, creative thinking, and organizational skills.

7.2.3 Shuaipeng Dong

Shuaipeng is familiarize with many programming languages, java, C, C++, python. He has research experiences with Machine learning, designed convolutional neural networks for cancer detection, Recurrent Neural Network for stock prediction; therefore, he can review the machine learning model that BP have already implemented and will be provided for us. He is also familiar with Web development, especially in Spring Framework, which will come in handy when we reach web development with React JS, creating GUI and maybe databases connection etc.

7.2.4 Bert Yan

Bert's skills can be utilized for the development of the simulation using platforms such as PyWake. His Python, Java, and C++ skillsets can help solve programming problems that may arise. His software development experiences can be applied to the eventual deliverable product. His background with Machine Learning and Data Mining can be used when testing algorithms and data handling. In his experience as robotics team mentor, Bert had effectively communicated technical knowledge and skills with his fellow mentees and team members, this experience helped him develop leadership skills that he can use to help the team advance forward.

7.2.5 Scott Carrol

Scott's skills mainly focus around the design aspects of mechanical engineering. He specifically is skilled with 3D CAD, with most of his experience in SOLIDWORKS. Scott also has significant experience with mechatronics, specifically using Arduinos to perform tasks that would be difficult for humans to perform themselves. He has some experience with being a leader within teams from his job as a summer camp supervisor, where he was tasked with leading more than 50 counsellors in maintaining the safety and happiness of over 500 campers. Using his knowledge and experience, Scott hopes to be a knowledge bank that much easier. his fellow teammates can use to make their time developing this project

7.2.6 David Rohrbaugh

David's skills focus around developing in an object-oriented setting in the python and java programming languages. Included in his skills of python and java is the ability to implement a functioning GUI for various projects He is also skilled with implementing and modifying various algorithms that can be used to solve a plethora of problems. David hopes to use his knowledge to help implement the GUI for this simulation so that it both looks clean and functions properly.

7.2.7 Marissa Stecko

Marissa's skills were developed in the research sector with some overlaps to industry, specifically in metal additive manufacturing. She is familiar with the process of taking an idea from the ideation and walking it through the design stages to a fully functional product ready to deliver to a sponsor. Marissa has experience in quality control and statistic analysis that will help her evaluate how well the group is meeting requirements by the sponsor. Given her work experience in research, Marissa also has formal experience in scientific report writing and technical communication that will prove useful when completing the writing deliverables for this project. In her experience at her job, Marissa also had an opportunity to manage other undergraduate students and guide them through different research efforts and has developed the necessary leadership skills to teach technical skills and delegate tasks in a group work setting.

7.3 Risk Plan and Safety

The biggest risks we foresee affecting our project would be scheduling delays, bugs in the software, and operating the wind turbine out of alignment which would affect the life of the turbine. Those would be a high level of risk as they would prevent us from moving further in our project. With scheduling delays, we would minimize these risks by ensuring that we stick to set deadlines and communicate at the earliest convenience when a deadline no longer works. Also, we could communicate when there are any blockers so that we as a team can figure out how to move past it or even if there are any tasks we can work on at that moment. As a fall-back strategy we would make sure that everyone has enough time in the schedule to get a task done and redistribute tasks to other team members. In the case of bugs in the software in order to minimize this risk we would read the documentation of the program that we choose to utilize and make sure that we are familiar with the syntax of the coding language. We will also look at sample code, using the ones that already exist so that we lessen the risk of messing up how the program was supposed to run. A fall-back strategy would be to contact the developer for help or figure out another approach to write the code.

In the worst case if we determine that the problem is with the software itself, we can switch to another software. If we were to run into the issue of operating the wind turbine out of alignment Some minor risks would be that our customer changes the scope of the project, or that they are not satisfied with results we deliver to them. In order to minimize the risk that the customer doesn't change the scope of the project we would stay in constant contact with our sponsors and getting their approval before moving on to the next part. A fall-back strategy would be to work with them to see if we can keep the scope of the project the same. Another fall-back strategy would also be to change the scope in accordance with the customer. In the case that the customer isn't satisfied with our results, to minimize this happening we would make sure that we have a clear idea of what the customer wants. A fall-back strategy would be to discuss what they don't like and ways to resolve those issues.

Table 1. Risk Management Plan

Risk	Level	Actions to Minimize	Fall Back Strategy
Software bugs	High	- Read documentation of program - Look at sample code	- Contact the developer - Approach the code differently - Change software
Schedule delays	High	- Stick to deadlines - Communicate with team members	-Build in safety time -Re-allocate resources or staff
Operating Wind Turbine out of Alignment	High	-Only use user inputs known to work for yaw misalignment -Be aware of max bending moments and forces on the structure	-Lessen the yaw misalignment until output values yield usable data
Customer changes scope of project	Low	-Stay in contact with sponsors	-Alternative design - Work to keep scope the same
Customer not satisfied	Moderate	-Understand the customer's needs	-Discuss ways to resolve what they don't like

7.4 Ethics Statement

Our team will be abiding by the ACM Code of Ethics and Professional Conduct by making sure that our work is in line with this Code of Conduct. As we are researching possible solutions, we will ensure that we are going with the solution that will not cause any harm to society in any way. We will consider the results of our efforts so that they will respect diversity, be accessible, and be used in responsible ways. We will respect any software that we use, crediting the creators and resources that was used within this project. We will respect any patents, copyrights, or license agreements. When working with our sponsor we will respect any policies or agreements that have been established prior or during the duration of our team working with them. We will honor confidentiality and respect privacy of both the stakeholders and customers.

7.5 Environmental Statement (if applicable)

At our current stage in project, we have not come across any task in our work schedule that would in some way have an effect on the environment. Therefore, do not think an environmental statement is applicable at the time.

7.6 Communication and Coordination with Sponsor

We meet with our sponsor weekly on Thursdays for an hour from 11:30am-12:30pm EST. During these meetings we give an update of what we did the previous week, as well as get any new updates from them. We also discuss any obstacles that we may have and get their insight on how to resolve them. During these meetings we also go over our plan of action for the next week and address questions pertaining to this plan. We have a Microsoft Teams chat with our sponsor in which we discuss any pertinent information, send links, and plan future meetings on a day-to-day basis.

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End of SOW

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8.0 References

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9.0 Appendices
Appendix A: Nelloe Anonyuo Resume

Chinelolum Anonyuo

cma5964@psu.edu• (614) 204-4153

EDUCATION

Degree	Institution	Graduation Date	GPA
Bachelor of Science in Computer Science Minor in Entrepreneurship & Innovation	The Pennsylvania State University	May 2023	3.54/4.00

SKILLS

Programming Languages: Python, Java, ABAP, RobotC
Web Frameworks: HTML, CSS
Software: Adobe Creative Cloud, SAP
Interests: Project Management, Software Engineering, UI/UX Design, Artificial Intelligence, Machine Learning

AWARDS

Penn State Bunton-Waller Fellowship Recipient

Penn State Lucier Engineering Equity Scholarship

Penn State Diefenderfer Scholarship in Engineering

PROJECTS/EXPERIENCE

Biological & Robotics Intelligent Fluid Locomation Lab, Researcher — **AUGUST 2020 - PRESENT**
- Worked with a team of graduate students and a professor to design and test a swimming robot modeled after fish
- Programmed, simulated, and optimized the control of the swimming robot using a robot simulator and control environment
- Worked directly with professor on analyzing different scientific articles related to fish and robotic swimming

IT Intern for Manufacturing and Material Flows Team, Steelcase, Grand Rapids, MI — **MAY 2020 - AUGUST 2020**
- Developed two projects related to process automation to increase the efficiency of labor and productivity
- Gained understanding in SAP, ABAP programming language, and Agile Development
- Served as project manager in intern projects centered around user experience and design thinking

Techopolist Blog, Founder — **JULY 2020-PRESENT**
- Created a social media type site dedicated to the connection and encouragement of POC in tech
- Utilized CSS and HTML to build site

Blackjack Python Program, Project — **MAY 2020**
- Coded a working blackjack game using python
- Utilized classes and data structures such as linked lists and trees

Accenture Innovation Case Competition, Contestant, Philadelphia, PA — **FEBRUARY 2020**
- Represented Penn State in a time sensitive competition
- Collaborated with 2 other people to design an application that solved a companies problem
- Implemented the design thinking process to come up with an innovative solution

Engineering Consulting Collaborative Case Competition, Finalist — **OCTOBER 2019**
- Given a hypothetical problem from a company and had to solve and present it within a week
- Served as team captain to a team of 4 as we collaborated on a plausible solution
- Selected amongst 10 teams to the finalist round; finished in 3rd place

INVOLVEMENT

Presidential Leadership Academy — **AUGUST 2020- PRESENT**
- Admitted to a program that selects 30 of the most promising leaders across the university to a 3 yr academic program
- Students take classes instructed by the President of Penn State University focusing on developing leadership fundamentals
- Program members travel to places like Washington D.C., Los Angeles, Puerto Rico, and more to interact with prominent leaders

Multicultural Engineering Orientation Program , Mentor Assistant — **AUGUST 2020 - PRESENT**
- Aided program coordinators and staff to run the mentoring program for over 80 students

Academic Integrity Committee, Student Representative — **MARCH 2020 - PRESENT**
- Nominated by Penn State College of Engineering to serve as a student representative on the Academic Integrity Board
- Collaborated with professors and graduate students to resolve academic integrity violation disputes

Engineering Consulting Collaborative, Marketing Associate — **OCTOBER 2019 - PRESENT**
- Managed all social media for organization as well as created and marketed campaigns and events

Impact Scholar, Mentor — **AUGUST 2019 - PRESENT**
- Helping execute and lead their first yearlong mentorship program for minority college students pursuing a degree in S.T.E.M

National Society of Black Engineers, — **AUGUST 2019 - PRESENT**
- Social Chair: Organized the first ever campus wide jeopardy game geared with the purpose of connecting black organizations on campus
- General Body Member: Developing professional skill set as an engineer while contributing to the community via volunteer services

Python Learning Organization, General Body Member — **AUGUST 2019 - PRESENT**
-Collaborated with peers to create different python projects with varying degrees of difficulty

Appendix B: Seyilayo Olagbami Resume

OLUWASEYILAYO OLAGBAMI

CONTACT

seyilayoo@gmail.com
(717)817-8535
801 Toftrees Avenue , Unit 231
State College, PA, 16803

EDUCATION

PENN STATE UNIVERITY
State College, PA
B.S. Computer Science (Engineering)
(Expected graduation Dec 2022)
Relevant Coursework
Systems Programming
Object Oriented Programming
Database Management Systems
Discrete Mathematics
Digital Design
Graphic Design

Additional Skills
HTML and CSS
Python, C++, Java, C
2D Animation
Adobe Design Softwares
Clip Studio, Procreate, Canva
First Aid Certification
High Level French

Awards & Honors
Study Sport Service Award 2017
Gold Merit in Sports /Culture 2017/ 2018

Extracurricular Activities
Multi-Cultural Engineering Orientation - Tech Team
Red Cross Ghana
Freelance Animation
Co-Captain of Swim Team
African Leadership Academy
Model African Union – Delegate
Co-founder of "Happy feet"
Graphic design Freelance

OBJECTIVE

Hard-working Computer Science major currently attending Penn State University, with 3 years of work experience. Aiming to leverage a proven knowledge of digital design, database design, and object oriented programming and leadership skills to successfully fill any given role. Frequently praised as adaptable by my peers, I can be relied upon to help my team achieve its goals.

WORK EXPERIENCE

BEDNAR LIBRARIES VR EXPERIENCE CREATOR
Penn State World Campus, State College, PA / Aug 2021 – Present
- A Bednar Libraries Internship
- Designing an Interactive VR Experience/Application for students who attend the university remotely.
- The VR experience will allow students to discover and utilize all the library services in one convenient application
- Creating a 360 video tour of the University's library
- Member of the Student advisory board

TECHNICAL ASSISTANT
Penn State Information Technology, State College, PA / Feb 2021 – Present
- Tech Tutors offer personalized learning experience and tech help designed to support all students, faculty, and staff to accomplish their teaching and learning goals.
- Tech TAs offer support in real-time to faculty members for preparing and hosting synchronous class meetings via Zoom.
- Tech Tutors support: Sites at Penn State (WordPress) Zoom, Canvas, Kaltura, TopHat, Adobe Creative Cloud Software, Microsoft Applications

SOCIAL MEDIA MANAGER
Frontida Ltd, Lagos / Jun 2018 – Dec 2018
- Handled most media ie presentation on PowerPoint
- Served as a PA to superior
- Managed social media profiles for Facebook, Twitter, and Instagram
- Created all the posts using a design tool.
- Created and Edited videos for clients

PROJECT MANAGEMENT INTERN
Plexada Ltd, Lekki, Lagos / Jun 2017 – Aug 2017
- At the time of my joining they were in the process of implementing a new system for the Mercedes Benz Dealership in Lagos.
- Conducted a survey for the entire company using descriptive data using notes and took minutes at various meetings.

Appendix C: Shuaipeng Dong Resume

Shuaipeng Dong

State College, PA | (814)-826-5214 | sjd5880@psu.edu

EDUCATION

The Pennsylvania State University Aug 2019 - May 2023
BS: Computer Science and BS: System Analysis GPA:3.57 / 4.0 University Park, PA

TECHNICAL SKILLS

Programming language: Java, C, C++, Python, MATLAB, VBA
Framework & Technology: TensorFlow, Spring, SQL
Production & Development tools: Linux, Jupyter Notebook, VSCode, IntelliJ

WORK EXPERIENCE

BMW Automotive Shenyang Plant May 2021 - Aug 2021
Data Intern of Launch and Change Dept

- Designed an automatic report generation program in VBA that Prepared, analyzed, and monitored month-end reporting requirements, organized total vehicle information in Excel, helped Dept by reducing processing time by **20%**.
- Developed a search program with Excel VBA, implemented search algorithms that traverse non-uniform dataset to obtain work line information and section header information, reduced search time by **80%**.
- Produced statistical inference on over thousand vehicle parts with information analyzed in yearly, monthly, and daily scale.

Calculus 1 Learning Assistant August 2022 - Dec 2022

- Leading office hours and review sessions for the entire class over 50 students.
- Facilitate group work with students during lecture time, recitation class, and homework sessions.
- Conducting weekly meetings to update student status and improve learning sessions efficiency by reviewing student feedbacks.

PROJECT EXPERIENCE

Data Prediction with Deep Learning Jan 2022-May 2022

- Designed a 9 – layer Depth wise Convolutional Neural Network using modified VGGNET structure in TensorFlow to detect Invasive Ductal Carcinoma, achieving high accuracy over **90%.**
- Developed 4-layer Recurrent Neural Network with LSTM cells to predict Google and Oracle stock prices from 2018 to 2021 with more than **90%** accuracy.

Online shopping Ecommerce Application July 2022 – August 2022

- Developed an E-commerce Application for Online Shopping platform by Spring Boot, Spring MVC, and Spring Data.
- Implemented server-side REST APIs, such as user profile service, goods service, goods category service, and shopping cart service using Spring MVC, Spring Data, and MySQL.
- Developed a single page front-end to integrate using HTML, CSS, and JavaScript.

Finding Dynamical degree of rational maps May 2022 - Aug 2022

- Developed python program in Sage math with real time system to calculate dynamical degree sequences of rational maps.

BP-Simulated wind turbine and wind farm generation and optimizations Aug 2022-Dec 2022

- Implement existing wind turbine and wind farm simulation libraries, build GUI interface simulating wind farm with 10 by 10 grid
- Work in an interdisciplinary team of 7, to review, compare, and test existing wind turbine and wind farm simulation libraries
- Follow up weekly reports and meetings with BP, provide project insight and progress report to ensure schedule deliverables.

Publications

Shuaipeng Dong, the first author, Predicting Invasive Ductal Carcinoma by Using Deep Convolutional Neural Network.
Accepted by 2022 3rd International Conference on Artificial Intelligence and Education (ICAIE 2022)

HONORS AND AWARDS

Pennsylvania State University

- Dean's List Aug 2020 – Dec 2020
- Behrend College Honors Student, The Pennsylvania State University May 2021

Appendix D: Scott Carroll Resume

Scott W. Carroll

267.454.4098 | scarroll1234@gmail.com | 4447 Summer Meadow Drive, Doylestown, PA
LinkedIn: https://www.linkedin.com/in/scott-carroll-224937191/

EDUCATION

The Pennsylvania State University, College of Engineering — University Park, PA
Bachelor of Science in Mechanical Engineering — December 2022
Dean's List: Fall 2018-Fall 2021 — GPA: 3.76/4.00

Relevant Courses

Design Methodology	Computational Tools
Mechanical Design	Vibration of Mechanical Systems
Circuit Instruments & Statistics	Modeling Dynamic Systems
Technical Writing	Mechatronics
Heat Transfer	Intro to Robotics
Engineering Design	Finite Element Analysis for Engineers

CERTIFICATIONS

Certified SolidWorks Expert: Mechanical Design
Certified SolidWorks Professional Advanced: Surfacing, Weldments, Sheet Metal, Drawing Tools

WORK EXPERIENCE

Qfix | Design Engineering Co-op | Avondale, PA — Jan 2022 - Jun 2022

- Developed devices that assisted production
- Created models, drawings, and assemblies in Solidworks
- Used Solidworks PDM to organize files
- Participated in project team meetings and project task planning

The Pennsylvania State University | Make Space Assistant — Aug 2019- Dec 2021

- Led Engineering Design 100 lectures on Solidworks
- Trained five new Make Space Assistants
- Developed students' knowledge of Engineering Design

The Pennsylvania State University | Design Project: Autonomous Etch-A-Sketch

- Created a program to take any picture and draw it on an Etch-A-Sketch
- Designed a screen clearing system in SolidWorks

YMCA - Bucks & Hunterdon Co. | Summer Camp Leadership Team Member — Jun 2016-Aug 2022

- Coordinated training for 100 Counselors
- Ensured safety of 500 campers

LEADERSHIP & INVOLVEMENT

CAD Chair, 3-D Printing Club	2021-2022
Member, Association of Mechanical Engineers	2019-2022
Member, Penn State FSAE club, Chassis Division	2022
Member, Penn State FSAE club, Aerodynamics Division	2022

Appendix E: David Rohrbaugh Resume

David Rohrbaugh

102A Dunham Hall, University Park, PA 16802
717-521-4708
Dwr5409@psu.edu

Education

The Pennsylvania State University
Pursuing bachelor's in computer science
expected graduation- May 2023
Current GPA: 3.49/4.00

Relevant Courses:
Cmpsc 465: Data Structure and Algorithms
Cmpsc 311: intro to systems programming
Cmpsc 221: object-oriented programming with web
Cmpsc 461: Programming language concepts

Skills

Java, python, and C

Object oriented programming

Systems programming

Work Experience

Worked at KFC as a packer/cashier — June 2016 – May 2019
Worked at UTZ as a packer — June – August 2019-2021

Volunteer

Shaver's Creek environmental center — February 2020

- Helped create paths and prepare it for the upcoming Maple Harvest Fest.

Appendix F: Marissa Stecko Resume

Marissa Stecko

814-574-3195 • mzs1219@psu.edu

EDUCATION

Bachelor of Science in Mechanical Engineering (Graduation - May 2023)
The Pennsylvania State University, University Park, PA (GPA – 3.69)

SKILLS

Descriptive & Inferential Data Analysis	VG Studio Max	MATLAB
Directed Energy Deposition (DED)	SolidWorks	ImageJ
Materials Characterization		

WORK EXPERIENCE

Research & Development Engineering Intern (March 2021 – Present)
The Applied Research Laboratory at Penn State University - Center for Innovative Materials Processing 3D (CIMP-3D)
Junior Engineer of Metal Additive Manufacturing

- Assisted on various research projects as a junior engineer to meet time sensitive deadlines
- Demonstrated effective communication styles for engineering environments helping to facilitate in the sharing of information
- Applied interdisciplinary knowledge evaluate, qualify and solve problems

Front Desk Agent (June 2019 – August 2019)
The Nittany Lion Inn - Penn State University, University Park, PA

- Ensured execution and maintenance of all hotel services
- Provided enthusiastic, prompt, and courteous customer service.

ENGINEERING PROJECT EXPERIENCE

Computed Tomography vs. Serial Sectioning Data Comparison
Principal Investigator: Griffin Jones – *Summer 2022*

- Prepared MATLAB scripts to automate image and volumetric analyses
- Diagnosed calibration inconsistencies of serial sectioning images
- Interpreted image registration software outputs to determine the quality of builds

In-Situ Process Monitoring and Data Collection of DED Systems
Principal Investigator: Dr. Edward Reutzel – *Spring/Summer 2022*

- Qualify through statistical analysis features of laser and arc welding processes
- Identified and classified patterns in data sets to develop a framework for isolating perturbations in data
- Communicated special information of DED process quality in volumetric plots to visualize build data anomalies

Materials Characterization and Metallography of Metal AM

Principal Investigator: various – *Spring 2021 to Summer 2022*

- Observed and defined bead on plate parameters for DED processes of numerous metals
- Gathered and interpreted mechanical testing data for several metallic alloys
- Conducted metallography of various materials to assist in material characterization
- Onboarded new undergraduates with equipment operation and lab procedures

Post-Processing Evaluation of Powder Bed Fusion Manufactured Parts

Principal Investigator: Cory Jamieson - *Summer 2021*

- Processed X-Ray/CT data in VG Studio Max
- Analyzed voxel data from non-destructive testing to observe surface roughness on non-viewable surfaces
- Verified mechanical integrity of parts post-processing to certify flight-readiness

Process Parameterization of Glass DED

Principal Investigator: Cory Jamieson - *Summer 2021*

- Parameterized AM DED of glass as primary research assistant
- Documented research steps visually and analytically for future reference in experiments and scientific literature

Appendix G: Bert Yan Resume

BERT YAN

State College, PA, 16803 | 814-248-8363 | bertyan.work@gmail.com
linkedin.com/in/bert-yan | github.com/Minrish

OBJECTIVE

Motivated Computer Science senior skilled in *software development*, capable of working under multiple IDE environments. Knowledgeable scholar in *Machine Learning* and *Exploratory Data Mining*. Fast learner bringing proficient understanding of *Swift, Java, Python, C*, and C++ seeking *internship/full-time* opportunity to help solving real-life problems and to expand personal growth.

EDUCATION

B.S. in Computer Science | Pennsylvania State University, University Park
2019-08 —— 2023-05 | *Cumulative GPA: 3.8/4.0* | Dean's List for multiple semesters

Minor in Mathematics | Pennsylvania State University, University Park
2019-08 —— 2023-05 | *Cumulative GPA: 3.8/4.0* | Member of Robotics Club, Badminton Club

EXPERIENCE

Robotics Team Mentor | Laurel Highlands Education and Robotics JUNE 2019 – PRESENT

- Engaged in study sessions to help students get familiar using Java and Android Studio IDE
- Communicated effective robotic programming skills and applied computer vision knowledge to optimize robotic vehicle pathing with object recognition.

EDUCATION

Tools
XCode, Android Studio, NetBeans, Emacs, Visual Studio Code, GitHub, Linux distros, ROS

Research
Machine Learning, Exploratory Data Mining, Data Analysis

Languages
Swift, Java, Python, R, C, C++

Software Development
iOS Software Development using MVVM Software Architecture Pattern; ROS

PROJECT

I SPY| Grade: 100 | GitHub Link: github.com/Minrish/I-SPY MAY 2022
Technology Used: Swift, CoreML, MobileNet V2, MVVM Design Architecture

Description: Designed and implemented iOS object classification application using trained CoreML model to intelligently identify surrounding objects, allowing voiced feedback for expanded use cases.

Campus Map| Grade: 100 | GitHub Link: github.com/Minrish/Campus-Map MAR 2022
Technology Used: Swift, MVVM Design Architecture, Apple's MapKit, User location services

Description: Deployed Apple's MapKit, this application demonstrates functionality of a tour guide, and direction telling software dedicated to Penn State University at University Park.