GAYATRI VIDYA PARISHAD COLLEGE OF ENGINEERING (Autonomous)
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Madhurawada, Visakhapatnam - 530048

WindTwin: A Digital Twin for Wind Turbine

Under the esteemed guidance of:
Dr. D.N.D. Harini
Associate Professor and
Head of the Department
Department of C.S.E
GVP College of Engineering(A)

Team-5
MEENUGU SIVAJI. 20135A0514
MD FIROZ KHAN, 20135A0516
B.V.S.S.L GAYATHRI, 19131A05P1
MATCHA SAI RAM, 20135A0513

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Abstract

A digital twin is a virtual representation of a physical asset, such as a wind turbine, that allows for real-time monitoring and analysis to improve efficiency, prevent potential failures, optimize operations, and reduce downtime. It can also be used for training and simulation purposes.

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Introduction

- A wind turbine is a device that converts the kinetic energy of wind into electrical energy.The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity.
- Wind turbines can be used as stand-alone applications, or they can be connected to a utility power grid or even combined with a photovoltaic (solar cell) system.
- Wind turbines requires maintenance such as regular inspections, repairs, and servicing to ensure the wind turbine working properly
- Apart from regular maintenance a person visits turbine manually and observes turbine speed, voltage fluctuations and wind turbine vibrations to ensure proper operation

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Existing system and its DrawBacks

- Many wind turbines are located in remote areas, making it difficult to access them for regular maintenance and monitoring. This can make it difficult to identify and address issues with the turbine in a timely manner.
- Collecting accurate data on wind turbine performance can be difficult, as it often requires specialized equipment and expertise.
- Analyzing the data collected from wind turbines can be challenging, as it requires a thorough understanding of the turbine's mechanics, control systems, and performance characteristics
- Analyzing potential failures such as mechanical, electrical, control system, vibration failures

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Proposed system

- Proposed model is a digital twin of actual wind turbine which is a digital replica of a physical asset used to simulate the behavior of that asset under different conditions.
- Wind twin allow users to see what's going on under the hood without needing to be physically present.
- Sensors allow us to collect data that is used for analysis, data collected through sensors allows for the detection of turbine failures

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Advantages of Proposed System

- Failure Diagnosis and Prediction.
- Optimized Modeling and Designs.
- Predictive maintenance.
- Real-time monitoring and analysis of the data from wind turbine.
- Improve efficiency of wind turbine
- Help to minimise wind turbine downtime, and reduce inspection and maintenance costs.
- It can also be used for training and simulation purposes.

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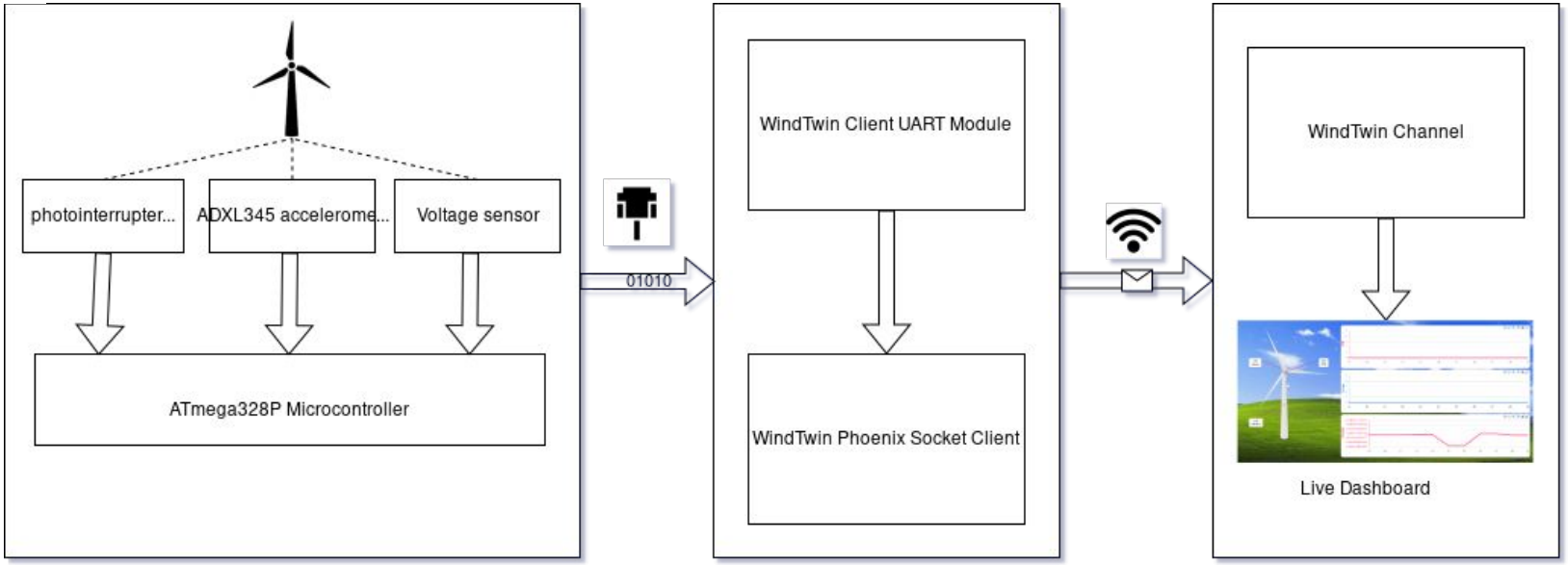
Block diagram



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Implementation

- WindTwin is a software platform designed to monitor and optimize the performance of wind turbines in real-time. The system implementation process for WindTwin involves a series of steps to ensure that the software is installed, configured, and integrated with your wind turbine correctly.
- The WindTwin Client is responsible for receiving data from the Arduino Uno via serial communication and then transmitting this information to the WindTwin Server.
- The responsibility of the WindTwin Server is to receive data from the client through websocket communication and render the same in the dashboard.

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Output

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Test Cases

If WindTwin Hardware Not Connected to WindTwin Client

```
PROBLEMS    OUTPUT    DEBUG CONSOLE    TERMINAL

WindTwin Hardware Not Connected
-
WindTwin Hardware Not Connected
-
WindTwin Hardware Not Connected
-
WindTwin Hardware Not Connected
-
```

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Test Cases

If WindTwin Hardware is Connected to WindTwin Client

```
Interactive Elixir (1.12.2) - press Ctrl+C to exit (type h() ENTER for help)
iex(1)> WindtwinClient.start
Database connection established
Starting Connction With Hardware..
Getting Data..
-
0.00,0.00,5.916398115971124
-
0.00,0.00,5.847167405390978
-
0.00,0.00,5.8942486091669615
-
0.00,0.00,5.871175350813498
-
```

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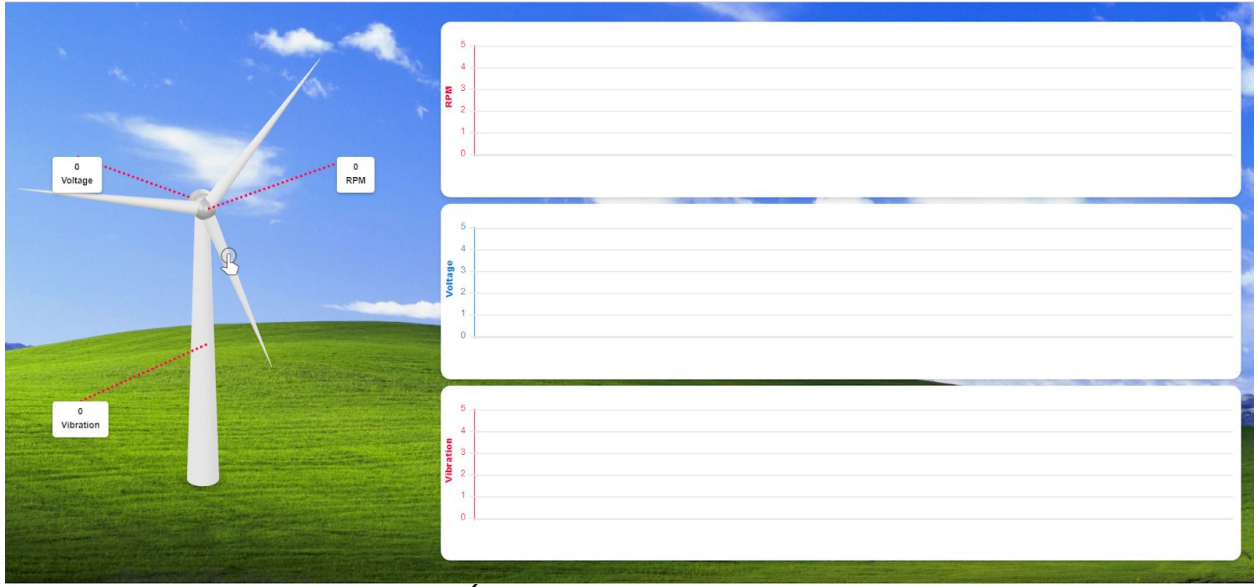
Test Cases

If WindTwin Server Not Connected to WindTwin Client



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Test Cases

If WindTwin Server is Connected to WindTwin Client:

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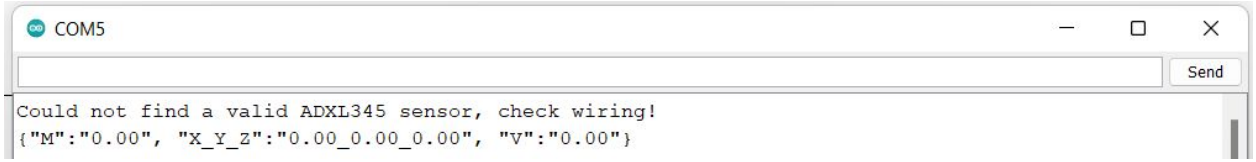
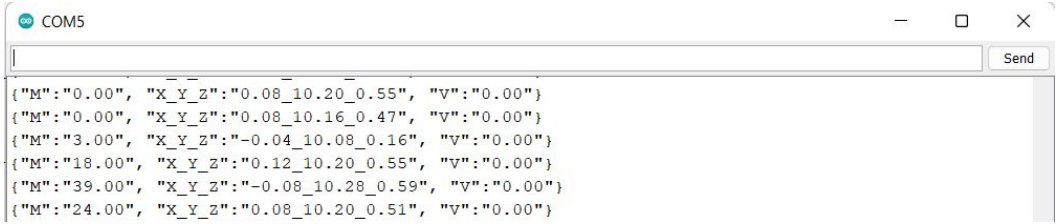
Test Cases

If WindTwin ADXL345 Sensor Not Connected



If WindTwin ADXL345 Sensor is Connected



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Hardware and Software Requirements

HARDWARE REQUIREMENTS:

WindTwin Hardware:

1. Photo interrupter
2. Voltage Detection Sensor
3. Accelerometer Sensor (ADXL345)
4. Arduino UNO (R3)
5. Generator Motor

WindTwin Server:

1. Processor -Intel Core 2 Duo or Higher
2. Hard Disk – 1 GB
3. RAM - 2 GB

SOFTWARE REQUIREMENTS:

WindTwin Server:

1. Erlang (Erlang 24.0.3)
2. Elixir (Elixir 1.12.2-otp-24)
3. Phoenix (Phoenix 1.6.2)
4. Model Viewer

WindTwin Client:

1. Erlang (Erlang 24.0.3)
2. Elixir (Elixir 1.12.2-otp-24)

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Conclusion and Future Scope

Digital twins for wind turbines are becoming increasingly important for optimizing the performance of physical turbines in real-time and ensuring predictive maintenance. By collecting data from various sensors installed on the turbine, such as those measuring rpm, voltage generated, and vibration of the turbine body, and feeding that data into a computer model, we can create a virtual replica of the physical turbine. This enables us to monitor the turbine's performance, detect any fluctuations or anomalies in the collected data, and predict potential failures before they occur. This approach helps to reduce downtime, maintenance costs, and improve overall turbine performance. Additionally, by installing other sensors to collect more data, digital twins have the potential to optimize turbine performance even further.

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Thank You