TECHNICAL IMPLEMENTATION

The Team Robotechs raised three major problem statements related to the Industrial environment:

1. Enhancing Industrial Safety and Energy Efficiency through Intuitive Plant Monitoring Systems
2. Revolutionizing Data Accessibility and Interpretation in the Industrial Landscape
3. Advancing Towards Global Net-Zero Goals - Overcoming Implementation Challenges in Industry

The team targets to solve these challenges by introducing a key module into the Ecostruxure ecosystem developed by Schneider electric. This module titled "**Ecostruxure Innovate**" creates a new way for operations management and fault detection, where in the control technicians can immerse themselves in the virtual plant environment and analyze the alerts and notifications raised based on the machine learning algorithms running in the backend. The plant managers can get the recent updates regarding the operations and the potential threats along with the actions to be considered, which enables the operations team to take swift and prompt decisions, resulting in the efficient use of resources and reduced downtime. Innovate module also integrates the predictive management of pollution from individual machines, so that the net-zero goals of the organizations can be achieved through the roadmap set by the company. The team also proposes an idea to implement electric power generation from the noise pollution using various methods. A detailed account of the proposed ideas is explained as follows.

3D Plant Level digital twin platform, which showcase the live plant operations coupled with advanced data analytics:

To ensure the optimal energy efficiency of a manufacturing facility, meticulous attention must be directed towards the operation of each individual machine as well as the entire plant, as even minor issues have the potential to disrupt critical processes. This report introduces the 3D digital twin platform, a robust technological solution that not only provides in-depth insights into plant performance without necessitating specialized technical expertise but also leverages the capabilities of artificial intelligence (AI).

A key feature of EcoStruxure is its intuitive user interface, which facilitates easy access to vital operational data for plant operators. It effectively offers a virtual replication of the plant, simplifying the process of visualization. In addition, combining virtual reality (VR) and augmented reality (AR) enhances the user experience by enabling people to fully immerse themselves in a digital depiction of the plant environment. The system integrates the 3D model of the machines along with the information received from the predictive data analysis to create a visualization to highlight the faults in the machines. This ensures that the issues with the machine are highlighted, and the operations team can take prompt actions at the right time. The module is enabled with 3D manipulation and highlighting features such as pan, zoom, snip, walk through etc., which enables the user to interact effectively with the digital twin to get the maximum insights regarding the plant operations.

The existing digital twin associated with EcoStruxure focuses mainly on a single machine, however in many of the cases the root cause of a production line cannot be identified by looking at a single machine, for this a plant level digital twin is essential. Also, the existing digital twin model has limited capabilities to highlight the predictive maintenance functionality of the machines which can be covered with the proposed implementation.

The system can be developed with a few modifications in the existing digital twin platform associated with the EcoStruxure, for scalability as well as to link it with the analytical algorithms of EcoStruxure plant simulation modules. The workflow of the proposed system is explained in the later part of this report.

AI based voice assistant

The AI-powered voice assistant seamlessly integrates with the system database and, in this context, has been enhanced to incorporate the advanced capabilities of GPT-4. This sophisticated integration marks a significant milestone in human-machine interaction, facilitating streamlined communication between operators and machines by reducing complexity. The voice assistant's user-friendly interface, tailored for easy accessibility, caters to both non-technical users and individuals with disabilities. It provides alerts and quick access to technician contact details in the event of component faults, ensuring a swift response. Leveraging its access to the database, the voice assistant excels in generating real-time plant working status reports and predicting maintenance requirements for proactive scheduling. The incorporation of GPT-4 augments its natural language processing, enabling it to understand and respond to user queries with unparalleled depth. This advanced capability, coupled with predictive maintenance, ensures optimal machine conditions, leading to quicker problem-solving, reduced downtime, and an overall enhanced user experience. The proposal aligns with the surging demand for improved human-machine communication, presenting a cutting-edge solution poised to elevate operational efficiency across diverse industries. The voice model takes input from the EcoStruxure predictive AI model, the requests raised by the user during the conversation as well as the information about the maintenance protocol to communicate with the GPT-4 module to create human like conversations. The explanation of the code we implanted for demo testing is given below.

AI based voice assistant code explanation

AI model used: GPT-4

Code: https://github.com/SpaceSapiens/SchneiderEcoTech2023/blob/main/SchneiderAIVoiceAssistant.py

This script showcases the development of an AI-powered voice assistant with integrated functionalities, employing both OpenAI's GPT-4 model and Google's Speech Recognition library. The key components and functionalities of the script are as follows:

OpenAI API Integration: The OpenAI API key is utilized for authenticating and accessing the GPT-4 model, allowing the generation of responses based on user prompts.

GPT-4 Response Generation (*generate_response* function): The *generate_response* function sends a prompt, which includes both the user input and context information, to the GPT-4 engine.

The generated response is processed, and the text is returned for simulating a conversation with the user.

Text-to-Speech Conversion (*text_to_speech* function): The *text_to_speech* function uses the Google Text-to-Speech (gTTS) library to convert GPT-4 responses into human-like speech. The speech is saved as an MP3 file and played using the default system player.

Speech-to-Text Conversion (*speech_to_text* function): Utilizes the Speech Recognition library to convert audio input from the user's microphone into text. Handles potential errors, such as unrecognized audio or issues with the Google Speech Recognition service.

Main Interaction Loop (main function): The main function sets up an initial context related to an industrial environment, and this context is updated with data received from an analytical AI integrated with EcoStruxure. The script enters a loop where the user can either speak or type 'exit' to end the conversation. User input is captured using speech recognition, and GPT-4 generates responses based on the input and context. The GPT-4 response is displayed, and text-to-speech is used to play the response for the user.

Usage: The script simulates a voice assistant responding to user queries within the provided industrial context, including information about plant operations and predictive analytics.

Exiting the Conversation: The user can type 'exit' to gracefully end the conversation. This script provides a foundation for developing a voice-activated assistant with advanced natural language understanding, making it suitable for various applications, especially in industrial settings where clear communication is crucial.

Pollution Monitoring:

The pollution Monitoring system, deeply ingrained in precision and innovation, commences with a comprehensive analysis of historical machinery data using Eco-strucxure innovate, seamlessly integrating the Industrial Internet of Things (IIoT) into our sophisticated pollution monitoring framework.

If a current machine's pollution readings align with those of historical instances that have previously contributed to environmental concerns, our system springs into action. An instantaneous alert is dispatched directly to the floor manager, serving as a responsive trigger for timely intervention. What sets this process apart is not just the alert mechanism but the accompanying wealth of contextual information.

The alert forwarded to the floor manager transcends conventional notifications by furnishing detailed guidance extracted from past instances featuring comparable pollution levels. This customized counsel endows the manager with a profound insight into specific actions taken in analogous environmental scenarios. Our approach not only ensures a swift response but underscores a judicious and strategic one, laying the foundation for a sustainable and environmentally conscious operational paradigm within our plant.

In the event of a present machine registering pollution levels reminiscent of historical environmental concerns, our system leaps into action. A prompt alert is relayed to the floor manager, functioning as a responsive catalyst for timely intervention. What distinguishes this process is not solely the alert mechanism but the depth of contextual knowledge it imparts.

Going beyond predictive analytics IIoT strengthens our remote monitoring and control capabilities, enabling real-time adjustments and swift responses to emerging pollution concerns. Smart sensors and drones, synchronized with IIoT, introduce a dynamic and versatile dimension into our data collection methods, elevating the overall sophistication of our pollution monitoring strategy.

The integration of artificial intelligence (AI) into predictive analysis increases our capabilities, enabling subtle pattern recognition and trend identification in pollution data. It's noteworthy that an AI voice assistant has been seamlessly integrated into Eco-Struxure, enhancing user experience and operational efficiency. This strategic inclusion illustrates our commitment to infusing intelligent and user-centric technologies into our ecosystem.

Noise to energy:

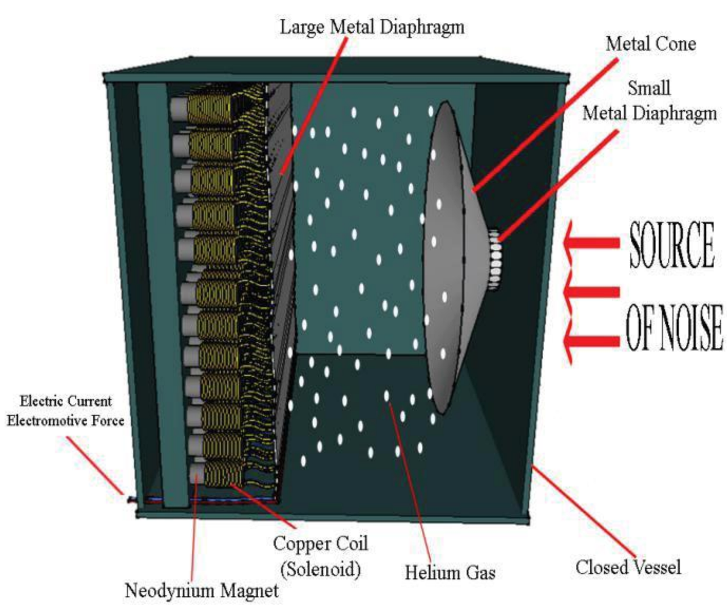

Figure 1: Sound to electricity conversion using diaphragm.[1]

Noise to energy conversion process typically involves using transducers or devices that can convert mechanical vibrations, including sound waves, into electrical energy. By strategically placing these devices in environments with high sound levels, such as industrial settings, it becomes possible to capture the energy from sound and convert it into electricity. This harvested energy can then be utilized to power electrical devices or contribute to the overall energy needs of the facility.

Implementing sound energy harvesting not only provides a sustainable energy source but also contributes to environmental conservation by reducing noise pollution. It represents an innovative and eco-friendly approach to energy generation, showcasing the potential for dual benefits in terms of sustainability and environmental impact.

It's worth noting that while this concept holds promise, the efficiency and practicality of sound energy harvesting systems depend on various factors, including the specific characteristics of the sound waves, the chosen transducer technology, and the overall environmental conditions. Advances in this field could lead to more widespread adoption of sound energy harvesting as a viable and sustainable energy solution.

A good transducer can transform sound energy into a practical source of electric power. Vibrations created by noise can be converted into electrical energy by means of a transducer. Electro-magnetic induction is a principle that allows vibrations caused by noise to be turned into electrical energy.

In this device (figure 1) Sound infiltrates the enclosed chamber via a small diaphragm, prompting vibrations in the metal diaphragm and the creation of sound waves. The cone-shaped metal structure amplifies these sounds by capitalizing on the irregular vibrations of the diaphragm. To intensify air molecule movement and heighten kinetic energy, Helium gas is introduced into the closed vessel.[1]

Upon encountering the large metal diaphragm, sound waves induce movement in a solenoid traversing a series of Neodymium magnets. This motion generates electromotive force (emf) through the principle of electromagnetic induction. The dynamic interplay between the movement of coils, magnet speed, and changing electromotive force unfolds a distinctive pattern.[1]

Nevertheless, the application of this process remains untapped on a large scale in the industrial sector. Embracing this technology holds the potential to significantly decrease noise pollution, boost energy efficiency, and advocate for environmentally friendly and sustainable practices.[1]

System Architecture and Process Flow:

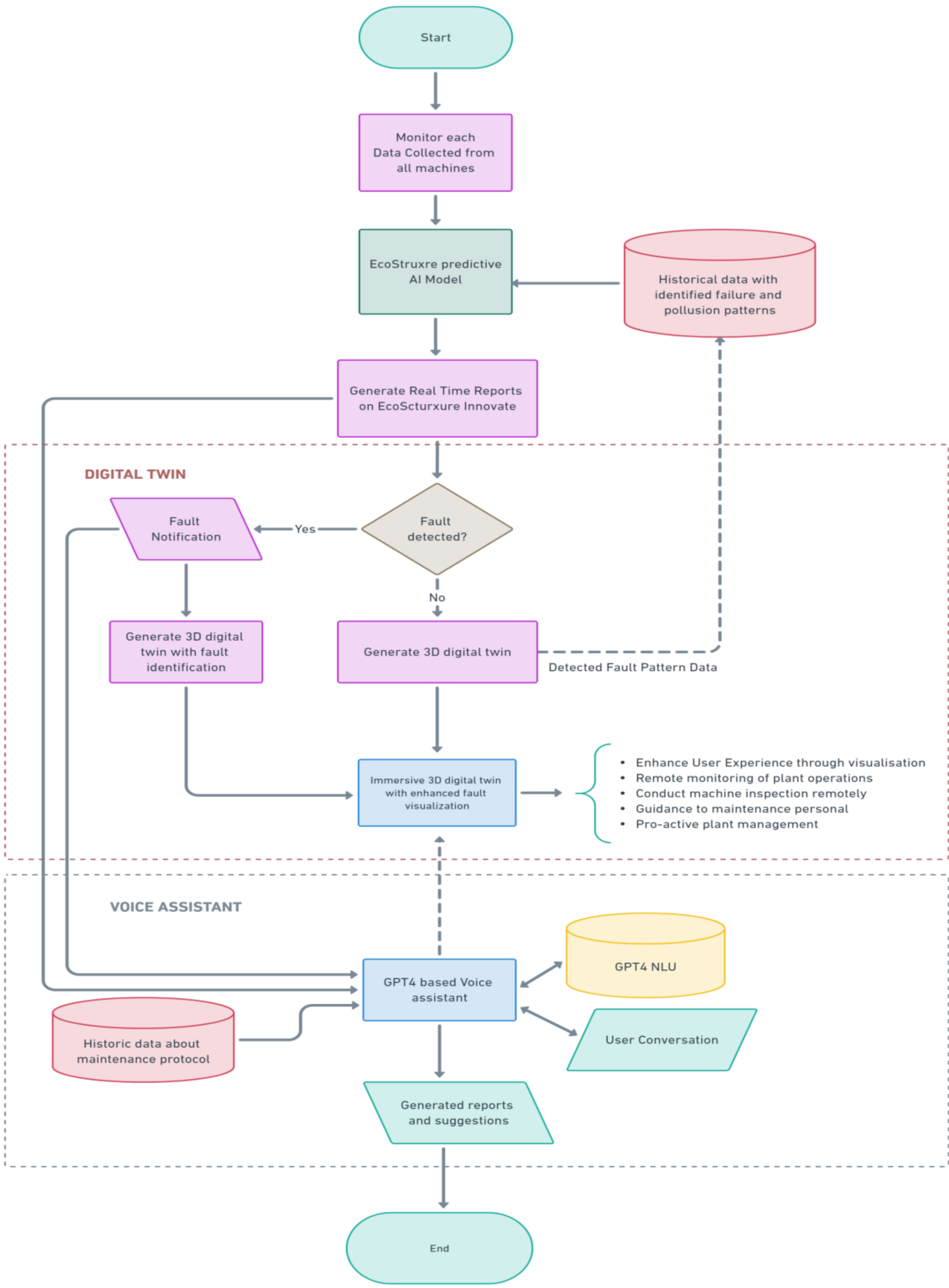

Figure 2: System architecture and process flow diagram

After the process is started, the AI model continuously analyzes the sensor data received from all machines and other parts of the plant. The proposed model is utilizing the advanced analytical capabilities of EcoStruxure AI model which is coupled with the database containing historical data regarding fault and pollution occurrence. The AI model repeatedly searches for these failure patterns in the received data from the machines, to create real time reports based on this analysis. Once these analyses are obtained, the system checks for the fault detection, if fault is detected in any component, a fault notification is created on the dashboard which will be reflected in the 3D model as well to enhance the visualization. If the faults are detected, they will be highlighted in the 3D model with suitable color code, as well as in the dashboard instance, the user can click on the dashboard notification to navigate to the exact component which went on fault and can have a deep study regarding the failure. If a fault is not detected a normal 3D model movement is generated according to the live plant operation. The fault detected patterns are logged to the database for verification and future reference. The immersive 3D thus generated by the model can be observed in a web-based platform, any device can be connected to this visualization using suitable credentials, and the authorities can control the level of data visible to everyone according to the role they offer. The 3D model can be viewed in the AR and VR platforms to perform the immersive walk-through study of the ongoing operations. Thus, the personals can see all the activities in the plant within the safety of their office and can even do routine checks on the machine without causing delay in the operations.

The voice assistant module integrates the advanced AI analytics with that of the operation suggestions through an interactive conversation with the user. In this the user can directly converse with the AI model which is linked with GPT4 to understand the status of the plant and schedule their activities according to the suggestions given by this model. Please note that the AI is not taking the decisions in this context but only suggests the conventional methods followed in different scenarios purely based on the historical data from the similar plant environment. The user can even command the AI model to traverse the viewpoint onto the component, which is currently faulty, so that the user can have more meaningful insights by combining the visual and auditory responses. The conversational AI combines the historical data as well as the maintenance protocols of the organization to come up with effective plans and has the capabilities to share these details with the user through dialogues as well as via text in the dashboard and email.

The system architecture effectively improves the analytical capabilities of the existing EcoStruxure module and creates a much interactive environment for plant monitoring and control, which will improve the operational efficiency and reduces the energy consumption.

Integration and Deployment:

The proposed system can be integrated with the existing EcoStruxure module. In the proposed idea, a new module titled **"EcoStruxure Innovate",** the system has to follow the system architecture defined in the System Architecture and Process Flow section. To implement this system, the system can collaborate with a client organization who is currently using the EcoStruxure Plant Simulation AI models, through which the data collection and integration can be implemented easily under the non-disclosure agreement with both the organizations. After successfully trying these system, it can be integrated as an individual product module in the

EcoStruxure product family and can be recommended to diverse client base utilizing the solutions of Schneider electric.

Conclusion:

The solutions proposed in the report align closely with Schneider Electric's objectives and the challenges posed by industrial cities. Let's link these solutions to the key points in your report summary:

1. **Enhancing Industrial Safety and Energy Efficiency through Intuitive Plant Monitoring Systems:**
- The 3D plant-level digital twin platform provides a comprehensive solution for optimizing energy efficiency in industrial facilities.
- It offers real-time insights into plant operations, ensuring efficient use of resources and reduced downtime, directly addressing the need for energy efficiency.
2. **Revolutionizing Data Accessibility and Interpretation in the Industrial Landscape:**
- The AI-powered voice assistant enhances data accessibility and interpretation by facilitating streamlined communication between operators and machines.
- It generates real-time plant working status reports, enabling informed decision-making, and aligns with the goal of effective decarbonization strategy.
3. **Advancing Towards Global Net-Zero Goals - Overcoming Implementation Challenges in Industry:**
- The pollution monitoring system integrated with AI aids in the effective decarbonization strategy by providing actionable insights and historical data analysis.
- It contributes to sustainability and environmental stewardship, helping industries reduce their environmental impact.
4. **Noise to Energy:**
- The concept of converting noise into energy presents a novel approach to energy generation and aligns with the objective of sustainable energy solutions.
- It offers dual benefits by providing a sustainable energy source while reducing noise pollution, addressing the need for energy efficiency and sustainability.

In summary, the solutions proposed in the report directly address the challenges outlined by Schneider Electric, focusing on energy efficiency, effective decarbonization, integration of solutions, and scalability. These innovations not only enhance operational efficiency but also contribute to the global pursuit of sustainability and environmental responsibility. Schneider Electric's commitment to the digital transformation of energy management and automation is reinforced through these forward-thinking solutions.

Reference

[1] Boco, Mervin A. "Sound Energy Harvesting and Converting Electricity (SEHCE)." Annals of Mathematics and Physics 5.2 (2022): 146-149.