Master Thesis Topic Proposal

Title: Using Raspberry Pi and Edge Impulse Together for Predictive Maintenance in Manufacturing for Industry 4.2

Abstract: The purpose of this thesis is to investigate how to fulfill the changing needs of Industry 4.2 by integrating the Raspberry Pi with Edge Impulse, a sophisticated edge AI platform. The key goals are to adapt the solution to different industrial equipment and production lines, use sophisticated machine learning for predictive maintenance, and optimize processes which also involved in building a seamless connection for real-time data analysis.

1. Introduction: Industry 4.2 the fourth industrial revolution, involves the integration of advanced digital technologies into manufacturing processes. This thesis explores the seamless integration of Edge Impulse and Raspberry Pi, focusing on real-time data analysis, predictive maintenance, and advanced machine learning capabilities, aligning with Industry 4.2 principles and goals.

1.1 Background: Industry 4.2 builds on previous principles, focusing on interconnected production lines, scalability across equipment, and autonomous decision-making. It demands innovative solutions for real-time data analysis, enabling timely decision-making across all aspects of manufacturing.

1.2 Research Gap: This research aims to address the gap in Industry 4.2 research on the seamless integration of Edge Impulse and Raspberry Pi for a versatile, adaptable, and scalable manufacturing solution, focusing on integrating advanced machine learning capabilities with edge computing.

2. Objectives:

2.1 Integration: In order to analyse sensor data in real time, the project intends to establish a smooth integration between Edge Impulse and Raspberry Pi from Industry 4.0 to 4.2.

2.2 Predictive Maintenance: To detect abnormalities and foresee equipment failures, the project will implement a predictive maintenance solution that makes use of machine learning models in industry 4.2.

2.3 Predictive Maintenance in Manufacturing: By continuously monitoring the condition of machinery and analysing data patterns, predictive maintenance can detect early signs of potential issues, allowing for timely repairs or replacements. This proactive approach not only increases overall operational efficiency but also extends the lifespan of equipment, ultimately maximizing productivity and profitability for manufacturers.

2.4 Scalability:

Industry 4.0 integrates digital technologies into manufacturing processes, enhancing automation and data exchange. Industry 4.2's advancements, like machine learning and real-time analytics, support this integration, enabling predictive maintenance and optimization. Edge Impulse's advanced machine learning capabilities further enhance manufacturing operations.

3. Literature Review Industry 4.0 refers to the integration of digital technologies and automation in manufacturing processes, enabling the creation of smart factories. It encompasses concepts such as the Internet of Things (IoT), artificial intelligence (AI), and big data analytics to optimize production efficiency and enable real-time decision-making. On the other hand, Industry 4.2 builds upon these principles by focusing on advancements in areas like cyber-physical systems, cloud computing, and augmented reality, aiming to further enhance productivity and flexibility in manufacturing.

4. Methodology:

4.1 Integration Process: Implementation of the Edge Impulse SDK on the Raspberry Pi and configuration of the device to gather and send sensor data in real-time comprise the integration procedure. Furthermore, in order to guarantee smooth communication between the Raspberry Pi and the Edge Impulse platform, the required network connectivity must be set up. It's crucial to make sure the integration works with various production line configurations so that it can be easily scaled and adjusted to various industrial settings.

4.2 Sensor Positioning: Add sensors to production machinery to keep an eye on important metrics.

4.3 Collecting and preparing data: Utilize Raspberry Pi hardware that has been connected to Edge Impulse to preprocess sensor data in real time.

4.4 Edge Computing for Real-Time Analysis: Using Raspberry Pi devices, apply machine learning models directly for predictive maintenance.

4.5 Alerting Mechanism: Create a maintenance team alerting system based on the machine learning models predictions.

4.6 Cloud Integration: Integrate the solution with cloud services for centralized data analysis and historical data storage.

5. Results to be Expected: Edge Impulse and Raspberry Pi are integrated for seamless data collection, processing, and analysis, enabling users to make informed decisions based on real-time insights, promoting adaptability, scalability, and continuous improvement, and enhancing collaboration and communication between manufacturing equipment.

6. Significance of the Study: This study will investigate the use of edge computing in predictive maintenance, enhances manufacturing efficiency and cost-effectiveness, and demonstrates its scalability for a variety of manufacturing environments industry 4.0 and 4.2.

6.1 Application at the Industry Level:

6.1.1 Multiple Production Lines:

- This allows for a more comprehensive and efficient maintenance strategy, as issues can be identified and addressed in real-time for each production line.
- Data collected from multiple lines can be analysed collectively to identify patterns and trends, enabling proactive maintenance planning across the entire manufacturing plant.

6.1.2 Integration with Enterprise Systems:

- By integrating the solution with enterprise systems, manufacturers can have real-time visibility into equipment performance and maintenance needs. This allows for better decision-making and resource optimization, ultimately improving overall operational efficiency.
- The integration with ERP systems enables seamless data sharing and synchronization, ensuring accurate and up-to-date information for effective maintenance planning and execution.

6.1.3 Continuous Improvement:

- Utilize Edge Impulse models' past data for improved predictive maintenance accuracy, regularly retraining them to adapt to changing equipment conditions and new data patterns.

6.2 Integration and Configuration:

- Languages: Bash, Python
- Platform: Linux Terminal
- Explanation: Python and shell programming (Bash) could be used to configure the system and integrate Edge Impulse with the Raspberry Pi initially. While Python may be used for more sophisticated interactions and automation, Bash can be utilized for generic system setup and configuration.

6.2.1 Model Training and Deployment:

- Languages: Python (Edge Impulse SDK)
- Platform: Raspberry Pi (Linux environment)
- Explanation: Model deployment and training are made easier with the help of Edge Impulse's Python SDK. For training models, downloading them, and deploying them on the Raspberry Pi, Python scripts may be utilized to work with Edge Impulse APIs. Machine learning features can be easily integrated into the Raspberry Pi environment with the help of the SDK.

6.2.2 Application Development:

- Languages: Python (for the backend), HTML, CSS, and JavaScript (for the frontend).
- Frameworks: Flask (for backend server), Web Frameworks (for frontend, if applicable)
- Platform: Raspberry Pi (Linux environment)
- Explanation: The Flask framework is a popular choice for developing backend servers in Python due to its simplicity and flexibility. It provides a robust set of tools and libraries for handling HTTP requests, managing databases, and implementing RESTful APIs. Additionally, using web frameworks like React or Angular can enhance the frontend development experience by providing reusable components and efficient state management. These frameworks enable developers to create dynamic and interactive user interfaces that seamlessly communicate with the backend server.

6.2.3 Networking and Communication:

- Languages: Python (for networking logic)
- Platform: Raspberry Pi (Linux environment)
- Explanation: Python's extensive library support for networking protocols and its ease of use make it an ideal choice for implementing networking logic on the Raspberry Pi. Additionally, the Linux environment provided by the Raspberry Pi platform ensures compatibility and stability for networking operations.

6.2.4 System-Level Integration:

- Languages: Bash, Python
- Platform: Linux Terminal, Raspberry Pi
- Explanation: For system-level integration tasks, such as configuring network settings, managing system resources, and handling peripheral devices, Bash and Python scripts can be utilized for system-level integration tasks like network configuration, resource management, and peripheral device handling, ensuring smooth integration.

7. Future Work:

7.1 Further optimization: Investigating the use of machine learning techniques to enhance edge decision-making processes is one suggestion for further improving the integrated system. This

can provide job prioritization based on real-time data analysis and dynamic resource allocation. Furthermore, to facilitate more effective and scalable Industry 4.2 deployments, future research directions may concentrate on creating standardized protocols and frameworks for smooth communication between edge devices and cloud platforms.

7.2 Extended Applications: Investigating additional features and use cases while looking into possible applications beyond predictive maintenance.