INDUSTRIAL PLACEMENT REPORT

Academic Year: 2022/2023

Host Company:

Huading Intelligent Manufacturing Technology Co. LTD

Building 44, Zone C, Fuzhou Software Park, Software Avenue

Fuzhou, Fujian Province, China

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CONTENTS

1. INTRODUCTIONS

The author participated in an Industrial Placement during the current semester. The Industrial Placement (IP) lasted for four months and aimed to guide students in applying the knowledge gained from their undergraduate studies to real-world industrial settings, expanding their cognitive perspectives, and ultimately gaining recognition from the industry. This chapter will provide an overview of the background, procedure, objective and educational value of the IP.

1.1. Industrial Placement (IP)

The Industrial Placement module is a program designed to provide students with practical experience in their field of study by working in a professional environment. The objectives of the program are to develop students' professional skills, enhance their understanding of industry practices, and provide them with networking opportunities. To obtain an internship placement, students must follow six specific procedures, as illustrated in the **Figure 1-1**. Firstly, students must adequately prepare themselves for the IP, familiarizing themselves with its objectives, requirements, and guidelines. Subsequently, they need to compile a tailored resume showcasing their academic accomplishments, skills, and experiences, which is then submitted to the Job Market. The next step involves attending interviews, where students demonstrate their suitability for the internship and endeavor to secure an offer.

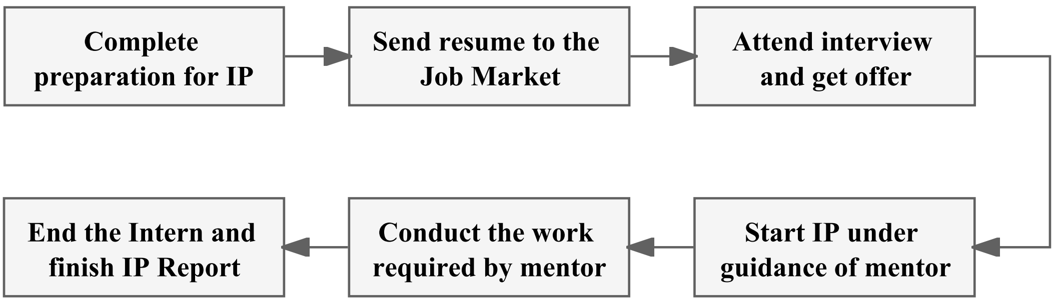


Figure 1-1 Procedures of Industrial Placement

Once selected, they commence their IP journey under the guidance of a mentor, diligently fulfilling assigned tasks and responsibilities. Finally, the internship concludes with students presenting a comprehensive IP report that reflects on their experiences and achievements throughout the program. By adhering to this systematic process, students optimize their chances of securing a valuable internship opportunity and capitalizing on the growth.

1.2. Educational Value of IP

From the author's perspective, the IP program offers substantial educational value to students. Specifically, the author believes the IP holds the following educational significance:

- ✧ **Practical application of theoretical knowledge:** IPs allow students to apply the knowledge and skills they have learned in the classroom to real-world situations, which can deepen their understanding of academic concepts and theories.
- ✧ **Professional development:** IPs provide opportunities for students to develop professional skills such as communication, teamwork, problem-solving, and time management, which are highly valued by employers.
- ✧ **Career preparation:** IPs can help students explore different career paths and gain insight into the expectations and demands of various industries. This can help them make more informed decisions about their future career goals.
- ✧ **Overall**, Industrial Placements offer a valuable educational experience that combines academic learning with practical work experience to prepare students for success in their future careers.

Additionally, to enhance the educational value of IP, universities, students, and employers must collaborate effectively. Universities should guide students in finding suitable placements, provide training in professional skills, and align internships with pedagogical approaches. Students should actively seek internships aligned with their career goals, applying theoretical knowledge in practical settings. Employers should offer meaningful assignments, clear expectations, professional development opportunities, and regular feedback to help interns improve their skills. By working together, universities, students, and employers can create a successful industrial placement experience that enhances academic learning and prepares students for future careers, as illustrated in **Figure 1-2** [1].

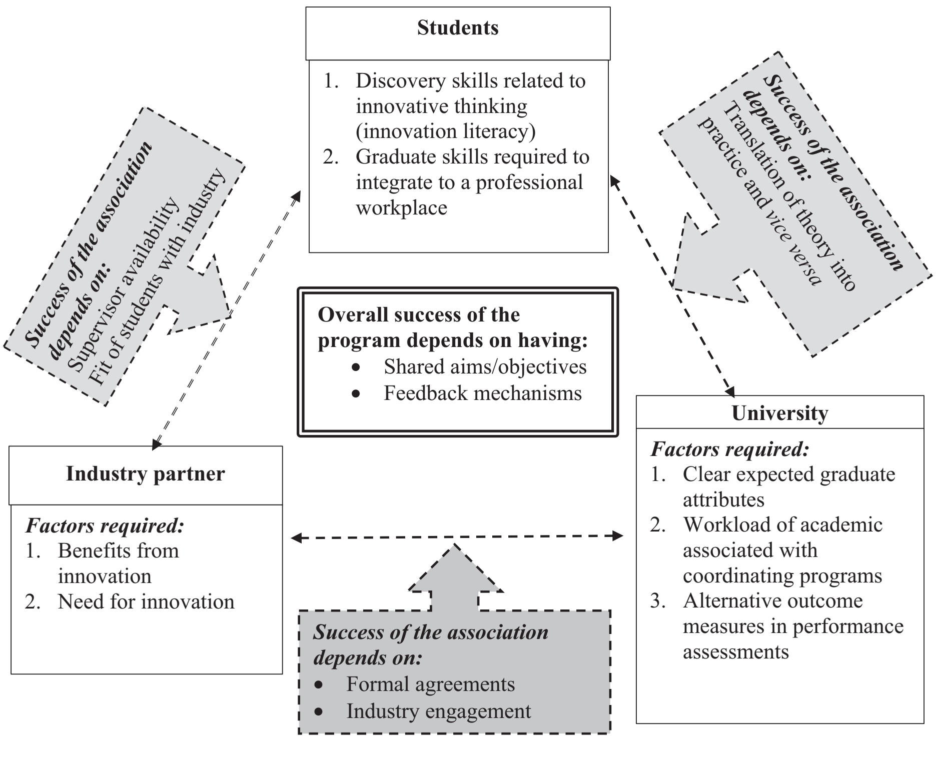


Figure 1-2 Factors required for a successful industrial placement

2. COMPANY DESCRIPTION

The author conducted an industrial internship at **Fujian Huading Intelligent Manufacturing Technology Co., Ltd. (Huading Tech)** from February to June 2023, under the guidance of Prof. Zhezhuang Xu and SN.ENGR Yuxiong Xia. This chapter aims to provide an introduction to the background, history, business, operating environment and ethics of Huading Tech.

Figure 2-1 Huading Tech Co., Ltd.

2.1. Background Information

Huading Tech is a comprehensive service provider specializing in assisting equipment companies with manufacturing transformation. Huading Tech offer a wide range of services to equipment companies, including transformation coaching, product lifecycle management, intelligent factory planning and implementation for clients, remote operation and maintenance platforms, and equipment financing and leasing risk control platforms.

The team of the company possesses over twenty years of experience in industrial control technology, more than a decade of expertise in information system development, and accumulated research and development experience of over five years in IoT technology. They have successfully completed over a thousand engineering projects and developed hundreds of platforms. With a clear understanding of the direction, path, and challenges involved in facilitating manufacturing transformation for equipment companies, Huading Tech has provided assistance to multiple equipment companies in strategic planning for transformation and the establishment of technological platforms.

2.2. Operating Environment

Harnessing their deep understanding of the industry and expertise in professional services, Huading Tech has established collaborations with renowned departments of leading enterprises such as Microsoft Azure IoT, Baidu Cloud TianGong, and Alibaba Cloud DataWorks. Leveraging mainstream PaaS platforms like Azure, Baidu Cloud, and Alibaba Cloud, they have developed the comprehensive **'Huading Cloud' SaaS platform**. This platform offers equipment companies a one-stop solution for service-oriented manufacturing transformation.

2.3. Ethical Operations and Achievement

With the mission **"To innovate products and provide sincere services"**, Huading Tech upholds a high-quality corporate culture and a strong sense of social responsibility, which has earned the trust of a wide range of customers. The company has received numerous accolades for its services provided to equipment manufacturing enterprises, including being selected as a national pilot demonstration project for intelligent manufacturing, a champion enterprise in the manufacturing industry by the Ministry of Industry and Information Technology, a pilot demonstration enterprise for service-oriented manufacturing at the provincial level, and a pilot demonstration project for intelligent manufacturing at the provincial level.

Due to the outstanding contributions made in the field, both the company and its team have been honored with several awards, including the First Prize in the China Informationization Achievement Selection, the Second Prize in the Fujian Provincial Science and Technology Progress Award, the Second Prize in the Fujian Provincial Standard Contribution Award, key projects in the integration of informatization and industrialization in Fujian Province, the 2016 Excellent Supplier in Intelligent Manufacturing, the 2016 Innovator in Intelligent Manufacturing, and the recommended solution for China Telecom's IoT applications. **Table 2-1** presents the social responsibilities undertaken by Huading Tech [2]. These honors and responsibilities serve as a testament to the company's exceptional performance and remarkable achievements in the industry.

Table 2-1 Social responsibilities undertaken by Huading Tech [2]

Social Organization	Role of Company	Social Significance
Fujian Intelligent Manufacturing Development Association	Vice President	Industry Leadership
Fujian Service-oriented Manufacturing Industry Alliance	Initiating and Leading	Promoting Collaboration
Fujian Service-oriented Manufacturing Public Servic Platform	Initiating and Leading	Enhancing Efficiency
China Intelligent Manufacturing 100 Talents Association	Council Member	Talent Development
China Service-oriented Manufacturing Alliance	Council Member	Advancing Manufacturing
China Telecom Tianyi IoT Industry Alliance	Council Member	IoT Innovation
Fujian IoT Industry Alliance	Council Member	IoT Industry Integration

3. JOB DESCRIPTION

During the internship, the author served as an **Embedded Development Engineer**, working under the guidance of Prof. Zhezhuang Xu. The department was involved in the development and maintenance of the biomimetic quadruped robot and a novel Internet of Things (IoT) module. This chapter will provide a detailed description of the author's job role, responsibilities, and reporting relationships during the IP period.

3.1. Roles and Responsibilities

Throughout the IP period, the author's role and responsibilities underwent significant transformations in response to the project's progression, as shown in **Figure 3-1**. Initially, the author focused on IoT data analysis, C program completion and quadruped robot testing. His tasks encompassed data analysis from IoT devices, ensuring the completion of the C program, and conducting rigorous testing of hardware modules and robots to ensure proper functionality.

As the project advanced, the author's role shifted towards front-end programming and UI design. He became responsible for implementing new features and enhancing the user interface of the visualization platform. This transition arose from the project's emphasis on creating a user-friendly and visually appealing interface to optimize user experience and engagement. Additionally, the author engaged in code review to ensure code quality, readability, and adherence to coding standards. He also participated in report writing, documenting the project's objectives, methodologies, findings, and recommendations.

These role and responsibility changes resulted from the evolving project needs. Recognizing the significance of front-end development and user interface design, the author's role was adjusted to align with these requirements. This enabled them to make effective contributions to the project's success and deliver a high-quality end product.

Overall, the internship provided valuable opportunities for the author to expand the author's skill set and adapt to diverse responsibilities, enabling them to contribute to the project's success at different stages of its development.

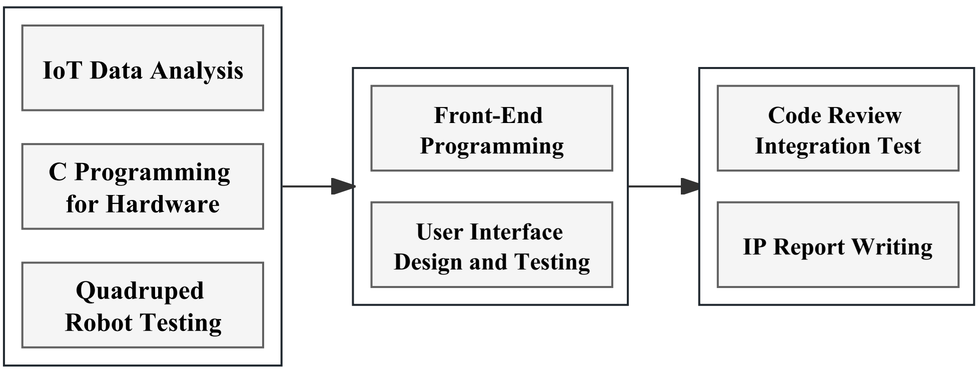


Figure 3-1 Role and responsibilities during IP

3.2. Organization Structures

During the IP, the author had a reporting relationship within the organizational structure of Huading Tech, as shown in **Figure 3-2**. The company comprises three core departments: Sales Department, Research Department, and Operation Department. Besides, the Research Department further consists of the Software Group, Hardware Group, and Interaction Group.

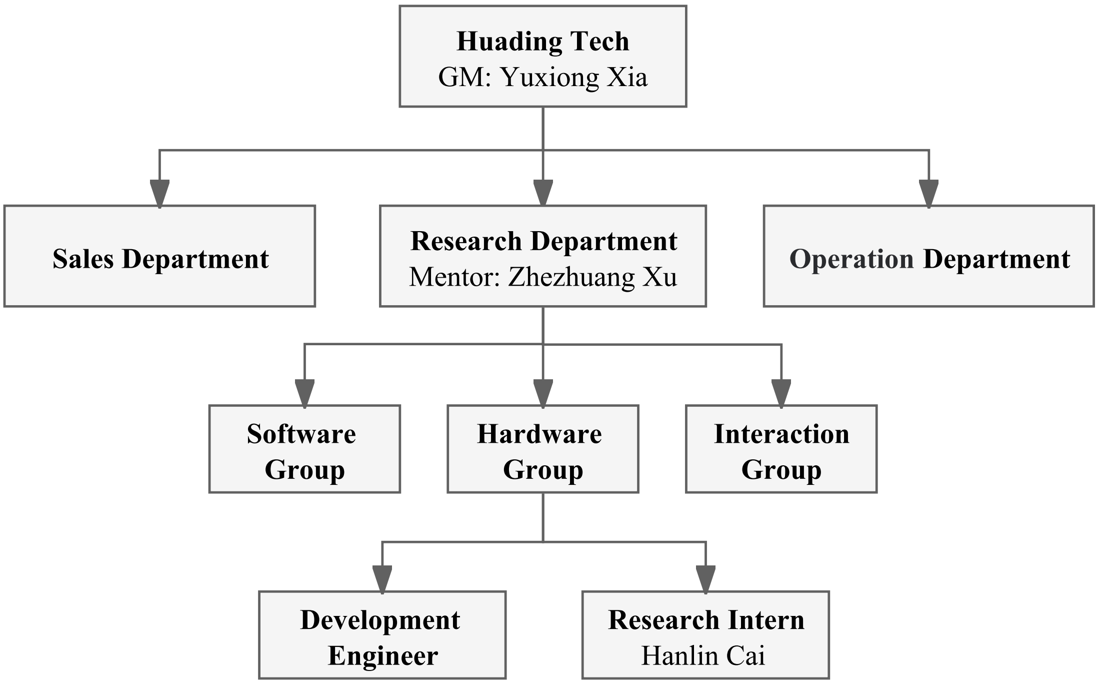


Figure 3-2 Main organization structure chart

As an intern, the author was assigned to the Hardware Group within the Research Department, reporting directly to Prof. Zhezhuang Xu. This reporting relationship ensured regular guidance, feedback, and support throughout the internship. On workdays, the author was required to upload his daily internship log, providing a detailed account of their activities, progress, and challenges. Additionally, every Friday, the author presented a comprehensive work summary to his mentor, highlighting the achievements, project updates, and any noteworthy insights gained during the week.

Towards the end of the internship, the author was responsible for submitting a final internship report, which documented his project objectives, methodologies, results, and recommendations. This report served as a comprehensive overview of the internship experience and showcased the author's contributions and growth. The reporting structure within Hua Ding Technology facilitated effective communication, mentorship, and supervision, ensuring a productive and successful internship period for the author.

4. WEEKLY WORKS SUMMARY

The IP work diary is a comprehensive record of the activities and achievements of the author during his industrial placement at Huading Tech. Spanning a period of **16 weeks**, the work diary provides weekly updates on the author's activities and portfolio. Its primary purpose is to document the author's progress and development throughout the IP experience, encompassing technical accomplishments, and the application of theoretical knowledge in practical work. Based on the weekly work summary, this chapter serves as an overview of the author's work experience and highlights his achievements and contributions to the host company.

4.1. Summary of Work Diary

4.1.1 Significant activities and achievements

During the internship, the author assumed the role of an Embedded Development Engineer and worked under the guidance of his mentor. They actively participated in the development and maintenance of a biomimetic quadruped robot and a novel Internet of Things (IoT) module. Throughout the IP experience, the author undertook various tasks and projects, carefully documenting his experiences in the Work Diary. Overall, the author's significant activities and achievements during the placement included:

- ✧ **Conducting IoT data analysis and C programming for the embedded system.**
- ✧ **Participating in the construction and testing of the Bionic quadruped robot.**
- ✧ **Undertaking front-end programming and user interface design.**
- ✧ **Performing code review, unit testing, and integration testing.**
- ✧ **Writing the Industrial Placement Report and publishing an academic paper.**

Generally, the author evaluated and documented his technical accomplishments, highlighted the acquisition of soft skills, and demonstrated the integration of theoretical knowledge into practical work. The initial phase involved familiarizing himself with the company's products and services while finalizing the Intern Proposal for the Industrial Placement (IP). Subsequently, the author engaged in IoT data analysis, C programming for hardware, and quadruped robot testing.

In the middle weeks of the placement, the author continued his work on front-end programming, initiated code review and integration testing, and commenced writing the Industrial Placement Report. This report encapsulated technical content, opinions, and conclusions. Notably, the author participated in the COMAP's Mathematical Contest in Modeling and Youth Science Popularization Innovation Project Competition during this period.

In the concluding weeks of the placement, the author concluded his IP experience and penned an IP report. He shared reflective thoughts, recommendations, and emphasized the most impactful aspects during the intern experience. Finally, a thoughtful report has been completed.

Moreover, the author achieved significant recognitions during the IP period, including the **First Prize** (Provincial Championship) in the Youth Science Popularization Innovation Project Competition and being the **Finalist** in the Mathematical Contest in Modeling, placing among the top 1% out of 20,508 competition paper. These accolades further highlight the author's exceptional abilities and the remarkable outcomes of his efforts during the industrial placement.

4.1.2 Key Projects and Corresponding Outcomes

➢ **Key Project 1:** Development of a Quadruped Robot for Industrial Applications

Objective: The objective of this project was to design and develop a quadruped robot suitable for industrial applications. The robot was engineered to possess exceptional maneuverability and adaptability across various terrains. It was also designed to have the capability of carrying heavy loads and executing complex tasks.

Innovation: The innovation lay in the creation of a groundbreaking leg design, optimizing the robot's movement efficiency and effectiveness. **Figure 4-1** shows the overall configuration dimensions of the quadruped robot, while **Figure 4-2** illustrates there type of action configuration. This design incorporated a combination of pneumatic and hydraulic actuators, providing precise control and enhanced maneuvering capabilities.

Figure 4-1 Configuration dimensions of the quadruped robot

Figure 4-2 Three type of action configuration of the proposed robot

Outcome: The outcome of the project resulted in the successful development of a functional prototype of the quadruped robot. **Figure 4-3** illustrates the hardware peripherals mounted on the quadruped robot. Besides, rigorous testing was conducted in diverse industrial environments, which exhibited substantial advancements in mobility and task performance. Additionally, the project culminated in the publication of two research paper detailing the development of the quadruped robot and machine vision [3, 4].

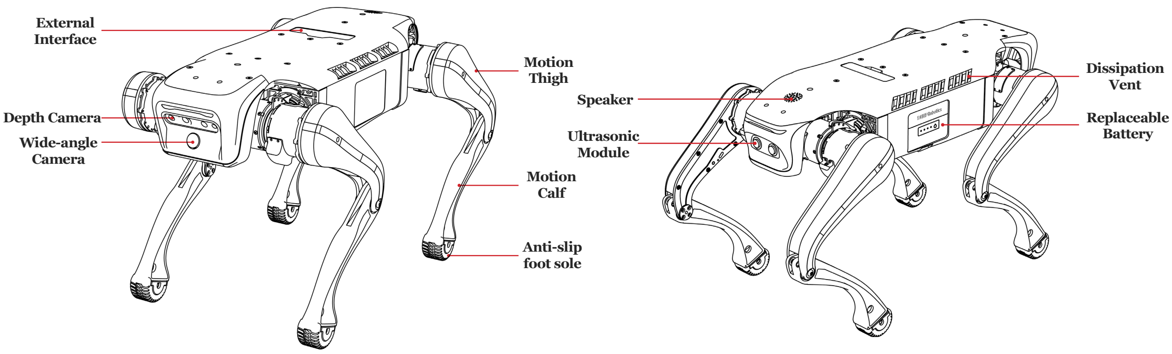
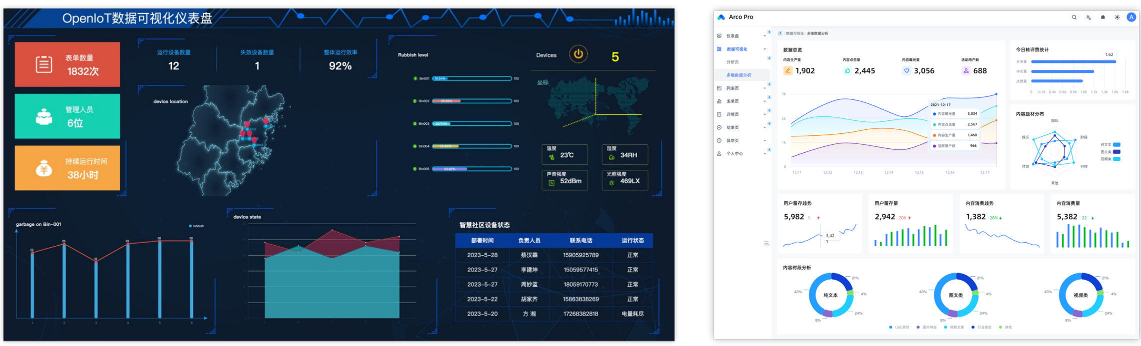


Figure 4-3 Hardware peripherals of the quadruped robot

➢ **Key Project 2:** Development of a User Interface for an Industrial Inspection System

Objective: The aim of this project was to design an intuitive and user-friendly user interface for an industrial inspection system. The interface aimed to facilitate easy monitoring and analysis of production processes by operators, while also providing customization options to meet specific requirements.

Innovation: The project proposed a unique user interface design that seamlessly integrated graphical and textual elements, as shown in the **Figure 4-4**. With a focus on visual representation, operators could quickly identify production trends and patterns. The interface's high interactivity allowed operators to personalize the system effortlessly.



Visualization Interface **Interactive dashboard**

Figure 4-4 User interface design for the Inspection System

Outcome: The project successfully developed a functional prototype of the user interface for the industrial inspection system. Rigorous testing in a real-world factory environment demonstrated significant improvements in operator efficiency and productivity. Additionally, the project resulted in the publication of a research paper detailing the development of the user interface for the industrial inspection system [5].

➢ **Key Project 3:** Development of an IoT Inspection System for Smart Factories Scenario

Objective: This project aimed to design an IoT inspection system tailored for the emerging field of smart factories. The system was engineered to provide real-time monitoring and analysis of production processes, facilitating early defect detection and optimization of production efficiency. Additionally, it was designed to be scalable and adaptable to various types of factories. **Figure 4-5** illustrates the design architecture for the safety inspection system.

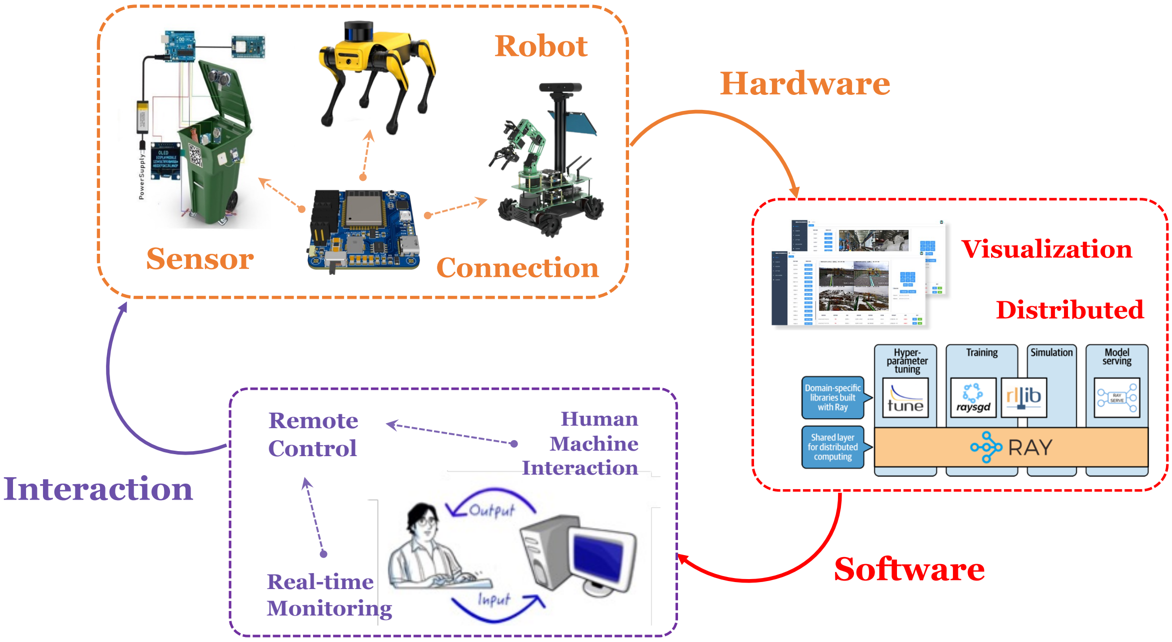


Figure 4-5 Overall architecture design for the safety inspection system

Innovation: Innovation lied in the seamless integration of IoT technology with traditional inspection methods. The system employed sensors and cameras to collect data on production processes, which was subsequently analyzed using machine learning algorithms. Cloud computing was leveraged to enable real-time monitoring and analysis of production processes.

Outcome: The outcome of the project included the successful development of a functional prototype of the IoT inspection system. Rigorous testing was conducted in a real-world factory environment, demonstrating significant improvements in production efficiency and defect detection. Moreover, this project has won the **First Prize** (Provincial Championship) in the Youth Science Popularization Innovation Project Competition.

Noted that the detailed content regarding these projects will be discussed in **Chapter 5**.

4.2. Summary Question List

➢ **Q1: Brief description of project (or projects) in progress or had completed.**

As mentioned above, during the internship, the author participated in three key projects. **Project 1** focused on designing and developing a quadruped robot for industrial applications, with exceptional maneuverability and adaptability. The innovative leg design enhanced movement efficiency and effectiveness, resulting in a functional prototype. **Project 2** involved creating an intuitive user interface for an industrial inspection system, combining graphical and textual elements for easy monitoring and analysis. The functional prototype demonstrated improved operator efficiency and productivity.

Currently, the author is actively engaged in **Project 3**, designing an IoT inspection system for smart factories. This system provides real-time monitoring and analysis of production processes, integrating IoT technology with traditional inspection methods. The project has developed a functional prototype, achieving significant improvements in production efficiency and defect detection. It is worth noting that this project won the First Prize (Provincial Championship) in the Youth Science Popularization Innovation Project Competition.

➢ **Q2: How do these activities progress from one week to the next?**

The projects progress in a logical sequence, with each project building upon the achievements and knowledge gained from the previous one. The progression between projects involved iterative innovation, learning, and application. Knowledge from each project informed the development of the next, ensuring continuous improvement and optimization.

In terms of specific measures, at the end of each week, the project team holds a summary meeting to review the progress made during the week and plan for the upcoming week. Additionally, the manager assigns tasks based on each engineer's specific responsibilities. During this procedure, the use of the 'Feishu (Lark)' software [6] significantly enhances the team's coordination efficiency. Overall, the projects advanced in a systematic manner, leveraging previous achievements, incorporating innovative designs, and continuously refining solutions to achieve their specific objectives.

➢ **Q3: Description and analysis of particular ethical issues encountered.**

In general, the development of IoT inspection systems and advanced technologies has brought numerous benefits and advancements. However, along with these advancements, there are also potential ethical considerations that need to be addressed:

- **Privacy and Data Security:** The collection and handling of sensitive data in such system raises concerns about privacy and data security. It is essential to implement robust measures to protect user information and ensure responsible data management.
- **Transparency and Accountability:** The design and operation of advanced

technologies, such as robotics and AI systems, should be transparent and accountable. Decision-making processes should be explainable, especially when these systems interact with humans or perform critical tasks.

- **Fairness and Bias:** Machine learning algorithms used in data analysis and decision-making must be monitored to avoid biases and unfair treatment. Unintentional discrimination or the reinforcement of social biases can have ethical implications.

➢ **Q4: In what ways has the author fulfilled his role and responsibilities during IP?**

During the IP, the author fulfilled his roles and responsibilities in the following ways:

- **Project Development:** The author actively contributed to the development of key projects: the quadruped robot, user interface, and IoT inspection system for factories.
- **Innovation and Design:** The author introduced innovative elements in each project. For instance, in the user interface project, a unique design seamlessly integrated graphical and textual elements.
- **Outcome and Testing:** The author successfully developed functional prototypes and conducted rigorous testing in real-world environments. The tests showcased advancements in mobility, task performance, operator efficiency, productivity, and defect detection.
- **Publication and Recognition:** The author published research papers detailing the project developments. Additionally, the author's work received recognition, winning the First Prize in the Youth Science Popularization Innovation Project Competition.

➢ **Q5: How has the author contributed to the company through the IP?**

The author has made significant contributions to the company through the IP process. Here are the ways in which the author has contributed:

- **Technical Expertise:** The author's expertise in robotics, user interface design, and IoT systems has been instrumental in the successful development of key projects. The author's deep understanding of the subject matter has enabled the company to tackle complex challenges and achieve innovative solutions.
- **Knowledge Sharing:** Through the publication of research papers detailing the development of the projects, the author has shared valuable insights and findings with the scientific community. This contributes to the company's reputation as a thought leader in the field and establishes its expertise in relevant domains.

The author's contributions through the IP process have led to remarkable technological advancements, improved operational efficiency, and an enhanced market position for the company. These achievements have not only benefited the company but also facilitated the author's personal growth and development. By successfully completing innovative projects and delivering impactful results, the author has gained valuable experience, expanded his skill set.

5. TECHNICAL CONTENTS

As previously mentioned, the author actively participated in a significant project during the internship, specifically the Development of **an IoT Inspection System for Smart Factories** Scenario. This project serves as the cornerstone of **Chapter 5**, as depicted in **Figure 5-1**, which encompasses three sections: Technical Knowledge and Achievements, Soft Skills Acquisition, and Integration of Production and Education.

This chapter aims to highlight the practical utilization of the author's technical expertise, the acquisition of valuable soft skills, and the seamless integration of production practices with educational experiences. Through this comprehensive exploration, the author seeks to demonstrate the real-world application of acquired knowledge, the development of essential skills, and the invaluable feedback gained throughout the IP internship journey.

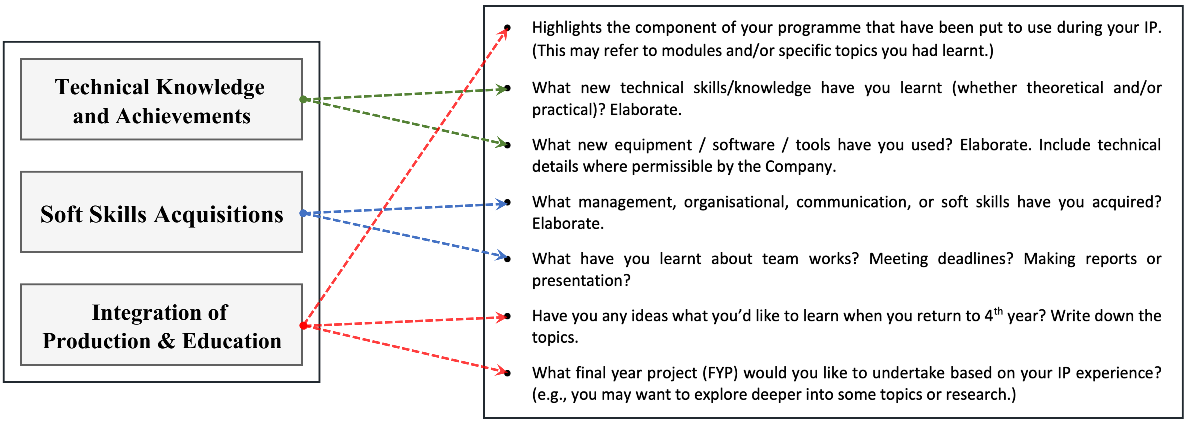


Figure 5-1 Corresponding structure of Chapter 5: Technical Contents

5.1. Technical Knowledge and Achievements

5.1.0 Procedure 0: Background Introduction

Based on the aforementioned context, this project focuses on the development of a self-built IoT security inspection system, gradually constructing three components: hardware modules, software services, and an interaction system. By implementing the design principle of "one mainline, interconnectedness of the three", the project aims to achieve an intelligent factory inspection workflow that includes "sensor module monitoring - robot pre-inspection - manual online assessment - instrument issue diagnosis". The specific implementation and production process are shown in **Appendices Figure I**, which will be described in detail below.

The team divided the project implementation into four stages based on the actual situation: Research Stage, Design Stage, Development Stage, and Presentation Stage. **Firstly**, during the research stage, the team will conduct detailed literature research, data collection, and policy summarization to propose the necessary technical foundations and specific solutions for the project. **Secondly**, in the design stage, the team will build the system's basic framework and conduct the first round of testing and optimization. **Furthermore**, during the development stage, the team will gradually complete the construction of hardware modules, deployment of software services, and system interaction configuration, followed by the second round of experimentation and validation. **Ultimately**, in the presentation stage, the team will transform the research results into a written report, ultimately completing the training of the innovative project with science communication.

5.1.1 Procedure 1: Preliminary Research

At the initial stage of project design, the team conducted thorough literature research and policy analysis focusing on keywords such as IoT technology and security inspection system application. As shown in **Figure 5**, the team conducted detailed research analysis based on 26 academic papers, 7 sets of industry reference data, and 3 authoritative government reports. The specific content of the preliminary research included:

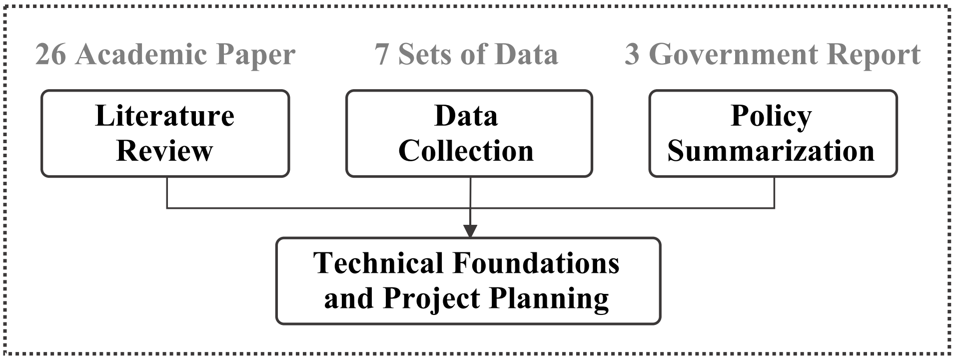


Figure 5-2 Preliminary Research Workflow Diagram

(a) Literature Review: The team organized and analyzed the development trends of IoT inspection systems and their key technologies. This included summarizing the development history and latest progress of intelligent inspection systems both domestically and internationally. The team examined the product dynamics of advanced robot manufacturing companies such as Boston Dynamics and DEEPRobotics. Additionally, a literature review was conducted on key technologies such as machine vision, object recognition, and online operations. Please refer to **Chapter 3** of this document for more details.

(b) National Policy Summary: The team examined government policies related to smart factory construction released in the past three years. The team extracted the essence of the following three government reports to conceive and construct this project: "Notice on Promoting the Accelerated Development of Industrial Internet (2021)", "Guiding Opinions of the Ministry of Industry and Information Technology on Accelerating the Development of the Internet of Things (2022)", and "Outline of the Information Technology Plan for the 13th Five-Year Period (2019)". Based on these authoritative government reports, the team optimized the proposed system accordingly.

(c) Data Collection and User Analysis: To accurately analyze user needs, the team extensively collected opinions from relevant personnel, including factory managers, employees, and technical staff. The team analyzed and summarized the issues encountered in industrial inspections through on-site visits, questionnaires, and user feedback. Among them, it was found that inspection efficiency and safety were the primary concerns of enterprise users. Furthermore, the team investigated, compared, and evaluated existing industrial inspection systems. Based on the preliminary research findings, the team ultimately defined the specific design concept and experimental testing plan for the inspection system.

5.1.2 Procedure 2: Hardware Construction

The team has divided the hardware component into two major application modules: Smart IoT and Dynamic Inspection, based on their specific operational functions. **Figure 5-3** illustrates the workflow and application examples of the Smart IoT sensors, **Figure 4-1 and Figure 4-3**, presented above, provide detailed information for the inspection quadruped robot.

(a) For the Smart IoT module: The system is equipped with various types of sensing devices to monitor the factory environment and relevant instruments. The DHT22 temperature and humidity sensor is used to monitor real-time environmental temperature and humidity data of underground utility tunnels, water pumps, and other instruments. The HC-SR04 ultrasonic sensor measures industrial parameters of relevant tanks or boxes. Additionally, the MH-Z19B gas sensor is utilized for comprehensive assessment of the indoor air quality, while the MAX4466 noise sensor monitors and alerts about noise pollution sources in the vicinity. Ultimately, this enables the collaborative operation of multiple sensor types.

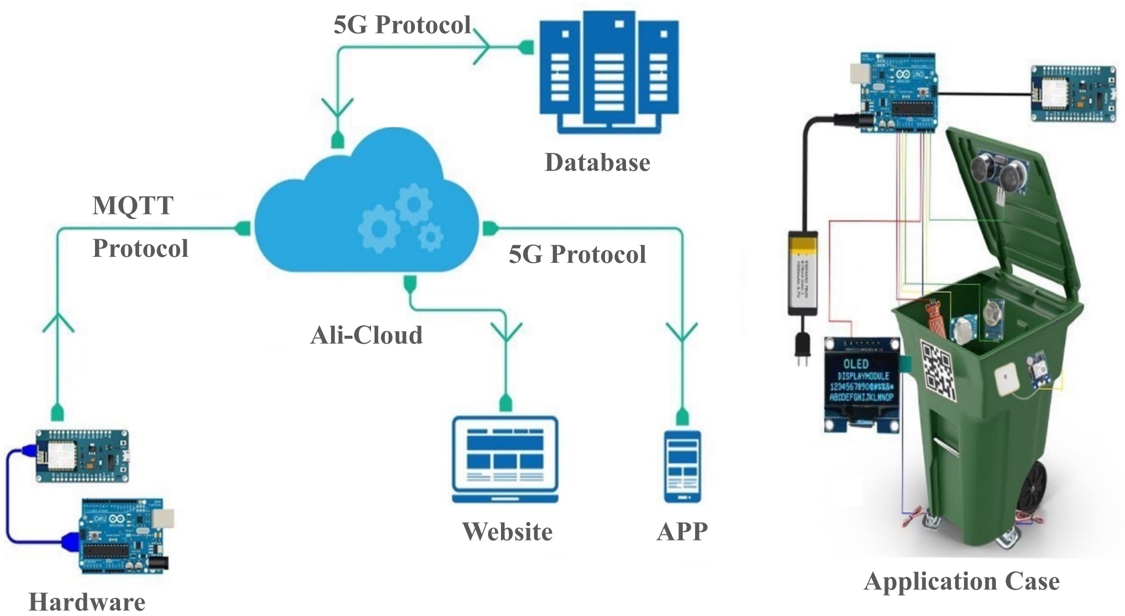


Figure 5-2 Workflow of the Smart IoT module

As shown in **Figure 5-2**, after the Smart IoT module's multi-sensor system collects the relevant data indicators, the ESP8266 communication chip facilitates information communication using the MQTT protocol. It provides feedback on the environmental indicators and device operating conditions to the system server. Furthermore, an asynchronous web service is created using the ESPAsyncWebServer library. The collected data is persistently stored in the cloud database through the Alibaba Cloud IoT platform for processing and utilization by the software backend.

(b) For the Dynamic Inspection module: The system utilizes the “Jueying Lite” quadruped robot developed by Hangzhou Yunshenchu Technology Co., Ltd., to perform dynamic inspections in industrial environments. The team conducted secondary development and motion control design of the quadruped robot's software and hardware, based on relevant technical documentation, and compiled it using the Ethernet protocol. Considering the practical environmental conditions in factories, specific development and deployment work were carried out to address aspects such as path planning, dynamic obstacle avoidance, and SLAM mapping during inspections.

As depicted in **Figure 4-1** above (Chapter 4.1.2), the “Jueying Lite” quadruped robot comprises moving limbs and a body trunk. Each limb consists of three joints, resulting in a total of 12 degrees of freedom for the robot. The standing dimensions are approximately $540mm \times 315mm \times 355mm$, and the overall weight is approximately $10.2kg$. Besides, **Figure 4-3** (Chapter 4.1.2) illustrates the equipment modules carried by the robot, including external interfaces, depth cameras, wide-angle cameras, ultrasonic modules, speakers, heat dissipation holes, and replaceable batteries, among others. Based on the specific inspection requirements, the team further optimized and modified the robot by adding a lidar module and applying a waterproof coating to enhance its adaptability to complex environments.

5.1.3 Procedure 3: Software Development

In the software section, the team has developed the system's software services based on the distributed architecture of Kitex. Following the DevOps development process, the team aims to achieve agile development, enhance development efficiency, and improve system security. The specific development tasks and service functionalities include:

(1) Integration with Smart IoT Module: The team establishes JSON-based communication to transmit the collected data from various sensors to the cloud server. The server validates and categorizes the received data, persistently stores the information on any exceptional data from the devices and provides it for viewing by the personnel and issuing action instructions to the quadruped robot.

(2) Integration with Dynamic Inspection Module: As shown in **Figure 5-3**, after the quadruped robot collects video stream data, it transfers the relevant data to the cloud server using the Ethernet protocol. The cloud service host incorporates a data processing module specifically designed for the quadruped robot, ensuring the collected data is persistently stored in the cloud database. The server also transmits specific instructions to the quadruped robot based on the data from the Smart IoT module, enabling targeted inspections.

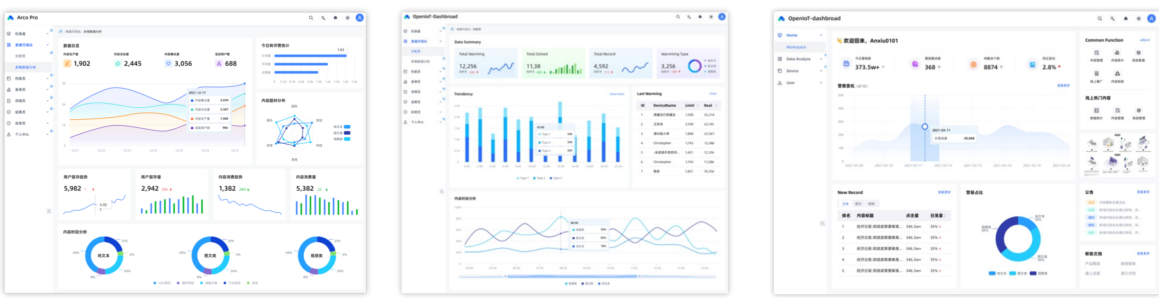
(3) Design of Real-time IoT Dashboard: Considering the need for maintenance personnel in the factory to monitor data in real-time through a user-friendly graphical interface, the team has developed a well-designed and intuitive visualization control panel. This platform helps administrators understand the data within their field of view and provides a natural interaction logic.

(a) Stream data interface (b) Robot control interface

Figure 5-3 Mobile APP system for data presentation and motion control

5.1.4 Procedure 4: Interaction Design

In the interaction component, the team has developed a user-friendly system interaction mode. Based on the Echarts framework, the team has designed a graphical dashboard for the IoT hardware, providing real-time data visualization to enterprise users. Through a series of chart styles, the data is presented in a more intuitive manner to the relevant staff, aiming to create a convenient and efficient user experience. **Figure 5-4** showcases the real-time visualization platform and system interaction dashboard of the system.



Visualization Page I Visualization Page II Interactive Dashboard

Figure 5-4 Visualization platform and interactive dashboard

(a) Real-time data updates: The team has established WebSocket long connections between the client and the server to update information on the client management panel. This approach, which does not require unnecessary refresh operations, achieves low-latency and high-concurrency data display. By avoiding traditional polling methods for data updates, this design approach further enhances the performance of the service.

(b) Satellite map display: The system uses satellite map visualization to provide precise location information of the IoT module nodes. It clearly shows the position status of each IoT node and the quadruped robot, enabling factory managers to formulate patrol strategies for the robot and meet the requirement of inspecting specified nodes in the shortest possible time.

(c) Dynamic inspection scheduling mechanism: The team has integrated the IoT dashboard with relevant information from the quadruped robot, enabling remote monitoring of the robot's working data and real-time assessment of its health status. This allows for proactive scheduling of low-battery robots to reach charging stations for energy replacement. Additionally, the system assists in path planning for the quadruped robot within specified time frames, helping inspection administrators with task scheduling.

5.1.5 Procedure 5: Experimental Testing

After completing the basic construction of the inspection system, the team proceeds with on-site deployment and targeted testing of the proposed inspection system. They perform unit testing, integration testing, and system testing to progressively test and optimize the system for improved robustness and adaptability.

In unit testing, the team checks the functionality of the hardware modules to ensure proper operation. They validate the data communication between the software and hardware to prevent any data misplacement or loss during transmission. Integration testing focuses on the Smart IoT sensors and the dynamic inspection quadruped robot modules, testing their integrated functionalities in real-world scenarios. **Figures 5-5** illustrate the data collection testing of the Smart IoT sensors in real industrial park environment and the inspection testing of the quadruped robot on industrial PLC devices in the field, respectively.

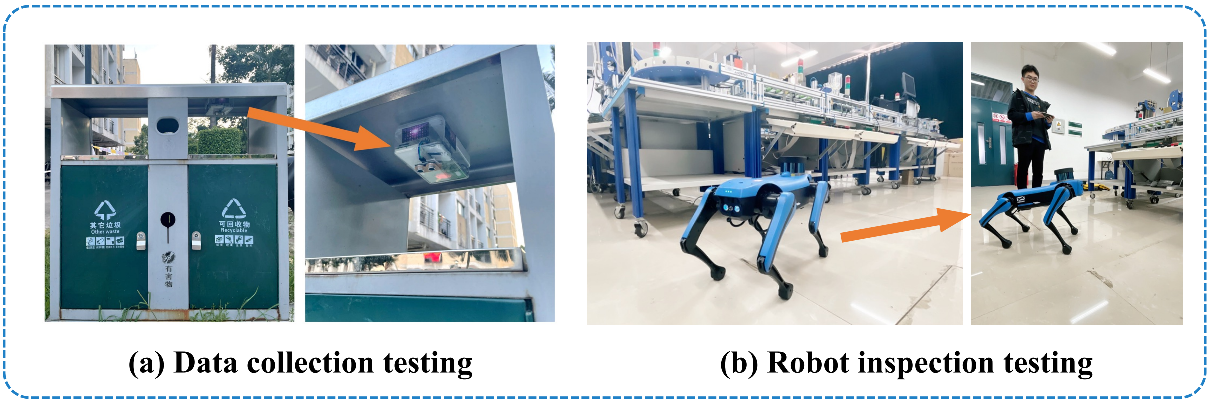


Figure 5-5 Real-world testing scenarios of the safety inspection system.

After completing unit testing and integration testing, the team performs comprehensive system testing. They deploy and validate the functionalities of the hardware modules, software services, and interaction systems following defined processes. The workflow diagram of the proposed Smart Factory Inspection System is presented in **Figure 5-6**. The sensors collect data metrics from the industrial site, which are visualized on a web-based dashboard for monitoring by the staff. If anomalies are detected, the quadruped robot is deployed for on-site inspection.

Then, the quadruped robot uses machine vision algorithms to read instrument data from the video stream, which is then assessed by human evaluators. If no safety issues are found, the robot autonomously returns to the charging area. If safety hazards are identified, the robot promptly addresses the issues, enabling autonomous and efficient inspections in industrial settings to address production safety concerns in smart factories.

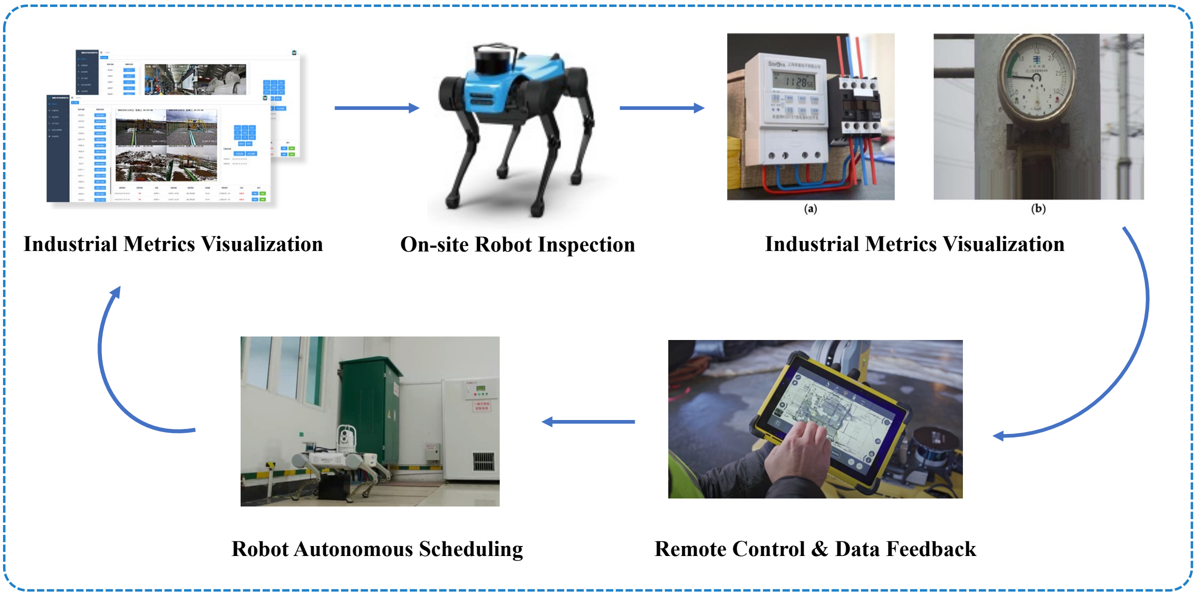


Figure 5-6 Workflow of the proposed IoT Inspection System

5.1.6 Procedure 6: System Evaluation and Acceptance

Ultimately, as depicted in **Figure 4-5** above (Chapter 4.1.2), the team has successfully achieved the interconnectivity of the hardware modules, software services, and interaction system, resulting in the realization of six major functional components: instrument monitoring, factory environment assessment, high-risk scenario inspections, manual online operations, data visualization, and interactive dashboard. Through meticulous and comprehensive field testing, the team have validated the efficiency and safety of the proposed inspection system in multiple industrial scenarios. This system effectively addresses real-world production and living requirements, fulfilling the objectives of academic training and significantly enhancing the team's collaborative and hands-on practical abilities.

In conclusion, with advancing technologies and expanding application scenarios, the safety inspection system is set to become a vital component of industrial parks and smart communities. It will bring forth efficient, intelligent, and secure production and lifestyles. Future developments will focus on enhancing data processing efficiency and security, leveraging big data and AI for smarter inspections and accurate risk prediction. This will ultimately benefit society and improve people's lives. The team in Huading Tech remains dedicated to driving innovation for a safer and advanced future.

5.2. Soft Skills Acquisitions

During the industrial placement at Huading Tech, the author acquired a diverse set of soft skills. This section outlines his proficiency in communication, teamwork, leadership, problem-solving, and time management. Additionally, the author gained hands-on experience in project management, demonstrating his ability to organize, and execute tasks efficiently and punctually.

5.2.1 Soft Skills Acquired during IP Internship

As illustrated in the **Chapter 4.2.** above, the author displayed exceptional teamwork skill throughout the IP. He exhibited effective collaboration, adept communication with team members, and adeptly delegated tasks to accomplish project objectives.

For instance, the author's active participation in weekly summary meetings played a crucial role in tracking progress and strategizing for the upcoming week. By assigning tasks based on individual responsibilities, as guided by the manager, the team maintained a streamlined workflow. The utilization of the 'Feishu (Lark)' software significantly enhanced coordination efficiency, facilitating seamless communication and task management within the team. This systematic approach fostered steady project progression, capitalizing on previous accomplishments, integrating innovative designs, and continuously refining solutions. Through this iterative process, the author gained valuable insights and practical experience in project management, problem-solving, and teamwork dynamics.

The author's notable achievements in effectively collaborating with the team, optimizing communication channels, and adeptly managing tasks not only contributed to the successful outcomes of the projects but also significantly enhanced his professional growth and expertise.

5.2.2 Feedback and Benefits of Teamwork Experience

After the IP, the author received valuable feedback on his teamwork skills. Colleagues praised his strong communication abilities, active participation in discussions, and effective expression of ideas. The author also demonstrated excellent interpersonal skills by working harmoniously with diverse team members and respecting different perspectives.

During the IP, the author had the opportunity to cultivate leadership qualities by leading team discussions, coordinating tasks, and motivating others. Specifically, he recognized the significant benefits of his teamwork experience, which included improved communication, enhanced interpersonal skills, and developed leadership abilities. The author deeply values the importance of collaboration, understanding the collective strength of a team and its pivotal role in achieving shared goals. This transformative experience will undoubtedly shape his future professional development and empower him to excel in collaborative work environments.

5.3. Integration of Production and Education

The integration of production and education is a valuable aspect that emerged from the author's journey. The IP experience provided a practical platform for the author to apply the knowledge and skills acquired during the college education. This section will discuss the author's reflections and prospects on university education after undergoing the internship in industry.

5.3.1 Application of Program Components during IP

The main component of programs which have been put to use during the author's IP:

(1) EE108: Computing for Engineers (taught by Prof. Ronan G. Reilly).

(2) EE301: Signals & Systems (taught by Dr. Chin Hong Wong).

(3) EE302: Real-Time and Embedded Systems (taught by Dr. Lijun Wu).

(4) EE308: Software Engineering (taught by Mr. Qifeng Lin).

(5) CS240: Operating Systems & Linux (taught by Dr. Ting Bi).

(6) CS323: Robotics and Automation (taught by Dr. Siyuan Zhan).

5.3.2 Further Learning Goals for Next Academic Year

After the 4-month IP experience, the author gained a clearer understanding of the gap between industrial demands and university education. In the coming academic year, the author intends to further delve into the following areas of study:

(1) Robot motion control, perception technologies, and programming based on ROS2.

(2) Advanced Python programming and applied machine learning.

(3) Application of deep learning in industrial Internet of Things (IIoT).

(4) Professional literature review, academic writing, and presentation skills.

5.3.3 Reflection and Prospects for the Final Year Project (FYP)

As described in Section 4.1.2, during the industrial placement, the author participated in the development of an industrial safety inspection system based on the smart IoT. This system was jointly developed by Huading Tech and the Provincial Key Laboratory of Industrial Automation Control Technology and Information Processing (**IACTIP**). In the final year of undergraduate career, the author will further engage in the system's research and development at the IACTIP Lab, and relevant works will serve as the author's Final Year Project.

Furthermore, since September 2022, under the guidance of Prof. Zhezhuang Xu, the author has been engaged in research on security attacks prevention for the IIoT. The manuscript for this research work has already been completed in its initial draft [7]. In the coming senior year, the author plans to conduct additional experiments to supplement the research, with the aim of publishing this paper in a reputable SCI index journal. In conclusion, the author has accomplished numerous competitive tasks during the internship, significantly enhancing their foundational research competence and industrial capabilities.

6. OPINION ON IP AND CONCLUSIONS

Based on the technical achievements and related outcomes illustrated in the **Chapter 5** above, the following **Chapter 6** provides an overview of the author's perspective on the IP experience, as well as a summary and recommendations. This chapter aims to reflect upon the key insights gained throughout the IP and provide valuable suggestions for future improvements.

6.1. Conclusion of IP Experience

During the industrial placement at Huading Intelligent Manufacturing Technology Co., Ltd., the author formed an exceptionally positive impression of the company. Huading Tech boasts a first-class corporate culture and demonstrates a strong commitment to social responsibility, as shown in **Table 2-1**, exemplified by their dedication to innovative products and genuine services. The company's remarkable achievements in the field of intelligent manufacturing have garnered widespread recognition, including their selection as a national intelligent manufacturing demonstration project, an industrial champion enterprise of the Ministry of Industry and Information Technology.

Throughout the author's internship at the company, he received outstanding guidance and support, which greatly contributed to their professional growth. The work undertaken during the internship provided invaluable experience and skill development opportunities. The author exhibited exceptional technical proficiency, unwavering dedication, and remarkable adaptability in their project assignments. This was particularly evident in the design and implementation of the IIoT inspection system, which necessitated the seamless integration of diverse hardware and software components. Furthermore, the author consistently demonstrated a strong work ethic and an unwavering thirst for knowledge. His ability to acclimate swiftly to the fast-paced and dynamic organizational environment and collaborate effectively with colleagues from different departments played a pivotal role in the project’s success.

Lastly, the author's impression of Huading Tech remains overwhelmingly positive, with their corporate culture, social responsibility initiatives, and technical prowess leaving an indelible mark. The IP experience not only provided him with valuable skills and experience but also garnered recognition from the company, boding well for his future endeavors.

6.2. Opinions and Recommendations

After reflecting on the IP experience at Huading Tech, the author wants to share his personal insights and recommendations to improve future IP programs in Maynooth International Engineering College (MIEC). The following opinions and suggestions are provided:

- **Integration into Academic Curricula: Bridging the Gap**

From the author's point of view, integrating IP programs into academic curricula is crucial to bridge the gap between theory and practice. By immersing students in real-world projects, IP experiences provide hands-on learning that complements classroom knowledge and lessons. Universities should prioritize incorporating IP programs to equip students with practical skills.

Undoubtedly, Dr. Wong Kah Hieng, the lecturer for EE381 and EE382, has made a commendable contribution by imparting valuable job-seeking and workplace skills to the students. However, enhancing the effectiveness of the courses through additional class hours and more efficient teaching methods would yield even more substantial outcomes. This stands as an area for improvement that MIEC can focus on in the future program.

- **Mentorship and Guidance: Nurturing Personal and Professional Growth**

Mentorship and guidance play a pivotal role during the IP program. In addition to company mentors, the involvement of academic mentors is also crucial. However, there is a need to address the current gap in the engagement of academic mentors in the students' internship. To enhance the IP program, FZU and MIEC should actively involve academic mentors by establishing mentorship programs.

These mentors can offer valuable insights, guidance, and feedback related to the students' academic pursuits and research. They can help align internship experiences with academic goals and foster professional development. For instance, regular check-ins and progress meetings between interns and academic mentors should be encouraged to ensure ongoing support and guidance. By integrating academic mentors into the program, students can benefit from a comprehensive mentorship experience that bridges the gap between theory and practice.

In conclusion, universities should prioritize the involvement of academic mentors in the IP program. This will provide students with a well-rounded learning experience, enhance their personal and professional growth, and foster better integration of academia and industry.

- **Strengthening Collaborations: Enriching the IP Experience**

Strong collaborations among universities, companies, and institutions are crucial for enriching IP programs. These partnerships facilitate knowledge exchange, foster joint research initiatives, and provide access to state-of-the-art resources, thereby enhancing the quality and relevance of the IP experience. By establishing robust collaborations, universities can leverage industry expertise and cutting-edge technologies, offering students real-world exposure and practical skills. Moreover, collaborations promote innovation and interdisciplinary collaboration, enabling students to collaborate with industry professionals and researchers. This expands their networks and enhances their problem-solving abilities.

Companies and institutions actively participating in IP programs, including curriculum development, internships, and mentorship opportunities, contribute to shaping the future workforce and ensuring alignment with industry demands.

In conclusion, strengthening collaborations among universities, companies, and research institutions is essential for enriching the IP experience. These partnerships provide students with valuable exposure, interdisciplinary skills, and a competitive edge in the job market. Overall, there is room for improvement in this aspect for MIEC in the coming year.

6.3. Highlights of Author's IP

During the IP internship, the author achieved the following notable outcomes and highlights:

(1) Technical Excellence in Core Project: The author played an active role in the core project "Industrial Safety Inspection System based on the Smart IoT" at Huading Tech, making significant contributions that garnered sincere praise from the company mentor. This experience deep involvement showcased the author's technical expertise and unwavering commitment to developing innovative solutions.

(2) Championship in Innovation Project Competition: Collaborating with colleagues, the author successfully completed the "Community Safety Inspection System based on the IoT" project, securing the championship in the Fujian Provincial Youth Science Popularization Innovation Project Competition. This accomplishment highlights the author's leadership and adeptness in leveraging cutting-edge technologies like AI and IoT to address real-world safety concerns and deliver practical solutions (relevant certificate is given in **Appendices V**).

(3) Recognition in International Mathematical Modeling Contest: Under the guidance of Prof. Zhezhuang Xu, the author participated in the esteemed MCM Competition, earning the distinguished Finalist Award and ranking among the Top 1% out of 20,508 submitted papers. This recognition underscores the author's analytical prowess, problem-solving skills, and ability to collaborate effectively within strict time constraints (as shown in **Appendices IV**).

The exceptional achievements of the author during the IP internship have a profound impact on his future undergraduate and graduate academic journey, highlighting his valuable contributions and potential. His substantial contributions to a core project, success in a provincial-level innovation competition, and triumph in an international mathematical modeling contest showcase his technical competence, innovative thinking, and proficiency in multidisciplinary environments. These accomplishments not only demonstrate his expertise and dedication but also position him as a promising researcher and professional in his field.

Ultimately, the author's accomplishments during the IP internship provide a solid foundation for his future academic and research pursuits, instilling confidence in his ability to tackle complex challenges and make significant contributions to his chosen field. These achievements serve as a testament to his talent and promise a bright future as he continues his educational journey, contributing to the advancement of science and technology.

APPENDICES

Appendices I: Overview flowchart of the author's work during IP

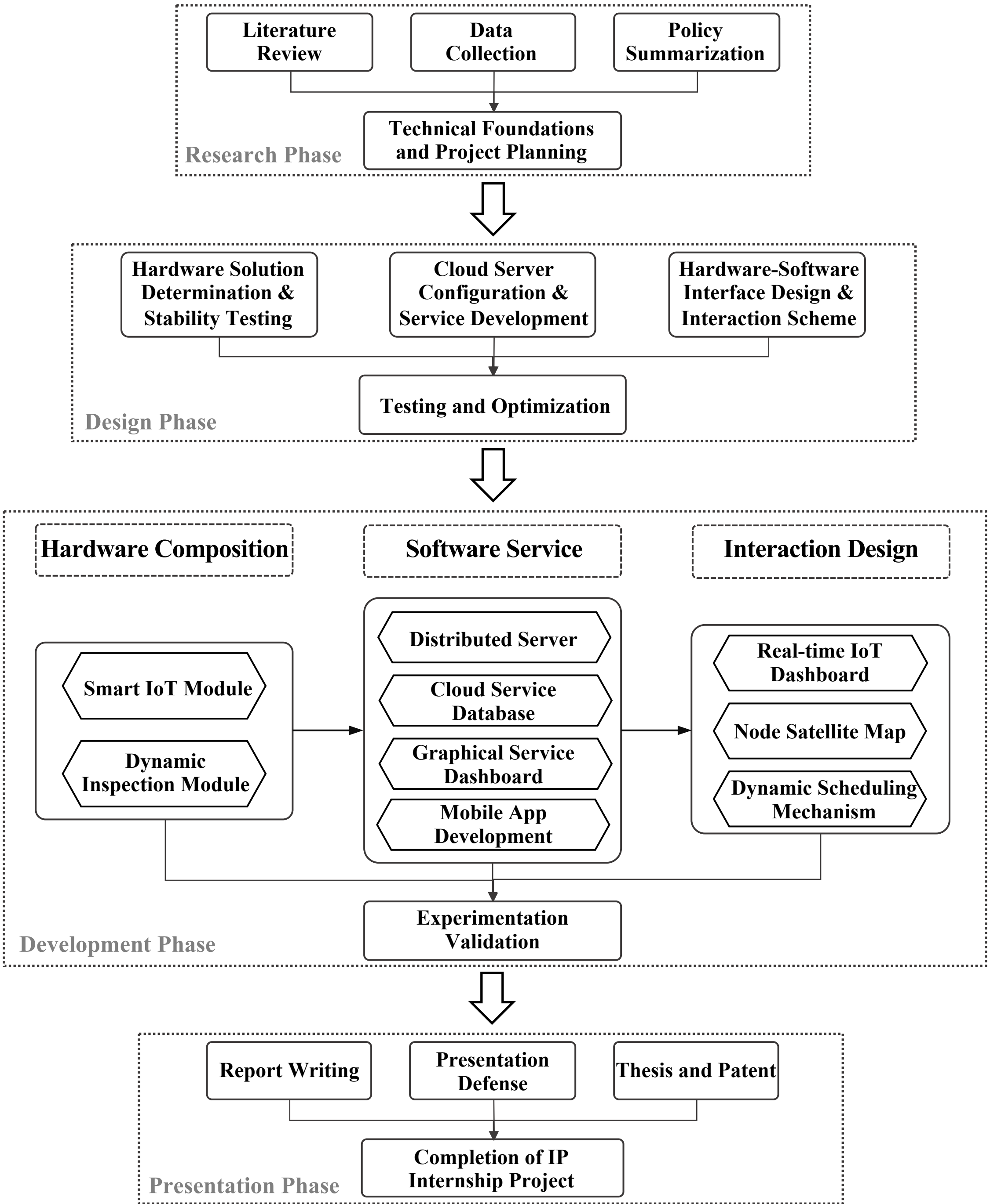


Figure I Overview of the author's work during IP

Appendices II: Real-time visualization interface of the Inspection System

The visualization interface can be accessed here: http://huaqi.site/

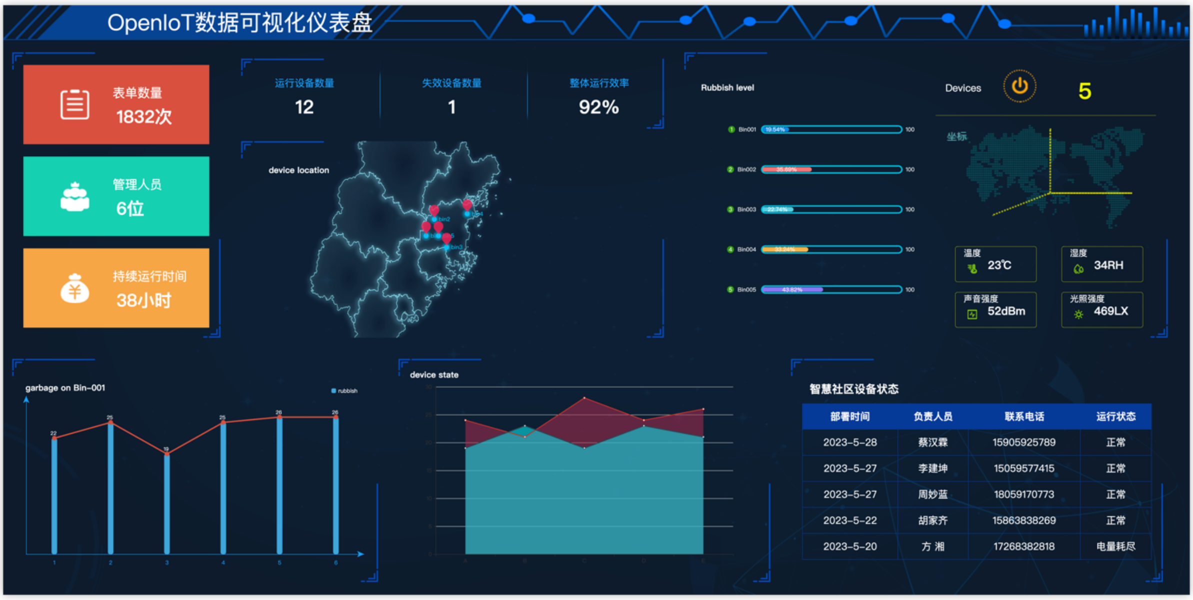


Figure II Real-time visualization interface of the Inspection System

Appendices III: Interactive dashboard of the Inspection System

The interactive dashboard can be accessed: http://openiot.space/home/workSpace

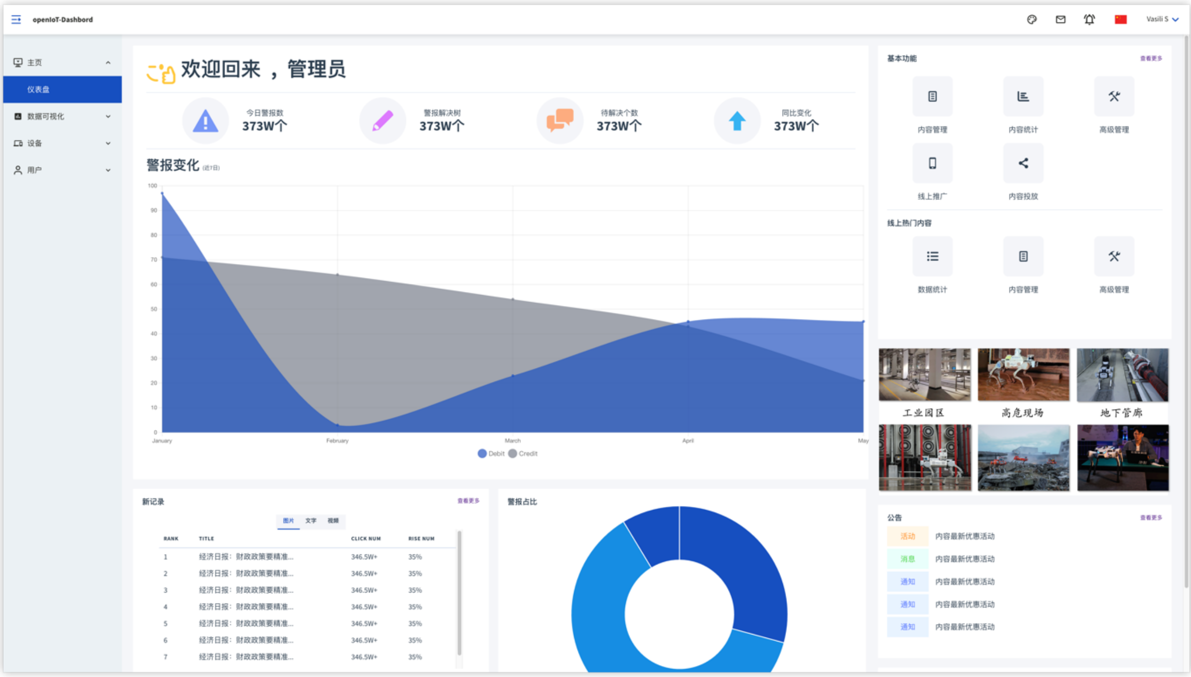


Figure III Interactive dashboard of the Inspection System (Under working)

Appendices IV: Finalist Award of the COMAP's Mathematical Contest in Modeling

The competition paper can be accessed here: https://caihanlin.com/publications/

2023

Mathematical Contest In Modeling®

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Be It Known That The Team Of

Hanlin Cai

Yufei Wu

Wenxuan Luo

With Faculty Advisor

Zhezhuang Xu

Of

Fuzhou University

Was Designated As

Finalist

Solomon Garfunkel, Executive Director

Administered by COMAP

With support from

Steven B. Horton, Contest Director

AMS ASA informs MAA siam

Figure IV The honor certificates of Finalist Awards (Rank top 1%)

Appendices V: Championship in the Fujian Innovation Project Competition

The official website of the author's team can be accessed here: https://fzuiot.site/english/

Figure V Championship in the Science Popularization Innovation Project Competition

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