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**School of Advanced Technology**

**Final Year Project**

**Project Specification Report**

Project Title: Mobile agent for smart home

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Project field: Smart home, IoT, Robot, Multimodal Deep Learning

Supervisor: Kyeong Soo (Joseph) Kim

Co-supervisor (if applicable):

1. **Project Description and Problem Statement**

Robotics is an emerging technology with far-reaching societal impacts, focusing on programming machines to achieve tasks through interactions with their environment [1]. According to DataHorizzon Research, the service robotics market size was valued at 24.2 Billion USD in 2022 and is projected to reach 104.7 Billion USD by 2032, exhibiting a compound annual growth rate (CAGR) of 15.9% [2]. This growth is attributed to the widespread utilization of robotics in diverse sectors, including finance, agriculture, and healthcare.

In addition, Multimodal Deep Learning has emerging as a new frontier in the field of deep learning, going beyond traditional single modality analysis. By fusing data from multiple modalities, it can achieve more accurate and superior performance compared to conventional single modality approaches [3]. The previously mentioned technologies have the potential to address common societal concerns while also enhancing the quality of life across various aspects. An aging society has been a societal issue for a long time. According to statistics from the World Health Organization (WHO) last year, it is predicted that the proportion of the global population aged 60 and over will increase from 12% to 22% i.e., nearly double the original proportion between 2015 and 2050 [4].

1. **Aims and Objectives**

This project aims to develop a smart home robot capable of detecting various events within a smart home environment, such as scenarios involving an unconscious elderly individual. The robot will employ hardware components, including Arduino, Raspberry Pi, Mic sensor, and camera. Additionally, the robot will be designed with multimodal deep learning to extract and analyze both sound and image data. The analyzed prediction results will be alerted to the user via messages.

The project objectives given the project aims are as follows:

* To implement a robot based on a robust hardware architecture and software system that integrates components such as Arduino, Raspberry Pi, mic sensors, and cameras.
* To design multimodal deep learning models for sound and image data, enabling the robot to extract, analyze, and respond to various events within a smart home environment.
* To ensure the robot’s ability to detect a wide range of scenarios, including identifying the sound of an elderly person falling.
* To develop a reliable alert system that can promptly inform users of detected events through messages or notifications.

These objectives should help ensure comprehensive and successful project implementation.

Based on present knowledge and understanding, the robot is expected to incorporate the following components:

* Arduino: The Arduino serves as the central control unit, responsible for interacting with the mic sensors or camera and controlling the robot’s actions. It collects data from the camera, processes the information, and communicates with the Raspberry Pi.
* Raspberry Pi: The Raspberry Pi complements the Arduino by providing more processing power and advanced capabilities for tasks such as image processing and multimodal deep learning. It responsible for analyzing the visual and sound data from the camera and microphone sensors and executing the multimodal deep learning model.
* Mic sensor and Camera: The mic sensor and camera are responsible for detecting abnormal situations based on established thresholds. For example, the mic sensor can identify sounds like an elderly person falling, which might indicate an emergency.

1. **Project Plan: Tasks and Milestones (Gantt Chart)**

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| **Period** | **Main Work** |
| **Semester 1** | |
| Week 1– Week 6 | * Understanding of theory(Smart Home, Arduino, Multimodal Deep Learning) * Define Project scope and objectives * Research on Necessary Hardware Components |
| Week 7 – Week9 | * Purchase Hardware Components * Setup of Arduino and Associated Hardware * Implementation Arduino Programming (Object Tracking) |
| Week 10 – Week 14 | * Extract sound and image data from sensors * Implementation the Multimodal Deep Learning Model |
| **Reading Weeks and Winter Vocation** | |
| Winter Vacation | * Continuously Implement and Test the Multimodal Deep Learning Model |
| **Semester 2** | |
| Week 1 – Week 4 | * Conduct Hardware and Software Testing for Reliability * Evaluation the Capabilities of Detection * Test the User Alert System |
| Week 5 – Week 9 | * Document the Results and Progress of the Project * Prepare Comprehensive Project Reports and Research Papers |
| Week 10 – Week 14 | * Finalize and Submit the Comprehensive Project Thesis |

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| Task | Semester 1 | | | | | | | | | | | | | | Semester 2 | | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Preliminary |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Setup Hardware |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Implement model |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Test and Evaluate |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Documentation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Finalize and Sumit |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

1. **Project Deliverables**

In the final project demonstration, the robot will be able to achieve functions as listed below:

* The robot will continuously monitor the activities of elderly individuals using the camera and microphone, and it will chase an elderly person based on the data acquired through these devices.
* The robot will detect the abnormal situations such as when an elderly individual falls or exhibits characteristics like an unusual sound and a fallen image on the screen.
* The robot will communicate with the user through a message protocol to provide real-time notifications about the situation.

These functions ensure that the robot can prevent and respond to emergency situations that may occur within a smart home in an ageing society.

1. **Project Industrial Relevance**

Future smart home environments represent the core of technological innovation that can enhance the safety and convenience of people’s lives. The smart home is defined as where appliances and devices can be automatically controlled remotely by a mobile or other network linked device via IoT [5]. By 2023, the automation of the smart home industry in the US is projected to reach 53.9%. This represents a figure that is nearly double that of 2019 [6].

Therefore, this project aims to integrate technologies such as robotics and multimodal deep learning to evaluate the smart home environment and improve the user experience. Moreover, it enables the smart home to respond promptly and effectively to unforeseen situations, especially within an aging society.

**References**

[1] Koditschek, Daniel E. “What is robotics? Why do we need it and how can we get it?” Control Robot. Auton. Syst, vol. 4, no. 1, pp. 1-33, May. 2021.

[2] GlobeNewswire, (2023, 10. 05). Service Robotics Market Size To Attain 15.9% CAGR By 2032 [Online]. Available: <https://www.globenewswire.com/news-release/2023/10/05/2755860/0/en/Service-Robotics-Market-Size-To-Attain-15-9-CAGR-By-2032.html>.

[3] P. Potrimba, (2023, 05. 10). Multimodal Models and Computer Vision: A Deep Dive [Online]. Available: <https://blog.roboflow.com/multimodal-models/>.

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[5] A. Hayes, (2023, 09. 29). Smart Home: Definition, How They Work, Pros and Cons [Online]. Available: https://www.investopedia.com/terms/s/smart-home.asp.

[6] G. Nick, (2023, 08. 28). 23 Eye-Opening Smart Home Statistics to Know in 2023 [Online]. Available: <https://techjury.net/blog/smart-home-statistics/>.