Report on the Visit of a Student to UWS

From 15th July to 15th August

Report submitted by:

- Fazeel Asghar

  (Student of IUB, Department of Information Technology)

Research Training Program Report

(Fazeel Asghar)

Proposal and Selection for the Safe-Rh Mobility Program

As a final year student of BS IT, I had the incredible opportunity to propose a research project for the Safe-Rh Mobility Program. My proposal focused on developing a smart wheelchair equipped with a GPS module, obstacle detection system, and vital signs monitoring capabilities. This innovative design aims to enhance mobility and safety for wheelchair users by providing real-time data to caregivers, ensuring better health management and immediate response to potential hazards.

I was thrilled when my proposal was accepted, and I was invited for an interview by Professor Dr. Naeem Ramzan at the University of the West of Scotland (UWS), UK. The interview process was rigorous, but I was ultimately selected to collaborate on this project. Working under the guidance of Professor Dr. Ramzan and his team was an invaluable experience. Their expertise and support played a crucial role in refining my project and bringing my ideas to fruition.

A Month of Learning, Growth, and Inspiration at UWS

My one-month visit to UWS was filled with learning and personal growth. The university provided a conducive environment for research and development, and I gained hands-on experience with cutting-edge technology. The exposure to Scotland's rich culture and the warm hospitality of its people made my stay even more memorable. I left with a deeper appreciation for the field of IT and a renewed enthusiasm for my future career.

This journey has been one of the most significant milestones in my academic life. The knowledge and skills I acquired during this period have been instrumental in shaping my professional aspirations. I am immensely grateful to UWS and Professor Dr. Naeem Ramzan for their mentorship and support. This experience has not only broadened my technical expertise but also inspired me to pursue further advancements in the field of assistive technology. The collaborative environment at UWS and the exposure to diverse perspectives have enriched my understanding of global research practices. I also had the chance to interact with fellow researchers and students from different cultural backgrounds, which enhanced my interpersonal skills and expanded my professional network. The hands-on experience with advanced tools and

methodologies has given me a solid foundation to tackle future challenges in IT and assistive technology. This remarkable journey has reaffirmed my commitment to making a positive impact through innovative solutions, and I am eager to apply what I have learned to future projects.

Active Participation and Professional Development in Safe-Rh Meetings

During my time at the University of the West of Scotland (UWS), I actively participated in the Safe-Rh meetings, where project leads discussed the key deliverables and progress of the initiative. These meetings provided me with invaluable insights into the project's goals and the collaborative efforts required to achieve them. The experience allowed me to absorb the dynamic and professional environment, gaining exposure to high-level discussions and strategic planning. I also had the privilege of assisting the delegation from my home institution, including the Dean of the Faculty of Computing, Dr. Dost Muhammad Khan and the Chairman of the Department of Artificial Intelligence, Dr. Najia Saher. Their arrival in Scotland for these meetings further enriched my learning experience, as I was able to observe and support the interactions between

the IUB team and the Safe-Rh project leaders. This engagement deepened my understanding of project management and cross-institutional collaboration, significantly enhancing my professional development.

Safe-Rh Project Celebration at Loch Lomond

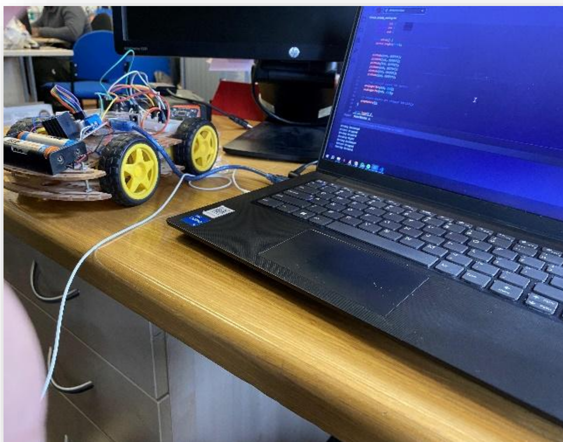
In the final days Safe-Rh meetings, the entire team went to Loch Lomond, Scotland, for a barbecue to celebrate the conclusion of the Safe-Rh project. We enjoyed a wonderful time together, and I had the privilege of being part of this memorable event. The highlight of the celebration was the ceremonial cutting of the cake to mark the successful completion of the project. This outing was not only a refreshing break but also an opportunity to bond with the team members in a relaxed setting, leaving me with cherished memories of my time in Scotland.

Initiation and Presentation of the Smart Wheelchair Prototype

After being free from the Safe-Rh project activities, I began working on my proposed research project: the Smart Wheelchair. Given the limited time available to complete the entire project, I presented a one-week work plan to Dr. Naeem Ramzan for his approval. I started by developing a small car model equipped with an ultrasonic sensor and an infrared sensor, all connected to an Arduino along with other essential components. This prototype served as a preliminary step towards the larger goal of creating a fully functional smart wheelchair. Upon completion, I delivered a presentation showcasing my work to Dr. Naeem Ramzan, fellow students, and other interns participating in the mobility program. The positive feedback and appreciation I received from them were incredibly encouraging, reinforcing the value and potential impact of my research.

Development and Troubleshooting of the Obstacle Detection Model

Given the limited time I had, I focused on developing a small car model to demonstrate obstacle detection and avoidance, which would serve as a foundational step towards the Smart Wheelchair project. Initially, I encountered challenges with integrating the components, as they were not functioning together as expected. However, I methodically troubleshooted the issues, ultimately resolving them by incorporating two additional infrared (IR) sensors. This adjustment allowed the system to more accurately detect obstacles. I thoroughly enjoyed the process of working on this model, coding primarily in Arduino IDE and Python to program the sensors and control the car's movements. In the final days of my stay at UWS,



Scotland, I successfully achieved the desired outcome—the car was able to detect and avoid obstacles autonomously, demonstrating the potential for further development in the Smart Wheelchair project. This hands-on experience was both challenging and rewarding, as it reinforced my technical skills and deepened my understanding of real-time sensor integration.

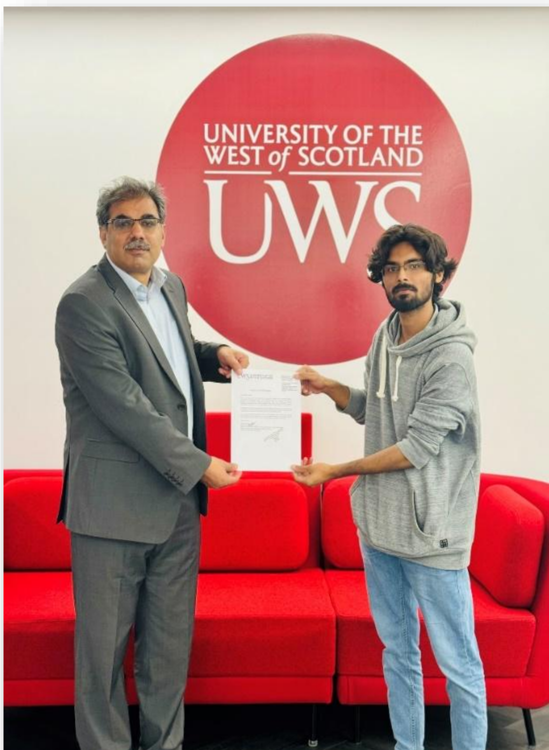
Components Used in Car Prototype:

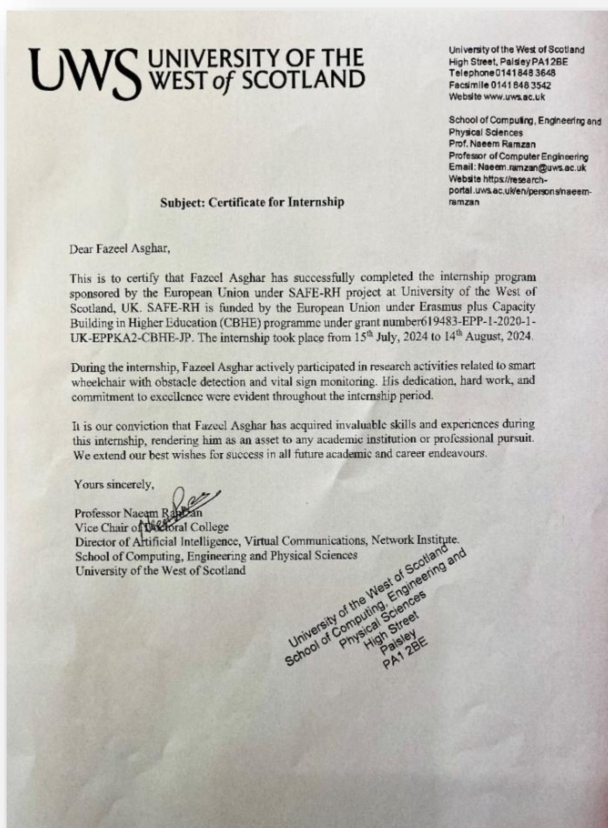
- **Arduino Uno (Microcontroller):** Acts as the brain of the system, processing inputs from sensors and controlling outputs.
- **Breadboard:** Provides a platform for easily connecting and integrating all electronic components without soldering.
- **Ultrasonic Sensor:** Measures distance by emitting sound waves and detecting their reflection, used for obstacle detection.
- **Two IR Sensors:** Detects the presence of objects in close proximity, enhancing the car's ability to avoid obstacles.

- **Motor Driver Module:** Controls the motors that drive the car's wheels, allowing for movement and direction changes.
- **Four Wheels:** Enables the physical movement of the car, driven by the motors.
- **Wooden Car Template:** Serves as the structural base for mounting and organizing all the components.

Certificate of Completion

In the final days of my stay at the University of the West of Scotland (UWS), I was honored to receive a certificate from Professor Dr. Naeem Ramzan. His mentorship and unwavering support throughout my time at UWS were invaluable, guiding me through the challenges of my research and ensuring my growth both technically and professionally. This recognition marked the successful culmination of my efforts and the significant learning I gained during this enriching experience.





UWS UNIVERSITY OF THE WEST of SCOTLAND

University of the West of Scotland
High Street, Paisley PA1 2BE
Telephone 0141 848 3648
Facsimile 0141 848 3542
Website www.uws.ac.uk

School of Computing, Engineering and Physical Sciences
Prof. Naeem Ramzan
Professor of Computer Engineering
Email: Naeem.ramzan@uws.ac.uk
Website https://research-portal.uws.ac.uk/en/persons/naeem-ramzan

Subject: Certificate for Internship

Dear Fazeel Asghar,

This is to certify that Fazeel Asghar has successfully completed the internship program sponsored by the European Union under SAFE-RH project at University of the West of Scotland, UK. SAFE-RH is funded by the European Union under Erasmus plus Capacity Building in Higher Education (CBHE) programme under grant number619483-EPP-1-2020-1-UK-EPPKA2-CBHE-JP. The internship took place from 15th July, 2024 to 14th August, 2024.

During the internship, Fazeel Asghar actively participated in research activities related to smart wheelchair with obstacle detection and vital sign monitoring. His dedication, hard work, and commitment to excellence were evident throughout the internship period.

It is our conviction that Fazeel Asghar has acquired invaluable skills and experiences during this internship, rendering him as an asset to any academic institution or professional pursuit. We extend our best wishes for success in all future academic and career endeavours.

Yours sincerely,

Professor Naeem Ramzan
Vice Chair of Doctoral College
Director of Artificial Intelligence, Virtual Communications, Network Institute.
School of Computing, Engineering and Physical Sciences
University of the West of Scotland

University of the West of Scotland
School of Computing, Engineering and
Physical Sciences
High Street
Paisley
PA1 2BE

Conclusion/Summary of My Journey

My time at UWS under the Safe-Rh Mobility Program was a significant milestone in my academic career. It began with the acceptance of my Smart Wheelchair proposal, aimed at enhancing mobility and safety with GPS, obstacle detection, and vital signs monitoring. Being selected for this program and presenting my ideas to Professor Dr. Naeem Ramzan was a key achievement that led to deep learning and growth.

At UWS, I gained valuable insights into project management and international collaboration through active participation in Safe-Rh meetings. With limited time, I developed a small car model to demonstrate obstacle detection and received positive feedback from Professor Ramzan and fellow participants.

The experience was enriched by a team outing to Loch Lomond, celebrating the project's conclusion. Receiving a certificate from Dr. Ramzan symbolized the knowledge and connections I gained. This journey has fueled my passion for assistive technology and provided a strong foundation for my future endeavors.

As I haven't got a chance to complete this complete, because of the limited time I had, I am considering it to make it my final year project, as I am in my final year of BS IT.

For further details on my proposed project:

Feasibility Analysis of the Smart Wheelchair Project

The development of a Smart Wheelchair equipped with obstacle detection, avoidance, and patient vital signs monitoring system is a technically feasible project with significant potential in the field of assistive technology. This project leverages advancements in sensors, microcontrollers, and wireless communication technologies to enhance the safety and well-being of wheelchair users. The following points outline the key factors supporting the feasibility of this research:

- **Technological Readiness:**
    - **Sensors:** The availability of reliable and cost-effective sensors, such as ultrasonic and infrared (IR) sensors, allows for accurate detection of obstacles, ensuring the wheelchair can navigate safely in various environments.
    - **Microcontrollers:** Platforms like Arduino and Raspberry Pi provide flexible and robust control systems for integrating multiple sensors and actuators, enabling real-time data processing and response.
    - **Wireless Communication:** Existing wireless technologies (e.g., Wi-Fi, Bluetooth) facilitate the transmission of vital signs data to caregivers, ensuring continuous monitoring and timely intervention.
- **Cost-Effectiveness:**
    - The components required for the initial prototype are affordable and widely available, making the project scalable for further development and potential commercialization.
- **User-Centric Design:**
    - The Smart Wheelchair project is designed with end-users in mind, aiming to improve mobility, safety, and health monitoring for individuals with disabilities. The integration of these features into a single system addresses multiple needs, making it a comprehensive solution.
- **Scalability and Future Development:**

- The modular design of the Smart Wheelchair allows for future upgrades and the addition of new features, such as GPS navigation and voice control, enhancing its functionality and user experience.
-

Roadmap and Possible Components for the Smart Wheelchair for Future Development

To successfully develop the Smart Wheelchair, the following roadmap outlines the key components and steps required, along with potential technologies to be used:

1. **Core System Development:**
    - **Microcontroller/Processor:**
        - **Arduino Uno/Raspberry Pi:** Acts as the central control unit, processing data from sensors and managing communication with other components.
    - **Power Supply:**
        - **Rechargeable Battery Pack:** Provides sufficient power to the microcontroller, sensors, and motors.
    - **Chassis and Wheels:**
        - **Customized Wheelchair Frame:** Designed to accommodate all electronic components and provide a stable base for movement.
        - **DC Motors with Motor Driver Module:** Controls the wheelchair's movement, enabling precise navigation and obstacle avoidance.
2. **Obstacle Detection and Avoidance System:**
    - **Sensors:**
        - **Ultrasonic Sensors:** Used for long-range obstacle detection, particularly for identifying objects in front of the wheelchair.
        - **Infrared (IR) Sensors:** Provides additional obstacle detection capability, especially for short-range and low-lying obstacles.
    - **Real-Time Processing:**

        - **Arduino IDE/Python:** Programming environment for coding the logic to process sensor data and execute avoidance maneuvers.

3. **Vital Signs Monitoring System:**
    - **Sensors:**
        - **Heart Rate Sensor:** Monitors the user's heart rate, providing real-time data for health assessment.
        - **Pulse Oximeter Sensor:** Measures blood oxygen levels, ensuring the user's vital signs are within safe ranges.
        - **Temperature Sensor:** Tracks the user's body temperature, alerting caregivers if there are any abnormalities.
    - **Data Transmission:**
        - **Bluetooth/Wi-Fi Module:** Enables wireless communication with external devices, allowing caregivers to monitor vital signs remotely.
    - **Mobile Application/Cloud Integration:**
        - **Custom App or Cloud Platform:** Displays real-time health data and sends alerts to caregivers if necessary.

4. **User Interface and Control:**
    - **Input Methods:**
        - **Joystick/Voice Control:** Provides users with intuitive control over the wheelchair's movement.
    - **Display:**
        - **LCD/OLED Screen:** Displays essential information, such as battery life and system status, to the user.
5. **Safety and Redundancy:**
    - **Emergency Stop Mechanism:**

        - **Manual Button/Automatic Trigger:** Allows the user or caregiver to immediately stop the wheelchair in case of an emergency.
    - **Failsafe Systems:**
        - **Backup Power Supply:** Ensures the wheelchair remains operational in the event of a power failure.

6. **Testing and Optimization:**
    - **Simulation and Field Testing:**
        - Conduct simulations to optimize sensor placement and performance.
        - Perform real-world testing to evaluate the system's reliability and effectiveness in different environments.
7. **Future Enhancements:**
    - **GPS Navigation:**
        - **GPS Module:** Integrates with the control system to provide navigation assistance and route planning.
    - **Voice Control and AI Integration:**
        - **Natural Language Processing (NLP):** Enables voice commands for controlling the wheelchair, enhancing accessibility.
        - **Machine Learning Algorithms:** Improve obstacle detection and avoidance through continuous learning and adaptation.

Report on the Visit to UWS

From 6th June, 2024 to 9th August,2024

Submitted by :

Rameen Fatima

MS-IT

Department of Information Technology

The Islamia University Of Bahawalpur

Co-funded by the Erasmus+ Programme of the European Union

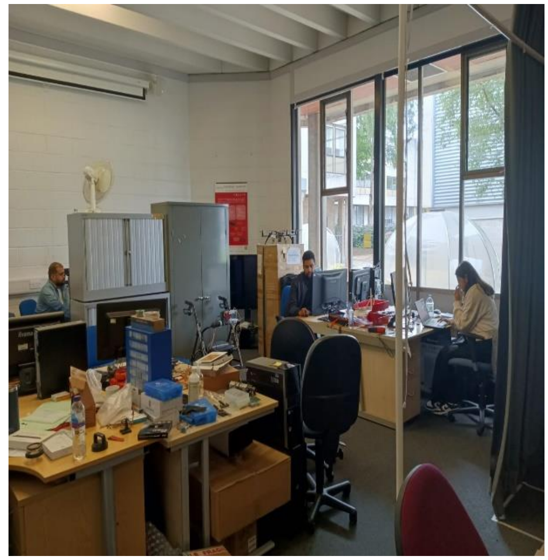
SAFE-RH

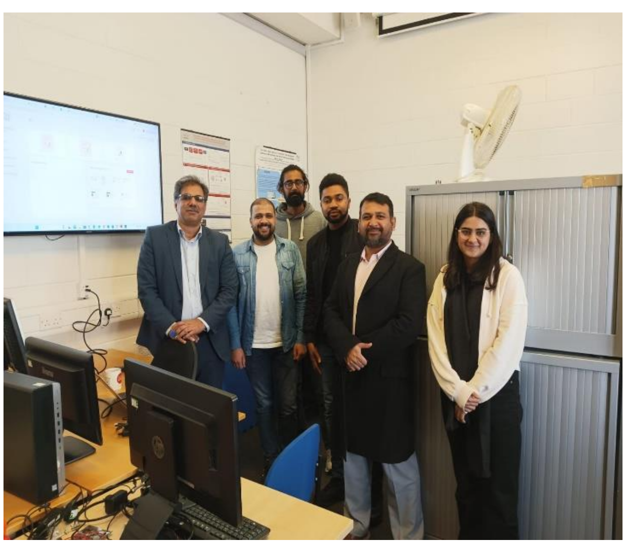
UNIVERSITY OF THE WEST of SCOTLAND UWS

This report summarizes the research activities and experiences gained during my research mobility program sponsored by SAFE RH at the University of the West of Scotland, funded by the European Union. My main focus during the program was developing and testing the Smart Food Calorie Monitoring System. I have acquired significant professional and personal experiences that have reasonably influenced my career and changed the world's view.

The primary objective of the research work is to design and develop an intelligent food calorie monitoring system. Advanced machine learning algorithms, supported by computer vision techniques, are applied in this system for high-value estimation of a wide variety of foods. That is, very large datasets of food images were collected, and algorithms capable of analyzing the images for proper estimation of calorie content were written, and rigorously tested for verifying accuracy. Good results were observed in that there were very accurate results with the system at an average error margin of less than 10%, as opposed to the conventional modes of calorie estimation. This innovation will allow people to control their food consumption at much finer levels than ever before.

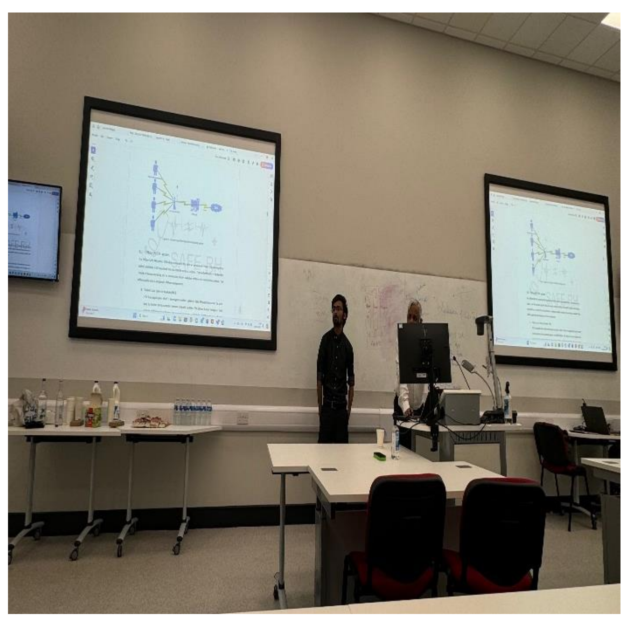
During this period of staying at UWS, I also became a contributor to testing and processes for SAFE RH. This involved the testing of the existing systems of the SAFE RH mechanism for its reliability and functionality. The required gathering and analyses in identifying possible ways through which the system could be improved. It includes quality standards and user needs. It has hands-on experience, which raises not only my understanding of the application but also provides much for its safety standards. This would be very useful, working as a team, with a lot to learn from their expertise, which enhanced my technical skill.





I actively participated in the testing of the application for RH safety together with the rest of the members and our head of the project Prof. Dr. Naeem Ramzan.

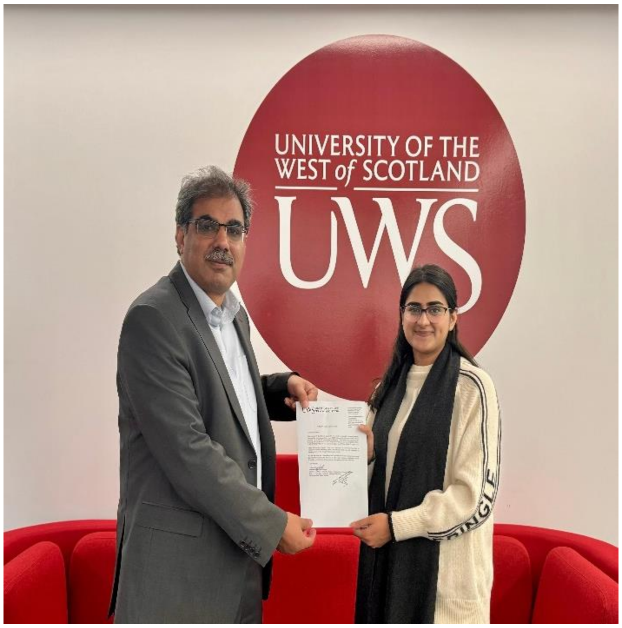
I also managed to attend the Safe RH Conferences and that filled me in on several details of the project. It was a great learning experience to meet all team members of the Safe RH project, including those from different universities. That way, my exposure enhanced the scope of the project since through professionals of diversified backgrounds there was very wide contact.



I felt privileged to be asked to assist my home institution's delegation, which included the Dean of the Faculty of Computing, Prof. Dr. Dost Muhammad Khan, and the Chairman of the Department of Artificial Intelligence, Prof. Dr. Najia Saher and Dr. Suleman Shah. Now, because the delegates from my institution were there, I could see my learning moving to the next level since I could be able to assist in smoothing up the dialogue between the IUB team and the Safe-Rh project leaders. This further elaborated my learning in project management and cross-institutional collaboration which contributed a lot to my professional development.

This research mobility program has turned my life upside down. It has shown me wider horizons, both professional and personal, underscoring the fact that in general, I am strongly interested in research, and in particular, in technologies. Adaptability and resilience are qualities quite important in today's globalized world where the exposure to different cultures and working environments has made me more adjustable. In fact, great; looking forward to applying the knowledge and skills gained in further projects.

In the end, I was permitted to present my project as a formal presentation with the research and results before the audience who were filled with industrial experts. Furthermore, I received a certificate that contributed to this very project. Apart from professional development with communication and presentation skills, the experience gave me an amount of valuable feedback from industry leaders.



Living and researching in the UWS, UK provided me with an immersive cultural experience. It widened my horizons, professionally and personally, and embedded my love for research and the technology study process even deeper. The blend of cross-cultural exposure through the working environment helped me to be more flexible and resilient - two factors highly required in today's flat world.

I am thankful for the opportunity and looking forward excitedly to the application of my knowledge and applied skills to future projects.

Report

on

Research Visit

of

Mr. Muzammil Ur Rehman

to the

University of the West of Scotland, Paisley, UK

from

02-05-24

to

19-06-24

Project Title:

Remote Lung Cancer Detection for Rural Health Care using Deep Learning Approach

Submitted by:

Mr. Muzammil Ur Rehman,
PhD Scholar,
Department of Information Technology,
Faculty of Computing,
The Islamia University of Bahawalpur.

Research Training Scholarship Report

(Muzammil Ur Rehman)

At Main Entrance of UWS on First Day of UWS Visit

Summary

Research visit at University of the West of Scotland (UWS), Paisley, United Kingdom (UK) is one of the remarkable journeys in my life. It was my very first international visit as well as the most exciting and educational experience. I was able to get awareness, not only on education and research, as well as about multi-culture communication and civilization. Learned how to live in a civilized, multi-culture environment, meet and greet people, in addition how to proceed in life spreading harmony, peace and happiness. It was supposed to be an eight weeks (02 months) visit, but it was reduced to six weeks (1.5 month) due to passport and VISA limitations.

During this six-week research and training visit at UWS, Paisley, UK under SAFE-RH program titled as "**Invitation to the First SAFE-RH training and project meeting under Erasmus+ programme grant number 619483-EPP-1-2020-1-UK- EPPKA2- CBHE-JP**", I am delighted to share the experience and vision gained during this period. The primary objective of this visit was to advance my academic and professional skills, with a particular emphasis on collaborative learning, hands-on training, and the completion of my PhD related research work which can become part of SAFE-RH program.

Being engaged with fellow Post Doctoral and PhD students has been a significant learning curve during the time I spent at UWS. There have been discussions, sharing of knowledge and experience, in addition to the fun time seeking stress on each other faces and then smiling looking at each other. The diversity of work nature, culture and the school of thought had a significant impact on my own way of inspecting problems and then coming up with solutions.

The lab environment was extremely professional, having our own working comfort zones, zero noise, comforting temperature and especially silent working people. Prof. Dr. Naeem Ramzan has been a very kind and connected supervisor. Always checking twice in the lab with not only seeking research progress as well as discussing real-life issues and guiding us.

We have been giving our research work progress every two weeks in the form of presentation and the question answer session has always been fruitful. Fellow researchers were eager to learn from my work as well as sharing their views and experience. Prof. Dr. Naeem Ramzan has been the true source of light and inspiration, his vision, looking at the problem, the way he reaches down the source of problem and helping me not only to get around the solution to the problem but also help me enlighten the other dimensions and possibilities has been priceless.

Work Progress

The milestones achieved during this visit are as follows:

- **Literature Review**

  Around 20 latest research papers were reviewed in this duration and I get to learn that after Deep CNNs now Vision Transformers are rapidly taking place to solve Deep Learning based Detection and Identification for Large Scale Datasets.

- **Dataset Selection**

  Even though I have small dataset of 50 patients obtained from Bahawal Victoria Hospital, Bahawalpur, Punjab, 63100, Pakistan. Unfortunately, this dataset wasn't labelled and it was small.

  There are many benchmark datasets available online like LIDC-IDRI, LUNA16, JSRT etc. I ended up selecting LIDC-IDRI having 1010 subjects (patients) with approx. 129GB dataset size.

- **Dataset Download**

  Following URL and parameters have been used to download the dataset. URL: https://nbia.cancerimagingarchive.net/nbia-search/?CollectionCriteria=LIDC-IDRI.
  Parameters: Collections (LIDC-IDRI) AND Image Modality (CT)

- **Dataset Pre-processing**

  After the dataset has been downloaded whose size was around 129GB the biggest challenge was to organize dataset and label the images with classes Cancerous and Non-cancerous. Thanks to Pylidc tool provided by Cancer Imaging Archive website which allows to read annotated data marked by 04 radiologists on this dataset, I was able to separate between Cancer and Non-Cancer images.

- **Dataset Class Imbalance and Data Augmentation**

  The dataset is large and has class imbalance when it comes to the training part of a deep learning project. The same is encountered here, when it comes to CT, the scan varies from 32 to 200 images in a single scan and it may or may not contain the lungs region. The annotations help only in marking the images which has lungs region and has any lung nodule (cancerous region). So, the remaining images must be taken into account for non-cancerous which are large in number than annotated data, presenting a large imbalance in dataset. To cover this issue, I have used data augmentation approach to balance the classes.

- **Deep Learning Algorithm Selection**

  Among thousands of available solutions I ended up with selecting following base article: https://doi.org/10.1186/s12880-024-01241-4 and a deep learning model https://github.com/BarriBarri20/Lung-cancer-detection-model-training to start with.

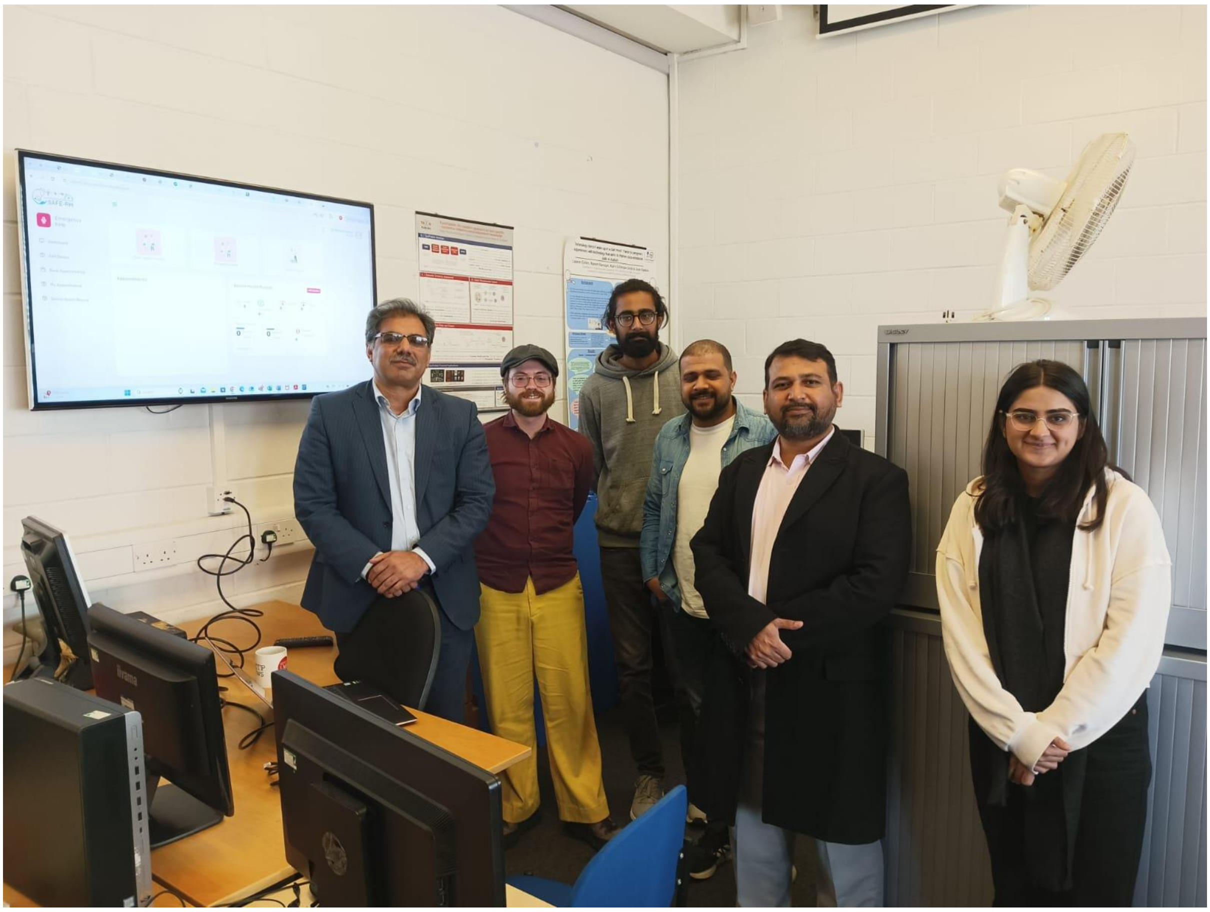
  The reported model states 95% accuracy with custom dataset but again it was small, the initial results of the same model were around 35% when I first tested the model on LIDC-IDRI without data augmentation. Which clearly represents the limitation of the model on a large-scale dataset.

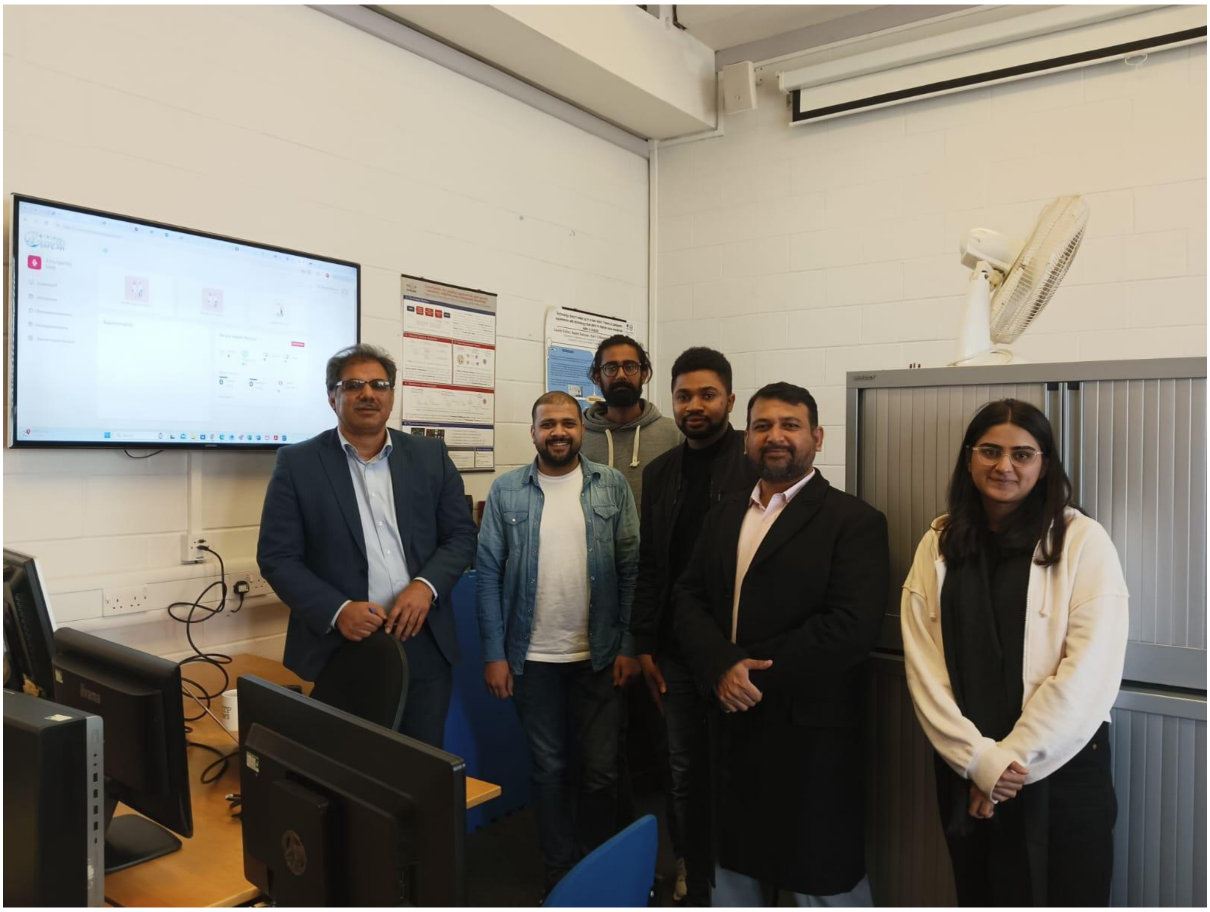
- **Challenges and Future Work**

  The very first challenge was to reduce class imbalance which was successfully solved using data augmentation technique. The second challenge was to improve results via hyper parameters and out of the box technique. Here, after discussion with Prof. Dr. Naeem Ramzan we came an out of the box solution to divide the CT image into 64x64x16 sub images so that we don't have to compress the image into 224x224x1 size thus reducing the amount of information available in CT image. Before leaving the UWS, I was working on this issue and hope to get better results.

SAFE-RH Activities

Apart from working on my Deep Learning project, I have been engaged in testing module of SAFE-RH application module 16.0. A glimpse of participants is as follows.





Memories


UWS UNIVERSITY OF THE WEST of SCOTLAND
UWS

Certificate of Completion

University of the West of Scotland
High Street, Paisley PA1 2BE
Telephone 0141 848 3648
Facsimile 0141 848 3542
Website www.uws.ac.uk

School of Computing, Engineering and Physical Sciences
Prof. Naeem Ramzan
Professor of Computer Engineering
Email: Naeem.ramzan@uws.ac.uk
Website https://research-portal.uws.ac.uk/en/persons/naeem-ramzan

Subject: Certificate for Internship

Dear Muzammil Ur Rehaman,

This is to certify that Muzammil Ur Rehaman has successfully completed the internship program sponsored by the European Union under SAFE-RH project at University of the West of Scotland, UK. SAFE-RH is funded by the European Union under Erasmus plus Capacity Building in Higher Education (CBHE) programme under grant number619483-EPP-1-2020-1-UK-EPPKA2-CBHE-JP. The internship took place from 2nd May 2024 to 19th June 2024.

During the internship, Muzammil Ur Rehaman actively participated in research activities related to Artificial Intelligence (AI) driven lung cancer detection. His dedication, hard work, and commitment to excellence were evident throughout the internship period.

It is our conviction that Muzammil Ur Rehaman has acquired invaluable skills and experiences during this internship, rendering him as an asset to any academic institution or professional pursuit. We extend our best wishes for success in all future academic and career endeavours.

Yours sincerely,

Professor Naeem Ramzan
Postgraduate research coordinator
Director of Affective and Human Computing for Smart Environment
School of Computing, Engineering and Physical Sciences
University of the West of Scotland

Conclusion

Overall, the environment of the lab under the supervision of Prof. Dr. Naeem Ramzan has been extremely stimulating, with presence of fellow intellectuals, I am envisioned with many research areas and dimension to explore in my future life.

I am really thankful to my selectors, Prof. Dr. Dost Muhammad Khan, Prof. Dr. Najia Saher, Dr. Omer Riaz for their selection and kind support, during, before and after this research visit.

The last meeting with Prof. Dr. Naeem Ramzan was an eye opener, where he enlightened me with many dimensions to pursue my research and academic career in coming future. I am extremely thankful for his kindness, time and support.

Report on the Visit of a Student to UWS

From 6th May to 19th July

Report submitted by:

- Muhammad Asad Abdullah

  (Student of IUB, Department of Information Technology

Extended Project Report: Deep Learning-Based Eye Disease Detection Using Fundus Images

1. Introduction and Project Motivation

1.1 Background

Medical imaging, particularly fundus photography, is crucial in diagnosing eye diseases. Fundus images capture the eye's interior surface, including the retina, optic disc, macula, and posterior pole. Detecting eye diseases such as diabetic retinopathy, glaucoma, and age-related macular degeneration (AMD) early can significantly reduce the risk of vision loss.

With the rapid advancement of artificial intelligence (AI) and deep learning, there is a growing potential to automate and enhance the accuracy of eye disease detection. This project aimed to leverage deep learning techniques to classify fundus images into multiple disease categories, initially starting with three classes and eventually expanding to eight.

1.2 Objectives

The primary objectives of this project were to:

- Develop a deep learning model capable of classifying fundus images into multiple categories.
- Evaluate and compare the performance of different models, including ResNet, VGG-16, and VGG-19.
- Address and mitigate issues related to dataset quality and computational constraints.
- Explore unsupervised learning methods to improve the model's performance and accuracy.

2. Phase 1: Initial Three-Class Model Development

2.1 Data Acquisition

The dataset was sourced from Kaggle, consisting of fundus images labeled into three primary classes:

- Normal
- Glaucoma
- Myopia

Images were collected from five different Kaggle repositories, ensuring a diverse set of fundus images. This initial dataset aimed to create a strong baseline for the model's performance.

2.2 Data Preprocessing

Data preprocessing is a critical step in deep learning to ensure that the model receives clean, standardized input. The preprocessing steps included:

- Resizing: Images were resized to 224x224 pixels to match the input requirements of most deep-learning models.
- Normalization: Pixel values were normalized to a range of [0,1] to improve convergence during training.
- Augmentation: Techniques such as rotation, flipping, and scaling were applied to increase dataset diversity and prevent overfitting.

2.3 Model Architecture

The initial model was a Convolutional Neural Network (CNN) with the following architecture:

- Convolutional Layers: Extract features from images using multiple convolutional filters.
- Pooling Layers: Reduce dimensionality and capture essential features by applying max pooling.
- Fully Connected Layers: Combine features from convolutional layers to produce final classification outputs.

2.4 Results

The three-class model achieved an accuracy of 89%, with high precision and recall across the classes. This initial success demonstrated the viability of using CNNs for eye disease classification.

3. Phase 2: Expansion to Four-Class Model

3.1 Addition of Fourth Class

To improve the model's comprehensiveness, a fourth class was introduced:

- Age-Related Macular Degeneration (AMD)

The addition of this class aimed to cover a broader spectrum of eye diseases. However, expanding the model to four classes introduced new challenges.

3.2 Data Preprocessing for Additional Class

The preprocessing steps for the additional class included:

- Labeling: Images were manually annotated to include the new class.
- Balancing: Ensured that each class had a sufficient number of examples to prevent class imbalance.

3.3 Model Performance and Challenges

Upon introducing the fourth class, the model's accuracy decreased to 80%. The confusion matrix revealed increased misclassifications, particularly between diseases with similar features. The model struggled to differentiate between these classes, indicating limitations in feature extraction and classification.

3.4 Supervisor Feedback

The supervisor's feedback highlighted the need for a more robust classification approach. It was suggested to integrate all eight classes to build a comprehensive model and evaluate its performance against advanced architectures.

4. Phase 3: Comparative Analysis and Supervisor Feedback

4.1 Comparative Analysis

A detailed comparison was conducted between the three-class and four-class models. Key metrics included:

- Accuracy
- Precision
- Recall
- F1 Score

The comparison highlighted the increased complexity and reduced accuracy when expanding to four classes. The confusion matrix showed that certain diseases were frequently misclassified, suggesting overlaps in feature representation.

4.2 Supervisor's Proposal for Eight-Class Model

The supervisor proposed expanding the model to include all eight classes, covering:

1. Diabetic Retinopathy (DR)
2. Glaucoma
3. Myopia
4. Age-Related Macular Degeneration (AMD)
5. Cataract
6. Hypertensive Retinopathy
7. Normal Eye
8. Un-identified Conditions

This proposal aimed to create a more detailed and comprehensive model, allowing for a thorough comparison with advanced architectures like ResNet, VGG-16, and VGG-19.

5. Phase 4: Transition to Eight-Class Model and Challenges

5.1 Expansion to Eight Classes

The dataset was expanded to include all eight classes. Each class was carefully annotated and preprocessed to ensure consistency. This process involved:

- Re-labeling: Accurate labeling of images for all eight classes.
- Data Augmentation: Enhanced the dataset further to address class imbalances and improve generalization.

5.2 Model Training and Accuracy

Training the eight-class model presented several challenges:

- Accuracy Drop: The model's accuracy initially dropped to 42%, reflecting difficulties in distinguishing between the increased number of classes.
- Confusion Matrix: The confusion matrix indicated that some diseases with similar retinal features were misclassified.

5.3 Data Quality Issues

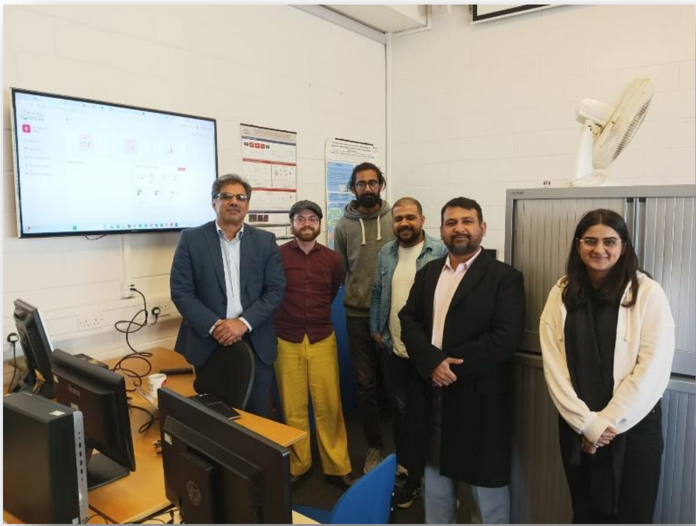
Dataset quality issues were identified as significant factors affecting model performance:

- Duplicate Images: The dataset contained numerous duplicate images due to sourcing from multiple repositories. These duplicates were detected and removed using a Python library.
- Annotation Inconsistencies: Inconsistent annotations across sources may have contributed to poor model performance.

After cleaning the dataset, the models ResNet, VGG-16, and VGG-19 were retrained. Despite these efforts, the accuracy improvements were marginal, indicating the need for further analysis.

5.4 Testing SafeRH Mobile Application

During the project, the SafeRH mobile application was tested. The application serves as a hospital management system, enabling interactions between doctors and patients, including:



- Appointment Scheduling: Patients can book appointments with doctors.
- Medical Records Management: Doctors can manage and access patient records.

This testing provided insights into how AI-based diagnostic tools could integrate with healthcare applications to enhance patient management.

6. Phase 5: Fine-tuning, Data Augmentation, and Computational Constraints

6.1 Fine-Tuning Strategies

Several fine-tuning strategies were employed to improve model performance:

- Learning Rate Adjustment: Dynamic adjustment of the learning rate during training to optimize weight updates.
- Regularization: Techniques such as dropout (to prevent overfitting) and batch normalization (to stabilize learning) were applied.
- Early Stopping: Monitoring validation performance to prevent overfitting by halting training when performance plateaus.

Despite these strategies, fine-tuning only marginally improved accuracy, reaching approximately 50%.

6.2 Data Augmentation and Computational Constraints

Data augmentation significantly increased the dataset size:

- Image Count Explosion: The number of images grew to over 100,000, placing a heavy burden on computational resources.
- Hardware Limitations: The augmented dataset caused code breaks due to insufficient memory and processing power.

To manage these constraints, the augmentation factor was reduced, resulting in around 6,000 images per class. This adjustment allowed successful training without overwhelming the hardware.

6.3 Supervisor's Conclusion

The supervisor concluded that dataset quality and annotation inconsistencies likely hindered model performance. With the dataset cleaned and refined, the focus shifted to exploring unsupervised learning techniques.

7. Phase 6: Exploring Unsupervised Learning and Future Directions

7.1 Unsupervised Learning Methods

Given the challenges with the labeled dataset, unsupervised learning methods were explored:

- Clustering Algorithms: Techniques such as K-means clustering or hierarchical clustering were considered to identify natural groupings in the data. This approach could reveal underlying patterns and assist in refining class labels.
- Dimensionality Reduction: Methods like Principal Component Analysis (PCA) could be used to reduce the complexity of the dataset and visualize class separations.

7.2 Proposed Approach

The proposed approach involves:

- Clustering Analysis: Identifying clusters within the data to understand the inherent structure and potentially reclassify or merge classes.
- Annotation Refinement: Using clustering results to guide the re-annotation of images, ensuring more accurate labels and reducing confusion.

7.3 Future Work and Publication

Once significant results are achieved through unsupervised methods, the findings will be compiled for publication. The research will focus on:

- Dataset Quality and Annotation Challenges: Highlighting the importance of high-quality data for deep learning models.
- Unsupervised Learning Applications: Demonstrating how unsupervised methods can improve model performance and classification accuracy.

8. Conclusion and Acknowledgments

8.1 Summary

The project provided valuable insights into the complexities of eye disease detection using deep learning. Key takeaways include the impact of dataset quality on model performance and the potential of unsupervised learning techniques to address classification challenges.

8.2 Key Learnings

1. Importance of Data Quality: Dataset issues such as duplicates and annotation inconsistencies significantly affect model accuracy.
2. Model Complexity: Expanding to more classes requires careful consideration of feature overlap and model capacity.
3. Unsupervised Learning Potential: Unsupervised methods may offer solutions to dataset challenges and improve classification outcomes.

8.3 Future Directions

1. Dataset Improvement: Further cleaning and refining of the dataset will be essential for achieving better results.
2. Unsupervised Learning Exploration: Continued exploration of clustering and other unsupervised techniques to enhance model performance.
3. Publication: Preparation of research findings for publication to contribute to the field of medical AI and deep learning.

8.4 Acknowledgments

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