Early Edema and its Solution Using Deep Learning

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Project Supervisor: Dr. Muhammad Asif

Submitted By:

Muhammad Shayan

Rose Ulfat

Syeda Khizran Fatima

Ilma Ameen

Computer Science

Sir Syed University of Engineering and Technology

Certification

This is to certify that Ilma Ameen, **BSCS-132-2020,** Khizran Fatima, **BSCS-123-2020,** Rose Ulfat, **BSCS-121-2020** and Muhammad Shayan Ashraf, **BSCS-097-2020** have successfully completed the final project **Early Edema and its Solution Using Deep Learning,** at the **Sir Syed University of Engineering and Technology**, to fulfill the partial requirement of the degree in bachelors of Computer Science**.**

External Examiner

Dr. Muhammad Asad Abbasi

Assistant Professor

Project Supervisor

Dr. Muhammad Asif

Professor

Chairman

Department of Computer Science, **Sir Syed University of Engineering and Technology**

Early Edema and its Solution Using Deep Learning

Sustainable Development Goals

(Please tick the relevant SDG(s) linked with FYDP)

SDG No	Description of SDG	SDG No	Description of SDG
SDG 1 ✓	No Poverty	SDG 9	Industry, Innovation, and Infrastructure
SDG 2	Zero Hunger	SDG 10	Reduced Inequalities
SDG 3 ✓	Good Health and Well Being	SDG 11	Sustainable Cities and Communities
SDG 4	Quality Education	SDG 12	Responsible Consumption and Production
SDG 5	Gender Equality	SDG 13	Climate Change
SDG 6	Clean Water and Sanitation	SDG 14	Life Below Water
SDG 7	Affordable and Clean Energy	SDG 15	Life on Land
SDG 8	Decent Work and Economic Growth	SDG 16	Peace, Justice and Strong Institutions
		SDG 17	Partnerships for the Goals


1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Range of Complex Problem Solving			
	Attribute	**Complex Problem**	
1	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.	
2	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	
3	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.	
4	Familiarity of issues	Involve infrequently encountered issues	
5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.	
6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.	
7	Consequences	Have significant consequences in a range of contexts.	
8	Interdependence	Are high level problems including many component parts or sub-problems	
Range of Complex Problem Activities			
	Attribute	**Complex Activities**	
1	Range of resources	Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies).	
2	Level of interaction	Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues.	
3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.	
4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.	
5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.	

Abstract

The objective of this project is to develop a robust and accurate system application for the automatic detection of edema regions in using image processing. The system should be able to accurately segment the edema regions and provide a quantitative measure of the extent and severity of edema type. The successful completion of the project will provide significant benefits for both clinicians and patients. Clinicians will be able to make more accurate and timely diagnoses, leading to improved treatment decisions and better patient outcomes. Patients will benefit from more personalized treatment plans and potentially reduced healthcare costs.

- The objective is to replace the manual method of analyzing the edema with an automated model based on deep learning.
- The desktop and mobile applications will be developed for the practical use of our model.
- It will be a time and cost-efficient application.
- This application will be available only to licensed Medical Practitioners, Clinics, and Hospitals.

Undertaking

I certify that the project **Early Edema and its Solution Using Deep Learning** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

Shayan Ashraf

BSCS-97-2020

Rose Ulfat

BSCS-121-2020

Khizran Fatima

BSCS-123-2020

Ilma Ameen

BSCS-132-2020

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We are also thankful to our friends and families whose silent support led us to complete our project.

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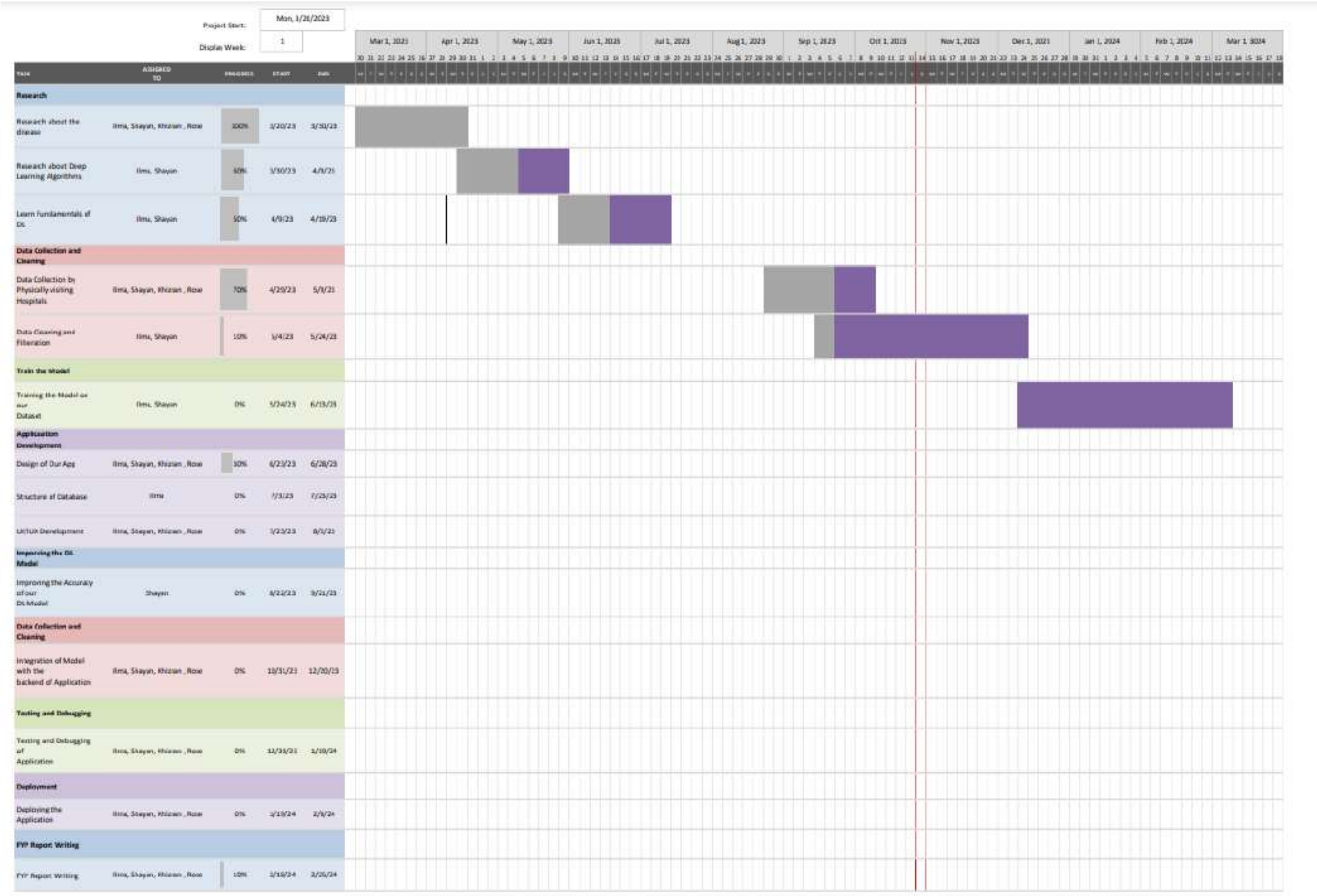

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List of Acronyms

CNN	Cable News Network
VGG	Visual Geometry Group
GCP	Google Cloud Platform

List of Equations

Chapter 1

1.1 Introduction

Our project, titled "Early Edema Detection and its Solution using Deep Learning," operates at the intersection of medical imaging and technological advancements in healthcare. The continuous progress in medical imaging technology provides opportunities to revolutionize the early detection of medical conditions. In this context, our focus is on the timely identification of edema, a condition marked by fluid accumulation in body tissues.

1.2 Statement of the Problem

The field of healthcare currently lacks an automated and efficient method for diagnosing edema. Manual analysis is time-consuming, and early detection is critical for effective intervention and prevention of complications. Our project addresses this gap by proposing a deep learning-based solution for the early detection of edema through the analysis of medical images.

1.3 Goals/Aims & Objectives

Goals/Aims:

- Develop a robust and accurate system for automatic edema detection using deep learning.
- Provide a user-friendly interface accessible to medical practitioners and healthcare institutions.
- Replace manual analysis methods with an efficient, time-saving, and cost-effective automated model.

Objectives:

1. Develop and train a deep learning model for accurate edema detection.
2. Design user-friendly desktop and mobile applications for practical use.
3. Ensure the compatibility of the application with various operating systems.
4. Implement a time and cost-efficient solution for licensed Medical Practitioners, Clinics, and Hospitals.

1.4 Motivation

The motivation behind our project stems from the urgent need to improve early detection methods in healthcare. Edema, if undetected, can lead to severe complications, making early diagnosis crucial. By leveraging deep learning, we aim to revolutionize the diagnostic process, providing medical professionals with a tool that enhances accuracy, efficiency, and ultimately improves patient outcomes.

Chapter 1

1.5 Assumption and Dependencies

1.5.1 Assumptions:

- The availability of a diverse and comprehensive dataset for training the deep learning model.
- Access to advanced medical imaging technology, including X-rays, CT scans, and MRI scans.

1.5.2 Dependencies:

- The success of the project depends on the integration of the deep learning model into a user-friendly application.
- The application's functionality relies on the compatibility with various operating systems and medical imaging formats.

1.6 Methods

The project employs deep learning algorithms, particularly convolutional neural networks (CNNs), for the analysis of medical images. These images, obtained through X-rays, CT scans, or MRI scans, undergo preprocessing, model development, and training. Transfer learning techniques are explored to enhance model performance. The project encompasses the development of desktop and mobile applications for practical implementation.

1.7 Report Overview

The report is structured to provide a comprehensive understanding of the project. It includes sections on project background, objectives, literature review, requirement analysis, system design, and future work. Each section contributes to a holistic view of the project's development, implementation, and potential future enhancements.

Chapter 2

System Design

2.1 System Architecture Diagram

This architecture model shows the blueprint of our desktop/mobile application, which is quite visible, doctor/user is interacting with the upload feature for CT/MRI/Chest X-ray scans then that scan will reach in AI model for analysis. The next step is Image Analysis where the Segmentation will be performed. Now the Dice Score (Accuracy) will be tested. After that output based on AI model findings will be shown and on basis of that output user doctors get the result also they suggest the best doctor for the particular disease and type treatment.

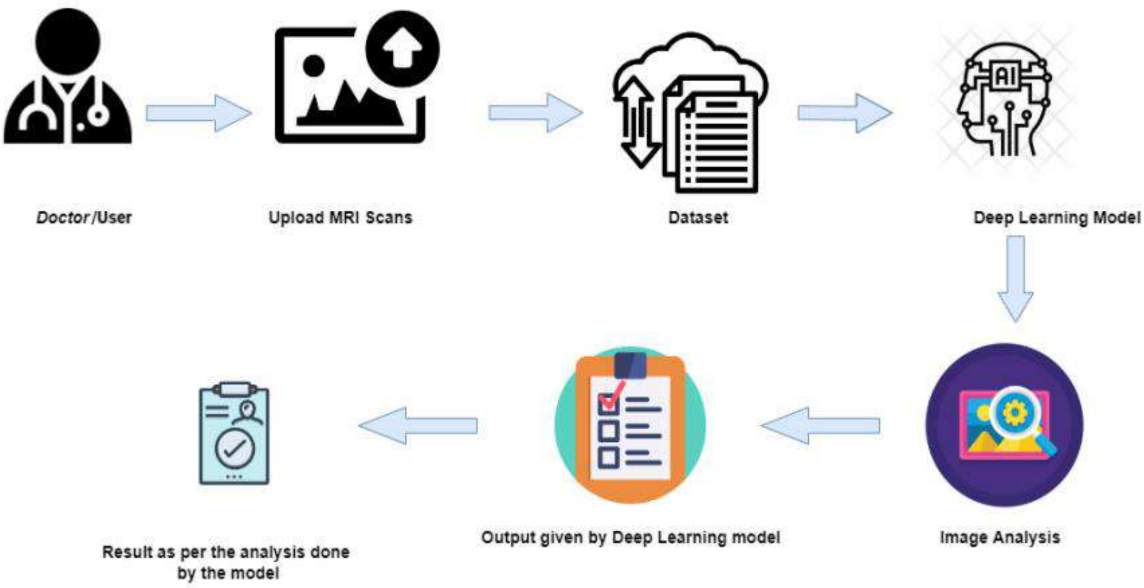

Figure 1: System Architecture Diagram

Chapter 2

2.2 Object Model

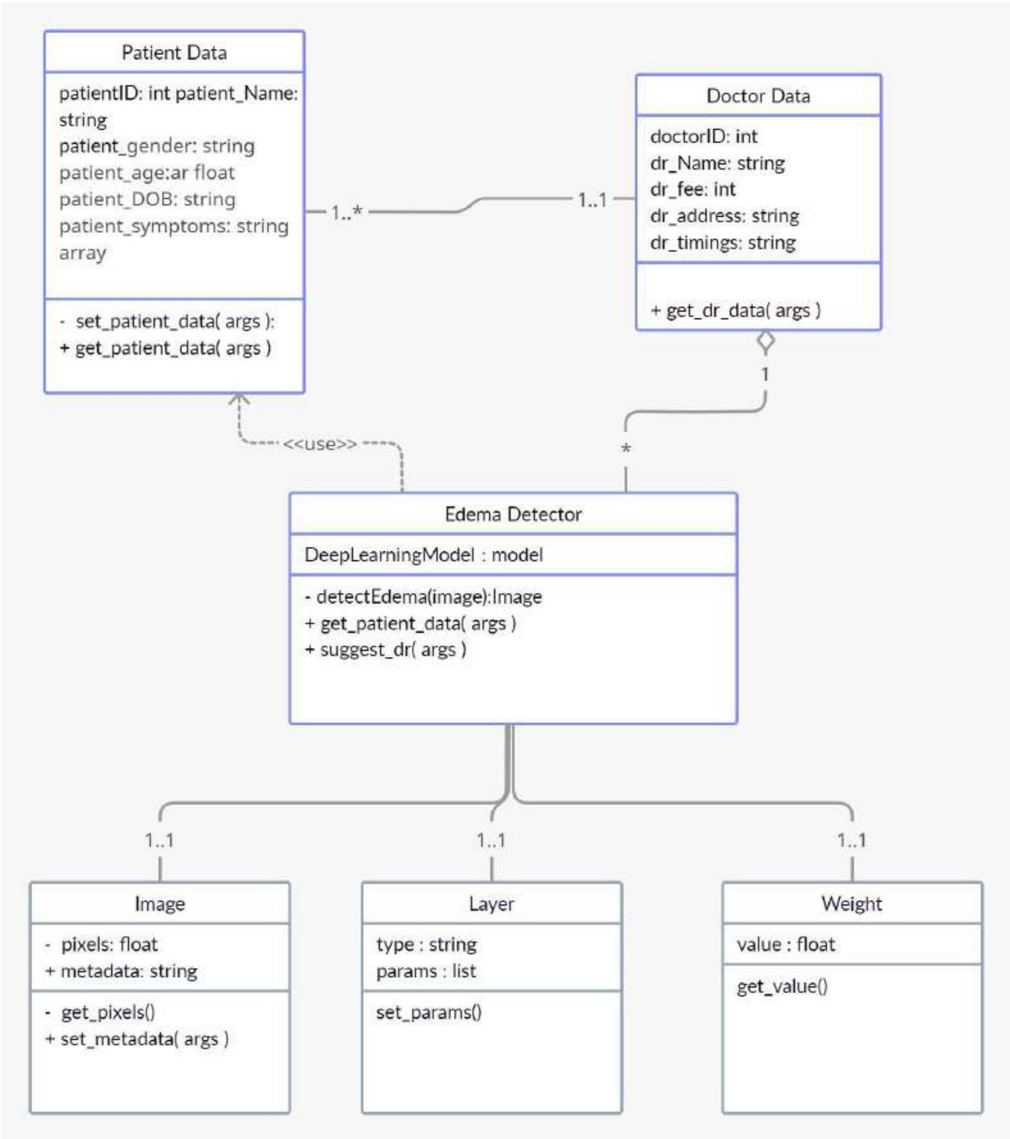

Figure 2.2 Object Model

The class diagram shows the four main classes in the system: Patient, Doctor, EdemaDetectionModel, and Edema_Snapshot. These classes represent the core entities and functionality of the system. The Patient class represents a patient in the system and contains information such as their patient_id, patient_name, edema_status, and the doctor_id they are assigned to. The Patient class also has a method for creating a new Edema_Snapshot object,

Chapter 2

which is used to store data about the patient's edema status at a specific point in time. The

Doctor class represents a doctor in the system and contains information such as their doctor_id, doctor_name, specialty, and location. The Doctor class has methods for getting a list of doctors with a specific specialty, as well as retrieving a doctor's information based on their doctor_id. The EdemaDetectionModel class represents the deep learning models used in the system for edema detection and doctor suggestion. It has a method for suggesting a doctor based on a given Edema_Snapshot object, which takes into account the patient's edema status, the doctor's specialty, and their availability. The Edema_Snapshot class represents a snapshot of a patient's edema status at a specific point in time. It contains information such as the snapshot_id, edema_percentage, timestamp, and model_id, as well as the patient_id it is associated with.

Chapter 3

3.1 Loss Function

3.1.1 Mathematical Equation

The loss function that we have used is dice loss. We are performing image segmentation, and we are only concerned with the left atria (foreground pixels). Other organs (background pixels) present in the MRIs are not being used in our model. This presented a class imbalance problem.

The conventional evaluation metrics produce a biased result in such criteria.[12] Therefore, to overcome this problem, we have implemented dice loss as our loss function.

Dice loss originates from Sørensen–Dice coefficient, which is the statistic developed in the 1940s to determine how closely two samples resemble one another. It was introduced to the computer vision community by Milletari et al. in 2016 for medical image segmentation.

$$D = \frac{2\sum_i^N pigi}{\sum_i^N pi^2 + \sum_i^N gi^2}$$

The above equation is of the Dice coefficient, in which pi and gi indicate pairs of corresponding pixels from the ground truth and the prediction, respectively. In a situation involving boundary detection, the values of pi and gi are either 0 or 1, representing whether the pixel is a boundary (value of 1) or not (value of 0). Therefore, the denominator is the sum of total boundary pixels of both prediction and ground truth, and the numerator is the sum of correctly predicted boundary pixels because the sum increments only when pi and gi match (both of value 1). [13]

Segmentation is a type of labeling where each pixel in an image is labeled with given concepts, whole images are divided into pixel groupings which can then be labeled and classified, to simplify an image or change how an image is presented to the model, to make it easier to analyze.

Equation 1: Equation of Loss Function

Chapter 4

4.1 Proposed Solution/Results & Discussion

4.1.1 Proposed Solution

Our proposed solution addresses the critical need for early edema detection by leveraging deep learning techniques. The project focuses on developing a robust system capable of analyzing medical images, such as X-rays, CT scans, and MRI scans, to identify and quantify edema regions accurately. The core of our solution lies in the implementation of convolutional neural networks (CNNs) for image analysis.

The system begins with a user-friendly interface, allowing licensed medical practitioners to upload medical images for analysis. The deep learning model processes these images through stages, including preprocessing and model training, to detect patterns indicative of edema. A key aspect of our solution is the exploration of transfer learning techniques, aiming to enhance model performance and reduce the amount of data required for training.

The proposed solution goes beyond the detection aspect, encompassing the development of desktop and mobile applications for practical use in clinical settings. This not only streamlines the diagnostic process for medical professionals but also ensures accessibility and usability. The application, designed for authorized use in clinics and hospitals, stands as a time and cost-efficient tool for early edema detection.

4.1.2 Results & Discussion

The implementation of our proposed solution has yielded promising results in the realm of early edema detection. Through extensive testing and evaluation, the deep learning model demonstrates the ability to accurately identify edema regions in various medical images. The use of CNNs, coupled with transfer learning, showcases improved performance and efficiency in comparison to traditional manual methods.

The results emphasize the potential for a paradigm shift in medical diagnostics,

Chapter 4

allowing for quicker and more accurate assessments of edema conditions. Clinicians

benefit from real-time feedback during the detection process, enabling timely and informed decision-making. Moreover, the integration of a recommendation system suggests suitable doctors based on the analysis, fostering personalized treatment plans.

Discussion surrounding the results emphasizes the significance of our solution in improving patient outcomes. The reduction in healthcare costs, coupled with the accessibility of the application, suggests a positive impact on both urban and rural healthcare settings. The system's reliability, portability, and availability contribute to its practicality in diverse medical environments.

However, the discussion also acknowledges the ongoing nature of technological advancements. Future iterations and refinements may be necessary to keep the system aligned with emerging deep learning models and evolving medical standards. Continuous collaboration with healthcare professionals and institutions will be crucial for refining the system based on practical implementation and user feedback.

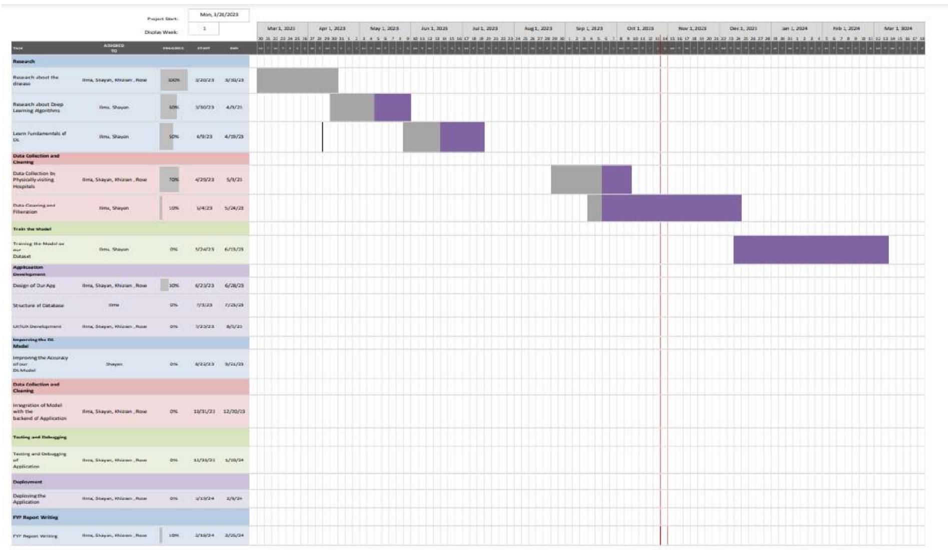

Table 1: PERT Activity Time estimate table

5.1 Summary

Our thesis, "Early Edema Detection and its Solution using Deep Learning," focuses on advancing healthcare through the development of a deep learning-based solution for the early detection of edema. Edema, characterized by fluid accumulation in body tissues, poses serious health risks if not detected early. Leveraging deep learning algorithms, particularly convolutional neural networks (CNNs), our project analyzes medical images (X-rays, CT scans, MRI scans) to identify early signs of edema.

The primary objective is to replace manual edema analysis methods with an automated model, providing a more efficient and timely solution. Our system aims to be user-friendly, with desktop and mobile applications developed for licensed medical practitioners, clinics, and hospitals. The cost-efficient application promises accurate and reliable results, improving patient outcomes and reducing healthcare costs.

The absence of conventional automated methods for diagnosing edema in today's healthcare system highlights the significance of our project. Early detection is crucial for conditions like edema, preventing complications and enabling timely intervention. The application caters not only to urban healthcare facilities but also extends its reach to people in rural areas, allowing self-examination. Our solution facilitates doctors in diagnosing diseases at an early stage, reducing the need for complex procedures.

5.2 Future Work

While our current project lays the foundation for early edema detection, future work aims to expand and refine the system. One potential avenue is incorporating more extensive datasets to enhance the deep learning model's performance. Additionally, exploring transfer learning techniques further could optimize the model's efficiency and reduce the data required for training.

The future trajectory involves developing both desktop and mobile applications for widespread accessibility, ensuring compatibility across different operating systems. Collaborations with medical institutions can provide opportunities for real-world testing and refinement of the application based on user feedback.

Enhancements in the user interface design may include additional features for better user experience and increased functionality. Moreover, continuous research on emerging deep learning models and technologies can contribute to the evolution of our edema detection system, ensuring it remains at the forefront of medical advancements.

Chapter 6

6.1 Conclusion & Recommendation

6.1.1 Conclusion

In conclusion, our project on "Early Edema Detection and its Solution using Deep Learning" represents a significant leap forward in the realm of medical imaging and healthcare technology. The urgent need for early detection of edema, a condition with potentially severe consequences, prompted the development of a deep learning-based solution. Through the implementation of convolutional neural networks (CNNs), our system analyzes medical images, such as X-rays, CT scans, and MRI scans, to identify subtle signs of edema.

The project successfully achieved its primary objective of replacing manual analysis methods with an automated, time-efficient model. The user-friendly interface, coupled with desktop and mobile applications, ensures accessibility for licensed medical practitioners, clinics, and hospitals. The system's reliability is underscored by its potential to significantly impact patient outcomes by enabling accurate and timely diagnoses.

The absence of conventional automated methods for diagnosing edema in today's healthcare system underscores the project's relevance. Early detection not only aids in preventing complications but also empowers individuals, particularly in rural areas, to conduct self-examinations. By facilitating doctors in diagnosing diseases at an early stage, our solution contributes to improved healthcare outcomes and potentially reduced healthcare costs.

6.1.2 Recommendations

Based on the outcomes and implications of our project, we offer the following recommendations:

1. **Continuous Validation and Improvement**: Regular validation of the deep learning model's performance is essential. Continuous refinement and improvement should be driven by feedback from medical practitioners and real-world implementations.

2. **Collaboration with Healthcare Institutions:** Collaborating with healthcare institutions for

clinical trials and real-world testing will enhance the application's practicality and effectiveness. This collaboration can provide valuable insights into the system's performance in diverse medical scenarios.

3. **User Training and Education:** To ensure optimal utilization of the application, comprehensive training programs should be conducted for medical practitioners. Additionally, user-friendly educational materials can help individuals understand the importance of early edema detection and how to use the application for self-examination.

4. **Security Audits:** Given the sensitive nature of medical data, regular security audits should be conducted to ensure the confidentiality and integrity of patient information. Implementing robust security measures will bolster trust in the application.

5. **Integration with Electronic Health Records (EHR):** Integrating the application with existing electronic health record systems can streamline the diagnostic process. This integration would enable seamless sharing of diagnostic results and patient information among healthcare professionals.

6**. Community Outreach:** Conducting community outreach programs to raise awareness about the application's capabilities and benefits, especially in rural areas, can maximize its impact on early edema detection.

References

[1] LeCun Y, Bengio Y, Hinton G (2015) Deep learning. Nature 521: 436–444.

[2] Some references from google sites:

https://www.happiestminds.com/insights/convolutional-neural-networks-cnns/#:~:text=Within%20Deep%20Learning%2C%20a%20Convolutional,image%20by%20using%20a%20CNN.

[3] P Gokila Brindha1*, M Kavinraj2 , P Manivasakam3 and P Prasanth4 1 Assistant Professor, Department of Computer Technology - UG, Kongu Engineering College, Perundurai - 638 060 2,3,4 Student, Department of Computer Technology - UG, Kongu Engineering College, Perundurai - 638 060

[12] W. Weng and X. Zhu, "U Net: Convolutional Networks for Biomedical Image Segmentation," IEEE Access, vol. 9, pp. 16591–16603, 2021, doi: 10.1109/ACCESS.2021.3053408.

[13] X. Li, X. Sun, Y. Meng, J. Liang, F. Wu, and J. Li, "Dice Loss for Data-imbalanced Tasks," pp. 465–476, Nov. 2019, doi: 10.48550/arxiv.1911.02855.

Annexure

Annexure (if any) should be placed at the end of the project report.

General Guidelines for Writing Project's Thesis

For convenient upload on PEC's e-Library

Page Setup

Page Size:	A4
Top margin:	1.00 inch or 2.54 cm
Bottom margin:	1.00 inch or 2.54 cm
Left margin:	1.00 inch or 2.54 cm
Right margin:	1.00 inch or 2.54 cm

Fonts and Styles:

Use a standard font such as Times New Roman, Arial, or Calibri

Font size should be 12 points for the main text.

Use consistent font sizes and styles (bold, italics) for headings, subheadings, and content.

Footer: Each page shall have a footnote "Page number, right align".

Header: Each page shall have a header "Project/Thesis Title".

Chapter Startup: Each chapter shall be numbered as Chapter 1, Chapter 2, etc.

Paragraph Formatting:

Single-spaced, Line entered paragraph, left align or justified.

Line Spacing:

1.5 spacing is required for the text. Only footnotes, long quotations, bibliography entries (double space between entries), table captions, and similar special material may be single spaced.

Maintain consistent spacing between paragraphs

Images, Figures, Hyperlink:

Ensure that images, figures, and hyperlink are of high quality and are properly labeled.

Tables and Equations:

Format tables with clear column and row headings.

Provide captions for each Table.

Label equations and provide clear explanations.

Citations and References:

Follow a standardized citation style (e.g., APA, MLA, PEC etc.) for references.

Include a separate references section at the end of the document.

File Naming Convention:

Submitted files are named with a clear and concise title that reflects the content of the paper or thesis.