Vivekanand Education Society's Institute of Technology

Department of Computer Engineering

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Image Analysis Using DICOM Standard

Dr. Prashant Kanade
Assistant Professor,
Department of Computer Technology

Swaraj Khadge
V.E.S.I.T
2021.swaraj.khadge@ves.ac.in

Jeet Dalal
V.E.S.I.T
2021.jeet.dalal@ves.ac.in

Manish Mulchandani
V.E.S.I.T
2021.manish.mulchandani@ves.ac.in

Mayuresh Sawant
V.E.S.I.T
2021.mayuresh.sawant@ves.ac.in

1. Abstract

Down syndrome (DS), also known as trisomy 21, is one of the most common chromosomal disorders, affecting approximately 1 in 700 live births. This study explores the effectiveness of using advanced ultrasound imaging techniques for identifying Down syndrome. By leveraging computer vision and machine learning, the system identifies specific facial and brain markers associated with Down syndrome from fetal brain images obtained through prenatal imaging. The research involves comprehensive data collection, preprocessing, and algorithm development. A diverse dataset, consisting of both Normal and Down syndrome cases, is compiled for supervised training. Customized Convolutional Neural Networks (CNNs) are developed to effectively extract features from fetal brain images. These images, standardized in **DICOM (Digital Imaging and Communications in Medicine)** format, are crucial for compatibility and seamless integration within our framework. The proposed solution not only offers a reliable screening tool for early Down syndrome detection but also incorporates a feedback loop where doctors' observations on the images are used to evaluate and enhance the model's performance. This approach aims to transform prenatal care by empowering healthcare professionals with accurate tools for early diagnosis, ultimately contributing to better health outcomes for affected individuals and their families.

Keywords - DICOM, U-Net, CNN, Down Syndrome, Deep Learning

2. Introduction

Down syndrome, a genetic disorder caused by an extra copy of chromosome 21, is characterized by physical and cognitive developmental delays, along with a higher incidence of certain medical conditions. Early diagnosis and intervention are essential for improving the quality of life for individuals with Down syndrome. Traditional diagnostic methods include prenatal screening and diagnostic tests, as well as physical and genetic testing after birth. However, advancements in medical imaging and artificial intelligence present new opportunities for enhancing the accuracy and efficiency of Down syndrome diagnosis. This project aims to develop a robust and accurate method for detecting Down syndrome using brain scans, leveraging advanced deep learning techniques such as Convolutional Neural Networks (CNN) and U-Net. The system will also allow healthcare providers to upload DICOM-formatted brain images, which will be analyzed by the CNN model. Additionally, doctors' feedback on the analyzed images will be incorporated to refine and improve the model over time. This approach has the potential to significantly enhance early and accurate diagnosis, thereby improving treatment outcomes and quality of life for individuals with Down syndrome.

3. Problem Statement

Current methods for diagnosing Down syndrome in the womb, such as genetic testing and ultrasound, often lack accuracy, causing anxiety for parents and delaying early intervention services essential for a child's development. We propose an application that uses machine learning to analyze DICOM-standard fetal brain images, enabling more accurate detection of Down syndrome. By training a machine learning algorithm on a dataset of DICOM-formatted brain images from fetuses with and without Down syndrome, the algorithm can identify specific features associated with the condition. The application will also facilitate the upload of images by healthcare providers, whose observations will be used to further improve the algorithm's accuracy. This system aims to provide a more reliable diagnosis, allowing for timely intervention and support for affected families.

4. Proposed Solution

Since Down syndrome can be detected during pregnancy, and early diagnosis is crucial, this system predicts whether a baby has Down syndrome by analyzing 3-D sonographic brain images.

4.1 Data Collection and Preprocessing:

- **Data Collection:** Gather a comprehensive and diverse dataset of prenatal ultrasound images, specifically focusing on brain images, including both normal cases and those with Down syndrome, covering various imaging conditions. Ensure the images are in DICOM format for compatibility and standardization across medical platforms.
- **Preprocessing:** Prepare the images by resizing and normalizing them. Use augmentation techniques (e.g., rotation, flipping, and brightness adjustments) to enhance the model's performance and generalization abilities.

4.2 Feature Extraction and Representation:

- Extract relevant features from the DICOM-formatted ultrasound brain images. These features should capture both local and global information, enabling the model to identify distinctive patterns associated with Down syndrome.

4.3 Classification Model:

- Develop a classification model based on the extracted features. The model should predict whether an ultrasound brain image indicates Down syndrome.
- Use fully connected layers in the neural network and consider incorporating recurrent layers to handle temporal information, which can be particularly useful for analyzing ultrasound data.

4.4 Training and Validation:

- **Dataset Partitioning:** Split the dataset into training, validation, and testing subsets.
- **Training:** Train the model using the training data and fine-tune its hyperparameters based on validation performance.
- **Optimization Techniques:** Apply techniques like dropout (to prevent overfitting), batch normalization (to stabilize and accelerate training), and early stopping (to halt training when performance ceases to improve).

4.5 Performance Assessment:

- **Evaluation Metrics:** Measure the model's performance using metrics such as accuracy, precision, recall, F1-score, and ROC-AUC.
- **Comparative Analysis:** Compare the model's predictions with expert human annotations to assess accuracy and reliability.

4.6 Interpretability and Visualization:

- Implement interpretability techniques to highlight the regions of ultrasound brain images that influence the model's predictions. This helps in understanding the features that the model uses to detect Down syndrome.
- **Doctor Feedback Loop:** Incorporate doctors' observations on the DICOM images into the model's training process to continually evaluate and improve its performance.

5. Methodology / Block Diagram

This section describes the technology related to the Down syndrome identification system, including the Down syndrome identification pipeline, image preprocessing, dataset, principles, and training details. Down syndrome identification is a kind of binary classification problem.

- The proposed methodology for recognition of Down syndrome in brain images is composed of four main stages :
    - Conversion of image to DICOM standard Image
    - Brain part detection
    - Feature extraction
    - Feature reduction
    - Classification

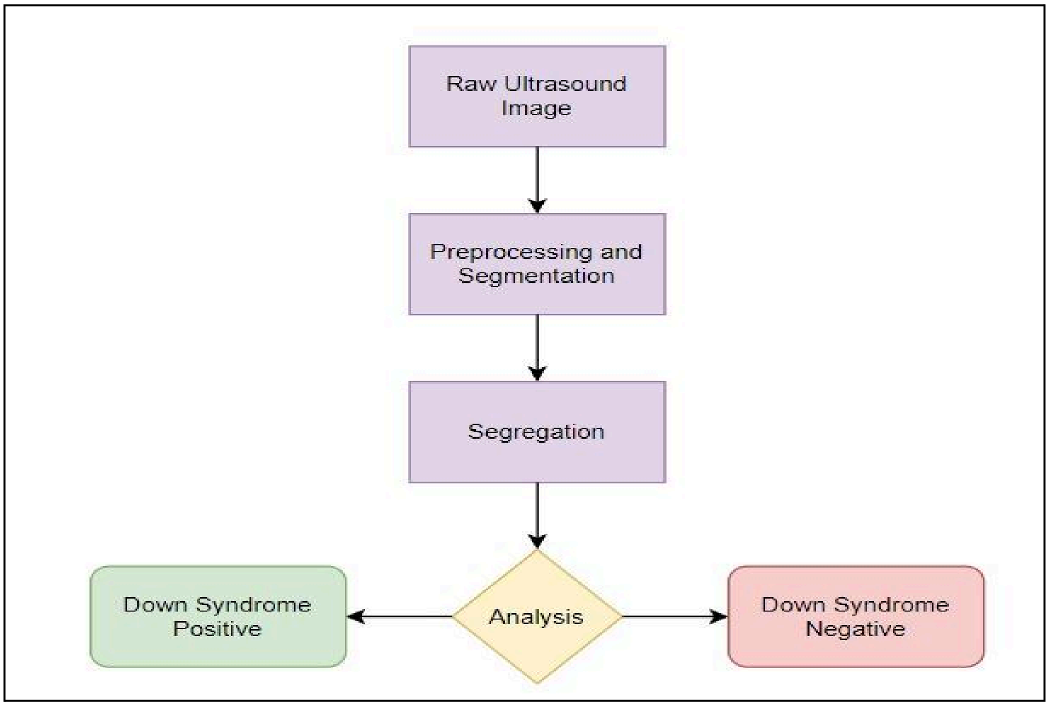

Figure 1: Algorithm Design:

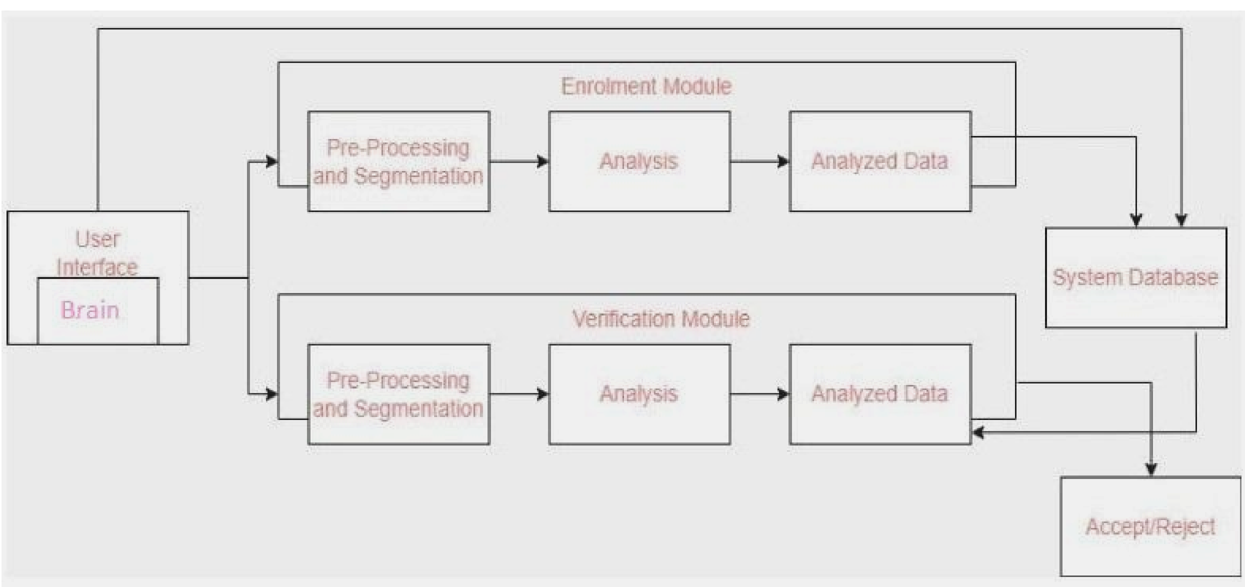

Figure 2: Component Diagram

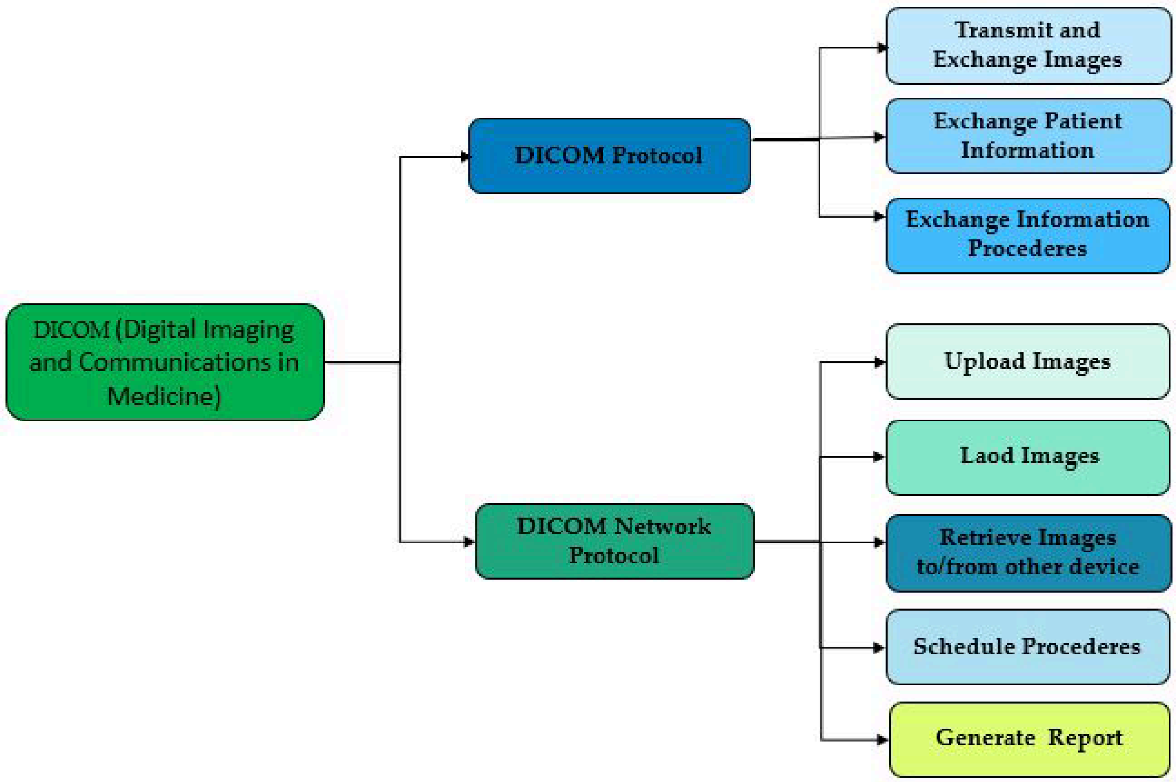

Figure 3: DICOM Overview

Hardware , Software and tools Requirements

The Software can be runned optimally with the following specifications

- Windows/IOS 13 or newer
- Android 12 or newer
- 1GB hard disk storage
- 2GB RAM or more
- Flutter
- Ngrok

7. Proposed Evaluation Measures

- **Accuracy** : This basic metric calculates the percentage of correctly identified fetal brains with Down syndrome out of the total brains in the dataset.
- **Precision** : Precision determines the proportion of correctly identified fetal brains with Down syndrome out of the total number of fetal brains classified as having Down syndrome.
- **Specificity** : Specificity calculates the ratio of correctly identified fetal brains without Down syndrome to the actual number of fetal brains without Down syndrome in the dataset.

- **False Positive Rate(FPR)** : FPR is the percentage of fetal brains without Down syndrome incorrectly classified as having Down syndrome.
- **False Negative Rate(FNR)** : FNR represents the percentage of fetal brains with Down syndrome incorrectly classified as not having Down syndrome.

8. Conclusion

To conclude, the proposed development of a fetal brain recognition system for early Down syndrome detection holds tremendous potential in transforming prenatal care.The solution aims to accurately identify specific facial markers associated with Down syndrome from fetal brain images acquired during prenatal imaging using advanced computer vision and machine learning techniques.The comprehensive approach involves data collection, preprocessing, and algorithm development using diverse metrics such as accuracy, precision, specificity, FPR, and FNR. Also an user-friendly interbrain and clinical validation could facilitate seamless integration of the system into prenatal care practices.

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Members Signature

(Swaraj Khadge)	(Jeet Dalal)	(Manish Mulchandani)	(Mayuresh Sawant)
D17A 29	**D17A 10**	**D17A 43**	**D17A 55**

Approval

Dr Prashant Kanade

Assistant professor, Computer Engineering

(Mentor)