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Conversion of Medical DICOM and NIFTI Files to JPEG File Format

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ABSTRACT

Medical Imaging plays a crucial process in the field of medical imaging and research. The motivation of the project is to enhance the complex and detailed medical files such as DICOM, NIFTI converting it to common JPEG format. The research is significant and it address the challenges of sharing and viewing complex medical files that have critical diagnostic information that can be used and accessed by healthcare professionals, educators, researchers. This complexity of medical files cannot be viewable directly they need specialized software to view them. The objective of the project is to develop the software that can convert complicated medical files, DICOM and NIFTI file to universal accessible JPEG format and that can be easily sharable and viewable. The methodology is to address the extracting and normalizing pixel data and voxel data for conversion to JPEG format. This study include enhancing the accessibility and usability of medical imaging data.and the future work will be using advance compression techniques and technologies might offer new ways to manage and access medical images efficiently.

Keywords: DICOM (Digital imaging and communication in medicine), NIFTI (Neuroimaging Informatics Technology Initiative), JPEG (Joint Photographic Experts Group), Medical Imaging, Image Data.

I. INTRODUCTION

Medical imaging plays a crucial role in modern healthcare, enabling detailed visualization of the human body. When a patient undergoes a radiology exam, such as a CT, MRI, or X-ray, the resulting imaging information is typically converted into a DICOM file [1]. Typically, MRI scanners generate file in the DICOM then DICOM is converted into NIFTI [2]. DICOM is also used in other medical areas such as pathology, dermatology, endoscopy, neuroscience, and ophthalmology [3]. NIfTI is primarily used in neuroimaging research and also used in medical research.

Digital imaging and communication in medicine (DICOM) is a generic file format used to handling, storing, printing, transmitting and displaying medical images. Dicom was developed by developed by American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA) in 1993 DICOM file consists of both meta data and image data. DICOM file ends with (.dcm, or .dicom).

Neuroimaging Informatics Technology Initiative (NIFTI) was created for handling Neuro- imaging but can be used for other fields as well such as brian imaging data both are obtained through MRI . NIFTI was devleloped by National Institute of Health (NIH) in early 2000’s. NIFTI file consists of medical image data. NIFTI file ends with (.nii, .nii.gz) [4].

Joint Photographic Experts Group (JPEG) Image is one of the most widely used image formats. JPEG images can be opened on virtually any device. The JPEG image ends with (.jpeg) [5].

1.1. DICOM file format

A DICOM file consists of File Pre-Amble (128 bytes), DICOM Header (Variable length), Data Elements (Variable length), Pixel Data (Variable length) and shown in Fig 1.

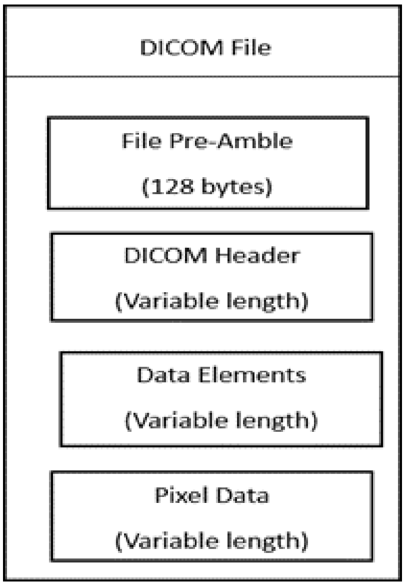

Fig 1: DICOM File Format

1.1.1 File Pre-Amble

At the start of a DICOM file, the File Pre-Amble which occupies the first 128 bytes. This segment is reserved for specific purposes such as padding and may often be filled with zeros or used by file systems for alignment.

1.1.2 DICOM Header

Immediately after the File Pre-Amble comes the DICOM Header. This portion begins with a 4- byte ASCII marker "DICM," which signifies the start of the DICOM header section. The header is crucial as it includes vital metadata that describes the file's format and provides the necessary information to interpret the subsequent data correctly.

1.1.3 Data Elements

Following the DICOM Header is the Data Elements section, which is composed of multiple encoded tags. Each tag is structured to provide detailed information about the image and its metadata:

- Tag: A unique identifier for the data element, specified by a Group and Element number.
- Value Representation (VR): Defines the type of data contained (such as string or integer).
- Value Length: Shows the size of the value field in bytes.
- Value Field: Contains the data associated with the tag.

1.1.4 Pixel Data

The final section of the file is the Pixel Data, which contains raw data that represents the visual information of the medical image. This section stores numerical values corresponding to the intensity or color of each pixel, and its format and size are determined by the type of image. It serves as the primary data source for reconstructing the image and is processed after all metadata and header information [6][7].

1.2 NIFTI file format

NIFTI file consists of the header is a fixed 348 bytes long, while the image data varies in the size based on the image dimensions and data type. And it is shown in Fig 2.

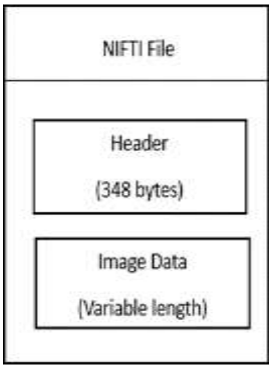

Fig 2: NIFTI File Format

1.2.1 Header

The NIfTI file format begins with a "Fixed Header" that is exactly 348 bytes long. This header includes essential metadata required for interpreting the image data, such as the image dimensions, voxel sizes, slice ordering, and transformation parameters. Specifically, the header contains fields like dim for image dimensions, pixdim for voxel size and time intervals, slice_code for slice order, descrip for a human-readable description, and transformation parameters like quatern_b, quatern_c, quatern_d, qoffset_x, qoffset_y, qoffset_z, and srow_x, srow_y, srow_z.

1.2.2 Image Data

Image Data contains the "Variable Length Data" section, which starts at byte 352 in a single-file format. This section holds the actual image data, and its length varies depending on several factors: the dimensions of the dataset (such as width, height, depth, and time), the voxel size, and the data type (such as 8-bit, 16-bit, or 32-bit). Because these factors can differ from one file to another, the size of the image data section is variable and not fixed [8].

II. LITERATURE SURVEY

PlatiPy addresses the limitations of tools like SimpleITK, scikit-learn, and pydicom by offering a unified Python toolkit for DICOM conversion, image registration, and visualization [9]. The existing tools like dcm2niix and BIDScoin require programming expertise, but BIDSconvertR introduces a more user-friendly, R-based option for neuroimaging data conversion [10]. An advanced compression method for NIfTI neuroimaging data enhances telemedicine by reducing file sizes and maintaining high image quality [11]. An efficient watermarking scheme for NIFTI images ensures integrity and authenticity in telemedicine, demonstrating high quality retention and robustness against attacks [12]. A robust watermarking technique for NIfTI images ensures authenticity and integrity, maintaining high-quality diagnostics and resilience against image-processing attacks in telemedicine [13]. A robust watermarking scheme for NIfTI medical images ensures integrity and authenticity while maintaining high quality and resilience against noise attacks, vital for secure telemedicine during the COVID-19 pandemic [14]. A robust watermarking method for NIfTI images ensures integrity and authenticity while maintaining high quality and resistance to attacks, crucial for secure telemedicine [15]. A robust blind watermarking scheme for lung CT-Scan NIfTI images ensures integrity and authenticity during transmission, maintaining high quality and resilience against attacks, crucial for telemedicine [16]. This review outlines techniques and tools for ensuring high-quality data in machine learning and AI applications in radiology, focusing on image annotation, curation, and regulatory compliance [17]. This article compression techniques for medical imaging, highlighting the preference for lossless techniques, comparing various formats like DICOM and NIfTI, and addressing the need for improved algorithms for 3D medical images [18]. This study provides a guideline for selecting open-source tools for medical imaging data curation in AI applications, emphasizing features, data security, and community-driven insights [19]. This study outlines a systematic two-stage de-identification process for DICOM CT images that removes PII and PHI, ensuring patient privacy while preserving diagnostic integrity and compliance with standards [20]. The study develops a methodology for classifying prostate cancer using MRI images, achieving 87% accuracy through DICOM conversion, data augmentation, and transfer learning techniques [21]. The study discusses the successful integration of the OHIF Viewer into the XNAT platform, enhancing data visualization and annotation tools for quantitative imaging research in large multicenter studies [22]. The project developed an automatic reporting system for Multiple Sclerosis using DICOM Structured Report standards to translate AI-generated outputs into clear, structured radiology reports, enhancing accessibility for healthcare professionals [23]. The study developed a modified digital signature algorithm to enhance the integrity and confidentiality of biomedical images in cloud environments, addressing critical data security challenges in medical imaging [24]. The review compares medical image compression techniques, highlighting the need for efficient algorithms that balance image quality, compression ratio, and speed, with a focus on promising hybrid methods [25]. The study proposes a selective encryption method utilizing a segmentation mask and chaotic Henon map for securing multidimensional medical images, improving retrieval efficiency and maintaining lossless image quality [26]. The study evaluates lossy image compression techniques on high-resolution volumetric biomedical data, demonstrating that significant data reduction can be achieved while preserving interpretative accuracy in tumor vasculature analysis [27]. The thesis develops an automatic segmentation method for femur bones using Deep CNNs on DICOM images from CT and MRI scans, significantly improving accuracy in bone quality assessment and fracture risk evaluation in clinical practice [28]. A comprehensive framework for the de-identification, cleaning, and compression of cardiac ultrasound images was developed, enhancing patient confidentiality and optimizing storage while ensuring high-quality analysis of echocardiographic data [29]. The study developed a framework with 'image data set' and 'image data set analysis' classes to streamline biomedical imaging data management and enhance automated analysis, achieving high predictive accuracy for MRI scan types [30]. The study reviews and analyzes various medical imaging annotation tools, emphasizing their features and applications to guide researchers in selecting appropriate tools for high-quality annotations while balancing efficiency and accuracy [31]. The study highlights critical pre-processing steps for CT and MR images that enhance deep learning performance in prostate cancer research, achieving notable accuracy improvements in classification and segmentation tasks [32]. The study presents a robust watermarking scheme using ROI and fuzzy logic to enhance the integrity and authenticity of medical images in telemedicine, demonstrating high PSNR, NC, and resilience against various attacks [33].

III. PROPOSED METHODOLOGY

3.1 SYSTEM ARCHITECTURE

The working process of converting DICOM and NIFTI files to JPEG begins with importing the files that can read the complex data structures of these medical images. Once imported, the image data is extracted from the files. This data often requires processing to adjust pixel intensity values. The processed image data is then converted to JPEG format using image processing tools, ensuring that the essential details are preserved. Metadata handling is crucial in this step to retain important information. Finally, the output consists of the JPEG images, which are now in a more accessible format, making it easier to share and view the medical images without specialized software.

The implementation of the DICOM and NIfTI to JPEG conversion is achieved through a well- structured system architecture in Fig 3.

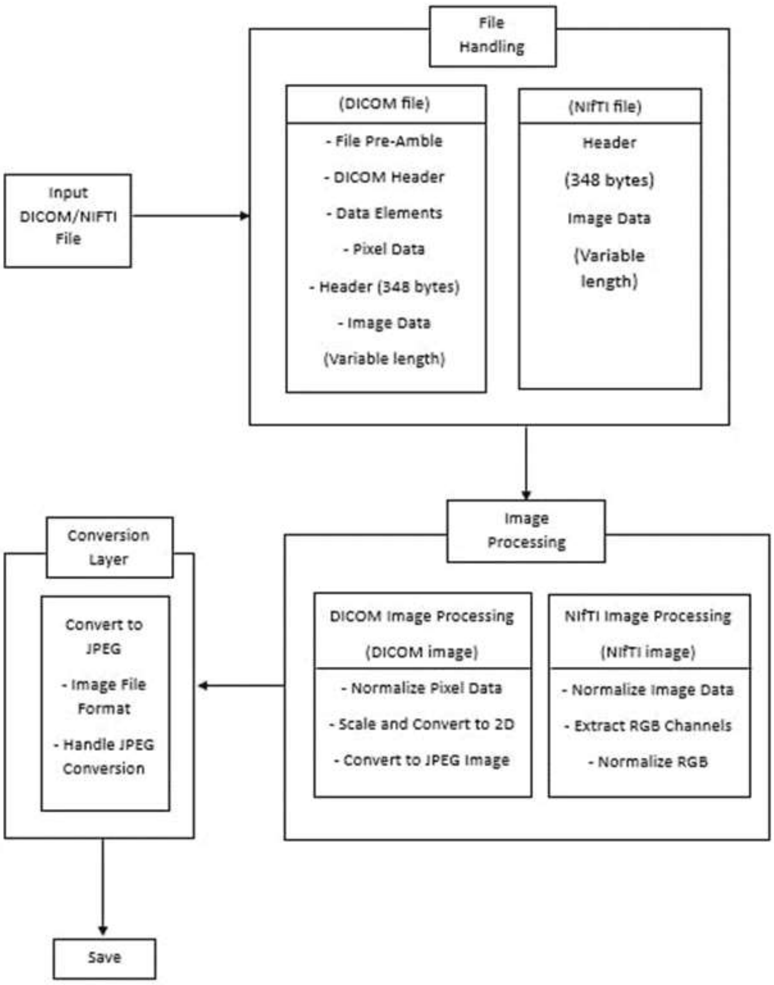

Fig 3: System Architecture

3.1.1 DICOM, NIFTI File

Load DICOM file into the software using Pydicom library. Facilitates the loading of NIfTI file into the software using the nibabel library.

3.1.2 File Handling Layer

- DICOM FILES: In the file handling layer, DICOM files are managed using the pydicom library.
  - File Pre-Amble: The DICOM file begins with a File Pre-Amble of 128 bytes, reserved for padding or alignment, typically filled with zeros
  - DICOM Header(Variable Length): Following this, the DICOM Header, which varies in length and begins with a 4-byte ASCII marker "DICM" to indicate the start of the DICOM header. The header contains metadata like patient information, study details, and image acquisition parameters.
  - Data Elements (Variable Length): Next, Data Elements section appears, where each data element is identified by a unique Group and Element number. The data elements include a Value Representation (VR), specifying the type of data (e.g., string, integer), its length in bytes, and the actual value (such as image dimensions or pixel spacing).
  - Pixel Data (Variable Length): Finally, the Pixel Data section stores the raw pixel values representing the image content, located after the header and data elements.
- NIFTI FILES: For NIfTI files, the nibabel library is used.
  - Header(348 bytes): Each NIfTI file has a fixed-size Header that is 348 bytes long, containing crucial metadata like image dimensions, voxel sizes, and transformation parameters. Specific fields include dim for image dimensions, pixdim for voxel sizes and time intervals, and slice_code for slice ordering. Transformation parameters, such as quaternions and offsets, also reside in this header.
  - Image Data (Variable Length): After the header, the Image Data section follows, starting at byte 352, and its length depends on the image dimensions, voxel size, and data type.

3.1.3 Image Processing

- DICOM Image Processing
  - Normalize Pixel Data: Pixel data is normalized to scale pixel values to a consistent range, typically between 0 and 255. This normalization allows for uniform display of the image across various platforms.
  - Convert to 2d: If the DICOM image is multi-frame or 3D, it is converted to a 2D format for easier visualization by extracting a single slice or projection of the image.
  - Convert To JPEG: Finally, the processed 2D image is converted into JPEG format using the PIL (Pillow) library.
- NIFTI Image Processing
  - Normalize Image Data: The Normalize Image Data function adjusts pixel values to a standard range, similarly ensuring uniform display across various platforms. This involves normalizing pixel values across RGB channels for consistent color representation.
  - Extract RGB Channels: The Extract RGB Channels function separates image data into Red, Green, and Blue channels for color processing.
  - Normalize RGB: while the Normalize RGB function scales these values to a standard 0-255 range.

3.1.4 Conversion Layer

- DICOM Convert to JPEG: The Convert DICOM to JPEG function manages the conversion of DICOM images into JPEG format. It utilizes the pydicom library to read DICOM files and extract pixel data. The extracted pixel array is then normalized and transformed into a JPEG image using the PIL (Pillow) library to ensure accurate rendering of medical images in JPEG format
- NIFTI Convert to JPEG: The Convert NIfTI to JPEG function manages the transformation of NIfTI files into JPEG format. This process involves loading the NIfTI file using the nibabel library to extract image data, followed by normalization and conversion into JPEG using the PIL (Pillow) library for handling the image output.

3.1.5 Save Image

- The Save Image manages saving the converted JPEG image to a specified location on disk. It uses a file dialog to allow the user to select the desired save location and filename.

3.2 PROPOSED ALGORITHM

Step 1: Load and Validate DICOM or NIfTI File

Step 2: Extract and Read Image Data

Step 3: Normalize Image Data for Standard Display

Step 4: Convert Image Data to 2D Format

Step 5: Convert Processed Image to JPEG Format

Step 6: Save JPEG Image to Specified Location

IV. MEHODOLOGY

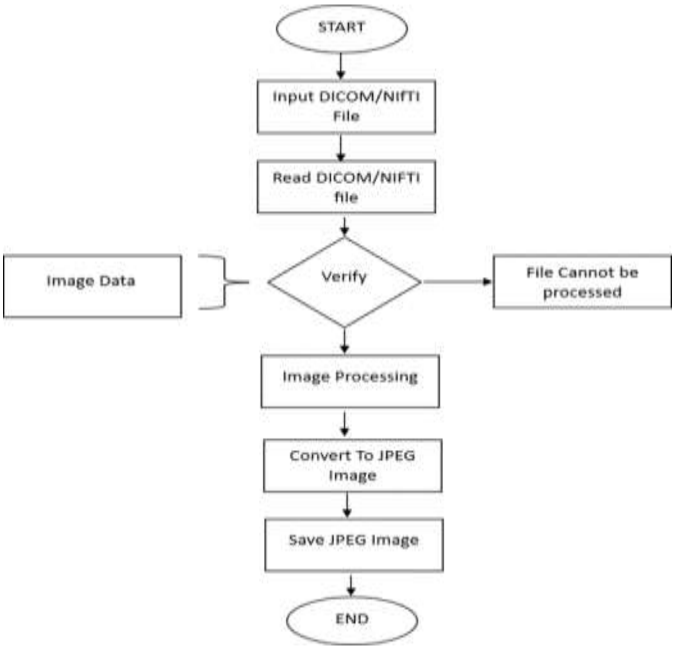

Fig 4: Methodology

The methodology diagram Fig 4 outlines the process for converting DICOM or NIfTI medical files to JPEG format. The process begins by selecting the input file, which can be either a DICOM or NIfTI. The system then reads the contents of the selected file and performs a verification step to ensure that the file is valid and can be processed. If the file fails verification it does not have image data, an error message is generated, indicating that the file cannot be processed, and the process stops. If the file is valid conatins image data, the system proceeds to extract the image data. This image data is then processed, though image processing can be minimal or skipped entirely, depending on the requirements. The next step involves converting the image data into JPEG format. Once the conversion is complete, the JPEG image is saved to the designated output location, concluding the process. Throughout the workflow, error handling and is essential to ensure only valid and processable files are converted, minimizing potential issues. The diagram effectively represents the step-by-step approach for converting medical files, with checks in place to ensure successful conversion.

Qualitative data includes the visual quality of the converted JPEG images, where qualitative assessments involve observing the preservation of detail, and any noticeable artifacts. And qualitative data also includes observations about the conversion process itself, such as the efficiency and effectiveness of the algorithms used, any issues or errors encountered, and how these impact the final results. Evaluations of information loss, including changes in image detail, color, or intensity, provide further insight into the conversion's fidelity. User feedback on the relevance and usefulness of the JPEG images for medical or research purposes also contributes to understanding the success of the conversion process. Collectively, this qualitative data helps in comprehensively assessing the performance and impact of converting medical imaging data into JPEG format. Quantitative data for the conversion of DICOM and NIfTI images to JPEG format includes several measurable metrics that evaluate the efficiency and effectiveness of the process. Processing time is one key metric, representing the duration required to convert images from DICOM or NIfTI to JPEG, typically measured in 1 second of single slice and for multiple slices depends upon the number of slices on average 15 seconds. File size is another important measure, reflecting how much the JPEG files differ in size relative to the original DICOM or NIfTI files, and is expressed in kilobytes (KB) or megabytes (MB). Pixel accuracy is assessed by measuring the differences in pixel values between the original and converted image, often quantified using metrics like root mean squared error (RMSE) or structural similarity index (SSIM). The compression ratio provides insight into the degree of compression applied during conversion, calculated as the ratio of the original file size to the JPEG file size. And error rates quantify the frequency of errors or failures encountered during conversion, such as incomplete or corrupted file. Finally, the image resolution of the JPEG image, measured in terms of width and height in pixels, is compared to the original image to evaluate any changes in image detail. These quantitative metrics offer objective insights into the compression view of the efficiency and effectiveness of the conversion process. For the conversion of DICOM and NIfTI images to JPEG format, secondary data can include several key sources. The secondary data for this research were sourced from publicly available repositories, including the DICOM Library and the NiiVue GitHub repository. The DICOM Library is a well-known resource offering a wide range of DICOM files for research and educational purposes, allowing for the exploration and testing of various image processing techniques. Similarly the NiiVue GitHub repository provides a collection of NifTI files samples that are widely used for neuroimaging research. The experimental data for the conversion of DICOM and NIfTI images to JPEG format involves several key components. Initially, the process includes handling DICOM file through an application interface where users can import these file and convert them into JPEG format. The DICOM pixel data is read and scaled to fit the JPEG color space using libraries such as `pydicom` and `PIL`. This conversion is evaluated based on visual inspections to verify that integrity of the JPEG images is maintained. Similarly, for NIfTI file, the application processes these file using the `nibabel` library, normalizes the data, and converts it to JPEG format. This process includes reshaping, with quality assessments focused on visual inspection.

V. EXPERIMENTAL RESULTS

Experiments obtained from the conversion of medical files from DICOM and NIfTI formats to JPEG, highlighting the following

5.1 Experiments

5.1.1 Conversion Success Rate

The experiment involved converting 50 DICOM files and 50 NIfTI files, each containing either single or multiple medical image slices, into JPEG format. The results showed the following outcomes:

- DICOM to JPEG: 40 out of 50 files were successfully converted, resulting in a success rate of 80%. The remaining 10 files included various issues, with the majority being single slices and a few containing multiple slices, leading to failures primarily due to corrupt image data.
- NIfTI to JPEG: 35 out of 50 files were successfully converted, resulting in a success rate of 70%. The remaining 15 files encountered errors related to problems in the image data.

5.1.2 Processing Time

The average processing time for converting a single DICOM file to JPEG was 1 second, while the NIfTI file conversion averaged 1 second. This difference in processing time is primarily influenced by the image size and complexity. If the DICOM or NIFTI file contain 300 slices it may take around 15 seconds. However, when dealing with files containing multiple slices, the total processing time increased depending on the number of slices in the file.

5.1.3 File Size Reduction

The conversion process resulted in a significant reduction in file sizes. The average sizes of the original DICOM files were average 300 KB, while the NIfTI files containing multiple slices averaged around 2 MB. After conversion to JPEG, the average file sizes were reduced to approximately 50 KB for DICOM and 200 KB for NIfTI images. The multiple slices of DICOM or NIFTI file has around 8 MB size after conversion the JPEG size is around 1 MB.

5.1.4 Anamolies and Errors

During the conversion process, some DICOM and NIfTI files failed to convert due to missing or corrupted metadata. These files were flagged for further analysis, which revealed that their pixel data could not be properly extracted. Additionally, some files experienced lower image quality after conversion

5.1.5 Conversion Outcomes

Conversion of Dicom and Nifti to JPEG with some losses in image quality and significant reductions in file size. While some slight visual degradation occurred in a small percentage of images.So over all the experiments tells that the conversion of both DICOM and NIfTI images to JPEG format is successful.

5.2 RESULTS

Conversion of Dicom and Nifti to JPEG with some losses in image quality and significant reductions in file size. While some slight visual degradation occurred in a small percentage of images.So over all the experiments tells that the conversion of both DICOM and NIfTI images to JPEG format is successful

5.2.1 Interface

Conversion of Dicom and Nifti to JPEG with some losses in image quality and significant reductions in file size. While some slight visual degradation occurred in a small percentage of images.So over all the experiments tells that the conversion of both DICOM and NIfTI images to JPEG format is successful the screenshot is shown below in Fig 5.

Fig 5: Interface

5.2.2 DICOM File Selection, Conversion, and Saving

In Fig 6, the software is shown with the DICOM files. The user can browse and select a DICOM file for conversion. The interface indicates the supported file formats, ensuring users are aware of compatibility. it enables users to browse for DICOM files (.dcm, .dicom). This feature enhances the usability of the software by allowing users to navigate through their file system. In the Fig 7, the conversion process from DICOM to JPEG format. It displays during conversion, indicating that the selected DICOM file is being processed. The interface updates to reflect the conversion's progress, informing the user of the number of slices converted and The converted slices are displayed in the GUI. In Fig 8, It shows the confirmation of saved JPEG images, indicating the successful completion of the conversion process and the output file names.

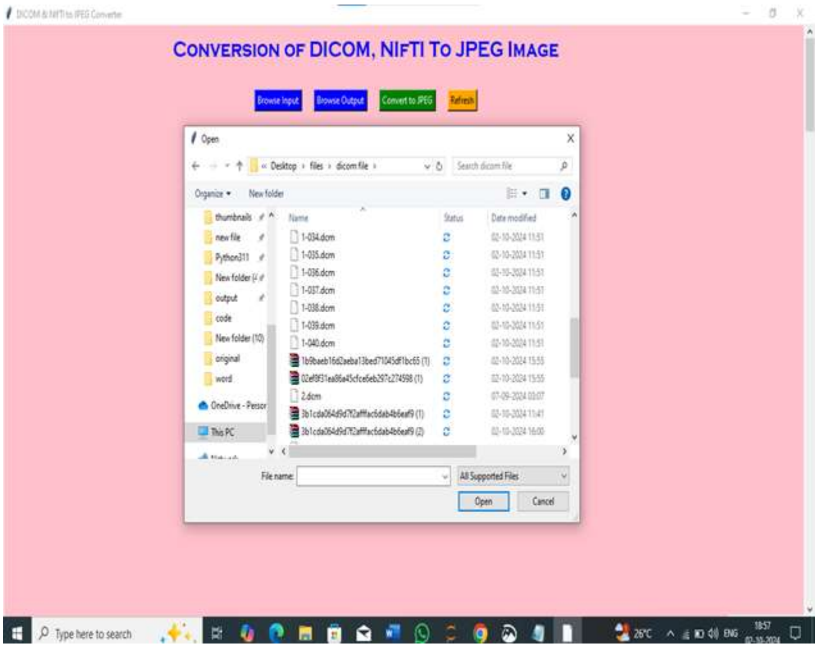

Fig 6: open DICOM files

Fig 7: DICOM to JPEG converted

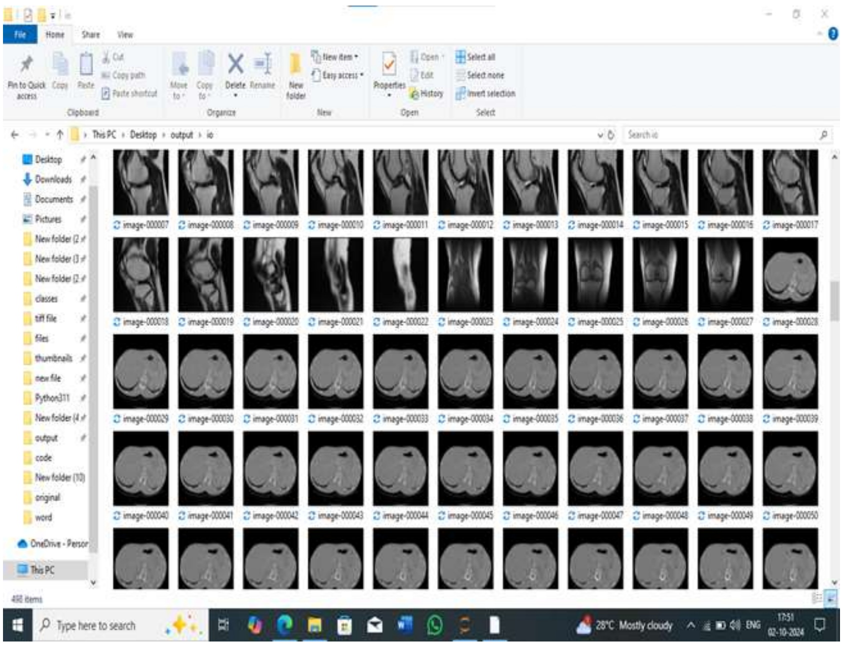

Fig 8: Saved DICOM to JPEG Conversions

5.2.3 NIFTI File Selection, Conversion, and Saving

Fig 9 presents the NIfTI file selection dialog within the software. Similar to the DICOM selection process, it enables users to browse for NIfTI files (.nii, .nii.gz) and select them for conversion. The interface maintains a consistent design, ensuring that users can efficiently navigate through their file directories. And In this Fig 10, the software shows the conversion progress for NIfTI file being transformed into JPEG format. The user is informed about the ongoing conversion through by displaying processing, which detail the processing of each slice, ensuring transparency in the conversion workflow. And interfaces displays the conversion of all slices with their count. In Fig 11 confirms the successful conversion and saving of NIfTI files as JPEG images in their saved locations.

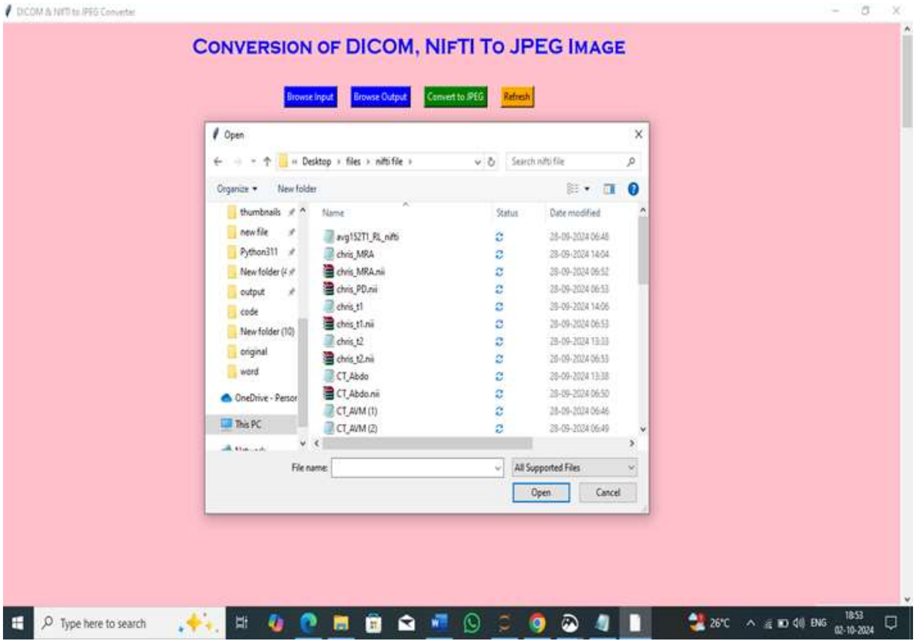

Fig 9: open NIFTI files

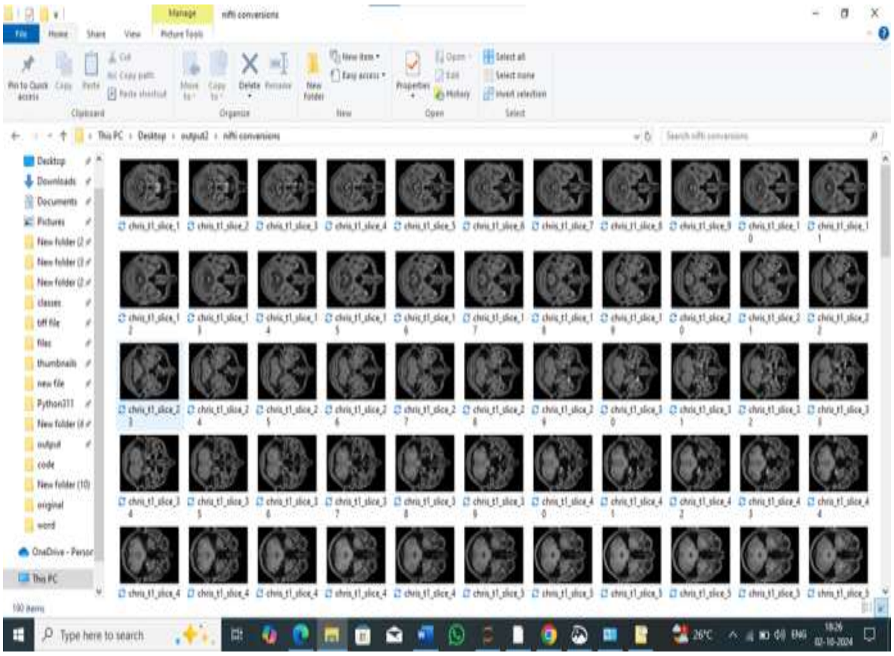

Fig 10: NIFTI to JPEG converted

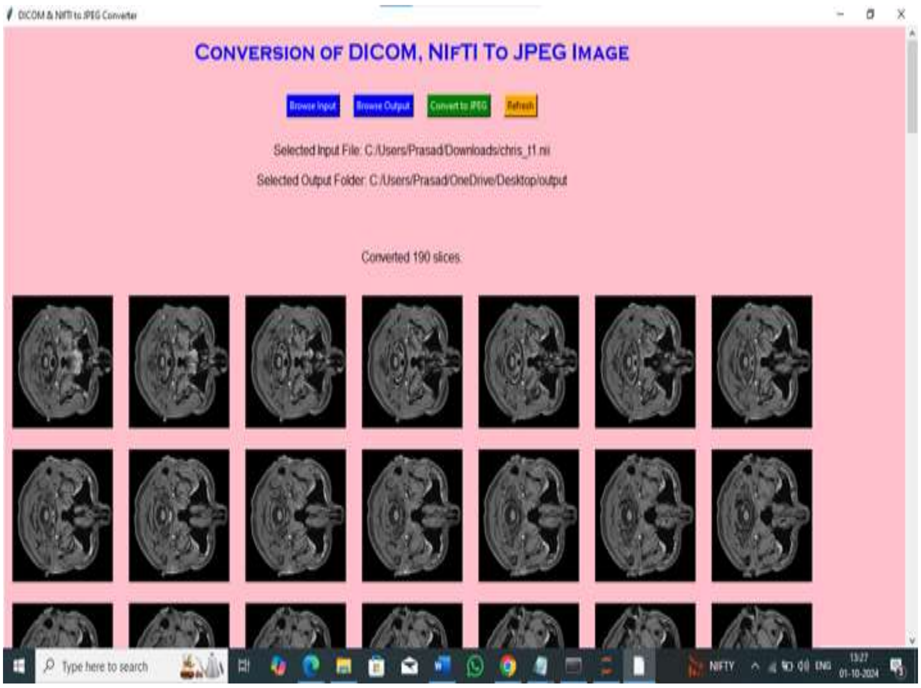

Fig 11: Saved NIFTI to JPEG Conversion

CONCLUSION

Medical files, often containing complex and specialized imaging data, require specific software for accurate viewing by the appropriate tools. This research focuses on the conversion of complex and detailed medical imaging files, DICOM and NIFTI formats into JPEG Image format to improve accessibility, usability, and storage efficiency. The goal is to address the challenges of visualizing and sharing complex medical images by converting them into a more universally recognized and easily viewable format on any devices or softwares. This facility will be easy collaboration among healthcare professionals, educational purposes, presentations, researchers, and patients. After conversion the JPEG image size will be reduced so there will be of lossy information. So DICOM and NIFTI are excellent for storing detailed medical information. So the jpeg image cannot replace the original files. By identifying the limitations of JPEG compression, Future research in medical imaging could focus on several promising directions. One key area is the development of advanced lossless compression algorithms and deep learning-based techniques to preserve image quality while reducing file sizes. Hybrid compression methods could balance efficiency and quality by applying different compression strategies to different image regions. Exploring emerging image formats and establishing standardization guidelines for compression could further enhance the preservation of diagnostic integrity. cloud-based solutions and real-time compression technologies might offer new ways to manage and access high-quality medical images efficiently.

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