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Knee Osteoarthritis Detection and Classification using on X-Rays

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ABSTRACT: Knee osteoarthritis is a common form of arthritis, a chronic and progressive disease recognized by joint space narrowing, osteophyte formation, sclerosis, and bone deformity that can be observed using radiographs. Radiography is regarded as the gold standard and is the cheapest and most readily available modality. X-ray images are graded using Kellgren and Lawrence's (KL) grading scheme according to the order of severity of osteoarthritis from normal to severe. Early detection can help early treatment and hence slows down knee osteoarthritis degeneration. Unfortunately, most of the existing approaches either merge or exclude perplexing grades to improve the performance of their models. This project aims to automatically detect and classify knee osteoarthritis according to the KL grading system for radiographs. We have proposed an automated deep learning based ordinal classification approach for early diagnosis and grading knee osteoarthritis using a single posteroanterior standing knee x-ray image. An Osteoarthritis Initiative(OAI) based dataset of knee joint Xray images is chosen for this project. The dataset was split into the training, testing, and validation set with a 7: 2: 1 ratio.

I. INTRODUCTION

Osteoarthritis (OA) is a degenerative disease that affects the knee joint and is characterized by cartilage deterioration that eventually leads to bone deterioration. Physical symptoms of OA include pain, stiffness, swelling, and limited joint movements. Risk factors for OA include age, gender, genetics, race, obesity, injury, vitamin D deficiency, and lifestyle. The disease progresses over time and has different stages of severity. Two forms of OA exist: Primary OA, which is found in older individuals as a result of aging or genetic factors. Due to injuries, diabetes, obesity, sports, rheumatoid arthritis patients, or other factors, secondary OA typically manifests earlier in life. The sample of normal & affected Osteoarthritis knee. These two figures display an example of a normal and affected osteoarthritis knee image. Joint stiffness in the morning or after extended rest is one of the primary symptoms of osteoarthritis (OA), along with pain and limited joint motion. The current assessment of OA is based on the clinical examination, symptoms, and basic radiographic methods such as MRI, CT, and X-rays. Although a number of alternative approaches have been put forth, the Kellgren-Lawrence (KL) system is a verified technique for dividing individual joints into five grades. Joint cartilage destruction, reduced joint space between neighboring bones, and the development of bone spurs are typical X-ray findings associated with osteoarthritis.

II. EXISTING SYSTEM

Existing system involves manually extracting features on small sample sets, to balance the validity of the learning results with the interpretability of the learning model, and to provide a framework for solving the learning problem when limited samples are available. Traditional machine learning can be sub-divided into supervised learning, unsupervised learning, and reinforcement learning, based on the training method and depending on whether the training data have labels or not.

III. PROPOSED SYSTEM

Our Proposed System have described the complete methodology to achieve the objectives mentioned describes the dataset. Then is significantly deeper, with 144 million parameters, and is a variant of the VGG model that comprises 16 convolutional layers, three fully connected layers, five max pool layers, and one softmax layer. Max pool layers are crucial for spatial subsampling and generic feature extraction. Our method works on unilateral posteroanterior knee X-rays and does not require images from multiple angles or other clinical data. Four Type ImageNet-based pre-trained models were fine-tuned. State-of-the-art results are achieved by each of these models individually.

3.1 BASIC WORKING

Detecting and classifying knee osteoarthritis (OA) using X-rays involves several key steps and considerations. X-ray imaging remains a primary diagnostic tool due to its accessibility, cost-effectiveness, and ability to visualize joint structures. In the context of knee OA, X-rays provide crucial information about joint space narrowing, osteophyte formation, and other signs of degenerative changes in the knee joint. The process typically begins with the acquisition of weight-bearing X-rays, which are essential for accurate assessment. Radiologists and orthopedic specialists then analyze these images using standardized scoring systems such as the Kellgren-Lawrence grading scale. This scale categorizes OA severity into five grades based on the extent of joint space narrowing and the presence of osteophytes. Key features that clinicians look for include joint space narrowing, where the space between bones in the knee joint appears reduced due to cartilage loss. Osteophytes, or bone spurs, often form at the joint margins as a response to degeneration. Subchondral sclerosis, which appears as increased bone density beneath the cartilage, is another significant indicator. Machine learning and computer vision techniques are increasingly being integrated into the process to assist radiologists in detecting and classifying knee OA more efficiently.

3.2 DESIGN METHODOLOGY

Designing a methodology for knee osteoarthritis (OA) detection and classification using X-rays involves careful consideration of several interconnected components to ensure accuracy and reliability in clinical practice. The process typically begins with the acquisition of X-ray images, focusing on weight-bearing views that provide optimal visualization of joint structures under load. These images are fundamental for assessing the severity of OA based on established grading systems such as the Kellgren-Lawrence scale, which categorizes OA into different stages from 0 to 4. The next step involves image preprocessing to enhance quality and standardize appearance, which is crucial for consistent analysis. Techniques like image normalization, noise reduction, and contrast adjustment may be applied to ensure that subsequent steps in the methodology are based on reliable data. Feature extraction is a critical phase where specific aspects of the X-ray images are identified and quantified. This includes detecting key indicators such as joint space narrowing, osteophyte formation, subchondral sclerosis, and other relevant biomarkers of OA progression. Automated algorithms and computer vision techniques play a pivotal role in this stage, utilizing pattern recognition and machine learning models trained on annotated datasets to extract and analyze these features accurately.

IV. SYSTEM ARCHITECTURE

Data Acquisition and Preprocessing:** The system begins with acquiring X-ray images of the knee joint, focusing on weight-bearing views that provide optimal visualization of joint structures. Preprocessing techniques are then applied to standardize and enhance image quality, including normalization, noise reduction, and contrast adjustment. This step ensures that subsequent analysis is based on clean and consistent data. **Feature Extraction**:** Automated algorithms and computer vision techniques are employed to extract relevant features from the preprocessed images. These features include characteristics such as joint space narrowing, osteophyte formation, and subchondral sclerosis, which are critical indicators of OA progression. Feature extraction methods may involve edge detection, texture analysis, or deep learning-based approaches using convolutional neural networks (CNNs). **Classification and Grading**:** Extracted features are input into classification algorithms to categorize the severity of knee OA according to established grading scales like the Kellgren-Lawrence scale. Supervised learning algorithms such as SVM, decision trees, or ensemble methods are commonly utilized for this task. These algorithms leverage the extracted features to classify X-ray images into different OA stages, providing quantitative assessments of disease severity.

The basic architect diagram is given below:

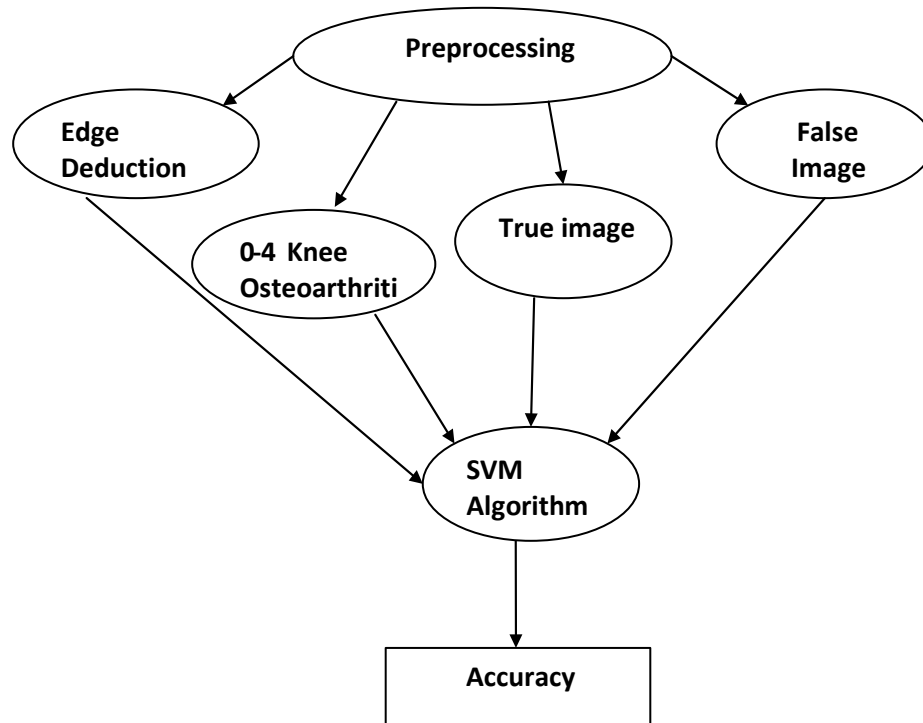


Fig-1:Architect Diagram

4.1 DATA FLOW DIAGRAM

Data Flow DFDs show the flow of data from external entities into the system, showed how the data moved from one process to another, as well as its logical storage. There are only four symbols. Squares representing external entities, which are sources or destinations of data. Rounded rectangles representing processes, which take data as input, do something to it, and output it. Arrows representing the data flows, which can either, be electronic data or physical items. Open-ended rectangles representing data stores, including electronic stores such as databases or XML files and physical stores such as or filing cabinets or stacks of paper.

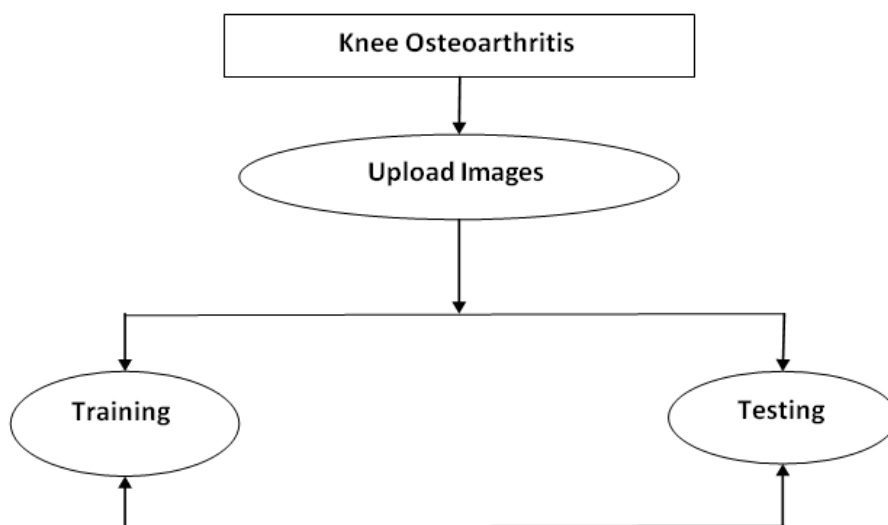


Fig-2: Data flow diagram

V. IMPLEMENTATION

Implementation is the process of having the system personal checks out and put new equipment to use, train the user to use the new system and construct any file that are needed to see it. The final and important phase in the system life cycle is the implementation of the new system. The file conversion is the most time consuming and expensive activity in the implementation stage. System implementation refers to the step necessary to install a new system to put into operation. The implementation has different meaning, ranging from the conversion of a basic application to complete replacement of computer system. Implementation includes all these activities that take place to convert from old system to new one. The new system may be totally new replacing an existing manual or automated system or it may be major modification to an existing system.

VI. RESULTS

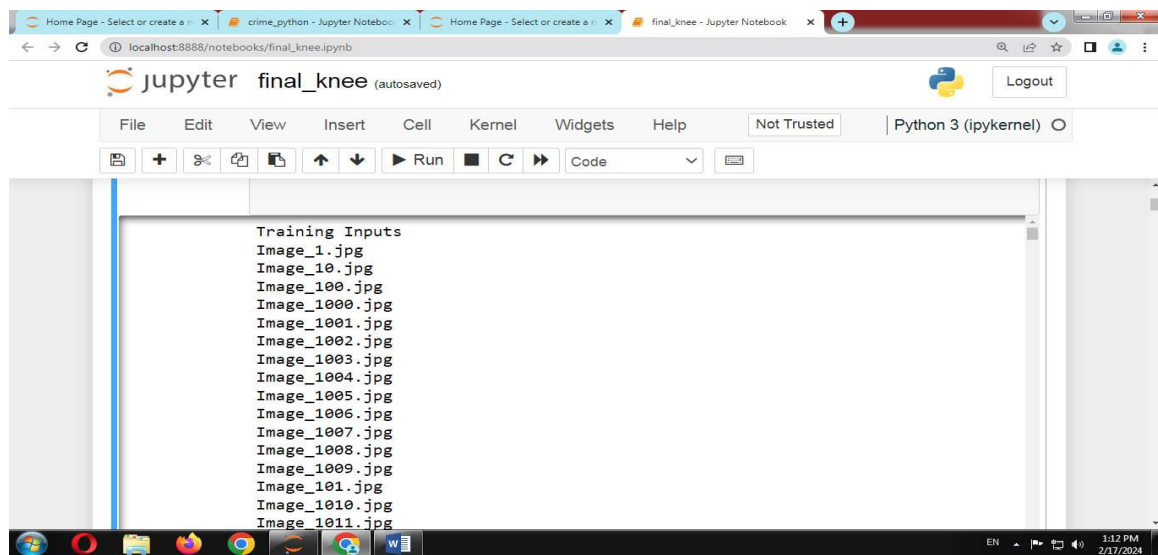


Fig-3: Training Input Images

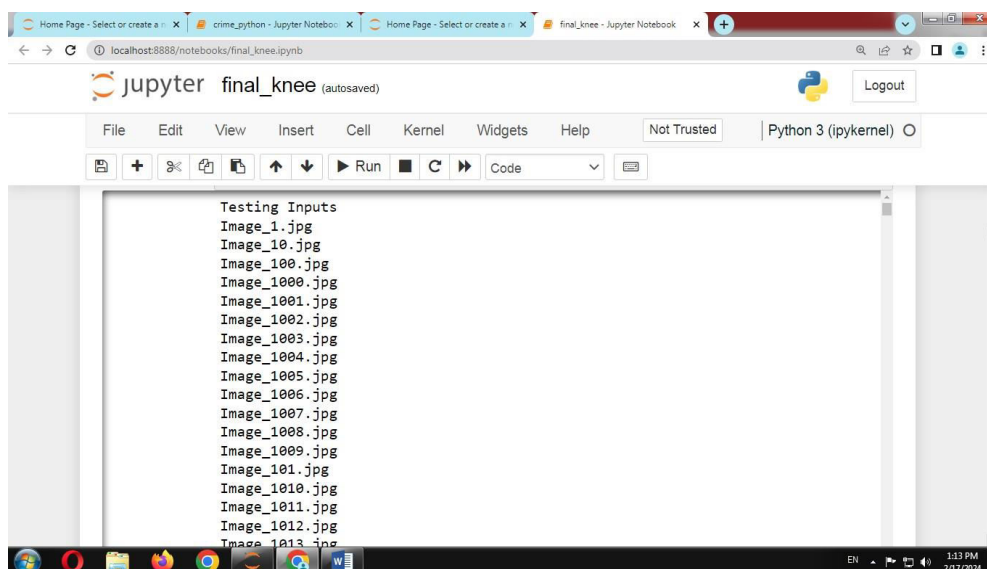


Fig-4: Testing Input Images

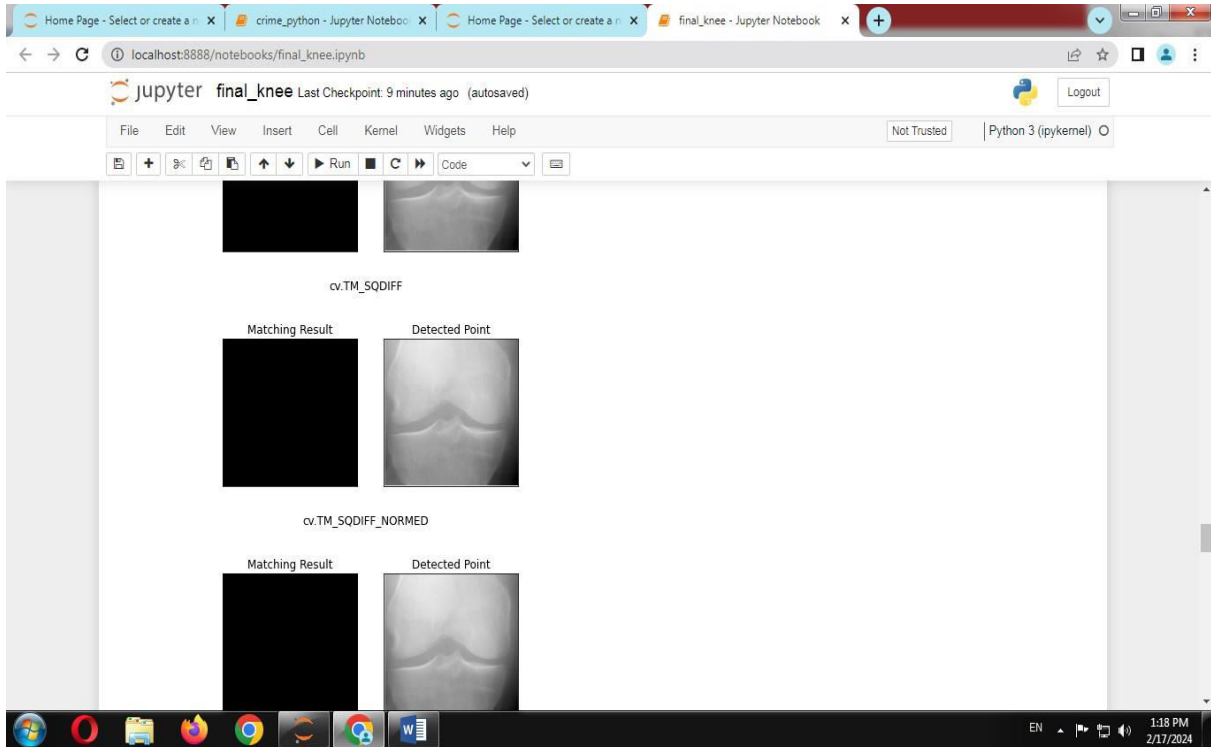


Fig-5: Matching deduction

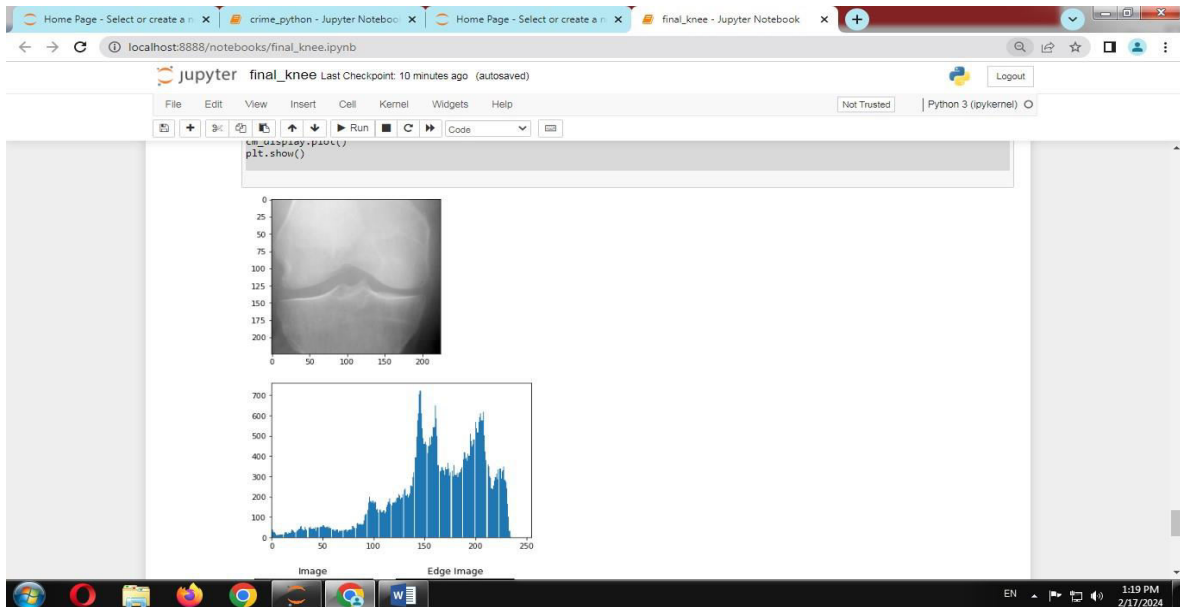


Fig-6: Algorithm Implementation

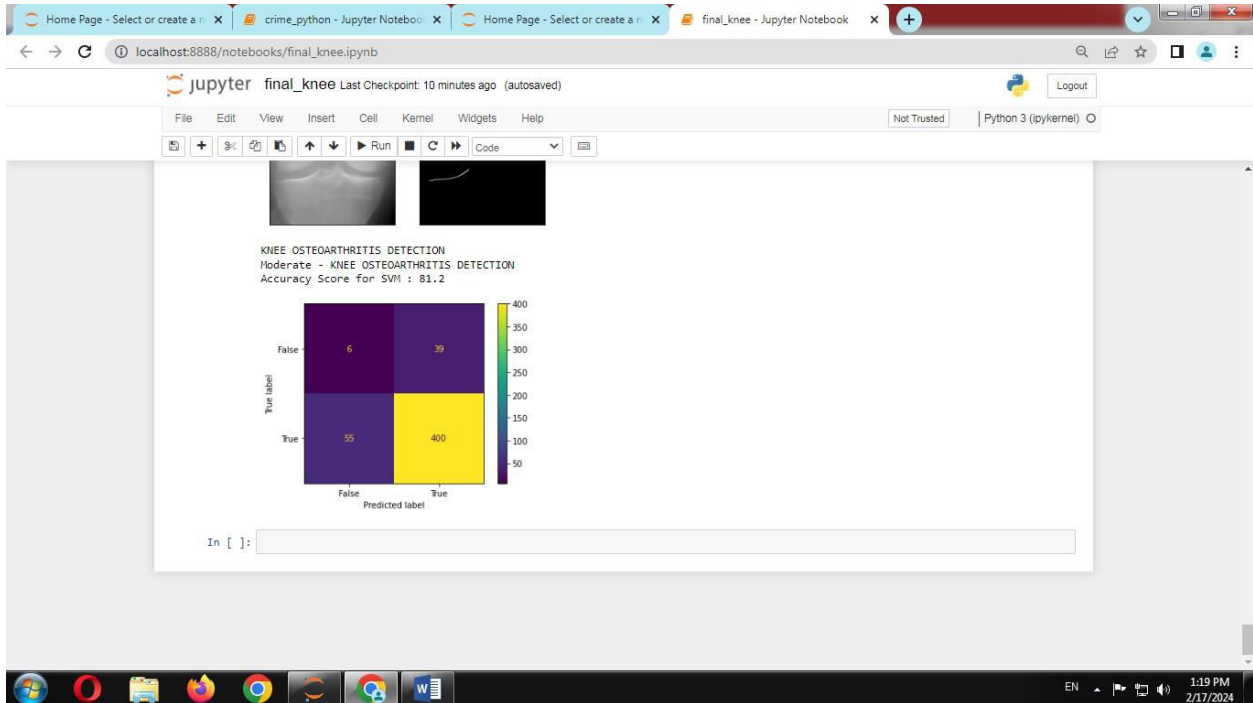


Fig-7: Accuracy

VII. FUTURE SCOPE

Future work will focus on training an end-to-end network to quantify the knee OA severity integrating the FCN for localization and the CNN for classification. It will be interesting to investigate the human-level accuracy involved in assessing the knee OA severity and comparing this to the automatic quantification methods. This could provide insights to further improve fine-grained classification. Many Knee X-rays from both rural and urban populations, varying in age and blood type, are used in the investigation. There are two hundred Knee X-ray samples used in the experiment. Forty percent of the investigation's testing and sixty percent of its training were done for the analysis. The image was classified using CNN. Using the algorithm, it was possible to demonstrate a classification rate of if the given image was normal or afflicted.

VIII. CONCLUSION

Implementation graded knee osteoarthritis X-rays using an ordinal classification approach based on deep learning. It showcase brand-new, cutting-edge findings in automated KOA classification across all KL grades. Furthermore, It improved our models' performance by creating an ensemble of optimized models. Medical professionals can use our method as a time-saving alternative because it offers a rapid, early, and reliable evaluation of input knee X-rays. The use of ordinal classification greatly enhanced our system's performance. Additionally, Ensemble has significantly improved across all evaluation metrics. It intend to add more datasets from various settings in the future. The deep learning model provided a sophisticated understanding of the visual cues and patterns associated with knee osteoarthritis, demonstrating impressive accuracy in this regard from medical imaging.

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