Osteoarthritis Prediction and Report Generation using Computer Vision

A PROJECT REPORT

Submitted by

SAMYAK MOHELAY (Reg No- RA1911027030031)
SHIVALIKA KARAN BORA (Reg No- RA1911027030034)
VANIKA GEHANI (Reg No- RA1911027030048)

Under the guidance of
Dr. Anand Pandey
(Associate Professor, Department of Computer Science & Engineering)

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BONAFIDE CERTIFICATE

Certified that this project report is titled " **Osteoarthritis Prediction and Report Generation using Computer Vision** " is the bonafide work of "**SAMYAK MOHELAY (Reg No- RA1911027030031), SHIVALIKA KARAN BORA (Reg No- RA1911027030034), VANIKA GEHANI (Reg No- RA1911027030048)** ", who carried out the project work under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

SIGNATURE

Dr. Anand Pandey
GUIDE
Associate Professor
(Dept. of Computer Science and Engineering)

SIGNATURE

Dr. R.P. Mahapatra
HEAD OF THE DEPARTMENT

(Dept. of Computer Science and Engineering)

Signature of the Internal Examiner

Signature of the External Examiner

ABSTRACT

- Creating a radiology report is time-consuming and requires extensive expertise in practice. Reliable, automatic generation of radiology reports is therefore highly desirable to reduce the workload. Although deep learning techniques have been successfully applied to image classification and image annotation tasks, radiology report generation remains a challenge in terms of understanding complex medical visual content and combining it with accurate natural language descriptions. .
- Moreover, the data scale of open access datasets containing pairs of medical images and reports is still very limited. To address these practical challenges, we propose an encoder/decoder generative model, focus on knee images and reports, and make some improvements.
- We first pre-trained the encoder with a large number of knee X-ray images to accurately recognize 1 common radiographic observations while leveraging multi-view imagery by enforcing cross-view consistency. Then, based on sentence-level attention mechanisms, we synthesise multi-view visual features in a late-fusion manner.
- We extract and refine medical concepts based on radiation reports in training data to enhance decoders with descriptive semantics and to enhance accuracy of deterministic medical-related content such as mentions and diagnoses. We tune the encoders to extract the most common medical concepts from the X-ray images. Such concepts are fused with the decoding steps with a word-level attention model. Experimental results conducted using the X-ray dataset from the Mendeley Database(Knee Osteoarthritis Severity Grading Dataset), show that the proposed model achieves state-of-the-art performance compared to other baseline approaches.

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-Samyak Mohelay
-Shivalika Karan Bora
-Vanika Gehani

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CHAPTER 1

INTRODUCTION

1.1 Introduction to System

Essentially the whole system can be summed up as an ‘Osteoarthritis Grade Prediction and Concise Report Generation System’. Primarily the main motivation behind the project was that the traditional method to observe X-rays and report generation by a Radiologist takes too much time mainly due to the high population, dependence on the experience of Radiologist, artifacts on X-ray images, management of physical reports and Lack of proper infrastructure and services in rural regions. A full-fledged system with 1/5th the size of an industry-standard model and a proprietary Pre-processing method that is able to resolve most defects from images. Alongside that, a robust web application with a proper database management system. The system is very modular and is designed in a way to be more scalable in the future.

1.2 Computer Vision Introduction

Computer vision is a field of artificial intelligence (AI) that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs — and take actions or make recommendations based on that information. If AI enables computers to think, computer vision enables them to see, observe and understand.

Computer vision works much the same as human vision, except humans have a head start. Human sight has the advantage of lifetimes of context to train how to tell objects apart, how far away they are, whether they are moving and whether there is something wrong in an image.

Computer vision trains machines to perform these functions, but it has to do it in much less time with cameras, data and algorithms rather than retinas, optic nerves and a visual cortex. Because a system trained to inspect products or watch a production asset can analyse thousands of products or processes a minute, noticing imperceptible defects or issues, it can quickly surpass human capabilities.

Computer vision needs lots of data. It runs analyses of data over and over until it discerns distinctions and ultimately recognizes images. For example, to train a computer to recognize automobile tires, it needs to be fed vast quantities of tire images and tire-related items to learn the differences and recognize a tire, especially one with no defects.

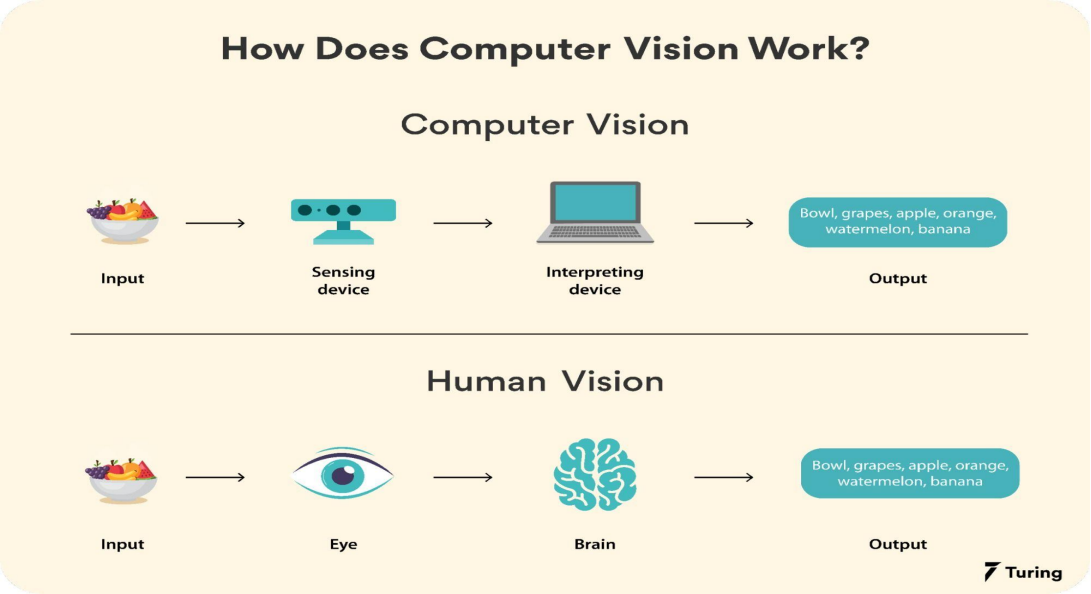

Figure 1.1: How does Computer Vision VS Human Vision work?

1.3 Details about Osteoarthritis

Osteoarthritis is one of the most common forms of arthritis, affecting millions of people worldwide. It occurs when the protective cartilage that cushions the ends of your bones wears down over time. Osteoarthritis is the second most common rheumatologic problem and it is the most frequent joint disease with a prevalence of 22% to 39% in India (over 10 million cases were observed last year). OA is more common in women than men, but the prevalence increases dramatically with age. The knee is one of the joints most commonly affected by osteoarthritis. Cartilage in the knee may begin to break down after sustained stress, leaving the bones of the knee rubbing against each other and resulting in osteoarthritis. To examine that, a Radiologist observes the XRay Report of the Patient. X-rays of arthritic knees may show a narrowing of joint space, changes in the bone and the formation of bone spurs(osteophytes). After determining the osteoarthritis grade, theradiologist gives corresponding comments and then reports are finalized.

Figure 1.2: An Osteoarthritis affected knee VS non affected knee

However, there is a significant time involved in this process (can vary from 2 to 4 days in India) of generating the final report and especially in areas where the population is considerably high and number of medicine practitioners are comparably low. Another thing to take into consideration especially for a developing country like India is that in private hospitals, the cost of treatment is high and in government hospitals there is a lot of overhead and managing physical reports can be difficult. In rural regions, there is an unavailability of infrastructure and healthcare services and considering results are highly dependent on the experience of radiologist it would be quite effective to automate this whole process

CHAPTER 2

LITERATURE SURVEY

Here this chapter contains the literature Survey of all the research papers that we have studied for this project.

Changchang Yin, Buyue Qian, Jishang Wei and four more presented research paper on Automatic Generation of Medical Imaging Diagnostic Report with Hierarchical Recurrent Neural Network which shows that how Medical images are widely used in the medical domain for the diagnosis and treatment of diseases. Reading a medical image and summarising its insights is a routine, yet nonetheless time-consuming task, which often represents a bottleneck in the clinical diagnosis process. Automatic report generation can relieve the issues. However, generating medical reports presents two major challenges: (i) it is hard to accurately detect all the abnormalities simultaneously, especially the rare diseases; (ii) a medical image report consists of many paragraphs and sentences, which are longer than natural image captions. We present a new framework to accurately detect the abnormalities and automatically generate medical reports. The report generation model is based on a hierarchical recurrent neural network (HRNN). We introduce a topic matching mechanism to HRNN, so as to make generated reports more accurate and diverse. The soft attention mechanism is also introduced to the HRNN model. Experimental results on two image-paragraph pair datasets show that our framework outperforms all the state-of-art methods.
In this paper they propose a new framework to learn to detect disease and generate medical reports from initial images. They propose a GLP mechanism and the abnormality detection experiment shows that GLP(Global Label Pooling) performs better than GFP(Global Feature Pooling).

Department of computer science project Presented research paper on automatic radiology report generation based on multi view image fusion and medical concept enrichment . Generating radiology reports is time-consuming and requires extensive expertise in practice. Therefore, reliable automatic radiology report generation is highly desired to alleviate the workload. Although deep learning techniques have been successfully applied to image classification and image captioning tasks, radiology report generation remains challenging in regards to understanding and linking complicated medical visual contents with accurate natural language descriptions. In addition, the data scales of open-access datasets that contain paired medical images and reports remain very limited. To cope with these practical challenges, we propose a generative encoder-decoder model and focus on chest x-ray images and reports with the following improvements.

In this paper they represent a novel encoder dash Decoder model for radiology report generation. The proposed model takes advantage of multi view information in Radiology by applying visual attentions in late fusion fashion and reaches the ccmantics involved in the hierarchical LSTM Decoder with medical concepts. Consequently , both the visual and textual contents have been better exploited to achieve the state of the art performance as a valuable added benefit: uncertain radiography observations are extracted and visualised by their model because it is important to direct more export attention to such uncertainties for further analysis in practice.

Maram Mahmoud A Monshi , Josiah Poon & Vera Chung from University of Sydney presented a survey on Deep learning and generating radiology reports. Substantial progress has been made towards implementing automated radiology reporting models based on deep learning (DL). This is due to the introduction of large medical text/image datasets. Generating radiology coherent paragraphs that do more than traditional medical image annotation, or single sentence-based description, has been the subject of recent academic attention. This presents a more practical and challenging application and moves towards bridging visual medical features and radiologist text. So far, the most common approach has been to utilise publicly available datasets and develop DL models that integrate convolutional neural networks (CNN) for image analysis alongside recurrent neural networks (RNN) for natural language processing (NLP) and natural language generation (NLG).

This is an area of research that we anticipate will grow in the near future. We focus our investigation on the following critical challenges: understanding radiology text/image structures and datasets, applying DL algorithms (mainly CNN and RNN), generating radiology text, and improving existing DL based models and evaluation metrics. Lastly, we include a critical discussion and future research recommendations. This survey will be useful for researchers interested in DL, particularly those interested in applying DL to radiology reporting.

S. NO.	ARTICLE	KEY CONTRIBUTIONS	RESULTS
1	**Pingjun Chen, Linlin Gao, Xiaoshuang Shi, Kyle Allen, Lin Yang's "Fully automatic knee osteoarthritis severity grading using deep neural networks with a novel ordinal loss", 2019**	This article discusses the impact of knee osteoarthritis (OA) on older adults, highlighting the importance of early detection and intervention in slowing down the progression of the disease. The current grading system, based on visual inspection, is subject to interpretation and can vary widely depending on the experience of the physician. To address this issue, the article proposes the use of two deep convolutional neural networks (CNNs) to automatically measure the severity of knee OA, as assessed by the Kellgren-Lawrence grading system.	The paper discusses the use of a customized YOLOv2 model for detecting knee joints and fine-tuning CNN models with a novel ordinal loss for knee KL grading. The approach achieves state-of-the-art performance for both knee joint detection and knee KL grading. The YOLOv2 model is found to be well-suited for detection tasks with less varied object size, based on its performance in knee joint detection. Furthermore, the proposed ordinal loss helps improve classification accuracy and reduces the mean absolute error (MAE)
2	**Changchang Yin, Buyue Qian, Jishang Wei, Xiaoyu Li's "Automatic Generation of Medical Imaging Diagnostic Report with Hierarchical Recurrent Neural Network", 2019**	This article presents a novel framework for accurately detecting abnormalities and automatically generating medical reports. The report generation model is based on a hierarchical recurrent neural network (HRNN) with the addition of a topic matching mechanism to improve the accuracy and diversity of the generated reports. The HRNN model also incorporates a soft attention mechanism for further refinement. The experimental results of the framework on two image-paragraph pair datasets demonstrate superior performance compared to existing state-of-the-art methods.	The paper introduces a new framework that aims to detect diseases and generate medical reports from initial images. The proposed framework includes a GLP mechanism, which outperforms GFP in the abnormality detection experiment. Additionally, the framework incorporates a topic matching mechanism, context, and semantic attention into a hierarchical RNN to enhance the diversity of the generated sentences.
3	**Jianbo Yuan , Haofu Liao, Rui Luo, and Jiebo Luo's "Automatic Radiology Report Generation based on Multi-view Image Fusion and Medical Concept Enrichment ", 2019**	The generation of radiology reports is a time-consuming process that requires a high level of expertise. To address this, there is a need for reliable automatic radiology report generation to alleviate the workload. While deep learning techniques have been successful in tasks such as image classification and captioning, generating radiology reports is challenging due to the need for understanding and linking complex medical visual content with accurate natural language descriptions.	Thanks to modern techniques for training convolutional neural networks, even the most basic architectures can achieve remarkable performance. For instance, networks consisting solely of convolutions and subsampling operations can outperform, or at least match, state-of-the-art models on CIFAR-10 and CIFAR-100. A similar architecture can also deliver competitive outcomes on ImageNet. It is noteworthy that contrary to previous findings, including explicit pooling operations like max-pooling doesn't always enhance performance of CNNs. This is especially true when network is large enough to learn all the necessary invariances using convolutional layers alone for the given dataset.

CHAPTER 3

EXISTING PROBLEM & PROPOSED SOLUTIONS

Problem

- Osteoarthritis, also known as a degenerative joint disease (DJD), is the most common type of arthritis. Osteoarthritis is more likely to develop as people age. The changes in osteoarthritis usually occur slowly over many years, though there are occasional exceptions.
- Inflammation and injury to the joint cause bony changes, deterioration of tendons and ligaments and a breakdown of cartilage resulting in pain, swelling, and deformity of the joint.
- To examine Osteoarthritis, a Radiologist observes the XRay Report of the Patient. X-rays of arthritic knees may show a narrowing of joint space, changes in the bone, and the formation of bone spurs(osteophytes). After determining the grade of osteoarthritis, the Radiologist gives corresponding comments and then reports are finalized.
- However, there is a significant time involved in this process (can vary from 2 to 4 days in India) of generating the final report and especially in areas where the population is considerably high and number of medicine practitioners are comparably low.

Solution

On the other hand Automated Osteoarthritis report generation helps diagnose patients and reduces the amount of work for doctors. A report generated by an automated medical report generator must be trustworthy, easy to understand and accurate in order to be used effectively in practice. The quality of the explanations on how the report was generated and how its diagnoses were reached is a key factor to meet these goals. Having a system that is explainable allows developers to identify any shortcomings or inefficiencies and clinicians to be confident in the decisions they make with the help of these systems.

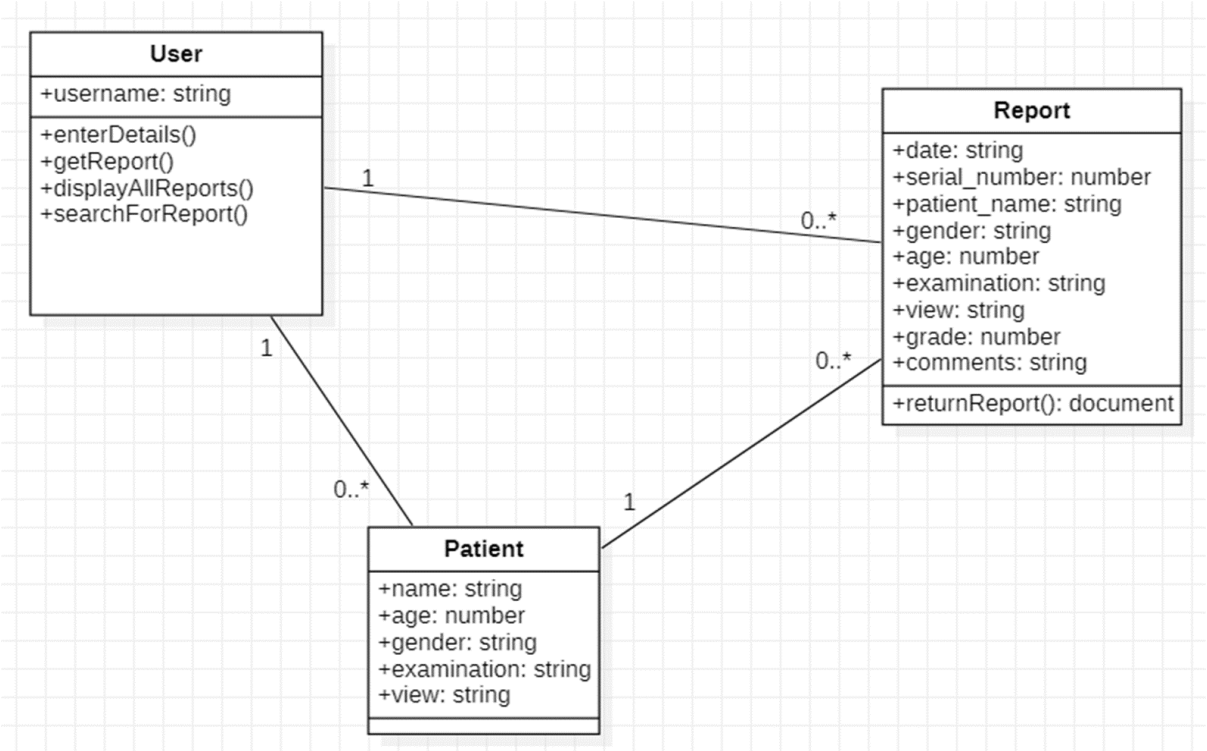

Figure 1.3: Class Diagram

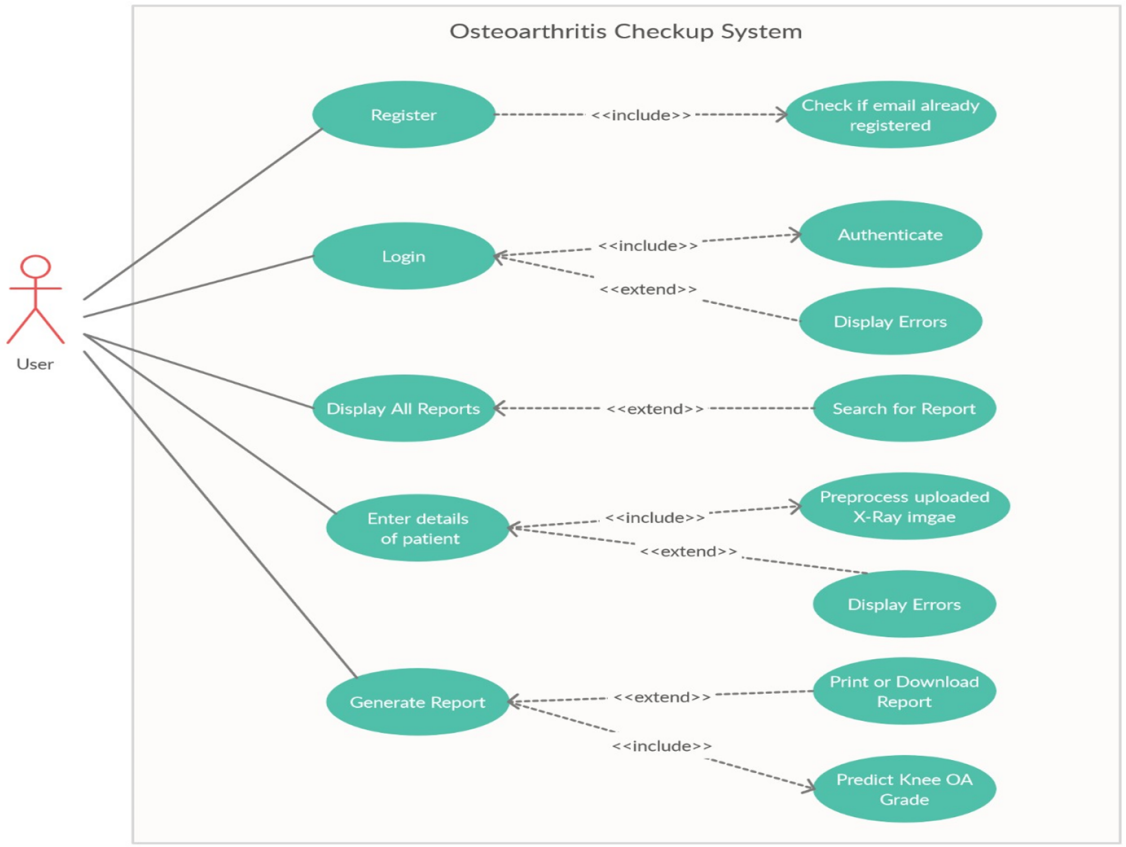

Figure 1.4: Use Case Diagram

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