Designing a Framework for Standardization of Ophthalmic Imaging Data using DICOM

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Standardization of Ophthalmic Data

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Declaration

I hereby certify that I have developed this thesis titled as *" Designing a Framework for Standardization of Ophthalmic Imaging Data using DICOM"* entirely on the basis of my personal efforts under the sincere guidance of my supervisor Dr. Muhammad Usman Akram. All of the sources used in this thesis have been cited and contents of this thesis have not been plagiarized. No portion of the work presented in this thesis has been submitted in support of any application for any other degree of qualification to this or any other university or institute of learning.

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Language Correctness Certificate

This thesis has been read by an English expert and is free of typing, syntax, semantic, grammatical and spelling mistakes. Thesis is also according to the format given by the university.

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ABSTRACT

Electronic Medical Record (EMR) and Medical Standard plans are used to save patient's information and medical records i.e. test report, radiology tests etc. This information can be useful to check patient history and also to predict disease trends in a specific region or age group. This data sometimes also needs to be shared between different hospitals and specialists which requires data compatibility. Medical standards like HL-7, DICOM and IHE etc are designed and developed to solve the issue of data compatibility while sharing the data between different nodes. DICOM is developed to have proper sharing of data which contains images. It is being used for proper saving of data containing MRIs, CT scans etc in different medical department but its use in ophthalmology is rare. Most of tests and treatment in ophthalmology consist of data in form of digital images and use of medical standard being capable of storing patient data along with images is required. In this research, we proposed a DICOM framework for identification of suitable tags which can be used in ophthalmology to facilitate doctors to save patient ophthalmic data along with digital images. For this reason, we conducted a workshop and survey in which ophthalmologists are invited to collect precise and ophthalmic related tags for OCT, Fundus and Slit lamp images. We support our framework with automated detection of laser marks from fundus images and the framework saves the diagnosis results along with the image in a DICOM format. Proposed framework proves that doctors can work, tag and view DICOM ophthalmic images easily.

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CHAPTER 1: INTRODUCTION

Medical imaging is a practice, art and process of making graphical demonstrations of the inner portion which cannot be examined easily of a human body for medical mediations and clinical analysis. Medical Imaging strive to expose the internal erection which is concealed by bones and skin as well as to diagnose and to treat the disease. With the help of medical imaging database of physiology and normal anatomy to make it potential for the doctors to identify different kind of diseases. However imaging of removed tissues and organs can be executed for medical reasons, such procedures are not the part of medical imaging but it is the part of pathology. In this chapter a brief account of the analysis of the Fundus Images, structure of eyeball, Laser Procedure, Diabetic Retinopathy and types of laser treatment in fundus images is explained. The detailed analysis of different structures is described step by step.

1.1. What is DICOM

DICOM (Digital Imaging and Communications in Medicine) used for transmission of medical images, waveforms and accompanying information. The Digital Imaging and Communications in Medicine (DICOM) standard is everywhere for more than a decade now. Though, it was not while waiting for the mid-nineties that the DICOM standard actually appropriated off. Nowadays, almost all medical imaging devices which are used in radiology, such as MRI, CT, RF, Ultrasound, and other various medical domain rooms, supports the DICOM standard for the interchange of related information and images.

1.2. What is FUNDUS

Fundus image is the creation of photograph of eye inner surface. The inner surface of eye includes macula, optic cup, Retinal vein, Retinal artery, Fovea and Neuro Retinal Rim.

1.3. Retinal Veins

The perivenular vessels finally form the four main branches (infer nasal, super nasal, infer temporal, and super temporal) earlier creating the central retinal vein at optic disc. In retina, vessels are cross over on one another.

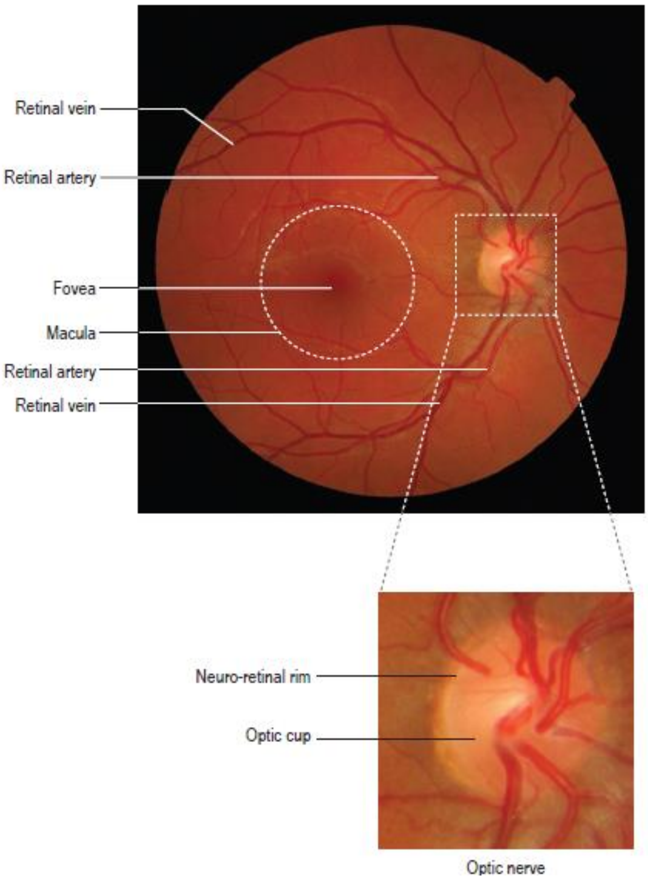

Figure 1 Normal Fundus Image

1.4. Retinal Arteries

We can see the blood flowing in the walls of Retinal blood vessels because it is transparent. The arteries seems narrower and lighter as compared to retinal veins. On fundosopy, arteries seemed to be finer and lighter in comparison with retinal veins. Central retinal artery which is emerged from optic disc is further divided into four paths i-e infer nasal, super nasal, infer temporal and super temporal. The superior branches normally do not converse with inferior branches because superior branches respect the horizontal raphe. Retinal capillary wall is lined by pericytes and endothelial cells, jointly form a close-fitted retinal inner barrier. Retinal vessels of blood are automatically regulated similar those of brain.

1.5. The Optic Disc

Measuring about 1.5 mm, the optic disc lies about 3 mm nasal to the fovea. The optic disc edge may be somewhat elevated. At the optic disc the neuro-retinal rim is made by the only neuro-retinal elements are the axons of the ganglion cells. The 30 % of the whole optic disc area is occupied by the central part, the optic cup, is lighter and seems dejected on binocular stereo fundoscopy. The dominant retinal vessels leave and enter in this dejection. Small capillaries also exist in optic disc. Physiologically the blind spot signifies optic disc. Fundus photography is used by ophthalmologists, optometrists, and trained medical professionals for monitoring development of a disease, disease diagnosis (combined with retinal angiography), or in epidemiology and screening programs [4][5].

1.6. THE EYEBALL

Human Eye Ball is a type of structure which maintains the pressure of intraocular and inflates by the pressure applied from the inside. It is normally denoted as globe in medical terms, the human eye is ablate spheroid in shape.

1.6.1 Dimensions of Mature Eyeball

Weight 7 gm

Volume 6.5 ml

Circumference 75 mm

Vertical diameter 23 mm

Horizontal diameter 23.5 mm

Anteroposterior diameter 24 mm

1.1.1. Human Eye Ball Coats

The human eyeball includes three coats: inner (nervous coat), middle (vascular coat) and outer (fibrous coat).

a. ***Nervous coat (retina)***. It involves the working of visual functions.

b. ***Vascular coat (uveal tissue)***. Its working is to supply diet substances to the numerous structures of human eyeball. It is further sub divided into three more parts known as choroid, ciliary body and iris.

1.7. Motivation

DICOM stands for Digital Imaging and Communications in Medicine and is a non-proprietary standard for managing, printing, storing and transmitting information in medical imaging. Since the initiation of this standard some 30 years ago, it developed the common standard of digital medicine and the motivating force after the entire medical imaging workflow. In different medical departments DICOM is emerged rapidly during the last decade and enabled doctors and patients for fast exchange of information between each other. Nowadays DICOM got all prerequisites to compete with other traditional medical standards. The aspect of platform independence and covering each medical departments makes DICOM even more promising for the future. Since medical software used in medical applications is commonly proprietary and mostly limited to a specific medical department like Cardiology, Dermatology, Haematology, Gynaecology, Neurology, Oncology e.t.c. The objective of our thesis is to apply DICOM on different ophthalmic medical images by keeping focus on their ophthalmic tags. Although there are tags in DICOM but these are general purpose tags and physicians want ophthalmic specific tags to enrol ophthalmic department more practical in DICOM. We provide Service Oriented Architecture to physicians to use DICOM services remotely.

1.8 Scope and Objectives

DICOM is the new research area in which scholars can add their work with respect to DICOM in different medical departments. Only few research papers are published related to image tagging with specific medical field [22, 26]. Scholars are working around DICOM generally, they are not specifying the research to its area. Most of the time patient history is not maintained with lab test results or if it is maintained then it is given in hard copy to the patients in the end. The objective of our thesis is to provide a platform to the physicians and patients to communicate its medical record easily. Proposed system has the following objectives.

- To grab the attention of students and researchers towards DICOM in different medical fields because more work is needs to be done in this area.
- To create awareness in academic persons such as students and researchers about the need of DICOM care systems in ophthalmic department.
- To create an environment for active research in biomedical applications in research & educational institutes of Pakistan.
- To facilitate physicians on hands on computer technology in purpose to carry out medical and medical technology parallel.

CHAPTER 2: Medical Imaging Techniques

Medical imaging includes various imaging techniques and processes of human body image for analysis and treatment purposes and as a result has an important part in the enhancement of civic health in all inhabitants groups. Moreover, medical imaging is acceptable also to monitor the sequence of an illness previously treated and/or identified. The area of medical imaging is very multifaceted and, be contingent to a circumstance, involves additional activities of medical physicists, biomedical engineers, medical doctors as well as technicians. The capability to acquire data about the human body has many useful clinical applications.

2.1 Medical Imaging Techniques

From years, various types of medical imaging devices has been developed. Each device is such designed to collect information from various parts of human body externally or internally. We will be discussing these imaging techniques step by step.

2.1.1 Computed Tomography (CT)

Computed Tomography (CT), also usually denoted by a CAT scan or CT scan. It is a medical imaging technique which combines several X-ray prognostications engaged from different angles to produce in depth cross-sectional images of regions inside the body. CT medical imaging permit doctors to acquire very detailed, 3-D sights of various parts of human body, such as the lungs, soft tissues, the heart, blood vessels, the pelvis, the brain, bones and abdomen. CT scan is also a lot preferred method suggested by doctors for identifying various cancer diseases, such as lung, liver and pancreatic cancers [1]. Figure 2.1 shows the normal CT image of human brain.

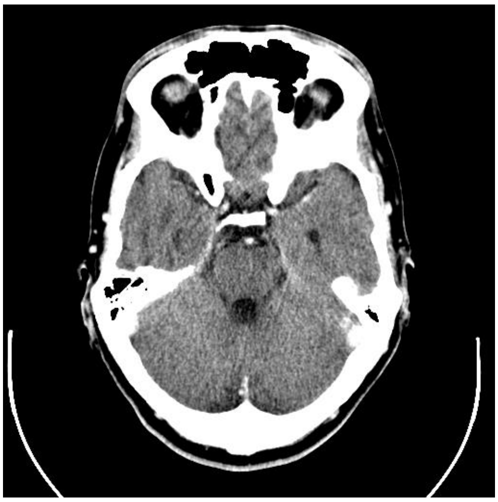

Figure 2.1 Computed Tomography Scan [1]

CT scan is every so often used to evaluate:

- Presence, size and location of tumors
- Abdominal aortic aneurysms
- Organs in the pelvis, chest and abdomen
- Colon health
- Traumatic injuries
- Vascular condition/blood flow
- Bone injuries
- Pulmonary embolism
- Cardiac tissue
- Cardiovascular disease

2.1.2 Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging (MRI) is a medical imaging technique which uses magnetic field and radio waves to create a detailed image of tissues and organs. MRI has shown to be extremely operative in diagnosing a numeral conditions by presenting the variance between normal and diseased soft tissues and organs of a human body. Figure 2.2 shows the MRI scan of normal brain sagittal view.

Figure 2.2 Magnetic Resonance Image Scan [2]

MRI is often used to evaluate:

- Blood vessels
- Breasts
- Abnormal tissue
- Joints and Bones
- Spinal injuries
- Organs in the chest, pelvis and abdomen (heart, liver, kidney, spleen)
- Tendon and ligament tears

2.1.3 Positron Emission Tomography (PET)

Positron Emission Tomography (PET) is a technique of nuclear imaging which deliver physicians with statistics about how organs and tissues are working in a human body. PET, often used in combination with CT medical imaging. It processes a scanner and a small amount of radiopharmaceuticals which is vaccinated into patient's vein to contribute in making computerize, detailed pictures of the areas present inside the human body.

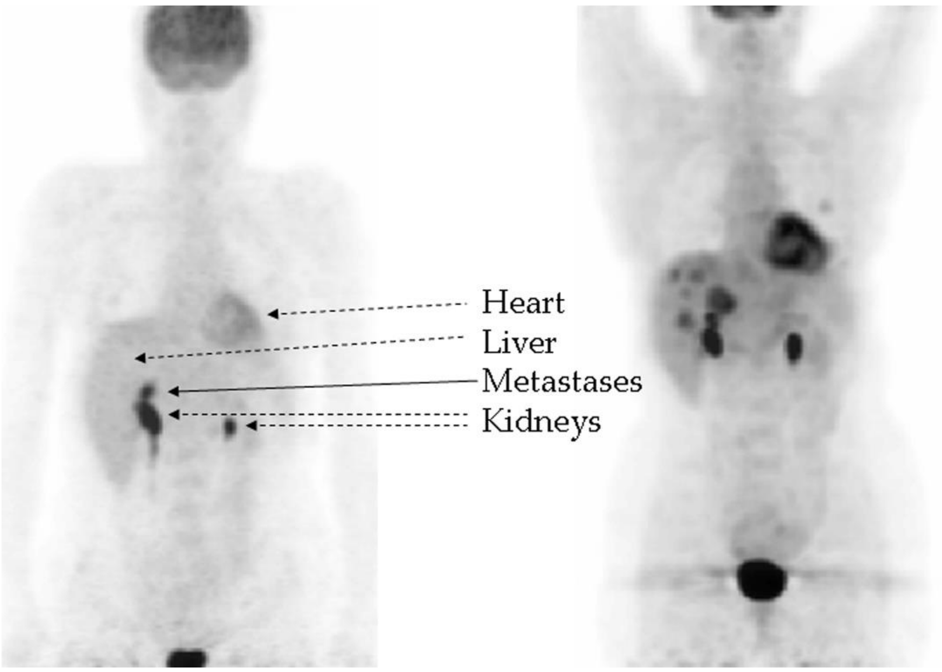

Figure 2.3 Positron Emission Tomography Scan [3]

In figure 2.3 Metastatic Cancer from a primary tumour in the colonis detected in right image. The major cancer in the colon is not observable as it was detached surgically, but the disease at present had spread closely shown in the PET image on the left. There's a progression on the liver, and the right image shows small lung mets and multiple liver met. (Keep in mind that darker area in image means more FDG (Fluoro-D Glucose) uptake.)[3]

PET is often used to evaluate:

- Neurological diseases such as Alzheimer's and Multiple Sclerosis
- Cancer
- Inefficiency of treatments
- Heart circumstances

2.1.4 PET-CT

For adding accuracy, doctor of medicine use a medical imaging method that syndicates CT and PET. This permits images picked up from both devices to be taken consecutively and collective into a distinct superposed image. PET-CT assists as a major tool in outlining of tumour volumes, performance and the preparation of patient management plans.

2.1.5 Ultrasound

Diagnostic ultrasound, also known as ultrasonography or medical sonography, produces high frequency sound waves to generate images of the inside of the body. Figure 2.4 shows the ultrasound image of a female in which Pregnancy is detected.

Figure 2.4 Ultrasound Scan of Pregnant Female [4]

The ultrasound machine directs sound waves into the human body and is capable to convert the recurring sound echoes into a picture. Ultrasound technology can also directs clear sounds of blood flow, allowing medical specialists to use both visuals and sounds for evaluating a patient's health.

Ultrasound is often used to evaluate:

- Pregnancy
- Swelling and infection
- Organs in the pelvis and abdomen
- Abnormalities in the heart and blood vessels
- Symptoms of pain

2.1.6 X-Ray

X-ray equipment is the first and most generally used form of medical imaging. X-rays use ionizing radiation to generate images of a person's internal body by transferring X-ray beams through the body, which are captivated in different quantities reliant on the density of the substance. Moreover, comprised as "x-ray type" devices are also interventional radiology, mammography, computed tomography (CT), computed radiography and digital radiography. Radiation Therapy is a selection of device which too make use of either x-rays, gamma rays, electron beams or protons for cancer treatment. Figure 2.5 shows the normal X-ray image of human hand.

Figure 2.5 X-Ray Scan [5]

X-ray images are typically used to evaluate:

- Broken bones

- Blood vessels
- Swallowed objects
- Lungs
- Cavities
- Breast (mammography)

2.1.7 Elastography

Elastography is a novel imaging technique which records the elastic features of soft tissue. This modality developed in the last decade. Elastography can use magnetic resonance, ultrasound, imaging and tactile imaging. Figure 2.6 human liver is detected. Based on how stiff the pressure wave, displays these comparative stiffness values in a color-coded image.

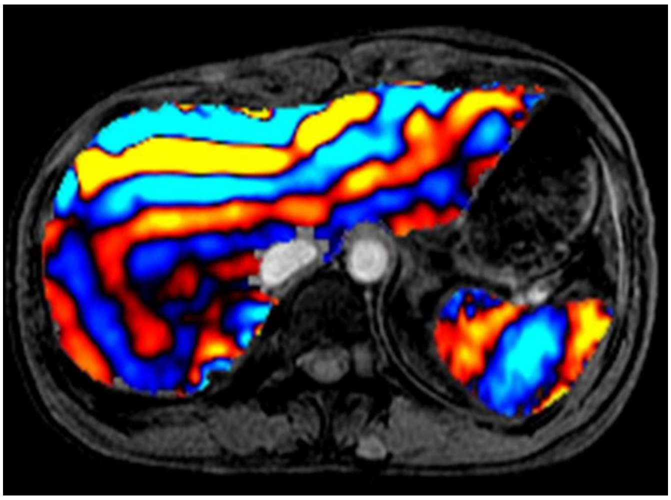

Figure 2.6 Elastography Scan [6]

2.1.8 Tactile imaging

Tactile imaging is a medical imaging technique which interprets the intelligence of touch into a digital image. Tactile imaging narrowly simulates physical palpation, since the probe of the device with a pressure sensor array mounted on its face acts similar to human fingers during clinical examination, slightly deforming soft tissue by the probe and detecting resulting changes in the pressure pattern. In the below figure 2.7 a tissue phantom with implanted hard insertions (simulated tumour) has been technologically advanced. The phantom is made of a silicone compound. [7]

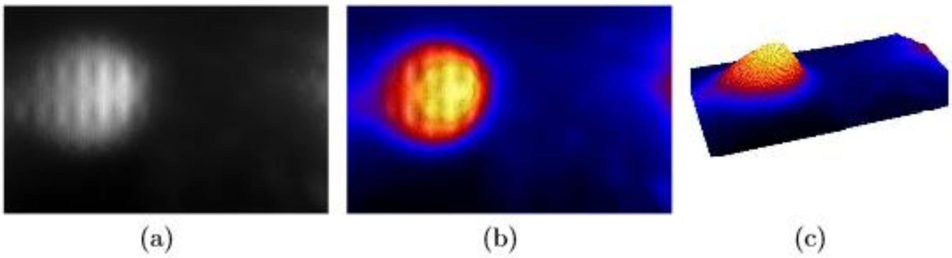

Figure 2.7 The tactile image of inclusion with 3.29 diameter placed at the 4.2 mm depth. A. Gray Scale Image . B. Color image. C.3-D reconstruction [7]

This modality is used for imaging of the prostate [8] breast,[9] vagina and pelvic floor support structures,[10] and myofascial trigger points in muscle.[11]

2.1.9 Echocardiography

When Ultrasound is used for heart image, it is referred to an echocardiogram. Echocardiography permits in depth structures of the heart, including heart function, chamber size, heart valves, as well as the pericardium (the sac around the heart) to be seen. Figure 2.8 describes an ultrasound of the heart. If a weakness in the heart's structure or mechanical function is causing problems, an echo frequently regulate the cause of it.

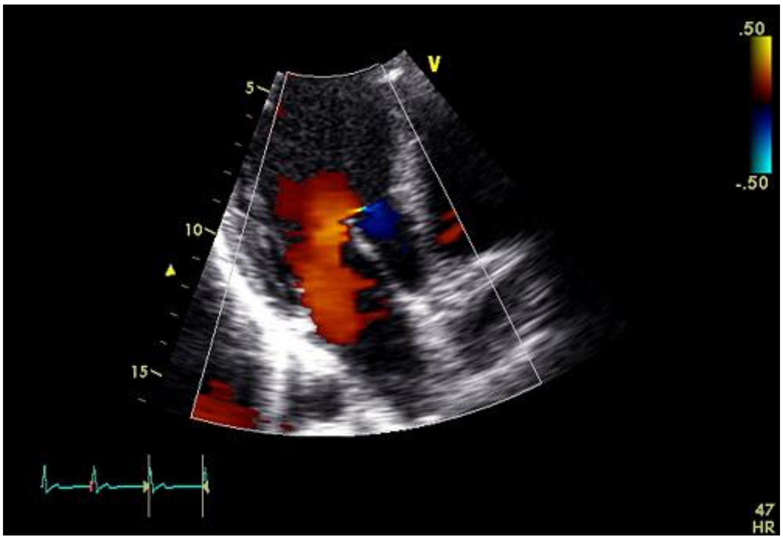

Figure 2.8 Ecography Scan [12]

Echocardiography uses Doppler Imaging 2D and 3D to create image portion of the heart and envision the flow of blood through the four valves of heart. Echocardiography is extensively used in an arrangement of patients going through indications, such as chest pain or shortness of breath, to those experiencing cancer treatments. Transthoracic ultrasound has stood proven to be harmless for patients of all ages, from babies to the old, without risk of unsafe radiation or side effects, distinguishing it from further imaging modalities. Echocardiography is one of the best normally used imaging modalities in the medical imaging domain due to its portability and use in a diversity of uses. In emergency circumstances, echocardiography is easily accessible, quick and intelligent [13]

2.2 Medical Imaging for Ophthalmology

Diagnosing Ophthalmic images bridges science and art resulting in images that diagnose different eye infections and conditions, provide images for treatment and teaching, to document the progress of treatment, and research in ophthalmology.

2.2.1 Colour Fundus Images

Ophthalmic diagnostic imaging combines art and science to result in images to diagnose eye diseases and conditions, to document the progress of treatment, and to provide images for teaching, and research in ophthalmology. The vessels form an arc round the macula which makes the principal 20 degrees of vision. At the midpoint of the macula lies the minute fovea, quantifying only 500 microns across, which is in control for our utmost significant reading vision. Figure 2.9 shows the colour fundus images

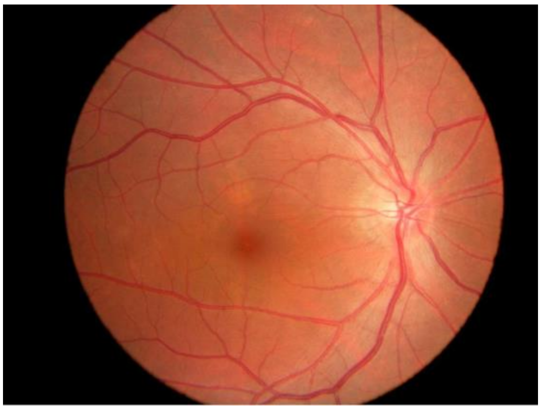

Figure 2.9 Color Fundus Image

Colour Fundus imaging is used to monitor the circumstance of these erections in order to document the existence of illnesses and analyse their variation over time.

2.2.2 Angiography

Fluorescein angiography stood first positively used in the human eye in 1961[14] and has progressed since then as one of an important medical imaging methods in the eye. It is a test which helps in the diversity of retinal ailment and is used to decide if laser cure of the retina is necessary. Figure 2.10 shows FFA image of eye

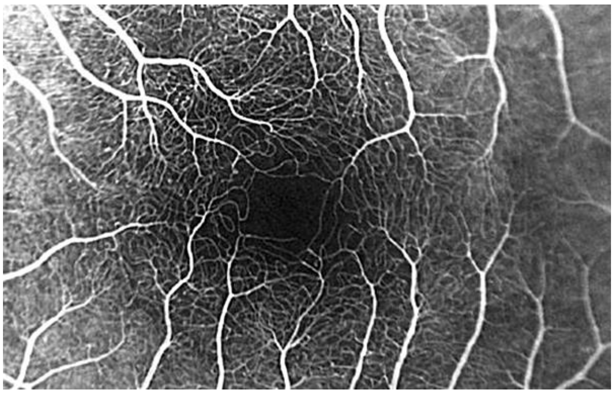

Figure 2.10 Fluorescein [14]

A distinction intermediate called Sodium Fluorescein is vaccinated into a vein in an arm. The colour movements quickly through the body's vascular system, and is snapped in black and white as it movements through the eye. The same camera used for fundus photography is engaged for this process. Two exceptional filters are used to bind the image to the colour of light being produced from the fluorescent dye.

2.2.3 Slit lamp Images

Slit Lamp Biomicrography is type of medical imaging with arrangements of the eye with a particularly planned horizontally mounted microscope. The main brilliance for the microscope is formed by a light which can be accustomed from a very wide pattern to a very thin slit of light. Figure 2.11 shows the normal slit lamp scan of human eye.

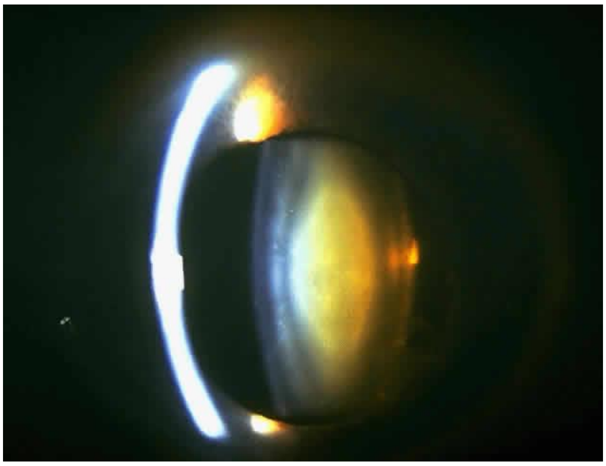

Figure 2.11 Slit Lamp Scan of Human Eye [15]

It is from this slit of light, Slit lamp derives its name. The slit can be used to insulate structures in the eye [15]. These images explains the use of a narrow slit of light to recognize the outsides of the cornea and lens of the eye.

2.2.4 OCT Images

Optical coherence tomography (OCT) is noninvasive, noncontact, imaging method which can make images of structures in the retina with a resolution of 10 to 17 microns. Cross-sectional images of the retina in a manner related to ultrasound but at an abundant advanced resolution and use light waves instead of sound waves [1]. Figure 2.12 shows the normal scan of Human eye.

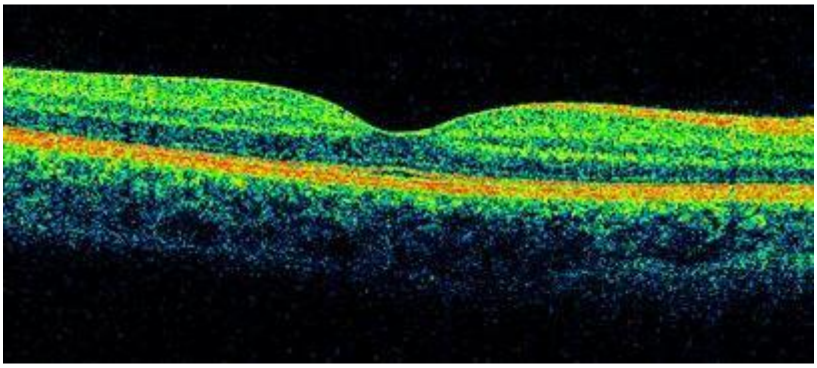

Figure 2.12 Normal OCT Scan of Human Eye [1]

In OCT, the anatomic layers within the retina can be visualized and the viscosity of the retina can be measured. It is an advance diagnostic imaging because it permits simultaneous visualization of the microstructure of a soft tissue lacking the necessity to process and excise a biopsy sample. It is used together for guide intervention and diagnosis. The OCT is useful in visualizing the pathology of several eye diseases together with diabetic retinopathy, macular degeneration, macular holes, central serous choroidopathy, macular edema, epiretinal membranes, and optic disc pits. OCT was first introduced in 1991[Huang, 1991] and has since been adapted to a number of clinical biomedical imaging settings including ophthalmology. The main ophthalmology influence has been the medical imaging of the retina [1].

CHAPTER 3: Health Care Standards

Most Health Care/medical standards malpractice cases hinge on whether a health care professional is negligent in treating (or failing to treat) a patient. And medical negligence is always measured by the medical standard of care that applied in the specific treatment setting in which the patient is harmed. Various healthcare standards or creativities serve the different healthcare segments effectively in delivering critical information between systems. Examples of key healthcare integration standards include:

3.1 Types of HealthCare Standards

3.1.1 HL7

Health Level Seven –It offers standards for swap in and swap out Clinical or Hospital Data. Clinical Document Architecture, announced (CDA R1), turn out to be an approved HL7 Standard in November 2000, HL7 in place of the first specification derived from the Health Level 7 (HL7). HL7 focuses mostly on how the standard has changed predominantly in the area of semantic depiction of clinical measures.

3.1.2 DICOM

Digital Imaging and Communications in Medicine – It delivers the functionality for storing, managing, printing, and transferring of patient information in medical imaging.

3.1.3 HL7 CDA

Clinical Document Architecture – It provides an exchange model (XML-based) for clinical documents (such as discharge summaries and progress notes); recently known as the Patient Record Architecture (PRA). The document of CDA is a distinct and comprehensive information object which contain images, text, sounds, and other interactive contents. It can be relocated within a message and can exist autonomously, outside the relocating message [16].

3.1.4 CCR

Continuity of Care Record – The co-occurrence of both HL7 and HL7 CDA standards might need plotting from one standard to the other, which can be go along with by a damage of functionality and information. CCR responds to the need to organize and make transportable a set of basic information about a patient's health care that is accessible to clinicians and patients. [17]

3.1.5 CCOW

Clinical Context Management Specification – allows clinical applications to share information at the point of care. Context Management permits an operator to gain a joined view of a specific area in medical, an encounter of patient or patient like, crossways many clinical uses at a single point at one time [18]. CCOW has been implemented in the Canada and USA in specific with many profitable sellers now they are providing CCOW-compliant clinical information systems.

3.1.6 LOINC

LONIC stands for Logical Observation Identifiers Names and Codes. LOINC relates universal identifiers and names in terminology of medical which is associated to e health records. The determination is to backing in the electronic discussion and collection of clinical results (such as clinical observations, laboratory tests, outcomes management and explorations). It is divided into two main portions i-e clinical LOINC and laboratory LOINC. Clinical LOINC comprises of Document Ontology which gives information about types of clinical outcomes and documents.

3.1.7 ELINCS

EHR-Lab Interoperability and Connectivity Standards – an emerging standard for reporting lab test results. Communication amongst medical and laboratory provider can be a ruptured procedure in which results and orders are sent by mail or fax. Laboratory results are sent on paper which must be filed in the patient's paper chart or manually come into the physician's HER [19].

3.1.8 SNOMED

Systematized Nomenclature of Medicine Clinical Terms – is an organized, computer automatic gathering of medical results, in veterinary medicine and human, to be responsible for codes, rapports, synonyms and characterizations which cover diseases, anatomy, findings, microorganisms, procedures, substances, etc. It permits a reliable technique to store, index, aggregate and retrieve medical data from corner to corner laboratories and specialties who care. Certainly, measures and diseases were methodical hierarchically and are promoted referenced back to additional fundamental standings.

3.1.9 NCPDP

National Council for Prescription Drug Programs – governs medicine transactions.it provides a precise process for miscellaneous healthcare investors to work in an organized manner for the joint good. NCPDP consensus-based standards that associate healthcare electronically, make more efficient the system and take safety measures for the patients to convey them.

3.1.10 IHE

Integrating the Healthcare Enterprise – promotes the coordinated use of established healthcare integration standards, such as DICOM and HL7, to address specific clinical needs in support of optimal patient care. IHE operates and create a practice over and done with which interconnectivity of health care organizations can be better-quality. The collection meets case necessities, recognizes existing standards, and advances practical procedures which companies can implement in their organizations. IHE also facilitates companies and other organization by "connectathons" and "interoperability showcases" in which company can easily establish the interoperability of their products [20].

3.1.11 CCHIT

Certification Commission for Healthcare Information Technology – work for known US certification authority for electronic health records (EHR) and their networks. In September 2005, CCHIT was awarded a 3-year contract by the U.S. Department of Health and Human Services to develop and evaluate the certification criteria and inspection process for EHRs and the networks through which they interoperate the goal of CCHIT is to decrease the danger of Health information Tech (HIT) asset by surgeons and other suppliers and to protect and secure the patient personal healthiness information. [21]

3.1.12 HITSP

Healthcare Information Technology Standards Panel – contributes in attaining extensively accepted and readily-implemented consensus-based standards that will allow and provision general interoperability between healthcare information technologies, especially as they would interact in a Nationwide Health Information Network (NHIN) for the United States. The main goal of HITSP is to keep the record of Medication History, Consumer Empowerment ,Registration Summary , Laboratory results reporting ,Clinical data , Radiology , Access to clinical data, Personal health record, On site care , Emergency care etc.

3.2 Evolvement of DICOM

The word DICOM stands for Digital Imaging and Communications in Medicine which is the fundamental and universal standard in the field of medical imaging. It provides all the necessary tools for the diagnosing the precise results and also represents the handling of data used in medical imaging. The manufacturing, using and selling of DICOM device spans a phase of several years .DICOM standard was considered in 1983 by a combined committee formed by the National Electrical Manufacturers Association (NEMA) and American College of

Radiology (ACR). The main goal was to make such a standard that would make medical imaging autonomous of some particular medical devices, thus simplifying the usage and development of digital imaging. The combined committee named it ACR-NEMA Digital Imaging and Communications Standards Committee and began it operational by studying many other medical standards which were well-known at that time. American Association of Physicists in Medicine (AAPM) implemented a standard for storing medical images on magnetic tapes. AAPM took the methodology of encoding all statistics or info as classifications of data elements. Each element must have a unique name (tag) and variable length (size). ACR-NEMA adopted the idea of tag and size for representing the data as classification of tagged data elements. Furthermore, DICOM is not only considered a file format or an image. It all-encircles data transfer, data storage, and define protocols for communication which covers all functional features of digital medical imaging, that is why many people view DICOM not only a single standard but a set of standards. No doubt, DICOM is truly leading practical digital medicine. All DICOM corporations include their names in PACS (Picture Archiving and Communication Systems). PACS consist of essential hardware and software design which is used to execute digital medical imaging. It consists of digital image stores (where the acquired images are stored), acquisition devices (modalities – such as ultrasound, Computed Tomography (CT) scanners) and computer unit (where radiologists view these images). When you acquire images with digital camera (modality), save these images in your hard drive (archive), and send these images to doctors for check-up (reviewers), you use the exact same model [22]. DICOM has accurately formed the background of modern medicine by providing the following facilities.

3.3 Universal standard of digital medicine

All existing, medical image acquisition devices acquire DICOM (.dcm) images which exchange data through DICOM systems. Present medical workflow is indirectly organized by DICOM.

3.3 Exceptional Image Quality

DICOM ropes up to 65,536 (16 bits) scales of gray level for monochrome images, therefore acquiring the minor degrees in medical imaging. Furthermore conversion of DICOM (.dcm) images into bitmap (.bmp)s or JPEGs (.jpg) are all the time partial to 256 shades of gray, every so often makes them impracticable for diagnostic reading.

3.4 Full backing for various image-acquisition parameters and different data Types

DICOM not only store the images but it also keep the record of image exposure parameters, multitude of other image-related parameters such as patient 3D position, physical sizes of objects in the image, slice thickness and so on. Such data enormously improve the informational content of DICOM images.

3.5 Complete Encoding of Medical Data

DICOM messages and files practice more than 2000 standardized attributes know as tags (DICOM data dictionary) to deliver several medical data from image color depth to patient name, to current patient diagnosis. These data are often essential for accurate diagnostics, and capture all aspects of the current radiology.

3.6 Precision in relating digital imaging devices and their functionality

DICOM defines the functionality of medical devices very precise .Practicing medical devices from end to end with DICOM interfaces turns out to be a very straight forward procedure, leaving little room for errors.

3.7 Scope and field of application

The DICOM Standard addresses the following:

- DICOM Tags and a medical directory configuration is used to facilitate patients and doctors to store patient information or data into the images and facilitates doctor to process and diagnose patient easily. This information can be easily exchanged to several other doctors because these unique tags contain a name, value characteristics and diagnosis of a patient.
- It defines a set of protocols for network communication .These protocols to be monitored by devices requesting conformance to the Standard.
- The semantics and syntax of Commands and related info which can be swapped via protocols.
- For media communication, a conventional of media storage facilities to be monitored by devices requesting conformance to the Standard
- Information that must be supplied with an implementation for which conformance to the Standard is claimed.

3.8 Structure of DICOM

DICOM is very simple and can be connected to variety of medical machines. DICOM system are already developed for Ultrasound machine, X-Ray, Computer Tomography (CT) scanner, Magnetic Resonance Imaging (MRI), Angioscopy , Biomagenetic Imaging, Computed Radiography(CR), Endoscopy, Positron Emission Tomography, Nuclear Medicine ,Diaphanography, Radiographic Imaging, Radio Fluroscopy, Radio therapy image, Inra Oral Radiography, Panoramic X-Ray, Slide Microscopy, Electrocardiography, Cardiac Electrophysiology, Intravascular Ultrasound, Intravascular Optical Coherence Tomography, Digital Subtraction ANgiog and Magnetic resonance spectroscopy.[23]

Figure 3.1 an example of DICOM structure to which a NON-DICOM ultrasound machine is connected .Images and video frames are collected from ultrasound machine which is furthermore sent to DICOM PC where these images and video frames are stored in DICOM for further action. DICOM PC is further connected to DICOM Cloud which provide the facility of Image Archive and Radiology workstation.

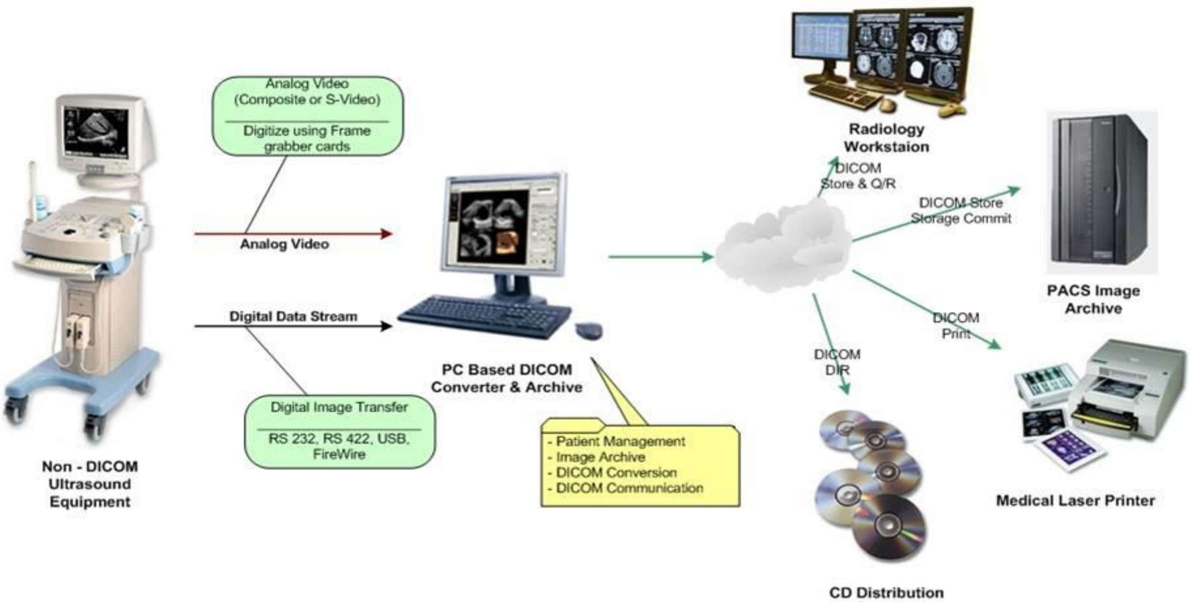

Figure 3.1 DICOM Structure [23]

3.9 Benefits of DICOM

DICOM facilitates us for transmitting and storing of diagnosis report of patient .This medical document can be communicated and stored in the form of images across all physicians where currently dicom is working. Modern medical Electronic Health potentials all the patients by providing timely access to their medical reports or records. These diagnostic images or reports are very important to patients as well as to doctors. Most of the time doctors need complete set of medical reports to study their previous diseases and its link to present disease. Usually imaging reports are devoted by radiologist who is understanding the images.

3.9.1 Well Communication with the Physician

DICOM reports are very complete and concise. They are at ease and faster to go through, particularly when the significant elements of the structure are accessible in such a way that they are highlighted or in indication. For case in point, the occurrence of a mass, its measurement, its situation, and its features can be spontaneously shown or printed in bold for an easier, faster and more actual communication to the person who reads about important elements.

3.9.2 Faster Improvement

With an organized input in DICOM, the understanding process is more rapidly and effects in a nearer turnaround that contributes to improve the further and larger procedure. In fact, with an organized input, the record step can be absolutely excluded. Therefore, the radiologist can make and validate the patient record in a single step, it helps in removing entirely waiting times from one step to another. In a less finest condition, wherever the record cannot be absolutely produced by the radiologist because more or less record is to be input by a typist, the other texts to be input is ordinary in small amount, which again reduces the probability of error occurrence and typing time. Furthermore, an organized input is likely to be extra operational than the speech recognition system, as typist errors are extremely doubtful, resulting in a precise actual confirmation job.

3.9.3 Minimized Typing

When the present organized input is used, not only user relations is lessened but also it amounts in lessening typing. Therefore, the time of typing is lessened and may be totally reduced. Furthermore, errors are reduced and spelling can be repeatedly tested by focused only on exact units of text (separating or leaving such properties, e.g., the patient’s name)

3.9.4 Guided understanding for a Complete Examination

This active structure can be operated to monitor the understanding procedure and quick the radiologist about the origins to study, delivering a comprehensive diagnosis result without any of missing mandatory or essential diagnosis. Missing diagnosis in a report lead to doubts, Doctor or person who reads the report will be unable to decide whether or not the omitted component has been studied or not.

3.9.5 Belongs the same Patient Report as the actual Image

The report is encoded as a DICOM file. So, it has the identical header as of DICOM images that were deduced to produce it. This preparation grasps an individual benefit in which the report shares the accession number, examination ID, patient name, patient ID, and other IDs with the image. Furthermore, it is a distinct sequence within the same study that encompasses the image series.

3.9.6 Transferring, Archived and Managed with the Images

The report can be moved amongst numerous DICOM imagining and archive workstations as the images. Additionally, it can be placed along or saved with the images. It can be exported on a CD, a DVD, or a long-term archive. It stays with the images within the same study. Table 3.1 shows the analysis of DICOM tools

Analysis of different DICOM Tools

Table 3.1 Analysis of DICOM Tools

Features	Sante DICOM	Radiant Dicom	Power Dicom	DICOM editor	OSIRIS	MATLAB	DICOM Works	EFILM	IFRAN View
Documentation	X	X	X	X	X	○	X	X	X
Maintainability	X	X	X	○	X	○		X	○
Extendibility	X	X	○	X	X	○	X	X	X
DICOM TAG Editing	X	○	X	X		X	○	X	○
Export Images as TIFF or JPEG	X	X	X	X	X	X	○		○

OS Dependent	○	○	○	○	**X**	○	○		**X**

In [24] N Skidmore et al. told that DICOM is almost existing or part of radiology but when it comes to ophthalmology DICOM interval stops in this regard. On daily basis Ophthalmologist’s store, create, interpret and retrieve medical images. These images are stored in repository of any clinic for decision making process on the basis of which Ophthalmologist do diagnosis and treatment of patients. The capability to effectively and accurately integrate the image and metadata into a workflow be governed by largely on devotion to the DICOM standard. In [25] Amatayakul M et al. discussed different medical standards such as CEN (Comite Europe´en de Normalisation), HL7 (Health Level 7), ASTM (American Society of Testing and Materials), DICOM and many more. Amatayakul M et al. added such standards which have made work easy for the doctors and patients to exchange their medical information or reports among system to system, doctor to doctor, Laboratory to Laboratory and doctor to patient.

In [26] M Nolden et al. tells us about the MITK (Medical Imaging Interaction Toolkit) which is been using and available as open source in market from last 12 years. M Nolden et al. mentioned that it provides the facility of modularization at various levels which includes image guided therapy, diffusion imaging, tool tracking and other external packages. Table 3.2 shows the literature review summary

Table 3.2 Literature Review Summary related to Health Care Standard

AUTHOR	YEAR	Purpose	FIELD
R.N.J. Graham, R.W. Perriss, A.F. Scarsbrook	2005	In this paper author give information about different image formats used in medical field	Radiology
WayneNewhauser a,b,n, TimothyJones a,b, StuartSwerdloff c, WarrenNewhauser d, MarkCilia d,e,	2014	In this paper author anonymized dicom tags and remove PHI(Protected Health Info) from Images	Radiation Therapy
Fiona Godlee, Neil Pakenham-Walsh, Dan Ncayiyana, Barbara Cohen, Abel Packer	2014	In this paper author give information of Medical field and sets some goals in medical field to be achieved or can be achieved in 2015 which can bring a change in medical records.	Medical
Denis Protti a,∗, Ib Johansenb, Francisco Perez-Torresc	2009	Author compared the status of primary care physicians in Denmark by collecting data.	EMR
Seok-Hwan Jang, Whoi-Yul Kim	2004	Author used to denote DICOM image with redundant channel which do not effect DICOM image	Chest and Skull DICOM images
Dan Grauer,a Lucia S. H. Cevidanes,b and William R. Proffit	2009	Author discusses diagnosis and treatment planning method in DICOM	Craniofacial images
Michael F. Chiang, MD,1 Michael V. Boland,	2011	Atuhor summarize the special requirements of EHRs that are important for ophthalmology	Ophthalmology

CHAPTER 4: Methodology

Very little work has been done on digital ophthalmic images with DICOM so far. Types of digital ophthalmic images are fundus images, OCT images and slit lamp images. Only very few research papers are found in which studies are performed on Dentistry with DICOM [27] perspective but no little work had been done for the detection of retinal signs with respect to image processing and DICOM. Our objective is to do a case study related to Fundus images and then apply the proposed private tags which are gathered during our survey for DICOM fundus Images. We will provide the option for doctors that they can add only those tags which they need for the patient. We are taking laser mark fundus images as a case study for our thesis. In fundus images a diabetic patient suffers from Diabetic Retinopathy, doctors suggest laser surgery to such patients. Once laser surgery is done then the surgeries area is considered to be normal region. Whereas normally when patient go for fundscopy after DR laser surgery then the region of laser mark is shown as abnormal region. Our objective of using DICOM is to apply medical standard on ophthalmic medical images that is FUNDUS, OCT and Slit Lamp. Previously very less medical standards are used for fundus, OCT and slit lamp images, if standards are used then it is not followed as standard. Only few of the medical standards are adopted in medical field with few functionalities. DICOM gives us the facility to tag the patient image. DICOM tags are such designed and are very generic which can be used in every medical department that is Neurology, Cardiology etc. In our thesis we are only dealing with DICOM tags. The elements of group 008 consist few tags for fundus image resolution, Patient and Physician references. These tags are very less informative for doctors to check patient history or to analyze patient fundus, OCT and slit lamp image. To specify and pin point our research for proposing tags for Ophthalmology we conducted a survey in which we met with different ophthalmologist. They suggested us that, with the tags which are listed in DICOM for ophthalmology is difficult to work with or of no need in ophthalmology because these tags are also used by other medical departments as well which fits for their purpose of using. Ophthalmologist need more specific tags or elements for fundus, OCT and slit lamp images to work with DICOM. So we divided our thesis in two parts. In part A, we proposed DICOM tags for Ophthalmology and proposed service oriented architecture. In part B, we take a case study of laser marked fundus images and tag the classified fundus image.

4.1 Proposed Framework

We have proposed Service Oriented Architecture for our thesis. Figure 4.1 shows the Data Flow of an eye Patient when he enters in the hospital for treatment. In the first stage the patient will register him/herself at the reception.

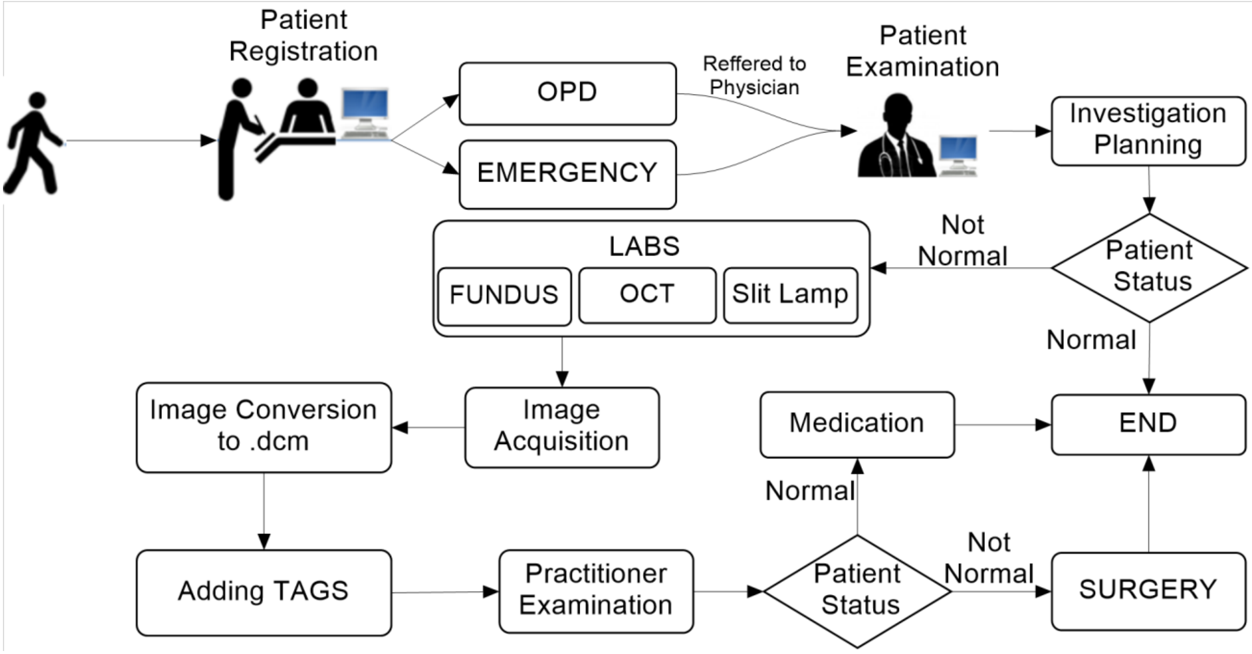

Figure 4.1 Proposed Frame Work Data Flow

Depending upon the case of patient, if patient is serious then he/she will be registered as an emergency case and referred to physician otherwise patient will be referred to OPD. Physician will further diagnose the patient status. If patient is normal and do not need further medication then patient status will come to end here. If patient is suffering from serious diseases the patient will be forwarded to laboratory for tests. In laboratory several Ophthalmology imaging devices are implanted which can carry out Fundus, OCT and Slit Lamp images. Once images are acquired from these devices then it be converted to DICOM ".dcm" format. Conversion to ".dcm" format is necessary because writing, updating and adding of DICOM tags can only be done when an image is in ".dcm" format. After adding or updating tags to the image the doctor will analyze Lab images and apply different filters on it to study the images in depth. If doctor find out some abnormalities in the image then the patient will be further treated with surgery or any other type of treatment needed by the patient or if patient lab images are normal then the patient status will come to end here.

Figure 4.2 describes us the overall work flow from case study to tagging a digital fundus image. We take Detection of Laser Marks as a case study for our work and then the rest of the DICOM work is done on digital fundus images.

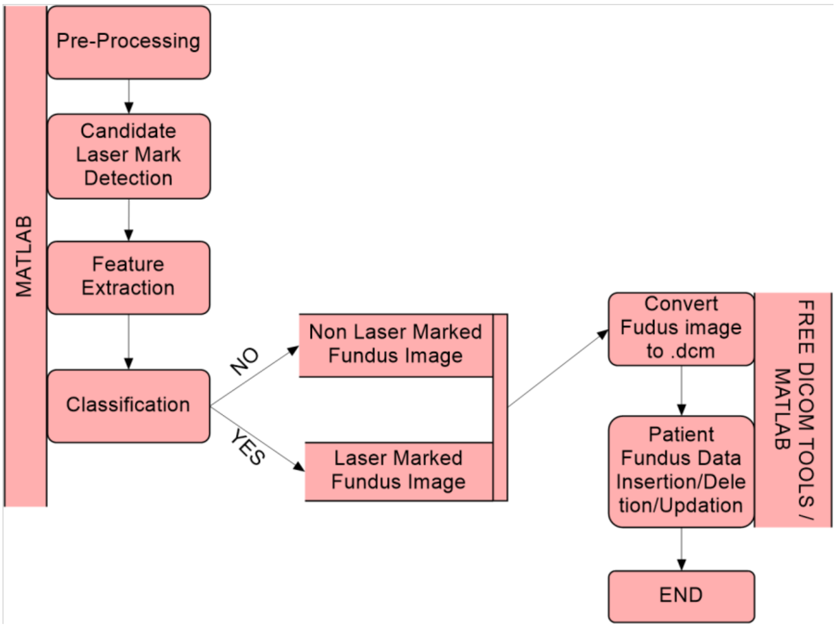

Figure 4.2 Flow of DICOM with Laser Mark Case Study

4.2 List of Tags to be Added

Following are the tags which are to be added in DICOM Ophthalmic Image. “N” is for those new tags which are collected during our survey and “AE” is used for already existing tags which are defined by DICOM standard.

Attribute Name	TAG	ACTION
Patient Group	(0010,0000)	AE
Patient Name	(0010,0010)	AE
Patient ID	(0010,0020)	AE
Patient Birthdate	(0010,0030)	AE
Patient Birth Time	(0010,0032)	AE
Patient Sex	(0010,0040)	AE
Patient Age	(0010,1010)	AE
Patient Size	(0010,1020)	AE
Patient Weight	(0010,1030)	AE

Patient Address	(0010,1040)	AE
Patient Mother Name	(0010,1060)	AE
Military Rank	(0010,1080)	AE
Branch Of Service	(0010,1081)	AE
Ethic Group	(0010,2160)	AE
Occupation	(0010,2180)	AE
Smoking Status	(0010,21A0)	AE
Additional Patient History	(0010,21B0)	AE
Pregnancy Status	(0010,21C0)	AE
Patient Comments	(0010,4000)	AE
Body Part Examined	(0038,0018)	AE
Drug Dose	(0038,0032)	AE
Heart Rate	(0018,1088)	AE
Study Read Date	(0038,0034)	AE
Study Read Time	(0038,0035)	AE
Study Completion Date	(0038,1050)	AE
Study Arrival Date	(0038,1040)	AE
Study Arrival Time	(0038,1041)	AE
Study Comments	(0038,4000)	AE
Admitting Date	(0038,0020)	AE
Admitting Time	(0038,0021)	AE
Discharge Date	(0038,0030)	AE
Discharge Time	(0038,0032)	AE
Special Needs	(0038,0050)	AE
Patient State	(0038,0500)	AE

Visit Comments	(0038,4000)	AE
Pre Medication	(0040,0012)	AE
Organ Dose	(0040,0316)	AE
Organ Exposed	(0040,0318)	AE
Over all Healthy	(0041,0010)	AE
Herpes	(0041,0020)	N
Hypothyroidism	(0041,0030)	N
Sjogrens	(0041,0040)	N
AIDS	(0041,0050)	N
HIV	(0041,0060)	N
LUPUS	(0041,0070)	N
Graves' Disease	(0041,0080)	N
Diabetes	(0041,0090)	N
Hyper Tension	(0041,0101)	N
Multiple Sclerosis	(0041,0120)	N
Hyperthyroidism	(0041,0130)	N
Rheumatoid Arthritis	(0041,0140)	N
Eye Infection	(0043,0010)	N
Foreign Body Removal	(0043,0020)	N
Refractions	(0043,0030)	N
Tonometry	(0043,0040)	N
Blepharplasty Functional	(0045,0010)	N
Cataract Surgery	(0045,0020)	N
Chalazion Excision from Eyelid	(0045,0030)	N
Iridectomy	(0045,0040)	N

Intraocular Lens Replacement	(0045,0050)	N
Laser, No Retinal Detachment	(0045,0060)	N
Trabeculectomy	(0045,0070)	N
Blepharplasty -- Cosmetic	(0047, 0010)	N
Corneal Transplants	(0047, 0020)	N
Enucleation	(0047, 0030)	N
Lid Repairs	(0047, 0040)	N
Permanent Lash Liner	(0047, 0045)	N
Radial Keratectomy	(0047, 0050)	N
Laser in-situ	(0047, 0060)	N

4.3 Use Cases

In this part, we have described the proposed framework use cases. In Use Case diagram we have three actors that is Doctor, Patient and System given in Fig--. Each Actor has its own use cases to interact with. The use cases for DICOM Ophthalmology may fall in the following categories:

1. Use Cases for Doctor with respect to DICOM
2. Use Cases for Patients with respect to DICOM
3. Use Cases for System with respect to DICOM

Figure 4.3 show the actors of use cases

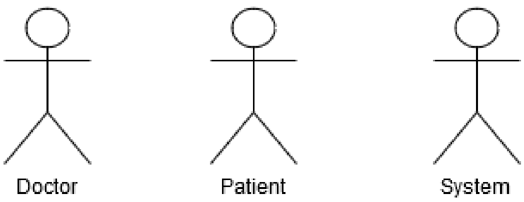

Figure 4.3 Use Case Actors

4.3.1 Use Case 1.1 Getting Data

Brief Introduction: The system will register new incoming Patients. Different Ophthalmic medical images that is Fundus, OCT and slit lamp images are received by the system from ophthalmic medical devices. These images are then converted in DICOM format that is “.dcm” for further processing.

Actors Involved

- **SYSTEM**

Extended Use Case 1.1.1

Use Case ID:	UC-1.1.1	
Overview:	Patient will be Registered	
Use Case Name:	Patient Registration	
Preconditions:	Patient should have their valid ID-Card	
Post conditions:	Patient is Successfully registered	
Normal Flow:	User action: 1. Users will submit their ID Cards for Registration. 2. Submit information.	System action : 3. System will save Patient Information. 4. Successfully Registered.
Alternative Flows:	N-A	
Exceptions:	When user submits wrong data type Information.	
Requirements:	N-A	
References	Use Case 1.1	

Table 4.2 Extended Use Case 1

Extended Use Case 1.1.2

Use Case ID:	UC-1.1.2	
Overview:	Collect Images from Different Medical System	
Use Case Name:	Image Acquisition	
Preconditions:	Only those Patients images should be acquired whom are referred by Physician	
Post conditions:	Image Acquired Successfully	
Normal Flow:	User action: 1. User have to go to Laboratory in for Test In time. 2. Wait for the test number	System action : 3. System will acquire and save the images into Data Base 4. Image Successfully saved.
Alternative Flows:	N-A	
Exceptions:	When user did not enter sequence number of image given to patient.	
Requirements:	N-A	
References	Use Case 1.1	

Table 4.3 Extended Use Case 2

Extended Use Case 1.1.3

Use Case ID:	UC-1.1.3	
Overview:	Image Conversion to “.dcm” format from other image formats.	
Use Case Name:	DICOM Conversion	
Preconditions:	User must have Patient Image for conversion into “.dcm” format	
Post conditions:	Successfully Converted	
Normal Flow:	User action: 1. Upload the image to convert into DICOM format.	System action : 3. Successfully Converted
Alternative Flows:	N-A	
Exceptions:	N-A	
Requirement	N-A	
References	Use Case 1.1	

Table 4.4 Extended Use Case 3

Figure 4.4 shows us system Use Cases

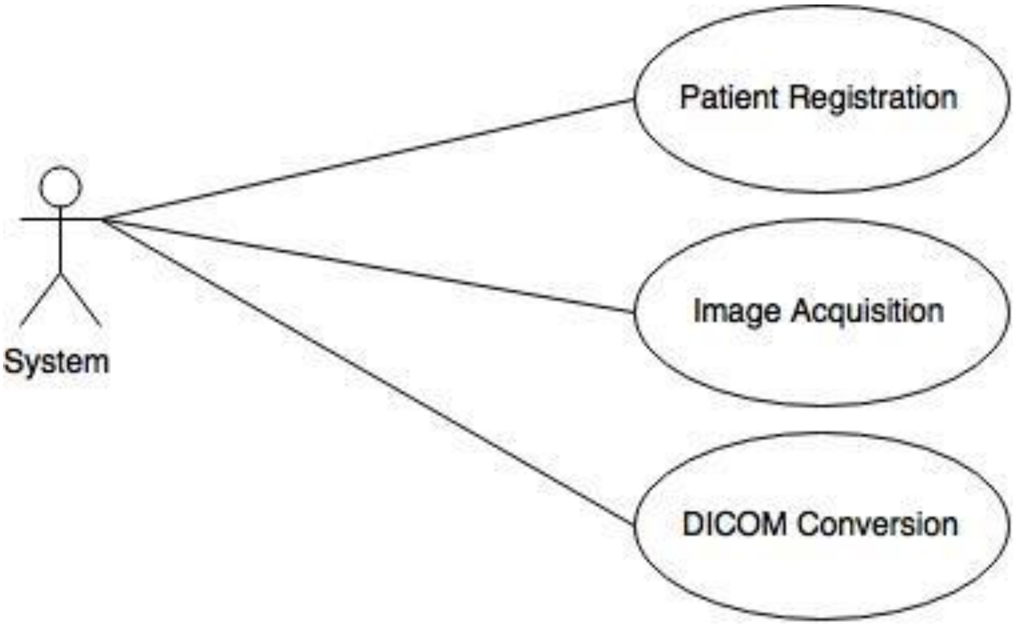

Figure 4.4 System Use Case

4.3.2 Use Case 1.2 Patient Data

Brief Introduction: In this use case, Patient registration and acquisition of different medical images are introduced. Serious or Abnormal Eye patients are referred to laboratory for further test. On the basis of these tests doctor will perform further examination. Patients are facilitated to do Fundus, OCT and Slit Lamp test.

Actors

- **Patient**

Extended Use Case 1.2.0

Use Case ID:	UC-1.2.1
Overview:	Patient will go to Lab for Optical Coherence Tomography Image Acquisition
Use Case Name:	OCT
Preconditions:	Patient must be referred by doctor for OCT test

Post conditions:	Image Acquired Successfully	
Normal Flow:	User action: 1. User will go to laboratory for OCT test 2. Wait for the test number to come	System action : 3. System will acquire and save the OCT image in Data Base 4. Image saved Successfully.
Alternative Flows:	N-A	
Exceptions:	When user did not enter sequence number of an OCT image which is to be given to patient.	
Requirements:	N-A	
References	Use Case 1.2	

Table 4.5 Extended Use Case 4

Extended Use Case 1.2.2

Use Case ID:	UC-1.2.2	
Overview:	Patient will go to Lab for Fundus Image Acquisition	
Use Case Name:	Fundus Image	
Preconditions:	Patient must be referred by doctor for Fundus Image test	
Post conditions:	Image Acquired Successfully	
Normal Flow:	User action: 1. User will go to laboratory for Fundus Image test 2. Wait for the test number to come	System action : 3. System will acquire and save the OCT image in Data Base 4. Image saved Successfully.
Alternative Flows:	N-A	
Exceptions:	When user did not enter sequence number of Fundus image which is to be given to patient.	
Requirements:	N-A	
References	Use Case 1.2	

Table 4.6 Extended Use Case 5

Extended Use Case 1.2.3

Use Case ID:	UC-1.2.3	
Overview:	Patient will go to Lab for Slit Imap Image Acquisition	
Use Case Name:	Slit Lamp Image	
Preconditions:	Patient must be referred by doctor for Slit lamp image test	
Post conditions:	Image Acquired Successfully	
Normal Flow:	User action: 1. User will go to laboratory for Slit lamp image test 2. Wait for the test number to come	System action : 3. System will acquire and save the Slit lamp image in Data Base 4. Image saved Successfully.
Alternative Flows:	N-A	
Exceptions:	When user did not enter sequence number of Slit lamp image which is to be given to patient.	
Requirements:	N-A	
References	Use Case 1.2	

Table 4.7 Extended Use Case 6

Extended Use Case 1.2.4

Use Case ID:	UC-1.2.4	
Overview:	Patient will go to doctor for further for analysis of Patient image	
Use Case Name:	Patient Examination	
Preconditions:	Patient must do eye test in laboratory	
Post conditions:	Further Treatment by the Doctor after image analysis	
Normal Flow:	User action: 1. User will go to doctor after laboratory test	System action : 3. After analysis doctor will check the status of patient for further treatment
Alternative Flows:	Patient can come at any other day for further treatment	
Exceptions:	N-A	
Requirements:	N-A	

References	Use Case 1.2

Table 4.8 Extended Use Case 7

Figure 4.5 shows Patient Use Cases

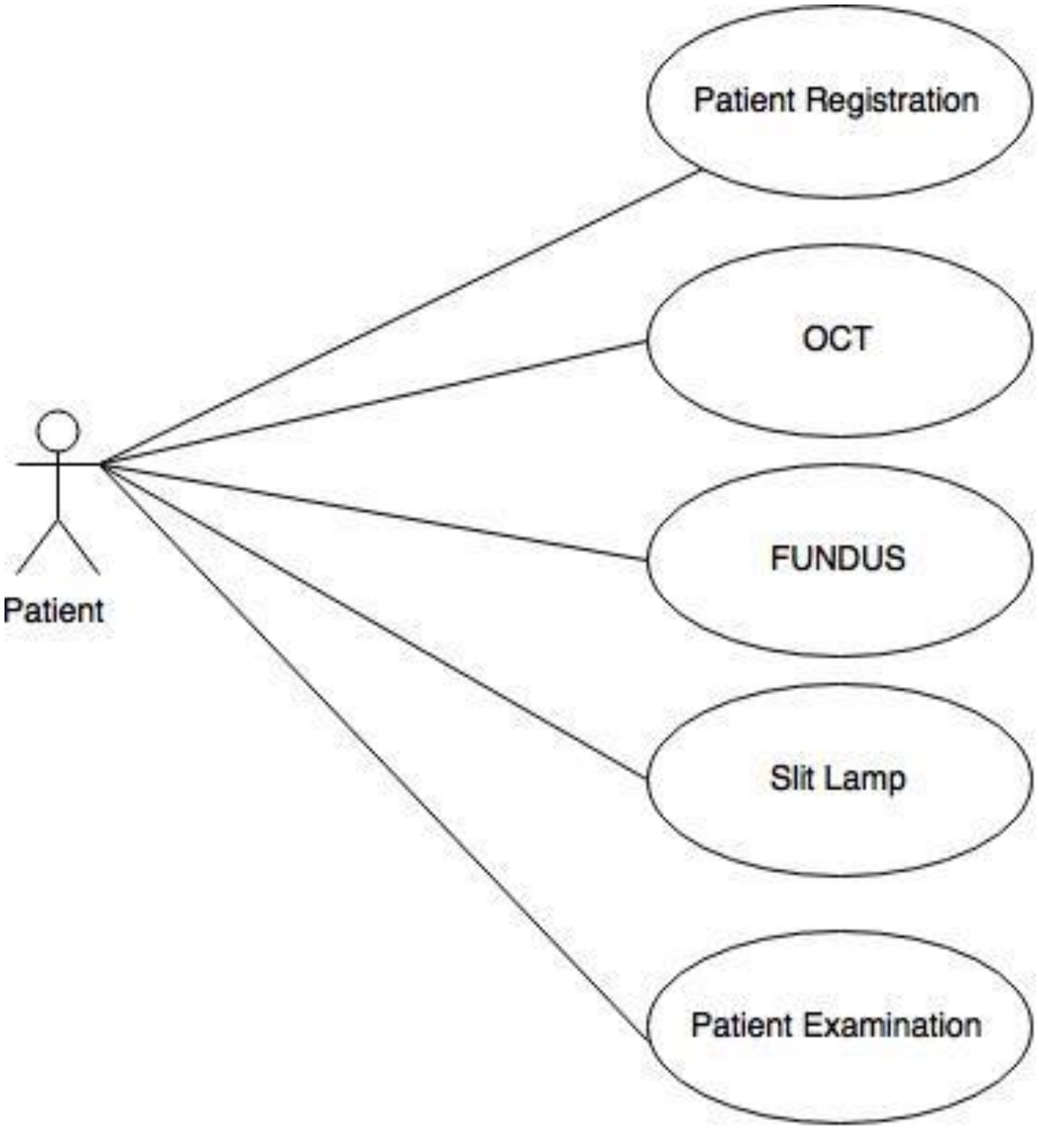

Figure 4.5 Patient Use Case

4.3.3 Use Case 1.3 Doctor Module

Brief Introduction: In this use case Doctor is performing the main role. From receiving patient to advising treatment all work is done by doctor. We will discuss it further one by one in extended use cases.

Actors

- **Doctor**

Extended Use Case 1.3.0

Use Case ID:	UC-1.3.0	
Overview:	If abnormalities are found in lab test then doctor will suggest surgery to patient	
Use Case Name:	Suggest Surgery	
Preconditions:	Patient Lab test and Practitioner examination must be done	
Post conditions:	It is patient choice to do surgery or not	
Normal Flow:	User action: 1. After Lab test analysis if something serious found in patient eye then doctor will suggest him surgery	System action : 2. Doctor will add surgical tags in the image
Alternative Flows:	N-A	
Exceptions:	N-A	
Requirements:	N-A	
References	Use Case 1.3	

Table 4.9 Extended Use Case 8

Extended Use Case 1.3.1

Use Case ID:	UC-1.3.1
Overview:	Physician will plan to investigate the patient and according to his status physician will take further action to refer patient as a serious case or medicate patient
Use Case Name:	Investigation Planning

Preconditions:	Patient registration must be done	
Post conditions:	Patient Status will be updated	
Normal Flow:	User action: 1. Patient will register at the start 2. Patient will then be referred to physician	System action : 3. Physician will save the referred doctor name
Alternative Flows:	N-A	
Exceptions:	N-A	
Requirements:	Patient must be registered	
References	Use Case 1.3	

Table 4.10 Extended Use Case 9

Extended Use Case 1.3.2

Use Case ID:	UC-1.3.2	
Overview:	When patient lab tests are done then specialized doctor of that image will examine it	
Use Case Name:	Practitioner Examination	
Preconditions:	Patient Tags should be added	
Post conditions:	Patient Status will be updated	
Normal Flow:	User action: 1. Patient will do lab test 2. From lab patient will be referred to concern doctor	System action : 3. N-A
Alternative Flows:	N-A	
Exceptions:	N-A	
Requirements:	Before and After Practitioner Examination tags should be added	
References	Use Case 1.3	

Table 4.11 Extended Use Case 10

Extended Use Case 1.3.3

Use Case ID:	UC-1.3.3	
Overview:	When patient is examined after lab test and patient status is normal then doctor will suggest some medicine to patient	
Use Case Name:	Medication	
Preconditions:	Add tags that which medicine will be suggested to patient	
Post conditions:	Patient Status will come to end	
Normal Flow:	User action: 1. Patient will do lab test 2. After analysis of lab test doctor will suggest some medicine	System action : 3. Tags of medicine should be added
Alternative Flows:	N-A	
Exceptions:	N-A	
Requirements:	Patient must have lab test	
References	Use Case 1.3	

Table 4.12 Extended Use Case 11

Extended Use Case 1.3.4

Use Case ID:	UC-1.3.4	
Overview:	Patient will go to doctor for further for analysis of Patient image	
Use Case Name:	Patient Examination	
Preconditions:	Patient must do eye test in laboratory	
Post conditions:	Further Treatment by the Doctor after image analysis	
Normal Flow:	User action: 1. User will go to doctor after laboratory test	System action : 3. After analysis doctor will check the status of patient for further treatment
Alternative Flows:	Patient can come at any other day for further treatment	
Exceptions:	N-A	

Requirements:	N-A
References	Use Case 1.3

Table 4.13 Extended Use Case 12

Extended Use Case 1.3.5

Use Case ID:	UC-1.3.5	
Overview:	Collect Images from Different Medical System	
Use Case Name:	Image Acquisition	
Preconditions:	Only those Patients images should be acquired whom are referred by Physician	
Post conditions:	Image Acquired Successfully	
Normal Flow:	User action: 1. User have to go to Laboratory in for Test In time. 2. Wait for the test number	System action : 3. System will acquire and save the images into Data Base 4. Image Successfully saved.
Alternative Flows:	N-A	
Exceptions:	When user did not enter sequence number of image given to patient.	
Requirements:	N-A	
References	Use Case 1.1	

Table 4.14 Extended Use Case 13

Figure 4.6 shows the Use Cases of Actor “Doctor”

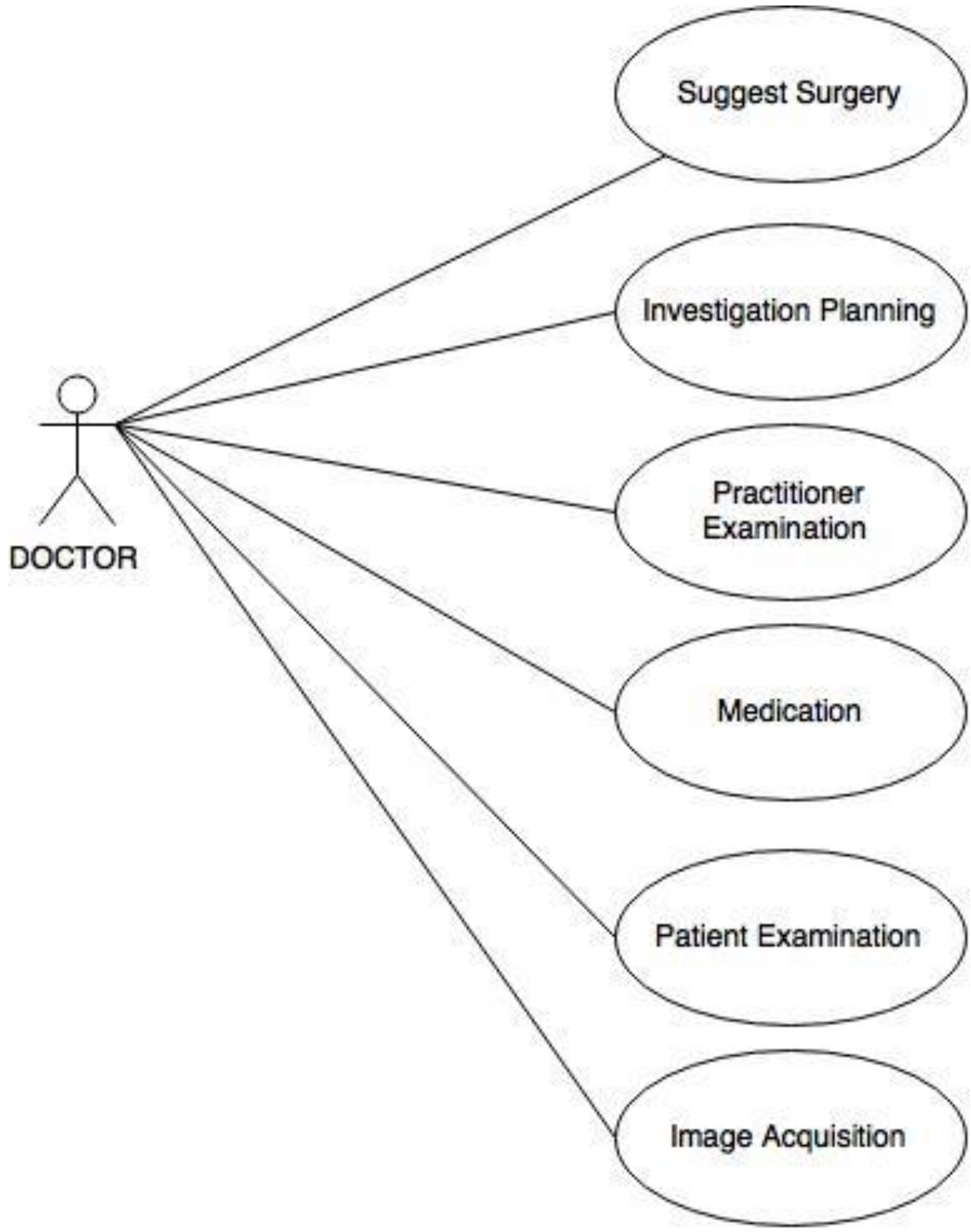

Figure 4.6 Doctor Use Case

4.4 Proposed Architecture

We proposed Service Oriented Architecture to model our system. Service Oriented Architecture (SOA) is a methodology used to construct an architecture based upon the use of services. Services such as Web Services carry out some small function, such as producing data, validating a customer, or providing simple analytical services [27]. In the proposed architecture Application Server is connected to Data Base Server. Application server provide few DICOM services i-e Read DICOM image, Write DICOM image, Add DICOM Tags to the image and Update DICOM image once image tag data is entered. These services are used by different

Doctors to work on DICOM images. Furthermore these DICOM images can be saved in database and also be given to patients in softcopy which can be helpful for patients to maintain their record and also helpful for doctors in future to check patient history. Figure 4.7 shows the Service Oriented Architecture of DICOM Ophthalmology.

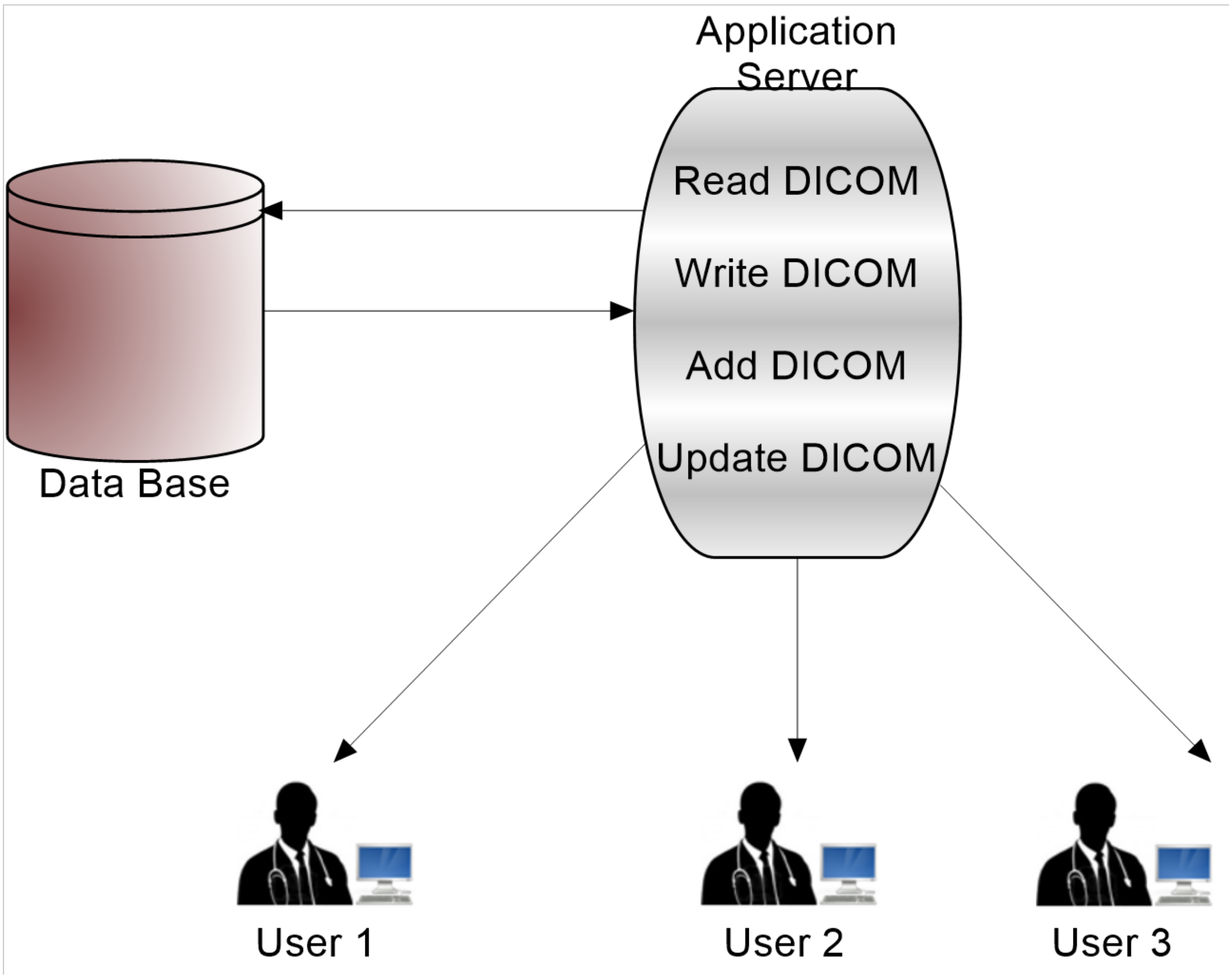

Figure 4.7 Service Oriented Architecture Flow

4.4.1 DICOM Write

We have used dicomwrite function to convert image from “:.jpg:” and “.jpeg” format to “.dcm” format in MATLAB. MATLAB allows few functions

4.4.2 ADDING TAG

For adding tags in an image first we converted the image into .dcm format. If the image is in already .dcm format than no need to convert then image from one format to “.dcm”. In medical imaging jpg and jpeg format is very common. We analyzed several different tools for converting a jpg and jpeg image to .dcm format but used only two tools for converting that is

MATLAB and SANTE DICOM. Furthermore keep in mind that when you are going to add tags from matlab so only those tags are added which are present in MATLAB DICOM dictionary. If tags are not present in DICOM dictionary then first add those tags manually in Matlab DICOM dictionary file which is named “dicom-dict.notepad”. The path for dicom-dict file is: “ProgramFiles/MATLAB/2014a /toolbox/images /iptformats /dicom-dict.notepad” .SANTE DICOM also provide us the facility to convert the image into DICOM and to add tags into that image. While using SANTE Dicom first you have to open the image in which you are going to add tags. In utilities file editor all tags will be displayed group wise which you want to add. In Patient tab all patient related tags are displayed. In study tab all physician related tags are displayed.

4.4.3 Update Tag Value

We update the value of tag in MATLAB and in SANTE DICOM. In MATLAB read the image in which you want to make changes by using “dicomread(‘image.dcm’)” command. Display the image in order to check that dicom image is read successfully using “imtool”.Once dicom image is read then use “dicominfo(‘image.dcm’)” function read all the tags and its values present in the image. Now we can easily change or update the values of tags present in an image.

CHAPTER 5: Results

Precision in medical imaging diagnosis systems are very critical that is why we have carefully tested and evaluated our system. This chapter comprises of proposed system results and details which we have used for system evaluation. We also evaluated survey results which is done for extraction of DICOM tags for Ophthalmology. We take survey input from thirty-seven specialized doctors in the field of ophthalmology which include 9 TMO (Trainee Medical Officer), 15 MO (Medical Officer), 8 JR (Junior Registrar) and 5 SR (Senior Registrar). We first demonstrate DICOM to those doctors who were not aware of DICOM standards. We gave them a brief introduction of DICOM in order to get accurate and close results of survey.

5.1 Survey Results

Figure 5.1 shows the result of survey in which it tells us about the Physicians who are technically sound with dicom and who are not.

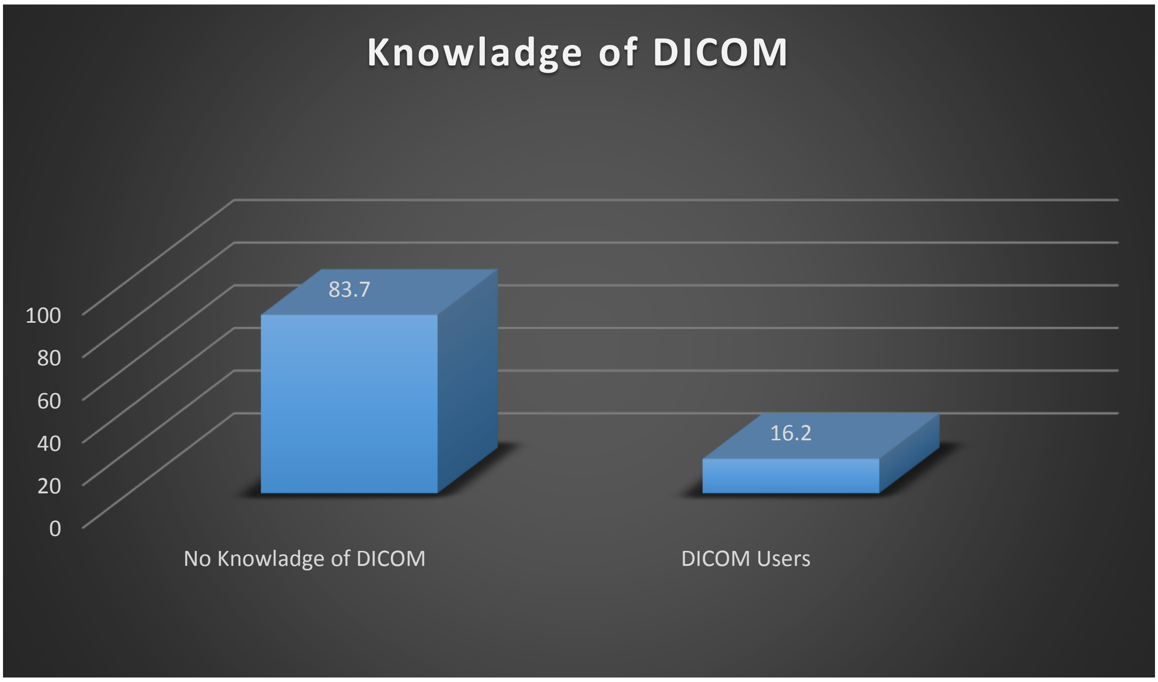

Figure 5.1 Knowledge of DICOM

During our survey we came to know that maximum of the doctors are not aware of medical standards. Most of the physicians think that medical standards are not a part of their field. This makes them far away from medical standard. It is also proved by our survey that only 17 % of the physicians were aware of medical standards but yet again they have not hands on practical experience on it or unaware of core functionalities of medical standards. The below graph shows us that very less physicians are aware of medical standards. Figure 5.2 shows the users of different medical standards.

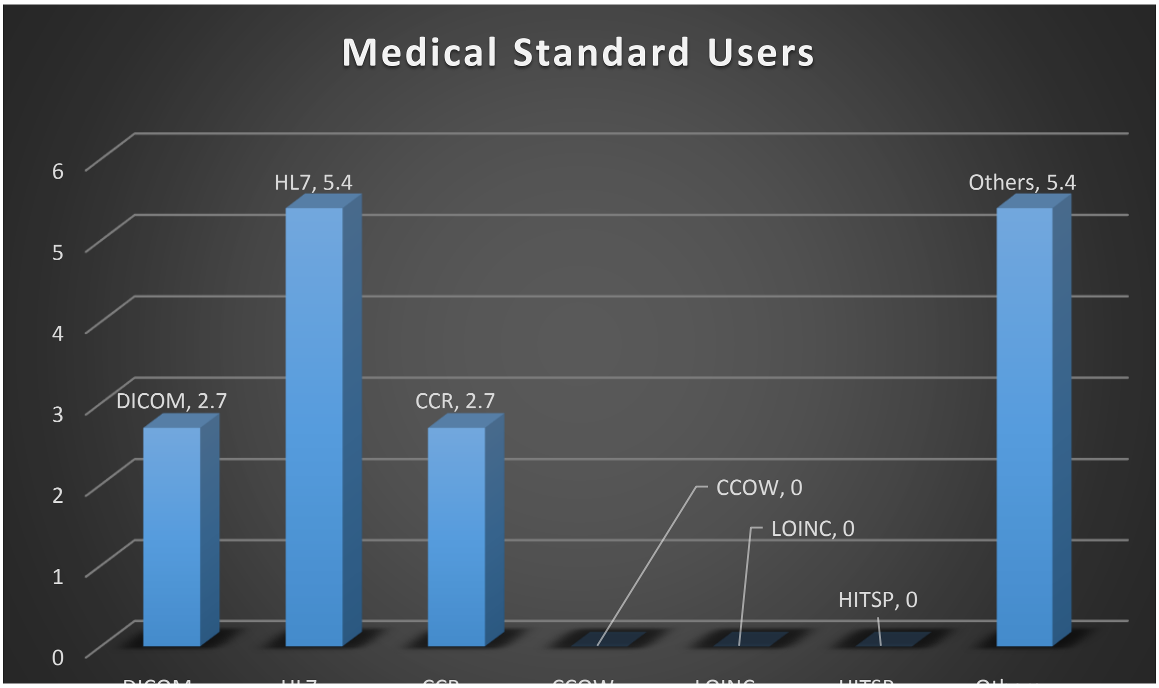

Figure 5.2 Users of different Medical Standard

We conducted a small workshop in which we introduce medical standard to them. We gave them a brief introduction of DICOM and other medical standards. We also discussed few advantages of DICOM over other medical standards. About 78% physicians preferred DICOM to be used in hospitals and 8% physicians preferred Health Level 7. 13 % physicians preferred to use some other medical standards. Figure 5.3 shows the preferred medical standard by different users.

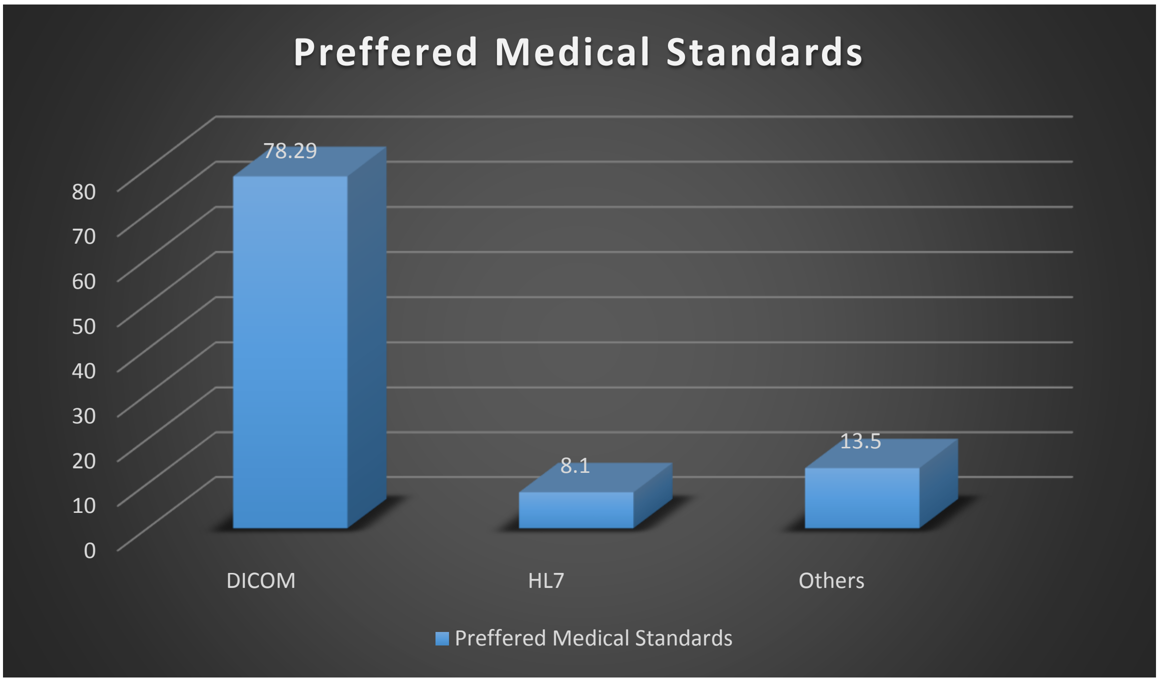

Figure 5.3 Preferred Medical Standard

We categorized DICOM ophthalmic tags for better understanding and also easy for the doctors to tag patient image category wise. Furthermore each category contains its related tags. Ophthalmologist can easily select the tag category wise. These categories and tags are made by mutual collaboration of doctors. Ophthalmology tags are divided into following six categories that is Ocular Significant Illness, Ocular No Surgery, Ocular Minor Surgery, Ocular Major Surgery, Ocular Major Symptoms and Eye historical problems.

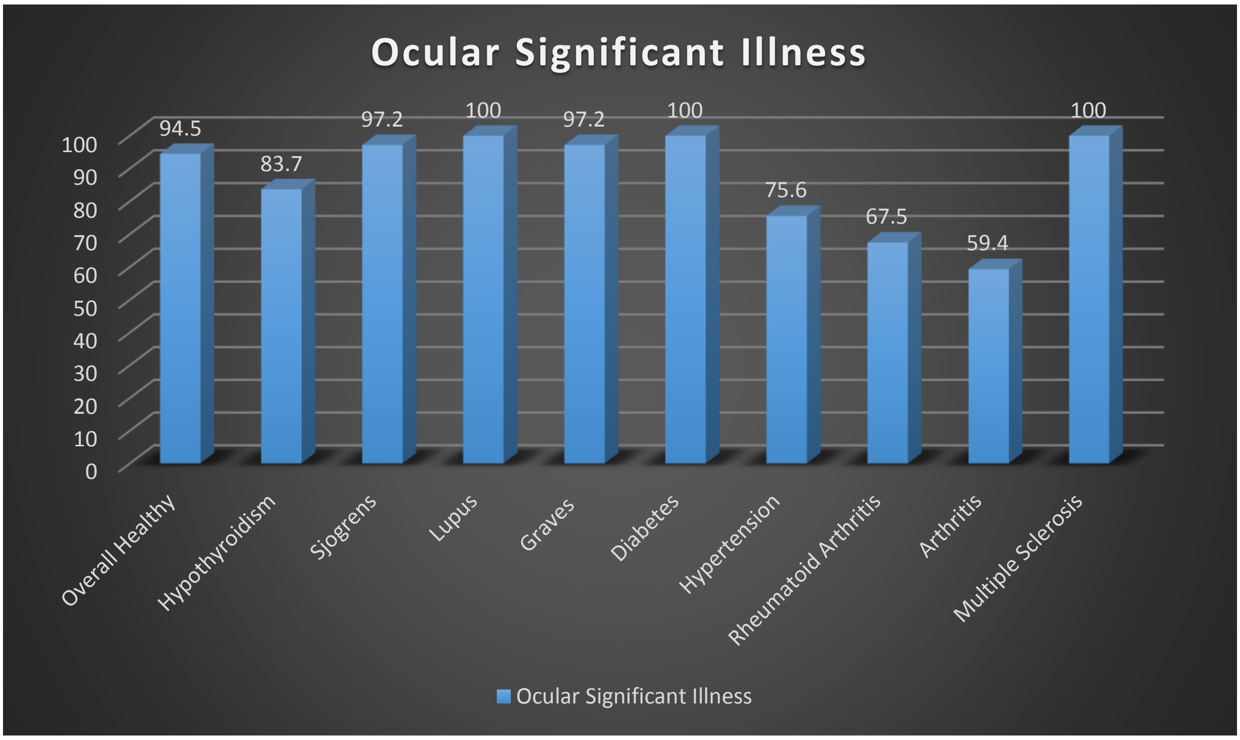

Figure 5.4 Ocular Significant Illness

Furthermore we divided surgery into three parts. Figure 5.4 shows the tags of Ocular Significate Illness. 100% of the physicians preferred Diabetes, Lupus and Multiple Sclerosis tags which means that these tags are more required in DICOM. 94% of the ophthalmologist preferred overall healthy tag, 97% preferred Sjogrens and Graves, 83% preferred Hypothyroidism, 75% preferred Hypertension, 67% preferred Rheumatoid Arthritis and 59% of ophthalmologist prefer Arthriris. Graph—shows the percentage of Ocular No Surgical Tags in which Tonometry and Eye Infection are preferred 100 %, 95% of the ophthalmologist preferred Foreign Body Removal and 89% of the ophthalmologist preferred refractions. Figure

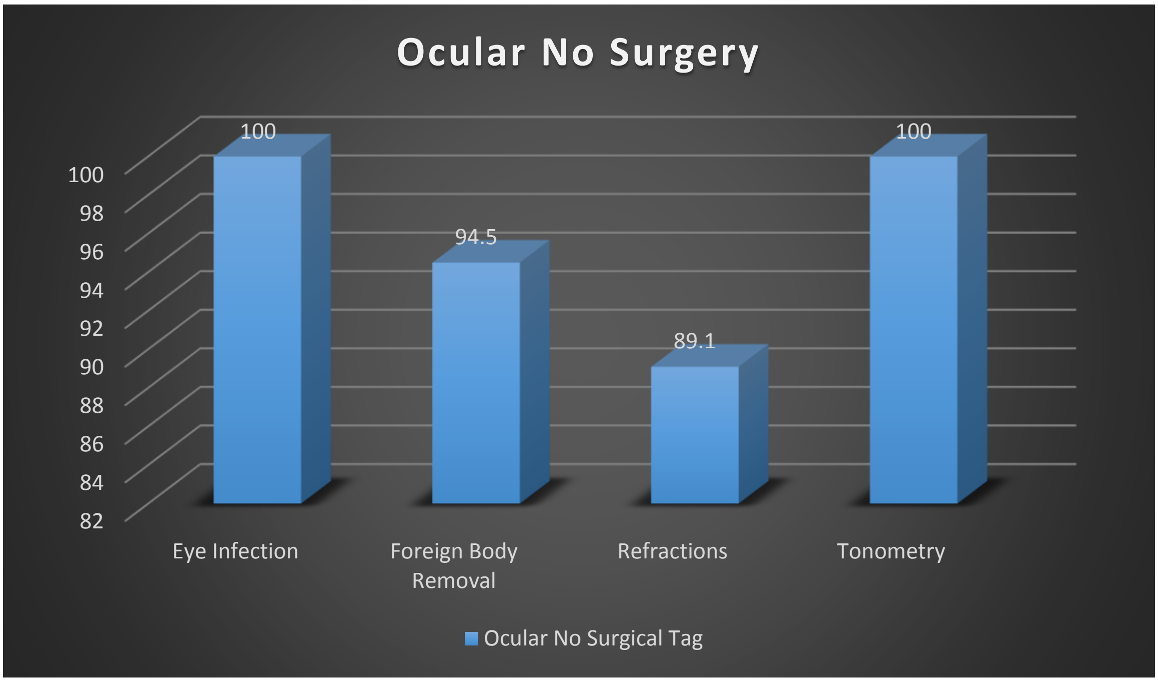

Figure 5.5 Non-Surgical Tag

The second category of surgery tags is Ocular Minor Surgery. In ocular minor surgery 100% of the ophthalmologist preferred Iridectomy, Intra Ocular Lens Replacement and No Retinal Detachment, 97 % preferred Chalazion Excision from Eyelid, 94% preferred Cataract Surgery and 91% preferred Blepharplasty. Figure 5.6 shows the tags percentage of Ocular Minor Surgery.

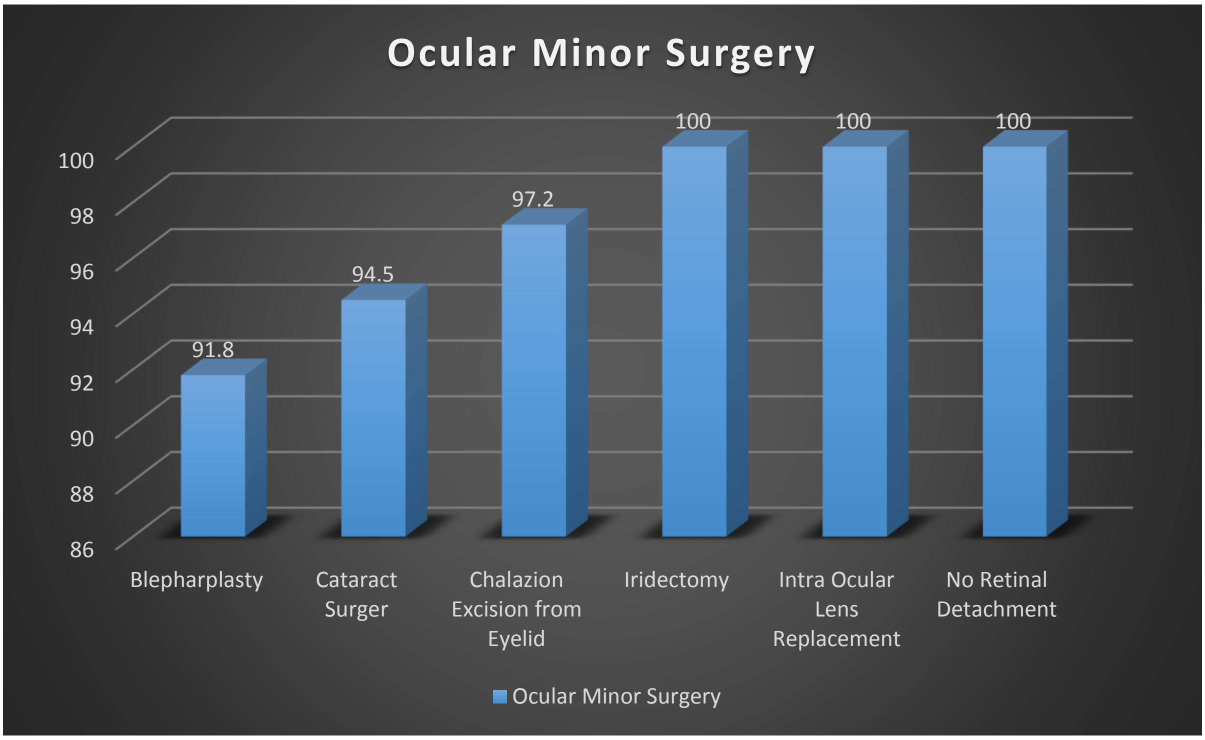

Figure 5.6 Minor Surgery Tag

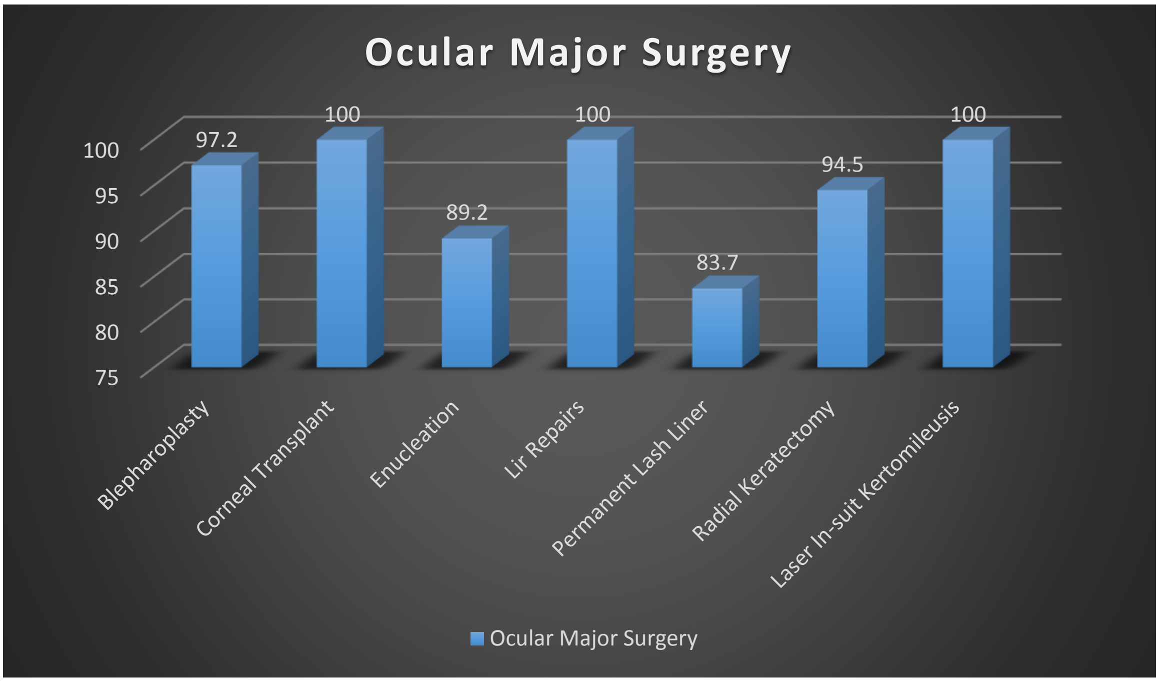

Figure 5.7 Major Surgery Tags

Figure 5.7 shows the percentage of each Ocular Major Surgical Tags. Third category of Ocular Surgery tags is Major Ocular Surgery. 100% Ophthalmologist preferred Comeal Transpland, Lir Repairs and Laser In-Suit Kertomileusis tags, 97% preferred Belpharplasty, 94% preferred Radial Keratectomy, 89% preferred Enucleation, and 83% preferred Permanent Lash Liner. Below graph—shows us the category for Ocular Recent Symptoms Tags.

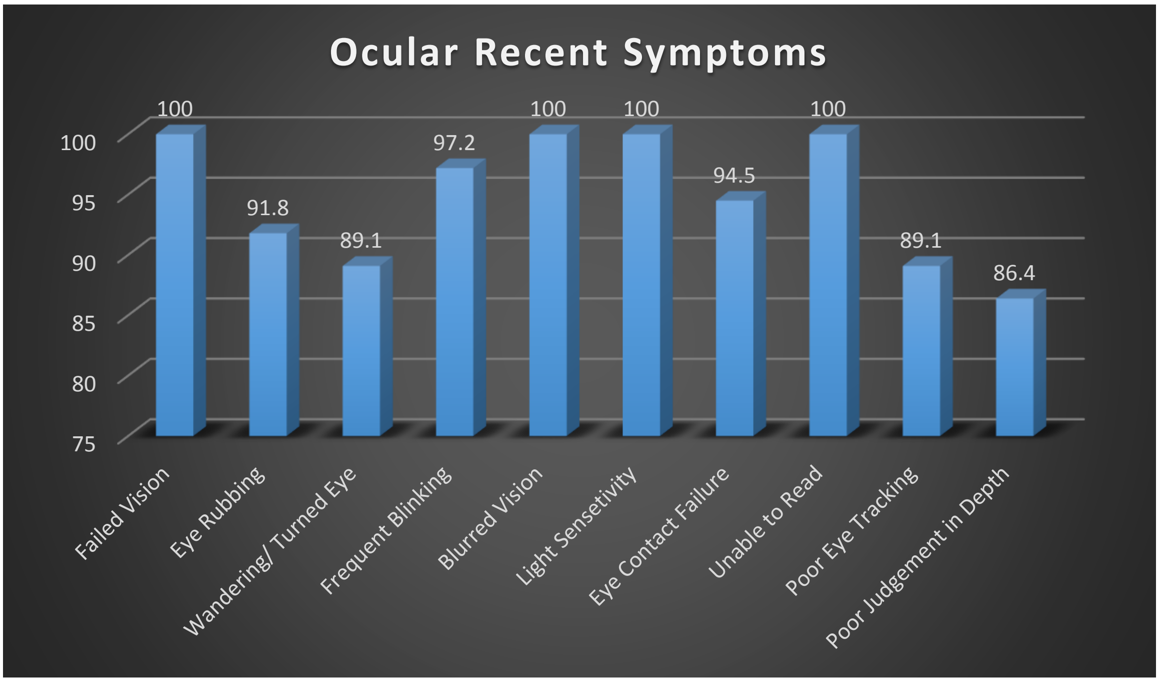

Figure 5.8 Recent Symptoms Tags

Figure 5.8 shows the percentage of Recent Symptoms Tags. In recent symptoms tags 100% of the ophthalmologist agrees to use Failed Vision, Blurred Vision, Light Sensetivity and unable to read tags,97% preferred Frequent Blinking,94 % preferred Eye Contact Failure. Figure 5.9 shows the percentage of Ocular historical problem Tags.

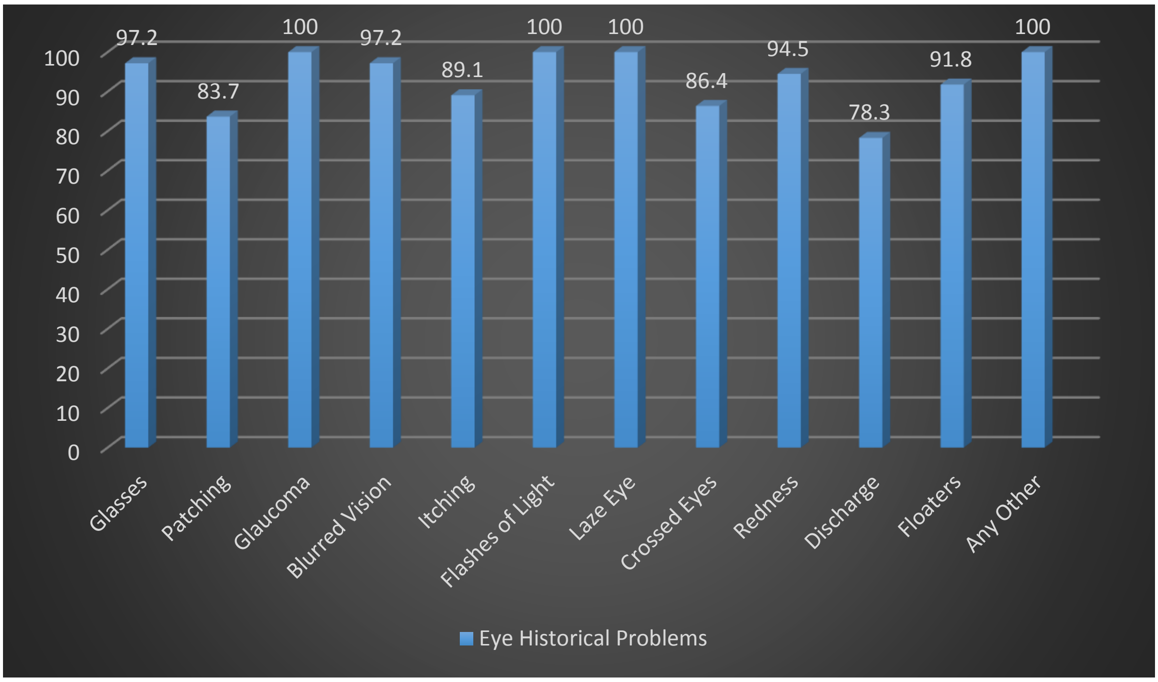

Figure 5.9 Historical Problem Tags

Tags for Eye historical category is considered the most important tags. Ophthalmologist uses such words in prescriptions too. 100 % ophthalmologist preferred Glaucoma, Flashes of Light, Laze Eye and other tags.97% preferred Glasses and Blurred Vision, 94% preferred Redness of Eye, 91% preferred Floaters, 89% preferred Itching, 86% preferred Crossed Eye Vision, and 83% preferred Patching.

5.2 Fundus Image Tags

We took a Laser marked Image out of the data set and tag it. Below are some figures which show MATLAB simulation to show image tags.

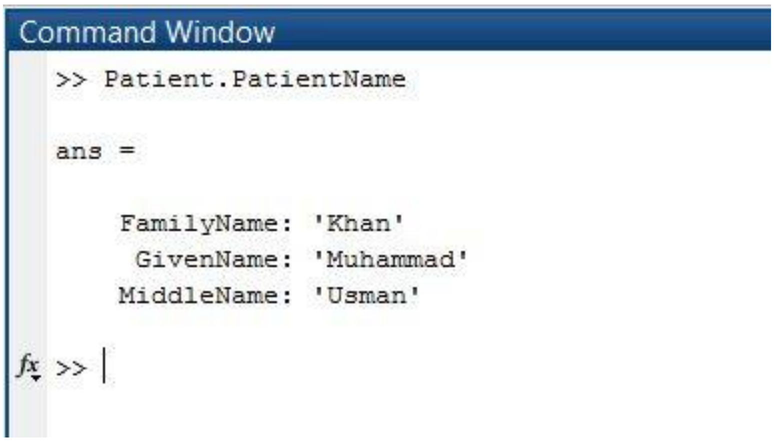

Figure 5.10 Patient Biological Data Tags

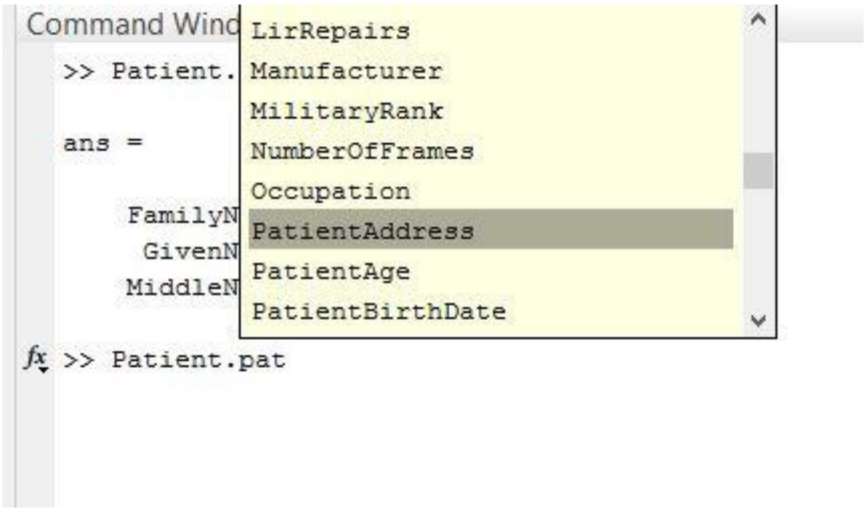

Figure 5.11 List of Patient Bio Data Tags

```
Command Window
>> Patient.PatientName

ans =

     FamilyName: 'Khan'
      GivenName: 'Muhammad'
     MiddleName: 'Usman'

>> Patient.PatientAddress

ans =

NUST University

fx >>
```

Figure 5.12 Patient Address Tag

```
Command Window
>> Patient.PatientName

ans =

     FamilyName: 'Khan'
      GivenName: 'Muhammad'
     MiddleName: 'Usman'

>> Patient.PatientAddress

ans =

NUST University

>> Patient.LaserInSuit

ans =

Laser Surgery Need at Right Side and around Macula

fx >>
```

Figure 5.13 Patient Surgical Tag

Chapter 6: Conclusion

The result of this thesis is to propose a framework methodology for adding ophthalmic tags into Fundus, Slit limp and OCT dicom image. The proposed framework makes it simple for physicians to study and keep history of patients in an image. It also help physicians to precise the data by using DICOM tags and makes it easier for administration to add moderate system that previously did not include any kind of access control at all. We faced a lot of problems while collection of tags from different ophthalmologists specialists. One of the biggest problem was to give them a brief introduction and details about DICOM because not of them were aware from DICOM. In Pakistan mostly of the physicians uses DICOM in medical cardiology department. Furthermore they are not aware from the fact that what is the main purpose of DICOM? , when DICOM is to be used and what are the scenarios in which DICOM is facilitating physicians of different medical departments. In cardiology department doctors use DICOM to analyze cardiology images and apply different types of filters to understand the diseases in depth. Physicians are taking advantage form Graphical User Interface of the DICOM instead of going into its technological advantages. Despite the many compensations of ophthalmic DICOM, the fact is that it offers various secondary uses when included in the Electronic Healthcare Record, Ophthalmic image tagging has not yet gained a wide acceptance because it encourages a major change moving the way the diagnostic interpretation is recorded. We accept as true that our thesis will help overcome the challenges required in DICOM ophthalmic imaging. By recognizing all the benefits and results of dicom tags, the end user becomes aware of the great enhancement in patient care and the improvements to the imaging process efficiency and effectiveness that it provides.

6.1 Future Work

The DICOM standard is a set of international imaging standard developed for medicine field and now extended to incorporate other professions .These standard encompasses primary digital and secondary primary images made for ophthalmic diagnostic procedures. DICOM provides a basis for the interoperability of digital systems, outputs, providing portability. There are some of the other application areas which is originating from DICOM standard. DICOS (Digital Image Communication in Security) and DICONDE (Digital Image Communication in Nondestructive Evaluation) are the application software which are originated from DICOM. In future we want to propose a framework of DICOE (Digital Image Communication in Education). In this system a student image will be floating around the school, college or university. There won't be any documentation of student. All exam record, fee record and other things related to student and associated to student will be recorded in student image in terms of tags.

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APENDIX A

Laser cure is operated to steady and deliberate syndrome progression by discontinuing or preventing the outflow of blood in to the retina from vessels. In moment of that it typically leaves behind scabs or laser marks and other marks that obstruct the image analysis methods of DR. Retinal laser operations are extensively made, so that the uncovering of the laser marks formed by it and the estimation of such laser marks is a significant problem which is to be addressed. In consequence to laser operation, laser marks are typically molded as circular and small spots or as large and asymmetric spots in the terrain of retina as shown in fig

Figure A1 Laser Marks Spots

These spots disturb the capability for the computerized or manual diagnosis of the retinal images. The computerized examination of fundus images may lessen the human arranging capability and consequently it is useful to increase the cost effectiveness of DR screening initiatives. There are several number of methods which is used for automated detection of DR.

A1. Literature Review

In [28] RN Graham et al. summarizes the number of image formats that are commonly used in our daily life. Author classified the types of images on the basis of data compression i-e Lossless and lossy. In this paper, RN Graham et al. mentioned that in lossless images the data or image contents remain the same when its file size is reduced and the original data can be covered easily if necessary. Whereas when lossy image is compressed, it permanently removes the data file and also results in decrease of file size. Joint photographic experts group (JPEG) format is considered to be lossy compression file type because it allow user to specify the compression applied to it, the more you compress the image the more you will lose its originality. Portable network graphics format (PNG), Tagged image file format (TIFF), Graphics interchange format (GIF) and Joint Photographic Expert Groups 2000 (JPEG 2000) are the types of lossless compression file. In paper [29] S Ganglr et al. discussed different image formats and proposed an efficient compression algorithm to exploit the similarities in medical images by keeping its file size constant. Here Principal Component Analysis (PCA) statistical tool is used to determine the common characteristics. S Ganglr et al. improved the methodology by using two projection spaces i-e General Projection Space (GPS) which contain general characteristic of medical images by covering whole human body and Specific Projection Space (SPS) which contain specific characteristics of medical images by covering the specific parts of human body. S Ganglr et al. achieved the compression of images by storing and generating a vector of projection coefficients which depend upon the number of images. This methodology proves that the results were much higher as compared of JPEG2000 and JPEG images. S Ganglr et al. concluded that further quality can be improved by implementing SPS additionally. In [30] W Newhauser et al. discusses about the Patient Health Information (PHI) burned on DICOM images and to remove the PHI from DICOM images because W Newhauser et al. mentioned that it is legal and ethical to anonymize patient data before it is made available to the public. In [31] D Grauer et al. discussed the visualization of DICOM 3d and 2d craniofacial images with three different DICOM software's. Software which are discussed by D Grauer et al. for craniofacial images are Dolphin Imaging (Dolphin Imaging, Chatsworth, Calif) ,3dMDvultus software (3dMD, Atlanta, Ga) and InVivoDental (Anatomage, San Jose, Calif). D Grauer et al. discussed that by using three different DICOM tools for craniofacial images, will help in diagnosis and treatment easily because few different software's provide different functionalities. Like in VivoDental DICOM software lets the user for segmenting the airway passages and quantifying their volumes where Dolphin Imaging has the functionality for segmenting the airway and permits for suspicious visual checkup of airway curves and shape. Dolphin imaging consents joining the CBCT data with either a 2D or a 3D image. The process is performed by landmark collection. The user locates homologous landmarks in both the CBCT image and volume. The 3dMDvultus software calculates airway volume and agree to visualization of the cross-section images along the airway. The smallest Airway stenosis or cross-sectional area is also detected by this software. It also provides the facility of virtual endoscopy which as an additional feature in this software. An implantation simulation unit is presented by InVivo-Dental software which lets the operator to measure and visualize the alveolar bone and sections of the dental arch. On the left lower corner, a colour map represents the density of bone around the implant. In [32] Protti D et al. gave a brief discussion of Spain health standards they are using and give comparison of current health in Spain and what are the remedies for health standard physicians are using to cure their patients. Protti D et al. a novel scoring system method centered on data which is gathered from different databases apprehended by the particular interviews and jurisdictional programs with the physicians or other peoples involved in the making of that systems. Protti D et al. applied the scoring methodology for the first time in a contrast of the degree of computerization in primary care physician offices in province of Alberta Canada and Denmark. This method was also used to relate New Zeland and Denmark. So this is the third paper presenting the method of scoring on EMR (Electronic Medical Records) which will be valid to other health authorities at state, provisional and national levels. In [33] F Lum et al. discussed the domain of ophthalmology and its numeral distinctive features likened with other medical and surgical areas concerning clinical data management and workflow. Ophthalmology is a high-volume fugitive exercise that includes workflow steps such as dilation, refraction and screening. Ophthalmologist and technicians often inspect different patients in several inspection rooms or in OT (Operation Theatres) instantaneously to improve competence. To ease medical records in such situation, EHRs should allow ophthalmologist and technicians to keep numerous records open simultaneously and steadily in different rooms. Furthermore, F Lum et al. conclude that ophthalmologists frequently do assessment of multiple concurrent windows (e.g. Fundus Images, clinical data, drawings) connecting to the same patient. F Lum et al. told us that Electronic health records avoid positions where multiple windows are open to display data of different patients, which can produce medical errors. Medical standard systems should subordinate electronically all relevant operative, preoperative and postoperative documentation which includes medical clearance of preoperative, clinical notes, informed consent discussion support tools for risk management, anesthesiology documents, informed agreement forms, clinical data required for surgical procedures (e.g., intraocular lens selection, axial length measurements) and operational reports. In the last F Lum et al. conclude that all such procedures should be connected to the additional study when possible and should be linked to vendor-neutral reporting or medical standards and profiles (e.g., DICOM) when available.

F Lum et al. believed that it helps ophthalmologists to classify significant features when examining for systems and will encourage vendors to identify and integrate such functions. Up to the level that EHRs deliver opportunities for ophthalmologists to exploit cooperation with major care providers or other specialists.

In [34] Tahir F et al. briefed us that Machine Learning and Image processing based systems shows an important role in medical treatment. CAD (Computer Aided Diagnostics) has established new tracks to the detection of various syndromes. CAD is playing a dynamic character in finding of Diabetic retinopathy. Tahir F et al. divided the proposed system into 3 steps, the input of retinal image and its preprocessing, candidate region detection and then eye set design and classification of the marks as laser marks.

A2. Proposed System

Machine learning and Image processing based systems shows a vital role in medical image diagnosis [35]. Computer Aided Diagnostics (CAD) has established novel paths for the diagnosis of different various diseases. Furthermore similarly CAD is performing a dynamic role in analysis of Diabetic Retinopathy. We present a comprehensive arrangement of our proposed system from proposing tags for DICOM to classification of the laser marks in Fundus images. Our proposed system is divided into two different parts. Detection of Laser Mark and Proposing tags for Ophthalmology. The techniques used for Detection of laser mark is based on image processing and machine learning and is further separated into 3 steps, the preprocessing of the input retinal image, detection of candidate region and then feature set formulation and classification of laser marks by using minimum distance classifier. Fig A2 show the setup of detection of laser marked fundus image.

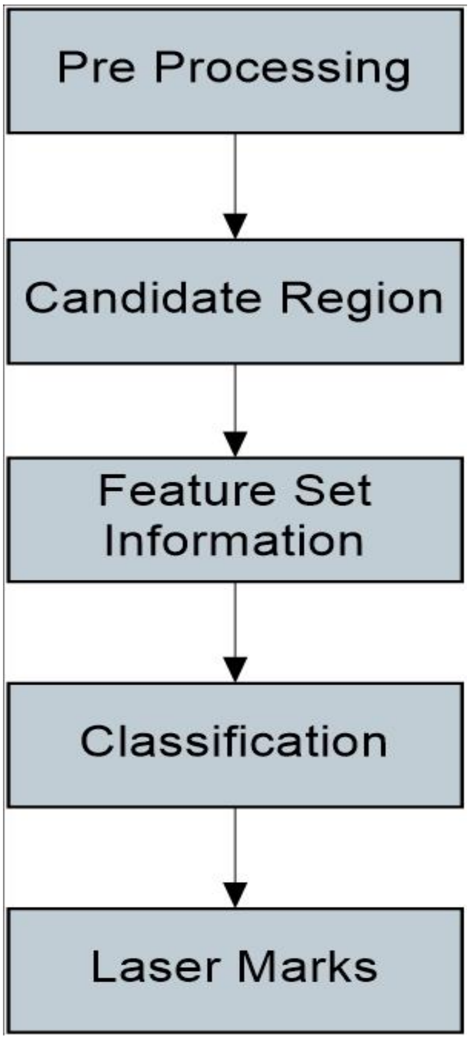

Figure A 2 Proposed System

A2. Pre-Processing

The data set of fundus images often comprise noise and lack proper illumination which is due to camera settings and unknown noise. Therefore the acquired fundus image is gone through several preprocessing steps. The step of preprocessing helps us to remove those unwanted objects that contain Adapt Histogram Equalization, green channel extraction and Background illumination estimation.

We use Adaptive histogram equalization to improve the contrast among the background and laser marks in fundus images as shown in figure A3.

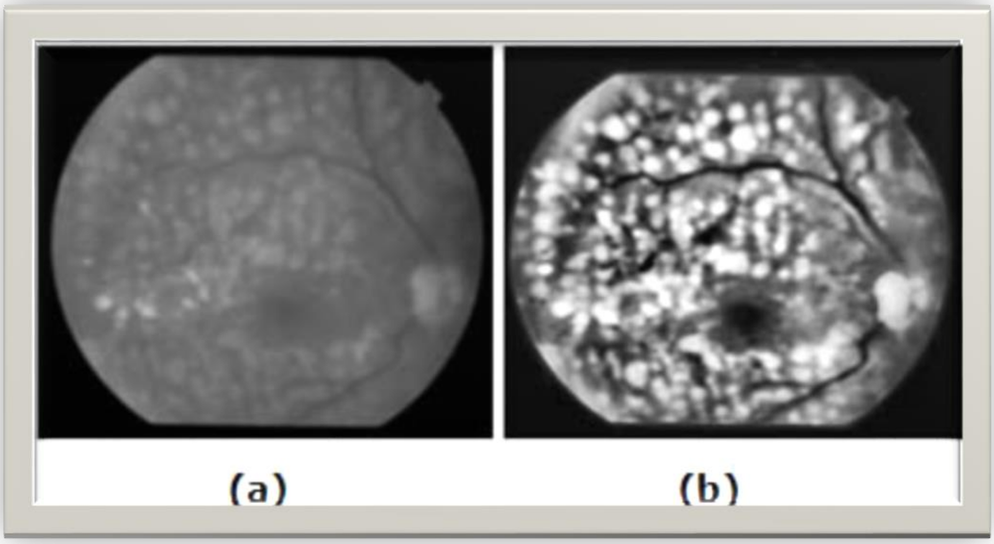

Figure A3 (a) Applying Averaging Mask (b) Adaptive Histogram Equalization

In green channel we extract green channel for further processing because in fundus images laser marks looks optimistic in comparison with blue and red so that's why we extract green channel

Furthermore for the reduction of noise further by blurring effect circular averaging filter is applied on the green channel. While extracting the region of interest from laser marked fundus image background illumination origins a lot of problem and it gives a lot of noisy objects to agree with if not pointed or figured out in advance, so to evaluate the background illumination morphological opening process is executed using equation 1

$$f \circ b = (f \ominus b) \oplus b$$

Equation A1

Where "b" represent structuring element and symbol " $\circ$ " represents morphological opening, symbol "$\ominus$" represents erosion and symbol "$\oplus$" represents dilation of the result after erosion. This morphological opening process gives us estimate of background illumination when it is deducted from the original image and the resultant image has uniform background .The resultant image is too dark which needs enhancement. We use Contrast enhancement to recover the contrast of laser marks for improved and easy detection of laser marks.

A3. Candidate region:

In preprocessing step we perform smoothing, green channel extraction, background estimation and contrast enhancement which eliminates some unwanted object from the image surface by overpowering and flattening down entirely the noise.

To get binary image which comprise of laser marks and undesired candidate region we calculate a threshold value for the preprocessed image which is applied on the image to get the binary. To get the possible laser marks out from the image we kept low its threshold value and then these laser mark images are classified by means of minimum distance classifier. Moreover some post processing steps are used to remove further undesired candidate regions from the binary image which are left from morphological filling operation.

A4. Classification

The candidate region extraction phase extracts all possible candidate regions. We kept low the threshold value in order to no region with laser marks should be unexplored. All other marks except laser marks are scrapped during the phase of classification.

A4.1. Feature Set Formulation

Laser marks look like circular and small spots or as large and irregular spots in the image. Laser marks might present a dark or bright exterior. All possible marks are extracted in candidate region extraction phase.

Assume that a fundus image Z contains N possible laser spots then the set which represents the laser spots can be formulated as z={z1,z2,z3……zn}. Each candidate region is presented by feature set while extracting out all the laser spots from fundus image. A candidate region is represented by extracted features from by taking sample image for classification.

Assume a candidate region X from an image "a" comprises m features then it represent the feature vector as X={a1,a2,a3,…., am}. Formulated feature set is briefly described below

- **Compactness (a1):**

It processes how professionally an edge measures the area inside it.

- **Max Hue (a2):**

Hue presents the component of visual demonstration and its determined value is selected as a feature.

- **Max saturation (a3):**

Max saturation calculate the intensity of color existent in image and its maximum value present in an object is selected as a feature for classification.

- **Standard deviation of saturation (a4):**

It calculates the standard deviation in the inundation channel of all the pixels of fundus image in candidate region.

- **Intensity mean (a5):**

It calculates the mean intensity value for all pixels in a candidate region.

- **Intensity max (a6):**

Maximum value is obtained in the intensity channel of candidate region.

- **Intensity standard deviation (a7):**

It expresses around the standard deviation of intensity in candidate region.

- **Mean Red channel (a8):**

It calculates mean value of Red plane in RGB model.

- **Max Red channel (a9):**

In candidate region it calculates the maximum value of a Red plane.

- **Max Green channel (a10):**

In candidate region it calculates maximum value of a Green plane.

- **Minimum Distance classifier**

In candidate region detection an insignificant threshold value is occupied in order to guarantee that most of the potential regions ought to be segmented. In this phase all false region will be removed of projected technique. We used Minimum distance Classifier in order to classify the candidate region as a laser spots.

Once the image is classified then after that the classified image is forwarded for conversion. For tagging fundus image first and the foremost step is to convert the fundus image into DICOM because image is acquired through fundoscopy and fundoscopy acquire image in ".jpg" format where as DICOM use ".dcm" format. So it is very necessary to convert fundus image after classification from .jpg to .dcm for further process. The second step is to tag the patient data in image. Tagging includes insertion, deletion and updating of patient data.

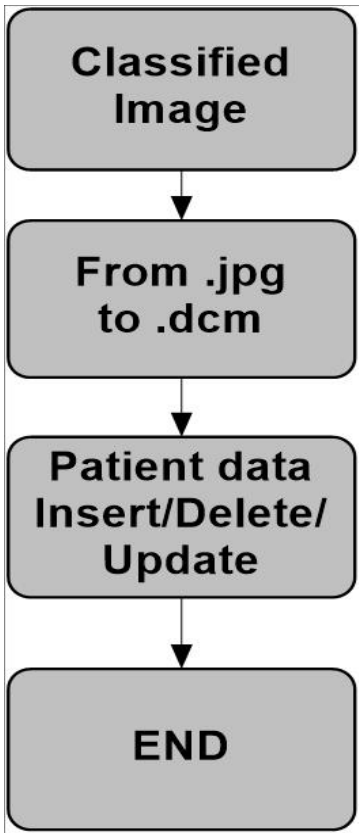

Figure A4 Proposed DICOM System

For this purpose first we study the tags and its purpose for dicom. In DICOM tags are used to store patient and its communication with physician in an image. There are several free and paid software's which are available on internet and can be used for DICOM image processing. MATLAB also gives us the facility to work with dicom images. MATLAB provide few built-in functions for DICOM images through which we can process .dcm images. Software's which we are analyzed and used during the process of .dcm images are SANTE DICOM, Radiant DICOM, OSIRIS DICOM, EFILM, IFRAN View , Power DICOM , DICOM Editor and DICOM Works. Some of them are demo versions.

A5 Proposing Tags for Ophthalmology

DICOM has implemented tags for some of the medical areas and those departments are working with the tags successfully. Each medical department have its own even group number i-e every single medical area is separated by its group number. Furthermore every group number will contain related tags of its medical domain. Let's say group number 0020 is reserved for angioscopy, so group number 0020 must contain the tags related to angioscopy. So here in this thesis we are proposed some private tags for Ophthalmology by conducting a survey. Furthermore first we discuss these tags with ophthalmologist in order to know which tags are related to ophthalmology and are necessary to be added in DICOM. In first step we conducted a workshop for ophthalmologist and give a brief introduction of DICOM because all the ophthalmologists were not aware of DICOM, which is also proved from the survey we conducted. With the collaboration of ophthalmologists we divided the tags into five sub groups in order to make the quality of survey better and to better understand the survey by different ophthalmologist easily. These groups are Ocular Significant Illness, Ocular History, Ophthalmic Surgical Information, Ophthalmic Recent Symptoms and History of Eye Problems. Furthermore there are about more than five thousand tags in DICOM which are used for numerous purposes in different medical departments. We analyzed and studied round about 1000 tags for our thesis. During the study we came to know that studying important tags can help us in doing our research which are important than studying irrelevant tags which cannot help us doing research and writing thesis, so we skip studying those tags which are not relevant to our thesis.

A6 Results

The evaluation of proposed system is performed on a locally gathered dataset of patients suffering from different retinal diseases. The dataset consists of 380 images with 1504 x 1296 resolution. The images are captured using Topcon 50EX mydriatic camera. These images are manually labelled as laser treated or not with help of ophthalmologists. The dataset contains a total 51 images which are treated with laser and contain some or more laser marks. The remaining images contain some image from normal patients and others with different levels of retinal diseases but without any laser operation. Fig. 6 shows some randomly selected images from our database containing different level of laser marks.

Table A1 shows the confusion matrix for whole dataset and the performance parameters calculated from this using equations 1-3 are given in table A2.

	Laser Marks	Without Laser Marks
Laser Marks	48	3
Without Marks	9	320

Table A1Confusion Matrix

These evaluation has been done at mage level means that if an image has been treated with laser and proposed system classifies it as positive, then it is considered as correct.

Total Images	Laser Treated	Sen	Spec	Acc
380	51	.94	0.97	0.96

Table A2

APENDIX B

Survey of DICOM Ophthalmic Fundus Image TAG'S

Dear Respondent,

I am student of Master of Science (M.S) in Computer Software Engineering at NUST College of Electrical and Mechanical Engineering, Rawalpindi. I am conducting a research on "Analysis and Impact of DICOM (Digital Image Communication in Medicine) on Ophthalmic Medical Images". Aim of questionnaire is to collect data on proposed research. Your valuable time in completing this questionnaire will help me to identify the required outcomes of this study. Your contribution towards this research is highly appreciated.

Name: ______________________________ Date: __________

Current Designation: ___________________________________

Date of Birth: ____________ Education: _________________

a. Do you ever used Medical Standards?

- ☐ Yes
- ☐ No

Out of 37 Doctors only 6 people used medical standard 31 people are not aware of medical standard

If *yes* select the medical standards which you have used.

- ☐ DICOM(Digital Image Communication in Medicine)
- ☐ HL7(Health Level 7)
- ☐ CCR(Continuity of Care Record)

- ☐ CCOW(Clinical Context Management Specification)
- ☐ LOINC(Logical Observations Identifiers Names & Code)
- ☐ IHE(Integrating the Health Care)
- ☐ HITSP(Healthcare Information Tech Standards Panel)
- ☐ SNOMED (Systematized Nomenclature of Medicine)
- ☐ Any Other ______________________________________

b. From the above Listed Medical Standards which one would you like to prefer for Ophthalmology Fundus Images

I. 29 says DICOM

II. 3 says HL7 because DICOM is complicated

III. 5 says others

c. Do you ever heard about DICOM (Digital Image Communication in Medicine) before?

- ☐ YES
- ☐ NO

If yes then how much you are experienced in DICOM. Kindly select one from below choices.

- ☐ Not Experienced
- ☐ Beginner
- ☐ Expert
- ☐ Professional

d. Which of the following activities would you be interested in seeing well without glasses?

- ☐ Reading the newspaper
- ☐ Reading the prescription medicine bottle

- Looking at your watch
- Working on your computer
- Dialing a phone
- (Ladies) Putting on your make up
- (Men) Shaving your face

e. Ocular Significant Illnesses: (Please read it carefully and mark the check boxes which you can think that these tags should be added in DICOM. Please mark all that should be available or applied in DICOM)

□ Overall Healthy □ Herpes □ Hypothyroidism □ Sjogrens □ AIDS □ HIV Positive □ Lupus □ Graves' disease □ Diabetes □ Hypertension □ Multiple Sclerosis □ Hyperthyroidism □ Rheumatoid Arthritis

f. Following is Ophthalmic Surgical Information. Tick mark Yes or NO that following Surgical Ophthalmic information should be the part of DICOM or Not?

Surgical Tags

Ophthalmic- No Surgery	YES	NO
Eye Infection		
Foreign Body Removal		
Refractions		
Tonometry		
Ophthalmic- Minor Surgery	**YES**	**NO**
Blepharplasty - Functional		
Cataract Surgery		
Chalazion Excision from Eyelid		
Iridectomy		
Intraocular Lens Replacement		
Laser, No Retinal Detachment		
Trabeculectomy		

Ophthalmology – Major Surgery		
Blepharplasty -- Cosmetic		
Corneal Transplants		
Enucleation		
Lid Repairs		
Permanent Lash Liner		
Radial Keratectomy (PRK)		
Laser in-situ Kertomileusis (LASIK)		

Recent Symptoms:

Symptoms	**YES**	**NO**	**Symptoms**	**Yes**	**No**
Failed Vision Test			Eye Rubbing		
Wandering or turned eye			Frequent Blinking		
Blurred Vision			Light Sensitivity		
Can't make normal eye contact			Problems with near work or reading		
Poor Eye Tracking			Poor Judgment of depth		
	YES	NO		YES	NO
Tearing or Discharge			Headaches		
Red or Swollen Eye			Double Vision		
Droopy Eyelid			Clumsiness or bumping into things		
Can't make normal eye contact			Difference in pupils or irregular shape of pupil		
Bulging or sunken eye			Frequent headaches		

Tired eyes when reading			Weakness or numbness		

History of Eye Problems:

Eye Problems	YES	NO	Eye Problems	YES	NO
Glasses			Eye Injury (Mention if any accidental)		
Patching					
Glaucoma			Wandering/ Crossed Eyes		
Blurred Vision			Redness		
Itching			Discharge		
Flashes of light			Floaters		
Lazy Eye			Other Eye Problems		

g. Past Ocular History: (Please mark all that should be available or applied in DICOM)

□ Overall Healthy □ Cataracts □ Hyperopia (Far sighted) □ Myopia (Near sighted) □ Amblyopia □ Diabetic Retinopathy □ Iritis □ Optic Neuritis □ Aphakia □ Dry Eyes □ Keratoconus □ Retinal Detachment □ Astigmatism □ Glaucoma □ Macular Degeneration □ Color Blindness □ Strabismus

h. Ocular Surgeries: (Please mark all that should be available or applied in DICOM)

□ No prior ocular surgery □Foreign Body Removal □ Punctual Plugs □ Trabeculectomy □ Blepharoplasty □Retinal Laser Surgery □ Glaucoma surgery □ Vitrectomy □ Cataract Surgery □ LASIK (Refractive Surgery) □ Strabismus Surgery □ Corneal Transplant □ PRK (Refractive Surgery)

i. **Ocular Significant Illnesses**: (Please mark all that apply)

□ Overall Healthy □ Herpes □ Hypothyroidism □ Sjogrens □ AIDS □ HIV Positive □ Lupus □ Graves' disease □ Diabetes □ Hypertension □ Multiple Sclerosis □ Hyperthyroidism □ Rheumatoid Arthritis