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Disruptive Technology Enabled Healthcare 4.0 Model for Lesion Identification with Reduced Latency

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Abstract: Advancement and innovations in technology have resulted in ease of accessibility and availability of resources, resulting in an increased liability on health-care services. However, the application of healthcare services in rural and undeveloped areas remains a foremost challenge, despite the investments made, largely due to unreliable communication infrastructures. Machine learning (ML) has witnessed a terrific amount of attention over the last few years in the field of medical imaging research for the lesion detection through a biomedical application such as Magnetic Resonance Images (MRI), CT scan, X-rays and Ultrasound etc. Normally, an MRI or CT scan are used by the experts to produce images of the soft tissue of the human body. Early detection of the lesion is a crucial part of follow-up care after completion of primary treatment. The goal is to reduce the mortality rate by early detection and treating the disease while it is still curable assuming a more effective salvage surgery and treatment. This paper presents a comprehensive review of the automated classification learning algorithms to identify lesion; indicates how learning algorithms have been applied to biomedical applications from data acquisition to image retrieval and from segmentation to disease prediction. This paper provides a brief overview of recent innovations and challenges associated with learning algorithms applied to medical image processing and analysis. Lastly, the paper concludes with a concise discussion and tries to predict direction for upcoming trends on more advanced research studies on lesion detection.

Index Terms: **Lesion, Pattern Recognition, Machine learning, Medical Image Analysis.**

I. INTRODUCTION

India is among the countries that potentially has the fastest growing economy across the globe. Evidence suggests that increases in education, economic opportunities and wealth have led to better living conditions and thus general health condition of the citizens of the nation.

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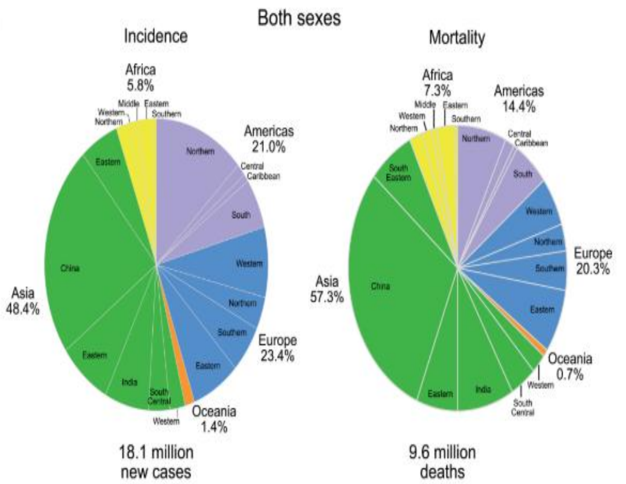

Fig.1. Distribution chart of Cases and Deaths by World Area in 2018 for Both Male and Female. Source: GLOBOCAN 2018.

However such changes in the economy have a flip side too, with ease in access to resources and better living, there is a tendency to grow careless, with consequences like reduction in physical activities, increase in accessibility to unhealthy lifestyles such as an increase in consumption of high calories food and use of tobacco [1]. These changes in lifestyle have resulted in an increase in number of non-communicable diseases, like diabetes, cardiovascular *diseases*, cancer and chronic lung disease/chronic obstructive pulmonary disease [2,3]. The second most common cause of death in India is Cancer after cardiovascular disease [4]. The term "Cancer" is derived from the Greek word "Karkinos" that denotes to a generic non-communicable disease characterized by the growth of malignant (cancerous) abnormal cells (lesion) in any part of the body. Globally, Cancer is the foremost cause of death and for 2018, it is predictable to be approximately 9.6 million death as shown in Fig.1. While several kinds of cancer have been detected, the most common places of these cancer tissue or lesion in bodies are stomach, lungs, breast and liver. Five most frequent cancers in India depending on the ranking is defined by the total cases of men and women are cervical, breast, dental, lung and colorectal (see Fig.2.) and these accounts for 47.2 % of all cancers present [5,6].

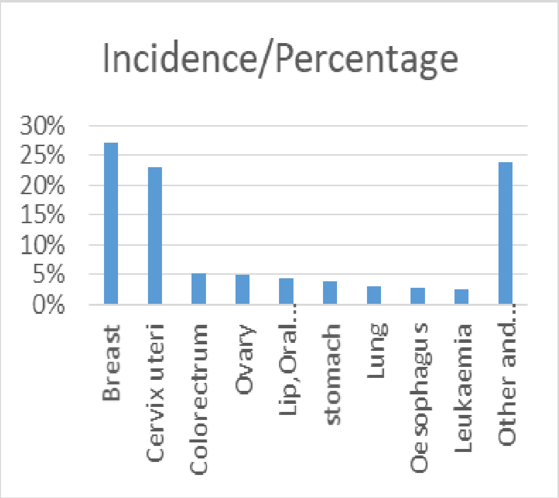

Fig.2. Cancer Incidence in India

In India, the most common form of cancer among men are stomach, liver, lung and colorectal cancer, while cervix, breast, lung, colorectal and thyroid cancer are the most common among women as shown in Fig.3. Worldwide deaths from cancer are estimated to continue to rise to over 13.1 million by the year 2030.

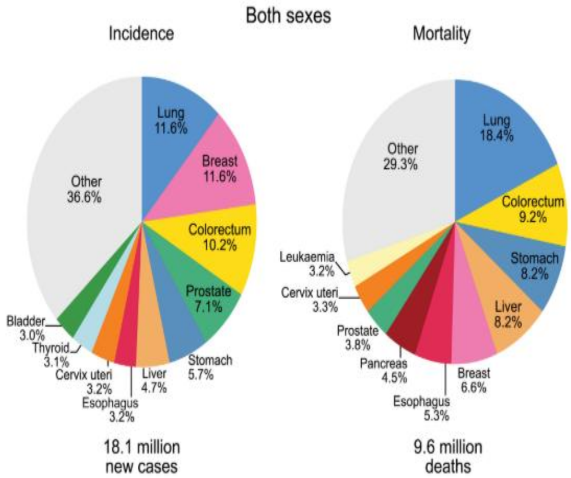

Fig.3. Distribution chart of Cases and Deaths for the 10 Most Common Cancers in 2018 for both Male and Female. Source: GLOBOCAN 2018.

One of the reasons for cancer is lesion (tumor). A lesion occurs due to any abnormal change in cells related to a tissue or organ due to injury or disease. The term 'lesion' is originated from a Latin word 'Laesio' which refers to 'injury or attack'. Lesions can occur anywhere in the body that comprises soft tissue. The definition of the lesion is so wide that there is no designated classification or naming convention for it as the varieties of the lesion are practically endless. The most frequent lesion is found on the skin, in the brain or in the mouth. In general, lesions may be categorised by their locations, their causes, their patterns or their sizes (see Fig.4.). Frequently, Lesions are also named after the person who discovered them. Specialized names are given to some lesions such as Ghon lesions in the lungs.

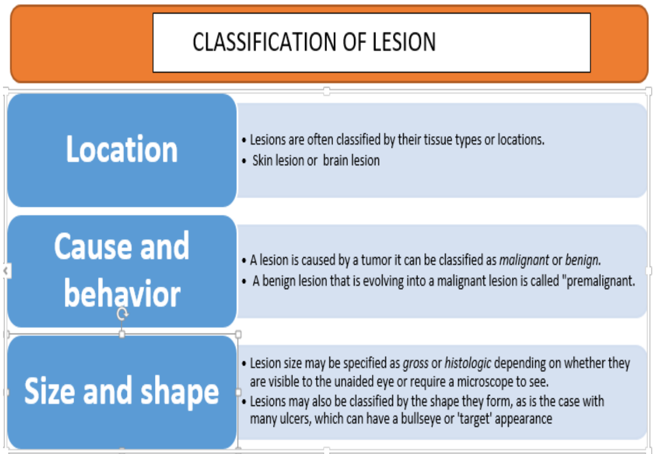

Fig.4. Classification of lesion

For every nation, the prevention of cancer is one of the major significant public health challenges of the 21st century [7]. Cancer can be cured by reducing exposure to cancer risk factors including physical activity, diet and nutrition around 40% of cancer cases can be prevented [8,9]. Approximately 30% to 50% of cancer deaths are preventable according to avoiding significant risk factors like reducing alcohol consumption and tobacco, maintaining body weight, exercising regularly. Moreover, a significant proportion of cancers can be treated especially if they are detected early by surgery, radiotherapy or chemotherapy [10-13]. Early detection of disease can be aided by employing technologies for example artificial intelligence, Internet of Things (IoT), Fuzzy logic, Data analytics and machine learning. With the rapid growth and innovations of technology, the techniques in the healthcare industry have evolved for fast and efficient treatment. IoT technologies are being used for the proactive diagnosis, delivery of smarter health care and remote patient monitoring. With the help of information technology the healthcare industry has been undergoing major changes that are mainly it is moving from traditional electronic medical records to e-health where the healthcare is supported by wearable devices or sensors, bio-medical data, context awareness, resilience communications, biomedical services, m-health applications, telemedicine systems, etc. [14,15]. All of these new healthcare services that are integrated with IT solution provide more coordinated patient cantered solutions. However according to WHO report, it recently represent that chronic non-communicable diseases for example stroke, diabetes, cancer and heart-lung disease still remain the leading causes of death globally though the technology has brought down the mortality rate. Traditional health management model is used to measure signal and was not suitable for daily monitoring for long-time period especially for some diseases with delayed symptoms like cancer. Generally wearable health equipment's like sports bracelets or smartwatches are used to observe a user's health. Currently, the significant feature of wearable health technology which are accessible at home are as follows, monitoring respiratory rate and blood oxygen concentration, ECG monitoring and diagnosis of heart diseases, monitoring exercise state and sleep quality.

Paper presents an overview of the healthcare industry from the perspective of modifications in healthcare from technology point of view, with an insight specifically into the detection of lesion aspect of the healthcare. The work proposes an efficient, secure, dependable and economical communication solution for e-health. Outline of the paper is as follows: Section-2 contain literature review on various work and progress in the area of healthcare and machine learning algorithm, Section-3 presents the major lesion identification algorithms used to detect different kind of lesion, Section-4 present current scenario of cancer lesion identification and treatment in India, Section-5 identifies challenges and issues that concern healthcare industry, Section-6 proposes a model to integrate disruptive technology for efficient and fast healthcare services , the paper in conclusion also dwells on open issues and challenges faced by healthcare industry.

II. LITERATURE REVIEW

Digital healthcare services are becoming a reality in today's world and it has the potential to wedge itself into a staid system that has been averse to change. Healthcare industry over the past few years has seen how artificial intelligence algorithms and IoT devices can be used to treat patients and they have more active presence in terms of monitoring like maintaining and circulating medical information, diagnostics, storage, clinical information, communications between different centres etc. These systems are useful for doctors, patients and medical workers to provide diagnoses and treatment in a more effective way. There is a need to expand the health-services from hospital to home with an objective to facilitate diagnosis in an appropriate time. Further to increase the speed of development of healthcare services, a novel paradigm known as telehealth has started which will allow individual health monitoring and disease management in non-clinical setting like homes, clinic and ambient assisted living(AAL) [16]. In healthcare monitoring framework, remote patient is monitored by sensors which are connected to the medical equipment and is used to collect data of patients, this data is then sent to cloud for providing universal access and it analyses the collected data and stores it for further need. Advancement in healthcare 4.0 systems comprises of computer, data, database and analytics along with telemedicine systems, these connect remotely to computer systems equipped with intelligent and efficient learning algorithms that can help in therapies with little input from medical staff [17]. Various algorithms till date have been proposed for identification and detection of lesions in human body.

1. Healthcare Generations: History and Origin of Healthcare

As the Industrial revolution, the Healthcare industry has enhanced from 1.0 to 4.0 generation as shown in Fig.5.

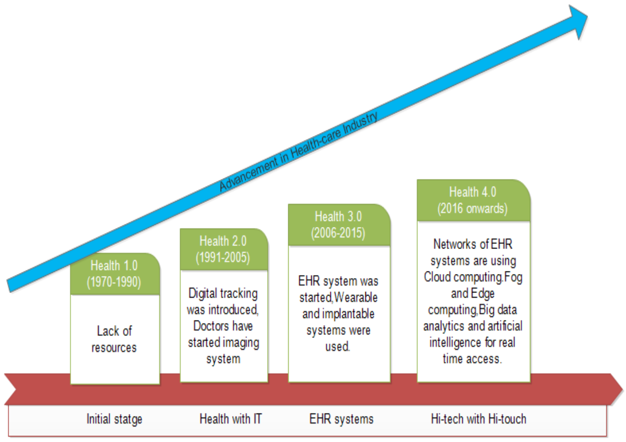

Fig.5. Revolution in Indian Healthcare Industry.

In decades of 1970-1990, the healthcare industry introduced emergence of IT modular system and within this duration, industry was termed as Healthcare 1.0. Over the next decade and a half, IT healthcare systems started getting networked and Electronic Health Records (EHRs) were generated with clinical image support which assisted the doctors to get better view. This duration was known as Healthcare 2.0. Healthcare 3.0 was introduced in year 2005 and it impact the development in the field of genomic information, the emergence of wearables devices. Further innovations were the need of hour since it was still hospital-centric, so the patients with long-lasting illness had to suffer due to multiple hospital visits for routine checkups which resulted in high expenditure and extensive tome for the treatment of patients. This issue was resolved with technological advancements Healthcare 4.0, involving all kinds of intelligent equipment (e.g., industrial robots), EHR system, Artificial Intelligence (AI), real-time data from wearable devices, fog and cloud computing [18]. Employing healthcare 4.0, remotely located patients were able to reach the doctor anytime, anywhere in the world and it allowed doctors to access the patient's data globally and extract insights from the data captured for different diagnosis and moreover medical responses were predicted timely.

The Indian healthcare industry is developing at a rapid pace and is estimated to be USD 280 billion by 2020. However there are several reasons for this change such as government policy, health insurance, increase in demand for better services from healthcare providers like physicians, surgeons, diagnosticians and hospitals as a whole are also increasing to use healthcare 4.0 - enabled tools and enhance their efficiency, emergence of patient-centred care and data revolution. Accessibility of affordable high-speed data connectivity has made possible for both doctors and patients from distant remote locations to access benefits of healthcare 4.0 as depicted in Fig.6.

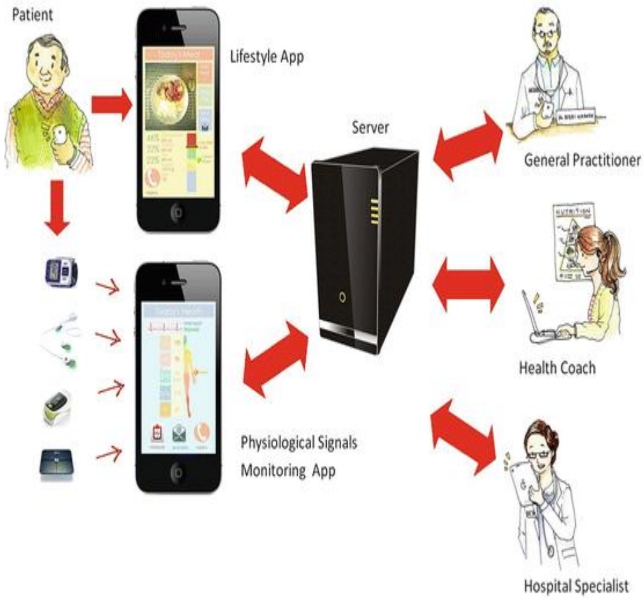

Fig.6. Medical data delivering to doctors at a distant hospital from patients' smartphone

2. Learning Algorithms employed for classification In Healthcare Industry

Learning algorithms have evolved over the years, so are the techniques for healthcare services, IoT and Artificial intelligence (AI) algorithms have played an instrumental role in bringing about the transformations in healthcare services, AI can be applied to both structured and unstructured data, for structured data machine learning algorithms (neural network, support vector machine and deep learning) are used and natural language processing used for unstructured data [19, 20].

AI techniques are being utilized for healthcare services, even certain diagnostic decisions are being re-affirmed with the help of AI algorithms, to some extent even in highly sensitive areas of health such as radiology. AI techniques have made it possible to access healthcare data, considered as big data owing to its volume and can reveal various important diagnostic information which helps doctors as well as researchers to make efficient decision [21,22]. Machine learning algorithms have been employed with high frequency to detect the presence and level of infection in patients. Patient's traits for algorithms include gender, age, disease history and disease-specific data like gene expression, diagnostic imaging, physical examination results, EP test, clinical symptoms and medication information. And patient's medical outcomes include disease indicators, quantitative disease levels such as tumor sizes, patient's survival times. Input to machine learning algorithm includes patient traits and occasionally medical outcomes of interest. ML algorithms can be categorized into two main categories depending on whether to incorporate the outcome that is supervised learning and unsupervised learning [23]. For predictive modelling, supervised learning can be used via building relationships between the input (patient traits) and output (outcome of interest), while unsupervised learning is used for feature extraction. Common unsupervised learning algorithm used is Clustering, in clustering, clusters are formed which is a group with either similar or dissimilar traits/characteristics without employing outcome information. In Clustering algorithms, result of cluster is labelled for the patients by maximizing and reducing the resemblance of patients within and between clusters. It frequently employed include Gaussian mixture clustering, k-means clustering and hierarchical clustering. Whereas, In Supervised learning the outcome is known, and that this information is explicitly used in training (Supervised) process to determine the best outputs associated with the inputs that are closest to the outcomes on average. Frequently employed supervised learning algorithms include naïve Bayes, linear regression, decision tree, logistic regression, random forest, discriminant analysis, nearest neighbor, neural network and support vector machine (SVM) [24-26]. The hybrid category also exists addressed as semi-supervised learning which is a mixture between unsupervised learning and supervised learning and is appropriate for situations where the result is missing for particular cases [27]. Fig.7. depicts the supervised learning techniques in medical applications, which emphases on popularity of SVM and neural network (NN).

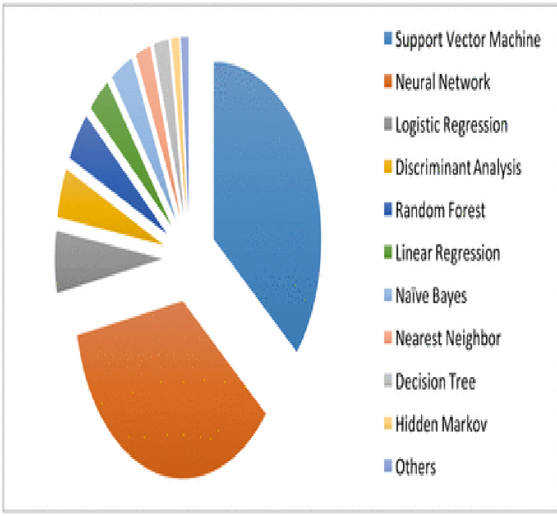

Fig.7. Machine learning algorithms used in the detection and classification of lesion

Learning algorithms have been penetrating all spheres of healthcare services, from improving healthcare management to new drug discovery. Some of the machine learning applications that have emerged in recent years are highlighted below:

i. Disease Identification/Diagnosis

Accurate diagnosis involves data analytics of all the information including the medical history of ascendants to make a prompt and an accurate conclusion about disease and for a doctor to recall all information is tedious. In addition to the modern abundance of textbooks, research papers and case studies, no doctor can master every aspect of medical care and recall every detail of similar cases. However, it is possible to feed an AI-based system with relevant data and let the computer sift through the extensive database. Disease identification was brought therefore at the forefront of ML research in medicine because of aforesaid reasons.

ii. Telehealth

In the last decade, due to the advancement in technology the healthcare industry is developing rapidly and it gave rise to new paradigm known as "Telehealth" which made it possible to monitor patients health and disease management in non-clinical setting like nursing homes, private homes and assisted living. The infrastructure of telehealth consists of Body sensor network which is a combination of wearable sensors and personal area network. Because of sensor-rich infrastructure, it generates medical big data for remote diagnosis.

iii. Smart Electronic Health Records

Electronic health records (EHR) are vital for digitalization and the spread of data in the healthcare industry. Accessing of digitalized data causes its own issues such as data overloading and burnout for users.

Using an intelligent tool that scans EHR data, can pretty accurately predict the stage and category of the disease, a person is suffering from. Closely connected to personalized medical treatment in the area of health-related documentation. Document classification using SVM, as well as optical character recognition that is transforming handwriting into digitized characters, are both vital to learning algorithms in the collection and digitization of e-health data.

iv. Drug Discovery/Manufacturing

Drug discovery is used in a range of activities, from initial screening of drug compounds to success rate prediction based on biological factors and learning algorithms are a powerful tool which can be utilized in preliminary stage for deriving conclusions based on data analytics. Through ML algorithms, drug discovery time is reduced, yet, the key players in this area is MIT Clinical Machine Learning Group and they conducted precision medicine research with the vision of the enhancement in existing algorithms for better understanding of disease for effective treatment such as Type 2 diabetes and Microsoft's Project Hanover who in cooperation with the Knight Cancer Institute is developing AI-assisted technology for early cancer precision treatment.

v. Clinical Trial Research

In clinical trial researches learning algorithm help with several potential application such as: using innovative predictive analytics in detecting candidates for clinical trials, which can facilitate wider range of data, including social media and doctor visits, as well as genetic information on the target populations. Good sampling methods would be small, less time taking and less costly for trials. For data access and remote monitoring learning algorithms can be used such as, continues observation of genetic signals for any symptoms which harm patient or may prove fatal. Learning techniques with reference to best sample size can reduce errors in data in medical records

vi. Epidemic Outbreak Prediction

Contagious infections sometimes take form of widespread epidemics, specific to locations or maybe across the globe, in such situations learning algorithm can be very well employed with statistics input for efficient predictions. The data sources include data collection from satellites, historical web data and social media updates. Predicting outbreak severity is significantly important for third-world countries, due to lack of medical infrastructure, educational opportunities, expertise, and access to treatments.

III. MAJOR LESION IDENTIFICATION ALGORITHMS

The lesion is defined as any abnormal change in cells related to any tissue or organ due to injury or disease. Lesions can take place in any part of the human body that comprises soft tissue. The term lesion is so vast that there is no significant categorization or naming convention for it as the varieties of the lesion are practically endless. The most common lesions are skin lesion, oral lesion, brain lesion, breast lesion, stomach lesion and etc. In general, lesions can be categorized by their locations, their causes, their patterns or their sizes. Lesion categories and identification algorithms can be categorized as:

1. Brain Lesion

Abnormal growth of cells in or around the human brain known as brain lesion. Lesions are capable of directly destroying healthy brain cells which causes inflammation, swelling and pressure in the skull. The lesion is either benign or malignant. A malignant lesion, are termed cancerous lesion, grows quickly and often invades healthy cells of the brain. Benign lesions are termed non-cancerous lesion, usually grow at slow pace and behave normally under microscope. Brain lesion has two types, one is primary and other is metastatic. In the primary brain lesion cancerous cells formed within the brain region on the other hand in metastatic lesion, cancerous cells form in the other parts of body but they transfer to brain after breaking from that location. It's classification based on the location of lesion, involvement of type of tissue as well as type of lesion (benign or malignant). According to survey there are various type of classification techniques available for MRI brain image such as supervised learning, unsupervised or semi-supervised learning, Supervised techniques give high accuracy among all techniques. Nowadays researchers are focusing on semi-supervised techniques for developing automated system. The supervised technique gives highest level of accuracy [28-30].

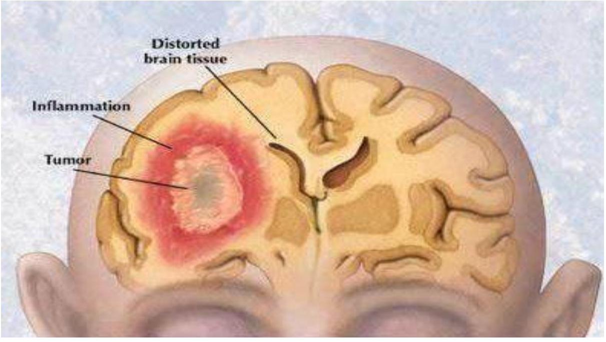

Fig.8. Brain Lesion[30]

Table-I: Qualitative Comparison of the significant models for segmentation and classification of brain lesion

Author / study	**Segmentation technique / Feature extraction technique**	**Classifier**	**Accuracy / Results**	**Limitations**
Lin et al., 2005	-	Fuzzy c-mean classifier	96.5%	It runs automatically except for the choice of a volume of interest and seed point. A user verification step must be added to ensure the quality of the result.
Chaplot, Sandeep, L. M. Patnaik, 2006	DWT (Discrete wavelet transform)	SOM (Self-Organizing Map)	94%	
Othman, Mohd Fauzi Bin, 2011	-	SVM + Radiant Basis Function (RBF)	65%	It doesn't work precisely when the data is large due to the training complexity of SVM itself that is highly dependent on the size of data.
Sachdeva, Jainy, et al., 2011	Spatial gray level dependence method- Genetic algorithm	SVM classifier	Overall accuracy is 91%	Having fresh training set whenever there is a change in image database. It has been observed that the performance of the classifier depends upon the features selected.
Zhang, Yudong, et al., 2011	Wavelet transforms + PCA	BPNN (Back Propagation Neural Network)	100%	Lost the time information of the signal, classification decrease as the time information is lost
Su, Po, et al., 2012	Knowledge-based fuzzy algorithm	SVM active learning approach	81%	Lack of a quantitative measure of the non-enhanced tumor area.
Arakeri, Megha P., 2012	Fuzz C-mean	Advance LS-SVM	97.95%	Stem could not achieve higher performance in retrieving most similar images
Arakeri, Megha P., 2012	PCA and LDA	KNN + SVM	97.95%	Stem could not achieve higher performance in retrieving most similar images
Sumitra et. Al., 2013	PCA	NN (Neural Network)	73%	Over discriminant accuracy is less. Determination of Unique feature vector is not possible
Saritha, M., K. Paul, 2013	Wavelet Entropy	PNN (Probabilistic Neural Network)	100%	When there is increase in image database fresh training in required
Vandhana, S., et al., 2015	Threshold segmentation method	SVM classifier	type of lesion is determined whether it is malignant, benign or normal	Lack of quantitative measures
A. Anbarasa Pandian and R. Balasubramanian, 2015	Contourlet transform	DNN (Deep Neural Network)	97.5%	Accuracy level can be increased more
Amulya, Ch, and G. Prathibha, 2016	SURF & SIFT	KNN	96.22%	Still accuracy is less than SVM
P. Rajkumar, Y. Justin dhas, 2017	Gray Level Concurrence Matrix features	DNN (Deep Neural Network	93.18%	Accuracy can be increased more.

Table-II: Comparison of different Classification technique

Accuracy of Classification Techniques	SVM	KNN	SOM	NN	Fuzzy c-mean	PNN	BPNN	DNN
Type of learning Techniques								
Supervised		96.22 %		73 %	96.5%	100 %	100%	97.3%
Unsupervised			94%					
Semi-supervised	95%							

2. Skin Lesion

Any anomaly on the skin or in medical terms, a superficial growth or spot on the skin which cannot resemble the area around it, is termed as skin lesion [31]. Skin lesion is caused due to various bacteria, viruses, parasites or fungi and warts, moles, actinic keratosis and chickenpox are best examples of skin infections and may lead to skin cancer. Skin lesions have two types; first primary and second is secondary. When skin lesion change in color or texture, it is termed as primary skin lesion. Generally it is present at birth, in the form of blisters, macule, nodule, papule, pustule, rash, wheals, birthmark or age spot and secondary skin lesion is an evolution of primary skin lesion and they are transformed into original lesion that results from a natural evolution of the lesion or aggravating the lesion; some examples are crusts, ulcers, scale, scars and skin atrophy. Past few years, have seen the rise in skin cancer cases across the world and the reason is prolonged exposure to ultraviolet radiation on skin. Parallelly in medical science computer-based diagnosis has experienced tremendous advances, through enhancement in the mechanism of identification and detection technology; and the development of algorithms to process the information [32, 33].

Fig.9. Skin lesion [32]

Table-III: Qualitative Comparison of the significant models for segmentation and classification of skin lesion

Author / study	Segmentation / Feature extraction technique	Classifier	Accuracy / Results
Ganster, H., Pinz, P., Rohrer, R., Wildling, E., Binder, M., & Kittler, H., 2001.	statistical feature subset selection methods	k-NN classifier	Sensitivity of 87% with a specificity of 92%
Celebi, M. E., Kingravi, H. A., Uddin, B., Iyatomi, H., Aslandogan, Y. A., Stoecker, W. V., & Moss, R. H., 2007.	Shape, color and texture related features	Support vector Machines	Specificity of 92.34% and a sensitivity of 93.33%
Cavalcanti, P. G., & Scharcanski, J., 2011.	3-channel image representation is generated and later used to distinguish between the lesion and healthy skin areas.	kNN	96.71%,
Abbas, Q., Celebi, M. E., Serrano, C., GarcíA, I. F., & Ma, G., 2013.	Color, texture features are extracted using Color-texture properties	Adaptive Boosting Multi-channel classification.	
Sumithra, R., Suhil, M., & Guru, D. S., 2015.	Region growing segmentation and GLCM with Haralick features.	k-NN, SVM and SVM + k-NN	34% and 46.71% of F-measure using k-NN & SVM classifier respectively and 61% of F-measure for SVM+k-NN.
Amelard, R., Glaister, J., Wong, A., & Clausi, D. A., 2015	High-level Intuitive Features (HLIF)		81.17
Almansour, E., & Jaffar, M. A., 2016	Color and Hybrid Texture Features	SVM	90.32

Table-IV: Comparison of different classification techniques

Accuracy of Classification Techniques	SVM	KNN	Logistic Regression	NN	Fuzzy c- mean	DNN
Type of learning Techniques						
Supervised		83.75	83.3	96.25%	87%	98.7%
Unsupervised						
Semi-supervised	95%					

3. Breast Lesion

A Breast lesion is referred to any abnormality in breast, lesion belonging to this category are of two types that are Benign or malignant lesions. Benign breast lesions grow in non-cancerous areas with slow pace whereas malignant breast cells grow abnormally and rapidly. Benign lesions cells form lumps but do not lead to cancer. They occur in a vast majority in the breast but are often neglected because they are not as dangerous as malignant lesions. These types of lesions do not spread but can be removed according to their size and location and appearance. Malignant lesions are cancerous in nature and are threat to life, malignancy infection is identified through a biopsy test. They are characterized by progressive and uncontrolled growth. These type of lesions must be removed immediately by surgery. The main causes of this disease include exposure to radiation, Diet, Genetics, Stress, injury or local trauma and infection or inflammation.

In Indian metropolitan cities (Mumbai, Calcutta, and Bangalore), owing to awareness early identification and cure is gaining pace, statistics suggest that all female cancer patient are 23% and in which 27% females suffering from cervical cancer but in rural areas it is still number one as far as mortality rate is concerned [34,35]. According to the Indian Council of Medical Research, it is estimated that number of breast cancer patient in India will rise from 106,124 in 2015 and to 123,634 in 2020. Early detection of breast lesion requires high-quality images and skilled mammographic interpretation. Learning algorithms in this scenario can be instrumental in assisting in early identification of the disease.

Table-V: Qualitative Comparison of the significant models for segmentation and classification of breast lesion

Author / study	Segmentation / Feature extraction technique	Classifier	Accuracy / Results
Francisco et al., 2002	wavelets	Geometrical and cluster	82:3%
Zhang et al., 2004	neuro-genetic algorithm	ANN	90.5%
Moayedi et al., 2007	fuzzy techniques	Support vector-based fuzzy neural network	97.5%
Talha et al., 2010	Wavelet-based features using PCA	SVM+ linear discriminant analysis classification	90%
Liu et al., 2011	Morphological features	level set segmentation and multiple kernel learning	76%
Javadi et al., 2012	Particle swarm algorithm + wavelet transform to pinpoint the major features.	Fuzzy classification	93.41%
De et al., 2014	Zernike moments	ELM, SVM neural networks, SVM with RBF kernel	80%
Al-Najdawi et al., 2015	breast-region segmentation	mass classifying algorithm	90.7%.
Antony et al., 2015	Intensity values, shape, density features and region features	k-means clustering algorithm	99%
Liu et al., 2015	Region growing and active contour segmentation. Geometry and texture features	fuzzy c-means (FCM) clustering algorithm and weighted support vector machine (WSVM)	82.68%
Pratiwi et al., 2015	Gray-level-Co-occurrence Matrix (GLCM) is used to get the features vector containing the texture information of mammogram.	BPNN (Back-Propagation Neural Network) and RBFNN (Radial Basis Function Neural Network)	computational experiments show that RBFNN is better than BPNN in performing breast cancer classification

IV. CURRENT SCENARIO: MALIGNANT LESION IDENTIFICATION & TREATMENT IN INDIA

Cancer is among the major epidemic, with a very high mortality rate often destroying families in terms of health and monitory terms. Cancer with not so adequate identification and detection facilities are one of the major causes of increase in the number of cancer infected patients [36]. Lack of awareness regarding cancer infection causes an unrealistic fear of this disease in Indian society and the reasons are:

1. People don’t accept and go for timely treatment due to illiteracy, lack of awareness, and financial constraints etc.
2. Lack of early diagnosis of cancer is also due to unavailability of organized cancer screening

program, paucity of diagnostic aids, and negligence towards their own health.

3. Lack of diagnostic facilities or community health centers nearby also restricts people to getting specialist/ doctor advice.

To overcome these challenges, need for systematic data collection and analysis of cancer patients is mandatory. In India documentation of cancer registries with standardized reporting can be structured to help the doctors, see patterns in cancer incidence, this platform can be achieved by using technology like Unique Identification Number (Aadhaar). Further such data can be made available on cloud and it can be used to maintain health records.

Recently healthcare industry has gone under revolutionary modification due to innovations and development in healthcare technology, availability of diagnostic and therapeutic equipment has also changed the practice pattern of doctors and this technological shift has brought a digital transformation in way doctor and patients interact.

Healthcare technologies are very effective to revolutionize medical support systems, unnecessary practices, manual procedures and to reduce the cost [37,38]. It is important to keep the patient's progress in days, months or years for effective treatment of the lesion. Technology-assisted medical institutes to electronically store patient data and medical images with capabilities to compare with the previous one in need. These records can be shared with other consultants and remain accessible throughout the treatment duration. The next technological evolution in healthcare involves financial management, workflows, collaborative data exchange and mobility. Apart from that, dependency on mobile equipment, cloud computing and wireless technologies will also help to reduce operational cost and increases workflow. Cancer institutes like Rajiv Gandhi Cancer Institute provides excellent diagnostics, treatment and intensive care for patients diagnosed with cancer. Use of Hospital Management Systems, Image storage and retrieval system, Electronic health records resulted more patient data to be available for analysis. Also, due to rapid increment in cancer growth, a patient's record needs to be easily accessible because a patient may visit a doctor on the next day, after a few weeks or maybe after 10 years. Which means the data containing patients records, medical images should be widely available instead of being stored in an archive. To meet the patient's requirements in technology-driven healthcare, a highly reliable data storage platform is required to store data-intensive images and patient records [38].

VI. OPEN ISSUES AND CHALLENGES

The implementation of e-healthcare 4.0 involves several issues and challenges to be addressed categorized as:

1. Scalability: Data collection is achieved through sensors of mobile medical devices. This facility can further be extended to the entire hospital, it aims to enable patient to use medical services and check their health status update from their smartphones. This practice will help saving wait time for patient appointments and for results as well. It will also provide direct access to a definite level of medical resources aimed to be achieved under Healthcare 4.0. Efficiency improvement, saving quality time, and building trust between patients and medical staff can be done by providing scalability benefit to a smart infrastructure, however with growing applications and interconnected devices, volume of data and complexity is increasing exponentially keeping technological solutions at equal pace is of prime importance.
2. Data management: In a country like United States, Almost 90% of hospitals are using EHRs (Electronic Health Records) as the statistics suggest. A standards protocol and a data format is required in cloud layer to handle this kind of complex data which includes image files and other patient record coming from different type of sources like smartphones, smartwatch and connected medical equipment.
3. Standardization, interoperability and regulations: There are no specific rules that exist for regulation of protocols and interfaces to diversify products and devices available under healthcare 4.0. To overcome this situation, more standardization work is required like a dedicated organization to regularize healthcare technologies to achieve faster response and resolve data discrepancies. The standardization should be covering different type important topics like Device/User Interface, Data collection gateways, transport protocols, gateways etc. Considering the interoperability, the cloud layer should be capable enough to communicate through protocols on various level of layer e.g. network layer, message layer, data annotation layer of cloud layer. Also, a multifarious regulatory system should be placed before commercial launch of healthcare products in the market.
4. Security and privacy: Since it is a major concern and one of the trending topics across the globe in the domain of internet technologies, original equipment manufacturer (OEMs) should ensure that no data is shared with unauthorized agencies or partners. Healthcare 4.0 is most of a data driven implementation where almost every procedure requires some kind of data to be extracted before execution; if data is stolen, it may cause severe damage to the credibility of the institution as well as the OEMs. This is why it should be taken seriously and implemented on all the layers, Data, FOG and Cloud.
5. Human-factors engineering and interfaces: To create patient-centric medical devices and user-friendly interface, feedback of multiple users is required like end-users, stakeholder or eHealth Devices. It is also important to make them a part of design team to provide genuine inputs before its commercial launch.

VII. GENERALIZED BLOCK DIAGRAM FOR DISRUPTIVE TECHNOLOGY ENABLED HEALTHCARE 4.0

With inclusion of innovations and technology healthcare industry is rapidly transforming towards more patient centric approach. During the past decade, there were number of patients who were affected by different diseases that created an unnecessary burden on several healthcare organizations and private agencies, to provide efficient, better and economical solution. E-health or mobile healthcare is one such solution where automated services are provided to remote patients with advanced clinical treatments through telemedicine. The advancement in technologies has made mobile healthcare systems possible and it is outcome of implementation of smaller, non-invasive and cheaper healthcare sensors.

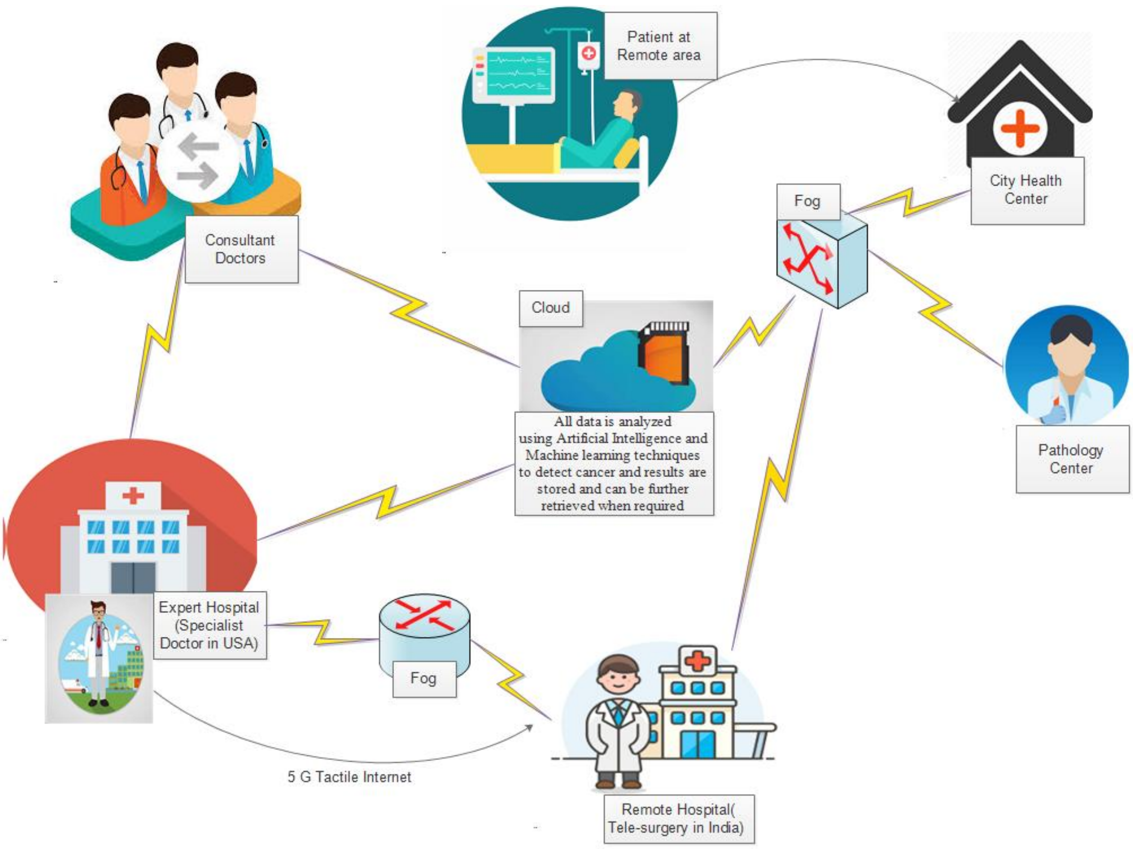

Fig.10. Model for Disruptive technology enabled healthcare 4.0 for lesion identification

Smart devices and sensors can be employed to monitor and asses the condition of the patients, the data so obtained can be directed to nearest access point, a fog layer. Fog layer assisted with IoT devices can be used for preliminary support and diagnosis as fog devices have adequate amount of memory and power for early processing of data obtained, while cloud layer may be employed to connect the patient to the expert doctor globally for performing detailed diagnosis, suggestive treatment or may be telesurgery for patients located in remote or far areas. To increase healthcare accessibility, improve patient's monitoring process and enabling telemedicine, E-health is essential. Various government and non-government organizations have begun investing resources to facilitate e-health, particularly in remote areas. However implementation of e-health applications in such area is held up due to underdeveloped communication infrastructure. The fig.10 depicts Disruptive technology enabled healthcare 4.0 Model, important components:

1. Wearable sensors

The wearable sensors are miniaturized integrated electronic sensors that can sense or monitor the condition of the patient and send this data to Fog server for analysis, where concurrently preliminary diagnosis is suggested and data is directed to cloud layer as the severity of the case may be. These sensors are implanted with the body of patient as additional wearable accessories. These sensors will capture physical signals like blood pressure, respiratory rate, heart rate and chemical signals like potassium, lactate, glucose levels. Sensors are generally integrated with smartphone to develop a more dynamic real-time monitoring system. Wearable monitoring system communicates the acquired data continuously to fog or cloud server for data processing and analysis, with active enabled feedback for further action.

2. Tactile Internet

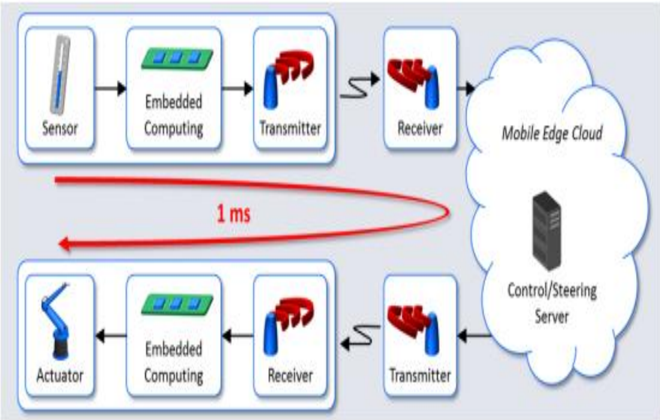

Fig.11. Tactile internet systems

It is an innovative technology that shifts the network from content delivery to skill-set delivery and the definition is a network that offers a response to a physical process in perceived real-time. Applications of tactile internet are ranging from factory automation, healthcare, gaming, robotics to autonomous driving, education and virtual/augmented reality. Skill set is of tremendous real time support for emergency issues in healthcare.

3. Internet of Things (IoT)

IoT refers to a worldwide network in which anyone and anything can inter-communicate with any services, any networks or "things" that are connected to the Internet and are available from anywhere and anytime. IoT coupled with wearable technology can improve the availability and accessibility of healthcare services to users at relatively low cost. IoT in the healthcare industry is frequently known as Internet of Healthcare Things and it ease the interactions cost via secure communication link among various parties in healthcare system such as clinics, patients and healthcare organisation. Healthcare system based on IoT is established using various technologies (Sensors, Micro-controllers, Micro-processors and healthcare gateways).

4. Fog Computing

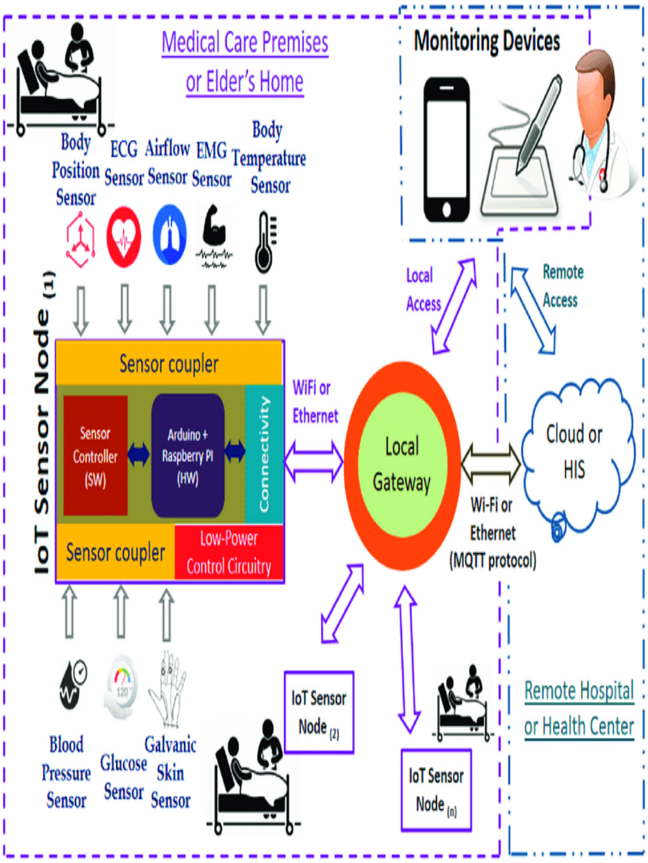

Fig.12. The system architecture of Fog (Local Gateway).

It is an evolving technology that brings the capabilities of cloud computing to the edge of the network. In Fog computing services are installed on remote devices to ease high efficiency, low latency and high reliability for end-user applications.

Fog computing act as a smart gateway that performs numerous tasks such as Local Connectivity, Computation, Onsite Database and Data Security with reduced with reduced latency. Patients with wearable sensors can communicate to physicians via fog computing for diagnoses and treatment. For the acquisition of health data, wearable sensors are used. Fog Computer has limited storage and computing resources as compared to computing resources available in the cloud. Figure 12 depicts the Fog architecture for tele-health services (collection, storage, and analysis of large amount of data for health monitoring). Fog architecture is a cascade of three sub-systems which includes body sensor network for acquisition of data, a Fog gateway for onsite processing and cloud server for storage and back-end analysis. The Fog layer transmits data to the cloud after preliminary analysis and filtering.

Fog architecture has a six-layer approach, comprises of physical layer, monitoring layer, pre-processing layer, storage layer, security layer, and transport layer. Data is usually analysed in physical layer. Monitoring layer performs the monitoring task like availability of resources. Pre-processing layer helps in analysing the data by doing filtration. Then data is sent for the storage according to requirement and distributed across as per the need with suitable protocols. Privacy and security services is offered to the data flow by the Security layer.

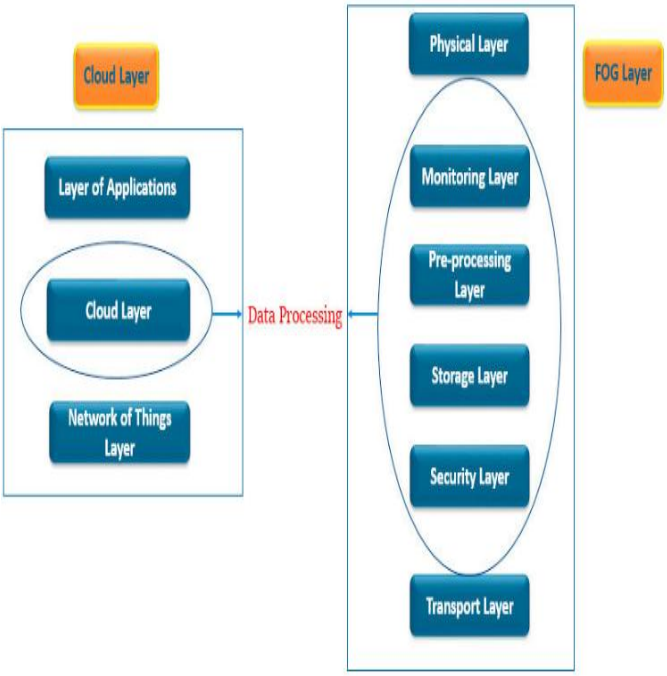

Fig.13. Data processing in the cloud and fog-based architectures of IoT

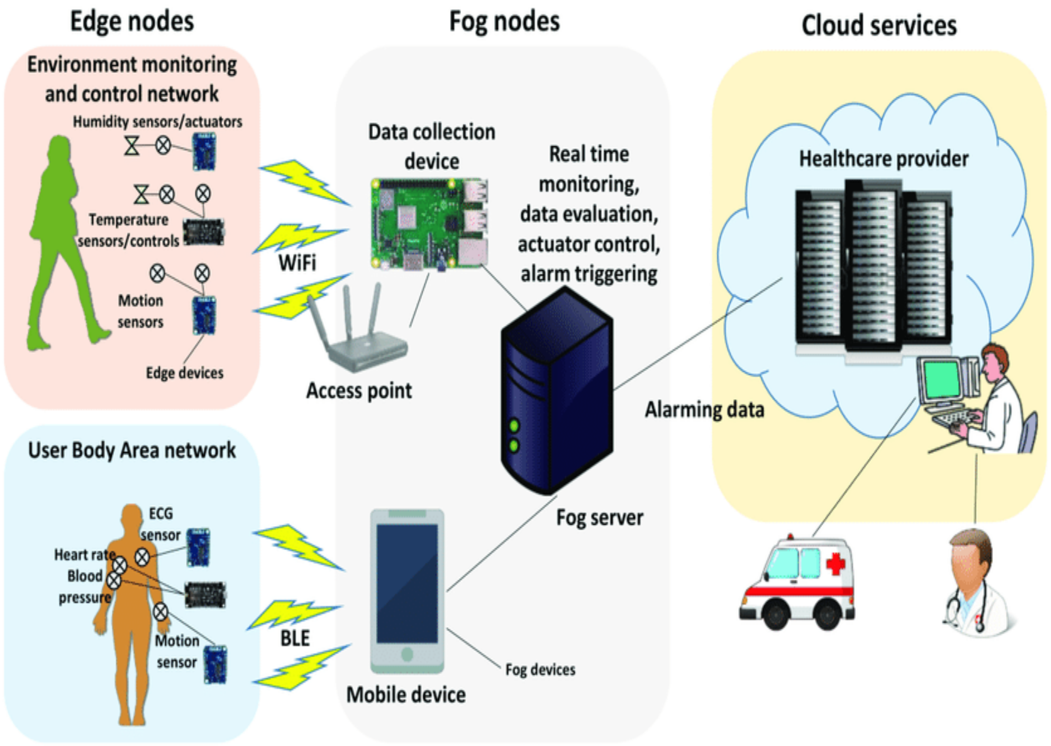

Fig .14. Network Architecture of Fog Layer

5. Cloud Computing

Cloud computing supports different services of IoT framework. These services involve data storage option, suitable platform, software tools & analytics and core infrastructure.

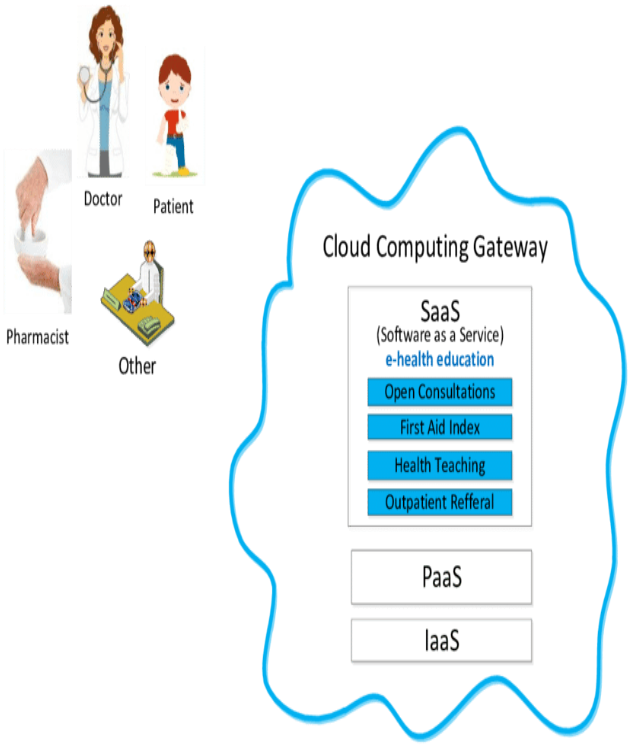

Fig.15. The architecture of Cloud computing

Cloud supports, users in data analytics, machine learning options for data. Fig.14. depicts the theoretical model for healthcare system that comprises of three subsystems:

1. Wearable smart devices used for data acquisition;
2. Fog layer acts as a gateway for onsite processing;
3. Cloud server for big data storage and back-end computation.

Healthcare Wearable's and IoT sensors are connected to doctors or consultant for diagnosis, evaluation, and treatment via fog gateway. Fog gateway also collects and processes patient's data. The acquired data is sent to the cloud; where they can be assimilated with data from other data repositories and processed by visual analytics module with more complex computing methods to meet requirements of different healthcare applications. Diagnosis concluded is displayed to the end-users through the visualization module providing predictions and action plans recommendations based on individual health-risks valuation.

Due to increase in the cost of healthcare services and scarcity of healthcare professionals, it is necessary that healthcare organizations search for economical alternative solutions and e-health can be one such platform, Fig.16. depicts the layered cloud architecture for the proposed e-health platform. The Platform allows the health organizations to provide services in cost effective and efficient manner. E-health architecture has five layers and those are E-health Portal, Smart Hospital/Clinics, Health information systems, E-health cloud and support infrastructure

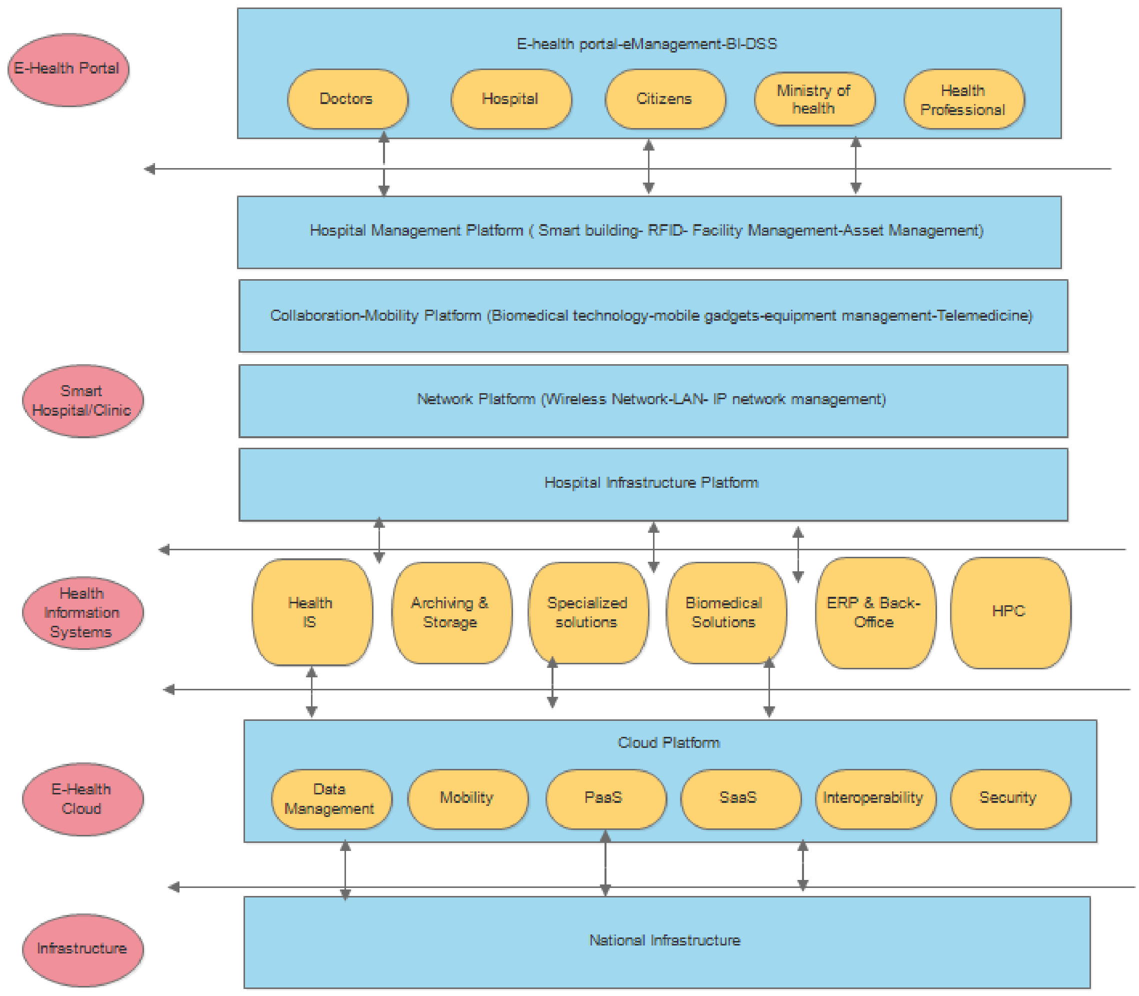

Fig.16. Layered Cloud Architecture E-health Platform

E-health platform is a Web-based application that combines an EHR system and a patient portal, not only for patients to interact with their support health care experts, but also to access their own medical records and diagnostic results. Smart hospital employs smart tablets and TVs to educate the staff and patients, and patients uses wearable remote monitoring devices or smartphone to monitor their vitals and medication. EHRs are used to collect patients' data and this data is shared with healthcare professional to provide quality care to patients.

A health information system involves systems which collect, manage, store and transmit a patient's EMR record to healthcare professional for diagnostic purposes and treatment plan. Electronic medical record (EMR) is a hospital's operational management a system which maintains and processes patient's related data as the need be.

For national E-Health infrastructure the key component is the ability to electronically, uniquely identify patients, healthcare providers, healthcare professionals and pharmacies. They are usually based on Aadhar card.

VII. CONCLUSION

India is a sub-continent with wide cultural, ethnic, economic diversity and variation in health care infrastructure. There is little room for error in healthcare domain as it directly affects the mortality data rate, so potential need for applied technological innovations in healthcare sector is of prime importance. However accurate and supportive they may be, their acceptability will count for little unless clinicians, and other healthcare practitioners, understand what has led to their decision-making advice, even otherwise parallel opinions are must in severe cases. The goal is to reduce the mortality rate by early detection and treating the disease while it is still curable assuming a more effective salvage surgery and treatment. This paper presents a comprehensive review of the automated classification learning algorithms to identify lesion; indicates how learning algorithms have been applied to biomedical applications from data acquisition to image retrieval and from segmentation to disease prediction

his paper provides a brief overview of recent innovations and challenges associated with learning algorithms applied to medical image processing and analysis. Lastly, the paper concludes with a disruptive technology enabled healthcare 4.0 model employing cloud and FOG support to reduce latency and tries to predict direction for upcoming trends on more advanced research studies on lesion detection. Over a period as lifespan keeps increasing and the natural ageing process starts taking its course, these measures will become invaluable for fighting against cancer, both at an individual and societal level.

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