International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 5
May 2018

PACS: An Overview of the Technology and Related Issues

Vedanti Deshmukh
SGGSIE&T, Nanded

Dr. Lenina SVB
Assistant Professor,
IEEE Membership Number: 94310317
Department of Electronics and Telecommunication Engineering, SGGSIE&T, Vishnupuri,
Nanded, Maharashtra State, India

Dr. Mohan Kulkarni
Independent Management Consultant and Professor
Long Island City, New York

Mr. Shailesh Kolharkar
Hedgewar Hospital, Aurangabad

.

ABSTRACT

Times In recent years, there is a huge increment in medical data and it is continuously increasing day by day. Handling or managing this big data is a serious problem. 90% of the data is image data generated from radiology department and should be archived for further use in diagnosis process, also for study and research. Picture archiving and communication system (PACS) is a solution for the volume problem as it can store, preprocess and archive the image data. This paper discusses the situation of healthcare sector with the PACS implementation and issues regarding it. Also, the paper discusses the benefits of PACS implementation and the situation before and after the usage of PACS and different procedures like digitization, compression for teleradiology, security of data etc.

Keywords : DICOM, PACS

I. INTRODUCTION

The medical sector, in every part of the world creates and handles huge amount of data, which mainly consists of patient's data based on their history, types of the disease he/she suffering from, and expected medication and actual results. Most of the data was occupied by the image data produced from radiology department in-terms of x-rays, CTs, mammography etc. This imaging data is uncertain that is, it can never be predicted and also, generally it is never accessed in the future after archiving it into the database. This staggered data should be well managed for study and research purposes. This data is like wine which has increased strength over time.

Before the introduction of PACS that is, in the start of 1960s, different systems were proposed for archiving and handling the image data. At mid-1960's, computer-based systems had came into picture which was quick and efficient in terms of time and money. They can store, transport, route and retrieve the image data easily which indirectly increases the efficiency of overall hospital/clinic [1].

After many researches, the name came into the picture, Picture Archiving and Communication System (PACS) which was able to satisfy all medical image problems as well as economical requirements. Since then it is been the solution for radiology departments' most of the problems.

PACS is a network of computers to store, retrieve, distribute and display medical images and data associated with it. It has the ability to handle the different types of images from medical machines like ultrasound, x-ray, mammography etc. The general workflow of X-rays and CT scan from capturing the image data to archiving them into PACS is shown in figure 1.

The basic functionality of PACS is to acquire the image from different types of equipment and then convert them into standard DICOM formats. These images are forwarded to PACS controller or to display workstation. Along with these basic functions, it also does pre-process, compression and data security of image metadata.

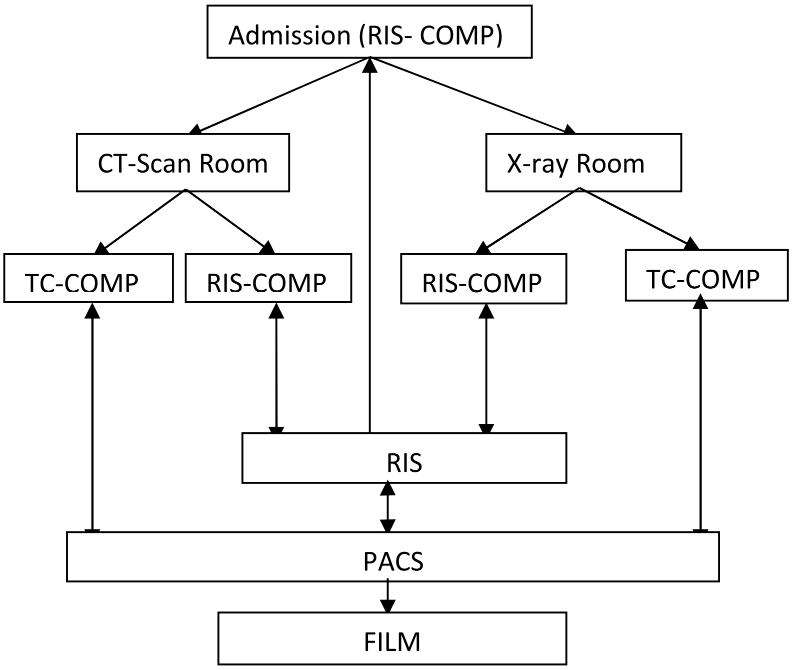

Figure 1: Workflow of CT scans and X-ray images in PACS

This paper provides a brief description about overall PACS technology, its work flow and teleradiology and different techniques to handle the data to increase the efficiency of overall system. Section II gives the overall work flow of PACS software in radiology department from acquiring the image to archiving the image along with metadata into database for permanent use. Section III discusses the teleradiology department which is special branch of radiology for remote areas. Section IV discusses the issues regarding the current technologies used in PACS software and different solution given by different researchers and respective results. Section V discusses the results of different techniques and concludes the paper.

II. WORK-FLOW

First part is to acquire the image from patient and save it into PACS. Image acquisition is process in which image is provided from different modalities and then it is converted into digital format. There are many techniques to digitize the acquired image, mainly digital fluorography (DF), film digitization and computed radiography (CR), where as there are some techniques that directly acquire the digitized data directly from modalities such as Computed Tomography, Magnetic Resonance Imaging, Digital Angiography etc [2] [3]. In DF, a special cathode ray tube-based camera is used to capture the image, namely Vidicon and convert them into a digitized image using film grabber [2]. But this method should be avoided as it gives lower quality of images. In film digitization technique, a laser is used to convert the optical intensities into pixels on film.

Currently, computed radiography is the solution for digital acquisition of image. In computed radiography, rays are directed on imaging plate and directly converted into a digitized image [2]. The main advantage of CR is its wide dynamic range which indirectly decreases the number of retakes. This method also has many drawbacks like its throughput is 10-200% slower than daylight processes, lower spatial resolution etc [3].

These digitized images are made available to PACS using two gateways or interfaces known as modalities gateway and Hospital Information System (HIS/RIS) gateway. The modalities gateway provides image information where as HIS/RIS provides image data information such as name of patient, age, gender etc. Currently digital modalities are being upgraded from ACR-NEMA to DICOM [3].

PACS uses Digital Imaging and Communication in Medicine (DICOM), as digital modality and standard which helps in storage of images and it also have metadata along with the image to provide additional information. DICOM is developed in 1983, by American College of Radiology (ACR) and National Electrical Manufacturer Association (NEMA). It consists 18 independent parts, which works on TCP/IP (Transmission Communication Protocol/Internet Protocol) model of networking [4]. Presently systems are using DICOM 3.0 version for practical use.

Archival of input images is next step which is required for radiologist to evaluate the results. There are two types of data for archiving, short term and long term. The short term archived image data should be use for period of patient's stay in hospital where as long term archived data should have capacity to store over period of 5-6 years. Short term data is stored in magnetic disk and long term is saved on optical jukebox. These archived images should be accessible and displayed on PACS workstations, which works as a window into the patient's metadata and their image data, whenever they are demanded [3].

There is an example discussed by Hyung Sik Choi and Duk Woo Ro about the implementation of PACS in Samsung Medical clinic which was done in 1994 [5]. It was a new hospital with 1000 patient beds and installed with centre PACS system [5]. Major factors for construction of SMC-PACS were the careful building design and site preparation, network coding phase, compatibility and interface of imaging modalities, and the expected budget for PACS. Goals of SMC-PACS were to implement large scale of filmless PACS. The main type of goals behind the implementation of PACS is research PACS, archiving PACS i.e., archiving the digital images and clinical PACS i.e. filmless radiology which is basic principle behind SMC-PACS. There are three basic methods for PACS research development and implementation.

1. In-house development and system integration,
2. The hospital provides basic requirements and then according to it, implementation is done,
3. Turnkey based system installation.

On the process of construction of hospital buildings, many meetings were held at to construction site to update the location of types of equipment as per requirement like ACs, cables, hubs etc. Total of 238 fiber optic cables and 268 UTP cables were installed in the first implementation of SMC-PACS [5]. Also, for this special system, all the staff that is going to use the system is trained well like doctors, radiologists, receptionists, etc. The time period between film operations to PACS operation is an important issue and required as minimum as possible. SMC took care of patients from 1994, before the actual implementation of PACS. From 12 September, an actual implementation of SMC-PACS started [5]. During this hard time, many doctors were not supportive as they thought it was unreliable, reports were not available at finite time period etc.

In general, implementing the SMC-PACS gives brief idea about the benefits, like it saves the medical time of filming the image data as well as it reduce wait time which is generated due to unavailability of films, better quality of image data for researchers, conferences; and there is record maintained of each patient according to their previous history. As image transit is easy, many patients can complete their health checkup in one day.

III. TELERADIOLOGY

Another version of radiology is teleradiology which can be defined as a branch which transmits the image data from and to sites for evaluation. Teleradiology in PACS gives access to send the image data from different hospitals or clinics to central hub which is transmitted to required hospital for evaluation and sent the results back in reverse path. Many factors affect these transmissions and different techniques are used to avoid the loss of data due to addition of noise over transmission [3].

There are different coders which are used to compress the medical data which have positive effect over storage space and transmission time. The techniques which are used to compress the image data are LJPEG

(Lossless JPEG), BTPC (Binary Tree Predictive Coding), FELICS (Fast and Efficient Lossless Image Compression System), S+P (compression with reversible embedded wavelets), and CALIC (combines non-linear prediction with advanced statistical error modeling technique) where as GnuZIP and STAT are general purpose coders [6].

One example of teleradiology is telemammography. Mammography technique is used to detect the breast cancer in its early stages. Telemammography discussed by A. Hagmuller and F. Aghdasi gives a new idea of implementing "South Africa Telecommunication Information Networking Architecture Trial" (SATIN) instead of current technology "Digital Imaging and Communication (DICOM)" [7].

The example given by K. K. Chan, K. S. Tong and H. Huang, regarding the filmless teleradiology in SARS at local hospital gives a practical perspective for the teleradiology. Severe Acute Respiratory Syndrome (SARS) is an infectious disease and for treatment of them chest X-rays and CT scans are required. As using film technology there are chances that this disease may be infected to doctors, radiologist and all the people who are handling the films. Solution of this is filmless lossless teleradiology. It is complex procedure as it requires large storage capability of system and high DICOM lossless compression where compression rate should be higher or equal to 2.5 [8].

IV. DIFFERENT ISSUES

Though these system works efficiently, there are several issues rather improvements which should be done to increase the strength of PACS. This section discusses few of them along with their solution proposed by different researchers.

The initial process in which the image data is acquired from different modalities like acquiring x-ray images from the machine, there are chances of an addition of unexposed areas like points of markers, unwanted body parts etc. This data is called as background and there is a technique discussed to recognize and remove the background by J. Zhang and H. K. Huang [2].

In CR technique, there are chances of an addition of background which should be removed for further research/study of the image data. There is an algorithm which can recognize and remove the background automatically known as Automatic Background Recognition and Removal (ABRR) [2]. This is a complex process which is automatic and irreversible i.e., it is the recognition and removal of the background are preceded simultaneously along with preprocessing of the image data; also the original data cannot be retrieved back after removal of an unexposed area. J. Zhang and H. K. Huang implemented this technique and achieved 99% efficiency and a probability of 100% removal of background is 0.91 [2].

The basic steps for removal of the background given by J. Zhang and H. K. Huang are as follows:

01. Compute the intensity distribution of each image using following formula. Using this intensity distribution graphs, given data can be analyzed.

a. $I(\theta, r) = a_0 \cos(\theta) / r^2$

Where a_0 is constant,

θ is by which radiation is preceded by the human body,

r is a distance between imaging plate and source of radiations.

02. Next step is to calculate the probability of particular pixel i.e., whether it belongs to the background or not and background score for each and every pixel. Using these two parameters and the relationship between them, we predict pixels which belong to the background.

03. The third and most important step is to find the pixels which are on the edges of background and the actual image. This is done by sampling, filtering and angle-resolved recognitions of the image data. To find the edges, line fitting technique is used, and then it can be removed from images.

04. As discussed earlier, this technique is irreversible, estimation should be done at each stage that calculates the advances of removal and if it is above some threshold, it proceeded or else cancelled out.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 5
May 2018

By this technique, J. Zhang and H. K. Huang, 99% times correct background recognition is done. Also, this algorithm achieves 91, 8.8, 0.2% full, partial and no background removal respectively [2].

Next area where improvement can be done is security of the patient's data as it should not be accessed or modified by unauthorized party. For the security purpose, there are different methods like watermarking, digital signature and encryption. The watermarking technique allows hiding security or other options for videos, audios and images. The basic objective of a watermarking technique is to hide the data from external threats, have control over the integrity and authenticity of data. There are no current standards for implementation of watermarking in PACS. Research is done on experimentation but not on the implementation.

Along with watermarking, tamper detection is done [4] and the process is very simple. Firstly for watermarking, the image is encoded and embedding system adds watermarks to a specific position over pixels and this data is transmitted over a channel. At the decoder side, decoding function removes the watermarks and the original image is available. There are two methods for the addition of watermarks based on domain's type, spatial domain and transformed domain. In the spatial domain, watermarks are added at least notable bits which cannot be easily seen by the user and does not affect the original data of the image. But this technique is not powerful against different cyber attacks. In transformed technique, different transforms like discrete Fourier transform (DFT), discrete cosine transform (DCT) are transformed over the pixels and data is transmitted. Also, there are schemes based on different domains, which are used for medical images. The peak signal to noise ratio (PSNR) is used to measure the efficiency of the watermarking technique. Higher the ratio, efficient is the scheme or technique. Currently, DICOM is using RSA algorithm for encryption of MAC for a digital signature. There is no option for implementation of the watermarking system in DICOM of data over security. S.C. Liew and J. M. Zain gives the simple watermarking scheme is which a technique is implemented for experimentation where it embeds watermarks on least significant bits and produces high PSNR ratios [4]. The basic steps for implementation are as follows:

01. Acquire the image from image modalities and proceed forward to convert it into DICOM format. Also, preprocessing is done during this process.

02. The image is watermarked, i.e., watermarks are added at specific positions. It is necessary to do watermarking as soon as the image is acquired.

03. The image is sent over different modalities and at the decoder, original image is retrieved back removing those watermarks

04. PSNR ratio is calculated using comparative study over input image and image acquired at the decoder side after removal of watermarks.

After experimentation over many images, the issues have been seen out as this process should be fully-automated to acquire the high PSNR ratio. Also, the removal of watermarks is not possible but in an ideal case, this should be done as per request. It does not allow compression over jpeg format of the image. But the main advantage of this is over compression in terms of size as PACS supports web browsers [4].

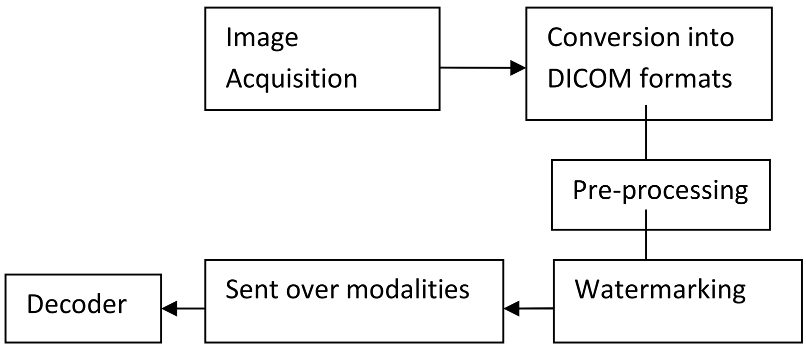

Figure 02: Flowchart for watermarking technique

The next technique for the security of data is a digital signature. It is based on the provision of a private and public key. The private key is provided to all the image modalities and private key which is secretive is only provided to systems who receive the data i.e. if anyone can send image data using public key but it can only be received to those who have private keys. The legal compatibility in this technique is a major issue like in fingerprint detection [8].

The technique, which is robust as compared to previous ones, is encryption. The basic idea behind encryption is plaintext that is; the original text is converted into cipher text or coded text using the encoder and transmitted over the specified area. At the decoder side, this cipher is again converted back into plain text i.e., into the previous form. There are two categories based on changes in pixels for security purpose. When the change is made by changing the value of pixels it is called as Pixel by substitution and where there is a change in the pixel position it is called as Pixel location scrambling [8]. There are different algorithms named DES, AES, RSA grouped by conventional cryptography are easy to implement. But the issues regarding them are they have large computational time, high computing time and high correlation, due to this they are not commonly used for application purpose in real time.

Next system is a chaotic system which is commonly used as it is sensitive to initial conditions and parameters and may spread the initial region over entire phase space. The security terms are based on real numbers and they offer high flexibility. Due to these characteristics, they can be used in real time practical applications.

V. RESULTS AND CONCLUSION

PACS improves handling and managing of the image data created and preprocessed by radiology department and used by each every sector of healthcare and hospital the image processing applied to digitized images is useful as per research and study's perspective.

According to J. Zhang and H. K. Huang, tamper detection and watermarking technique for security purpose is effective in DICOM format. It gives the recovery rates of watermarked images in 100% [2] Also some issues were observed such as it does not allow compression over JPEG format it should be fully automated system to maintain the efficiency if there is large amount of data and it should be reversible process as per demand. Currently PACS supports image view in web browser the compression in-terms of file size is an advantage from watermarking system.

The use of Automatic background recognition and removal algorithm gives the output images better visual quality as well the losses over compression are less due to size reduction, as compared to original images. This method was implemented in clinical PACS and as per observed results by J. Zhang and H. K. Huang, 246 images were taken with background and 84 were without background are 99% images are detected correctly out of 330 images, out of them 91% images have successful removal of full background and 8.8% were with partial background removal [2]. The conclusion from this is that the ratio of correct recognition to the removal of background is greater than 1 which means some built-in mechanism is preventing the system from removing the detected background. Also, this process secures the irreversible removal process saving the important data.

S.C. Liew and J. M. Zain concluded that the recovery rates for watermarked images after transmission is at 100 % and the recovered areas are identical. The outcome of the experiment performed by them shows that the chosen watermarking scheme works effectively and efficiently in a DICOM format and in PACS environment [4].

VI. FUTURE WORK

The issues discussed in section IV are solved by different researchers. There are many methods which can be implemented to solve these issues and make new and better improvements in the software for betterment of the overall results. The results from different methods can be compared and evaluated. In future, next paper will try to implement the novel system to detect the lung disease infected people using the CT scans given by PACS software.

VII. REFERENCES

[1] W. J. Dallas, "A digital prescription for X-ray overload," in IEEE Spectrum, vol. 27, no. 4, pp. 33-36, April 1990.
[2] J. Zhang and H. K. Huang, "Automatic background recognition and removal (ABRR) in computed radiography images", IEEE Transactions on Medical Imaging, vol-16, pp 762-771, 1997.
[3] E. L. Siegel, "PACS: current technology, clinical requirements, and future trends," Proceedings of the Fourth International Conference on Image Management and Communication (IMAC 95), Oahu Island, HI, 1995, pp. 2-8.
[4] S.C. Liew and J. M. Zain, "Experiment of Tamper Detection and Recovery Watermarking in PACS", 2010 Second International Conference on Computer Research and Development, pp 387-390, 2010.
[5] Hyung Sik Choi and Duk Woo Ro, "Clinical implementation of Samsung Medical Center PACS", Proceedings of the Fourth International Conference on Image Management and Communication (IMAC 95), pp 14-19, 1995.
[6] K. Denecker, J. van Overloop and I. Lemahieu, "An experimental comparison of several lossless image coders for medical images", Data Compression Conference, 1997. DCC'97.Proceedings, Snowbird, UT, USA, 1997, pp. 435-
[7] A. Hagmuller and F. Aghdasi, "Object oriented telemammography", IEEE Africon 5th Africon Conference in Africa (Cat. No.99CH36342),1999. Vol 1 pp 297-302.
[8] K. K. Chan, K. S. Tong and H. Huang, "Application of PACS in fighting against SARS in a local hospital", 2004 IEEE International Engineering Management Conference (IEEE Cat.No.04CH37574), vol 2 pp -640-642.
[9] Wimol San-Urn and Natthorn Chuayphan, "A Lossless Physical-Layer Encryption Scheme in medical Picture Archiving and Communication Systems using Highly-Robust Chaotic Signals", The 2014 Biomedical Engineering International Conference, 2014.
[10] S. K. Mun; M. Freedman; R. Kapur, "Image management and communications for radiology", IEEE Engineering in Medicine and Biology Magazine, vol-12, pp 70-80, 1993.