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COMPUTER-AIDED MEDICAL IMAGE ANALYSIS FOR PROSTATE CANCER DETECTION: A REVIEW

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ABSTRACT. Second most detected cancer among men all over the globe is prostate cancer. Today cancer related diseases are the most dominant and deadly diseases causing considerable number of deaths worldwide. Cancer is curable if detected at early stage, but cancer does not show symptoms in early stage. During last few decades medical imagining methods are improved to diagnose the cancer at very early stage. Chances of survival can be increased if cancer is detected correctly at its early stage and can save many lives. Prostate cancer is usually detected at later stages, thus reducing the chances of early treatment and recovery of the patient, result in reducing the survival rate. Men over 50 years age are more prone to prostate cancer. Computer aided diagnosis plays significant role in medical research, automated diagnosis, planning of the treatment and help the radiologists. This paper aims to provide broad survey of the various medical imaging modalities and basics of computer aided detection system of prostate.

1. INTRODUCTION

Computer-aided detection (CADe), also called computer-aided diagnosis (CADx) or simply CAD system is automated methods used for detection of specific diseases. CAD is brining together machine learning, deep learning, image processing and radiology technology for effective and accurate detection

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of disease. CAD systems commonly highlight and evaluate the malignant part of the image. CAD systems also classify the diseases into various categories e.g. classification of prostate diseases into two categories i.e. benign prostatic hypertrophy (BPH) and carcinoma of the prostate (CaP) [4]. This is also called unsupervised or automated detection of diseases in medical images. Computer algorithm for detection of abnormal structure and other region of interest (ROI) are key component of CAD systems.

2. Prostate cancer detection

Prostate cancer also known as carcinoma of the prostate (CaP) is most commonly diagnosed cancer after skin cancer among male populations all over the world. Growth of prostate cancer can be slow or fast. Slow growing tumor restrict to prostate gland and accounted for approximately 85% cases of CaP. Fast spreading CaP may transfer from prostate gland to other near by organs like bones. Prostate conditions can be classified into Prostatitis, Enlarged prostate, Prostate cancer. Prostatitis is inflammation of the prostate, sometimes caused by infection and can be treated with antibiotics. Whereas enlarged prostate is benign prostatic hypertrophy (BPH), symptoms of BPH are like difficult urination; BPH can be cured by medicines or surgery. Prostate cancer also called carcinoma of the prostate (CaP) is the development of cancer in the prostate, a gland in the male reproductive system. Prostate gland is divided into four zones: the peripheral zone (PZ), the central zone (CZ), the transition zone (TZ), and the anterior fibro muscular stroma (AFMS). Carcinoma of the prostate (CaP) can develop in specific regions of prostate gland. It is observed that 70-80% CaPs develop in peripheral zone, 10-20% CaPs develop in transition zone and only 5-10% CaPs originate in central zone [3].

2.1. **Methods of prostate cancer detection.** Diagnosis techniques have significantly improved; commonly employed methods detection of prostate cancer are discussed as follow [4].

(i) **Digital Rectal Examination (DRE)**
(ii) **Prostate-specific antigen (PSA)**
(iii) **Prostate Biopsy**
(iv) **Prostate Imaging Techniques**

Firstly Prostate-specific antigen (PSA) test is performed to analyze the risk level (low or high) of CaP. Then for verification transrectal ultrasound (TRUS) biopsy is performed. Despite results of PSA helps in early detection of CaP but its inadequacy of reliability inspires further examination using imaging modalities like MRI, CT, Ultrasound. Also TRUS biopsy does not gives promising results due chances of missing aggressive tumors (which invade other organs). So this motivates the researchers to develop CAD system that can assist radiologists in their clinical practice [1, 6].

2.2. **Need of CAD System.** With the easy availability of heath facilities, insurance and medical care equipment, the rate at which medical images are generated is considerably very high. Analysis of medical images by expert is a laborious and exhausting task because region of interest (ROI) in the medical images show complex structure and borders of anatomical structures are not clearly visible. Medical imaging identifies abnormalities a long before the disease symptoms appear. So radiologists have convenience to enhance their diagnosis with the application of computer aided detection systems [2].

3. Types of medical imagining modalities

Selecting an appropriate imaging technique is an important decision. Imaging technique depends on the problem of the patient and affected body organ. Recent advances in medical imaging techniques like Positron emission tomography computed tomography (PET-CT) and Positron emission tomography magnetic resonance imaging (PET-MRI) uses radioactive isotopes to trace physiological functions and anatomic structure of the body. A comparison of major image modalities is given in Table 1 [3, 4].

4. Image enhancement

Image enhancement is modifying the gray level intensity values of each individual pixel so as to improve the overall visual quality of whole image. Most of the de-noising algorithms assume some noise model e.g. Gaussian model. It is important to understand the noise characteristic like Gaussian noise (additive, independent of source intensity), Salt & Pepper noise (pixels having extreme values), shot noise (follow Poisson distribution), Uniform noise (uniform distribution, quantization error). Other major types of noises are

Item	X-Ray	CT	MRI	Ultrasound	Digital Mammography
Main Characteristics	Use Electro-magnetic waves	Uses computer-controlled X-rays to create images	Uses radio waves	Uses Sound waves	Uses X-rays
	Can identify bone Structures	X-rays emitted in all possible angles and distances	Different tissues like tumor emit different intensity signal		But the data is collected on computer
	Oldest medical imaging modality		T1, T2, PD parameters		
Merits	Painless and non-invasive	High sensitivity	Higher Resolution	High spatial resolution	Minimal radiation exposure
	Can produce image of any body part	High penetration	3D tumor simulation	No side effect	Reliable
	3-D images	3-D images	No short term effects observed		Highly sensitive
	Easy to use	Best for soft tissues behind bone structure	More accurate for soft tissues		
De-merits	Radiation risk	Uses higher doses of radiation than X-ray	High Cost	Less accurate than mammography	High Cost
	Random noise		Injection of a contrast medium	Limited Resolution	More acquisition time
Type of Radiation	Ionizing	Ionizing	Non Ionizing	Non Ionizing	Non Ionizing
Radiation Used	X-Rays	X-Rays	Electromagnetic Radio Waves	High frequency Sound Waves	X-Rays
Contrast Agent	No	No	Yes	No	No
Cost	Very Low	High	Very High	Low	High
Type of Noise	Random Noise	Random Noise	Rician Noise	Speckle noise	Random Noise
Contrast	Low	High	High	Low	Medium
Application	Bone Injuries	Brian diagnosis	Tumor of Chest	Liver tumor	Breast Cancer
	Chest radiographs	Prostate Cancer	Neurological diseases	Prostate biopsy	
	Mammograms	Lungs exam	Angiography	Swelling	
	Arthritis		Heart, Liver	Fetus health	
			Kidney	Breast Cancer	

TABLE 1. Comparison of various medical imaging modalities [3, 4]

Speckle noise, Rician noise (present in MR Images), Random noise, Non-uniform noise, Additive noise, Impulse noise, Poisson noise, Additive white Gaussian noise (AWGN), Random valued impulse noise (RVIN), Rayleigh noise.

4.1. **Effect of removing noise.** Noise in images is random variation of pixel intensities. Image enhancement algorithms improve the contrast of the image, visibility of desired features and interpretability. Enhancement algorithms cannot enhance or provide the information that is not present in the original image. Valuable and significant information may lose or enhanced image may be a degraded interpretation of the original image. Noise removal often brings out artifacts and causes suppression of image features like edges, color etc., blurring, loss of detail in textured areas and over smoothing of the images.

5. Soft computing and digital image processing

Soft Computing techniques are nature inspired computational algorithms used to find imprecise, inexact or approximate solutions to difficult and computational extensive problems. Soft Computing is a part of Artificial Intelligence (AI) and can be divided mainly into four categories. First category is based on model of human mind e.g. Fuzzy Logic, Rough Set Theory etc., second category is Artificial Immune System based techniques e.g. Genetic Algorithm (GA), Artificial Neural Network (ANN) etc., third category is based on Swarm Intelligence e.g. ACO, BFO, CS etc.

6. Classification of diseases

Classification is process of labeling the pixels extracted from ROI based upon their intensity values. Given a feature set of size n, the feature selection problem is to find the subset of minimum features of size s, $(s < n)$ while maintaining high classification accuracy and speed. Features with small size and high classification ratio are selected. The objective of classification phase of CAD system is the Classification of each lesion or cluster as benign or malignant using minimal set of features. To measure the performance Confusion matrix and ROC analysis methods are used.

7. Steps for developing CAD system to detect cancer

This section lists the common stages for developing CAD system.

Step 1: Collection of medical images database for prostate cancer detection
Step 2: Enhancement of medical images for improving the quality of images

Step 3: Extraction of Region of Interest (ROI) using Segmentation Techniques
Step 4: Extracting the prostate related features in various domains from ROI
Step 5: Selecting the optimal set of features using Soft Computing techniques
Step 6: Classifying normal and abnormal regions using optimal features.
Step 7: Performance evaluation using Confusion Matrix and ROC analysis.

8. Conclusion and future trend

Various solutions were proposed in the literature to increase the accuracy and sensitivity of automatic disease detection systems, so as to minimize the number of unnecessary biopsies. An important concern is these studies are high rate of false positive (FP) and false negative (FN). Most of the researchers used texture-based feature to classify the diseases, geometry-based, shape-based, and color-based features are need to be explored. Statistical methods have been extensively used for extracting texture-based features. Although the performance achieved by various systems is satisfactory, still there is need to develop efficient, fast, accurate and sensitive system for automatic disease detection in medical images. Magnetic Resonance Imaging (MRI) perform better in terms of higher accuracy for prostate cancer detection as compared to ultrasound [5]. Due to complex nature of CaP such as variation in size and location, fuzzy nature of appearance tissue properties of CaP makes prostate cancer detection a difficult task and it is matter that development of CAD systems for detection CaPs is lagging behind as compared to other cancer fields. Prostate cancer detection methods using Convolutional Neural Network (CNN), Machine Learning and Deep Learning are gaining momentum [6].

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