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A Methodical Review on Issues of Medical Image Management System with Watermarking Approach

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Abstract

Objective: The main objective of this research article is to study how watermarking has solved issues evolved in medical management system through various techniques. **Method/Analysis:** With the advent of technology, medical management system has improved to great extent by sharing medical data for clinical diagnosis, treatment, education, research and other applications. The common uses of watermarking in medical image management system are safe archiving, memory storage, captioning, authentication, controlled access retrieval and effective distribution of information. . In order to conduct the survey, various digital libraries have been explored and research work of last five years is taken into consideration for analysis. **Findings:** Based on the analysis, the identified techniques have been classified into three main broad categories and few subcategories. The three main categories are: 1. Tamper Detection and authentication/Integrity/ Security 2. EPR hiding 3. Hybrid/ all-in-one solution. **Novelty/improvement:** Later on for further analysis and understanding we have presented the findings in Table 1.

Keywords: EPR, DICOM, Spatial and Transform Domain Techniques, Watermarking

1. Introduction

Due to the newfangled technologies, manipulation of digital data has become an easy task. One can easily create the new, clone the old, disseminate, and distribute digital content in a facile way. This brings protection and security of data into picture. Many researchers are working over the security issues. Medical information is badly at risk due to its critical use. One can't compromise with the security of medical information[1]. Through the internet advancement, medical data is shared among doctors and clinics for diagnosis purpose, among students for educational and research, and many other commercial/non-commercial applications. In modern times now, all the integrated health care systems like Hospital Information System (HIS) and Picture Archiving and Communication System (PACS) allow easy distribution of medical data which can be accessed and manipulated without much effort[2]. Any small change in the content of medical image can prove to be precarious in the long run. Hence, it is obligatory to secure medical data from any attack or risk[3].

Medical management systems handle very large volume of medical data daily generated by hospitals, clinics, etc. This data contains text and images which needs to be processed, stored and distributed for e-diagnosis and treatment. These factors bring into notice the security issues like integrity, authenticity and confidentiality. Moreover, storing large volume of data and then distributing it requires large memory and bandwidth. Saving storage space is also one of the tasks while dealing with issues of medical system. The first one to deal with security of medical images were Wong et al. in 1995. They dealt with integrity of medical images and brought up this issue as a significant one[4].

Digital Watermarking is a technique which can address and solve all the issues mentioned above[5]. It is a technique which inserts a special and hidden piece of data, called a watermark in obscured or bare way. This piece of data is retrieved later and verified to check the

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authenticity whether the image is disseminated with the actual source (authentication) and the data has not been modified (integrity). The main purpose for which watermarking was originally proposed is authentication and integrity of images. In medical images it is also used for hiding the patient's information and EPR. This will help in saving the storage of the management system and bandwidth requirement for transmission, reduce the risk of detachment of information from image, securing the content important for patient's confidentiality. Medical Image watermarking has many advantages, applications and requirements discussed next.

This paper is organized into four sections. Introduction in first section is followed by MIW application and requirements. Third section presents the literature review with the categorisation of the techniques after analysis. Fourth section is the conclusion part of the paper considering all the review in detail.

2. Medical Image Watermarking Applications and Requirements

This section of paper is divided into two parts. First part discusses the various applications of watermarking in medical image management system. Second part is all about the basic requirements while using watermarking to solve the issues in medical images.

2.1 Medical Image Watermarking Applications

a) Saving memory: Embedding the medical information of patient and identification details in the corresponding medical image saves memory required for storing the complete information (EPR).
b) Avoid detachment: Detachment of medical information from image can lead to blunder. Embedding of EPR avoids this detachment risk and misplacing of the records.
c) Saving bandwidth: Embedding the EPR into the image also reduces bandwidth requirement while distributing the data among hospitals, clinicians, physicians, etc.
d) Confidentiality and security: Through MIW techniques, confidentiality and security of patient data can be resolved by using advanced encryption techniques along with imperceptibility and dependency on key.
e) Controlling integrity: MIW can very well resolve the integrity issues through fragile watermarks as well as can evaluate the extent to which image is tampered and also the modified regions.
f) Authentication: MIW can be combined with cryptographic techniques to resolve authentication issues.
g) Indexing: Watermark can be used as keywords or indices which help in proper retrieval from database through queries.
h) Controlling access: In Medical images DICOM metadata are embedded in the image which can be accessed only through proper keys. These different keys give an access control to MIW.
i) Captioning: Some small Captions as watermarks provide extra beneficial information about the patient's report.

2.2 Requirements of MIW

General watermarking requirements as well as specific to medical image management system are given below:

a) Imperceptibility: The embedded watermark in the image should not be visible to human eye.
b) Robustness: system should be robust enough or able to withstand various attacks possible on images while distribution.
c) Capacity: it is the amount of data payload that can be hidden in the image as a watermark.
d) Authenticity: The data content should only be accessible to legal users after proper authentication. Cryptography is used for this purpose.
e) Reversibility**:** The image should be recoverable after extracting the watermark.
f) Intactness of ROI**:** The ROI should not be affected by watermarking process in any way. Damaged ROI can have serious consequences with respect to patient's health.
g) Complexity**:** less complex algorithm is always profitable with respect to user as well as system by saving execution time.

3. Literature Review

Digital watermarking technique can very well handle all the problems coming up in medical management system. In order to conduct the systematic review, we have searched the various digital libraries which include

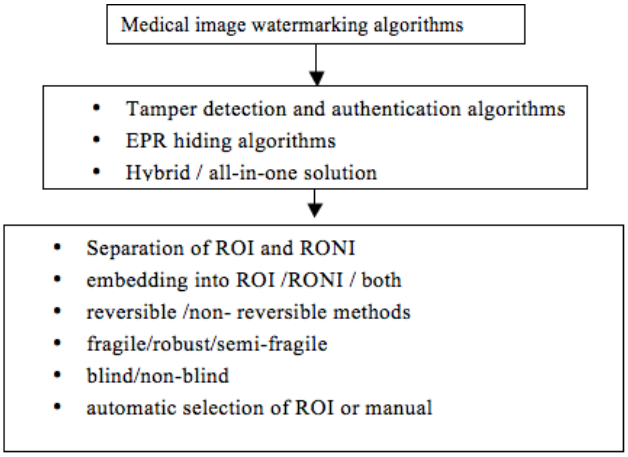

Figure 1. Categorisation of MIW techniques.

IEEE explorer, ACM, Science direct, Elsevier and Google scholar. We found almost 16,600 research articles related to the topic and 22 are selected manually and discussed in detail after reading the title, abstract and conclusion.

In Medical Image Watermarking (MIW), a different aspect is the preservation of ROI part. ROI (Region of Interest) is critical part of image. It is only mainly used for diagnosis purpose by technicians. Any change in the quality of ROI can lead to wrong diagnosis and can be dangerous. Hence, preserving the quality of ROI is very essential[6].

The algorithms are categorised primarily in three categories and then subcategorised further.

Many researchers have worked on this medical system issues using watermarking techniques which are categorised on the basis of:

3.1 Tamper Detection and Authentication Algorithms

These algorithms detect the tampered regions in the image during the extraction process [7–9]. The important information in the image which is in ROI part should not be modified in any case. So, the algorithm must be capable enough to detect the modification and also locate the exact modified area[10–13]. Moreover, it must also be able to recover the complete image without degrading the quality. Imperceptibility is prioritised over robustness and capacity in these tamper detection and authentication algorithm[14–17].

3.2 EPR (Electronic Patient Record) Hiding Algorithms

EPR is the patient record details like name, sex, address etc. It also contains the medical diagnosis report of the patient, digital signatures of the physician, some specific patient's id and many other important details[18–21]. In many hospitals, EPR and images are stored separately. This may lead to requirement of large storage and also bandwidth while transferring the data from one place to another[22,23]. Moreover, detachment of the image from the corresponding EPR will cause serious problems in diagnosis[25,26].

4. Hybrid/ All-in-one Solution

Some handle with both the issues of tamper detection, authentication, and EPR hiding[27–33].

The above categories are further classified on the basis of:

a) Separation of ROI and RONI: In a medical image some region is very critical with respect to the diagnosis of the patient. Many researchers have taken this into consideration and separated the ROI (Region of Interest) and RONI (Region of Non-Interest). The papers which didn't separate the ROI and performed embedding on full image are[34,35]. All others do separate ROI and RONI part of the image.

b) Embedding into ROI /RONI / both: Watermarks are embedded into the image, but in medical images embedding is either done in ROI part or RONI or both. These things are considered for specific purposes like whether algorithm is for EPR hiding or tamper detection Authentication purposes. These embed the watermark in total image without considering ROI and RONI separately[9,18–20,27]. These embed in ROI part as well as RONI part[8,10,11,28–30]. Some embed only in RONI region for saving the quality of ROI part[7].

c) Reversible /non- reversible methods: Reversible watermarking technique is one which checks for the authentication while extraction and as also recovers the original image after the watermark extraction. It is very essential in MIW as recovering the original medical image is very important for diagnosis purposes. Some used reversible watermarking schemes[7,8,10,11,28–30] and some used non-reversible watermarking techniques[9,18–20,27].

d) Fragile/robust/semi-fragile: Reversible methods are further classified in fragile and semi fragile. Fragile means the watermark is destroyed completely after

Table 1. Comparison of MIW techniques

SN	Author name	Objective	Embedding region	Techniques	Reversibility	Tamper Localization	Tamper Recovery	Robust
1.	Giakmouki et.al [1]	Authentication, Indexing,EPR	Total image	DWT	No	Yes	No	Yes
2.	Venkatram et.al[2]	Authentication Integrity Control	Total image	LWT,SVD	No	No	No	Yes
3.	Das et al.[3]	Authentication Integrity,EPR	ROI,RONI	LSB	Yes	Yes	Yes	Yes
4.	Nambaksh et al.[4]	Security Authentication	Total image	DWT	No	No	No	Yes
5.	Qershi et al.[5]	Authentication Data hiding	ROI,RONI	DE,DWT	Yes	Yes	Yes	Yes
6.	Gunjal et al.[6]	Security	RONI	DWT	Yes	No	No	Yes
7.	Faoziyah et al.[7]	Recovery Security	ROI,RONI	LSB	Yes	Yes	Yes	Yes
8.	Kannamal et al.[8]	Authentication Security,Integrity	Total image	DWT	No	No	No	Yes
9	Eswaraiah et al.[9]	Authentication Integrity	ROI,RONI	LSB	Yes	Yes	Yes	yes
10	Memon et al.[10]	Security Confidentiality Integrity control	ROI,RONI	Hybrid	Yes	Yes	Yes	Yes
11	Ajung et al.[11]	Recovery Authentication	ROI,RONI	LSB RLE	Yes	Yes	Yes	Yes
12	Hernadez et al. [12]	EPR hiding Imperceptibility	Total Image	DFT	---	No	No	Yes
13.	Mousavi et al.[13]	Security Automatic ROI selection	--	--	--	--	Yes	Yes
14	Rayachoti et al[14]	Integrity	RONI	IWT,LSB	Yes	Yes	Yes	Yes
15	Natarajan et al.[15]	Security EPR hiding	RGB Component	DWT,SVD	Yes	No	No	Yes
16	Eswaraiah et al.[16]	Integrity	ROI,RONI	RLE,LSB	Yes	Yes	Yes	No
17	Lu et al.[17]	Increase robustness	ROI,RONI	DWT,DCT	No	Yes	--	Yes
18	Aherrahrou et al. [18]	automatic ROI selection	ROI,RONI	PDE,DWT, DFT	No	Yes	Yes	Yes
19	Solanki et al.[19]	Security,integrity	RONI	RSA,DWT	--	Yes	--	Yes
20	Nyeem et al.[20]	Generalise ROI selection	RONI	LSB	--	--	--	--

some attack on the watermarked image. While in semi-fragile the watermark is able to survive attacks at some level. Robust is a part of semi fragile methods in which watermark is able to survive all the possible attacks[7–11,18–20,27–30].

e) Blind/non-blind: Watermarking techniques are classified into blind and non-blind methods. In blind methods, the cover image and watermark are not required during extraction process while in non-blind methods they are required.

f) Automatic selection of ROI or manual: Region of interest needs to be selected in the image before embedding process. Most of the times, ROI is selected manually by doctors or physicians[7–11,18–20,27–30] while sometimes it is selected automatically[13,31].

Table 1 shows the comparison of MIW techniques on the basis of certain parameters discussed in literature review. The table is also categorised and subcategorised on the basis of the analysis.

5. Conclusion

Over previous years, many watermarking algorithms have been proposed for medical image system by different research scholars in this field, but each method has certain disadvantages associated as well as strengths. Some have only focussed on tamper detection and recovery and some have worked on data authentication and integrity of patient's records (EPR). MIW has brought up many interesting concerns like the ROI and RONI, securing ROI from distortion, embedding of EPR, area of embedding whether in ROI or RONI, prioritizing capacity over imperceptibility when embedding EPR etc.

The research still continues to find out an optimal balance between all the basic watermarking requirements and specifically medical image watermarking.

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