Design of a ‘Smart’ Patient Record System for Mammography Patients

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Abstract. One of the most common cancer types among women is breast cancer. Regular mammographic examinations increase the possibility for early diagnosis and treatment and significantly improve the chance of survival for patients with breast cancer. Keeping an informed and complete patient record is of great importance as the doctor needs this information for every patient examination. The proposed implementation is a patient record system that includes ‘smart’ algorithms in order to automatically use data from the patient’s record to calculate well established epidemiological breast cancer models. A computer-aided diagnosis system is also used in order to analyze each mammogram and obtain a certain risk percentage concerning whether the patient has to undergo biopsy or not. The aforementioned system has been implemented to support a large set of patient data (1,178 patients) which included detailed personal patient data, medical history and examination details per date and is used in the daily clinical practice of a breast cancer diagnostic center facilitating patient record retrieval, storage and supporting the doctor’s decisions.

Keywords. patient record, smart system, mammography, breast cancer

1. Introduction

One of the most common cancer types among women is breast cancer [1, 2]. Mammography has been established as the most efficient method in the early diagnosis of this type of cancer and early detection is critical as it substantially improves prognosis [3-5]. Keeping an informed and complete patient record is of great importance as the doctor needs this information for every patient examination. Radiologists and breast cancer experts need patient data (medical history and current patient condition) as well as previous mammographic images in order to make an informed decision. In order to ensure this, along with the computer-aided diagnosis

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(CAD) system that we have developed [6, 7], a smart patient record for mammography patient is designed and implemented using open source software and was tested in a sample data set of 1,178 patients.

2. Scope

Our goal is to provide the doctor with a paperless patient record that includes a CAD Image Analysis System and integrated implementation of epidemiological breast cancer models (Figure 1). As all of the above seem very important and helpful to radiologists the most important aspect of this system is the continuity of care as the doctor has the ability to retrieve over LAN or internet all of the patient’s history files and mammographic images in order to consult and make an informed decision.

![Figure 1. Overview of the computer-assisted diagnosis process](image)

3. Methods and Materials

The system is designed using PHP as the programming language (including some modules in JavaScript) and MYSQL as the database engine. The selected tools allow for the system’s operation through all operating systems using graphical interface and support web browsing applications. It is tested to be working on Microsoft Windows XP and Vista as well as on Ubuntu 8.04 and Opensuse 10.3 Linux.

To ensure user acceptance there was a thorough analysis of the user needs prior to system design and implementation. The system was designed based on the doctors’ clinical workflow and daily data needs. It was successfully implemented and it was able to manage all 1,178 patients that were imported.

Between September 1999 and August 2008, we collected data on 1,178 Greek women in order to conduct a case-control study. Cases included 540 women (age range
28–87 years, median 53 years) with a histologically confirmed diagnosis of breast
cancer. All women were admitted to a diagnostic breast clinic in Athens. Controls were
chosen from women who admitted to the breast diagnostic center for a precaution
gynecological control during the same interval. A total of 638 women were included in
the control group, while women with a malignant, endocrine or gynecological disease
did not participate. Information was collected on general characteristics, menstrual and
reproductive history and family history of cancer (i.e., first- and second- degree
relatives). Family history was regarded as positive if a first-degree (mother, sister) or
second-degree relative (aunt, others) had had breast cancer formerly. None of the
relatives of the patients, who visited the diagnostic breast centre, were admitted to the
control group.

4. Results

All routine operations such as patient data retrieval and mammographic image viewing
over LAN and over the internet were successfully performed with multi user access.
The patient data includes a basic set of fields that are usually filled in during the
patient’s first visit such as demographic data and medical history and date-specific data
such as findings per date and the mammographic images that were obtained on a
specific date.

4.1. System Features

The most important features of the proposed system include:

- Full featured patient record for mammography patients. Storage of medical
  history data, search functions and update per date of examination/visit. The
  patient record contains all medical data of the patient along with the associated
  mammograms in digital form.

- CAD using Image Analysis with Hippocrates-mst, a well documented system
  that can provide tools for image enhancement and microcalcification detection.
  Radiologists consider breast microcalcifications a very useful index of
  malignancy, which helps in the early detection of breast cancer [8, 9].

- Web browser accessible (Figure 2). The system can be accessed either from a
  Local Area Network (LAN) or from the internet through all known web
  browsers (Internet Explorer, Mozilla Firefox, Opera etc).

- Parametric search module along every field of the patient record using
  multiple criteria.

- Smart Patient Record module. Implementation of well known epidemiology
  breast cancer models such as the Gail model [10] and Myriad Tables [11] as
  well as the model that we are currently developing and calibrating based on
  the analysis of 1,178 patients known as the AIAS model. The implementation
  of these models in the patient record allows for the automatic calculation of
  risk percentages just after the doctor fills in the required field in the patient’s
  record.

- Operable across operating systems. The web-based architecture allows the
  system to function regardless of the client’s operating system. Even handheld
  devices running web browsers can access all data on the system. Portable
devices that are supported and tested include those running Windows Mobile operation system as well as the Apple’s iphone.

- Graphical representation of data regarding the risk of breast cancer development according to the patient’s age.

![Image of a network diagram](image)

**Figure 2.** Schematic representation of the proposed system

### 4.2. Smart Module

The Smart module of the system consists of the integration of three statistical models that are automatically computing risk percentages right after the doctor inserts data in the appropriate fields of the patient’s record. The three risk models are:

- **The Gail model** that is the most common risk estimation model used in breast cancer. It looks at a number of factors including a woman’s current age, the age she began menstruating, her age at menopause, age of first live birth, previous biopsies and family history.

- **The Myriad Tables percentage.** According to this statistical model known as Myriad Tables, a percentage is calculated stating whether a woman has the BRCA1/BRCA2 genes that have been linked to hereditary breast cancer. The Genetic testing is already being used among women with a strong family history of breast cancer to determine if the BRCA genes are present.

- **The AIAS risk estimation model.** It is a risk estimation model that we are currently developing using regression models and multiple imputation methods for the analysis of 1,178 cases that underwent mammography examination using data from their medical history.

### 4.3. Security

Medical data require security as the patient’s right for confidentiality is of paramount importance. User (doctor) identification via password ensured data protection and that
every doctor will have access to the patients he/she has registered to the system. No
patient records can be accessed without prior login to the system.

5. Conclusion

We have designed and prototyped a ‘smart’ patient record based on published risk
estimation models and on heuristic models as well. With the help of this system
radiologists will have real time information whether the case under examination is of
high risk or not. In the near future we plan to perform a user evaluation study as well as
to implement the proposed system in a national level in order to collect data across
Greece that can later be used to structure a national registry for breast cancer. The
collected data can also be analyzed to identify patient needs and breast cancer risk
factors that are more common in Greece in order to take appropriate action in primary
health care.

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