

# Clinical Decision Support System for the Diagnosis of Migraine and Headache

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*Received: May 31 2013*

*Accepted: July 8 2013*

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## ABSTRACT

This paper, presents a clinical decision support system that will aid physicians and doctors in diagnosing migraine and other headaches. Headaches, in a variety of forms, are one of the most common areas of complaint presented to physicians and doctors. They present a diagnostic challenge to doctors as, they can be caused by more than hundred causes or diseases and accurate diagnosis of the cause is essential to optimal treatment. The Clinical Decision Support System (CDSS) is capable of diagnosing migraine and other headaches by gathering patient's data, processing it, and providing decision support diagnostic recommendations. It provides, clinician the facility to enter patient data. The information for each patient is stored in the Electronic Medical Record (EMR) for processing and retrieving. The resultant CDSS, is efficient and easy to use. It is compared with real time diagnostics and proved to be cost effective and robust solution for rapid diagnosis.

**KEYWORDS:** Decision support system, expert system, migraine, classification

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## 1. INTRODUCTION

Human brain, is the core and most complex part of the body which, makes its analysis and treatment difficult and risky as compared to other human organs. Headache, in a variety of forms, is one of the most common complaints presenting to physicians and doctors. It is a diagnostic challenge, as it can be caused by more than hundred diseases and accurate diagnosis of the cause is essential for the optimal treatment. One of the most common headache related disease is migraine which, is affecting most of the population. With respect to migraines, individualized treatment is more effective than non-specific therapies in relieving symptoms, preventing attacks and maintaining patient function. However, migraines are frequently under diagnosed or misdiagnosed as tension type headaches. Consequently, many patients do not receive appropriate treatment and continue to suffer attacks with associated disabling symptoms. The proposed system will aid physicians and doctors in diagnosing migraine and other headaches. The system will be easily accessible and help the patients in getting proper diagnosis. Firstly, the information about the patient is taken and recorded in the system. Secondly, the inference engine, knowledge base, and the image processing module work on the stored patient information. Finally, the system displays disease diagnostic recommendations which, are used by the physicians and doctors for giving the proper prescriptions to the patients. The proposed clinical decision support system will aid physicians and doctors in proper diagnosis of migraine and other headaches like brain tumor. Clinical Decision Support System [1-5] will gather patient's data, record it, find any headache disorder and assist the doctor in the decision making process. Data about the patient will be entered by the clinician, from one end using website. The patient's record, will be stored in the electronic medical record for the purpose of retrieval and manipulation. Inference engine, knowledge base, and image processing module will take action on the record and provide decision support diagnostic recommendations. The doctor can access and take suggestions made by the CDSS through internet.

The system architecture of CDSS is shown is Figure 1. CDSS, is a Clinical Decision Support System capable of diagnosing migraine and other headaches by gathering patient's data, manipulating it, and providing decision support diagnostic recommendations.

At present, patients in Pakistan are facing a serious problem in getting proper headache treatment. Doctors tell the patients to undergo various tests and it takes a significant amount of time before the disease is identified and properly diagnosed. The specialist doctors for headaches and neurological disorders in Pakistan are mostly in the big cities. People living in remote areas travel a long distance for medical checkups. Time is the very critical factor for the patients. So, there should be some easy accessible and automated system which will make things easier and time efficient for the doctor and the patient too.

CDSS, will aid physicians and doctors in diagnosing migraine and other headaches. The system will help the doctors in identifying the headache disorder timely and giving proper medical treatment to the patients. Providing a web based system will prevent the patients living in remote areas from travelling long distance for medical checkups.

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The system will be able to differentiate migraine from its subtypes and flexible enough to detect brain tumor from MRI scans.

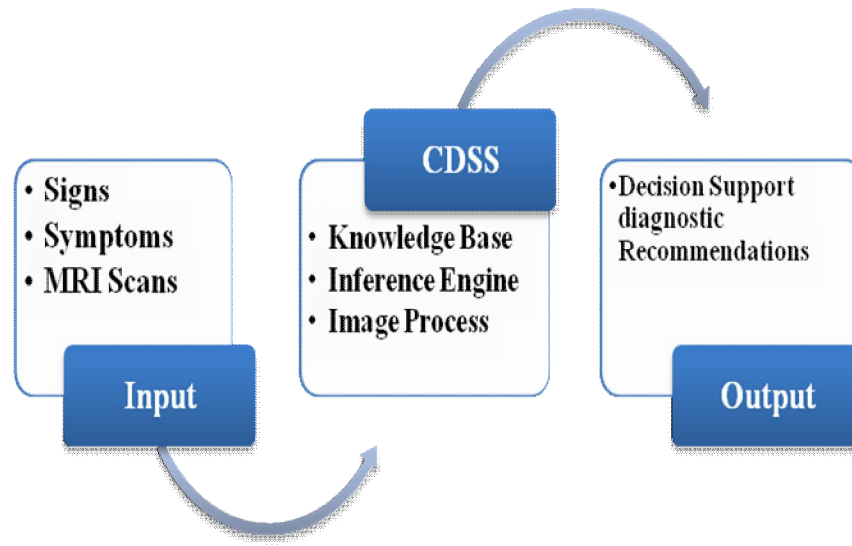


Figure 1. System modules

## 2. Problem Formulation

Headaches in a variety of forms, present a diagnostic challenge as they can be caused by more than hundred diseases and accurate diagnosis of the cause is essential to optimal treatment. Headache disorders are ranked amongst the ten most disabling conditions in the world by the World Health Organization (WHO). The global prevalence of active headache diseases in the adult population is 46%.

Migraine, is one of the most common headache disorders affecting most of the population. With respect to migraines, individualized treatment is more effective than nonspecific therapies in relieving symptoms, preventing attacks and maintaining patient function. However, migraines are frequently under diagnosed or misdiagnosed as tension type headaches. Consequently, many patients do not receive appropriate treatment and continue to suffer attacks with associated disabling symptoms. Most Clinical studies have originated in developed countries and there is scarce literature to support treatment guidelines or public health interventions to deal with headache in low and middle income countries. The idea, is to develop a system that will help the patients with migraine and headache disorders in Pakistan. The system will aid physicians and doctors in diagnosing migraine and other headaches so that patients can get maximum benefit and proper diagnosis in small time span. Classification scheme for headaches and the rules laid down by the International Headache Society for diagnosing migraine will also be considered for giving the patients a proper medical treatment.

Currently, there is one doctor for 1,837 persons, one dentist for a population of 46,498, one primary health care facility for 14,900 persons (rural) and one hospital bed for 1,503 persons. The problems being faced by the health sector include:

- Inadequate primary health care
- High rate of population growth
- Communicable diseases
- Managerial deficiencies
- Inadequate funding
- Manpower imbalances

Besides, there are other contributing factors like malnutrition, inadequate water supply, lack of coordination and environmental pollution. At present, patients in Pakistan are facing a serious problem in getting proper headache treatment. Doctors tell the patients to undergo various tests and it takes a significant amount of time before the disease is identified and properly diagnosed. The specialist doctors for headaches and neurological disorders in Pakistan are mostly in the big cities. People living in remote areas travel a long distance for medical checkups. Time is the very critical factor for the patients. So, there should be some easy accessible and automated system which will make things easier and time efficient for the doctor and the patient too. Migraine is one of the most common

headache disorders affecting most of the population. It involves recurrent attacks of moderate to severe pain that is throbbing or pulsing and often strikes one side of the head. Untreated attacks last from 4 to 72 hours. Other common symptoms are increased sensitivity to light, noise, and odors; and nausea and vomiting. Routine physical activity, movement, or even coughing or sneezing can worsen the headache pain. Migraines occur most frequently in the morning, especially upon waking. Some people have migraines at predictable times, such as before menstruation or on weekends following a stressful week of work. Many people feel exhausted or weak following a migraine, but are usually symptom-free between attacks. A number of different factors can increase the risk of having a migraine. These factors, which trigger the headache process, vary from person to person and include sudden changes in weather or environment, too much or not enough sleep, strong odors or fumes, emotion, stress, overexertion, loud or sudden noises, motion sickness, low blood sugar, skipped meals, tobacco, depression, anxiety, head trauma, hangover, some medications, hormonal changes, and bright or flashing lights. Medication overuse or missed doses may also cause headaches.

### 3. Clinical Decision Support System

The clinical decision support systems help the medical experts in making decisions to diagnose the diseases. CDSS, forms a significant part of the field of clinical knowledge management technologies, through their capacity to support the clinical process using expert level knowledge, diagnosis, investigation, treatment and long term care. CDSS, is active knowledge management system which is used to generate case specific advice from the patient data. One of the key functions of clinical decision support system, is supporting clinical diagnosis and treatment plan processes.

The proposed CDSS is capable of diagnosing migraine and other headaches by gathering patient's data, manipulating it, and providing decision support diagnostic recommendations. It provides clinician the facility to enter data about the patient. The information about the patient is stored in the Electronic Medical Record (EMR) for manipulation and retrieval. The inference engine and knowledge base work on the patient's data stored in the EMR is to identify the headache disorder. Image processing module is also included to work on the data about the patient stored in the EMR. Classification, segmentation, and enhancement techniques [6-14] help in the detection of brain tumor. After analysis of patient's record, decision support diagnostic recommendations are displayed for helping the doctor in giving correct prescription to the patient.

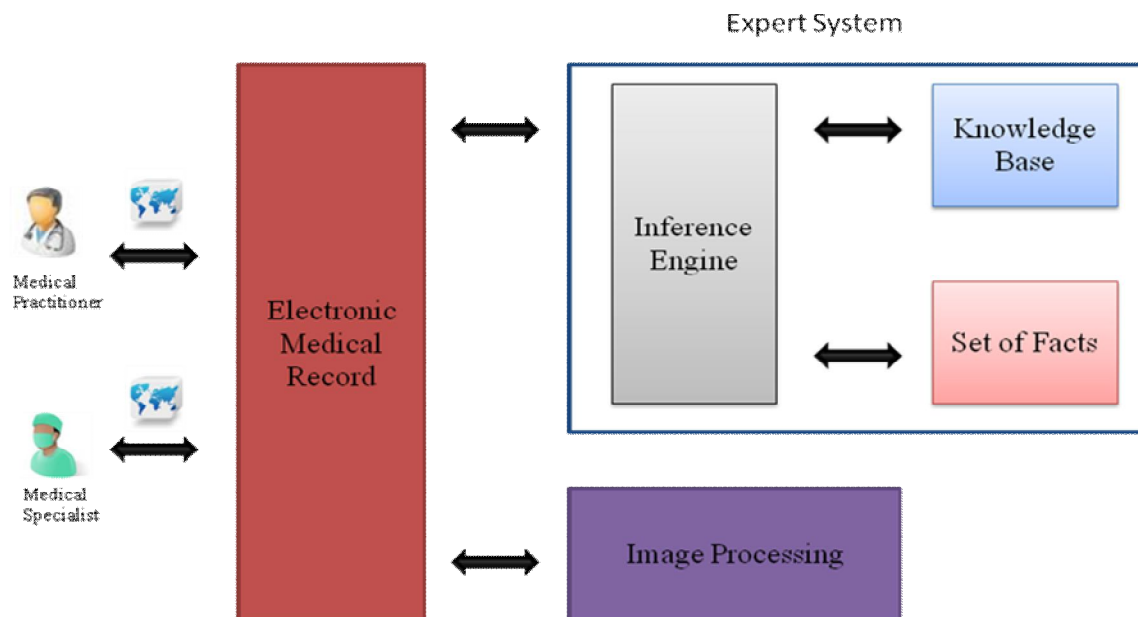


Figure 3: System Architecture

#### 4.1. System Modules

The CDSS is divided into four main components:

- Electronic Medical Record
- Knowledge Base
- Inference Engine

- Image Processing module

#### **4.1.1 Electronic Medical Record**

An electronic medical record, is usually a computerized legal medical record created in an organization that delivers care, such as a hospital and doctor's surgery. Electronic medical records tend to be a part of a local standalone health information system that allows storage, retrieval, and manipulation of records. An Electronic Medical Record system keeps track of patient's medical history and assists in the report creation process. EMR, stores the new data as well as the results of the analysis performed by CDSS.

#### **4.1.2 Knowledge Base**

A knowledge base is a special kind of database for knowledge management, providing the means for the computerized collection, organization, and retrieval of knowledge. It is the compilation of the relationships between all of the diseases in the system and their associated manifestations which includes signs and symptoms. The knowledge base, contains the rules and associations of compiled data which most often take the form of IF-THEN rules. If this was a system for determining drug interactions, then a rule might be that IF drug X is taken AND drug Y is taken THEN alert user. Our knowledge base consists of the information about the diseases related to primary and secondary headache disorders. This information is used by the inference engine to determine the disease that the patient may have.

#### **4.1.3 Inference Engine**

An inference engine, is a computer program that tries to derive answers from a knowledge base. It is the "brain" that expert systems use to reason about the information in the knowledge base for the ultimate purpose of formulating new conclusions. Inference engine consists of the following components:

- An interpreter: The interpreter executes the chosen agenda items by applying the corresponding base rules.
- A scheduler: The scheduler maintains control over the agenda by estimating the effects of applying inference rules in light of item priorities or other criteria on the agenda.
- A consistency enforcer: The consistency enforcer attempts to maintain a consistent representation of the emerging solution.

The inference engine can be described as a form of finite state machine with a cycle consisting of three action states: match rules, select rules, and execute rules. Rules are represented in the system by a notation called predicate logic. In the first state, match rules, the inference engine finds all of the rules that are satisfied by the current contents of the data store. When rules are in the typical condition-action form, this means testing the conditions against the working memory. The rule matching's that are found are all candidates for execution: they are collectively referred to as the conflict set. Note that the same rule may appear several times in the conflict set if it matches different subsets of data items. The pair of a rule and a subset of matching data items are called an instantiation of the rule. The inference engine then passes along the conflict set to the second state, select rules. In this state, the inference engine applies some selection strategy to determine which rules will actually be executed. The selection strategy can be hard-coded into the engine or may be specified as part of the model. Finally the selected instantiations are passed over to the third state, execute rules. The inference engine executes or fires the selected rules, with the instantiation's data items as parameters.

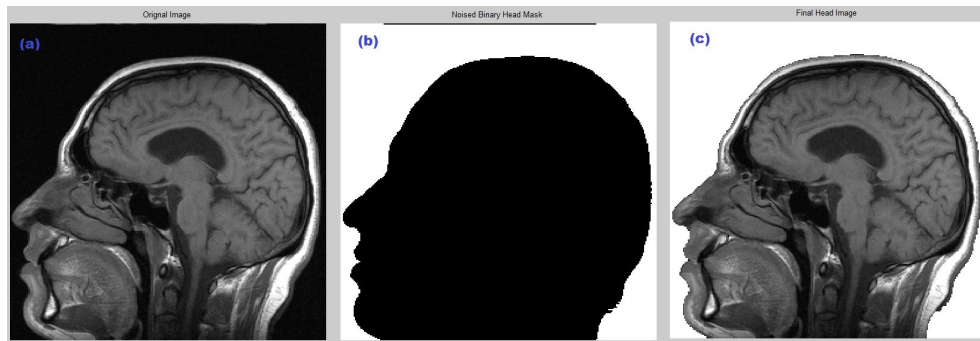
#### **4.1.4 Image Processing Module**

Image processing module is basically used for the detection of brain tumor from MRI scans. The images which will come from the patient end will be processed by this module. It will perform, specific actions on the images and suggest appropriate options for the doctor. This module, will involve image enhancement, segmentation, and classification. Image enhancement is the improvement of digital image quality, wanted for visual inspection or for machine analysis, without knowledge about the source of degradation. Image enhancement improves the clarity of images for human viewing. Removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations. Segmentation of images will help in the separation of head from magnetic resonance images (MRI). MRI scans produce pictorial representation of processes, forming a complete image of a brain. In order to perform detailed studies of these images we need to distinguish the patterns of brain. It includes the following:

- **Head Mask Generation:**

An operator is used that starts from two corners of the image and moves along two opposite directions. It identifies background pixels and pixels with a grey level within a range fixed in the configuration phase of

the system. Threshold, would produce speckles inside and outside the mask so morphological operations (erosion and dilation) are used to get a perfect binary image without any noise and distortions.

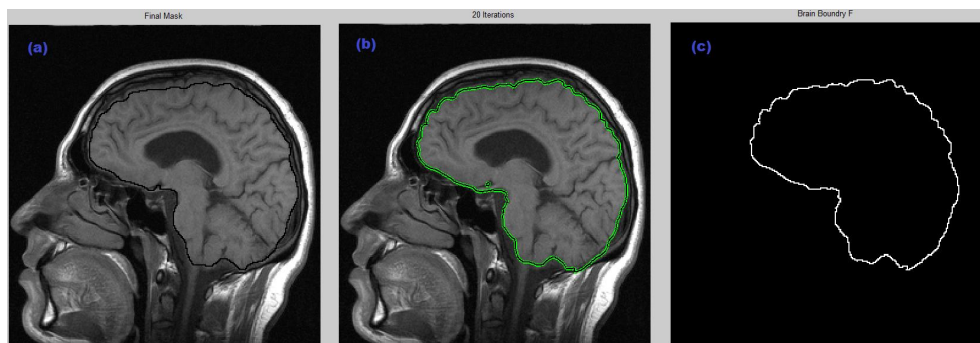


**Figure 4.1: Images in Matlab (a) Original Image, (b) Noised binary Image, (c) Head Mask**

- **Initial Brain Mask Generation:**

After, head segmentation, we need to generate an initial brain mask that would help us to distinguish only the brain part from the rest of the head's image. Gaussian filter will be applied to the background noise removed image of the head. Then, centering and locating origins on the image will help to detect only the brain part. It includes the following:

- Binary Conversion
- Anisotropic Diffusion
- Noised Removed Image
- Head Mask Boundary
- Region Filling
- Erosion
- Eliminating Non brain parts
- Dilation
- Mapping the initial brain mask



**Figure 4.2: Mask in Matlab (a) Initial Brain Mask, (b) Final Brain Mask, (c) Brain Boundary**

- **Final Brain Mask Generation:**

The generation of final brain mask still has a problem. The mask that is produced does not fit very nicely on the brain part. There are some parts of the brain that fall outside the boundary. To eradicate this problem another process is applied.

Classification of images will aid in determining the normal and effected human brains from MRI scans. This is of great importance for research and clinical studies. The module will involve feature extraction from MRI images using discrete wavelet transformations and reduction of features of MRI images using principal component analysis technique.

## 5. Modules of CDSS

CDSS focuses on helping physicians and doctors in diagnosing migraine and other headache disorders like brain tumor. It enables doctors to take accurate decision depending upon the results that it provides. The system will be able to provide a basic and easy interchange of information. In addition, the system will be accessible from anywhere around the world through the internet which will aid the patients, living in the remote areas, in getting proper and early treatment.

### 5.1 Major functions of CDSS:

- CDSS provides clinician the facility to enter data about the patient.
- The information about the patient is stored in the Electronic Medical Record (EMR) for manipulation and retrieval.
- Inference engine and knowledge base work on the patient's data stored in the EMR to identify the headache disorder.
- Image processing module is also included to work on the data about the patient stored in the EMR. Classification, segmentation, and enhancement techniques help in the detection of brain tumor.
- After, analysis of patient's record, decision support diagnostic recommendations are displayed for helping the doctor in giving correct prescription to the patient.

### 5.2 User Characteristics

An ideal user in this case will be a clinician or a doctor, who most probably will have a sign in ID and password, which can be used to grant the user access to the software. Users must be familiar with the web technology in order to access and fill the patient's form. The application will be accessible from anywhere around the world through the use of internet.

### 5.3 General Constraints

The system will enforce user authentication security so that personal data about the patients can only be accessed by the doctors or clinicians. Many doctors will be able to access the EMR at the same time for the retrieval and manipulation of patient's data. Patient data entry form, will be designed in such a way that the clinician sitting in any remote area can easily understand and enter the information about the patient.

### 5.4 Assumptions and Dependencies

Knowledge base and inference engine will be expert enough to identify the headache disorder and differentiate migraine from other headaches like brain tumor. Image processing module will be able to detect the brain tumor by properly analyzing magnetic resonance image (MRI) scans. Updates in the knowledge base and inference engine will aid in getting the accurate decision support diagnostic recommendations.

## 6. External Interface Requirements

### 6.1 User Interfaces

The external users are the clinicians or doctors. The user interface is available as a web application which requires an authentication before use. Design of the user interface will be such that the users using the application for the first time can find it easy to handle.

### 6.2 System Interfaces

CDSS consists of four major components:

- Knowledge base.
- Inference Engine.
- Electronic Medical Record.
- Image Processing Module.

Knowledge base and inference engine will identify the headache disorder and differentiate migraine from other headaches like brain tumor. EMR will be used for patient's data storage, retrieval, and manipulation. Image processing module, will be able to detect the brain tumor from MRI scans.

## 7. Conclusion

The proposed clinical decision support system, is capable of diagnosing migraine and other headaches and provides recommendations. It provides, clinician the facility to enter data using the module electronic medical record for manipulation and retrieval. The inference engine and knowledge base work on the patient's data stored in the EMR to identify the headache disorder. Image processing module is also included to work on the stored patient data. The classification, segmentation, and enhancement techniques help in the detection of brain tumor. The proposed CDSS is reliable, cost-effective and efficient solution for rapid knowledge based diagnostics and can be incorporated easily in clinics, hospital and medical colleges for training and diagnostics. The CDSS, provides timely diagnostic services and even helps in early diagnosis of brain tumor.

## ACKNOWLEDGMENT

The authors declare that they have no conflicts of interest in the research.

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