Analysis of human brain by magnetic resonance imaging using content-based image retrieval

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ABSTRACT

Objective: Content-based image retrieval (CBIR) is the most suitable and alternative method for older text searches that use keywords. This article aims to improve feature extraction as well as matching techniques designed for more accurate and precise CBIR systems, especially for brain scan images associated with various brain diseases and abnormalities. Tests should be described at an appropriate success rate.

Methods: Various methods of producing medical images are discussed, and examples of biological applications are given. The discussion emphasizes as an introduction to CBIR the new method of echo-planar imaging, which is fully described. We have done here many methods related to digital image processing and we had developed a code for retrieving everything automatically. This application has been developed in Matlab software.

Results: Testing the correctness and effectiveness of the system evolved becomes more important when the system is going to be used in real-time and more when it is for humankind, i.e., medical diagnosis. Nowadays, our science and technology areas as develop as we can say that we have such advanced medical equipment so that our thought and program can be capable that it is giving us useful results. Determining if whether the two images are identical or not, it depends on the point of view of the person.

Conclusions: In this paper, the outcome of feature extraction and matching by setting cutoff limit and threshold is pretty promising. Further studies can be done apart from computed tomography scans for a more generalized CBIR system.

Keywords: Computed tomography, computer-assisted diagnosis, cutoff limit, entropy, mean weight factor, magnetic resonance imaging scan image, threshold

Introduction

Our brain is not just a piece of fat in our body. It is a powerhouse of the human body and a control center for all kinds of activity.[1] Our body has a different kind of system that controls all kinds of activity in our body parts. This is known as the nervous system, which also involves a large arrangement of human nerves and thin but large structures which is known as the spinal cord. It is a complex yet powerful collection of nerves which is the must have electrical wiring of any living thing. This system is known as neurons that control the various body parts. In the human brain, 73% of its body part is made up of water.[2] The central nervous system contains a major part known as the brain. The brain covers up with the hard skull. Actually, the brain swims inside the liquid in that skull. It is responsible for cognitive functions, executive, and regulates the functioning of the other parts of the nervous system. The nervous system governs everything from your muscles to the senses of your entire body.[3-5]

When our brain is damaged, it can affect various diverse things, containing recall of our memory, our awareness, and even our nature and behavior. Brain sicknesses contain any circumstances or incapacities that distress the patient's brain. Those conditions include some reasons such as illness, genetics, and traumatic injury.[6]

There is a vast category of brain disorders, which could be varied according to symptoms and severity. However, doctors keep reading to learn about some of the biggest brain illnesses due to unnatural causes. Actually, it depends on which type of injury you have and then treatment may include rehabilitation, medication, brain surgery or even in some cases, there may be a combination of these treatments.

Almost half of the people who have severe brain injuries due to major accidents they must require surgery to eliminate or restoration damaged tissue or to reduce heaviness. On the other hand, people who have minor brain injuries, they may

not need any action beyond pain relief medicines. But in any case, the doctor needs brain imaging and he/she need to match it with the prior cases according to some of the profile keywords such as swelling, clotting, damage tissue, and even something more.[7] For such cases, our approach will help doctors to get results about what they want and the result should come within time.

As far as the technological enhancement spreading rapidly, outdated information accessing techniques based on keywords is not as useful as required. Sufficient purposefully content-based image retrieval (CBIR) has been a vigorous area of research for at least the last two decades.[8] CBIR technologies giving facilities to find images in big databases (DBs) using exceptional descriptors from a trained image. It plays a central role in the application areas such as multimedia DB systems in recent years. The work focused on using low-level features such as color, texture, shape, and spatial layout for image representation.[9]

Advances in medical imaging technology and computer science have greatly enhanced the interpretation of medical images and contributed to early diagnosis.[10,11] However, searching for and identifying similar reference cases (or images) from the large and diverse clinical DBs is a quite difficult task.[12] The progress in digital technologies for computing, networking, and DB storage has enabled the automated searching for clinically related and visually similar medical cases to the inquired case from the huge image DBs.[13,14] However, medical image retrieval can also be useful for the training tool for medical students in education for identifying the growth of tumors, and for another area such as writing on research purposes.[15]

The article describes an improvement in the methods of extracting and adapting functions for a more accurate and precise CBIR system, specifically designed to scan images of various diseases and deformities of the brain.

Methods

Different approaches to producing medical images have been discussed so far, and examples of biological applications have been given. CBIR is also recognized as a query by image content, presents the technologies permitting us to establish digital pictures by their visual features. The computer vision techniques are having image retrieval problems in big DBs based on the computer application.

CBIR consists of retrieving the best visual images to a given query image from a DB of images. It includes two steps to feature extraction and texture matching.

The above steps described in detail in our next Section III and Section IV. The CBIR system will work on two types of images. First is the query image or input image; in this type of image,

doctor used to input the patient's brain resonance image to the system input area. Another option is DB images; these images will be preprocessed before performing a comparison among DB images and the query image. Preprocessing of both types of images consists of the following steps:

1. Converting all images into greyscale images
2. Resizing all greyscale images into 400 × 400 scale
3. Quantizing all images into ten grey levels [Figure 1]
4. The mean frequency for each quantized image computed.

However, CBIR is a very perfect and efficient technique for such a complex purpose, but like others, it has some pros and cons which are described here. The major objective of CBIR is to remove the justification that is based on textual use. CBIR is such a technique that will ease the data usage; thus, the user can effortlessly access the data so that the CBIR, access of image which is founded on likenesses in their stuffing such as textures, colors, and shapes is inferior level properties of the image.

However, like other algorithms, it also has some disadvantages such as false acceptance and false rejection of images. But during the time, these issues must be managed. In my point of view, the major disadvantage of this issue is the high level of system architecture such as huge solid-state drives, high-end processor, and a set of graphical processing unit because if your system is good then you can find results rapidly and in time.

The human could have lots of brain diseases that is why the doctor should have to query images among such kinds of brain diseases. Here, the DB images are of various brain disease response image scan images.

Feature extraction

The first step in this process is to get the image features to a different scope. The feature must be described as a function of single or multidimensions, each of which specifies some computable features of an object, and must be calculated in this way that it measures some important features of the given object.[16] We categorize the various features presently active as follows:
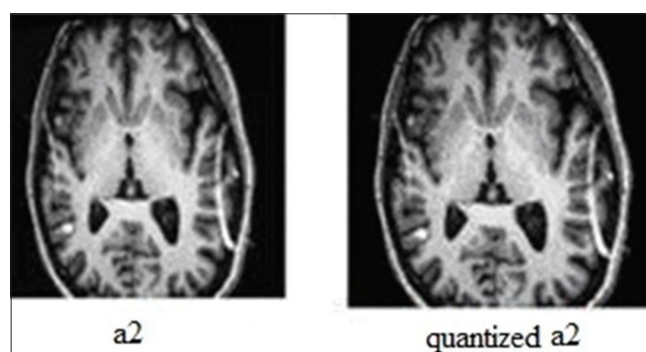

Figure 1: Quantization of image a2

General features

The features do not depend on applications such as texture, color, grey-level, and shape. They can be further categorized into the given subgroup according to the abstraction level:

- Pixel-level features: It can be computed according to features at the pixel level, for example, pigment and position
- Local features: It can be computed according to features of the results of the sub-division of the image band that is the segmentation of image or edge detection
- Global features: It can be computed according to features over the whole image or just related to consistent the part of an image.

Domain-specific features

Features depend on applications such as human faces, fingerprints, and abstract features. These features are repeatedly a combination of low-level features for a definite domain.

On the other hand, all functions could be classified into lower and upper-level services. Lower-level features can be removed directly from the input images, and higher-level features must be based on lower-level features. Thus both types of features are very important in this method.

Matching

After completing the feature extraction, the next step includes matching these structures to return a fruitful result that is visually related. As a result of feature extraction, a vector of each sample is created in the DB that has been produced.[17,18] The resulting vectors will be stored in an indexing vector, including the names and the images of the training DB,[19] and the index of the images.

The same process is followed for the query image and a vector of the same dimensions as the training DB is produced. This is because we are using the same reduction of dimensionality technique principal component analysis for the query image as well. Cluster analysis and outlier analysis are also very important to figure out the similarity between features of images at the time of classification. Steps to perform matching can be given as below:

- Level by level comparison between DB image and the input image is done only for those frequencies which are above the computed mean frequency
- Matching weight factor increases as the difference between the frequencies of both the images falls within the range of cutoff threshold
- Matching weight factor organized and corresponding images is shown in the result.

Here, in Figure 2, a2 is query image and comparison is being done with DB image a8. For Texture matching histogram in Figures 3 and 4 is plotted for each of the two. Its X-axis
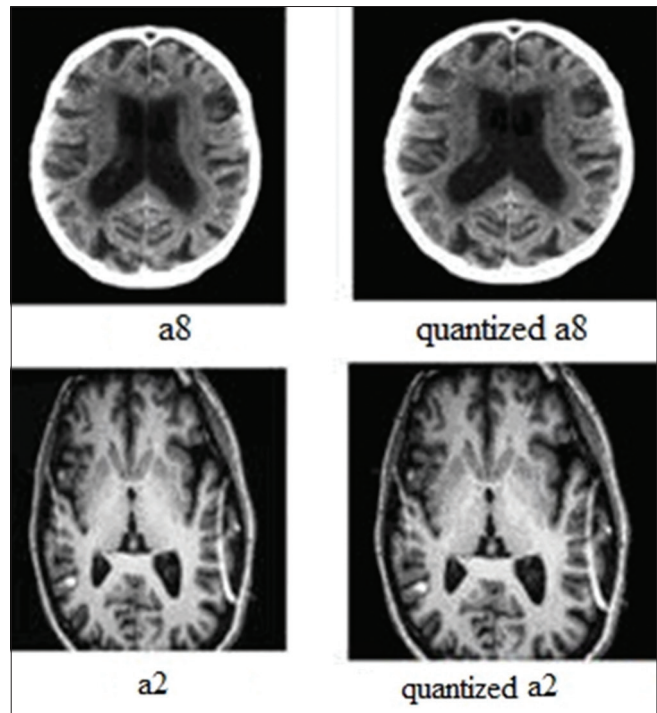

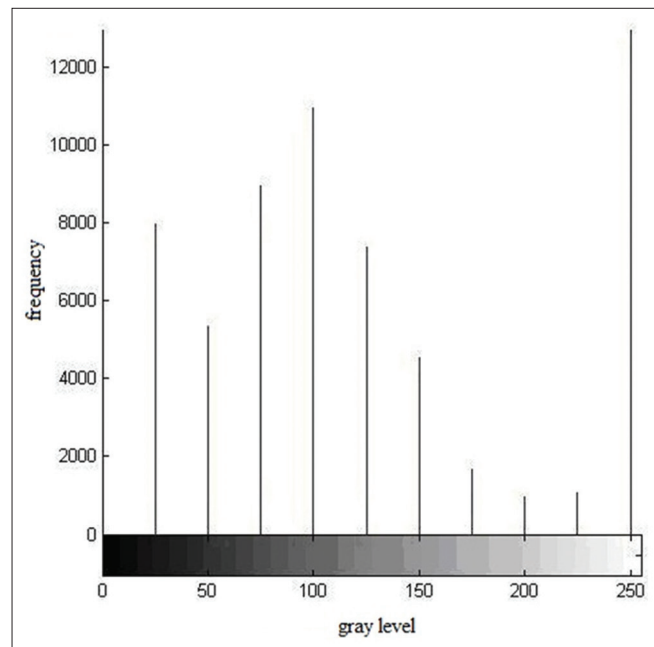**Figure 2:** Quantization of image a2 and a8

Figure 3: Histogram for quantized image a8

shows ten grey levels and the Y-axis shows frequency per bin (grey level).

This histogram will help in comparing the query image to various DB images. In Figure 5, column B and C are frequencies for quantized image a2 and a8. The frequencies greater than mean frequency are only frequencies to be
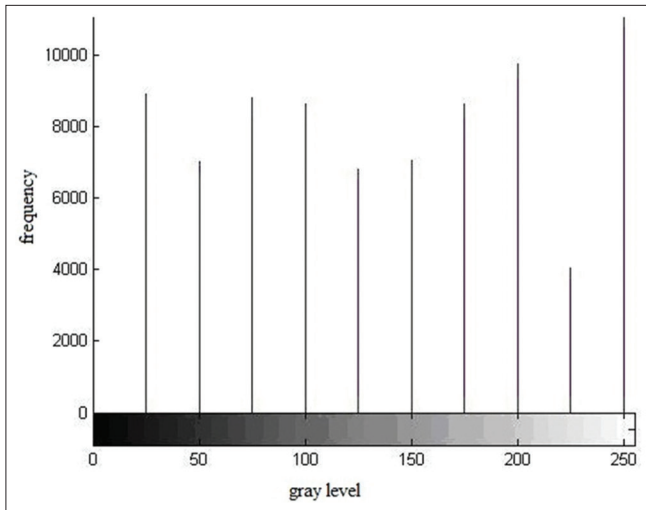
Figure 4: Histogram for quantized image a2

gray level	a2	a8
25	8922	7956
50	7013	5350
75	8798	8951
100	8620	10947
125	6822	7378
150	7038	4554
175	8618	1662
200	9746	952
225	4045	1071
250	10000+	12000+
avg. freq. M	7962	6082

Figure 5: Comparison among the frequencies of quantized image a2 and a8

considered for matching shown shaded. Taking cutoff limit of ±2500 (predefined) total four matches found between both the images are shown red marked in Figure 5. Hence, four are stored as a mean weight factor for the DB image a8.

Similarly, the mean weight factor for each of the DB images will be calculated and stored. Finally, all metalworking fluids (MWFs) will be sorted and DB images of MWFs greater than the predefined threshold will be displayed in results. Deciding cutoff limit is quite critical and results keep varying as it changes.

Flowchart

The flowchart for the whole CBIR process for brain computed tomography (CT) scan images is shown in Figure 6.

Results, System, and Performance Evaluation

Testing the correctness and effectiveness of the system evolved becomes more important when the system is going
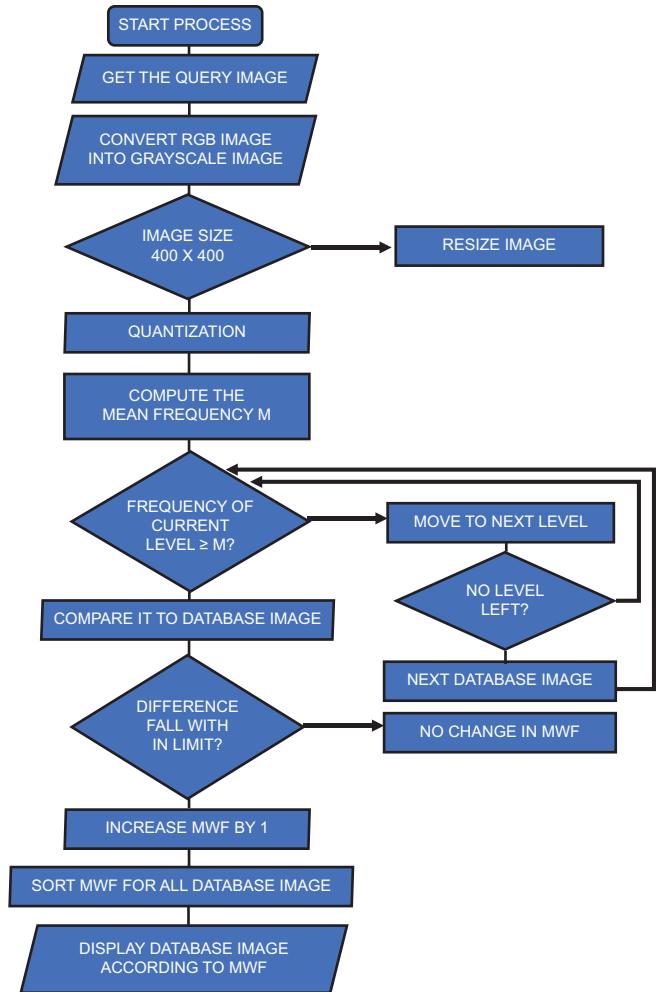

Figure 6: Flowchart

to be used in real-time and more when it is for mankind, i.e., medical diagnosis. Defining if two images are the same or not is the same, is simply up to the user's opinion. Human opinions can easily identify the likeness among two images although in some cases, different users can give changed opinions when the computer-assisted diagnosis is considered then more care is needed before recommending any system. Different assessment measures were used here to observe the efficiency of the image search engine structure. These are as under:

i.   Precision
     It is a measurement of the capability of a system to present only relevant items.
     Precision = (Total relevant images retrieved/Total images retrieved)

ii. False acceptance ratio
     For every request, the method returns the x neighboring images to the request, including itself query image. The total number of mismatches can be figured out as the rich amount of images reverted that fit to a specific class difference than that of the requested image.
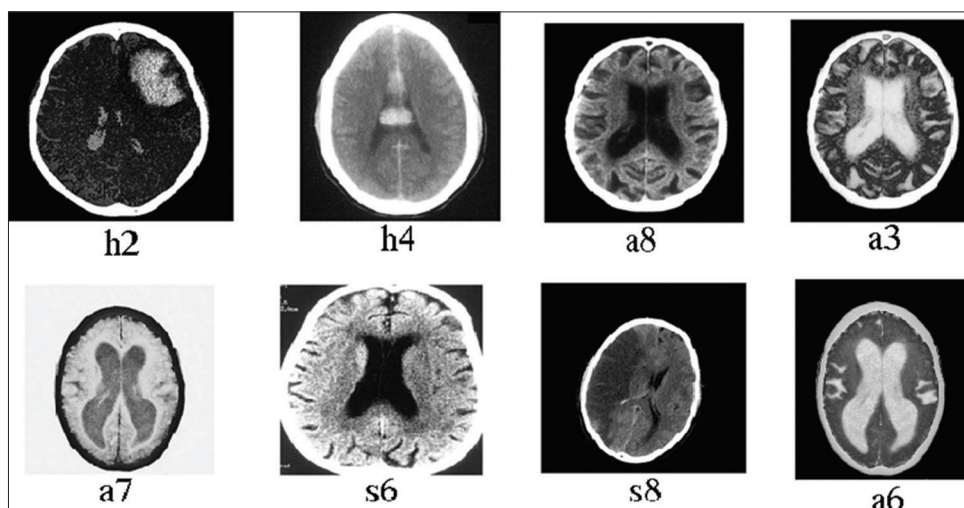   False acceptance ratio = (mismatch/x)
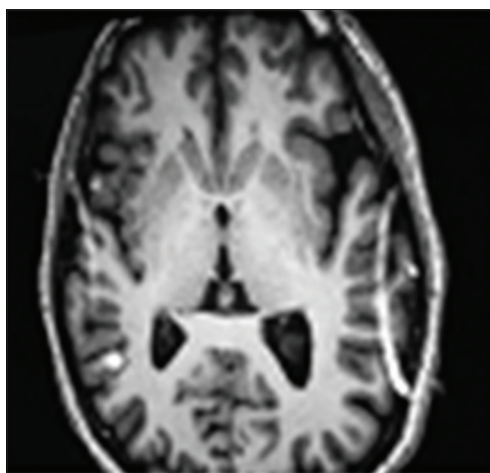
Figure 7: Sample database images

Figure 8: Query image a2

iii. False rejection ratio

The total numbers of images that were exactly related to the requested image class, but somehow have not been getting back by the method, i.e., mismatch.

False rejection ratio = (mismatch/x)

iv. Retrieval score.

The retrieval score for one query image can be then calculated as.

Retrieval score = (1–[mismatch a+mismatch r]/x) × 100%

For sample DB of eight images [Figure 7] and the query image that we are going to search [Figure 8], what result the system will give, the effectiveness and accuracy can be measured with the help of search results [Figure 9] as under:

Recall = 4/4

Precision = 4/5

False acceptance ratio =1/5

False rejection ratio = 0

Retrieval score = 80%

Here, threshold = 2 MWF (predefined)

Cut off limit = ±2500 (predefined).

Discussion

This paper described the analysis of the human brain by magnetic resonance imaging (MRI) using CBIR.[20] For many decades, the brain is considered to be the most important and complex organ in the human body, as the whole functioning of the body is directed by the neural system of the brain.[21]

Brain associated disorders are highly common and frequently occurred in almost all communities across the globe.[22] However, the doctors and scientists are doing so much effort to reduced seriousness and provide a well-established solution, but as the human brain is so much sensitive and it is almost unknown for us so the outcome should not come in the proper way.

When our brain is injured, it can disturb various diverse things, containing recall of our memory, our awareness, and even our nature and behavior. Brain sicknesses contain any circumstances or incapacities that distress the patient's brain. Occasionally, doctors found that tumors developed in the brain and it could be extremely risky. Such kind of tumors is called primary brain tumors. On the other hand, cancer somewhere else in your body could spread and reach to our brain. Such kind of tumors is known as metastatic or secondary brain tumors. There are two types of brain tumors, malignant (cancerous), or benign (noncancerous). The brain tumors could be categories into the difficulty levels. Doctors set it from 1st to 4th level of difficulty. The bigger number shows that the more dangerous tumors. The reason for brain tumors is mostly unidentified. The people of any age could be infected by it. Signs of brain tumors may vary on the size and location of the tumor.[23] Neurodegenerative disorders cause your brain and nerves to weaken as time passes. They can change your personality and cause confusion. They may abolish the brain's tissue and nerves system of the brain. There are so many brain diseases, such as Alzheimer's disease and Parkinson's disease that can develop as your age growth. They can gradually weaken your memory and thought progressions.[24]
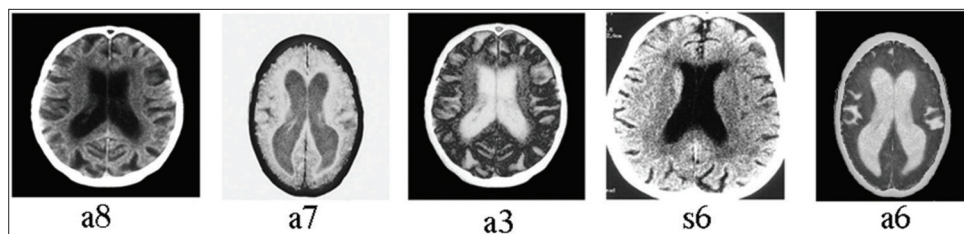
Figure 9: Search results

For this type of disorder, either to understand it or to diagnose it, MRI technique is very useful. MRI is the analytical technology that presently offers the highly delicate non-invasive way of imaging the spinal cord, brain, or other body areas.[25] It is the favorite imaging technique to help found analysis and to observe the course of the disorder. MRI has made it possible to envision and recognize much more clearly the underlying pathology of the disorder. Disparate a CT scan or established X-ray, MRI does not use radiation.[26] Instead of those technologies, the MRI uses strong magnetic fields and radio waves that produced the inside picture of a human body organ. It can also record the inside to measure the qualified water content in tissues both regular tissue and irregular in the body.

This anticipated method has been tested in a minor DB of CT scan brain images. Nowadays, we have much faster processors and cheap data storage but as the amount of images increases, complexity also increases. Various methods of producing medical CT scan images are discussed and examples of biological applications are also given. If the doctor wants to see inside a human body, a CT or CAT scan allows it very easily. It shows more detail than a regular X-ray and as it saves on a computer so it is very easy and convenient in future use. Still, in most of the hospital, doctors are using a traditional way to fetch out valuable information. In this technique, keywords are the main source of information retrieval. However, we have another kind of problem that is with our valuable data; keywords are having much more unusable data with them.

However, our technique will help the surgeon to find out what he wants and it must be well-polished information and well before in time. However, day by day engineering and technology going terribly fast and also the growth in not solely the facility of computation, not just for having a lot of-more storage however in no time. Hence, all these factors could make computing, even more, easier, and faster also.

Testing the correctness and effectiveness of the system evolved becomes more important when the system is going to be used in real-time and more when it is for humankind, i.e., medical diagnosis. Defining whether or not both images are alike, it totally depends on the prospect of the person who is observing those images. We have some challenges and we shall resolve it in near future. Some are:
- Precision is the issue by which the system gives back only related items
- False acceptance ratio is that by which accidentally system accepts irrelevant data
- False rejection ratio is that by which the system rejects some of the relevant data.

These are some issue that has to consider in the future for further investment of the algorithm, but all method or system must have all these listed issues. The refined system has a very nominal quantity of such an issue. As even this system should be implementing on a proper server or a desktop supercomputer, so we do not have to worry about how long it will take the giving result. However, the process is too complex and it takes time still we could get desirable results in distinguish time.

We can use indexing on brain images and other mathematical representations such as entropy, contrast, variance, sum average, difference variance, sum entropy, sum variance, difference entropy or a mixture of any of them to deal with this increasing complication.[27] This paper is the result of functional extraction and comparison, the setting of a cutoff limit and a threshold which is pretty promising. Image localization can also be added in the preprocessing part so that the system will emphasize on the consistent particular region of attention only and give more polished results.

Conclusions

The features such as data extraction and matching by the outcome of this process, setting cutoff limit and threshold are very promising. Further studies can be done apart from brain scans for a more generalized CBIR system. We show that our methodology is in a position to searching for brain scan images in an efficient way with precisely. The planned methodology is often used as an element in the real-time CAD or CBIR systems.

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