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Approaches of Artificial Intelligence in Biomedical Image Processing a Leading Tool Between Computer Vision & Biological Vision

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Abstract: **-- Artificial Intelligence or AI is a subfield of computer science, which can be defined as the intelligence exhibited by a machine or a software having a remarkable impact on the field of biology and medicine. Imaging, on the other hand has become an essential component of many fields in medicine, biomedical applications, biotechnology and laboratory research by which images are processed and analysed. Putting together AI and imaging, the tools and techniques of artificial intelligence are useful for solving many biomedical problems and using a computer based equipped hardware software application for understanding images, researchers and clinicians can enhance their ability to study, diagnose, monitor, understand and treat medical disorders. Therefore the main idea behind this research paper is to focus on understanding the artificial intelligence, its concepts and various models available for the segmentation(or classification) of medical images, its applications, advantages and disadvantages and results and more.**

Keywords**:— Artificial intelligence, fuzzy logic, medical imaging, medical tools, neural networks, segmentation methods.**

I. INTRODUCTION

Making natural or artificial systems intelligent by understanding the principles of computational intelligence is the main idea of AI. It is the study and design of an intelligent system that itself uses its tools and techniques and widens the chances of success. In terms of biomedical imaging, artificial intelligence develops and implements algorithms and strategies based on geometrical, statistical, physical, functional etc. models and then by using image datasets, it solves many types of problems like visualization, feature extraction, segmentation, image-guided surgery, texture, shape and motion measurements, computational anatomy (i.e. modelling normal anatomy and its variations), computational physiology (i.e. modelling organs and living systems for image analysis, simulation and training), telemedicine with medical images, etc. Due to increased growth of medical data volume on a daily basis, human mistakes in their manual analysis has also been increased which in turn demands to analyze them automatically. Therefore, usage of Artificial Intelligence (AI) techniques in medicine proves helpful here as it can store data, retrieves data and provides most desirable use of information analysis for decision making in solving problems. In healthcare system, treatment and diagnosis of disease is so important in medical imaging, that for such complex issues, algorithms of automatic medical image analysis are helpful in providing better and accurate understanding of medical images as well as their increasing reliability. Therefore using intelligent methods, accurate analysis and precise identification of biological features can be done[3]. Such AI methods include digital image processing and visualization and analysis of medical images in combination with methods like machine learning, fuzzy logic and pattern recognition.

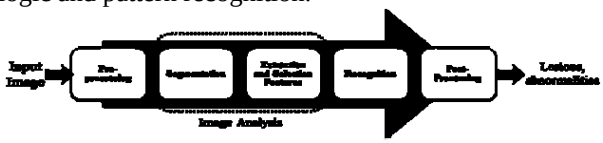

Fig. 1. Represents How An Image Is Processed And Analysed Using Several Techniques. (Automatic Medical Image Segmentation by Intelligent Methods)

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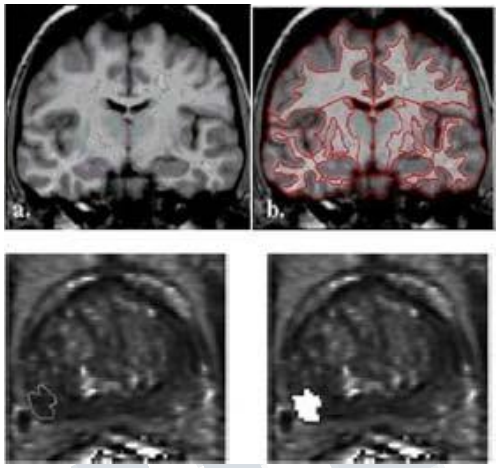
The above Fig.1 showing automatic medical image segmentation, many image processing techniques are needed. In the processing phase after the image is input, noise removal, image enhancement, edge detection etc. types of many pre-processing operations are carried out[8]. After these operations, analysis of the image is done. Then comes the segmentation phase where image mining is carried out using combination of intelligent methods. And finally, feature extraction process is done and sometimes feature selection is performed by which tumour, lesion, abnormality and so on is identified and recognized.

II. MEDICAL IMAGE SEGMENTATION (or CLASSIFICATION)

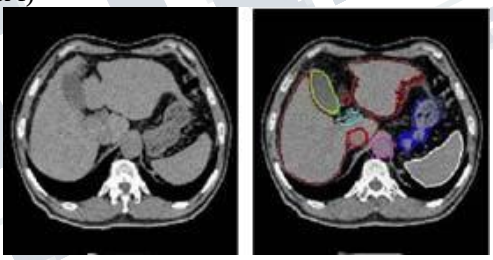
The main purpose of image segmentation is the division of an image into disjoint parts having a strong correlation with objects or areas of the real world. It is one of the most important steps in analysis of digital images. In diagnostic and teaching purposes in medicine, medical image classification plays an important role. Classification basically refers to assigning a physical object into one of a set of predefined categories. Image classification or segmentation can be done in many ways based on both grey-scale and colour image analysis; Textural analysis; Data Mining Techniques; Neural Network Classification etc.

By medical image analysis, information like volume measurement, description of anatomy structures by Reliable quantitative analysis of medical images is obtained. In later steps, other segmentation processes like feature extraction, image measurement and Region of interest representation are focused[8]. Then segmentation of Region of interest is correctly carried out by diagnosing features of disease or subsequent lesion in medical image analysis. But unfortunately this manual segmentation is too time-consuming and segmentation of many scans is not possible. Therefore, this makes intelligent tools so essential because using them segmentation is done automatically. Various artificial intelligence techniques such as artificial neural network and fuzzy logic are used for classification problems in the area of medical diagnosis.

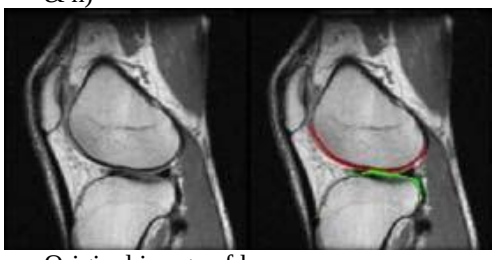


a) b) c) & d)

a) Original image of brain
b) Segmentation of brain parts
c) Original image of prostate
d) Segmentation of prostate tumors
e) & f)



e) Original image of abdomen
f) Segmentation of abdominal parts
g) & h)



g) Original image of knee
h) Segmentation of Femoral and Tibia Cartilngs

Fig. 2. Represents Differences Between The Original Image And Segmented Image of Various Body Parts. (Some Samples Of Several Segmentation)

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The Current Available Models For Image Segmentation Are:-

A. Image Segmentation Using Fuzzy Logic

Fuzzy Logic, initiated in 1965 by Prof.Lotfi A. Zadeh. is an organized method that deals with imprecise data[12]. Methodology- There are two different approaches of Fuzzy logic: Region-based segmentation, that is, classification by thresholding, in which sets of attributes, region growing, division and merging are being looked. The other is Contour- based segmentation, which is, looking for local discontinuities like derivatives operators, mathematical morphology, etc. These two approaches solve a dual problem, representing each region by its closed boundary, where each closed boundary describes a region[5]. A two-dimensional fuzzy image representing a real function is taken on each pixel coordinate having properties like brightness, texture, edginess are defined by membership function. The aim of contour based segmentation here is to detect fuzzy contour of objects that represent their mechanism and not the shape of contours[5]. On the other hand, the aim of region based segmentation is to use partitional clustering , region growing and data clustering(in hierarchical order)[3].

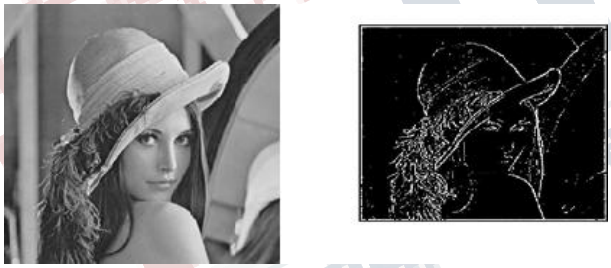

Fig. 3(a). Represents Edge Based Segmentation Performed On The Original Image(left) Giving Outcome Image After Segmentation(right). (Contour-Based Segmentation)

Fig. 3(b). Represents Image Segmentation On Region Based Technique On The Original Image(left) Producing The Resultant Image(right). (Region-Based Image Segmentation)

B. Image Segmentation Using Artificial Neural

Networks Artificial Neural Networks are nonlinear, nonparametric, and adaptive[2]. Artificial Neural Networks have successfully covered a wide variety of real world classification such as speech recognition, fault detection, medical diagnosis etc. Methodology- Using arbitrary accuracy, they can theoretically approximate any fundamental relationship[6]. Artificial Neural Network as a classifier is popular because it uses iterative training by which weights representing the solution are found. Its physical implementation structure is simple and complex class distributions can be easily mapped through it. Neural networks, uses supervised and unsupervised classification techniques. Also with the usage of 'Self Organizing Maps' of neural networks, cluster based medical image classification is done which is helpful in 'Computer Aided Diagnostic' decision making as well as in categorization[1]. The supervised classification in Artificial Neural Network can be achieved by using various methods like Bayesian Decision Theory, Linear Discrimnant Analysis, Support Vector Machine; each of them offering their unique techniques to carry out classification. Normally the data is divided into training and testing subsets performing classification of the image and validating results[1].

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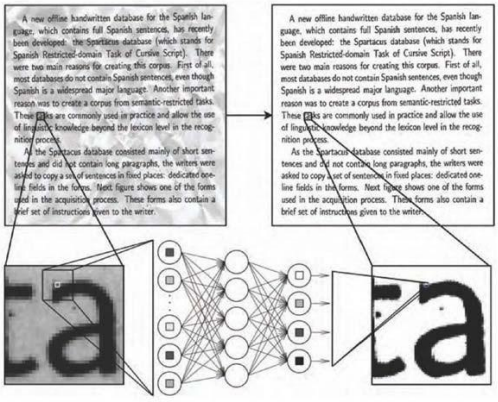

Fig. 4. Represents Enhanced Image Of A Particular Document Using Artificial Neural Network Where The Noise Scanning Is Done(on the enitre left image) & Cleared Image Is Obtained(right). (Image Segmentation Based On Artificial Neural Network)

C. Image Segmentation Using Textural Classification Applications covering Textural Classification can be, Industrial and Biomedical Surface Inspection (for example finding the defects and disease), ground classification and segmentation of satellite or aerial imagery, etc. Methodology- In texture classification, analysis is done based on texture of image by subcategorising it into four methods, viz. statistical, geometrical, and model-based and signal processing[1]. The process takes place as an unknown sample image is assigned to one of a set of known texture classes where a successful classification or segmentation requires an efficient description of the image texture. This technique being gigantically adaptable that it can be applied to virtually any modality of digital image[7].

Also, another concept of Wavelet transform is an important part of textural classification which enables evaluation of spatial frequencies at multiple scales by designing the wavelet functions[14]. For this spatial information of the image, 'Markov Random Fields' are very popular for their modelling of images. These models assume that the intensity at each pixel in the image depends on the intensities of only the neighbouring pixels.

The next process used in texture classification is Feature Selection and Feature Extraction techniques. The selection of feature is key factor required for a particular data set because the machine learning algorithm performs based on this statistical feature. The good the quality of feature, the best is the result obtained[9]. Similarly, extraction of a unique feature enables better classification performance[9]. It includes computing of intensity histogram features like Mean, Standard deviation, Energy, Entropy, Homogeneity[2]. It is widely used in applications like face detection, face recognition etc. by using image processing techniques.

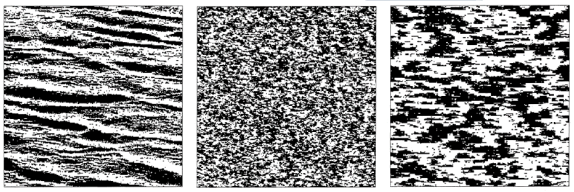

Fig. 5. Represents (a)Original Water Texture Image, (b)Image Of Synthesized Water Texture Using Markov Random Fields Modelling, (c) Image Of Synthesized Water Texture With Multiresolution Markov Random Fields Modelling. (Textural Based Analysis Segmentation Of An Image)

D. Image Segmentation Using Data Mining Technique

Being an interdisciplinary field, data mining brings together the techniques from machine learning, pattern recognition, statistics, databases and visualization addressing the issues of information extraction from large data bases. This technique can be used for preprocessing, extracting, analysis and segmentation areas.

Methodology- Using Data Mining technique of classification, a wider variety of data can be processed. It involves use of sophisticated data analysis tools that figures out the relationships in large data set including analysis and prediction of data[1]. For preprocessing purposes, cluster analysis can be used. The method by which data with similar characteristics can be grouped into larger units for analysis is known as Cluster analysis. The C-MEANS algorithm is the most popular non- hierarchical iterative clustering algorithm[1, 13].

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The other form of classification using data mining method is Association rule, in which image are generated by frequent tree pattern algorithm. These are Decision Tree Algorithm which are useful in decision support application, providing physicians with the better option to classify benign and malignant images by mining the data with association rules, hence making the diagnosis easy[13].

III. APPLICATIONS OF AI TECHNIQUES

In various fields like medical diagnosis, stock trading, robot control, law, remote sensing, scientific discovery and toys etc., artificial intelligence is widely used. AI applications are deeply embedded in the infrastructure of every industry.

A. In Computer Science

To solve all the major and complex problems in computer science, many AI tools have been invented in AI Laboratories. These include time sharing, interactive interpreters, Graphical User Interfaces and the computer mouse, the linked list data structure, automatic storage management, programming's like symbolic, functional, dynamic & Oops[10].

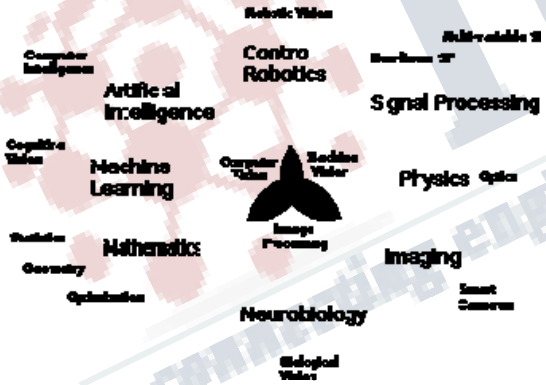

Fig. 6. Represents How A Computer Vision Is Interrelated To A Machine Vision Using All Other Fields In Image Processing. (Relationship Between Computer Vision And Other Fields)

B. Clinical Applications

Planning Surgery Of Brain And Skull Base- An improved understanding of the relationship among the lesion, adjacent critical structures, and possible approaches of surgical procedure is provided to the surgeon by registration procedure, that is, combining images of Magnetic Resonance Imaging and Computed Tomography of the head which results in quicker operations with less time and also provides better positioning of craniotomies as well as reduced craniotomy size[15].

Localizing Electrodes In The Brain- Implantation of electrodes over the surface of brain helps in locating diseases like epilepsy and it becomes easier to operate them. Other diseases like Parkinson's disease can be traced by implanting the electrodes in the subthalmic nucleus in patients to alleviate tumor[15].

C. In Health Care Industry

From organizing bed schedules, to making a staff rotation, and providing medical information including other important tasks in a medical clinic, Artificial Intelligence is used as such in the healthcare industry. Artificial Neural Network Systems are used as clinical decision support system. Techniques like Computer-aided interpretation of medical images are helpful in scanning digital images, e.g. from Computed Tomography to highlight conspicuous sections for tracing possible diseases like detecting a tumor. Heart sound analysis is one of the common uses of AI. Diseases like lung cancer and heart ailments can be early predicted using data mining techniques of AI[3].

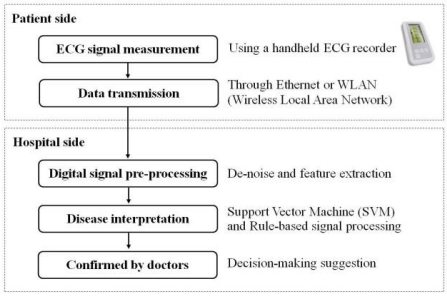

Fig. 7. Represents A Example Of An Intelligent System

Used By Patient Transmittimg Information On Its Own Using Less Time To The Healthcare Center. (An Intelligent System Through Which Information Is Automatically Transmitted At The Healthcare Center When A patient Uses A Single lead- ECG Recorder)

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D. Cloud and Medical Image Processing

Cloud computing has evolved a new computing model that has promising characteristics to help healthcare industry[4]. Medical Image Computing is an interconnecting field of disciplines like computer science, data science, electrical engineering, physics, mathematics and medicine. For solving problems related to medical images, extraction of information from the medical images that is clinically authentic and relevant is done and then various computational and mathematical methods are developed[10].

E. Other Major Applications

Finance, Heavy Industry, Telecommunication, Music, Aviation, Transportation, Toys and Games, News and publishing, Automation, Pattern Recognition etc. are some of the major fields where AI has been successfully implemented[10].

V. ADVANTAGES & DISADVANTAGES

Below are tabulated the several advantages and limitations of artificial intelligence methods.

Table 1: Pros & Cons Of Artificial Intelligence

Advantages	Disadvantages
1. Proves helpful in improving way of our life; faster than human. 2. Provides decision making capabilities and mental alertness. 3. Multi-tasking, i.e. Use of robots for heavy construction, personal assistance, companion to old people, military benefits etc. 4. Quick diagnose and possible solution to health issues. 5. There will be less stress to human brain and life and also less possibility of injuries. 6. New and exciting prospects for entertainment like gaming etc.	1. Only programmed work can be done. 2. Susceptible to higher forms of risks and critical threats, like malfunction may lead to the opposite of what work is programmed. 3. By making a system or device so intelligent, human jobs could be replaced. 4. Can be misused and lead to massive destruction. 5. Overdependence of younger generation on the technology, which may corrupt them.

VI. RELATED WORK

A lot of research work is going on in the field of image segmentation using AI tools and techniques from many years now. The detailed description of the findings and work done using various AI methods are summarized as follows[4]:

In year 2001, High Degree B-Spline Interpolation technique was used which improved the quality of images in medical images and served many benefits. Then in 2004, the technique called Wavelet Transform & Inverse Transform which served the purpose of Electrocardiography signal processing was used in clinical diagnosis. By 2007, Cellular Automata Algorithms were used which determined hypothesis spots of breast cancer leading to diagnosis of breast cancer.

In 2008, Denoising and Contour Extraction Algorithm was used that lead to medical image analysis, image enhancement, image smoothing, feature extraction and image reconstruction. In the same year, Distributed System for medical request processing was implemented that helped physicians to have diagnostic requests remotely. Temporal Recursive Self Adaptive Filter as well as Shape –Preserved Fitting was implemented for the pre-processing of the medical images and X-Ray images improving the quality of scanned images , later in the same year[4].

Finally by the end of 2008, Contourlet Transform was developed which was better than wavelet transform and it helped in time frequency localization & multi scale analysis. In 2009, Interactive Image Processing technique was used which was user friendly assisting diagnostics and was clinically useful. To serve the purpose of medical image registration, in the same year, Mixed Type Registration Approach was developed that increased the speed of registration and provided accuracy. In the same year again, Wavelet Edge Detection & Segmentation was found for quantitative coronary analysis which helped in diagnosis of heart ailments.

In the year 2010, Embedded 3D Medical Image Processing was developed that was used in tomographic imaging and visualization. In 2011, Cloud Service for BL Sharing was developed which due to its consistency, interoperability and security provided sharing access to the applications of BL medical image processing[4]. One most remarkable work of this approach is the very renowned Prof. Stephen Hawking, who is the living example of using an artificial intelligence system.

VII. CONCLUSION & FUTURE SCOPE

Result: To conclude, we would say that this journal paper focuses on Artificial Intelligence & Its Approaches in Biomedical Image Processing and insights on the working and understanding of the

concepts of AI and how a medical image is segmented using several models. The models presented are introduced, described and what methods of classification are used by them is also presented along with the better understanding of their methodology. Each model is also represented in terms of example figure for their proper understanding. And the conclusion is driven. These models are not defined in-depth as the paper concerns on literature review and not on deep defining of models. Apart from the above mentioned models, there are several other methods like Gaussian Filters & Gabor Filter in Artificial Neural Network Analysis; Clustering Techniques in Data Mining etc. for image segmentation. Radiologists can easily diagnose cancers, heart disease, tumors and muscular skeletal disorders more accurately by using special AI techniques in medical imaging analysis tools[8].

Future Vision: Recent advances in the techniques of AI mentioned in the paper like image processing, machine learning, fuzzy logic, neural networking has driven better enhancement of diagnosis information by computer[11]. Image segmentation and classification algorithms have achieved and are expected to keep gaining these features like robustness, repeatability, least dependency on operator, reliability and accuracy etc. Many brain inspired projects like Blue Brain, Google Brain, aHuman Project are some of the specialized on-going projects in the artificial intelligence field. Merging science and mathematics together has always lead to innovative advancements in the medical industry and the most notable advancements using AI technology are seen in biomedical research and medicines which have raised the hopes of society at another level. It has much more to offer in the coming years provided required support and sufficient funding is made available.

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