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Relevance of Artificial Intelligence in Medical Laboratory Science with Emphasis on Histopathology Specialty

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Summary

The act of creating machines that carry out functions requiring intelligence performed by humans is often known as artificial intelligence (AI). When the act is replicated in Medicine and especially in the current day histopathology practice, then it is termed as artificial intelligence in Medicine as it relates to medical practice and or histopathology. In this paper, we reviewed and discussed numerous works that have been done relating to Artificial Intelligence in Medical Laboratory Science with an emphasis in the field of histopathology. The aim of this article is to discuss the relevance of artificial intelligence in Medical Laboratory Science and its particular usefulness to the Medical Laboratory Scientists and Pathologists in histopathology sub unit / departments in Nigeria. Another goal was to deduce specifically a method in artificial intelligence, which is best suitable for a pathological diagnosis in tissues. Relevant literature from MEDLINE and PubMed indexed journals were searched electronically with the keywords: AIM, ANFIS, CANFIS, MANFIS, Neural Network and histopathology. The searches were limited to articles in the English language, and the items describing AIM as it relates to histopathology and Medical Laboratory Science were collected and reviewed concisely. Studies, however, showed that AI has reportedly been used for different tumor diagnosis in the field of histopathology, which helps in the accuracy of the final output. Unlike other areas of business and engineering, in which the programming methods are purely statistical and probabilistic compared to the medical AI in which the input factors are based on clinical

manifestations. We, however, advocate for the proper integration of Artificial Intelligence in Medical Laboratory Science especially in histopathology practice, which will assist in making a rapid, accurate and valid diagnosis.

Keywords: *Artificial Intelligence, Artificial Neural Network, Medical Laboratory Science*

Introduction

Artificial intelligence is defined as "the science and engineering of making intelligent machines" to work as if they were humans (Kalev, 2014). However, the concept of an artificial Intelligence (AI) has been defined by different individuals, which include: a branch of computer science that deals with the intelligence of machines where an intelligent agent is a system that takes actions, which maximize its chances of success (Dean and Desh, 2014). It has also been defined as the act of creating machines that perform functions that require intelligence when performed by humans (Gabriel, 2014). Over time computer scientists have dreamed about creating an 'electronic brain, which could assist in performing tasks that ordinarily may be difficult for an individual to perform (Gabriel, 2014). In the early 21st century, AI was utilized for logistics, data mining, medical diagnosis and other areas (Simon, 2015). The success was due to increasing computational power (), greater emphasis on solving specific problems, new ties between Artificial Intelligence (AI) and other fields and a commitment by researchers to mathematical methods and scientific standards (Russell and Norvig, 2009). With such motivations, a small but talented community of

computer scientists and healthcare professionals set about shaping a research program for a new discipline called Artificial Intelligence in Medicine (AIM) (Patel *et al.*, 2008). These researchers had a bold vision of the way AIM would revolutionize medicine, and push forward the frontiers of technology (Rajendra, 2014). One of the most important tasks now facing developers of AI-based systems is to characterize accurately those aspects of medical practice that are best suited to the introduction of artificial intelligence system (Rajendra, 2014). The central principles of AI include reasoning, knowledge, planning, learning, communication, perception and the ability to move and manipulate objects (Abhishek *et al.*, 2015). Thus, the object of research in artificial intelligence (AI) is to discover how to program a computer to perform the remarkable functions that make up human intelligence, in which this aspect is our primary focus. The aim of this article is to articulate the relevance of artificial intelligence in Medical Laboratory Science and its particular usefulness to the Medical Laboratory Scientists and Pathologists in histopathology in Nigeria. Another goal is to deduce a specific method in artificial intelligence, which is best suitable for pathological detection in tissues.

Understanding Artificial Intelligence

Artificial Intelligence has been grouped into categories based on the patterns and methods. The categories according to the patterns are Expert systems, intelligent systems (Agent), Genetic Algorithms and Artificial Neural Network (ANN). The categories according to the methods are Conventional Artificial Intelligence and Computational Intelligence; where the former involves symbolic signs, the latter deals majorly on development and learning. Conventional Artificial Intelligence: Expert Systems, Case-based reasoning, Bayesian networks, and Behavioral based Artificial Intelligence while, the Computational Intelligence deals with Neural Networks, Fuzzy Systems, and Evolutionary Computation (Ammaarah, 2015; Kanchan and Vikas, 2014; Robin, 2010).

- An expert system is a computer program

that simulates the judgment and behavior of a human that has expert knowledge and experience in a particular field. These programs mimic the reasoning process that an expert would follow when solving difficult problems in a particular area. This intelligent system gives advice to individuals (Robin, 2010).

- Genetic Algorithm- A search procedure that is based upon the mechanics of natural selection and genetics, that seeks to continually produce better solutions to a problem (Kanchan and Vikas, 2014).
- Intelligent Agent- A program that gathers information or performs a service without a user's immediate presence and on a regular schedule (e.g. an alarm system). An agent program, using specifications that the user has provided it with, searches all or certain parts of the Internet, gathers information the user would be interested in and presents the information on a periodic basis (Ammaarah, 2015).
- Artificial Neural Network- is a computer model that tries to copy a biological neural model of the human brain. It is an adaptive model that is structured to function in the same way that a human brain would even in a multitasking event (Graham, 2015). The categories mentioned above will be appropriately discussed in the literature review as well as an application (field) of artificial intelligence known as hybridization. Hybridization will be briefly discussed because it gives rise to the following subcategories of Artificial Intelligence like Adaptive Neuro-Fuzzy Inference System (ANFIS), Coactive Adaptive Neuro-Fuzzy Inference System (CANFIS), Multiple Adaptive Neuro-Fuzzy Inference System (MANFIS) and Fast Adaptive Neuro-Fuzzy Inference System (FANFIS) (Sourabh, 2013). The subcategories are combinations of both artificial neural network and fuzzy logic systems (Pegman and Ardeshir, 2012). In the field of Histopathology, ANFIS has reportedly been used for different tumor diagnosis with the ultimate goal of applying

such a system to getting rid of imprecise information and to avoid the ambiguity of results (Minakshi and Sourabh, 2010). Unlike other fields such as business and engineering, in which the programming methods are purely statistical and probabilistic methods, medical AI programs are based on symbolic models of disease entities and their relationship to patient factors and clinical manifestations (Mohammad *et al.*, 2015).

Many intelligent systems have been developed for the purpose of enhancing health care and provide better health care facilities, reduce cost and reduce time consumption like the design of pattern recognition system for the diagnosis of gonorrhoea as well as medical expert system for ECG diagnosis (Umoh *et al.*, 2012; Bourlas *et al.*, 1999). The intelligent system was developed to assist users (particularly doctors) to aid patient's diagnosis and prediction in preventing serious illness. Even though the system is equipped with "human" knowledge, the system will never replace human expertise as human are required to frequently monitor and update the system's knowledge to ensure system validity (Umoh *et al.*, 2012).

Relevance in Medical Laboratory Science

In Medical Laboratory Science practice, there are different areas of specialization and sub-specialties. In clinical chemistry, artificial neural network (ANN) has been proven to be useful in the analysis of blood and urine samples of diabetic patients (Fernandez *et al.*, 2010). In microbiology, studies have shown the use of artificial intelligence in the diagnosis of tuberculosis (Elveren and Yumuşak, 2011). In haematology, the artificial neural was used as a diagnostic tool for leukaemia classification while in immunology, artificial intelligence based expert system has been utilized for the diagnosis of hepatitis B (Dakshata and Seema, 2011).

Emphasis on Histopathological Specialty

Medical Laboratory Scientists and Pathologists have been widely diagnosing diseases in the same way and for the past decades by manually reviewing images through a microscope. New

works suggest that computers can help doctors improve accuracy and significantly change the way a scientist diagnoses cancer and other diseases (Nasser *et al.*, 2010). A research team headed by Keith (2016), studied artificial intelligence as it achieves near-human performance in diagnosing breast cancer, which was aimed at developing artificial intelligence (AI) methods used in the training of computers to interpret pathology images, with the long-term goal of building AI-powered systems to make pathologic diagnoses more accurate. The both research teams called this approach the Beck lab's approach. They reported in their studies that the accuracy of humans in diagnosing breast cancer was 96% while that of their artificial intelligent approach was 92%. They also reported that when the both methods were combined, the level of accuracy gave 99.5% which left them with the conclusion that combining both approaches together yielded a greater reduction in error and would also lead to a more precise and clinically valuable diagnosis to guide treatment decision (Keith, 2016). This approach teaches machines to interpret the complex patterns and structure observed in real-life data by building multi-layer artificial neural networks, in a process which is thought to show similarities with the learning process that occurs in layers of neurons in the brain's neo-cortex (Keith, 2016). The Beck lab's approach was recently put to the test in a competition held at the annual meeting of the International Symposium on Biomedical Imaging (ISBI), which involved examining images of lymph nodes to decide whether or not they contained breast cancer. The Beck labs approach came out first in two separate categories. Keith (2016) reported in this method that slides containing lymph nodes were given to researchers to determine whether or not they contained cancer, the team's automated diagnostic method proved accurate approximately 92 percent which was close to human accuracy (96 percent) of the time. The team trained the computer to distinguish between cancerous tumor regions and normal regions based on a deep multilayer computational network. The automated diagnostic method was trained several times with more complex images (slides), which improved the performance of the computer. The

researchers however, revealed that when they combined the pathologist's analysis with their automated computational diagnostic method, the result improved to 99.5 percent accuracy, which is in line with the improvement of breast cancer diagnosis worldwide.

In another development, Bekaddour and Chikh, (2012) in their study on a neuro-fuzzy inference model for breast cancer recognition with the aim of recognizing breast cancers, reported that ANFIS model was able to recognize cancerous cases accurately with approximately 98.25% of the testing dataset. They, however, concluded that a method is an important tool, which can be integrated into a computer-aided diagnosis (CAD) for assisting in diagnostic decision making, thereby, providing an understandable explanation of the underlying reasoning. We can say that the used method is a very promising approach in medical data recognition, which is a breakthrough in aiding histopathological diagnosis of breast cancers.

Bhattacharya and Das (2010); developed a treatment planning system by implementing genetic-based neuro-fuzzy approaches for accurate analysis of shape and margin of tumor masses appearing in the breast using digital mammogram. In the proposed methodology, Genetic Algorithm (GA) has been used for searching effective input feature vectors combined with the adaptive neuro-fuzzy model for final classification of different boundaries of tumor masses. Das and Bhattacharya (2008); also revealed that the boundary-based features of the tumor lesions appearing in the breast had been extracted for classification. The shape features represented by Fourier descriptors introduce a significant number of feature vectors. Therefore, GA has been used as a feature selection step to select significant input feature vectors. Fernandes *et al.* (2010) further suggests that the following steps are applied as the pre-processing part to enable a complete understanding on how GA performs: Region of Interest (ROI) extraction, image background removal, image contrast enhancement and noise reduction. In the next step, the features that are extracted from the final image are entropy, energy, and homogeneity. Das and Bhattacharya

(2008) described the shape and texture-based features that have been considered earlier. While the radius, texture, perimeter, area, smoothness, compactness, concavity, hollow points, symmetry and fractal dimension of breast mass were used in a later study (Al-Daoud, 2010).

In a similar study by Übeyli (2009), in which ANFIS was used for automatic detection of breast cancer, the attribute descriptors are clamp thickness, uniformity of cell size, uniformity of cell shape, marginal adhesion, single epithelial cell size, bare nuclei, bland chromatin, normal nucleoli, and mitoses. Again, Bhattacharya and Das (2009) stated that the suspicious locations of the breast masses are specified by the radiologists, and then masses are accurately segmented using the fuzzy c-means clustering technique. Fourier descriptors are utilized for the extraction of shape features of mammographic masses. These shape features along with the texture features are fed to the input of the ANFIS classifier for determination of the masses as benign, lobular or malignant.

Relevant Areas Where AI Has Been Successfully Utilized

Sanoob *et al.* (2016); designed a framework for the diagnosis of pancreatic cancer using the artificial neural network. Their aim was to use the model in the diagnosis of pancreatic cancer and thus, reported that the new Artificial Neural Network (ANN) methodology was able to distinguish between affected and non-affected Pancreatic Cancer patients based on specified symptoms and concluded that early detection and precise diagnosis could be accurately achieved using Artificial Neural Network (ANN). Sanoob *et al.* (2016) further stated that the detection of cancer in the pancreatic cells at its early stage is necessary for better treatment and cure. Hence, it is important to detect pancreatic cancer automatically to mitigate the real-world medical problems. In addition, Scheipers *et al.* (2003) used neuro-fuzzy classification systems to diagnose prostate cancer in high images, which proved to be a new regime for prostate diagnostics based on multi-feature tissue characterization with ultrasonic imaging and allows the detection of tumor at an early stage.

Odigie *et al.* (2016), premeditated on a model framework for cervical lesions (CL) diagnosis using the adaptive neuro-fuzzy inference systems (ANFIS) with the aim of formulating a model that is understandable, practicable and able to predict correctly and assess the accuracy of the ANFIS model. The report has it that ANFIS model was able to classify approximately 98.75% of the testing dataset accurately. In the formulated model, the cervical lesion was screened amongst the commercial sex workers in the state. The result showed that ANFIS model could adequately serve as an alternative for histopathology diagnosis in the medical settings. They further concluded that ANFIS framework for cervical lesion diagnosis has an excellent accuracy for predicting a diagnosis of the cervical lesion. Again, relevant studies using ANFIS have been conducted specifically to automate both the Pap smear and the LBC classification based on artificial intelligence (Jusman *et al.*, 2012). In the case of CL, which is similar to the cervical cancer ANFIS classifier, the classification requires CL features to be determined manually by human experts from the Pap smear and pre-clinical data or LBC images as input data (Mustafa *et al.*, 2008). However, the automated diagnostic systems may not only reduce the time required for cancer screening but may lessen the misdiagnosis by the pathologist due to eye fatigue or human errors and even negligence.

Akgundogdu *et al.*, (2010); used ANFIS for diagnosing osteoporosis by using intelligence systems, the authors have developed various image processing and simulation techniques to investigate bone micro-architecture and its mechanical stiffness. Morphological, topological and mechanical bone features are evaluated using the hybrid skeleton graph analysis (HSGA) method. HSGA relies on a new hybrid skeletonization process that contains morphological, topological and volumetric information. Accordingly, several properties can be measured, including volume, section, and thickness of each element as well as global features such as rod/plate proportion or anisotropy. The features extracted by this technique contain significant topological and morphological information. The use of the

HSGA with finite element analysis allows the extraction of mechanical features, which are the input vector of classification.

A similar method in feature extraction approach was used by Bhattacharya and Das (2010); Das and Bhattacharya (2008) suggesting that Fourier descriptors are used for accurate extraction of boundary feature of the tumor region. However, these features introduce a significant number of feature vectors that may cause the problem of over learning or misclassification. Accordingly, these works are followed by GA as a feature selection step, in which GA develops an efficient searching algorithm to combine the features that are too few with the significant ones that are capable of representing that particular class. Hemanth *et al.* (2009); suggests other kinds of functions that are applied for brain tumor detection. The features such as contrast, inverse difference moment, correlation, variance, energy, and entropy are used (Hemanth *et al.* 2009). Before the above, Basri (2008) used the principal component analysis (PCA) as a feature extraction algorithm for brain tumor classification with the aid of ANFIS. PCA is one of the most successful techniques that have been used in image recognition and comparison. The picture in this work is brain magnetic resonance image (Hosseini and Zekri, 2012).

Odeh (2010) used ANFIS for skin cancer detection, before applying the ANFIS classification methodology, the feature selection step is necessary because there are an enormous number of features and only a few of them are relevant for the prediction. Feature selection is the task of choosing a small set out of a given set of features that capture the relevant properties of the data. The need for feature selection arises to avoid the presence of a vast number of weakly related and redundant features in the data set. A good choice of features is the key to building compact and accurate classifiers. The feature selection part that is used by Odeh (2010) is the Greedy feature flip algorithm (G-flip) for skin cancer diagnosis. G-flip is a greedy search algorithm for maximizing the evaluation function (F), where F is a set of features. The algorithm repeatedly iterates the feature set and updates the set of chosen features. After applying

the G-flip algorithm, relevant features are presented and fed into the ANFIS classifier.

Huang *et al.* (2007) used glaucoma detection by ANFIS model, the feature extraction part consists of the following steps: at first, the measurements of the glaucoma variable (retinal nerve fiber layer thickness and optic nerve head topology) are obtained by Stratus optical coherence tomography. Then, in the feature extraction part, the orthogonal array is used to detect glaucoma eye from the normal one. Another method of feature extraction was introduced by Acharya *et al.* (2006) for detecting eye diseases by using intelligent systems for diagnosis.

Conclusion

Artificial Intelligence in Medical Laboratory Science will eliminate the presence of errors due to eye fatigue, reduce cost and time required for complex laboratory diagnosis, while, the Adaptive Neuro-fuzzy Inference System (ANFIS) from this review will be best used for histopathology examinations. However, we recommend that histopathology diagnosis by microscopy is necessary to complement artificial models.

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