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A survey on artificial intelligence based techniques for diagnosis of hepatitis variants

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ABSTRACT

Hepatitis is a dreaded disease that has taken the lives of so many people over the recent past years. The research survey shows that hepatitis viral disease has five major variants referred to as Hepatitis A, B, C, D, and E. Scholars over the years have tried to find an alternative diagnostic means for hepatitis disease using artificial intelligence (AI) techniques in order to save lives. This study extensively reviewed 37 papers on AI based techniques for diagnosing core hepatitis viral disease. Results showed that Hepatitis B (30%) and C (3%) were the only types of hepatitis the AI-based techniques were used to diagnose and properly classified out of the five major types, while (67%) of the paper reviewed diagnosed hepatitis disease based on the different AI based approach but were not classified into any of the five major types. Results from the study also revealed that 18 out of the 37 papers reviewed used hybrid approach, while the remaining 19 used single AI based approach. This shows no significance in terms of technique usage in modeling intelligence into application. This study reveals furthermore a serious gap in knowledge in terms of single hepatitis type prediction or diagnosis in all the papers considered, and recommends that the future road map should be in the aspect of integrating the major hepatitis variants into a single predictive model using effective intelligent machine learning techniques in order to reduce cost of diagnosis and quick treatment of patients.

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1. Introduction

Hepatitis is a soreness of the liver tissue. The term *hepatitis* originates from the Greek words: *hêpar* (ἧπαρ), which means "liver"; and *-itis* (-ῖτις), connoting "inflammation" [1]. Though some persons with hepatitis may not show signs or symptoms, some may develop symptoms like yellow staining of the skin and whites of the eyes, poor desire for food, diarrhea, abdominal pain, vomiting and tiredness. Hepatitis disease could be serious if it is not resolved within the first six months; perhaps, delicate if it exceeds six months. The delicate case could steps forward to never-ending hepatitis, leading to liver malfunction, malignant cells and heightened liver failure [2].

Hepatitis variants are majorly of five (5) different types namely Hepatitis A, B, C, D, and E, usually caused by virus [3]. However, heavy alcohol usage, toxins, autoimmune diseases, non-alcoholic steato hepatitis (NASH) and infections can cause the

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disease. Hepatitis A and Hepatitis E mostly spread by infected water and food while Hepatitis B is primarily transferred through body fluids; either sexually transferred, from mothers to babies at childbirth (during pregnancy) or through blood transfusion, as in hepatitis C where contaminated instrument like needles and sharp objects, can spread the disease. The five different types of hepatitis viruses have the capability to cause severe disease, but the maximum numbers of deaths all over the world are as a result from chronic hepatitis virus B or hepatitis C disease contamination [4].

According to [5] about 33% of the world population have hepatitis B disease; between 300 - 400 millions of people also have chronic hepatitis B. Hepatitis B is extremely endemic and most likely affects a likely rate of 5 – 8% of the entire populace in Africa [6]. Nevertheless, it is anticipated that about 19 million adults are infected with the chronic hepatitis C in the Central and West Africa [4]. Hepatitis D can be transmitted only to persons infected with Hepatitis B. Apart from hepatitis C and E, other variants are avertable with immunization. In the case of unrelieved viral hepatitis, antiviral medications are normally suggested except in situation, which limit the life expectancy of the patient. A healthy diet, physical activity and weight loss are suggested for NASH. A liver transplant sometimes are suggested for both heightened and never-ending liver failure. It is worth mentioning that a patient should consult specialists at the early stage for further diagnosis and treatment, and the use of artificial intelligence for diagnosis of the disease could be essential [7].

The main purpose of this survey is to consult widely from published literatures about the concept of the dreaded hepatitis disease, it's variants and infection modes and more especially how computers based on the concept of artificial intelligence has helped in providing alternative and fast means of probing and prognosis of the dreaded diseases based on the comments and recommendation in [7].

2. Literature Review

The concept of artificial intelligence (AI) was first devised by John McCarthy during the mid-fifties in a conference at Dartmouth College [8]. Artificial intelligence describes the ability of a machine or artefact to perform similar kinds of functions that characterize human thought [9]. It is a kind of intelligence designed, development and deployed to machines that enables them reason correctly in order to handle more complex and imprecise task autonomously that ordinary would have required the intervention of human beings. AI is a rapidly growing tool that can overcome most of the limitations of the traditional-based techniques [10]. Machine leaning, natural language processing, knowledge representation, reasoning, etc., are central problem areas of AI [11], [12]. Some AI techniques such as fuzzy logic (FL), artificial neural networks (ANN), rule based expert system (RBES), genetic algorithm (GA), case based reasoning (CBR), soft computing (SC) and hybrid systems, have been used to model intelligence in medical diagnostic applications [7], [13] and it has formed new research area for computer scientist [14].

2.1. Fuzzy Logic

Fuzzy Logic (FL), an AI technique addresses uncertainty in knowledge and can be used to simulate human cognitive thought processes for example reasoning and thinking [11]. According to [15], FL prototype was intellectualized by L. A. Zadeh in 1965, but it took extra nine years for it to become extensively acknowledged [16]. Fig. 1 shows the FL system, comprising four major parts: fuzzifiier module, knowledge base, inference engine, and defuzzification module [17].

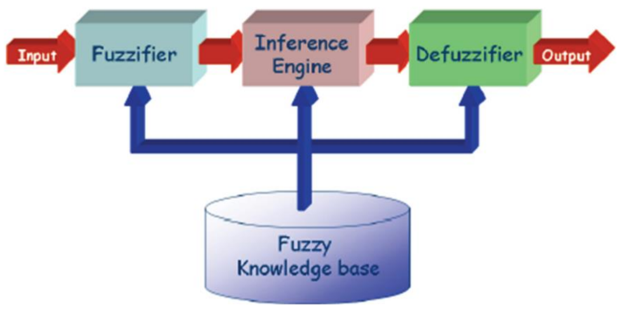

Fig. 1 Fuzzy logic system [17]

Despite the fact that FL reasons on a higher level using linguistic variables like that of humans, it still has concerns arising from the inability to learn properly, though appreciably good in other areas like imprecision tolerance, explanation ability and knowledge representation [13]. Several researchers have recently used the concept of FL to model intelligence into medical applications for diagnosis of ailments such as Lassa fever [18], [19], Lung Cancer [20], Hepatitis B [21]-[23], Typhoid Fever [24], HIV [25], Back pain [26], Arthritis [27], Breast Cancer [28], Diabetes [29], [30], Pelvic Inflammatory Disease [31], Leprosy [32], Multi-Fever [33], Medical Diagnosis [34], Diseases classifier [35], Asthma and Chronic Obstructive Pulmonary Disease [36]-[38], Prostate cancer [39], Peptic Ulcer [40], Multiple Sclerosis [41], Gonorrhea [42], Enteric Fever [43], Cat Anal Gland Cancer [44].

2.2. Expert System

Expert System (ES) as a subdivision of AI utilizes human knowledge to resolve issues that involves human's proficiency; though most ES developed before now utilizes specialized software called shells, recent ES uses strictly rule-based and other AI based techniques. The rule-based expert systems uses rules to represent the expert knowledge and these rules are always called upon whenever they are needed to resolve issues, though it has challenges such as ineffective search system, imprecision acceptance, flexibility, knowledge breakthrough a well as its lack of capacity to learn [13]. Long-established rule-based expert systems are being utilized globally to diagnose medical conditions such as malaria and typhoid [45], fever [46], viral infection [47], influenza [48], memory loss disease [49], Lassa fever [50], [51], dengue fever [52], blood testing [53], and human diseases [54]-[55]. ES will continue to advance for unambiguous utilizations in medical diagnosis owing to invasion of novel and enormous information, which makes experts to be dedicated [56].

2.3. Artificial Neural Networks

Artificial neural networks (ANN) are non-algorithmic approach for processing information that is motivated by biological neurons systems [57]. There are no less than 100 billion interconnected neurons in the human brain meant for reading and processing of sensory input data in the human senses. ANN is a low level computational makeup that learns using supervise, unsupervised and reinforcement learning techniques. In recent times, the ANN has been classified as a significant part of AI due to the initiation of the back-propagation algorithm that facilitates the adjustment of network hidden layers of neurons under supervised network training [58]. As a significant tool in machine learning, can be utilized for medical diagnosis. According to [59] ANN is very good for example in areas like knowledge recovery, learning, imprecision tolerance, maintainability and adaptability. Fig. 2 depicts a single perception or neuron consisting of three major layers: input, hidden and output. The first layer receives the input signals, which propagate through the hidden (middle) layer with final results at the output layer.

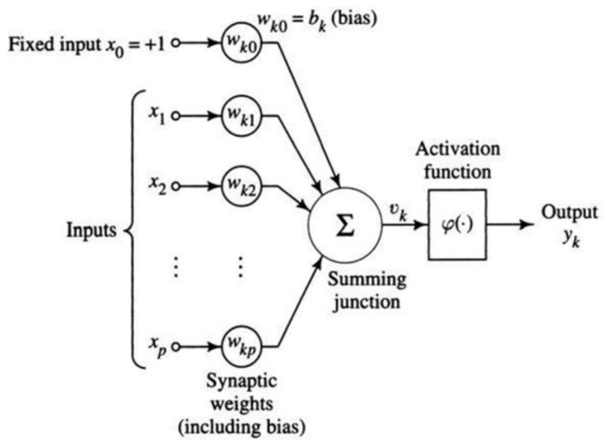

Fig. 2 Non-linear model of a neuron [17]

The concept of ANN has also been used by different researchers to model complex intelligence into applications for medical probing and prognosis such as Glomerulonephritis [60], Hepatitis B and C diagnosis [61]–[68].

2.4. Genetic algorithm

Genetic algorithm (GA) is merely a search tool that is based on the principle of survival of the fittest [11] that enables biological class to get used to its surroundings in order to compete efficiently for resources. The essential thought of GA is to uphold population of chromosomes; representing candidate solutions to a particular problem, which will change more than a period through contest and restricted deviation [69]. GA is tough and potent in complicated situations where the space is frequently huge, sporadic, multifaceted and inadequately unspoken. GA has been functional in an extensive variety of difficulty areas, though it immediately guarantees a satisfactory solution in a rapid manner, perhaps, not a global best possible resolution to a given problem.

Basic operations of the GA is illustrated in Fig. 3. The power of GA has been combined with other AI techniques by some researchers to proffer diagnostic solution to some medical conditions such as tuberculosis [6], [70], Nurse rostering problem [71] and diabetes mellitus [72].

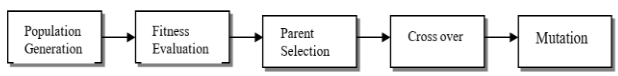

Fig. 3 Basic operations of genetic algorithm [11]

2.5. Neuro-Fuzzy Hybrid Systems

Hybrid systems can be referred to as the integration of the weaknesses and the strengths of two or more techniques to resolve a common drawback in order to yield a better result or performance. The complex nature of ANN and fuzzy logic have been hybridized for the purpose of finding better solutions to problems in fault diagnosis, predictive analysis, health diagnosis, etc. [73].

Consequently, many computer scientist / researchers have bond the design of fuzzy logic with neural network to form a hybrid system referred to as neuro-fuzzy model (Fig. 4) in order to diagnose different medical ailment such as Lassa fever [13], cells classification either as cancerous or non-cancerous [17], lung disease [74], breast cancer [75], tuberculosis [76]-[78], thyroid diseases [79], heart disease diagnosis [80], multiple sclerosis [81], diagnosis of Ebola hemorrhagic fever [82], monkey pox diseases [83], disease diagnosis [84], leukemia [85], bipolar disorder [86], Alzheimer [87], malaria [88], colon cancer [89], thyroid disorder [90], and autism recognition [91].

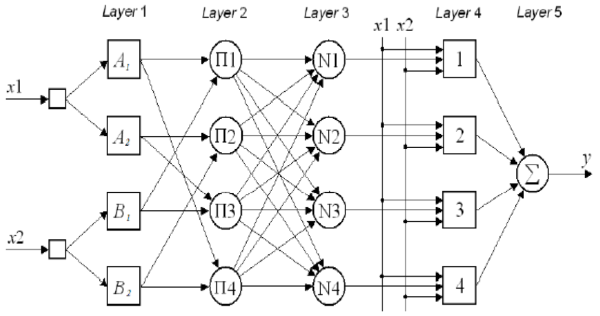

Fig. 4 Schematic of an adaptive neuro-fuzzy model [92]

2.6. Case Based Reasoning

According to [13] the Case Based Reasoning (CBR) relies strongly on the procedure of reasoning by similarity in order to resolve a novel problem; the set of procedures are as follows: (i) there is a new problem, how can it be solved?; (ii) evaluate the new problem to all the problems scenarios that has been solved in the past, in order to determine which scenario the new problem bear a resemblance to the most; (iii) reprocess the solution of the most alike previous problem by changing it to get an answer for the current problem; and (iv) lastly, store the current problem and its solution as a reference purpose for resolving future problems. The Euclidean distance nearest neighbor algorithm is one of the many algorithms that can be used to design CBR intelligence in solving problems as structured in Fig. 5.

2.7. Soft Computing

The term soft computing (SC) was introduced by L. A. Zadeh, the inventor of FL, who described SC as a collection of methods aimed to utilize the tolerance for imprecision and uncertainty in order to achieve a low cost solution with robustness and tractability. The main components of SC are neuro computing, fuzzy Logic and probabilistic reasoning. It should be noted that the role model of SC is the human mind. A typical structure of SC model is depicted in Fig. 6.

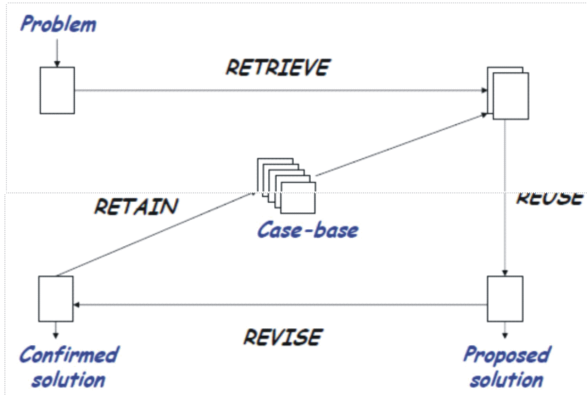

Fig. 5 Structure of a case based reasoning system [13]

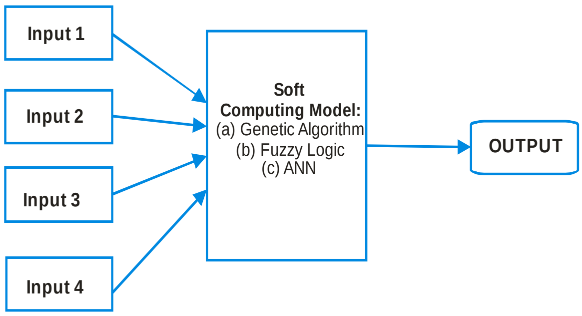

Fig. 6 A typical structure of soft computing model

Characteristics of soft computing are that (a) it does not requires any mathematical modeling of problem solving; (b) it may not yield the precise solution; (c) the algorithms are adaptive i.e., it can adjust to the change of dynamic environment; and (d) it uses some biological inspired methodologies such as genetics, evolutionary computing, ant colony, particle swarming, human nervous system, etc.

Recently, research scholars in the field of computational intelligence have also used soft computing approach to diagnose different medical conditions such as Tuberculosis [11], [70], [93], Stroke [94], Diabetes Mellitus [72], [95], Medical Diagnosis [96], Disease Diagnosis [97], Glaucoma Disease [98], Childhood Autism [99], Common Skin Diseases [100], Image Diagnosis [101]. However, the usage of AI techniques for medical diagnosis generally and prognosis and probing of Hepatitis in particular has highly increased. Early treatment of patients with diseases can lead to effective control if the disease is detected early [7].

A summary of the core related works done on hepatitis detection and classification using artificial intelligence based techniques is presented in a tabular format.

Table 1 Summary of related works done on general hepatitis disease diagnosis (Unclassified)

Author	Techniques	Strengths	Weaknesses
Henok [3] Kh et al. [64] Ansari et al. [68] Ozyılmaz and Yıldırım [108] Ozyılmaz and Yıldırım [120] Onursal et al. [121]	Artificial neural network (ANN) – A single technique)	Adaptive learning, self-organization, real time operations, fault tolerance through redundant information coding and generalized capacity	Has difficulty in deciding number of layers and the number of neurons; it usually cannot be initialized with prior knowledge; not easy to check if the solution is plausible; solutions from its learning process cannot be easily interpreted; and it uses only training data available
Imianvan and Obi [23]	Fuzzy clustering means (FCM) – A single technique	It provides users friendly approach of presentation, easy to understand and implement; provides efficient performance, easy extension of base knowledge; and has capacity to represent inherent uncertainties of human knowledge with linguistic variables.	It has problems finding suitable membership values; requires more fine tuning and simulation before operational; sometimes difficult to develop fuzzy model; depends on the existence expert to determine the inference logical rule; and not robust in relation to topological changes
Karlik [112]	Naive Bayes classifiers (NBC) – A single technique	It is easy to implement, requires a small amount of training data to estimate the test data with less training period.	It implicitly assumes that all the attributes are mutually independent, and makes a very strong assumption on the shape of data distribution
Sathyadevi [116]	Classification and regression tree (CART) algorithm – A single technique	It can inherently perform multiclass classification; can provides model interpretability and can handle both numerical and categorical data; has nonlinear relationships among features and do not affect the performance of the decision trees.	A small change in the dataset can make the tree structure unstable which can cause variance; decision tree learners create under fit trees if some classes are imbalanced; hence, it is recommended to balance the data set prior to fitting with the decision tree.
Bascil and Oztekin [63]	Probabilistic neural network (PNN) – A hybrid technique	It is much faster than multilayer perception network; generates accurate predicted target probability scores; approaches Bayes optimal classification; relatively insensitive to outliers; and is more accurate than multilayer perception network.	It is slower than multilayer perception networks at classifying new cases and it requires more memory space to store the model.
Mahdieh et al. [102]	Genetic algorithm and adaptive neuro-fuzzy (GAANF) – A hybrid technique	The methodologies are tolerant to imprecision and vagueness; can solve problems with an element of uncertainty as is found in real life; can construct and perceive linguistic variables; capable of delivering appropriate solutions to problems; can deal with issues consisting of non-statistical data; and can form equations based on a range of over lapping values instead of those with hard boundaries.	The dialogue system is not user friendly; does not follow multiple approaches; lacks the tree structure; and is often difficult to model.
Waheed et al. [103] Rahmon et al. [119] Dogantekin et al. [106] Mehrbakhsh et al. [114]	Adaptive neuro-fuzzy Adaptive network based on fuzzy Neuro-fuzzy model (Hybrid techniques)	It is robust and efficient model, has massive parallelism and ability to model imprecise and qualitative knowledge, learning in data-rich environments into the system, and uncertainty is possible using the fuzzy logic	It has the problem of finding suitable membership values; no dynamic rule creation or redundancy; has difficulty in handling more than one output systems; and more difficult to train and to model

Table 1 Summary of related works done on general hepatitis … (Continuation)

Author	Techniques	Strengths	Weaknesses
Hui-Ling et al. [104]	Local fisher discriminant analysis (LFDA) and Support Vector Machines (SVM) – A hybrid technique	It can learn automatically; can be extended to deal with non-linear dimensionality reduction situations; best for performing supervised dimensionality reducing metric learning; be used to solve multiple measurement problems; works relatively well when there is clear margin of separation between classes; more effective in high dimensional spaces; effective in cases where number of dimensions is greater than the number of samples; and is relatively memory efficient	It has issues with small sample size and when the discriminative information are not in the means of classes; not suitable for large data sets; does not perform very well, when the data set has more noise; under perform in cases where number of features for each data point exceeds the number of training data sample; and no probabilistic explanation for the classification done as the SVM classifier works by putting data points, above and below the classifying hyper plane.
Mehdi et al. [105]	Fuzzy Hopfield neural network (FHNN) – A hybrid technique	It is good for content type of address memory and for solving some kind of optimization problems; does not have any type of network learning algorithm; and patterns are simply stored by using and setting weights to the lower network energy.	It has issues with memory capacity; has discrepancy limitation; spurious states of attraction, orthogonality between patterns; weight symmetry; and local minima problems
Calisir and Dogantekin [107]	Principal Component Analysis-Least Squares Support Vector Machines (PCA-LSSVM) – A hybrid technique	It removes correlated features; improves visualization and performance; reduces over fitting; works relatively well when there is clear margin of separation between classes; more effective in high dimensional spaces; and is relatively memory efficient.	It is not suitable for large data sets; information loss; under perform in cases where number of features for each data point exceeds the number of training data sample; and there is no probabilistic explanation for the classification done as the SVM classifier works by putting data points, above and below the classifying hyper plane.
Polat and Gunes [109]	Feature selection (FS) and artificial immune recognition system with fuzzy resource allocation – A hybrid technique	Good for reducing the number of input variables when developing a predictive model; desirable to reduce the computational cost of modeling; improves performance of the model; provides users friendly presentation approach; and has the capacity to represent inherent uncertainties of human knowledge with linguistic variables	It has problems finding suitable membership values; requires more fine tuning and simulation before operational; depends on the existence expert to determine the inference logical rule; and is sometimes difficult to model.
Sartakhti et al. [110]	Support vector machine and simulated annealing – A hybrid technique	It more effective in high dimensional spaces; can deal with arbitrary systems and cost functions; statistically guarantees finding an optimal solution; is relatively easy to code, even for complex problems; and generally gives a “good” solution.	It is not suitable for large data sets; can repeatedly anneals with a very slow schedule, especially if the cost function is expensive to compute; and cannot tell whether it has found an optimal solution.
Khorashadizade and Rezaei [111]	Reduction feature (RF) and machine learning (ML) – A hybrid technique	It removes multi-co linearity resulting in improvement of machine learning model; decreases the number of dimension, making the data less sparse and more statistically significant for machine learning	It is computationally intensive; and has higher risk of over fitting.

Table 1 Summary of related works done on general hepatitis … (Continuation)

Author	Techniques	Strengths	Weaknesses
Neshat et al. [113]	Case based reasoning (CBR) and particle swarm optimization (PSO) – A hybrid technique	It is intuitive, requires no knowledge elicitation to create rules or methods, this makes development easier; solves unconstrained minimization problems efficiently; has easy maintenance; uses fully connected topology; and can be applied in solving many diverse problems using animal behaviors	It has complex computation; occupies large storage and large processing time; adaptation may be difficult; can easily fall into local optimum in high-dimensional space; and has a low convergence rate in the iterative process.
Yılmaz and Murat [115]	Rough set and extreme learning machine – A hybrid technique	It provides algorithmic approach, fast training using back propagation; has high performance, very effective for classification, regression, clustering, sparse approximation, compression and feature learning; can effectively analyze imprecise, and incomplete information; and additional or prior information about data not needed.	It does not work well for large data sets; cannot encode multiple layer of abstraction; and has very slow evaluation process.
Roslina and Noraziah [117]	Support vector machine and wrapper method – A hybrid technique	It is more effective in high dimensional spaces; has higher performance; less prone to local optima; can interact with the classifier; and can model feature dependencies	It is computationally intensive; not suitable for large data sets; and has higher risk of over fitting.
Saeed and Mahdi [118]	Artificial neural network and Support vector machine – A hybrid technique	Adaptive learning, self-organization, real time operations, fault tolerance, more effective in high dimensional spaces, and relatively memory efficient.	Has difficulty in deciding number of layers and the number of neurons; not easy to check if the solution is plausible; not suitable for large data sets; and no probabilistic explanation for the classification done.

Table 2 Summary of related works done on disease diagnosed: Hepatitis B

Author	Techniques	Strengths	Weaknesses
Dakshata and Seema [2] Panchal and Shah [67]	Rule based – A single technique	It has natural expression; separation of control from the knowledge; has modularity of knowledge; has relevant knowledge pertinent to rules fire; consistency checking is possible; cost efficient; fast and accurate with less error rate; heuristic reasoning is possible; and utilization of uncertain knowledge	It requires exact matching; search engine may slow down as the rules increases; not appropriate for all problems; time consuming; has less learning capacity; and a more complex domain
Amapwan and Blamah [61] Raoufy et al. [62] Mahesh et al. [125]	Artificial neural network – A single technique	Adaptive learning, self-organization, real time operations, fault tolerance through redundant information coding and generalized capacity	Has difficulty in deciding number of layers and the number of neurons; it usually cannot be initialized with prior knowledge; not easy to check if the solution is plausible; solutions from its learning process cannot be easily interpreted; and it uses only training data available
Gulzar et al. [122]	Fuzzy based – A single Technique	It provides users friendly approach of presentation, easy to understand and implement; provides efficient performance, easy extension of base knowledge; and has capacity to represent inherent uncertainties of human knowledge with linguistic variables.	It has problems finding suitable membership values; requires more fine tuning and simulation before operational; sometimes difficult to develop fuzzy model; depends on the existence expert to determine the inference logical rule; and not robust in relation to topological changes

Table 2 Summary of related works done on disease diagnosed: Hepatitis B (Continuation)

Author	Techniques	Strengths	Weaknesses
Mahesh et al. [65] Ogah et al. [123]	Generalized regression neural network (GRNN) – A single technique	It has high estimation accuracy; can handle noises inputs; requires only less number of datasets; and has a single pass learning.	It is computationally expensive, and there is no optimal method for improvement.
Mehdi and Yaghobi [21] Mehdi and Yaghobi [124]	Neuro-fuzzy Adaptive neural network fuzzy system (Hybrid techniques)	It is robust and efficient model, has massive parallelism and ability to model imprecise and qualitative knowledge, learning in data-rich environments into the system, and uncertainty is possible using the fuzzy logic	It has the problem of finding suitable membership values; no dynamic rule creation or redundancy; has difficulty in handling more than one output systems; and more difficult to train and to model
Rezaee et al. [66]	A novel approach SVM + FCM – A hybrid technique	It is more effective in high dimensional spaces; relatively memory efficient; has the ability to model imprecise and qualitative knowledge; and uncertainty is possible using the fuzzy logic	It is not suitable for large data sets; has problems finding suitable membership values; requires more fine tuning and simulation before operational; could be difficult to model; and no probabilistic explanation for the classification done

Table 3 Summary of related works done on disease diagnosed: Hepatitis C

Author	Techniques	Strengths	Weaknesses
Jilani et al. [126]	Principal Component Analysis-Artificial neural network (PCA-ANN) – A hybrid technique	Adaptive learning, self-organization, real time operations, fault tolerance, improves performance and visualization, and reduces over fitting.	Has difficulty in deciding number of layers and the number of neurons; not easy to check if the solution is plausible; independent variables may become less interpretable; and information loss.

3. Methods

This section used the secondary data collection techniques to gather already published papers from open access journals over the Internet, and the papers structures were categorized according to hepatitis variants detection and classification, types of AI approaches, types of prediction techniques, etc., using descriptive statistical tools such as pie charts and bar graph for easy interpretation.

This survey considered thirty-seven (37) research papers on core hepatitis prediction and classification models for analysis based on their availability in open access journals as established in Tables 1, 2 and 3. Simple percentage ratio and number count were used for analysis; also criteria such as types of hepatitis predicted and classified, number of AI based approaches or techniques used in their models, and so on were considered based on the researcher's core expertise and experience in building intelligent systems.

4. Results and Discussion

This section evaluates and analyzes the different types of Hepatitis diseases predicted and diagnosed by the different research scholars using different types of techniques. Fig. 7 to Fig. 9 and Table 4 show the analyses of papers for hepatitis prediction. As observed (Fig. 7) 11(30%) of the authors used AI based techniques to predict and properly classify their diagnosis as Hepatitis Type B, 1(3%) diagnosed and classify as Hepatitis Type C while 25 (67%) diagnosed as Hepatitis without classification into any type.

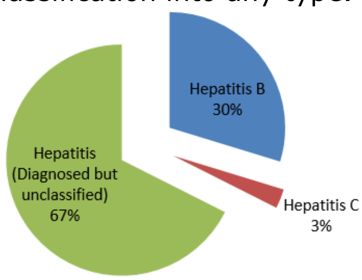

Fig. 7 Analysis of papers for hepatitis prediction

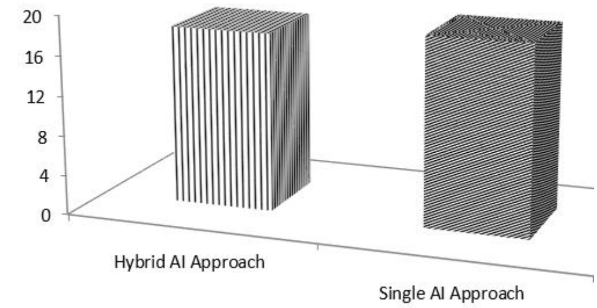

Fig. 8 Analysis of papers that used AI approach for Hepatitis prediction

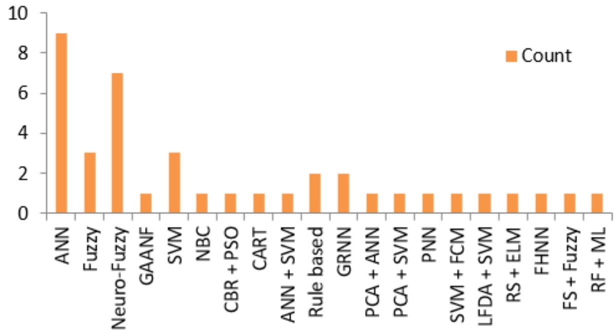

Fig. 9 Analysis of techniques used for Hepatitis Prediction

As earlier stated [2], hepatitis B is primarily transferred through body fluids; either sexually transferred, from mothers to babies at childbirth (during pregnancy) or through blood transfusion. This could be the obvious reason(s) or passion why the AI based researchers [2], [21], [61]–[62], [65]–[66], [122]–[125] corresponding to 30% (Fig. 7) decided to venture into such area, and possibly the other 25 (67%) of hepatitis detection but unclassified cases may also have been related to hepatitis B.

Fig. 8 shows that the AI based approach the researchers deemed fit to use in modeling and implementing their diagnostic applications is of no significant in terms of single or hybrid techniques, because 18 authors used the hybrid approach, while 19 used single approach, and all their predictive models were effective. But in terms of the actual techniques used by the authors for the hepatitis diagnosis.

Fig. 9 revealed that artificial neural network techniques tops the chart as nine (9) out of the thirty-seven (37) authors used the concept of ANN to model intelligence into their diagnostic application. This may be due to the fact that ANN learns and processes information efficiently using neurons like the biological neurons in human beings [17]. Next to the ANN is the hybridization of ANN and Fuzzy logic to form a formidable neuro-fuzzy model for more efficient results used by 7 authors.

It was noted by [3] that hepatitis has types (A, B, C, D and E) but Table 4 revealed that only two of the five types were predicted and properly classified by the various researchers using different AI based techniques: type B [2], [31], [61]–[62], [65]–[66], [122]–[125], and type C [126].

Table 4 Major hepatitis variants versus AI-based approach of hepatitis detected & classified

Parameter	Count
Major Hepatitis Variant (A, B, C, D & E) [3]	5
AI-based Approach for Hepatitis prediction and classification as Type B [2], [21], [61], [62], [65], [66], [122]-[125], and Type C [126]	2

It is also observed and noted that all the core 37 research papers selected and reviewed for hepatitis diagnosis using AI based techniques; almost all of them delved into the probing and prognosis of a single type of hepatitis prediction and classification or prediction only. This has become the very crux of this research survey because it is worrisome that almost the entire designed predictive model can only diagnose a single type of hepatitis viral infection considering the strength of the various artificial intelligence based techniques implemented. The various approaches are considered ineffective in terms of cost, alternative diagnosis pattern consideration and dispensation of treatment. Furthermore, since there are no research evidence to show the faintest possibility of integrating two or more out of the five major types of hepatitis viral disease infection in a single model for the ease of detection and classification in order to save lives; let alone the entire five major variants. This has become a major gap in knowledge as notice or observed from this comprehensive research survey conducted. It is our sincere opinion that scholars in the field of general artificial intelligence or computational intelligence should consider bridging or filling this research gap identified as the road map to the proper diagnosis and classification of the five major types of hepatitis disease.

5. Conclusion

In this paper, the concept of hepatitis disease was described and their infectious nature. The study also discussed the different major types of the dreaded hepatitis disease (type A, B, C, D, and E). The survey also discussed about most of the AI-based approaches available for proper probing and prognosis of ailments. The results from the survey showed that most of the papers reviewed concentrated more on finding alternative solution to hepatitis type B, this may be due to its association with sexually transmitted disease, which of course is not a bad research idea but the other types should not be completely left out because they are very deadly as well.

The survey also identified that accurate treatment depends on the efficient method that is used in diagnosing the hepatitis disease, and thereby recommends that the future road map should be in the aspect of integrating the major Hepatitis variants into a single diagnostic or predictive model using either single or a combination of intelligent machine learning techniques such as fuzzy logic, artificial neural networks, case based reasoning, genetic algorithm, neuro-fuzzy technique, etc., for a more effective and efficient results.

As a guideline for designing and implementing highly effective and efficient artificial intelligence based information systems; this paper recommends that researchers should take cognizance of the various techniques and their strengths and weaknesses.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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