A SURVEY ON APPLICATIONS OF FUZZY COGNITIVE MAPS IN MEDICAL FIELD

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Abstract

A Fuzzy Cognitive Map (FCM) is a cognitive map in which the relationships of a "mental landscape" between the elements (e.g. ideas, events, and project resources) can be used to compute the "effect power" of these elements. These maps can be used to relate features/concepts. They are more useful for classification and detection. Fuzzy Cognitive Maps are widely used in Medical fields and diagnosing diseases. This paper gives a review of Fuzzy Cognitive Map that have been developed for the detection and classification of diseases. Over the last two decades, a survey of FCM contributing to the medical field is concentrated.

Keywords: Fuzzy Cognitive Map, Decision Support System, Machine Learning

I. INTRODUCTION

Computer-aided detection and classification mechanisms have played a vital role in human life for the last two decades. Computer Aided techniques are regularly used from normal checkups to complex surgery.

Experts and researchers invent new technologies for timely diagnosis and treatment. Around the world, importance is given to health, hygiene and environment. Accurate diagnosis is very essential due to the rapid spread of diseases. At the late of 2019, Covid – 19 had a major outbreak worldwide [1]. The sudden spread of disease made a huge loss to society. Medical Experts and radiologists try to find new ways in detecting the disease. The current diagnosis of Covid – 19 and future perspectives are the main objectives of researchers [2,15] to overcome from the disease. But the practical difficulties in detecting diseases become challenging and may lead to death. Hospitals and research laboratories need modern equipment to detect the disease accurately. For effectiveness, therapeutic applications are grouped into four main sections: prediction, diagnosis, detection and classification. To incorporate various types of FCMs and assess their impact made in the medical fields, different diagnosis and evaluation support issues are discussed by FCMs in latest years are also reviewed.

II. FUZZY COGNITIVE MAP

Fuzzy Cognitive Map was developed by Kosko in 1986 [3]. Using any grading tool / feature extraction techniques, concepts are frames. The model needs an expert, to draw the causal relationship map by using the concepts / features / node. The inter-relation between the concepts is made and the weights are calculated. Each node is linked to one or more other nodes by an arrow on which it has a causal effect. The path of causality is delineated by an arrowhead, e.g., an arrow linking variables A and B with the arrowhead at B implies that a change in A induces a change in B (with an associated probability).

Figure 1 shows an example of Fuzzy Cognitive Map for the detection of Oral Tumor. C1 to C9 are the concepts. The numerical values indicate the relationship weights between the concepts.

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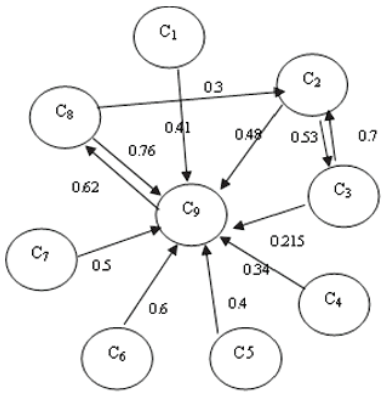

Fig. 1 Fuzzy Congnitive Map for Oral Tumo

According to the symbol of the weight wij, there are three potential ways of causal relationship between concept Ci and concept Cj:

A positive causality between concept Ci and concept Cj is indicated by wij>0 This implies that the value of concept Ci increases/decreases leading to an increase/decrease in the value of concept Cj. (Causality positive).

A negative (inverse) causality between wij<0 indicates, that the increase in Ci will be decreased in Cj.

Wij=0 shows no relation between the Ci definition and Cj. (Null Causalities)

III. DETECTION OF DISEASES USING FCM

Few researchers used Fuzzy Cognitive Map in diagnosing and detecting diseases. A Fuzzy Cognitive Model along with decision tree model was developed by Papageorgiou et al.,[4] To detect diseases by providing different types of input data and the behavior of the model is studied. A medical decision support system to assess the risk factors of gastric cancer was performed by using Fuzzy Cognitive Map [5]. To improve the performance of FCM, non – linear Hebbian Learning algorithm was used. Data were collected from 560 patients. The accuracy of the method was 95.83%. A general architecture for advanced medical decision support system was proposed by Papageorgiou [6]. It is based on FCM and the data available. Here, a hybrid attempt was introduced to deal with situations with different types of medical and/or clinical data available and with difficulties in handling decision support tasks by using soft computing techniques. Mahsa Khodadadi et al [7] predicted the occurrence of stroke by using Fuzzy Cognitive Map. The criteria for predicting stroke are used to draw the FCM. The non – linear Hebbian Algorithm is used to improve the performance of FCM. 90 actual cases were used in this study. They obtained an accuracy of approximately 95.4%. Later, [8] used 10 – fold cross validation for testing 110 real cases of Ischemic stroke. The same methods as in [7] were used to predict the occurrence of stroke. They achieved an accuracy of 93.6%.

Papageorgiou et al., [9] used Fuzzy Cognitive Map for predicting infectious diseases. Pulmonary infections were the main cause of severity of pneumonia. With the guidance and knowledge of experts, fuzzy cognitive map was drawn. A decision support system for diagnosing Rheumatic-Musculoskeletal Disease using Fuzzy cognitive Map technique was developed by Boluwaji A [10]. The model had 87% accuracy. A risk assessment system was developed by Shaista Habib and Muhammed Akram [11] to predict the cardio vascular risks in the infants aged 0 – 6 months. Two intelligent decision support systems using 18 inputs totally were proposed. Büyükavcuet al.[12] used decision-based cognitive maps to assess the successful risk factors in the incidence of breast cancer based on the expertise of oncologists, modelling the issue and finally evaluating the risks are identified.

Urinary Track Infection (UTI) was examined by using Fuzzy Cognitive Map by Papageorgiou EI et al [13]. 47 clinical concepts and eight therapy concepts have been identified for the issue of antibiotic therapy for UTIs. Finally, the root cause of UTI was found to be E-Coli. The authors

[13] concluded that the use of FCM in UTI detection was found to be reliable and useful.

Due to multiple parameters in assessing pulmonary infections, treatment becomes complex. In [14], a Fuzzy Cognitive Map was developed to predict the disease. A rule – based Decision Support System was framed during the patient admission into the hospital. Live tests were taken and the values were calculated by using the Fuzzy Cognitive Map. The causes for the pulmonary infections were detected and the necessary treatments were suggested.

A Huge challenging in detecting Covid – 19 was proposed by P. P. Groumpos [15]. Due to the insufficient knowledge in describing mathematical models, the factor of causality has not been considered. The initial causes and the present symptoms are not relevant to each other. Though, the majority of symptoms from various countries are taken for consideration, the model cannot be designed easily. Sixteen concepts which are different for each person are used to construct the Fuzzy Cognitive Map. The symptoms vary from day to day. A classification category "positive" or "negative' was obtained. However, the author believed that the proposed FCM will be a better way to understand the Covid – 19. The experts and doctors can use the new FCM and can modify according the timeline and causes.

IV. CLASSIFICATION OF DISEASES USING FCM

Detection of diseases is not sufficient; classification of diseases is important. Few researchers used Fuzzy Cognitive Map for staging of diseases. Breast tumor grading using Fuzzy Cognitive Map was developed by Roopa Chandrika et al [16]. Gray Level Co-occurrence Matrix Features were used to construct Fuzzy Cognitive Map. The severity of abnormality present in the digital mammograms were identified and the classification was performed by Fuzzy Cognitive Map.

Oral cancer classification was performed by Anuradha K and Uma KP [17] by using Fuzzy Cognitive Map. Eight Histopathological features were used to design Fuzzy Cognitive Map. The model classified high grade oral tumors and low grade oral tumors with an accuracy of 89.47% and 90.58% respectively. Ramalingam et al., [18] designed a model to classify oral squamous carcinoma into poorly differentiated, well differentiated, and moderately differentiated. They constructed a Fuzzy Cognitive Model and compared with other models and concluded that Resnet 50 with Random Forest model gives the highest accuracy of 92.08%. Tratt, E et al., [18] used Fuzzy Cognitive Map for screening cervical cancer.

V. CONCLUSION

In this survey, a common trend for future studies in medical environment is provided. by comparing the various FCM structures for detection and classification were used for medical purposes and the results of each category. It is a practical tool for discussing medical problems. Though it requires expert knowledge, the accuracy is good.

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