LIFE SPAN PREDICTION IN LIVER TRANSPLANTATION USING CONVOLUTION NEURAL NETWORK

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ABSTRACT

Due to unavailability of prediction system, the success rate of a liver transplant is subordinate. For optimal organ allocation, MELD score is used which follows the sickest first policy. In sickest first policy, the sickest patient gets transplanted without considering its characteristics. This can sometimes result in transplanting liver to a person who is undeserving instead of the person who is suitable for the liver. Data mining can be a boon to predict the accurate lifespan of the patient. So proposed model uses a learning model powered by convolution neural network which predicts the lifespan of the patient.

Keyword: - *Fuzzy C Means clustering, Convolution Neural network, Naive bayes theorem, Bayesian probability, liver disease*

1 INTRODUCTION

Patients around the globe suffering from the liver disease have to consider the priority of liver transplant, which can be a cure for their disease. The prediction system can be helpful to determine the lifespan of the patient before undergoing the transplantation. It takes input from the datasets of previous records from different hospitals and health organizations, processes it and provides classification. The attributes of the receiver and donor are provided to the system, which it classifies from the previous dataset and predicts the expected lifespan of the receiver. The output is later stored and processed for improving the accuracy of prediction and increasing the efficiency. For understanding the working of proposed system it is necessary to understand concepts required in the system.

1)K-means*:* K-means is a clustering technique in which observations are divided into different clusters of similar type. K-means is an unsupervised learning technique in which the data are not defined by categories. The data are divided into different clusters and the total number of clusters is represented by the variable K. The algorithm works repeatedly to delegate each data point to one of the K groups based on similarity. It is a versatile and simple technique which is used to find groups and label the unknown data.

Working: In K-means algorithm, initially, k random points are selected as cluster centroids which are followed by two steps. In the first step, the algorithm compares the distance between each data point and cluster and assigns that data point to the nearest cluster. The second step calculates the average of all the points in the clusters and

moves the centroid to the average location. This process continues until the centroid doesn't change and clusters remain same.

Uses: K-means algorithm can be used to find out unlabeled groups and types of groups in a complex data sets. It can be used to allocate new data to the appropriate group after the groups are defined and algorithm runs successfully.

2)*ANN:*Artificial neural network (ANN) is a software model that is based on working with the human biological neural network. ANN is a self-learning model that detects patterns in the data and relationships among them and learns by experience. The structure of the ANN changes as the information flows in a neural network based on the input and output. It consists of hundreds of small units called as artificial neurons organized in a layered manner. It works by connecting neurons in a neural network and each connection can transmit signals from one to another.

Working: Artificial neural network layer consists of a series of layers where thousands of neurons are interconnected to each other. Some artificial neurons are called input neurons which receive information from the outside world to learn, recognize or process. On the other side of the network are neurons that decide how it responds to the information it has learned called as output neurons. Between these input and output neurons, there are layers of hidden neurons, which is the brain of an artificial neural network. Most neural networks are fully connected, i.e. every neuron from the hidden unit and output unit is connected to every other neuron on the layers either side. A weight is assigned to the neuron which represents the connection between one unit and another unit. It is a positive number if it exhibits a connection and a negative number if it inhibits a connection.

Uses: ANN has a variety of applications such as handwriting recognition, image compression, stock exchange and many more. Nowadays it is also used for facial recognition which enhances the security of devices.

3)*HMM*: A Hidden Markov Model is a type of graphical model used to model unlabeled data. It assumes that the observed data are not the actual state of the model, but instead is the hidden data which defines the state. It is a tool for representing probability distributions over a sequence of observations. It is flexible in nature which makes it a definite choice in a wide variety of applications.

*Working:*In Markov model, we classify days as cloudy, sunny, snowy, etc. Then we determine this classification for a transition period of a particular day. There will be nine transition probabilities as there are three states. So for calculation transition probabilities for 50 days we observe the weather every day and divide the total transition probability with 50. But in cases where we can't observe the weather, we can derive transition probability. However, we observe some activity related to weather such as people carrying umbrellas, we can guess it raining. Although it isn't precise but more the umbrellas, better the probability. Here we are interested in weather which is hidden but we are deriving it using some phenomenon.

4)Fuzzy Logic:Fuzzy logic is recognition system which is based not only on logical statements but also on a range of probabilities such as 'almost certain' to 'very unlikely'. A model based on fuzzy logic allows modern devices to learn and know about human reasoning more closely. It is implemented so as to make decisions with incomplete or uncertain data. Additionally, fuzzy logic provides the benefits of flexibility and simplicity.

*Working:*Fuzzy logic is generally based on assumptions from which we derive some output. It works on the basis of sets where each set represents a variable defining the possible state of the output. The state of input and the degree of change of state are a part of set upon which the output is predicted. The sets are represented graphically using membership functions. The output of the model is decided based on the degree of membership in each part of the function. The membership of fuzzy sets is derived using if-else logic.

Uses: Fuzzy logic is used in a lot of applications such as aerospace, automotive, business, defense electronics finance etc. It is used in pattern recognition and speech recognition in various computer and handle-held devices.

2. LITERATURE SURVEY

[1] In this paper, Naveen Trivedi and Suvendu Kanugo describe a method to find initial centroids with the help of an entropy-based farthest neighbor. The K- means algorithm is used to effectively analyze the data by comparing sample profiles. The algorithm used in this paper is a variant method of using a k-means algorithm for finding best initial centroids. Thus the different approach of clustering illustrates the accuracy of gene clusters having less number of iterations which was not available in traditional k-means clustering.

[2] Mahmut Emin CELIK and Ebrahim BALOUJI studied the process of neural activity for characterization of the individual retinal ganglion. In this study, they found out that current implantable retinal implants generate large volume data which is required to be sorted to provide strong neural signals. For this purpose, the algorithms like spike sorting and k-means clustering are used. Firstly, spike activity is detected and isolated using the neural activity recorded from neural experiment later data is pre-processed and sorted using k- means clustering to distinguish spikes. Accordingly, neural activity is sorted and efficient approach is developed.

[3] In this paper, Eslam Nader Desokey , Amr Badr, and Abdel Fatah Hegazy attempt to enhance the stock market prediction framework by implementing a new proposed model. It was found that previous experiments in this field were not promising and did not achieve significant results. thus cluster algorithms were developed by combining genetic algorithm and k-means. These algorithms were further used to optimize the clustering of stock market prediction.

[4] Bagus Adhi Kusuma proposed an algorithm of how to define spinal curvature with the aid of a computer digital X-ray image quickly. The preprocessing in this algorithm is done by canny edge detection. The k-means clustering algorithm is used to detect the centroid. Later, after the segmentation and preprocessing of the spinal segment and polynomial curve fitting will be used in this process. The algorithm used in this system is low-cost, easy to implement and less time-consuming.

[5] In this paper, Gandhi Margi and Prof.Bijal Talati have proposed a segmentation method and neural approach to improving the accuracy of medical images using ANN. The segmentation of medical image is an essential and first step in medical image processing. The authors have proposed an Artificial Neural Network for the choice of segmentation method where an evaluation of the quality of segmentation by different methods is carried out. Later the characterization of images based on some objective parameters is performed. Thus by using RBF ANN better results can be obtained

[6] Ezekiel Karl A. Cotoco, Delfin Enrique G. Lindo, Renan G. Baldovino* and Elmer P. Dadios introduced a technique to understand the discoloration of steel when it undergoes extreme temperature. The algorithms like artificial neural network or ANN is used to identify the color patterns of steel when heated to high temperature. This technique is considered as a cheaper and accurate compared to the previous ones. The use of neural network technology can easily adapt to classify a wide range of discoloration from different metals especially steel.

[7] Eduardo Nunes dos Santos, Tiago Piovesan Vendruscolo, Eckhard Schleicher, Uwe Hampel, Rigoberto Eleazar Melgarejo Morales and Marco José da Silva presented an image-reconstruction approach for optical tomography in which a layered back-propagation of the neural network is used. By using Levenberg-Marquardt algorithm the reconstruction of two-dimensional images of two-phase gas-liquid flow is done. The ANN understands the relationship between the reference sensor and optical tomography projections. Thus neural network approach produces reconstructed images with good details preserving the values of raw data.

[8] In this paper, Anwar Ahmed Khan, Mohammad Shoaib Jamal and Shama Siddiqui presented a simple asynchronous MAC scheme for the wirelesssensor network. Efficient management of duty-cycle in wireless sensor network improves the MAC protocols. Thus, the Artificial neural network is deployed for predicting the data arrival instants in order to achieve dynamic duty cycles. The scheme that is being used has revealed significant improvement in terms of delay and energy as compared to traditional techniques.

[9] Xiaona Liu, Chen Gong, Shangbin Li and Zhengyuan Xu have proposed a method to characterize and detect VLC or visible light communication under weak illumination. In this system, the signal characterization and transmission rate of VLC with low transmission power are done. Firstly, the characterization of the LED nonlinear effect is done then by using hidden Markov model or HMM the characterization of LED under low peak power.

[10] Tekenori Yoshimura, Keeiichiro Oura, and Kei Hashimoto proposed a novel method to build multiple decision trees as a structure of factor-analyzed hidden Markov model for speech synthesis. In this method, the multiple decision trees grow simultaneously rather than sequentially to take into account the relationship between the trees. Further two computational complexity reduction algorithms are proposed that achieve a significant reduction in the computational time. However, the results show that the proposed method outperforms the conventional one based on a single decision tree.

[11] Medical Workflow Modeling Using Alignment-Guided State-Splitting HMM
Sen Yang, Moilang Zhou, and Shuhong Chen present a novel alignment-guided state-splitting HMM inference algorithm or AGSS to discover the workflow models based on observed traces of process executions. In this paper, the comparison of AGSS to existing methods using four real-world medical workflow datasets and a more detailed case study on one of them is done. The numerical results show that AGSS not only generates more accurate workflow models but also better represents the underlying process. The case study results show that our approach produces a more readable and accurate workflow model that existing algorithms.

[12] Beibei Li, Rongxing Lu and Gaoxi Xiao proposed a novel having hidden Markov model or HMM-based method to detect false data injection attacks in AMI. In this method, a global-state HMM of the whole-house appliances is built. Later it is trained by sufficient historical meter data in a mode which is called an offline mode. Then, a new Viterbi algorithm is used to decode the hidden states of the HMM. The decoded states are then verified through the partial sub-meter data in an online mode, this helps in detecting the false data.

[13]. In this paper, Preety Dagar, Aman Jatain, and Dr. Deepti Gaurhave proposed a system for medical diagnosis which is a generated using Fuzzy Logic Toolbox in MATLAB. Specifically, it focuses on medical diagnosis. In India, Diseases such as tuberculosis and typhoid fever are some of the major causes of deaths. The reasons behind such deaths are a misdiagnosis and late diagnosis. The system that is proposed will not only benefit the at-risk populations in the rural regions, it can be applied in the remote places where no doctor is available for the analysis.

[14] Nasar Iqbal, Salman Saleem, WaleedShah Jehan, Kashif Ahmad have introduced a new combined technique to improve the quality of degraded medical images. the method used in this system comprises of three techniques. Bays threshold is one of the techniques that is used to reduce speckle noise. The wavelet transform is another technique which is used to enhance edges, while contrast is enhanced by fuzzy logic. Finally, three enhanced images are combined, using image fusion, in the transform domain. The obtained results demonstrate improvement in quality by the proposed method.

[15] S.Ananthi and V.Bhuvaneswari have developed a fuzzy classification model to predict heart and kidney complications using diabetic clinical data. In this paper, a fuzzy classification model is designed and developed so as to predict the heart and kidney complications prone to diabetic populations. The proposed fuzzy classification is implemented in three phases.By using the cost function and analyzed data the best-classified rules are identified to predict the heart and kidney complications.

[16] V. Pooja, P. Jayanthi, and K. L. Shunmuganathan have come up with a design for a smart air-conditioning system which can screen the encompassing air and alter the temperature consistent to the user. This is achieved by using the technique of fuzzy logic. In addition to that, it gives a customized mode which catches every client's solace temperature and shifts automatically when the individual enters the doorway. With the help of image processing and neural networks, it is accomplished. The neural networks take in as it peruses from client's information frequently and distinguishes a specific pattern, it finds regularities in the arrangements of examples and perceives the right temperature for the ideal individual.

3. PROPOSED METHODOLOGY

The proposed model of life span prediction of liver transplanted person can be explaining with the following steps as depicted in the below mentioned figure 1.

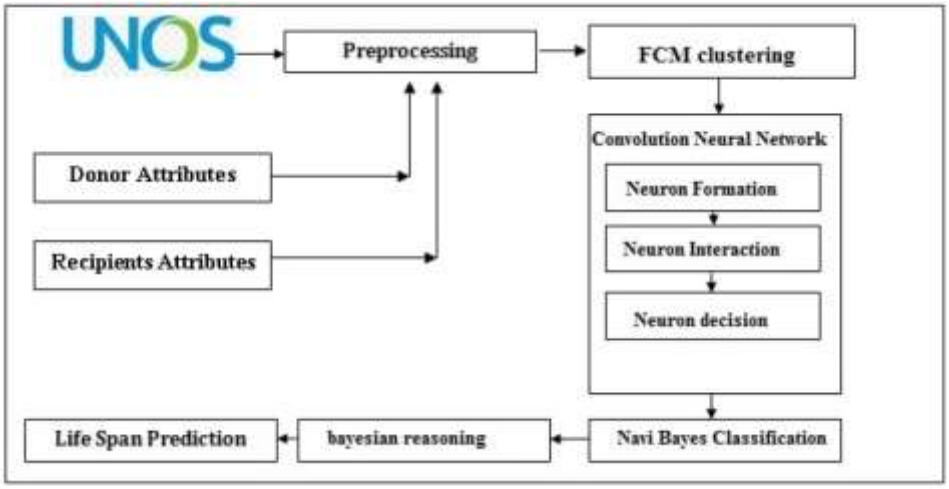

Figure 1: System Overview

Step 1: Here in this step a data set is prepared based on the attributes mentioned in the UNOS web portal for the liver transplantation process. All the data is collected in workbook format for the Donor's and Receiver's attributes. The attributes for the Donor is age, clinical infection, creatinine, diabetes, Donor type (living or dead), gender, SGOT, SGPT, Terminal bilirubin. And the same sense Data for the receiver is also collected in the workbook with the attributes like BMI, Albumin, bilirubin, MELD, Serum sodium, age etc.

Step 2: Preprocessing- Once the dataset is gathered proposed model asks same attributes from the user for both the Donor and receiver. Once these data are given as the input proposed model reads the data set which is stored in the database into a list for both the donor and receivers. And this double dimension list of dataset is subjected to preprocessing, where predefined attribute column data is selected for the further process of life span prediction for liver transplantation. Attributes like creatinine, SGOT, SGPT and Terminal bilirubin. are selected. Whereas for the recipient BMI, Albumin, bilirubin and MELD attributes are collected through their respective indices into a double dimension list.

Step 3: Fuzzy C- means clustering - Here in this step preprocessed data of both Donor and Recipient is subjected to fuzzy C means clustering. where average normalized Euclidean distance is being evaluated for each row using the following equation 1.

$$Ed= \sqrt{(x1 - x2)2} + (y1 - y2)2 \quad \text{(1)}$$

Once this Euclidean distance is calculated then each row is appended to this at the end to cluster based on fuzzy rules. Where smaller and bigger values are evaluated for the found Euclidean distance to form five rules of the fuzzy logic like VERY LOW, LOW, MEDIUM, HIGH and VERY HIGH. Then, based on these crisp values the data is being clustered which can be shown in the below mentioned algorithm 1.

ALGORITHM 1: FUZZY C MEANS CLUSTERING

//Input : Donor and Receipient Data Vector E_v
//Output: Classified list C_L
1: Start
2: Set small=0, big=0
2: **For** i=0 to size of E_v

```
3:                  T_Set = E_vi   [ T_set = Temporary Set]
4:                  Sc=T_set[1]
5:                   IF ( Sc <small) [ sc= Score]
6:                   small=Sc
7:                   IF(Sc>big)
8:                   big=Sc
9:   End for
10:          d=( big-small)/5    [ d= Distance ]
11:              For i=1 to 5
12:                  IF(i==0)
13:              Fc(min=small, max=d) [ Fc = Fuzzy Crisp Set ]
14:                  else
15:                  Fc(min=Fci-1(max),max= Fci-1(max)+d
16:              End For
17:                   For i=0 to Size of Fc
18:                        For j=0 to size of Ev
19:                        T_Set = Evi   [ Tset = Temporary Set]
20:                        Sc=Tset[1]
21:                           IF Sc ∈ Fci
22:                           add T_Set to C_L
23:                           END IF
24:                       End For
24:                  End For
25: return C_L
```

Step 4: Convolution Neural network (CNN) -First Layer - Here in the First layer of CNN both donor and recipient clusters are subjected to find the smallest distance cluster. This Smallest cluster is evaluated based Euclidean distances in between the cluster rows and the given attributes from the user for Donor and recipients.

Deep Layer - Once this smallest clusters are evaluated respectively for the Donor and recipients then these clusters are tending find the convolution inner range and the outer range based on the mean and standard deviation ranges as mentioned in the below equation 2 to 5.

$$\mu = \frac{(\sum_{i=1}^{n} Edi)}{n} \quad \text{_____ (2)}$$

$$\delta = \sqrt{\frac{1}{N}\sum_{i=1}^{n}(Edi - \mu)^2} \quad \text{_____ (3)}$$

$f(I_p) = \mu - \delta \rightarrow \mu + \delta$ _____(4)

$f(Op) = < \mu \rightarrow > \mu$ _____ (5)

Where

δ - Standard Deviation

μ- Mean

Edi - Euclidean distance of instance row

N- Number of Rows in cluster

$f(I_p)$ - Inner Range Function

$f(O_p)$ - Outer Range Function

Based on these inner and outer range size a probability cluster is identified for both Donor and Recipient.

Step 5: Naive bayes and Bayesian Probability - A mid probability segmentation is estimated for the Donor and Recipient probability cluster with respect to input data by the user for Donor and recipient. After this a full probability is estimation index is calculated for the donor based on the age, clinical infection, Diabetes and donor type. And another estimation is index is also calculated for the recipient based on the recipient age. Once these indices are estimated then this is subjected to Bayesian law to finite this probability into living span of the liver transplanted patient in terms of months.

4. RESULTS AND DISCUSSIONS

To evaluate the performance of the proposed model some experiments are conducted by using windows based Java machine. The machine is powered with Core i3 CPU with 4 GB of primary memory. Netbeans 8.0 is used as an IDE with MYSQL 5.0 as a database server. The proposed model is tending to perform some tests to evaluate its strength and accuracy by performing some tests as mentioned below.

As we know that human is the best evaluator for the correct predictions of the life span based on the facts collected over many web portals. So here we consider a parameter based on ranks given to the extracted patterns through a different number of users. This can be more clearly achieved by the best performance parameter like Mean reciprocal ratio (MRR).

Here user need to give the ranks for the identified prediction of life span from 1 to 6. For rank 1 its reciprocal ratio is 1/1, for 2 it is 1/2 and so as for 5 it is 1/5. So finally any pattern which receives the rank 6 means its reciprocal ratio is 0. This can be given by the equation 6.

$$MRR = \frac{\sum_{i=1}^{N} 1/Rank_i}{N} \quad \text{—— (6)}$$

Where

$Rank_i$. Rank for the i^{th} instance

N- Number of ranks given

We performed an experiment to evaluate the rank retrieval using the MRR metric as shown in the table 1 for different input.

Data Set Size	MRR
20	**0.55**
40	**0.58**
60	**0.61**
80	**0.69**
100	**0.79**

Table 1: Mean Reciprocal Ratio results

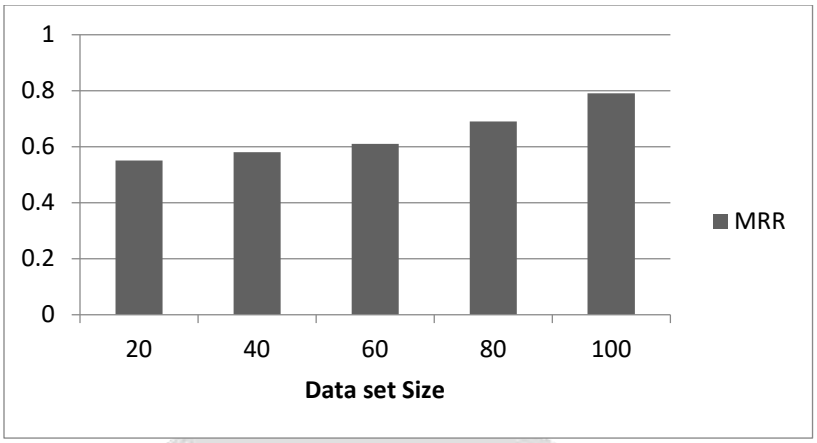

Figure 2: Performance Evaluation through MRR

In the Fig. 2, we observe that the tendency of MRR is increasing as the size of the dataset is increasing. This indicates that system learns thoroughly from the input data to provide a proper life span prediction, this is a good sign of the system in the first attempt.

5. CONCLUSION AND FUTURESCOPE

It is very hard task to predict any once life span, but this job is doing by our doctors since very long for any patient who under gone the knife. As an opportunity to do this proposed model predicts the life span of the patient who is undergone or willing to transplant the liver from the deceased or living Donor. To achieve this proposed model collects the dataset based on the UNOS standard protocols. System uses Fuzzy C- means clustering and Convolution neural network to predict the probability of the data. This process is catalyzed by the Bayesian law and naive bayes theorem to predict the life span in terms of months. And the system also shows the significant sign of learning as the number of dataset increases for the estimated MRR.

This model can be enhanced in the feature by applying deep learning mechanism for very huge data using big databases. And this can be deployed in the form of web service or mobile apps.

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