International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-5, January 2020

Digitalization in Dental problem diagnosis, Prediction and Analysis: A Machine Learning Perspective of Periodontitis

Lakshmi T.K, Dheeba. J

Abstract: ***Artificial Intelligence, Machine learning, deep learning and image processing is becoming popular in medical sciences.*** *The present digitalized world is remodelling each facetadditionally impacting dentistry and medical field from patient record maintenance, data analysisto new diagnostic methods, novel interference waysand totally different treatment choices. Oral health contributes to various diseases and conditions like Endocarditis, Cardio vascular diseases, diabetes, osteoporosis, pregnancy and birth and many more. Bad breathe, tooth decay, periodontitis, oral abscess, tooth erosion, dentinal sensitivity and many more can be even trickier to detect in plain dental radiography. The most prevalent disease periodontitis is a gum disease when left untreated, leads to tooth loss and more hazardous complications. Early Prediction and Proper diagnosis in time will protect our health from the mentioned diseases which can be implemented by making use of emerging technologies to assist and support dentists in predictions and decision making. Hence focusing more on oral health, In the current paper, the most contributing risk factors and parameters like Pocket Depth, Black Triangles, Alveolar Bone Loss, Furcation, Periodontal Abscess, Smoking, Gingivitis, Clinical Attachment Loss, Mobility Etc. that progresses the disease were taken in to consideration and a Python code was implemented which can be used as a Decision making aid to check whether person suffers or likely to suffer in future or not suffering from the disease.In this paper, literature reviews on the various automated computerized methods used to detect and diagnose the disease were discussed and an attempt was made to clearly identify and describe both the clinical and radiological parameters that a dentist/Periodontist use as a metric to grade/assess the periodontitis. The present strategy can be enhanced as a tool and can be used as a decision making aid by dentists' in the prediction of periodontitis and can also be used for demonstrating fresher's or upcoming dentists the progress of gum disease, grading the severity of the disease and the associated risk factors considering clinical, radiological findings and adverse habits thereby improving overall time period taken for manual predictions.*

Index Terms - Fuzzy systems, Periodontitis, Neural Networks, caries, Artificial intelligence, Machine Learning, Dental image analysis, disease prediction, gingivitis, gum disease, dental decision making, bone loss, dental radiograph, tooth problem, automated dental diagnosis

Manuscript published on January 30, 2020.
Correspondence author *
Lakshmi T.K, Research Scholar, SCOPE,Vellore institute of Technology, Vellore, Tamil Nadu.lakshmi.tk2016@vitstudent.ac.in, lucky.its@gmail.com
Dheeba J*, Associate Professor, SCOPE, Vellore institute of Technology, Vellore, Tamil Nadu. dheeba.j@vit.ac.in

I. INTRODUCTION

A. Tooth:

Human teeth are a marvel of nature. They function for many years without undergoing much degradation. However its health depends on the maintenance of tooth and in case of damage, there is a necessity to repair immediately defective tooth with restorative material to prevent further loss. Teeth mainly composed of Enamel, Dentin, Pulp, and Cementum.Enamel provides a hard and durable shape for the teeth protecting dentin and pulp providing aesthetics to the tooth. Dentin provides colour to the enamel, protecting pulp andprovides strength and rigidity to the tooth, which initiates

pulpal defence response. Pulp supplies nutrients to dentin, forms reparative dentin to protect itself and transmits pain impulses to brain. Cementum covers and protects dentin and pulp and attaches the tooth to alveolar bone.

B. Tooth defect conditions:

Dental caries, tooth wear, traumatic injuries, developmental defects, aesthetic corrections, gum disease etc. are the various conditions that cause tooth defects. Other than these conditions, there are also few terminologies related to defects of tooth like Attrition (wear of incisal or Occlusal surfaces of teeth due to frictional contact between opposing teeth), Abrasion (Tooth surface loss due to force between the teeth and external objects Ex: Brushing), Erosion (Tooth loss due to chemical/mechanical action), Enamel hypoplasia (defective formation or calcification of enamel) etc. Even though tooth is a small part in human body, its importance and impact is always high during mastication of food, maintenance of aesthetics, proper speech and protection of supporting tissues which represents the overall wellbeing of a person.

C. Most common dental problems:

Halitosis (Bad breathe), Dental cavity (Caries), Gingivitis & Periodontitis (Gum disease), Oral carcinoma (oral cancers), Mouth sores, tooth erosion, dentinal sensitivity, dental pain and tooth urgencies.

D. Oral health vs. Systemic diseases:

There is an association between our body's health and our tooth health. Oral health has high impact on Diabetes i.e Diabetes is more prone to several oral health conditions. Gum disease influences cardiac diseases and problems, respiratory problems, pre mature low birth weight infants.

Systemic disease like diabetes, cardiovascular diseases, joint diseases,rheumatoid arthritis and osteoporosis, respiratory problems, hormonal imbalance, pre term babies and low weight babies during pregnancy are few related with oral manifestations.

Although dental problems are neglected, the dental pain is next to labour pain which results in serious consequences if left untreated and hence section II summarizes literature survey on various dental problems, work carried out and the different areas where there is a lot of scope for further research.

E. Periodontitis:

It is a gum disease which initially starts as Gingivitis and if left as such leads to Periodontitis. Due to improper oral hygiene and personal habits, a yellow coloured soft thin layer forms surrounding gums called Plaque. The plaque if not removed or left as such, becomes harder and harder resulting incalcium deposits surrounding gums called Tartar. At this stage, a visit to a dentist is necessary. If they are not cleaned, penetrates deep in to the gum line destroying alveolar bone, ligaments, forming periodontal pockets, slowly tooth mobility occurs resulting in tooth loss. Early diagnose and visit to a dentist prevents the problems associated with periodontitis like cardiac disease, respiratory disease, osteoporosis, diabetes, preterm births, low birth weights babies and many more. Cigarette smoking is an adverse habit that triggers periodontitis. Periodontitis depends upon socio, behavioural, environmental, hereditary life style of a person which needs more attention of having regular dental check-ups and proper oral care. So in this paper an attempt was made to sort out the list of parameters both clinical and radiological that a Periodontist usually considers to identify and grade the severity of the gum infection (Periodontitis) after discussing with a dentist and a simple python programming was applied to represent the same whether a person suffering from disease or not based on input parameters.

II. LITERATURE SURVEY

Brickley, Shepherd etal in 1998 concluded that on proper training of Neural Networks, one can attain reliable decision support aid for treating dental problems. They made 2 different studies, training the network with datasets whose values are obtained from clinical findings. Dentists' opinion was considered in screening and the main focus is on prediction of oral tumour. In study 1, cross validation technique was used to avoid over training after every cycle [1]

S.A. Gansky in 2003 compared Logistic regression model on Artificial NN, Classification and Regression Tree for caries prediction. Fluoride, calcium and phosphate levels from salivary assays are the inputs taken. The outputs obtained from different selected algorithms were compared based on Receiver Operating Characteristicsand cumulative captured-response curves. The limitations of this methodology is small number of predictors were used. Parameters like PH, salivary flow rate were not considered. The accuracy of the results could be increased by considering radiographs for better predictions[2]

Karina Lopes Devito, Flávio de Souza etal in 2008 worked on Multilayer Perceptronto diagnose proximal caries considering radiological findings. 160 radiographswere taken as input to collect dentists' opinion for the presence of caries. After the radiographic study, MLP, NN with back propagation was built.The Nguyen-Windrow method was used for assigning weights at the beginning. ROC curves of clinical examination and neural network was compared and obtained 39.4% improvement. [3]

Vijay Kumar Mago, Bhanu Prasad etal in 2008 used Bayesian model for decision making on the treatment planning of dental caries.Authors tabulated different signs and symptoms of the patients and treatment planning. Conditional probabilities are obtained from Dental practitioner. GeNIewas used to build BN. For server-side programming, ASP .net, C# was used. BN produced 91.33% of accuracy with 5% level of significance. [4] The process can also be utilized for other oral diseases as well radiographic evaluation can also be incorporated in decision making.

Grace F. Olsen, Susan S. Brilliant in 2009 worked on digital dental photograph to classify carious/non carious regions. The input taken was 6 segmented teeth from 6 Digital photographs. Feature extraction was done on the factors influencing demineralization were expressed as vector. Statistical measures were done on certain parameters. For segmentation, color based method, for classifications C4.5 were used. [5] The drawback with the paper is that the images considered for the study had very small caries region. Large database is suggestible to improve the overall performance. The same methodology can also be applicable for diagnosing periodontitis.

ArumugamBanumathi, S. Rajuetal in 2011 used cephalometry image as input for finding out dental deformities using Support Vector Machine.For 100 input images, histogram equalizationwas applied for pre-processingto increase the quality as pre-processing method. Projected Principle Edge Distributionalgorithm was used for feature extraction; PPED Gini SVM classifier was used to distinguish landmarks and implemented in MATLAB environment. After training, during testing phase SVM differentiated landmark from non-landmark vectors. [6] The present method has given accurate results but can be cross verified with many cephalometry images considering the opinions of dentists.

Vijay Kumar Mago, Anjali Magoetal in 2011 implemented Fuzzy Expert Systemfor decision making on mobile Tooth. Certain parameters like pain, infection etc were the inputs whose membership values are in between 0 and 1 for which expression was obtained by different functions followed by framing IF THEN rules and implemented Fuzzy Inference System mechanism. In FIS, Mamdani algorithm is used; Defuzzification is done by centroid method and the performance was tested with dentists' opinion using chi square test. [7] The method discussed in the present paper has given good results so the same method can also be extended to diagnose periodontitis considering parameters extracted from radiographs.

NovruzAllahverdi and TevfikAkcan in 2011 implemented A Fuzzy Expert System to diagnose Periodontal Dental Disease. Inputs are clinically and radigraphically obtained variables along with risk factors and the result of FES was the disease severity. The output was linguistic variable representing stages like Healthy, gingivitis, periodontitis etcbased on which treatments were displayed. From rules framed and various indices, probing depth, alveolar bone loss etc the status of the result was decided. Mamdani approach was used for output process and centre of gravity method for Defuzzification. [8] The advantage of the method is reduction in time consumption than it takes for manual way of decision making. The same method can also be extended for studying dental diagnosis in diabetic patients.

Ali Al Haidan, Osama Abu-Hammadetal in 2014 predicted Tooth surface loss severity with an accuracy of more than 80% by Using Genetic Algorithms – Optimized Artificial Neural Networks taking dataset of 46 patients to construct ANN model and 15 patients data for testing it. The dataset includes parameters like Age, smoking status, type of brush tooth, frequency of brushing, bruxism, eating citric fruits, pickles, dried seeds, drinking carbonated fizzy drinks. [9] The accuracy achieved was 73.3% which can be enhanced by considering more number of patients'. The same methodology could also be used for grading periodontitis.

GeorgiosPapantonopoulos, KeisoTakahashetal in 2014 worked on Diagnosis, classification of Aggressive, chronic Periodontitis using Artificial Neural Networks. Different samples were used as inputs. One set of sample with patients severely suffering from the disease, the other with blood picture, the third set with Immunoglobulin levels and final set with serum antibody levels. Kernel density estimation was done and data fit was tested by probability models. MLP ANN was built based on cross entropy values. Automatic relevance determination was used at input layers for feature selection. [10] The same methodology can also be implemented considering risk factors, environmental and Personal factors, clinical and radiological factors as input.

VoulaGeorgopoulosand ChrysostomosStylios in 2014 implemented augmented Fuzzy Cognitive Mapscombined with Case based reasoning in medical decision making. Critical factor concepts wereincluded to which the logical majority rule operation was applied. That is CFCM will receive inputs of factors whose majority is high and activatedelse CBR will becalled. [11]

Vijay Kumar Mago, Elpiniki I. etal in 2014 employed flexible FCM for analysingPD. Dentist collected data like Trauma occlusion, Mal alignment, Smoking, Pregnancy, Oral hygiene, Hormonal changes from the patients. Linguistic values like Strong, weak etc were considered to reflect the impact of nodes on the disease and Fuzzy inference process was implemented and verified performance with Gold standard which was considered as dentist opinion. [12] Radiographic findings such as alveolar bone loss should have been considered for better results.

Elias D. Berdouses, Georgia D. Koutsourietal in 2015 worked on 103 digital dental colour images to find out dental cavities. After detecting needed area, pre-processing, segmentation [using K means algorithm], Feature extraction and object eliminationwere done. In Classification,feature extraction, selection and classification processwere carried outfor occlusal caries detection. During classification, J48, Random tree, Random forest, SVM, Naive Bayes methods were used and compared. [13]

FO Ozden, O Ozgöneneletal in 2015 considered clinical and radiological findings of 150 patients directed to periodontal therapy. Back propagation NN with sigmoid transfer as activation function, SVM in which one against one strategy and Decision trees (C4.5) were used and compared. Finally SVM, DT achieved 98% of accuracy in predictions. [14] It wasthe first time that the 3 algorithms mentioned were compared but further study should focus on considering other risk factors like systemic diseases to better diagnose. Study on large number of patients and treatment planning can also be included in further work.

Philip M Preshaw in 2015 discussed theoretical methodologies for detection of periodontal conditions. Russell Index, Community Periodontal Index, gingivitis, periodontal probing depths were used to assess the impact of disease. Bone loss, plaque &calculus, apical pathology, caries, enamel lucencies, ledges/overhangs of restorations etcwerethe radiological findings considered to grade the periodontitis. [15]

Anita Thakur, PayalGuleriaetal in 2016 worked on NN for diagnosis of gum diseases for which symptoms, risk factors of the disease taken from the patients were the inputs. BFGS quasi Newton, gradient descent BP, resilient BP, Scaled Conjugate Gradient and LevenbergMarquardetalgorithms were used to test the results after training.MSE was obtained for x number of iterations along with correlation coefficient and LM method had given 82% of CC indicating highest precise neural network model. [16] There might be improvement in diagnosis if radiological findings were also considered.

Le Hoang Son, Tran Manh Tuan in 2016 used dental X ray image dataset and found image segmentation method that can be further applied for dental diagnosis considering semi supervised fuzzy clustering frame work. Otsu method was used for pre-processing the image and FCM to distinguishdifferent areas of teeth. In this paper Semi Supervised Entropy Regularized Fuzzy Clustering was used to increase clustering performance and achieved better accuracy than FCM, OTSU, and Semi Supervised with Standard Fuzzy Clustering. [17]

KirtiNagane, Nikita Dongreetal in 2017 worked on a system to predict the gum disease based on the parameters given by the user using Machine Learning. The input considered is a data set containing 10 attributes like name, age, sex, symptoms, risk factors, genetics, obesity, stress, medications and image name. Inputs are preprocessed to 2D vector list, labelled, K – means clustering was used to cluster given data set, Shannon information gain was used to analyze distribution factor of input parameters and finally Dumpster –Shaffer Reasoning was used to identify the proper reasonable evaluation factor for gum disease to predict the probability of gum disease. Performance evaluation was done by Mean Absolute Error compared with human predicted parameters. [18]

The methodology can be implemented as mobile application in future as it has given good results and easy to implement too.

Lin, Huang etalin 2017 used 12 periodontitis periapical radiographs from which 18 tooth images segmented to designcomputerized methodologies formeasuring Alveolar Bone Loss. Authors described various segmentation methods using threshold like TSLS, ABL–ifBm, a threshold segmentation method for alveolar bone loss area localization, Bilateral filtering, the Cementoenamel junction localization method which includes Bilateral filtering for noise reduction & power law transformation for contrast stretching during image enhancement, Length-based ABLmetrics. [19]

Magda Feres, YoramLouzoun in 2017 used SVM to study periodontitis. Clinical findings were considered fromsub gingival plaque samples of the patients.Principle Component Analysis was used. An SVM classifier was used with a Box constraint of 1 and a linear kernel. The precision or accuracy of the output was determined by ROC [20]

Tran Manh Tuan, Nguyen ThanhDucetal in 2017 worked out on Diagnosis of dental diseases like cracked, hidden infection, cavity, missing tooth and periodontitis. From the given dental image, entropy edge – intensity is calculated. LBP is calculated using the method proposed by Ahonen, Hadid, and Pietikainen. RGB values for an image are calculated. To obtain Gradient feature, Gaussian filter was first applied to reduce noise. Patch level feature was obtained by using formulas proposed by Oad, DeZhi and Butt. FCM clustering algorithm was used for rule set generation and Gauss function was used to avoid unexpected rules and weights are obtained. Mamdani method was used to build fuzzy inference system. Performance was evaluated by using MSE, MAE and accuracy. [21] Discussed method can come out with other clustering methods and inference methods for quality performance improvement and the dental features considered in this paper could be increased for better results.

AbdolvahabEhsanietal in 2018 found automated detection system BPNN for caries diagnosisusing 120 radiographs. The methodology makes use of intelligent level set method for segmentation in which Initial contour (using Morphological Region-Based Initial Contour) and parameter generation (using Signed force function & speed function parameter) was done. Parameters like image texture, intensity, and gradient direction were taken in to consideration. Further caries detection was made following 3 steps Tooth isolation done by integrated intensity value, tooth feature map and identification. [22] The same method can also be used to find alveolar bone loss for periodontitis diagnosis

ArmanHaghanifar, AbdollahAmirkhani in 2018 used the data obtained from 86 patientsto identify Caries.For FCM, the concepts values were the responses of the sufferers, the degree of severity. Every patient was identified as either healthy or carious by doctor. The main disadvantage of this method is intervention of dentist. Real-Coded-Genetic-Algorithm was used to avoid above disadvantage in which Real Coded Genetic Algorithmwas used for weights matrix and multilayered FCM model was implemented. [23]

Jie Yang, YuchenXieetalin 2018 introducedautomated system for assessing periapical dental radiograph reducing time taken for manual procedures. Input was a radiograph of before and after treatment. They first used the SIFT and SURF feature matching algorithms. Best ternary points were identified by random sample consensus and minimum average grey scale. Affine matrix was constructed and the authors used disjoint set data structure for finding adjacent apical area followed by construction of Convolutional NN. [24] The same procedure can be extended to large datasets for improving further work.

Jae-Hong Lee, Kimetalin 2018 worked on automated system for cavitiesidentification with 3000 periapical radiographs. Google Net Inception v3 CNN network was implemented with the taken dataset for pre-processingusing transfer learning inKeras library on top of Tensor Flow in Pythonenvironment. [25] This method achieved an accuracy of 92%, 91% and 83% for premolars, molars and premolar, molar together. The same methodology can also be used for diagnosing other dental diseases like periodontitis.

Maurizio S. Tonetti, Henry Greenwell etal in 2018 discussed theoretical methods on Staging and grading of periodontitis. Based on interdental Clinical Attachment Loss, radiographic bone loss and tooth loss marginal values were calculated based on which stages were decided. Certain influencing factors like smoking, diabetes, biomarkers etc were used for grading the severity. [26]Grading and scoring system was discussed which can be used as template for implementing automated periodontal patients diagnosis in future studies.

SaminArbabi, FarzadFirouzietal in 2018 presented a Model for Periodontal Diagnosis byANN algorithmswith 190 periodontal disease cases. Inputs taken were PPD, CAL, gender, age and plaque index. In this present study, LM and SCG algorithms were implemented and compared on error management, time consumption and number of iterations. MLP model was designed. LM method has achieved better performance than SCG. [27]The same methodology can be implemented in future with extended and added inputs apart from considered in this paper for more accurate results.

III. PROPOSED STUDY

In the proposed study, the following step by step process was planned to be implemented.

Step 1:Identification & Listing most influencing factors:

From the parameters listed below in Table 1, the most contributing and important factors that highly influences gum disease has to be identified and listed with the help of dentist.

Step 2: Data extraction:

For each person, values for clinical findings: Gingivitis, Tooth mobility, clinical attachment loss, periodontal pocket depth, furcation, periodontal abscess, black triangles and radiological findings: alveolar bone loss has to be obtained from dentist. Smoking, an adverse habit was also to be considered.

Step 3: Building Code:

For the values obtained in step 2, all the possible conditions for the disease occurrence has to be checked based on which output is obtained.

CASE 1: person with smoking habit, having gingivitis and all other parameters are showing positive then it results in periodontitis

CASE 2: person having smoking and no gingivitis, results in no periodontitis or treatment taken and rectified or may occur in future based on oral hygiene

CASE 3: person with no smoking but having gingivitis and positive values for other parameters results in periodontitis

CASE 4: person with no smoking, no gingivitis does not have periodontitis.

Other cases like people with smoking, having gingivitis but no other prominent symptoms seen and people with

no smoking, having gingivitis but no other prominent symptoms seen may likely to suffer with disease in future if not treated.

Step 4: Output Generation:

Output is obtained for user inputs after checking all the cases mentioned in step 3 whether person has disease or not. The below mentioned table represents different parameters used to assess gum disease. [28]

Table 1: Parameters used to assess Gum disease

ADVERSE HABITS	GINGIVAL EXAMINATION
Pan chewing Smoking Alcoholism Tobacco chew Tooth Picking/Chewing Betel/Betel leaves	Gingiva Contour Consistency Surface Texture Size Gingival recession Gingival exudates Bleeding on probing
ORAL MUCOSA EXAMINATION	**PERIODONTAL EXAMINATION**
Buccal mucosa Labial mucosa Palate Floor of the mouth Tongue Frenal attachments Vestibule Oral malodour	Periodontal pocket depth Mobility Periodontal Abscess Clinical Attachment Loss Endo Perio Lesions Occlusal findings Mucogingival findings Furcation involvement
PERIODONTAL RADIOLOGICAL EXAMINATION	
Dental Caries Horizontal & Vertical Bone Loss Furcation Alveolar dehiscence Black Triangles Crown Root Ratio Root Morphology Periapical Abscess Periodontal Abscess Cysts & Tumours Impacted tooth Fractured Teeth Widening of Periodontal ligament space	

The above mentioned parameters are generally used by Periodontist to assess the disease severity for further proceeding with the treatment. With the help of a Periodontist regarding evaluation of the gum disease process, most important parameters including Adverse effects, clinical and radiological findings contributing from the above list were identifiedfor which python coding is done to decide whether person suffers from disease or not.

According to The American Academy of Periodontology (AAP), the staging of periodontal disease is given as follows based on certain important parameters [29]:

TABLE 2: Staging of Periodontitis

PARAMETER\STAGE	MILD - I	MODERATE - II	SEVERE - III
CLINICAL ATTACHMENT LOSS(in mm)	≤ 1-2 mm	≤ 3 – 4 mm	≥ 5 mm
BONE LOSS IN %	< 15%	15-33 %	>33 %
TOOTH LOSS(in number)	No tooth loss	No tooth loss	≤ 4
PROBING DEPTH(in mm)	≤ 4 mm	≤ 5 mm	≥ 6 mm
BONE LOSS TYPE	horizontal	horizontal	Vertical ≥ 3 mm
FURCATION	Not present	Not present	Class II - III

Based on above standards and discussion with dentist, generalizing presence or absence of parameter as 1(present) / 0 (not present) and according to AAP,

1. **Smoking (SM), Alcoholism, and Tobacco**: Cigarette smoking associated with increased risk of generalized aggressive periodontitis in young adults (19-30 years). Smokers are 3.8 times more likely to have periodontitis than non-smokers. Persons with these habits are more prone to periodontitis.[30]
2. **Gingivitis (GIN):**
   If not treated, leads to periodontitis
   If treated, chances of periodontitis is very less
3. **Periodontal pocket depth (PPD):** According to American Academy of Periodontology
   >=2-3 mm leads to periodontitis
   <2 mm means no problem
4. **Mobility(MOB):** 1 = present, 0= not present
   Wasserman, Geiger and Turgeon[31] describe a slight modification of the Miller Index which is used at the Columbia Dental School. This method utilizes a 1 to 5 scoring system where:
   1 = normal tooth mobility.
   2 = slight mobility—less than approximately ¾ mm
   of movement buccolingually.
   3 = moderate mobility—up to approximately 2 mm of movement buccolingually.
   4 = severe mobility—more than 2 mm of movement.
5. **Clinical Attachment Loss(CAL):**1=present, 0= not present
   According to American Academy of Periodontology**,**
   1-2 mm – Slight periodontitis
   3-4mm – Moderate Periodontitis
   5-6mm – Severe Periodontitis
6. **Alveolar Bone loss (ABL):** According to American Academyof Periodontology,
   >1 mm leads to periodontitis
   < 1 mm, no periodontitis

Note:

1-2 mm – Slight bone loss

3-4mm – Moderate bone loss

>5mm – Severe bone loss

7. Furcation (FUR): Depends on bone loss**.**According to Glickman method [32],

>1 mm of bone loss leads to Periodontitis

< 1mm of bone loss, no Furcation, no Periodontitis

Note:

Grade 1= Incipient bone loss

Grade2= Partial bone loss

Grade3= Through and through

Grade4= Visible of Furcation area

8. Black Triangles (BT): More Black Triangles Present

(>30%), leads to Periodontitis.

No Black Triangles, no Periodontitis

9. Periodontal Abscess (PA): If present (yes), leads to Periodontitis

If not present (No), no Periodontitis

IV. IMPLEMENTATION OF CURRENT WORK

Considering the parameters smoking habit, gingivitis, periodontal pocket depth, mobility, clinical attachment loss, alveolar bone loss, furcation, black triangles, periodontal abscess taken as inputs, a Python program was implemented in Windows 10 operating system using Python 3.7.3 version.If a patient/person obtains positive value (1) formore than one of these 9 parameters, it was observed as person suffers from periodontitis. These 9 values in the form of yes/no, 1/0 was given as user inputs for each person. Code was written based on two main conditions firstly person having smoking habit and secondly person suffers from gingivitis. For persons having both the habits and obtains positive value (>2mm for pocket depth and > 1mm for all other parameters) towards all the other parameters results person suffers from the disease. Similarly for other possible cases like persons with smoking habit alone and no gingivitis, the risk of periodontitis is less and may occur in future based on tooth /gum condition, for persons with no smoking habit and no gingivitis, there is no point of periodontitis at that instance and there may be chances of occurring in future based on tooth/gum condition, persons with no smoking but having gingivitis and positive towards all other parameters also suffers from periodontitis. Likewise considering the above cases, python program was implemented to decide whether the person suffers from the disease or not based on the clinical, radiological findings and adverse habit.

V. RESULTS& DISCUSSION

Considering the habitual, clinical and radiological tooth/gum findings as mentioned, results were obtained indicating whether a person suffers from the periodontal disease or not. For persons having adverse habit and gingivitis with positive values for other parameters resulted that they suffer from periodontitis and persons with no adverse habit, no gingivitis and negative towards other parameters resulted that they did not suffered from periodontitis. Similarly if either of them true and depending on other input values, this implementation could decide whether periodontitis is present or not. The following was the screen shot obtained after running the code. So the current strategy is a simple one which can be used as a decision making aid for deciding whether patient suffers from the gum disease or not. The same principle could be used to build a computerised tool which can help an upcoming dentist in proper decision making as well the current strategy can be used with an ease for house surgeons, fresher's for demonstration purpose. In the present digitalization era, digital technology is revolutionizing the quality of potential applications in every field in modern practices enhancing the communication between the user and the system using GUIs in user friendly environment. Advantage of Digitalization in medical and dental care is high especially in early prediction of disease, analysis, diagnosis and treatment planning for the clinicians. Now a days, Data entry, patient record keeping and maintenance, hospital management, legal and ethical issues investigations everywhere automated computerized systems were used which reduced manpower and time consumption. Especially in radiography, when conventional radiographs were used, it needs a separate dark room, tankers, solutions and many more to print an image where as digital radiography replaced all those and in seconds the image gets printed and with tools available, analysis is also easily done. So there is a huge need of digitalization and computerized tools in medical/dental field for early prediction of disease and treatment planning. So this paper reviewed many such articles where computerized tools were used in dentistry to predict, analyse and assess different dental problems like caries detection, periodontitis severity grading, alveolar bone loss measurement, detection of impacted tooth and many more where Artificial intelligence, neural networks, image processing, Fuzzy logic, machine learning and many other technologies were used through which many challenging factors like time consumption, radiographic image pre-processing, segmentation, enhancement, registration, restoration and other features were addressed.

TABLE 3: Sample Inputs (I/P) (1/0 – Present/Not Present) & Outputs (O/P) (P: Periodontitis, NP: No periodontitis)

I/P	SM	GIN	PPD	MOB	CAL	ABL	FUR	BT	PA	O/P
CASE 1	1	1	1	1	1	1	1	1	0	P
CASE 2	1	0	0	0	0	0	0	0	0	NP
CASE 3	1	0	0	0	0	0	0	0	0	NP
CASE 4	0	1	1	1	1	1	1	1	1	P

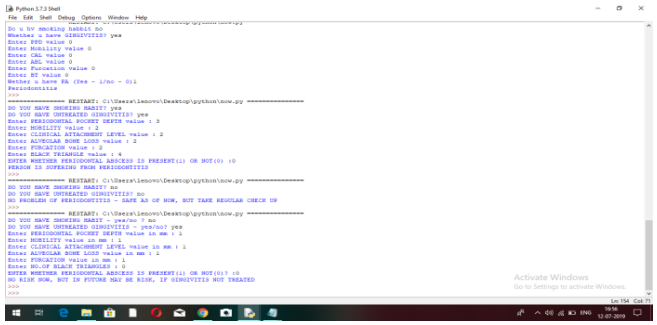

Fig: 1 Screenshot of output obtained when executed code

VI. CONCLUSION& FUTURE WORK

As there is a highneed for further research in the area of dental disease prediction and analysis, thepresent paper providedtwo vital information's' first one being supportive information on past work details, a summary of different strategies implemented by various authors for dental disease detection and diagnosis and the second one is decision making code in python that resulted in output representing whether person has periodontitis or not or will likely to suffer in future. There might be lot of factors influencing gum disease but the current study focussed on the most important factors having high impact progressing the disease aggressively.Clinical findings such as gingivitis, periodontal pocket depth, mobility and clinical attachment loss, radiological findings like alveolar bone loss and furcation and adverse habit smoking were identified as input parameters for code, themost contributing 9 parameters after discussing with dentists'. An attempt was made with those parameters implementing in Python for decision making and arrived at the conclusion, the presence or absence of gum diseasedepending on all possible if conditions as described in results and obtained outputs satisfactorily.Authors of the current paper realised that there is an urgent need for designing smart tools and decision support systems for diagnosing periodontitis to reduce the severe damage affecting periodontal tissues worsening the patients tooth health if not predicted, identified and treated in right time. So as future work, authors were decided and planned to work on designing automated toolfor predicting periodontitis as decision making aid especially in diabetic patients as systemic diseases has a high impact on periodontitis with real time habitual, clinical and radiological findings or the data obtained from patients or by collecting dataset from dental clinics with proper consent to improve prediction accuracy which will be useful for dentists as a decision making aid.

ACKNOWLEDGMENT

Our sincere Thanks and gratitude to Dr. M. Naresh Kumar, Orthodontist, Al Taj clinic, Taif, Saudi Arabia, Dr. Mohammad Sameevulla, Periodontist& Implantalogist, KT super speciality dental hospital, Tirupati and Dr. Sundeep Narahari, Periodontist & Implantalogist, Sai Sundeep Dental care, Tirupati for their extended support in gaining appropriate information, data and for sharing their advises and knowledge without which it couldn't happen.

REFERENCES

1. M. R. Brickley, J. P. Shepherd etal, Neural networks: a new technique for development of decision support systems in dentistry, Elsevier, Journal of Dentistry, Vol. 26, No. 4, pp. 305-309, 1998
2. S.A. Gansky, Dental Data Mining: Potential Pitfalls and Practical Issues, International American Associations for Dental Research, Adv Dent Res 17. Pp.109-114, 2003
3. Karina Lopes Devito, Flávio de Souza Barbosa etal, An artificial multilayer perceptron neural network for diagnosis of proximal dental caries, OOOOE, Vol. 106, No 6, pp.879-884, 2008
4. Vijay Kumar Mago, Bhanu Prasad etal, A Decision Making System for the Treatment of Dental Caries, Soft Computing Applications in Business, Springer, Studfuzz 230, pp. 231–242, 2008
5. Grace F. Olsen, Susan S. Brilliant etal, An Image-Processing Enabled Dental Caries Detection System, IEEE 2009
6. ArumugamBanumathi, S. Raju, Diagnosis of Dental Deformities in Cephalometry Images Using Support Vector Machine, Springer, J Med Syst, 35: pp.113–119, 2011
7. Vijay Kumar Mago, Anjali Mago, Fuzzy Logic Based Expert System for the Treatment of Mobile Tooth, Software Tools and Algorithms for Biological Systems, Advances in Experimental Medicine and Biology 696,Springer, pp. 607-614, 2011
8. NovruzAllahverdi, TevfikAkcan, A Fuzzy Expert System Design for Diagnosis of Periodontal Dental Disease, IEEE 2011
9. Ali Al Haidan, Osama Abu-Hammadetal, Predicting Tooth Surface Loss Using Genetic Algorithms-Optimized Artificial Neural Networks, Computational and Mathematical Methods in Medicine, Volume 2014, Article ID 106236, 2014
10. GeorgiosPapantonopoulos, Keiso Takahashi etal, Artificial Neural Networks for the Diagnosis of Aggressive Periodontitis Trained by Immunologic Parameters, PLOS ONE, Vol 9, Issue 3, 2014
11. VoulaGeorgopoulos, ChrysostomosStylios, Augmented Fuzzy Cognitive Maps Supplemented with Case Based Reasoning for Advanced Medical Decision Support, PP. 391-405, 2014
12. Vijay Kumar Mago, Elpiniki I. Papageorgiouetal, Employing Fuzzy Cognitive Map for Periodontal Disease Assessment, Fuzzy Cognitive Maps for Applied Sciences and Engineering, 375, Intelligent Systems Reference Library 54, pp. 375-389, Springer 2014
13. Elias D. Berdouses, Georgia D. Koutsouri, A computer-aided automated methodology for the detection and classification of 73 cclusal caries from photographic color images, computers in Biology and Medicine 62, Elsevier, pp. 119–135, 2015
14. FO Ozden, O Ozgoneneletal, Diagnosis of periodontal diseases using different classification algorithms: A preliminary study, Nigerian Journal of Clinical Practice, vol 18, Issue 3, pp. 416-421, 2015
15. Philip M Preshaw, Detection and diagnosis of periodontal conditions amenable to prevention, BMH Oral Health, 15(Suppl 1):S5, 2015
16. Anita Thakur, PayalGuleriaetal, Symptom & risk factor based diagnosis of gum diseases using neural network, 6th International Conference – Cloud System and Big Data Engineering,pp.101-104, IEEE 2016
17. Le Hoang Son, Tran Manh Tuan, A cooperative semi supervised fuzzy clustering framework for dental X-ray image segmentation, Expert Systems With Applications 46, pp. 380–393, 2016
18. KirtiNagane, Nikita Dongreetal, Enriching Gum Disease Prediction using Machine Learning, International Journal of Science Technology & Engineering, Vol 3, Issue 11, 2017
19. Lin, P. L., Huang, P., etal, Automatic methods for alveolar bone loss degree measurement in periodontitis periapical radiographs, Computer Methods and Programs in Biomedicine 148 pp.1–11, 2011
20. Magda Feres, YoramLouzounetal, Support vector machine-based differentiation between aggressive and chronic periodontitis using microbial profiles, FDI World Dental Federation, International Dental Journal, 2017
21. Tran Manh Tuan, Nguyen ThanhDucetal, Dental Diagnosis from X-Ray Images using Fuzzy Rule-Based Systems, International Journal of Fuzzy System Applications, Vol 6, Issue 1, 2017
22. AbdolvahabEhsani Rad, MohdShafryMohd Rahim etal, Automatic computer-aided caries detection from dental x-ray images using intelligent level set, Multimed Tools Appl, Springer, pp.1-20, 2018
23. ArmanHaghanifar, AbdollahAmirkhanietal, Dental Caries Degree Detection based on Fuzzy Cognitive Maps and Genetic Algorithm, 26th Iranian Conference on Electrical Engineering, IEEE, pp.976-981, 2018
24. Jie Yang, YuchenXieetal, Automated Dental Image Analysis by Deep Learning on Small Dataset, 42nd IEEE International Conference on Computer Software & Applications, IEEE computer society, 2018

25. Jae-Hong Leea,Do-HyungKimaetal, Detection and diagnosis of dental caries using a deep learning-based convolutional neural network algorithm, Journal of Dentistry, Elsevier 2018
26. Maurizio S. Tonetti, Henry Greenwell etal, Staging and grading of periodontitis: Framework and proposal of a new classification and case definition, Journalof Periodontology, 89(Suppl 1):pp. 159–172, 2018
27. SaminArbabi , FarzadFirouzietal, Presenting a Model for Periodontal Disease Diagnosis Using Two Artificial Neural Network Algorithms, Health Scope,vol 7, issue 3, pp.1-6, 2018
28. Michael Newman, Henry Takei, Perry Klokkevold, Fermin Carranza, "Clinical Periodontology", 13thedition, Saunders publishers, Elsevier, July 2018
29. The American Academy of Periodontology – web site
30. Gurparkash Singh Chahal, KamalpreetChhinaetal, Smoking and its Effect on Periodontium – Revisited, Indian Journal of Dental Sciences, Volume 9, Issue 1, January-March 2017
31. Larry Laster, Kenneth W. Laudenbach, etal, An Evaluation of Clinical Tooth Mobility Measurements, Journal of Periodontal, October 1975
32. Dr. Amit Mani, Dr. Rosiline James etal, Classifications for Furcation Involvement, Galore International Journal of Health Sciences and Research, Vol.3,Issue: 1, Jan.-March 2018

AUTHORS PROFILE

MrsLAKSHMI T.K. B.Tech CSE, M.Tech Bioinformatics, M.Tech CSE and currently Pursuing PhD in CSE at Vellore institute of Technology, Vellore in the department of School of ComputerScience and Engineering. She is currently workingin Sri Venkateswara college of Engineering, Tirupati having teaching experience of 12 years. She has published many papers in National, international journals and conferences. She has been awarded as Best Teacher by IEAE, Young professor of the year by ITAP and Dr. Sarvepalli Radha Krishnan Life time Achievement award by IRDP, Best Teacher Award by ITAAP & Indian servers. Her research interests focus on Medical data &image processing and analysis, soft computing, Network security and Pattern recognition and mining.

DR. DHEEBA. J. B.E CSE, M.E CSE, MBA HRM and PhD in I&C, working as Associate professor in School of computer science and engineering, VIT, Vellore having rich teaching and research experience of 12+ years. She has a credit of 365 Citations of publications in referred journals. She published papers in many National and International journals, conferences and book chapters indexed by Scopus, Springer, dblp, SCIE and many more. Her areas of interests are Algorithms, AI, Medical Imaging, Network security, Mobile communications, and Computer networks.