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DECIDUOUS TOOTH EXTRACTION IN DENTAL X-RAY USING ADAPTIVE FUZZY C-MEANS CLUSTERING AND CAVITY FINDING USING SVM

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Abstract –Children suffer from a tooth eruption because their permanent teeth do not push their ways through the gums. Therefore, dentist will need to diagnose dental X-ray image based on characteristics of the gap between deciduous teeth and permanent teeth. In this project, we present an efficient workable method to find the teeth gap area between deciduous teeth and permanent teeth, which is based on dental work information extracted out from dental data. The method we have proposed here comprises of four main processing stages. The initial stage is pre-processing, i.e. initial work of the dental data then the segmentation step, i.e. getting the relevant part of dental data and other processing steps in segmentation. Then Feature extraction is performed on segmented images and finally teeth gap area is calculated. The method is tested on dental radiograph images. In this method we are using Fuzzy c-means clustering algorithm for segmentation of an image. In addition to this we are detecting cavity present in the teeth by using SVM.

***Key Words*: Adaptive fuzzy c-means clustering, Cavity finding using SVM.**

1. INTRODUCTION

In today's era where there is tremendous change in life of people along with their health habits too. The main problem among children is their tooth problem. There are different tooth problem arising among the children because of their unhealthy eating habits.

This is considered as main problem because this defaulting structure of teeth or cavity can cause many problems in the later life of these children.

The most common problems among these children are projection of permanent teeth before falling of deciduous teeth either frontward or backward, and another is cavity problems that arises from eating too much of sweet items. This is considered as one the main problem of children and further in this paper the depth between the deciduous teeth and permanent teeth is calculated and, it is also examined where there is cavity present is the teeth.

2. RELATED WORK

In 2016, Arisa Poonsri and Theekapun Charoenpong "Teeth Segmentation from Dental X-ray Image by Template Matching". 3D digital dental model is used for orthodontic treatment. Teeth segmentation is an important process for a 3D model construction. In this paper, we propose a method to segment teeth from a panoramic dental x-ray image. The proposed method consists of three steps: tooth area identification, template matching, and teeth area segmentation. First, to identify tooth area, the Otsu's threshold and Mahalanobis distance technique are used. Second, teeth template images with different image size are used to match with a tooth in x-ray image. Finally, overlap area from matching multiple templates is used to segment teeth. To test performance of the proposed method, twenty-five dental images are used. Totally, there are 450 single-rooted teeth, and 250 double-rooted teeth. Accuracy is 42.20 and 49.04 percent for single-root and double-root teeth, respectively. Accuracy should be improved in further. However, this is first fully automatic teeth segment method by using panoramic dental x-ray image.

In 2016, Veerabhadrappa S. T. And SnehAnand proposed "Analysis of Cardiac Dynamics due to Local Anesthesia during Third Molar Tooth Extraction using Heart Rate Variability". In this study, we performed heart rate variability (HRV) analysis of the non-medically compromised patients undergoing tooth extraction procedure using 2 ml local anesthetic volume of 2% lignocaine with adrenaline. The increase in heart rate due to vasoconstriction in the peripheral blood vessels has been quantifying the sympathetic stimulation to the local anesthesia (LA). The ECG signal is recorded from dental patients in resting condition (before local anesthesia), 2-3 min after injection of local anesthesia and 5-10 min after the tooth extraction. The time domain and frequency domain analysis of HRV are used to quantify autonomic nervous system activity (ANS). Results show that increase in LFnu and LF/HF ratio and decrease in other parameters of HRV after injection of local anesthesia (PostLA) as compared to pre-local anesthesia (PreLA). The obtained result refers to the activation of sympathetic tone instead of discharge of vagal tone due to local anesthesia.

In 2015, Dangxiao Wang, Hao Tongproposed "Interactive haptic simulation of tooth extraction by a constraint-based haptic rendering approach". Tooth extraction is a typical process in clinical dental operations. Interactive haptic simulation of tooth extraction may provide a useful tool for dental students to learn the correct force pattern and tool posture to accomplish a safe tooth extraction. In this paper, we extended our previous configuration-based optimization approach to simulate the six Degree-of-Freedom (DoF) haptic interaction process of tooth extraction. A multi-phase model was proposed to simulate progressive changes of the connection strength between the target tooth and its surrounding gingiva. An energy accumulation model was proposed to compute the small-scale rotation and translation of the target tooth under active forces from some dental forceps. The proposed approach could support training of coordinated force and motion control skill required for tooth extraction. Experimental results validated the stability and efficiency of the proposed approach to simulate various force-displacement profiles for extracting diversified target teeth.

In 2014, JuthamasNuansanong and SupapornKiattisin proposed a" Diagnosis and Interpretation of Dental X-ray in Case of Deciduous Tooth Extraction Decision in Children Using Active Contour Model and J48 Tree". Normally, children suffer from a tooth eruption because their permanent teeth do not push their ways through the gums; therefore, dentist will need to diagnose dental X-ray image based on characteristics of the gap between deciduous teeth and permanent teeth. This paper proposes image processing based on Active Contour Model and data mining for analyzing the ratio of teeth's gap area. In addition, the experiment relates to medical knowledge so as to evaluate the treatment. The results show that the ratio of teeth's gap area in a case of extraction is 20 ± 5 and tooth extraction decision in expert's way is 78 ± 7%. In a case of no extraction, the ratio of teeth's gap area is 40 ± 4.5 and tooth extraction decision in expert's way is 60 ± 6%. Therefore, if the teeth's gap area between the deciduous teeth and the permanent teeth is small, then an occasion of the tooth extraction will be higher. The decision to retain or extract a questionable tooth is one that occurs frequently in dental practice. There are many factors to consider when making this decision. Some cases are very straightforward while others fall into an unclear area of decision-making. This proposed method creates the decision model supported for the dental tooth extraction using J48 tree, and the accuracy is approximately at 98%.

In 2014, N. Kafel and J. Kolodziejski proposed "Separation of the Periodontal Ligament for A traumatic Tooth Extraction". Over 20 million tooth extractions are performed each year in the United States (2). During this procedure, the surgeon uses a perio to me to sever the ligaments anchoring the tooth to the jaw. However, this technique has proven to be traumatic to the patient's hard and soft tissue and can result in longer recovery time. Damage to the surrounding tissue also prolongs any further dental treatment and requires more time in the operating room. The Periolectric is a piezoelectric based device employing vibratory oscillations to separate the surrounding soft tissues from the tooth thereby minimizing the risk of trauma during extraction.

3. EXISTING SYSTEM

Canny edge detection technique was used for this purpose and also K-Means clustering was also used for cavity detection problem.

4. PROPOSED METHOD

In this paper the main problem among the children is taken in consideration and the depth i.e. gap between the permanent and deciduous teeth is calculated using Adaptive Fuzzy C-Mean clustering.

Initially the radiograph images of teeth are analysed. This analysing includes acquisition and pre-processing stages. Here in this paper for pre-processing stage the Gaussian filter is being used.

Later for the feature extraction, the SIFT algorithm was used. These features extracted from those dental radiograph images are further being segmented using Adaptive Fuzzy C-Means clustering. After this the calculation of tooth gap is preceded.

Further it is processed with decision making system.

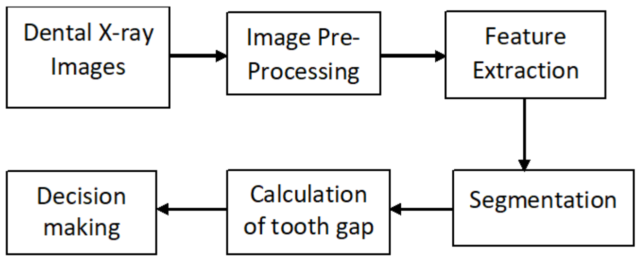

Fig. 1 Block diagram proposed system

4.1 GAUSSIAN FILTER (ENHANCEMENT)

Gaussian blur in image processing which is also known as Gaussian smoothing, using Gaussian filter results in blurring of an image, (in statistic it also represents or expresses the normal distribution) for calculating the transformation to be applied to each pixels of the image. Especially to reduce noise in an image and reduce detail, it is widely used in graphics software. Smooth blur is the visual effect of this technique that conducts resembling i.e. viewing the image through a translucent screen, entirely different from the bokeh effect generated by the shadow of an object under usual illumination or an out-of-focus lens.

Mathematically, convolving the image with a Gaussian function is same as applying a Gaussian blur to an image. This is also known to be two-dimensional Weierstrass transform. Since the Fourier transform of a Gaussian is another Gaussian, applying a Gaussian blur includes the effect of reducing the image's high-frequency components; a Gaussian blur is thus a low pass filter. The equation of a Gaussian function in one dimension is

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$$

In two dimensions, it is the product of two such Gaussians which is one in each dimension:

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Where

- x is the distance from the origin in the horizontal axis,
- y is the distance from the origin in the vertical axis,
- σ is the standard deviation of the Gaussian distribution.

4.2 ADAPTIVE FUZZY C-MEANS CLUSTERING (SEGMENTATION)

The filtered radiograph image of teeth is segmented using Adaptive Fuzzy C-Means Clustering. The Fuzzy (also refers to soft clustering) is a form of clustering in which each data point can belong to more than one cluster. Clustering or cluster analysis involves assigning data points to cluster are similar as possible. Clusters are as dissimilar as possible. In non-fuzzy clustering i.e. hard clustering, data is divided into distinct clusters, where each data point can only belong to exactly one cluster.

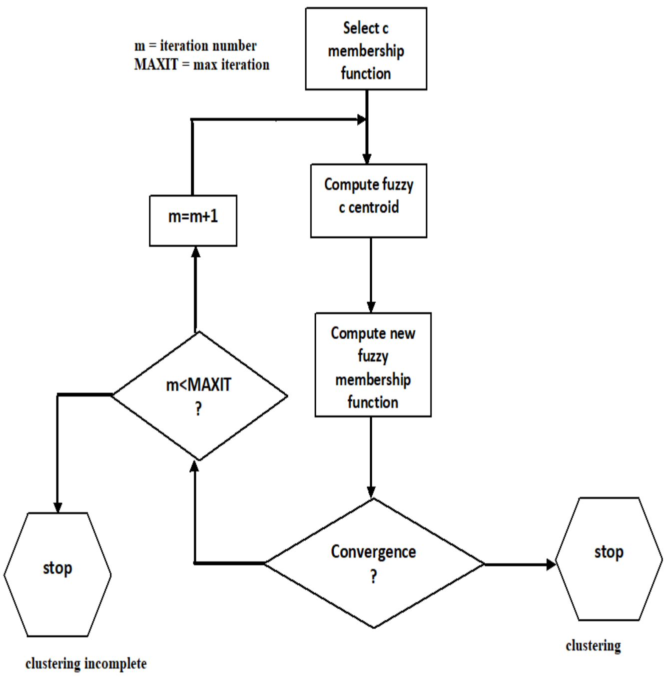

Fig. 2 Flow chart of FCM

ALGORITHM:

A Fuzzy partition F, of a set S, is defined by its membership functions for the fuzzy sets F_k:k= 1,2,...K.

$\mu_1 = [\mu_{F1}(x_1), \mu_{F1}(x_2) .... \mu_{F1}(x_n)]$

$\mu_2 = [\mu_{F2}(x_1), \mu_{F2}(x_2) .... \mu_{F2}(x_n)]$

$\mu_k = [\mu_{Fk}(x_1), \mu_{Fk}(x_2) .... \mu_{Fk}(x_n)]$

Fuzzy partition of the above expression is,

$F_1 : \mu_1 = [\mu_{11}, \mu_{12}, ... \mu_{1n}]$

$F_2 : \mu_2 = [\mu_{21}, \mu_{22}, ... \mu_{2n}]$

.

.

$F_k : \mu_k = [\mu_{k1}, \mu_{k2}, ... \mu_{kn}]$

Where,

$$0 \le \mu_{ki} \le 1$$
$$\sum_k \mu_{ki} = 1 \quad \forall i$$
$$0 < \sum_i \mu_{ki} < n \quad \forall k$$

Each value is bounded by 0 and 1.

Sum of each column values=1.

Sum of each row is less than n.

Step 1: Initialization.

Select initial membership functions such that,

$$0 < \mu_i(x_k) < 1 \quad for\ i = 1, 2, \ldots, C$$
$$\sum_{i=1}^{C} \mu_i(x_k) = 1 \quad for\ k = 1, 2, \ldots, N_S$$
$$0 < \sum_{k=1}^{N_S} \mu_i(x_k) < N_S \quad for\ i = 1, 2, \ldots, C$$

This is equivalent to specify Fuzzy clusters $F_1, F_2, \ldots F_c$. One method to accomplish this selection is to choose r_{ki} randomly from the open interval (0,1) and then normalize

$$\mu_k(x_i) = \frac{r_{ki}}{\sum_{j=1}^{C} r_{kj}}$$

$$for \quad \begin{matrix} i = 1, 2, \ldots, N_S \\ k = 1, 2, \ldots, C \end{matrix}$$

Step 2: Computations of Fuzzy centroids.

Compute the Fuzzy centroid as,

$$V_i = \frac{\sum_{k=1}^{N_S} [\mu_i(x_k)]^m x_k}{\sum_{k=1}^{N_S} [\mu_i(x_k)]^m}$$

$$i = 1, 2, \ldots, C$$
$$k = 1, 2, \ldots, N_S$$

Step 3: Compute new fuzzy membership functions.

Using the v_i, i=1,2,3…c from step 2 compute $\mu_i(k)$

$$\mu_i(x_k) = \frac{\left(\frac{1}{d^2(x_k, V_i)}\right)^{\frac{1}{(m-1)}}}{\sum_{j=1}^{C}\left(\frac{1}{d^2(x_k, V_j)}\right)^{\frac{1}{(m-1)}}}$$

Step 4: Check for convergence.

- If membership functions do not change convergence had occurred.
- If the algorithm converges μ_i represents the fuzzy clusters and we stop.
- If the converges has not occurred and the number of iterations is not less than some preassigned maximum values (MAXIT) then return to step 2.
- If otherwise then stop with no solution.

4.3 SCALE INVARIENT FEATURE TRANSFORM (FEATURE EXTRACTION)

Scale-invariant feature transform (SIFT) is an algorithm in computer vision to detect and describe local features in images. i.e. feature extraction of the image. This feature extraction is used to extract the features in an image such as mean, variance, entropy, skewness and kurtosis etc. This algorithm is used to extract the features that are invariant to rotation, scaling and partially invariant to changes in illumination resulting features are highly distinctive.

It contains the following steps:

1. **Detection:**
   - Under the location/scale change the detected points can be repeatably selected.
2. **Description:**
   - Assign orientation to detected feature points.
   - Construct a descriptor for image patch around each feature point.
3. **Extraction:**
   - Extracting the features and finding the corresponding values for a given input image.

4.4 SUPPORT VECTOR MACHINE (CLASSIFICATION)

The SVM is a classifier based on standard theory of statistic learning that finds an optimal separation surface minimizing the classification error. It can be used in linear problem solutions as well as non linear problems. In this proposed method SVM is used to classify the difference between the cavity affected tooth and normal tooth. The SVM classifier is a binary classifier that maximizes the margin. The separator hyper plane is the midway between the planes and parallel to marginal planes. The SVM algorithm finds the hyper plane with maximum margin separating. Margin plane determined by the points of each class are called Support Vectors (SVs).

5. SYSTEM REQUIREMENTS

5.1 SOFTWARE TOOLS

TYPES OF TOOLS

- MATLAB

5.1.1MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

•Math and computation

•Algorithm development

•Modeling, simulation, and prototyping

•Data analysis, exploration, and visualization

•Scientific and engineering graphics

•Application development, including graphical user interface building

5.2 Hardware Requirement

Processor	:	Any processor above 2GHZ
RAM	:	2GB
Hard Disk	:	300GB and above

6. RESULT ANALYSIS

The result of this paper is given below, which is obtained using Adaptive Fuzzy C-Means Clustering for segmentation, SIFT for feature extraction and SVM for finding cavity through classification.

Result of teeth gap detection:

If the gap present between permanent and deciduous teeth is greater than the value 4, then removal of teeth is possible.

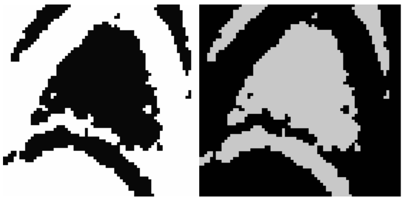

Fig. 3 Diagram of enhanced and segmented image for teeth gap detection

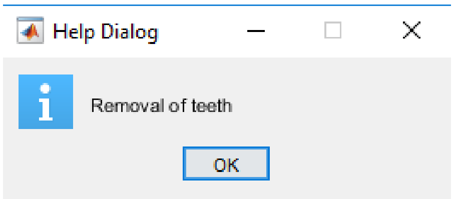

Fig.4 Dialog box showing result of teeth gap detection.

Result of cavity detection:

Below are images related to result of cavity detection.

Fig. 5 Diagram of enhanced and segmented image for cavity detection

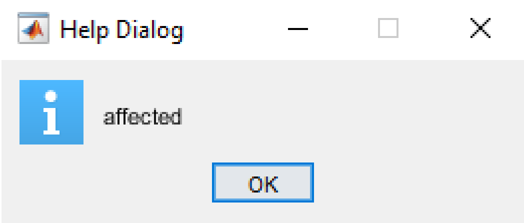

Fig. 6 Dialog box displaying tooth to be affected by cavity.

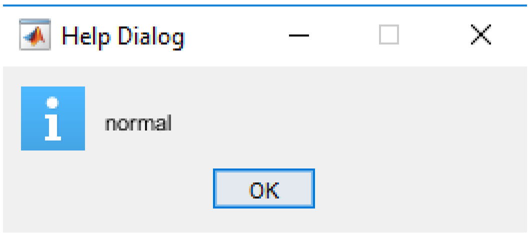

Fig.7 Indicates that the tooth is not affected by cavity.

CONCLUSION

This paper presents a more novel and efficient way for calculating the dental gap between deciduous teeth and permanent teeth and also finding the cavity problem from the radiograph image is the teeth i.e. X-ray image of the teeth, using Adaptive Fuzzy C-Means clustering and SVM is used for classification purpose.

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