SEMI AUTOMATIC LANDMARK LOCALIZATION ON 2D CEPHALOMETRIC IMAGES

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Abstract: The significant localization of desirable features to skull structures of cephalograms are clinically useful for cephalometric diagnosis, superimposition and treatment planning for malocclusion. For computation of analysis steps and for determination of underlying structures, provided landmarks should be correctly localized. Due to the complexity of human anatomy sensed in a cephalometric x-ray, the landmarks are localized by human experts. In the last few years, efforts have been made to automate this process. In this paper a novel methodology has been stated for localization of cephalometric landmarks. A combination of Multilayer Perceptron and Back propagation algorithm has been introduced to localize the landmarks. A set of fifty images has been used for training the neural network, at first nasion, gonion and menton are located manually on each of the 50 images, further based on the location of these three landmarks 21 features has been extracted from each of the training images. Now these 21 features exhibit as they represent each image. Now a Multilayer Perceptron (MLP) neural network has been trained with these 21 features as the input layer with reference to the output layer. After training the MLP is used to detect the location of landmark based on knowledge obtained by trained neural network.

Keyword: Cephalometric; Cephalogram; Multilayer Perceptron; Malocclusion

1. INTRODUCTION

Cephalometry is the science of measuring the human head in living individuals to diagnose craniofacial growth and development. This is an orthodontic application for assessing craniofacial growth using the measurement of the dimension of head through standardized lateral skull radiograph or cephalogram. These measurements are done by many studies which are based on analysis of sets of feature points called Cephalometric Landmark in hard and soft tissue. Orthodontics, orthopedics, and other areas of oral and maxillofacial surgery are used x-ray images to detect landmark points to perform analysis and measurements of the various angular and linear parameters.

Currently a cephalometric analysis is manually intensive, and it can take an experienced orthodontist up to thirty minutes to analyses one cephalogarm. General step of cephalometric analysis is taking photographs and radiograph, tracing the radiograph, identify landmark, measurement, compare to normal at last identify class of malocclusion or abnormality. Figure2 demonstrates location of different cephalometric landmarks on human skull. It was the first time when Cardillo et. al. [1] proposed a soft computing based approach for detecting Cephalometric landmarks. Later a number of researchers [2, 3, 4] demonstrated their effort for detecting landmarks by soft computing approach. The remainder of this paper is organized as follows Contribution is depicted in Section 2, it shows that how the new method are suitable for extracting most of the landmarks required for cephalometric analysis and in Section 3 by describing the result and discussion, it is manifested that how the approach is efficient for fulfilling the requirement.

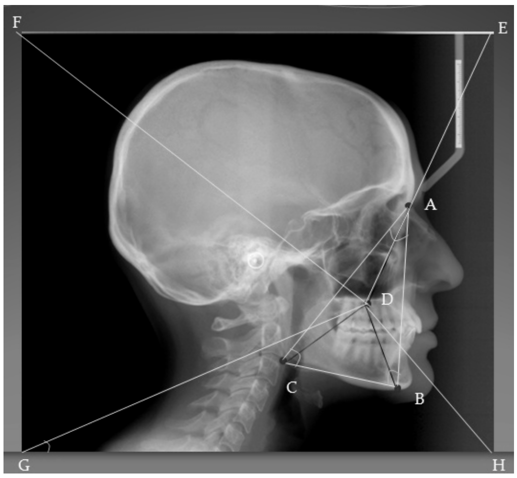

Fig. 1: Features extracted using these three points

2. FEATURE EXTRACTION

Feature means some geometrical parameter which representing a specific image. For feature extraction a graphical user interface (GUI) has been designed. Firstly using GUI three landmark points are marked on each image then using these three point extracting 21 features are extracted from each image. These feature parameter measures the exact position of skull and rotation of skull according to relative position.

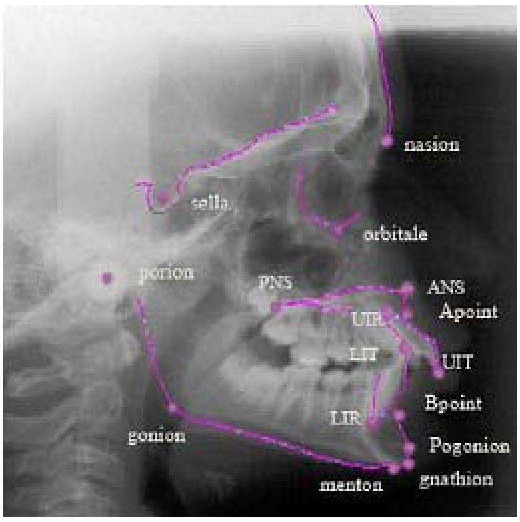

Fig. 2 Landmark locations

The distance between two points having coordinate (x1, y1) and (x2, y2) are calculated as:

$$D = \sqrt{(x_2 - x_1)^2 - (y_2 - y_1)^2}$$

And for calculating angle between two line

$$\tan\theta = \frac{m2 - m1}{1 + m1m2}$$

Where θ angle between two line and m is slope of

the line, $m = \frac{y_2 - y_1}{x_2 - x_1}$

For calculating area of polygon, by considering a polygon made up of line segment between N vertices (x_i,y_i), i=0 to N-1. The last vertex (x_N,y_N) is assumed to be the same as the first i.e. the polygon is closed. The area of polygon is defined as:

$$A = \frac{1}{2}\sum_{i=0}^{N-1}(x_i y_{i+1} - x_{i+1} y_i)$$

For calculating centroid as in the calculation of the area above, x_N is assumed to be x_0, in other words the polygon is closed.

$$c_x = \frac{1}{6A}\sum_{i=0}^{N-1}(x_i + x_{i+1})(x_i y_{i+1} - x_{i+1} y_i)$$

$$c_y = \frac{1}{6A}\sum_{i=0}^{N-1}(y_i + y_{i+1})(x_i y_{i+1} - x_{i+1} y_i)$$

Fig. 1 depicts how features are extracted using three point A,B,C and other point E,F,G and H which are all corner coordinate of images. Table 1 describes 21 features, like area, distances, perimeter, angle. By considering these features according to the fig. 1 a representation of each image has been demonstrated.

Table 1: Describes feature name and description. These features denoted in a matrix structure, represents the input data set

S.N0.	**Name**	**Description**
1.	AB	Distance between point A and B
2.	BC	Distance between point B and C
3.	CA	Distance between point C and A
4.	FH	Distance between point F and H
5.	Dx	Horizontal coordinate of triangle centroid.
6.	Dy	Vertical coordinate of triangle centroid.
7.	DE	Distance between point D and E
8.	DF	Distance between point D and F
9.	DG	Distance between point D and G
10.	DH	Distance between point D and H
11.	M	X coordinate of image size
12.	N	Y coordinate of image size
13.	O1	Angle between line AB and BC
14.	O2	Angle between line BC and CA
15.	O3	Angle between line AB and CA
16.	O4	Angle between line DC and vertical
17.	A	Area of triangle ABC
18.	Pr	Perimeter of triangle ABC
19.	DA	Distance between D and A
20.	DB	Distance between D and B
21.	DC	Distance between point D and C

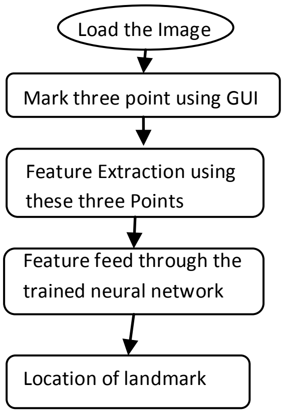

Fig. 3: Demonstrates the proposed

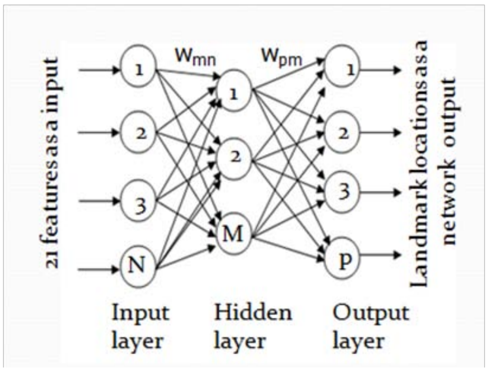

Fig 4: Architecture of MLP

Figure 3 revels the proposed methodology. According to the flow chart at first the image on which we want to perform operation, or cephalometric analysis are loaded, later using GUI three points A, B and C are manually marked. The next approach is feature extraction, using these three points as well as other four corner of image explained in table 1, and then these features are feed through a trained/simulated neural network and at last desired landmark locations are obtained as a network output.

3. NETWORK STRUCTURE AND TRAINING

For training the neural network we are using three layers MLP and for updating the weight and biases back propagation algorithm have been used on the basis of least mean square. In this application MLP made up with three layers as input layer, hidden layer, output layer as it shown in fig. 4 showing the architecture of MLP

As explain earlier using three points 21 features are extracted for 50 images which generates an input dataset this dataset randomly divided into three dataset, these are training data set, cross validation data set, testing dataset. This input dataset used as an input layer corresponding with output dataset i.e. location of the landmarks, trains/updates connection weight according to the back propagation algorithm. We start training procedure consisting 15 hidden layers and it increases up to 22 layers as per the increasing hidden layer, the convergence time increases, error is decreases until the stable structure reached. Network works as a mapping function which maps the input output relations corresponding to the data set, this procedure continue until the mean square error reduces by10^{-3}.

4. RESULT

We performed experiment on 255 gray level images of 300 dots per inches using MATLAB neural network toolbox on Intel (R) Pentium (R) D CPU 3.40 GHz processor, 2GB RAM computer. Network takes 20-30 minute to train but after training it simulates within micro second. We used variable learning rate gradient descent back propagation algorithm, 21 hidden layers, 0.01 learning rate with these parameter network are trained. The error rate varies from 2-5 mm for different landmark locations. By the observation it can be stated that some of the landmarks are located at exact location but some is error prone. Fig. 4 showing the result how using three points the other landmarks are located.

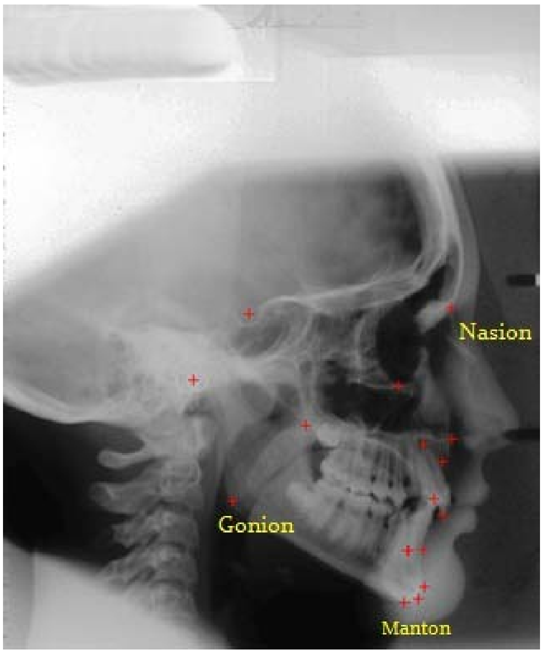

Fig. 5: Result of landmark

Table 2 Obtained Result

S.No.	Landmarks	Max. Diff. (mm)	Min. Diff. (mm)	Avg. Diff. (mm)
1.	Porion	8.2	2.3	5.2
2.	Sella	5.6	1.0	3.3
3.	Orbital	5.8	1.0	2.6
4.	Upper incisor root	6.4	0.7	3.3
5.	Upper incisor tip	7.3	0.9	3.4
6.	Gnathion	5.9	0.7	2.7
7.	Pogonion	5.7	0.3	2.7
8.	B-Point	3.8	0.1	2.1
9.	PNS	2.8	1.1	1.8
10.	ANS	8.2	1.4	3.9
11.	A – point	7.5	1.0	3.5
12.	Lower incisor root	5.0	1.0	2.8
13.	Lower incisor tip	6.0	1.1	3.2

5. . CONCLUSION

In this paper we proposed semi automatic landmark localization on 2-D cephalogram can be find out approximate location of landmark. We expect that if we increase data set we can find out exact location of landmark. Using only 50 images data set we located 76 % of the landmark with some variation.

6. REFRENCES

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