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Research Article

DIGI ANALYSIS: STATIC AND DYNAMIC EVALUATION OF FACIAL ASYMMETRY & MANDIBULAR DEVIATION

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ABSTRACT

Asymmetry can be defined as lack of equivalence between parts or aspects of something. The face often presents with a mild degree of asymmetry. Perfect bilateral symmetry is rarely found. In relation to the face, the midsagittal plane is taken for symmetry and balance, with respect to size, shape and arrangement of the facial features. Various factors such as cleft lip, hemi-facial microsomia, and childhood fracture of the jaw have been reported to be associated with facial asymmetry resulting in pathologic asymmetry of the face. On the other hand, minor non-pathologic facial asymmetry, which is defined as the difference in size between the left and right hemifaces, or normal asymmetry, is relatively common. Nevertheless, slight asymmetry, also known as relative symmetry, subclinical asymmetry or normal asymmetry, ends up being unperceived by its carriers and everyone around them. Management of facial asymmetry is one of the arduous and challenging task to accomplish in disciplines of orthodontics and maxillofacial surgery. Mandibular laterodeviation is one of the most evident malformations of the face, because it alters the lower third of the face. Etiologically it can be classified into: Static laterodeviations caused by teeth; Static laterodeviations caused by skeleton change: by monolateral hypertrophy (condyle, condyle and neck of the condyle, half mandible hypertrophy); by monolateral hypertrophy (congenital pathological); Dynamic laterodeviations which are functional in nature. The aim of this study is to evaluate the face for symmetry, proportion and any presence of mandibular deviation both statically and dynamically calibrated to millimetre scale. DLIB facial landmark detection model, are pretrained models for point detection is being used to write a program to assess symmetry, proportion and any presence of mandibular deviation both statically and dynamically calibrated to milli metre scale using an open CV and python 3 platform. Video of the patient during opening and closing of the mandible will be recorded and given as input to the developed software and the desired output will be given.

INTRODUCTION

In everyday life, the most important stimulus in interpersonal communication is the face. Faces are the focus of attention in human interaction and our initial impression of other people is formed from what we perceive when we look at them[6]. The human face often manifests with a mild, moderate, severe degree of asymmetry. Nevertheless, slight asymmetry, also known as relative symmetry, subclinical asymmetry or normal asymmetry, ends up being unperceived by its carriers and everyone around them. However, whenever the degree of asymmetry is more severe, the condition is typically rendered noticeable, which negatively affects one's facial and smile esthetics[7]. Deviations and deflections during temporomandibular gait may be caused by muscular, neuromuscular or mechanical dysfunction. Deflection of the mandible is movement away from the midline during opening without return to center during the movement. In this paper, we aim to design and implement an automatic midline deviation diagnosis tool (MDD) that takes input a video of a patient opening and closing their mouth, and outputs a graph plotting the magnitude of deviation in their midline versus the length of their mouth opening and also numerically evaluate the facial fifths in terms of the magnitude. To the best of our knowledge, we believe MDD is the first automatic software tool that guarantees accurate results in estimating the midline deviation and facial asymmetry.

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Design of MDD

Figure 1 gives an overview of the components involved in MDD.

Clinician records the video of t patient slowly opening and closing their mouth and feeds it into MDD tool.

The diagnoser has three main modules in it: (1) Face and facial landmark detection (2) Camera calibration and (3) Diagnosis tool itself.

Face and Facial Landmark Detection*:* A video is made up of several individual image frames captured at different continuous time stamps.

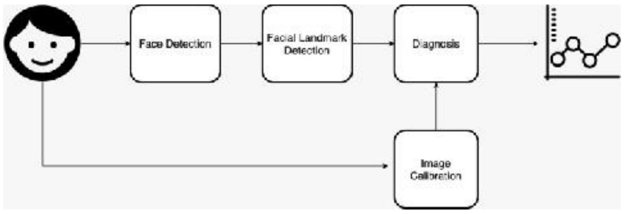

Figure 1 Workow of Midline Deviation Diagnoser

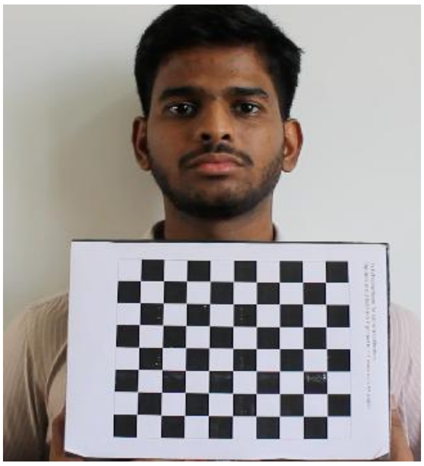

Figure 2 Patient holding a checkerboard in their hands while recording the diagnosis video for camera calibration purposes.

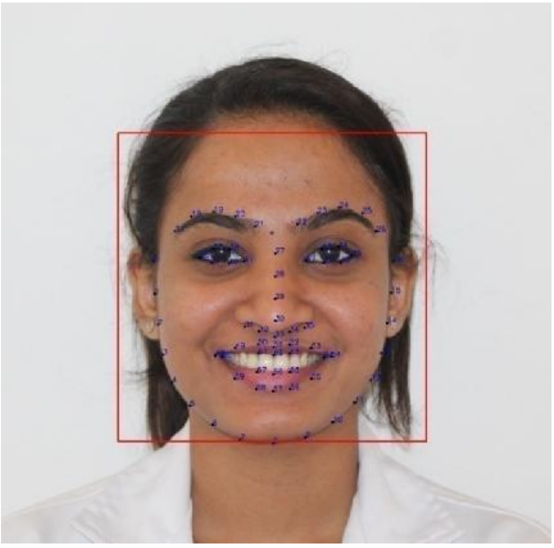

Figure 3 Image showing patients Face and corresponding facial landmarks. The red bounding box is the detected face using Dlib and Haar frontal face classifier and the within this bounding box there are 68 facial landmarks which are detected using Dlib and its inbuilt pretrained shape predictor**.**

As a first step, we read each image frame in the video and detect faces in it. MDD expects to find a singular face in every image to perform the next step, that is, facial landmark detection. Facial Landmarks are the key facial points in a human face, such as end points of eyes, ears, mouth, nose and chin. There are existing architectures which detect faces and subsequently detect at least 32 key facial points which characterize a face. They are mostly based on Haar classifiers and deep convolutional neural networks (DCNN). MDD relies on two main key points, nose and chin points. It traces the path in which these key points traverse across the frames in the video to estimate the amount of deviation at different dimensions of mouth opening.

Note: we assume that a video contains image frames of the same patient, that is, the entire video should be of the same person.

Camera Calibration This step maps the pixel units of the image frame into real-world dimension. To estimate the real length of each pixel in the frame, we use the checkerboard method[5]. While recording the video, doctor asks the patient to hold a checkerboard, for which they know the dimension of each square, in their hand. During camera calibration, MDD reads the first frame of the video and detects the checkerboard in it to estimate the number of pixels length-wise for each square, and accordingly measures the real length of each pixel.

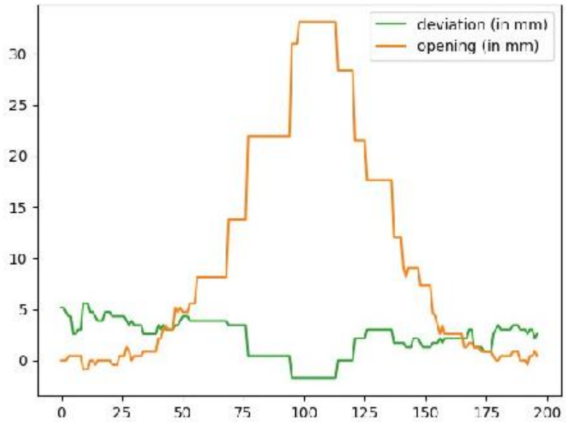

Figure 4 Opening and Midline Deviation analysis using MDD. Note that the input video for which this output graph is generated has 200 frames in it and thus, the x-axis goes from 0 to 200. Y-axis is distance in millimeters.

Diagnosis Tool After detecting the nose and chin points, this tool finds the horizontal and vertical distance between these points and converts them into real-world length using the real pixel length from the camera calibration module. The vertical distance is the mouth opening length and the horizontal distance is the midline deviation. Repeating this procedure for all the frames in the video, gives a comprehensive diagnosis report of how much deviation is observed (along with the direction of the deviation) at each interval of the mouth opening. This Diagnosis tool is also equipped with estimating the lengths of facial segments using the facial landmarks. It can output precise measurements of five vertical and four horizontal face segments. These segments are also configurable. Doctors can choose which segments they want to output and configure the tool to output those segments along with the default segments.

Implementation Details MDD is implemented in Python with approximately 200 lines of code. MDD uses Open CV library[4] for preprocessing the video and reading each frame from it. We used a checkerboard with 21.5 mm squares and asked patients to hold them during video recording (see figure 2). Since Open CV already includes an API for finding checkerboard squares, we directly use this API in MDD to get the length of each square of the detected checkerboard and estimate the length of each pixel. For face detection, MDD uses Face Recognition v1.2 library[3], which is basically a wrapper on Dlib[1], with Haar front face classifier to detect a face. And for the facial landmarks, MDD uses Dlib's shape predictor module with inbuilt 68 face landmark predictor which is pretrained using iBUG 300-W Dataset[2]. We are primarily interested in points numbered 8 (for chin) and 30 (for nose) in this predicted set of 68 key points. Figure 3 shows a sample detected face and facial landmarks. Finally, MDD outputs a graph similar to the one shown in figure 4 with x-axis as the frame number and y-axis as distance in millimeters. The orange line depicts the vertical length of the mouth opening and the green line shows the horizontal deviation of the midline. It is evident from the figure that as mouth opening increases and decreases, the pattern in which the deviation changes remains approximately symmetric over the center of the graph (at 100th frame), because that is when the patient starts to close their mouth after opening it to the maximum extent. MDD's deviation measure accuracy depends on the video quality and performance of Dlib's facial landmark detection mechanism. Better the quality and better the performance of the underneath detection models, better the accuracy of the diagnosis via MDD.

CONCLUSION

It is worthwhile to rely our diagnosis on presicion. MDD gives us an opportunity to evaluate the mandibular deviation and facial asymmetry accurately, at a faster rate and also helps the clinician to have a check on the progress of the treatment rendered.

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