Letters

OBSERVATION

A Machine Learning Approach for Automated Facial Measurements in Facial Palsy

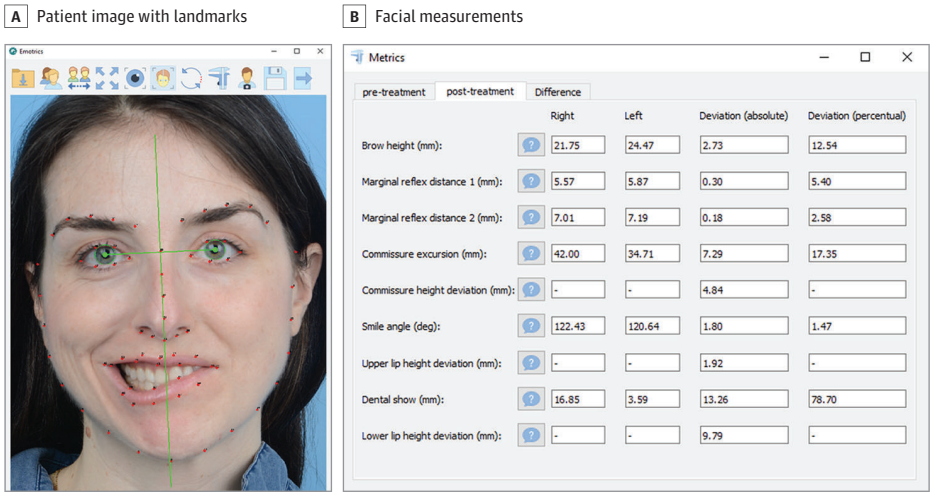
An ongoing problem in the management of facial neuromotor disorders is the lack of a universal outcome measurement system.[1] Objective systems have been developed to quantify facial symmetry.[1-3] However, these systems are time consuming, require expensive and complicated hardware, and can be difficult to implement in clinical practice. Recently, machine learning techniques have been developed that enable automatic localization of facial landmarks using large data sets of facial photographs.[4-6] We have leveraged these technological advances to develop Emotrics, a simple, high-throughput software platform that enables automatic facial landmark localization and computation of facial measurements.

Emotrics is designed for use with frontal-view clinical photographs, automatically placing facial landmark dots on an uploaded image. Emotrics automatically generates multiple facial measurements by scaling iris diameter to pixel width in each image. This measurement technique uses a mean human population iris diameter of 11.77 mm; this value is comparable to that used in the Massachusetts Eye and Ear Infirmary's FACE-gram software (Sir Charles Bell Society). However, Emotrics has 2 important advantages over FACE-gram. Emotrics rapidly computes multiple relevant facial measurements simultaneously, with full analysis of one image taking less than 5 seconds on average. Emotrics can also analyze the differences between 2 photographs, which allows automated calculation of smile excursion.

Functionalities | The user can manually reposition any facial landmark dot requiring refinement (red dots). Facial landmark dots should outline the superior border of the brow, the free margin of the upper and lower eyelids, the nasal midline, the nasal base, the mucosal edge and vermillion-cutaneous junction of the upper and lower lips, and the lower two-thirds of the face. The locations of the eye centers (green dots) and iris borders (green circles) may also be finely adjusted, which provides additional flexibility and accuracy. The facial midline may be displayed to ensure that the user is satisfied with its position (**Figure 1**); this line is computed as a line perpendicular to the interpupillary plane at the midpupillary point.

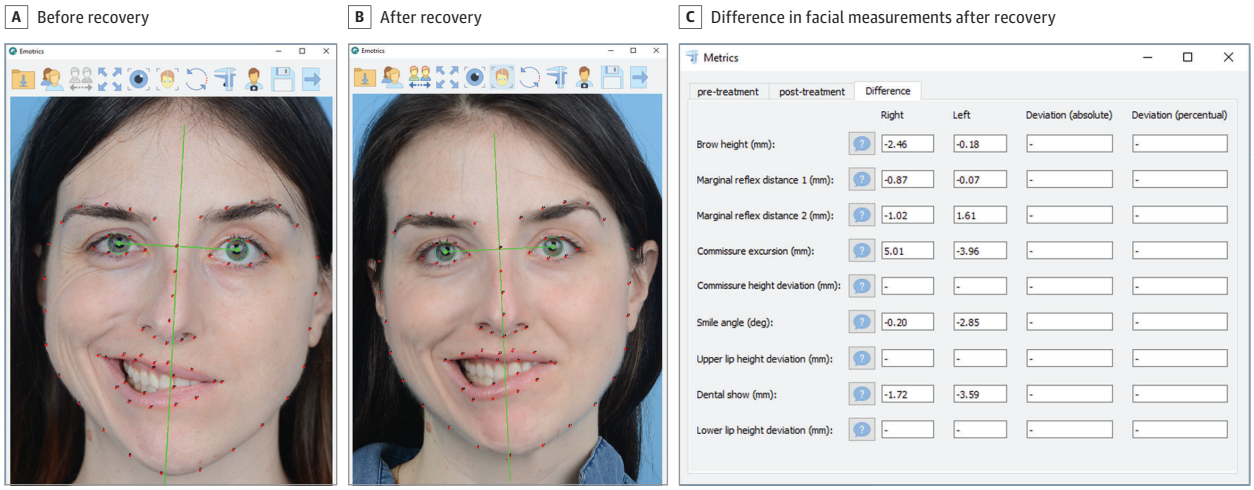
Emotrics automatically computes a literature-established set of facial measurements relevant to facial palsy (Figure 1). Brow symmetry, palpebral fissure width, smile excursion, and smile symmetry outputs are automatically generated. During future development of Emotrics, outputs will appear in an even more user-friendly fashion. Emotrics can also measure differences between any 2 images manually selected by the user (**Figure 2**), although ultimately this process will be automated. By comparing images obtained before and after intervention, users can rapidly obtain measures of treat-

Figure 1. Graphical User Interface of Emotrics and Facial Measurements Computed From the Facial Landmarks



A, Icon bar displays the different functionalities: load image, load patient, compare 2 images, change image, fit image to window, resize iris diameter, find facial midline, toggle landmarks, show facial measurements, take screenshot, save results, and exit. Each function is fully described in the video tutorial. The window of Emotrics displays the facial photograph with the 68 facial landmarks (red dots) and bilateral iris positions (green circle). The face midline (vertical green line) can be easily estimated and displayed as a reference. B, Pixel width is automatically normalized using a mean iris diameter of 11.77 mm to produce millimetric values. A complete description of each facial measurement is available within Emotrics by clicking on the help icon.

Figure 2. Case Example of a Patient With Aberrant Recovery From Left-Sided Bell Palsy



This example shows photographs taken before (A) and after (B) recovery. The facial midline is shown in both patient images, computed as a line perpendicular to the interpupillary plane at the midpupillary point. The difference in facial measurements between photographs obtained before and after recovery (for both sides of the face) is shown in panel C.

ment effects. Similarly, comparing the facial position during maximum smile effort with the resting facial position enables automated measurement of smile excursion.

Discussion | Emotrics was created using a database of normal faces, which renders the program prone to localization errors in cases of gross facial asymmetry. User verification of landmarks is recommended for photographs of patients with facial palsy. An additional limitation is that the accuracy of the measurements is dependent on image quality. Image resolution of at least 1 megapixel is ideal; at least 1 iris should be visible, and there should be no head yaw or tilt (head roll is acceptable). If the eyes are closed, the user can import pupil positions from a previous photograph in the same clinical series, which would enable measurements in these images. Where there is strabismus or orbital dystopia, the user may manually select an ideal pupil position that enables facial measurements.

An objective means of characterizing facial displacements is essential to the management of facial palsy. Emotrics harnesses recent advances in machine learning to automatically compute facial displacements from standard photographs. This tool may facilitate communication of disease severity and outcomes within the field of facial reanimation by means of shared, objective, data-driven language. Emotrics is freely available and can be downloaded, along with detailed tutorial videos, from the Sir Charles Bell Society website (http://www.sircharlesbell.org/).

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