Automated Cleft Severity Rating

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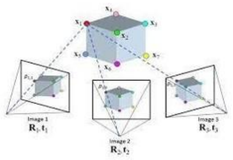
Introduction

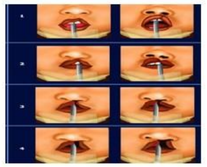
A cleft lip is a congenital deformity affecting the nasolabial area, with a frequency of approximately 1 in 700 births worldwide [1]. The severity of the condition can vary greatly, leading to functional complications or psychological challenges.Therefore, to treat cleft lips, facial reconstructive surgeons perform multiple surgeries. However, assessing healing progress is challenging without a reliable severity index to measure and track the severity of the condition.

Literature Review



Stereo-Photogrammetry

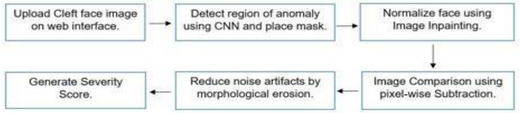
3D image of head created by overlapping 2D images from various positions.



Cleft Severity Index

Four discrete categories - Mild Incomplete, Incomplete, Complete, and Severe Complete.

Modeling and Analysis



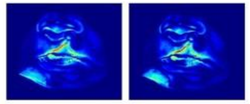
Functional System Diagram of an Automated Cleft Severity Rating Mechanism

To automate the severity rating of cleft lips, the doctor uploaded the image containing the cleft lip on a web interface. A Convolutional Neural Network (CNN) is used to identify the cleft-affected area, and a mask is applied to it. The mask hides the pixel values of a given area which is regenerated by using an image inpainting model called **Stable Diffusion** [2].

Cleft Image | *Anomaly Masked* | *Normalized Image* | *Difference Heatmap*

Inpainted images sometimes have noise artifacts, such as changes in lighting and softened colors, which can affect the comparison process. So, to reduce the noise, we use morphological erosion on the difference image.

This procedure involves examining individual pixels, determining their neighbourhood pixels, and subsequently substituting the pixel value with the minimum value of its neighboring pixels as shown in the equation above. The mean squared error value of the eroded image was then calculated and converted into a severy score on a scale between 1 to 7.



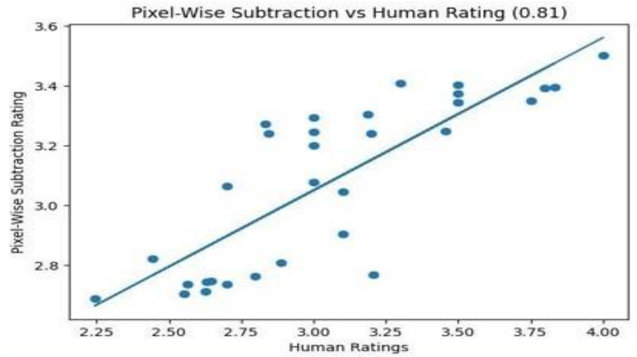
Before Erosion | *After Erosion*

Data Collection

A survey was created to ensure that the rating of the cleft severity generated by Pixel-wise Subtraction is comparable to the rating of human evaluators. The participants were asked to rate the severity of 30 cleft images by assigning each image a value between **1 to 7**, where **1** represented the **least normal** and **7** represented the **most normal**. There were a total of 100 participants in the survey. The ratings given by the participants were averaged and then compared with the rating generated by the model.

Results

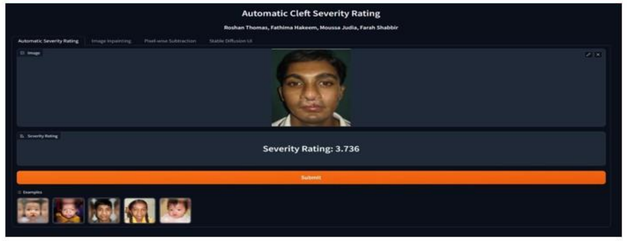
The performance of our model was measured by comparing the score generated by our model to the human ratings collected through the survey and calculating the Pearson Correlation Coefficient. This was done using 31 images of cleft patients, for which our model proved to show a 81% correlation.



Future Work

The model can be improved by training it with large number of cleft images with corresponding human ratings. We can also use other similarity score mechanisms such as LPIPS and SSIM to provide alternative accuracy measures. Our solution for an automated mechanism can be improved by further refining the parameters used in Stable Diffusion (image inpainting) and PSE.

Web Interface



The web interface allows the rating process to be automated. The doctor is only required to upload an image of the cleft patient. The interface will then provide a normalised image, a difference map, a heat map and a a severity score. The web interface will be locally hosted at the hospital's servers to avoid data privacy concerns.

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Conclusion

Facial Reconstructive Surgeons do not have an automatic rating mechanism to rate the severity of cleft lips. Our solution produced a web interface, where doctors can rate and track the progress of their patients. It is an automated process of image inpainting and image comparison techniques to produce a severity rating. The results were verified

References

[1] "Cleft Lip and Palate | Children's Hospital of Philadelphia." [Online]. Available: https://www.chop.edu/conditions-diseases/ cleft-lip-and-palate

[2] R. Rombach, A. Blattmann, D. Lorenz, P. Esser, and B. Ommer, "High-Resolution Image Synthesis with Latent Diffusion Models," Apr. 2022. arXiv:2112.10752.

[3] R. G, "How to Repair your Damaged Images with Deep Learning." https://medium.com/@renithprem/how-to-repair-your-damaged-images-with-deep-learning-cc404aec144, Aug. 2020

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