

Using Machine Learning to Identify Key Features for Facial Gender-Affirming Surgery

Emily S. Chwa, BA¹; Toshinobu Harada, PhD²; Taiki Yamada, BA²; Saki Otsuda, PhD²; Sophia Allison, BASc¹; Akira Yamada MD PhD^{1,3}

¹Northwestern University Feinberg School of Medicine, Chicago, IL ²Wakayama University, Wakayama, Japan ³Division of Plastic & Reconstructive Surgery, Ann & Robert H Lurie Children’s Hospital, Chicago, IL

Background

Applications of artificial intelligence to plastic surgery have been limited despite its ability to advance practice. The goal of this study was to create a validated machine learning mode using three-dimensional (3D) images to identify and measure differences in facial feature curvature by gender.

Methods

Three-dimensional photos of 75 men and 75 women aged 20-29 were each divided into 100 cross-sectional images and used as training/validation and test data to build a convolutional neural network that could classify gender based on facial imaging through curvature analysis. Gradient-weighted Class Activation Mapping (GRAD-CAM) was then implemented to measure the facial curvatures used by the model as the basis of inference when determining gender.

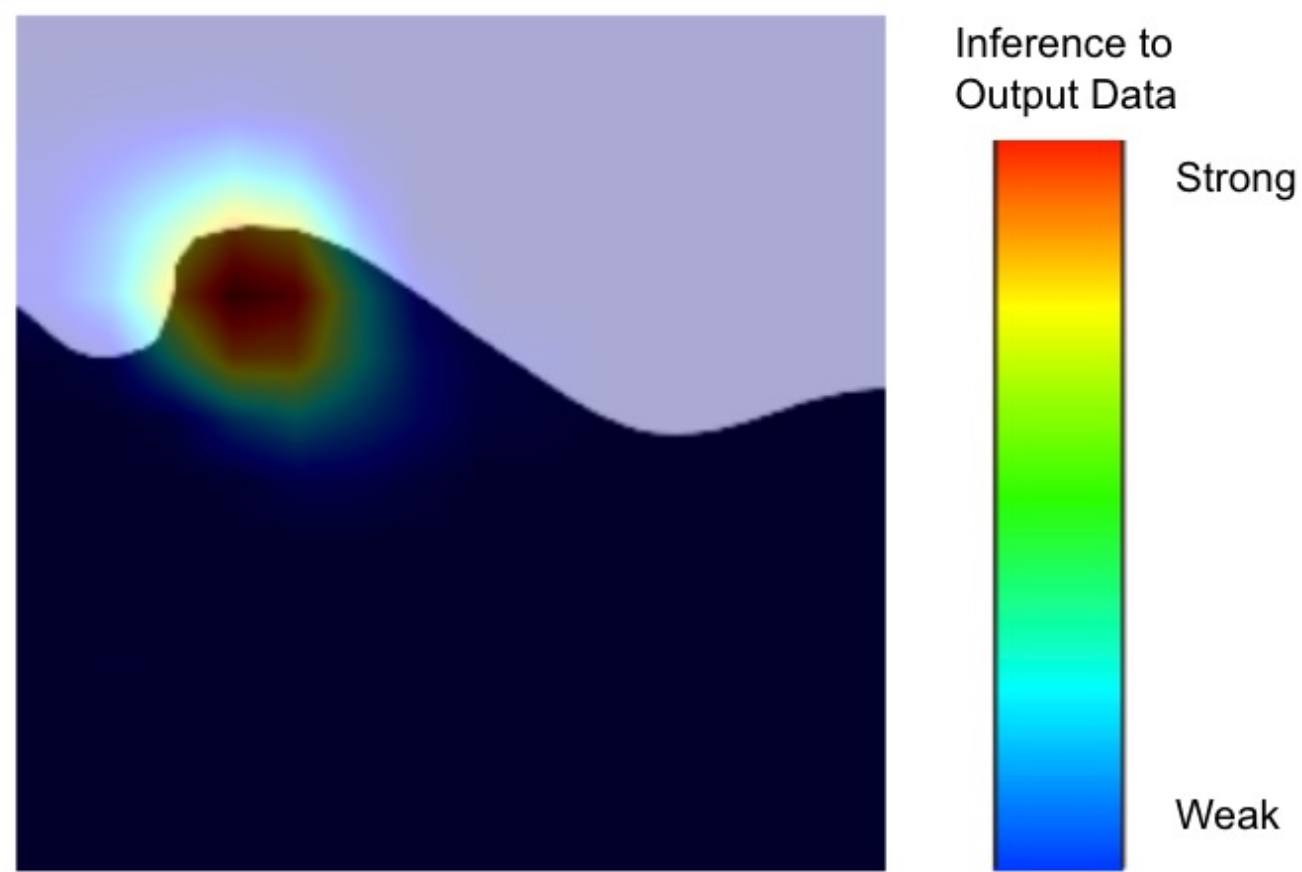


Fig 2: Application of Grad-CAM software to the test data to train the model before validation

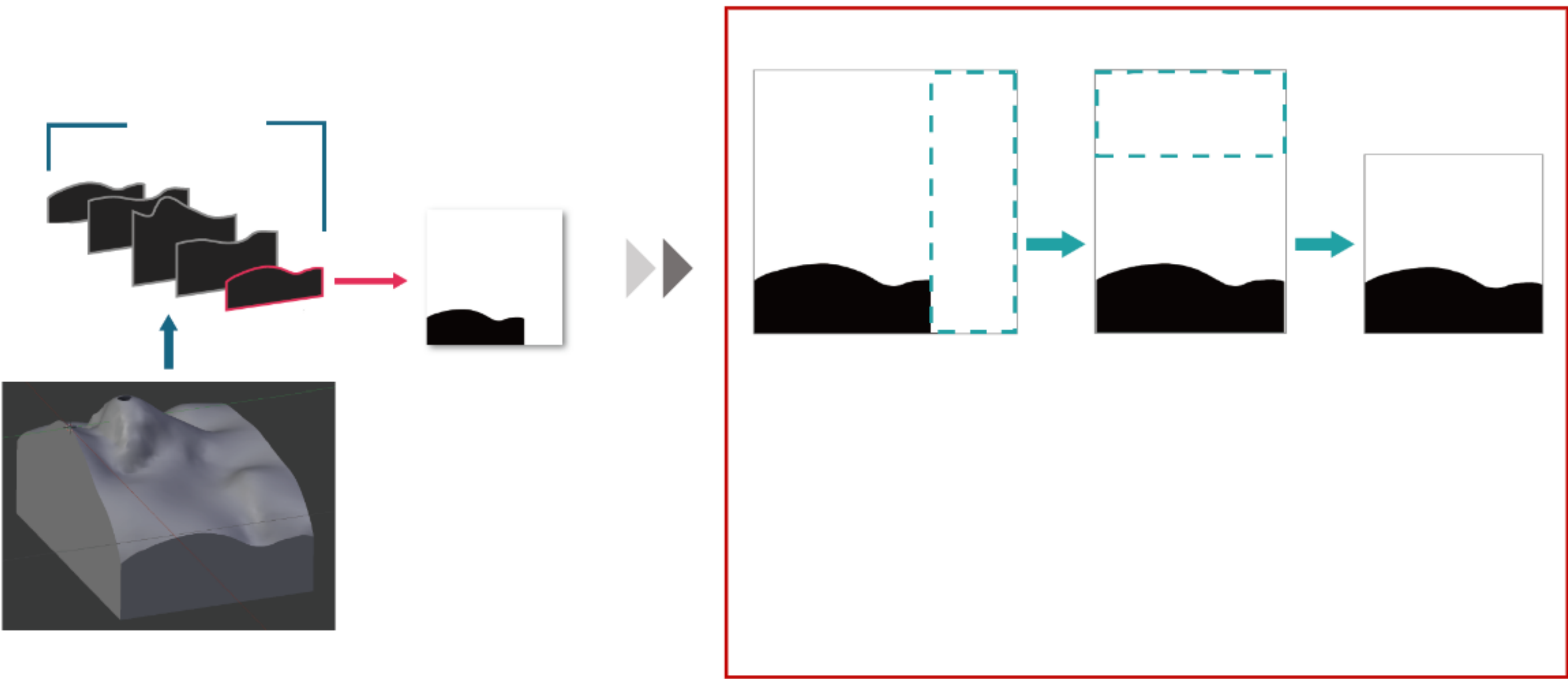
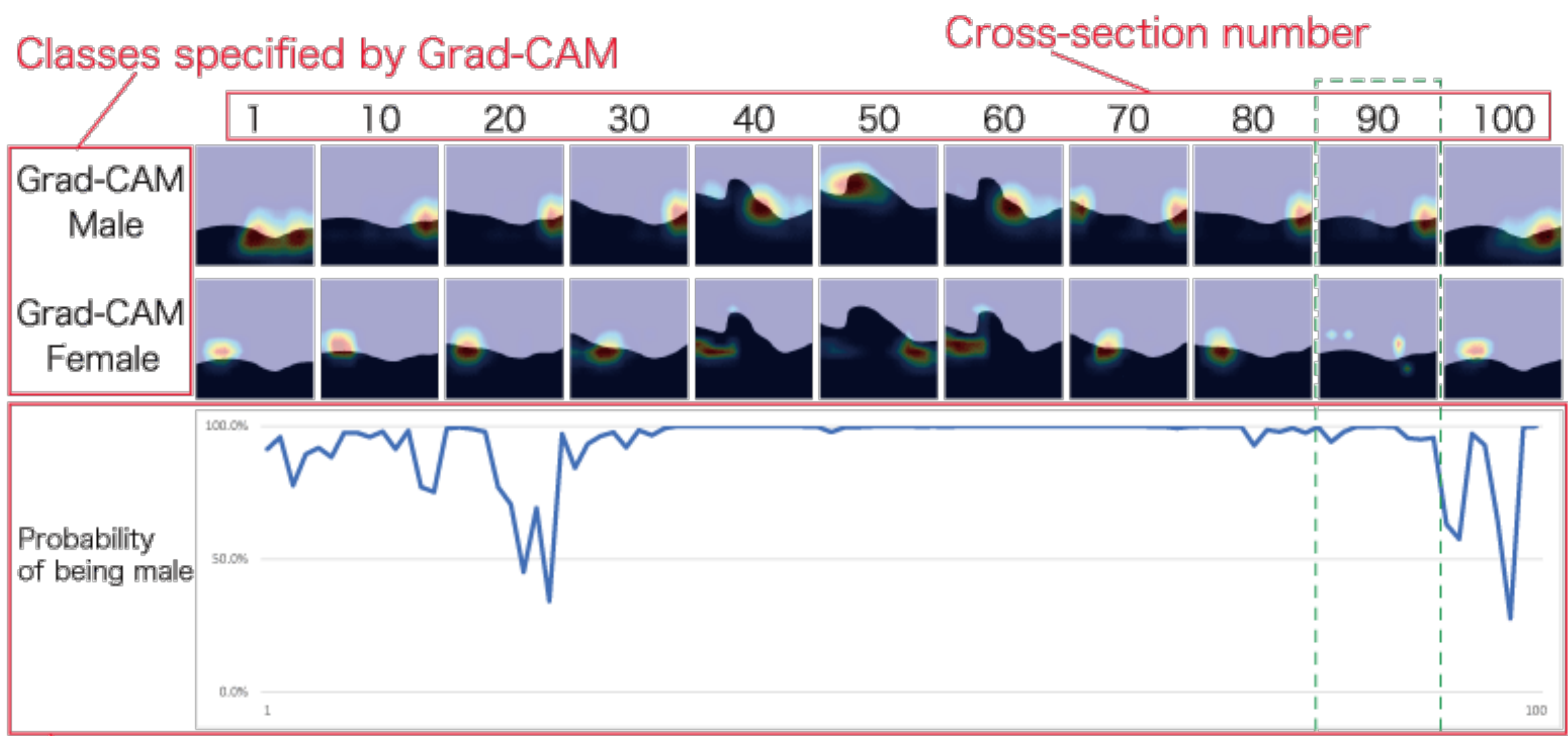


Figure 1: Process of using 3D images to generate 100 cross-sectional images from the left to right zygomatic apices. These images were then analyzed by the Grad-CAM software.

Figures



Graph of classification accuracy that can classify a cross section of men as male (Graph of classification accuracy that can be classified as female if female)

Fig 3: Results of applying Grad-CAM software to the test data (30 people randomly selected from the sample) after creating the model using training data (120 people randomly selected from the sample)

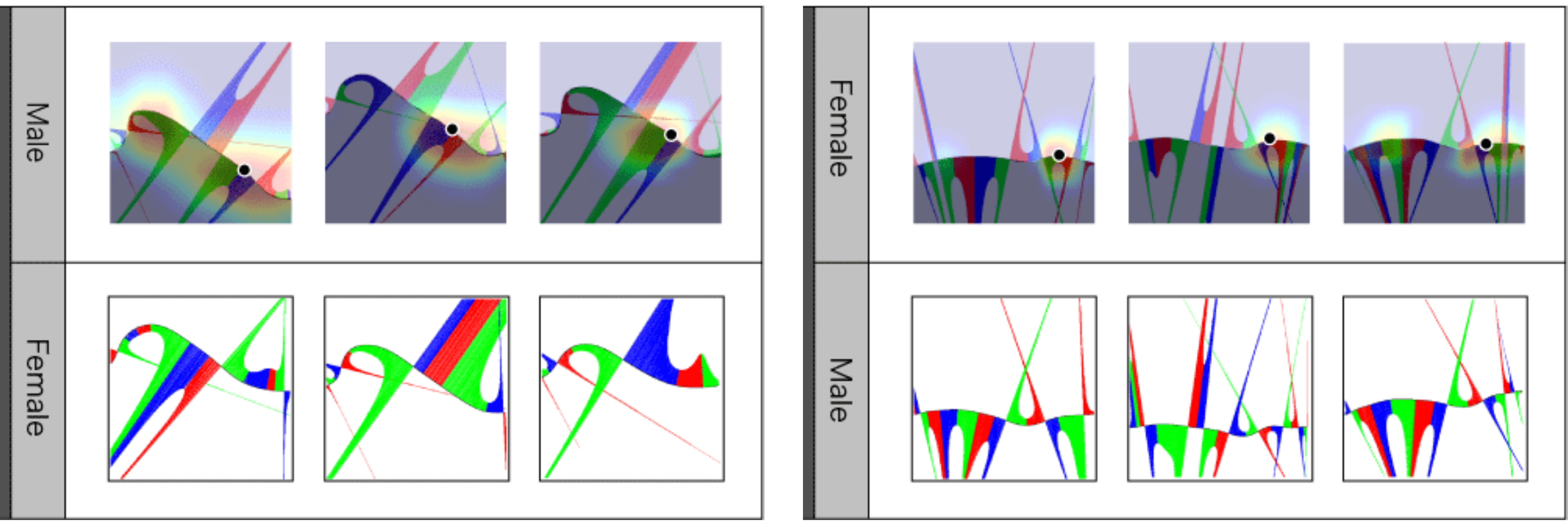


Fig 4: Examples of the heat map response for 2 of the 7 facial curvatures (left: nasal dorsum, right: eyelid) identified as significant in the machine learning model built to classify the gender of the patient.

Results

- The facial target area used by the model was bounded superiorly by the eyebrows, inferiorly by the upper vermillion, and laterally by the cheekbone apices.
- The model could classify gender with over 90% accuracy using any sagittal plane within the target area for females and any sagittal plane lateral to the oral commissures for males.
- Convexity of the nasal ala, protrusion of the supraorbital ridge and nasal dorsum, and a pointed nasal tip were all predictors of male gender in the model. Flat glabella and convexity of the cheeks and eyelids were determined to be feminine features.

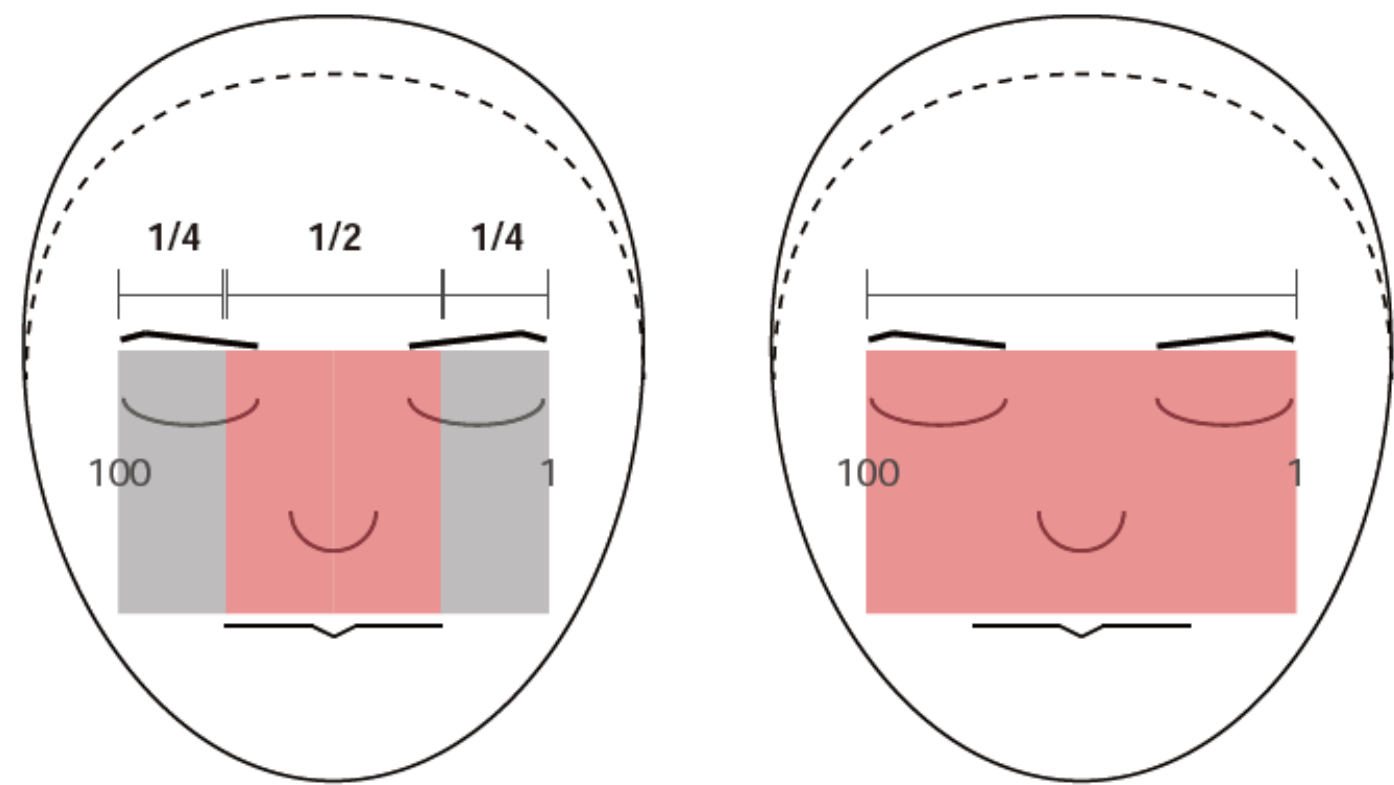


Fig 5: Cross-sectional images taken from the areas in red signify where classification accuracy was at least 90% or higher in men (left) and women (right)

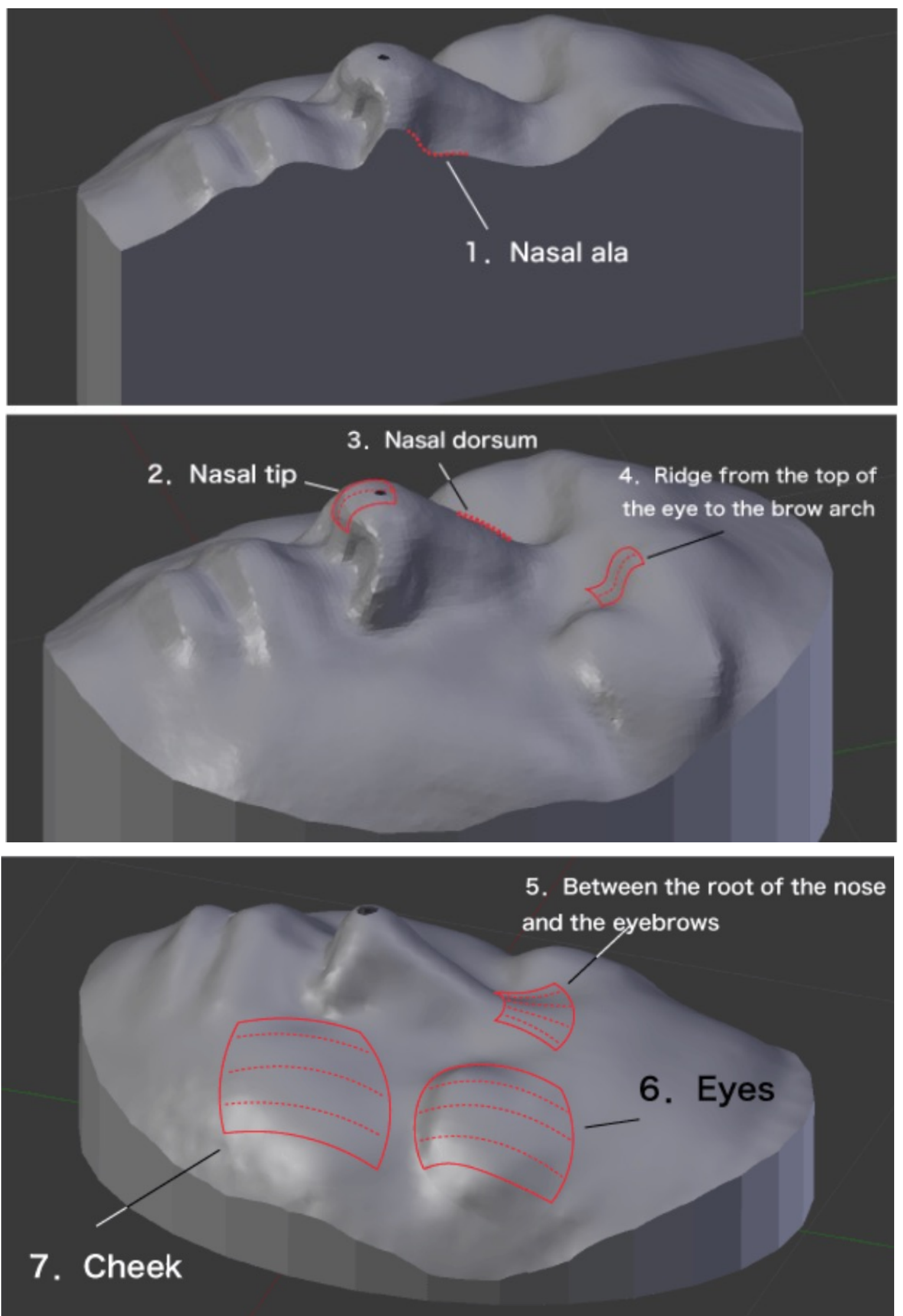


Fig 6: Three-dimensional depiction of the 7 facial curvatures utilized by the machine learning model to identify patient gender

Conclusions

The machine learning model identified novel features as determinants of gender that currently do not serve as areas of focus for gender-affirming surgery. The objective measurements of curvature advance the sparse, subjective literature on facial feminization/masculinization, and this method of curvature analysis can be applied to pre-operative planning for all facial reconstruction or aesthetic procedures.