

3D Torso Image Retrieval of Prior Patient Cases for Enhancing Breast Reconstruction Clinical Consultation

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INTRODUCTION

- Prior patient image retrieval plays a crucial role in pre-surgical planning, enabling surgeons to tailor procedures for optimal aesthetic results.
- Our study introduces a 3D torso image retrieval (3DTIR) algorithm that leverages suggestive contours to search a database by matching torso silhouettes between query and archived images.
- We assessed the algorithm's ability to retrieve medically appropriate images, considering how much counseling would be needed to ensure the images retrieved do not mislead.

METHODS

- The 3DTIR algorithm used suggestive contours¹ as a shape descriptor, capturing detailed surface features that extend beyond traditional contours. MeshCNN² was employed for mesh simplification of the 3D torso images.
- Suggestive contours were extracted from nine predefined viewpoints (0°, ±30°, ±40°, ±60°, ±90°), emphasizing surface variations and distinguishing neighboring surface directions relative to the camera view.
- To streamline the analysis, structure tensors were used to analyze curvature features, followed by Principal Components Analysis (PCA). The top 30 components were retained for final shape comparison after an ablation study.
- Cosine similarity was used to compare the query images to the database of patient images.

SAMPLE POPULATION

- 140 breast cancer patients who underwent breast reconstruction were selected, ensuring that the clavicle, inframammary fold (IMF), and umbilicus were clearly visible in the 3D torso images.
- Patients were enrolled in an IRB approved study from 2011 to 2014 at The University of Texas MD Anderson Cancer Center and provided consent.

Table 1. Demographics of sample population

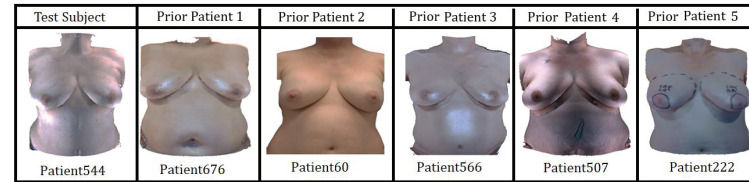
Variables	Mean ± STD (range)
Age, years	47.65 ± 10.24
BMI, kg/m ²	27.05 ± 5.78
Race	N (%)
Caucasian	112 (80)
African American	13 (9.29)
Asian	8 (5.71)
Other	3 (2.3)
Not available	4 (2.86)
Ethnicity	
Hispanic	5 (3.57)
Non-Hispanic	128 (91.43)
Not available	7 (5)

RESULTS

- The 3DTIR evaluation was conducted using the dataset of 140 patients, with ground truth established by experienced surgeons who assessed the medical appropriateness³ of retrieved images.

- Experimental validation: From the dataset of 3D torso images of 140 patients, 10 patients representing various BMI groups were selected as the query set, while the remaining 130 formed the search set. Five validation sets were then created, each using one query patient as input.
- To assess retrieval and ranking performance, DCG and K τ metrics were calculated for all five validation sets, along with the average medical appropriateness score.

Figure 1. Demonstrative results of the image retrieval of top five patients for participant 544



- Results indicated that retrieved images are highly relevant and strongly correlate with the surgeons' rankings for most of the tests.
- The high mean appropriateness score (3.77) with concentration of scores at the upper end of the likert scale indicate the retrieved images are suitable for clinical use.
- The 3DTIR surpassed HAPT, CompactBoFHKS, and FVF_WKS across five test sets, yielding significantly higher medical appropriateness scores (p < 0.0002).
- The 3DTIR ranked 6th out of 37 methods on the Shrec15 dataset⁴ and 4th out of 21 methods on the Faust dataset⁵, demonstrating its effectiveness across a variety of 3D shape retrieval tasks.

CONCLUSIONS

- This study enhances 3D image retrieval for breast reconstruction planning, allowing surgeons to quickly access relevant patient images, supporting more personalized and improved patient care.

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