**Project Report: Face Morphing via 3D Mesh Deformation using MediaPipe and Trimesh**

**Team:**

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**Project Aim**

The primary objective of this project is to implement a 3D face morphing system that uses 2D facial landmark detection on a reference image to deform a high-resolution 3D face mesh. The deformation is guided by landmark correspondences between the 2D image and the 3D mesh, allowing a base mesh to be customized to resemble a new individual’s facial structure. This technique has potential applications in avatar generation, digital doubles, and facial animation.

**Work Completed**

The project is composed of two main Python scripts:

1. **generate\_landmark\_map.py**  
   This script automates the mapping between MediaPipe’s 468 facial landmarks and the corresponding vertices on the 3D mesh. It performs the following tasks:
   * Uses a static reference image to detect MediaPipe face landmarks in 2D.
   * Projects the 3D mesh vertices into the 2D plane using a perspective transformation informed by estimated pose (using OpenCV's solvePnP).
   * For each of the 468 MediaPipe landmarks, the nearest projected vertex is found and recorded as the corresponding 3D mesh vertex.
   * A JSON file is produced containing this landmark-to-vertex mapping.
2. **morph\_face.py**  
   This script performs the actual morphing:
   * Captures an input image and extracts 2D landmarks using MediaPipe.
   * Loads the 3D face mesh and the precomputed landmark-to-vertex map.
   * Computes displacement vectors by comparing the current detected landmark positions with the reference ones.
   * Applies weighted deformations to mesh vertices, ensuring the deformation is not too sharp by interpolating based on distance.
   * Applies Laplacian smoothing to mitigate artifacts and improve surface continuity.
   * The final deformed mesh is exported as a new .obj file.

**Remaining Work**

Before the final version is completed, the following enhancements are planned:

* **Morph Accuracy Improvements:**  
  A more robust deformation model is being considered—either by incorporating mesh topology (e.g., cotangent weights) or by switching from Euclidean to geodesic distances to better handle curved facial regions.
* **Texture Preservation and Warping:**  
  The current pipeline morphs geometry only. The next step will add support for updating the texture coordinates or re-projecting the input image onto the morphed mesh.
* **Error Metrics and Validation:**  
  Quantitative error metrics (e.g., average landmark distance between reference and morph) will be implemented to assess morphing fidelity.

**Conclusion**

The project has successfully established a semi-working pipeline for image-driven 3D face mesh deformation. The final version will refine realism, interactivity, and generalizability to make the morphing pipeline suitable for real-world applications.