

Automatic Lens Placement for Personalized 3D Printed Eyewear

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Abstract

The growing need for comfortable eyewear, from prescription frames to AI-enabled glasses, increases the demand for personalized eyewear fitting for different facial morphologies. However, customization is challenging because each custom design must coordinate lens alignment, nose-pad contact, and frame geometry. We propose a pipeline that automatically aligns the lenses with the pupils. Specifically, we reconstruct a 3D face model from smartphone camera images and extract facial landmarks. We use the pupil landmarks to compute the Interpupillary Distance (IPD) to determine the lens positions. Then we refine the frame mesh using lattice-based deformation. We validate our method by manufacturing a personalized 3D printed eyewear prototype for three test users. All three test users report a comfortable fit, neither too loose nor too tight.

CCS Concepts

• **Computing methodologies** → **Computer vision**; *Shape modeling*; • **Applied computing** → *Computer-aided design*.

Keywords

Personalized Eyeglasses, Photogrammetry, 3D printing

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1 Introduction

The rise of AI and Augmented Reality (AR) glasses [18], together with the growing demand for prescription lenses [9], highlights the need for eyewear that provides both wearing comfort and appropriate optical alignment. However, conventional eyewear design often relies on standardized geometries, making it difficult to satisfy diverse optical and face morphologies. Specifically, lens centers should align with the wearer’s eyes, while the rims, bridge, nose pads, and temples must accommodate individual facial morphology. Therefore, Standard frame sizes cannot satisfy all these constraints for every combination. Although manual customization can address these individual requirements, it can involve repeated measurements and iterative adjustments, making the process labor-intensive and time-consuming.

Our work introduces a pipeline for designing personalized eyewear. The pipeline starts with a reconstruction of a 3D facial model of a target user from multi-view photographs captured by a smartphone. Then we use MediaPipe [7, 15] to detect eye- and nose-related landmarks on the reconstructed 3D model and position the lenses relative to those landmarks. Lattice-based deformation then

supports interactive manual frame refinement. We manufacture three personalized prototypes using a 3D printer, see Figure 1. Our contributions are:

- **Automatic Lens Placement.** We formulate an automatic pipeline to determine lens positions using an off-the-shelf multi-view facial reconstruction method.

- **Geometric Assessment Procedure.** Our pipeline combines manual mesh editing and lattice-based deformation to adjust the overall shape of the frame. We report mesh overlaps, minimum surface distances, image-derived IPD, and eye relief before fabrication.

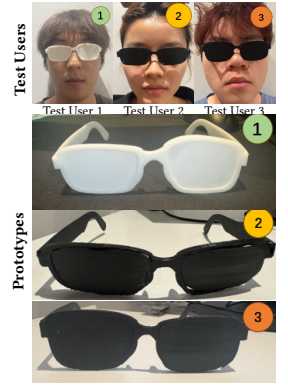


Figure 1: Test Users and 3D-printed frames.

2 Related Work

Recent works extensively explore 3D content generation from diverse input modalities. For example, text-conditioned methods [14] generate 3D objects from natural-language prompts, while GET3D [6] can generate textured 3D meshes from collections of 2D images. CRAFT [8] incorporates contact and penetration constraints into body-aware 3D object synthesis. Kardash et al. [10] optimize scoliosis-brace geometry using simulated contact forces between the brace and the trunk. DiffAvatar [13] jointly optimizes body and garment parameters using differentiable simulation of cloth-body interactions. Near-eye displays also require facial fit and alignment between the pupils and viewing optics, since a limited eyebox restricts the usable pupil positions [12] [4]. Tian et al. [17] use measurements from 3D scans of the head and face to drive a parametric eyewear model. De Alba Campomanes et al. [5] use smartphone-based 3D surface imaging and designer-led modeling to produce custom 3D-printed glasses frames. Akşit et al. [1] combine 3D printing, optical bonding, and vacuum forming to prototype optical components for near-eye displays. Generating a 3D model alone does not ensure appropriate lens positioning and facial fit. Our workflow combines photogrammetry with automatic landmark-guided lens placement, then keeps the lenses fixed during interactive manual frame refinement.

3 Personalized Eyewear Pipeline

We combine smartphone-based 3D face reconstruction with facial landmark detection to position lenses and nose pads, followed by interactive frame refinement. Figure 2 shows the facial model, which is reconstructed from multiple images, with the integrated eyewear geometry.

3D Face Model Reconstruction. For each test user, we used a smartphone camera and took 23 sequential images covering an area from the left to the right side of their faces. Kiri Engine [11] reconstructs a textured 3D facial model from the captured images. We then rescaled the imported model into Blender [3] to match the actual size (height 192mm, width 173mm, depth 262mm) of the user’s head that we measured with an actual ruler.

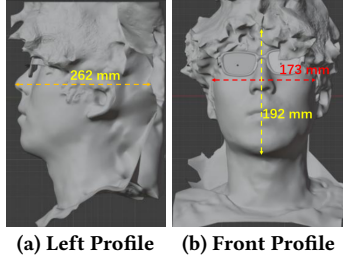


Figure 2: Reconstructed 3D face with eyewear geometry.

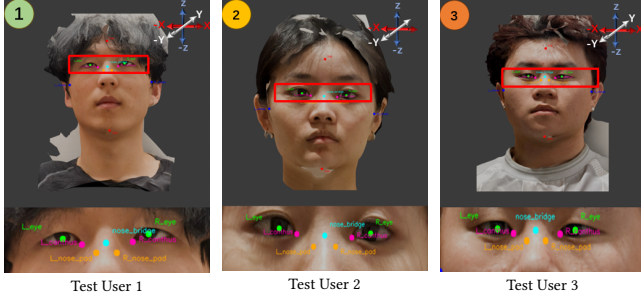


Figure 3: Frontal landmarks for three test users.

Landmark Detection. As show in Figure 3 MediaPipe [7, 15] detects iris and facial landmarks in each image and returns normalized 2D coordinates. To obtain these landmarks, We render the reconstructed face in Blender from five orthographic views at yaw angles of -25° , -15° , 0° , 15° , and 25° , see Supplementary material Figure 4. We project selected 2D landmarks onto the face mesh by casting rays from their corresponding positions on the orthographic camera plane along the viewing direction. For each eye, the coordinate-wise median of valid intersections across views gives a surface-based 3D reference, not a direct measurement of its anatomical center.

Lens and Nose-Pad Positioning. We calculate the image-derived IPD from the distance between the two eye reference points obtained by the landmark detection process. Then align the center of each lens’s bounding box horizontally and vertically with its corresponding eye reference. We choose the eye relief as 16 mm in the design of near-eye-displays [16]. We place this center 16 mm in front of the reference along the scene’s negative Y-axis. We estimate initial nose-pad locations from the inner eye corners and the nose-bridge landmarks, then refine them against the reconstructed nose surface. The script automatically moves each pad toward the nose in small steps. If it detects cheek contact, the script reverses the last inward step, raises the pad slightly, and repeats the approach. When it detects nasal-side contact, the script reverses the final inward step and stops. The script limits the number of search steps and checks the final position for remaining overlaps.

Frame Deformation. We keep the lenses fixed as reference geometry and refine the surrounding frame in Blender [3]. Manual mesh editing allows us to translate, rotate, or locally reshape the rims, bridge, hinges, temples, and nose-pad area. For broader shape adjustments, we place a lattice cage around the frame or a selected

region and manually edit its control points to bend or reshape the enclosed geometry towards the fixed lenses.

Collision Detection. After lens and nose-pad placement, we use Bounding Volume Hierarchy (BVH) queries [2] to report remaining overlaps and approximate minimum surface distances between these components and the reconstructed face. These final diagnostic checks do not move the lenses or modify the frame.

4 Results and Discussions

The image-derived IPD values for test users 1, 2, and 3 are 69.58 mm, 69.41 mm, and 64.89 mm, respectively. Both lenses reach the target geometric eye relief of 16 mm in all three models shown in Figure 1. A sample assessment from test user 1 reveals the following technical details: MediaPipe returns usable landmarks for all five rendered views. Neither nose pad has reported BVH overlap pairs; their approximate minimum face distances are 0.055 mm (left) and 0.206 mm (right). The left and right lenses have zero and 190 overlapping triangle pairs, with approximate minimum face distances of 0.12 mm and 0.01 mm, respectively. Visual inspection suggests that the right-lens overlaps mainly involve reconstructed hair and scan artifacts. The collision test treats these regions as rigid mesh geometry and does not model hair deformation. These overlaps remain diagnostic warnings and do not by themselves establish whether physical contact is acceptable. Overall, all three test users report a comfortable fit, neither too loose nor too tight. During a brief wearing demonstration for photography, test user 1 reports appropriate nose-pad positioning, no pressure from the temples, and a stable fit without manual readjustment. Test user 2 describes the glasses as comfortable and reports no slippage during wear. This test user also considers the lens size appropriate. Test user 3 reports that the overall wearing experience feels similar to wearing his usual glasses and considers the lens angle suitable.

Limitations. Reconstruction noise, missing surfaces, and uncertainty in the approximate head measurements can affect landmark projection and component placement. We use surface-based eye references and estimated nose-pad contact locations, while frame refinement requires manual judgment. Beyond the three test users, for generalization of our method, more studies on diverse populations are required.

Conclusion. Although hurdles remain in our implementation, our work focuses on addressing the customization problem in eyewear by connecting individual facial geometry with personalized frame design. Our workflow enables designers to use smartphone-based facial reconstructions to guide lens placement automatically, and adapt the surrounding frame while keeping the lenses fixed. This provides a path from individual facial geometry to physical eyewear prototypes, combining geometric guidance with the flexibility of interactive refinement. Our pipeline still rely on partial manual frame adjustments, identifying a fully automatic pipeline remains as a future work. Another direction is to extend the approach to personalized AR glasses with integrated eye tracking for gaze-based interaction, such as selecting virtual objects. This extension would require evaluating how IPD-based alignment, changes in lens spacing, and frame slippage affect gaze-estimation accuracy and calibration stability. More test users should also assess alignment accuracy and long-term wearing comfort.

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