# Distortion-Free Wide-Angle Portraits on Camera

YiChang Shih, Wei-Sheng Lai, Chia-Kai Liang

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## Problem

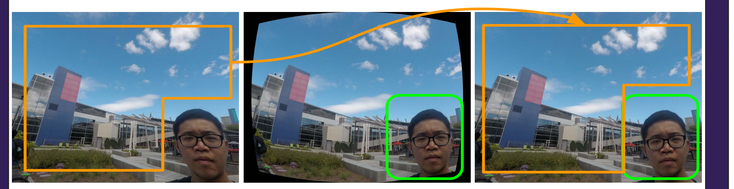
Photographers take wide-angle shots to enjoy expanding views. A wider field-of-view (FOV) introduces a stronger perceived distortion when subjects are near the corners and edges. Faces are stretched, squished, and skewed. We introduce a new algorithm to undistort faces without affecting other parts of the photo. Given a portrait as an input, we formulate an optimization problem to create a content-aware mesh warp for distortion correction.

Input: 97° FOV | Our result

## Observations

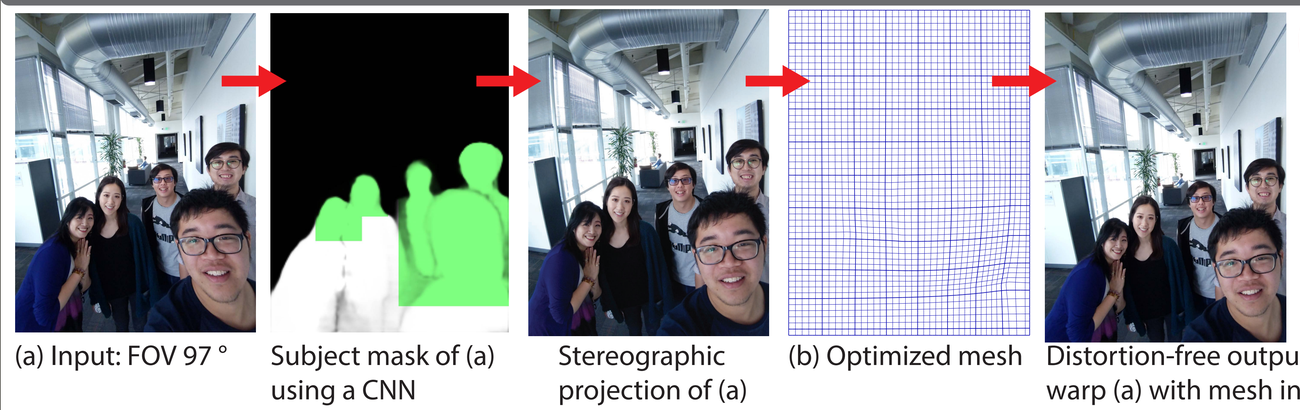
*Perspective projection* preserves straight edges from the 3D world but stretches faces at the image corners. *Stereographic projection* preserves face shape but distorts straight edges in the background.

**Key idea:** combines both projections into a single warp. *Locally* applies stereographic projection on face regions, and perspective projection on the background.



*Perspective projection. Face looks squished. Background looks good.* *Stereographic projection. Face looks good. Background looks distorted.* *Optimal projection by local warp.*

## Algorithm Overview



(a) Input: FOV 97 ° | Subject mask of (a) using a CNN | Stereographic projection of (a) | (b) Optimized mesh | Distortion-free output: warp (a) with mesh in (b)

Tech-talk: Tue 30 Jul
2pm - 3:30pm, Photo Science
Room 150/151

**Mesh Optimization (b)**

$$\{\mathbf{v}_i^*\} = \underset{\{\mathbf{v}_i\}}{\operatorname{argmin}}\, E_t(\{\mathbf{v}_i\})$$

**A novel per-face energy term:**

$$E_{s,k} = \sum_{i \in \mathbf{B}_k} w_i m_i \|\mathbf{v}_i - (\mathbf{S}_k \mathbf{u}_i + \mathbf{t}_k)\|_2^2 + \lambda(\mathbf{S}_k)$$

$$\mathbf{S}_k = \begin{bmatrix} a_k & b_k \\ -b_k & a_k \end{bmatrix}$$

$$\lambda(\mathbf{S}_k) = w_s \|a_k - s_t\|_2^2$$

**Line-bending term**

$$E_b = \sum_i \sum_{j \in N(i)} \|(\mathbf{v}_i - \mathbf{v}_j) \times \mathbf{e}_{ij}\|_2^2$$

**Regularization term**

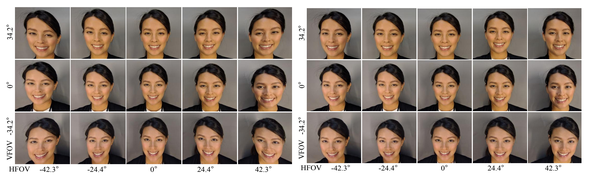
$$E_r = \sum_i \sum_{j \in N(i)} \|\mathbf{v}_i - \mathbf{v}_j\|_2^2$$

## Results

- Validates on 4k+ photos. FOV ranges from 70°-120°. Group size from 1-20 people.
- Efficient on mobile phone: 920ms on SDM845 chipset.


Input | Our result

Left/right: input (79° FOV) and output




Validation over 5x3 grid on 97 ° FOV camera.

## References

[1] Thomas K Sharpless, Bruno Postle, and Daniel M German. 2010. Pannini: a new projection for rendering wide angle perspective images. In Proc. 6th international conference on Computational Aesthetics in Graphics, Visualization and Imaging. 9–16.

[2] Denis Zorin and Alan H Barr. 1995. Correction of geometric perceptual distortions in pictures. In SIGGRAPH. 257–264.

## Comparisons

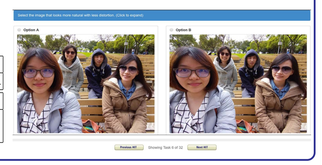
Input | Adobe Photoshop Perspective Warp | Pannini projection [Sharpless et al. 2010] | Our result

Input | [Zorin et al. 1995] | Our result

**User study on Amazon Mechanical Turker**

5235 questions on 1047 testing images from 117 testers.

| Compared to input (perspective projection). | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5 | 4 | 3 | 2 | 1 | 0 | Total |
| Percentage (%) | 25.0 | 39.2 | 28.2 | 6.6 | 0.9 | 0.0 | 100 |
| Cumulative percentage | 25.0 | 64.2 | **92.4** | 99.1 | 100 | 100 | N/A |



**Limitations**

- Body (torso) are missing from correction and may look unnatural overall.
- Fails when missing face detection.
- Long edges very close to face may be distorted.

Input | Our result

## Acknowledgements

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