

Photographic Obstruction Mapping

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Daylight is awesome, manual shades are not.

- Daylight and Views are widely desired
 - Daylight is the most desirable benefit employers can offer to employees
 - Homes with ample daylight are more valuable than those with less
- Humans are terrible at manual control of shading
 - We are triggered by glare
 - The un-trigger is ambiguous and rarely noticed
- Shades stay down far longer than needed
 - Daylight is squandered
 - Views are blocked

Automated control is the way forward

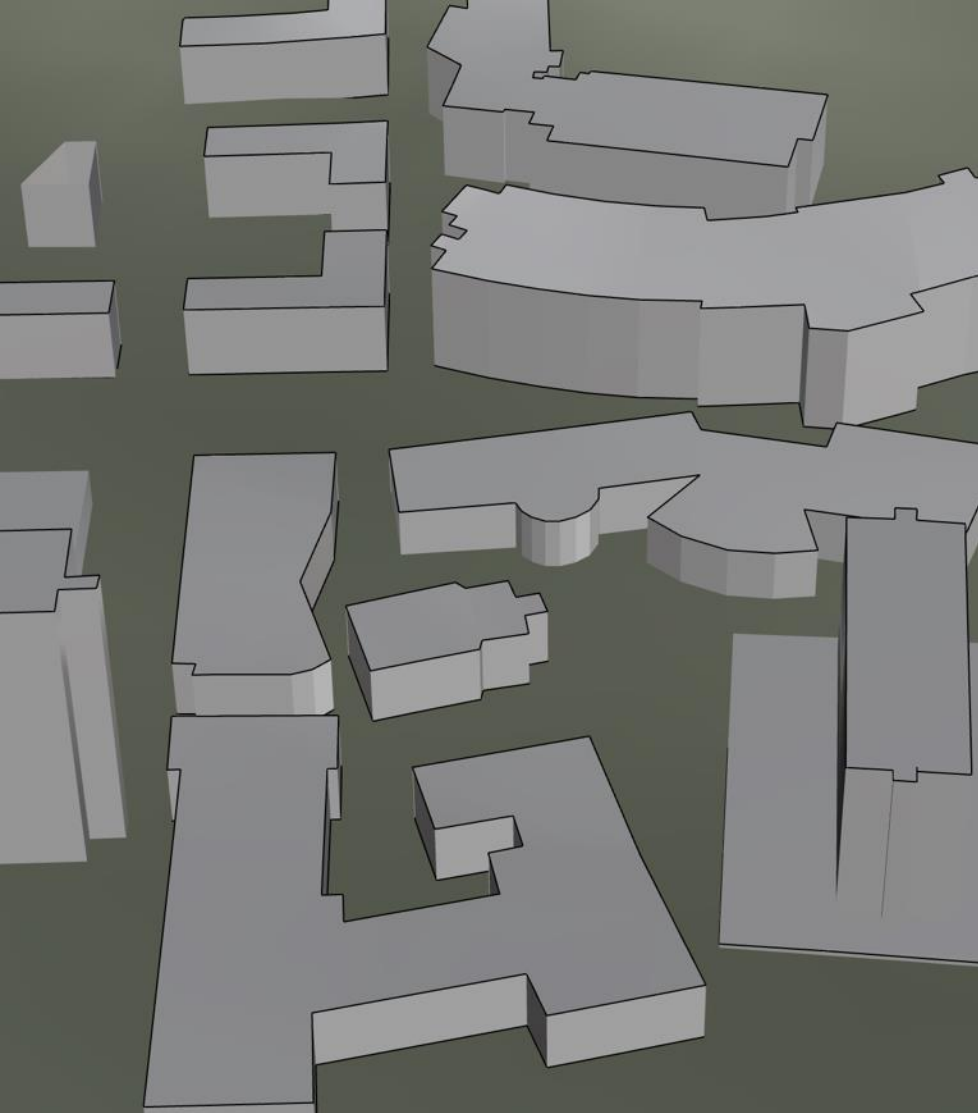
- Automation needs to be cost effective at small scale
 - € / window for 10 windows vs. 1,000 windows
- Automation needs to do the 'right thing' all the time.
 - 95% correct = Wrong 2 hours per work week
 - 99.5% correct = Wrong 12 minutes per work week
- One thing that needs to be done right:

Don't activate shading when the window is in a shadow!

Obstructions...

- Cast shadows on windows
 - Neighboring buildings
 - Static Shading devices, eg. overhangs, fins
 - Mountains / Hills
 - Trees (?)



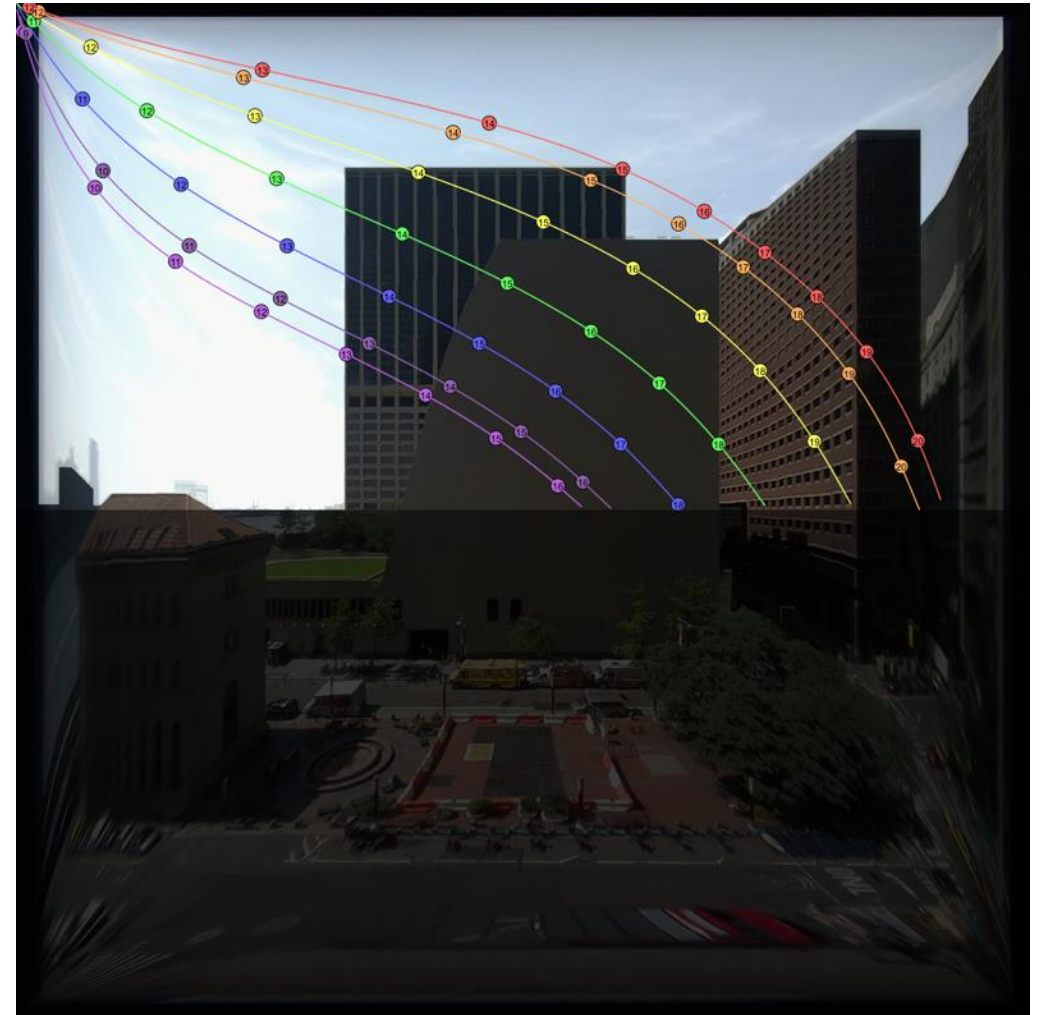


Currently accounted for by ray-tracing CAD models

- Model preparation can be time consuming and costly
- CAD model availability is spotty.
 - Often limited to building outlines
 - Height needs to be estimated
- Errors are often baked into the schedule, and difficult to diagnose and correct.
- Substantial up-charge is passed on to the customer
 - Economical for large projects
 - Not practical for small projects

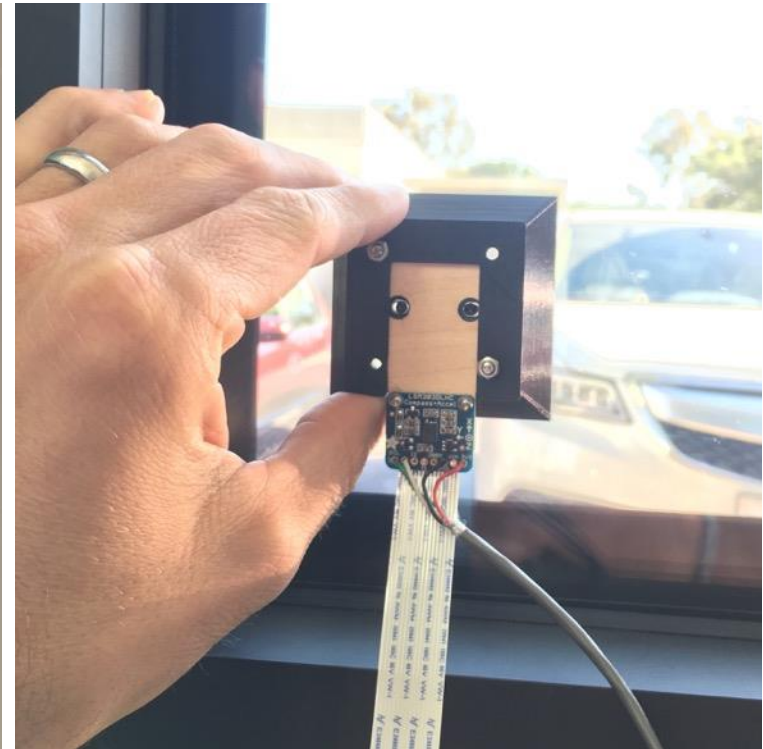
Photographic Obstruction Maps

- Collect obstruction information onsite with calibrated camera.
- Remap pixels to angular coordinates
- Identify sky vs. obstruction
- Query with sun position



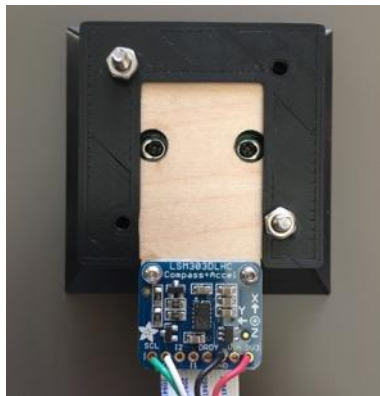
Calibrated Camera (Prototype)

- 180° Fisheye lens
- Black shroud for positioning



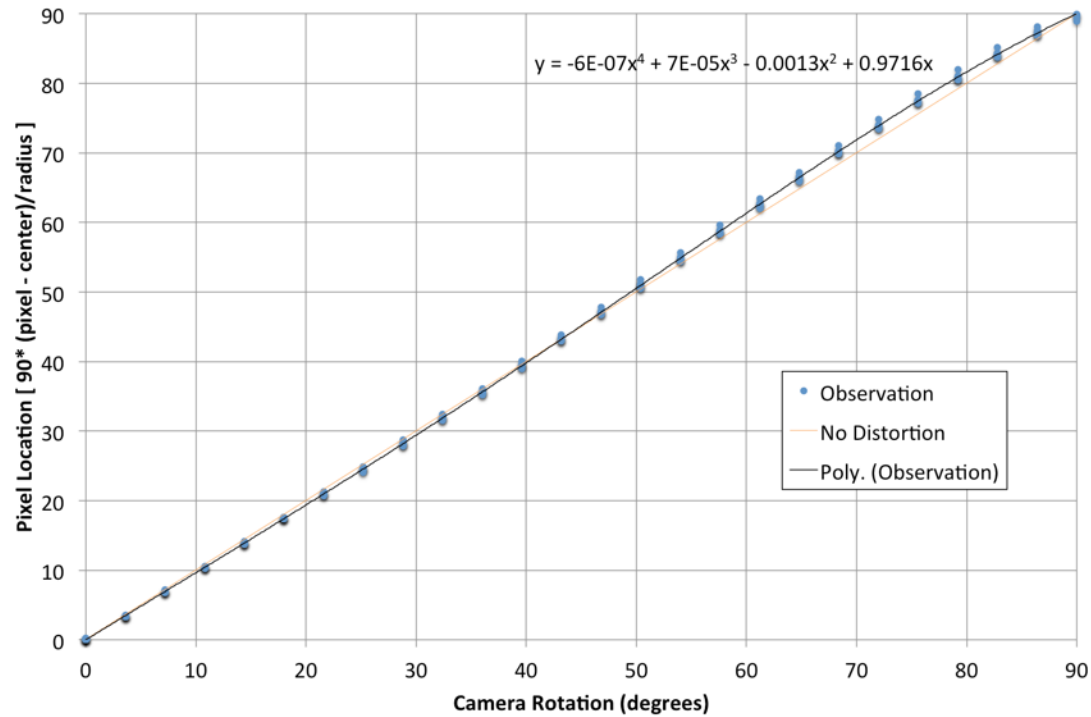
Accelerometer

- Accelerometer to correct for crooked hand



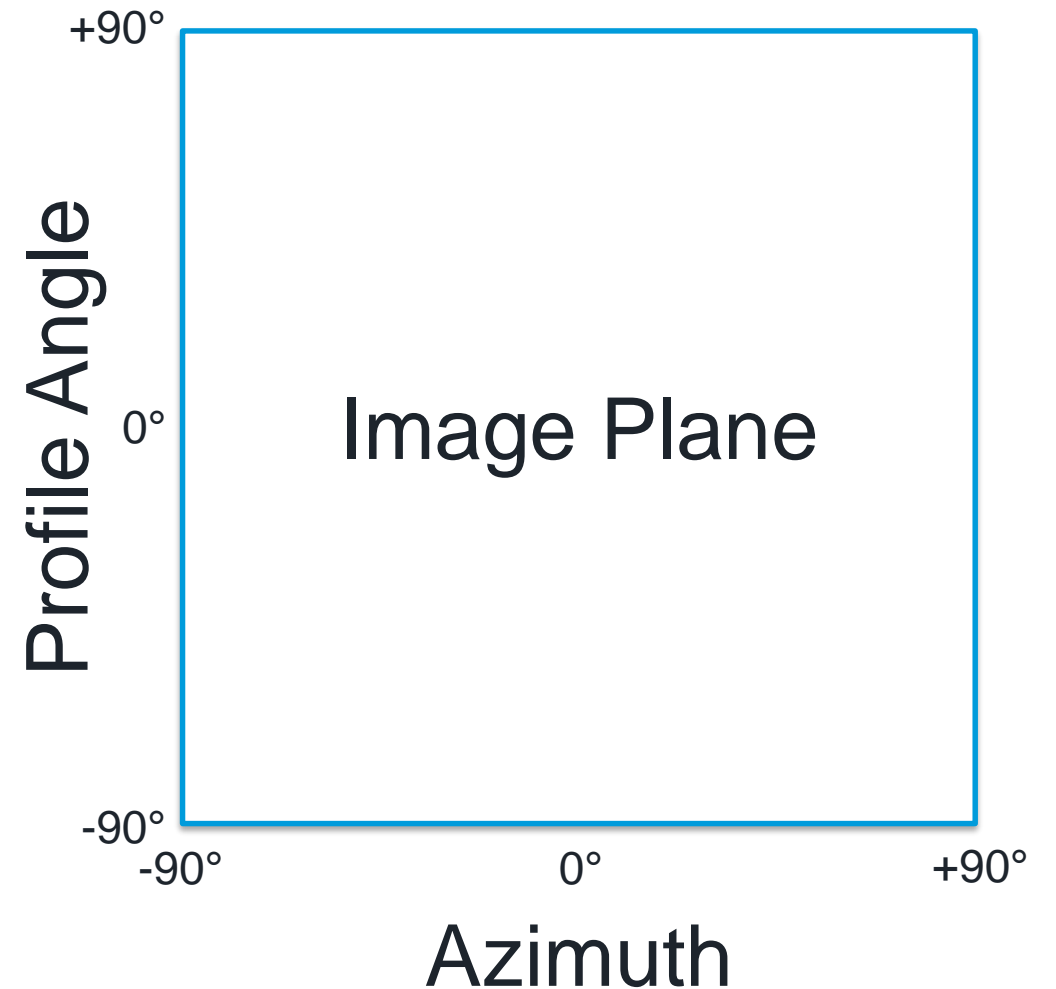
Lens distortion

- Angular calibration to correct for lens distortion

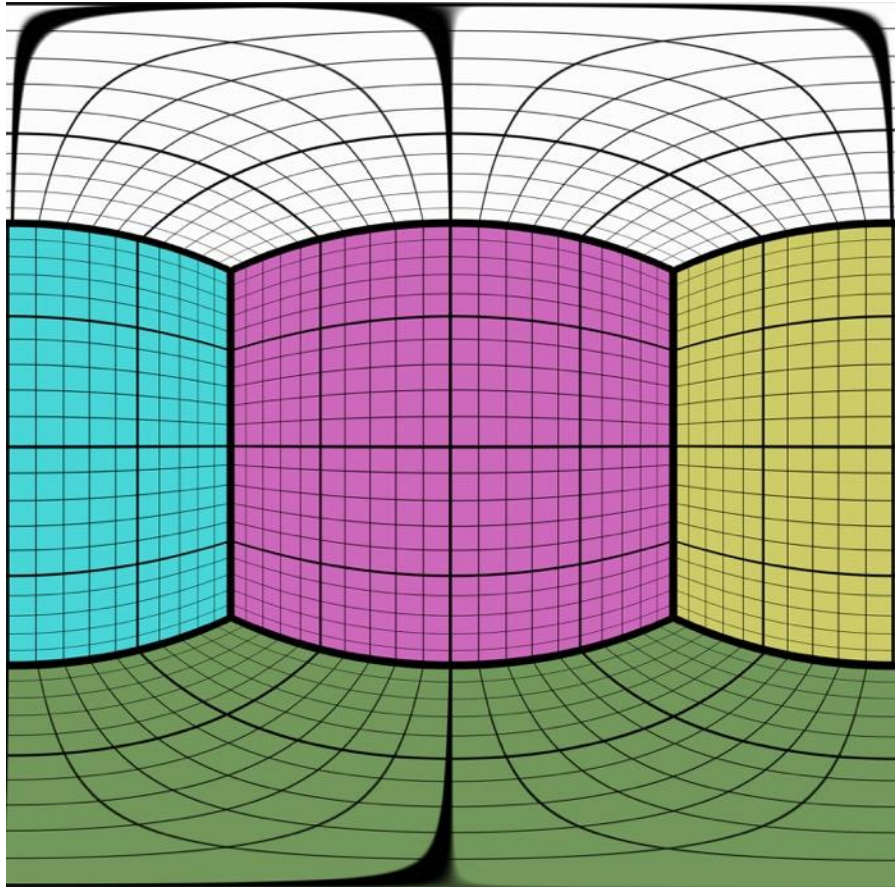


'Orthonormal Pseudocylindrical' Projection

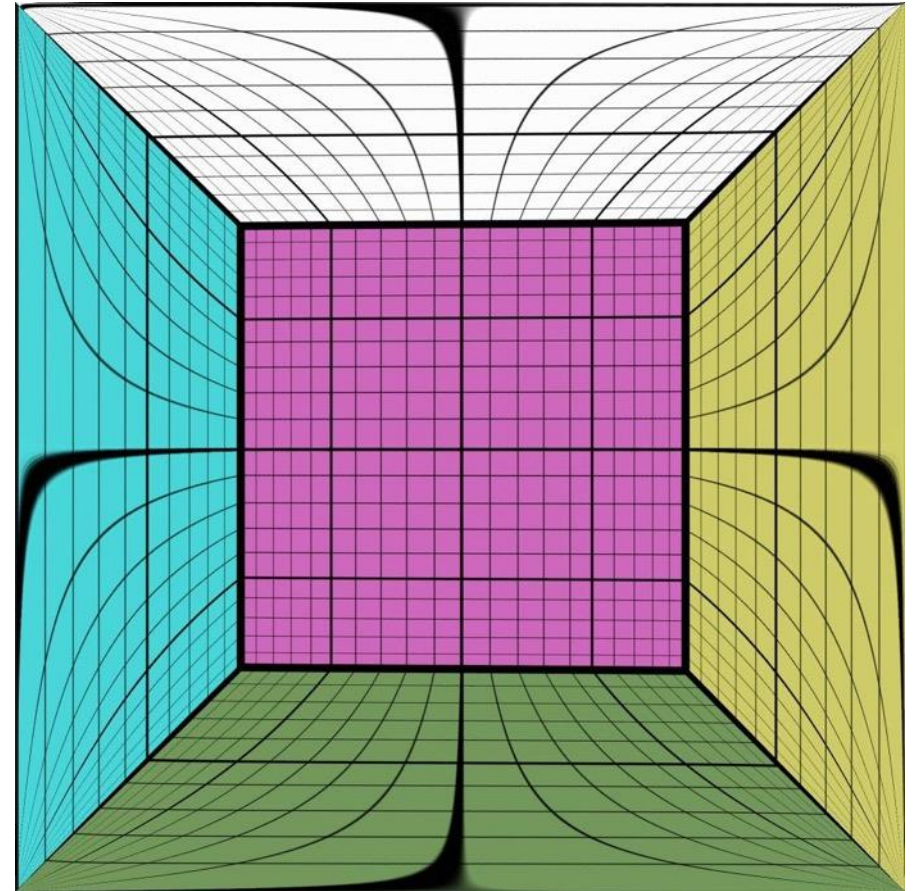
- X-axis:
 - azimuth angle
 - projected into horizontal plane
- Y-axis:
 - profile angle
 - projected into vertical plane
- Lines that are orthonormal to the direction of view are straight lines in the orthonormal projection.



'Orthonormal Pseudocylindrical' Projection



Equirectangular Projection



Orthonormal Projection

Re-projection

- Fisheye to orthonormal projection
- Straight Line = Pleasant!

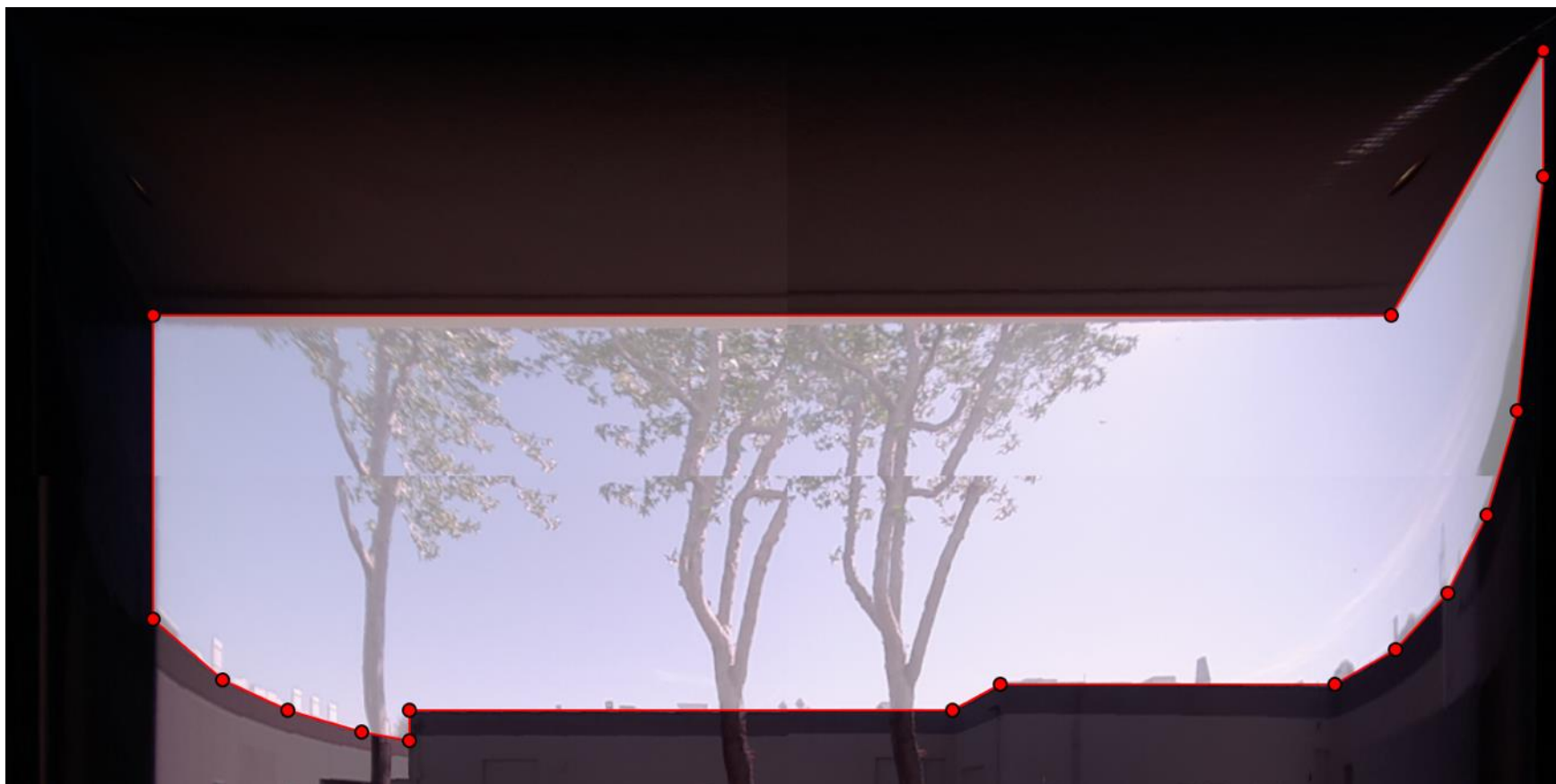


Equirectangular...

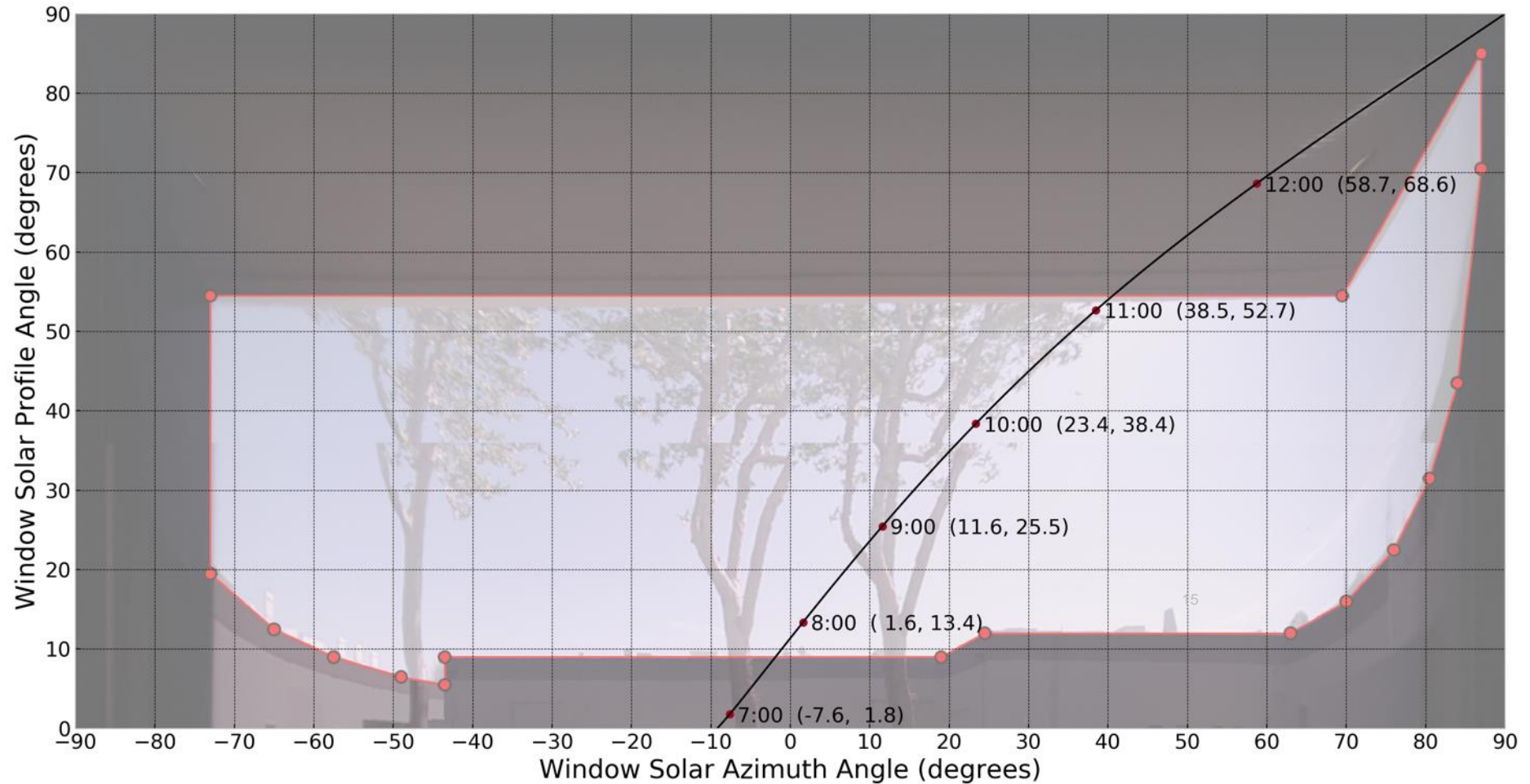
- Not straight line = awkward



Trace Visible Sky



Now it's an angular obstruction map!



Validation



Sun begins to shine on the window

- Predicted time:
7:39
- Actual time:
7:42
- Error of 3 minutes, 0.4°



Sun ceases to shine on the window

- Predicted time:
11:06
- Actual time:
11:03
- Error of 3 minutes, 0.7°



Summary

- A calibrated camera can be used to generate angular maps of exterior obstructions
- The maps are thought to be accurate to within 1°, though validation is ongoing.
- This method is economical for small projects.

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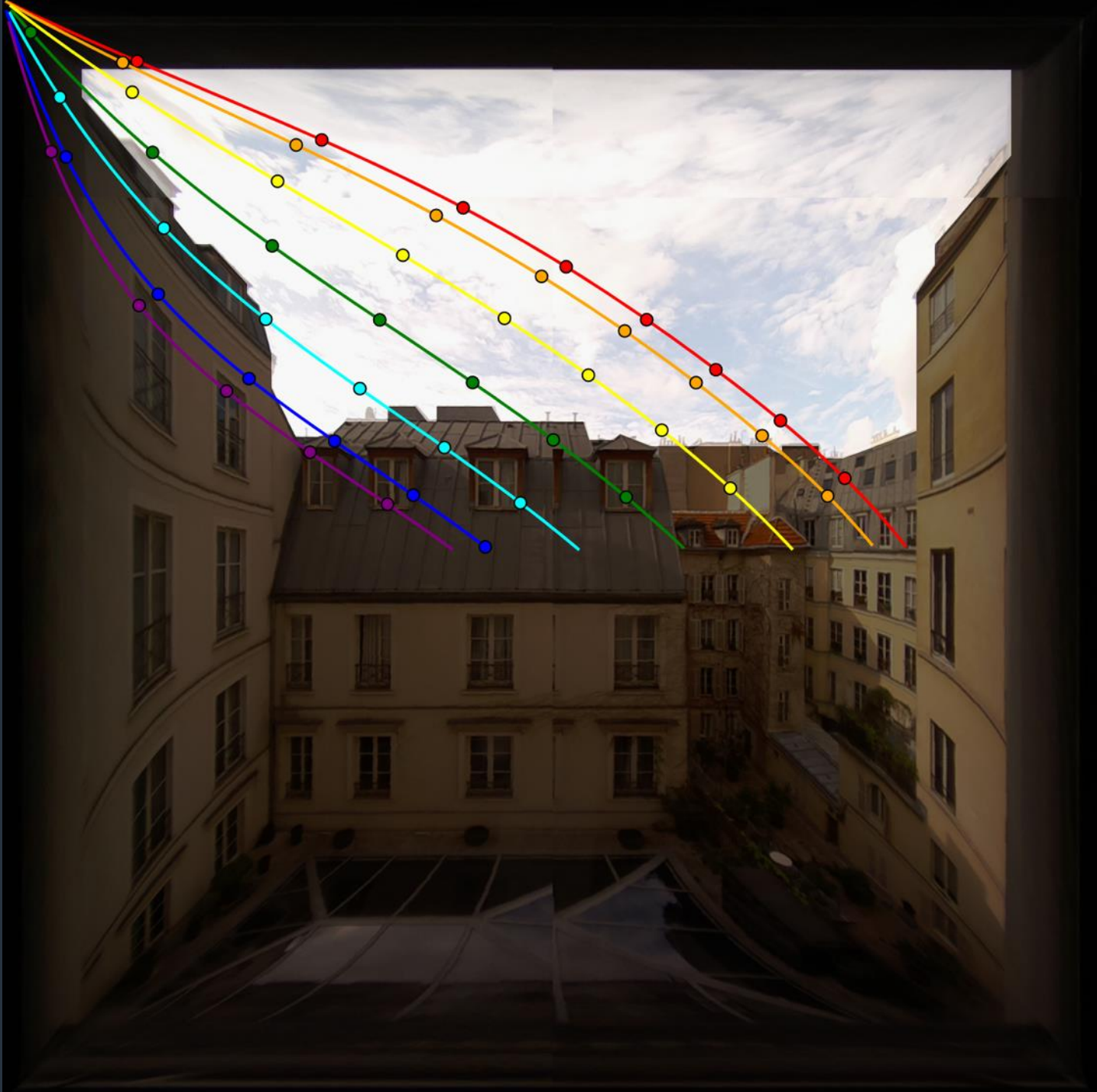
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Example:
Paris Hotel









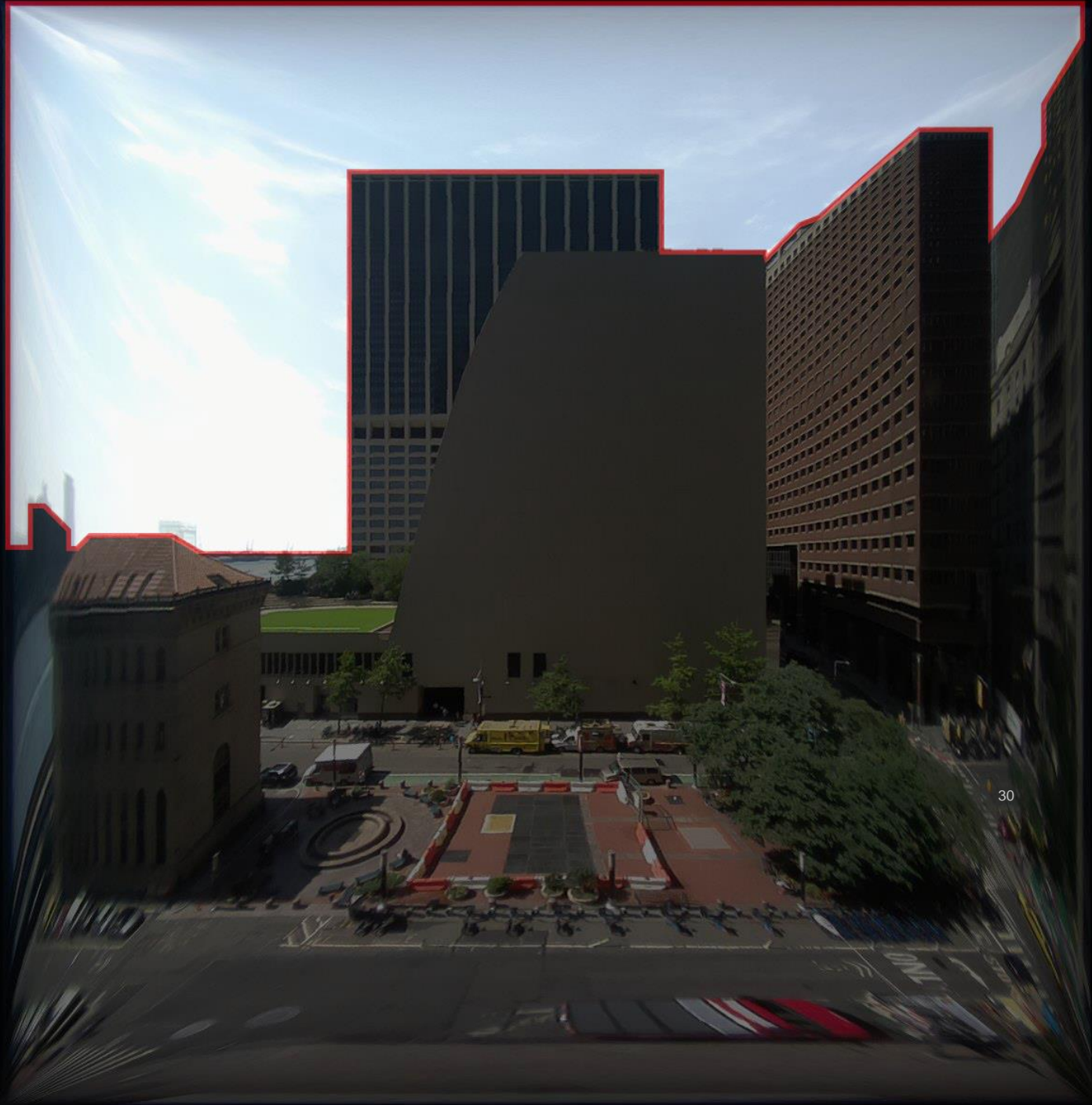


Example:
New York City Office

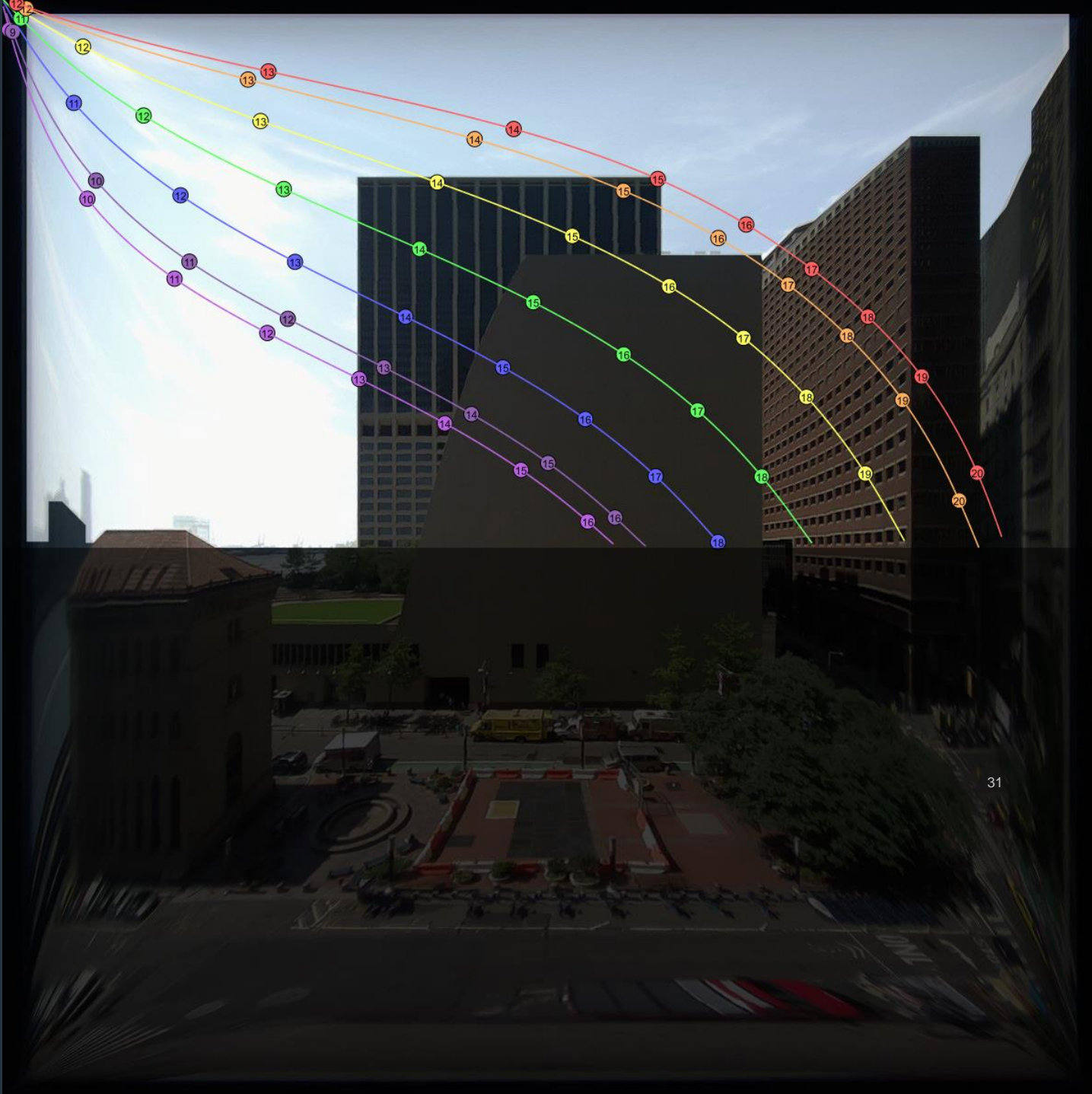


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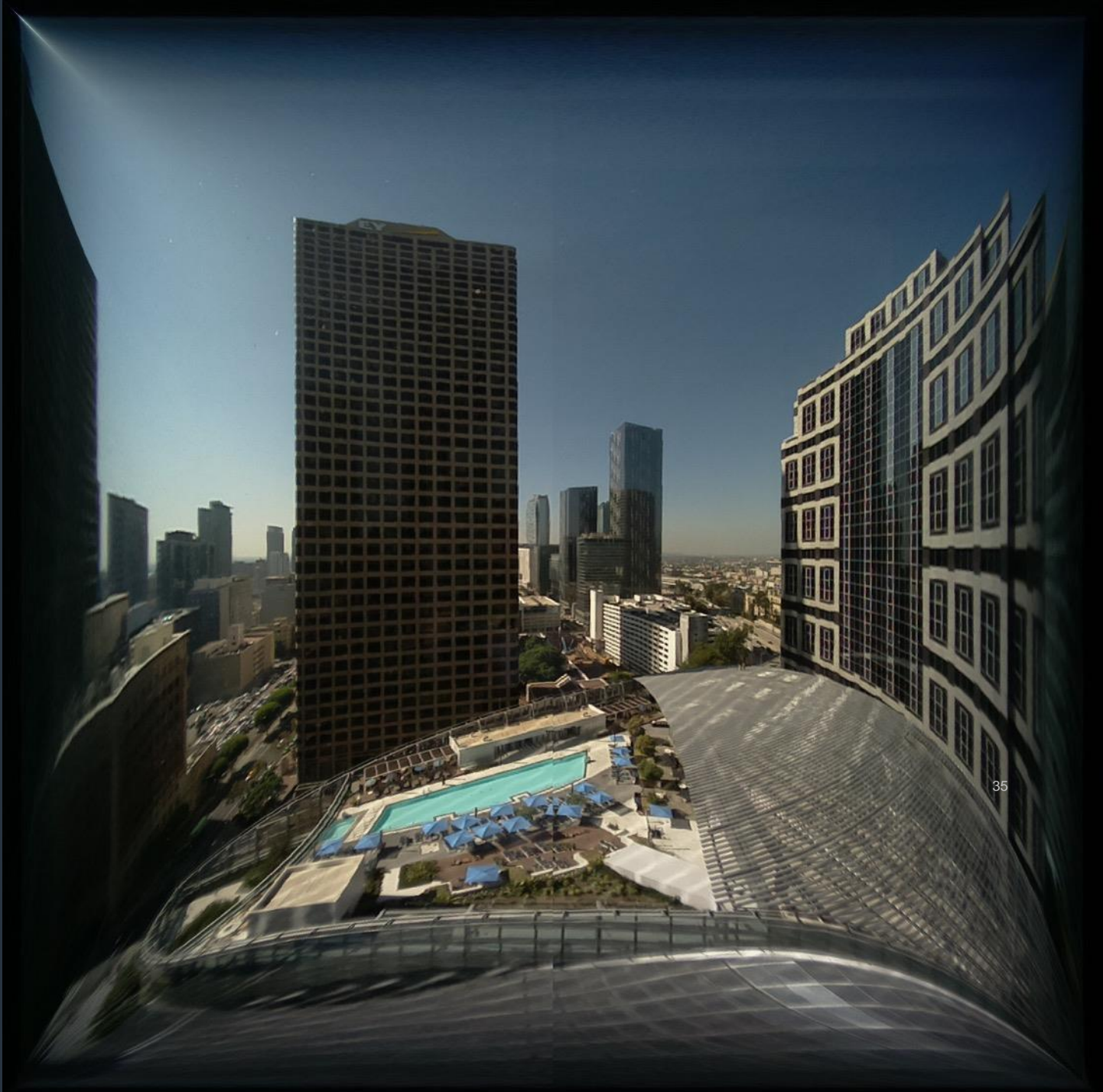




Example:
Los Angeles Office



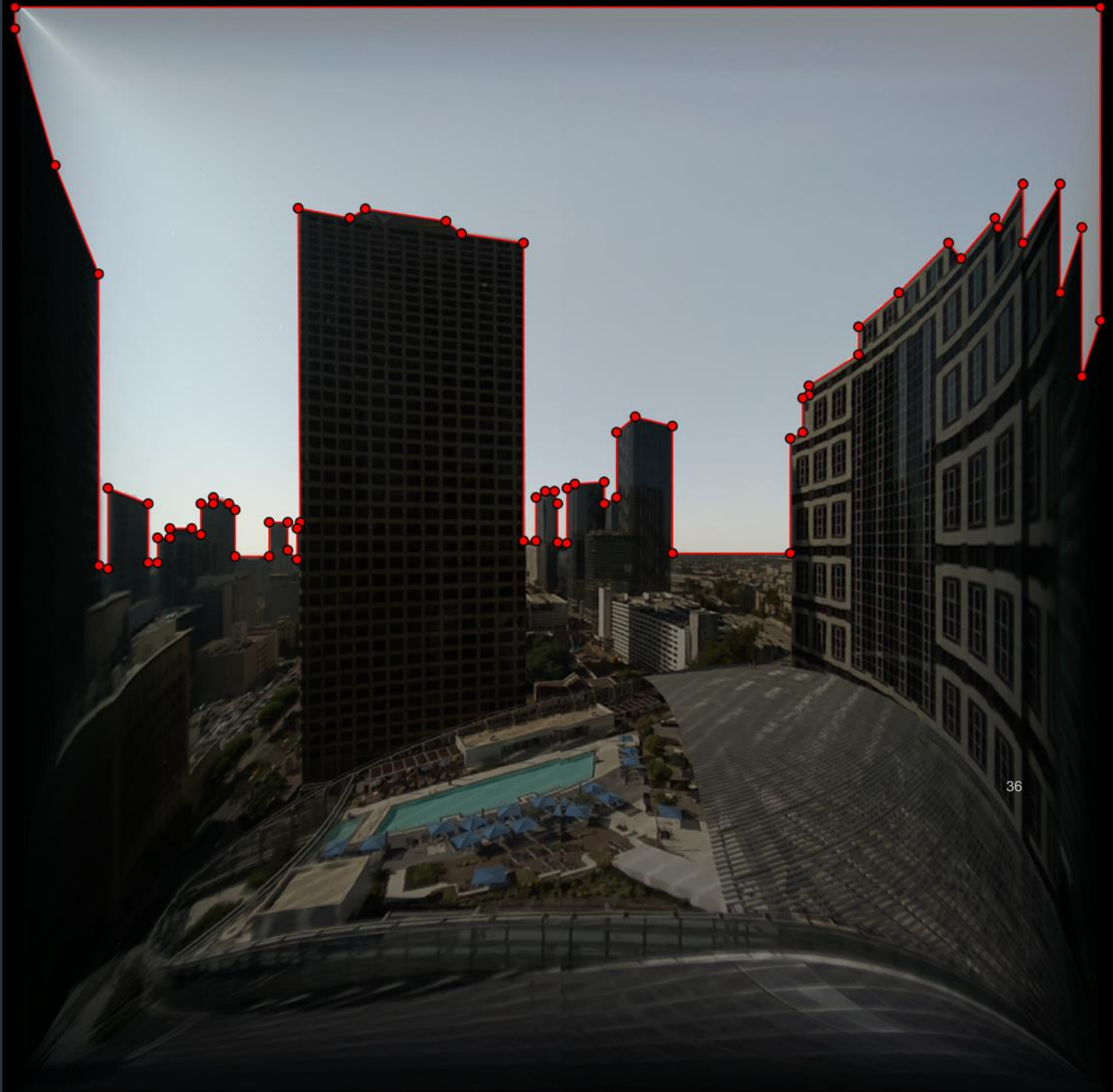
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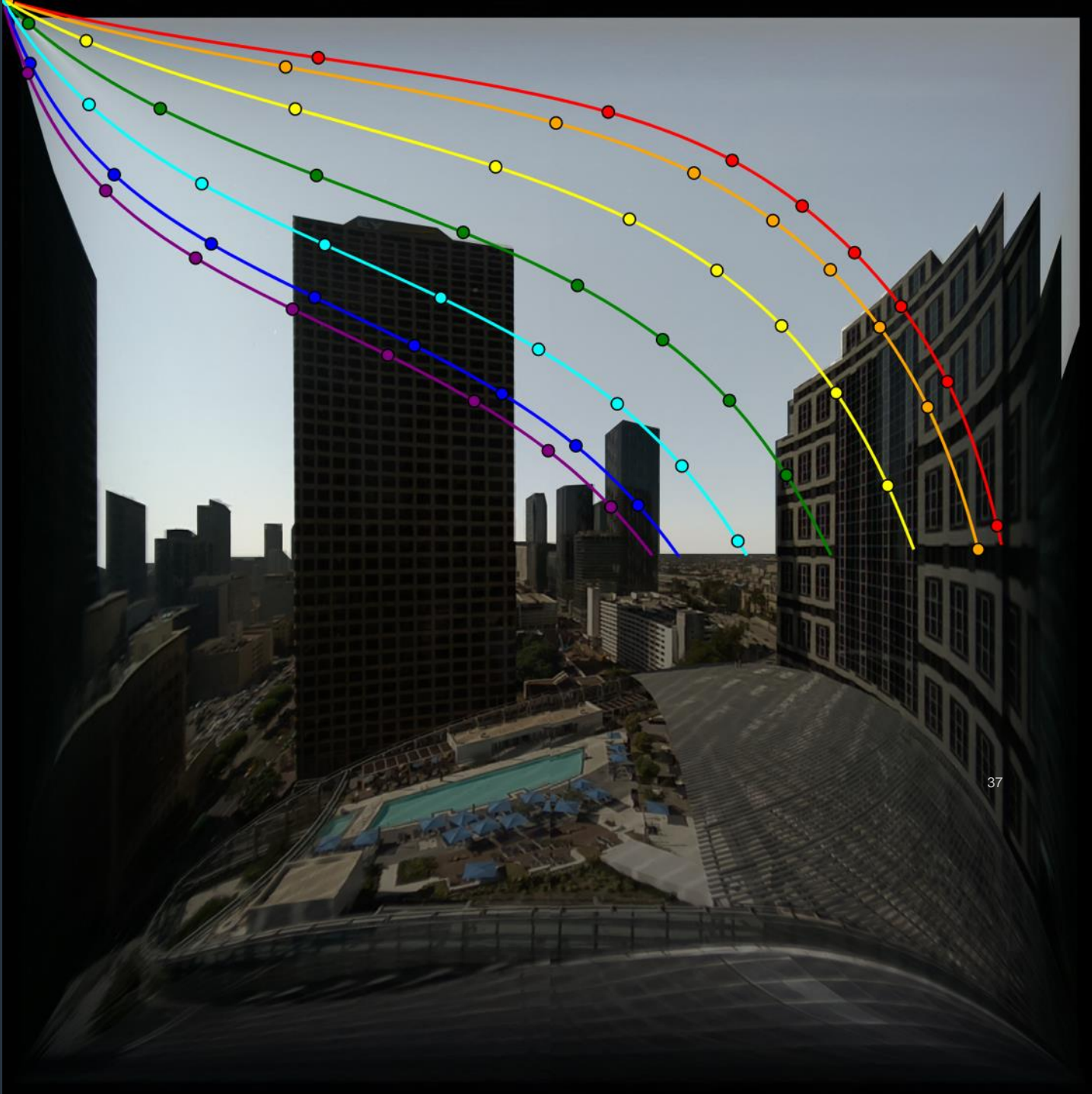
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