Omnidirectional Camera | definition

- An omnidirectional camera is characterized by a very large field of view (ultimately, a spherical field of view)

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<td>Wide FOV dioptric cameras (e.g. fisheye)</td>
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<td>Catadioptric</td>
<td>&gt;180° FOV</td>
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Image courtesy of T. Pajdla
Omnidirectional Camera | catadioptric camera

- Vertical field of view larger than 100 degrees
- Horizontal field of view 360 degrees
Omnidirectional Camera | catadioptric camera

- Mirror + perspective camera
Omnidirectional Camera | central catadioptric camera

- **Central** catadioptric camera
  - Mirror is surface of revolution of a conic

  • single effective viewpoint
Why is a central camera preferable?

- We can unwrap parts or all omnidirectional image into a perspective one
- We can transform image points into spherical vectors
- We can apply standard algorithms valid for perspective geometry
Omnidirectional Camera | projection model

What are the intrinsic parameters?

- Center of distortion
- Intrinsic parameters of the perspective camera
- Relative orientation and position between camera & mirror (for catadioptric cameras)
- Distortion model
  - Mathematical model of the mirror
  - Distortion of the fisheye lens
- All these parameters define the intrinsic parameters of an omnidirectional camera
Omnidirectional Camera | distortion model

- We can model the distortion through an $n^{th}$-order polynomial

$$f(u,v) = a_0 + a_1 \rho + \ldots + a_N \rho^N$$

- $n = 4$ describes accurately most catadioptric and fisheye cameras

Image courtesy of T. Pajdla

$p = \begin{bmatrix} x \\ y \\ z \\ f(u,v) \end{bmatrix}$

$||p|| = 1$
Goal: to determine the intrinsic parameters of the camera model

The standard method consists of measuring the 3D positions of \( n \) control points on a calibration object and the 2D coordinates of their image projections

- \( n \geq 6 \) non-coplanar control points on a three-dimensional calibration target
- \( n \geq 4 \) non-collinear control points on a planar pattern
Unified Spherical Representation
Unified Spherical Representation
Points from a perspective or central omnidirectional cameras can always be represented on the unit sphere (always possible when the camera is calibrated)