Chapter 11
Bird's-eye-view

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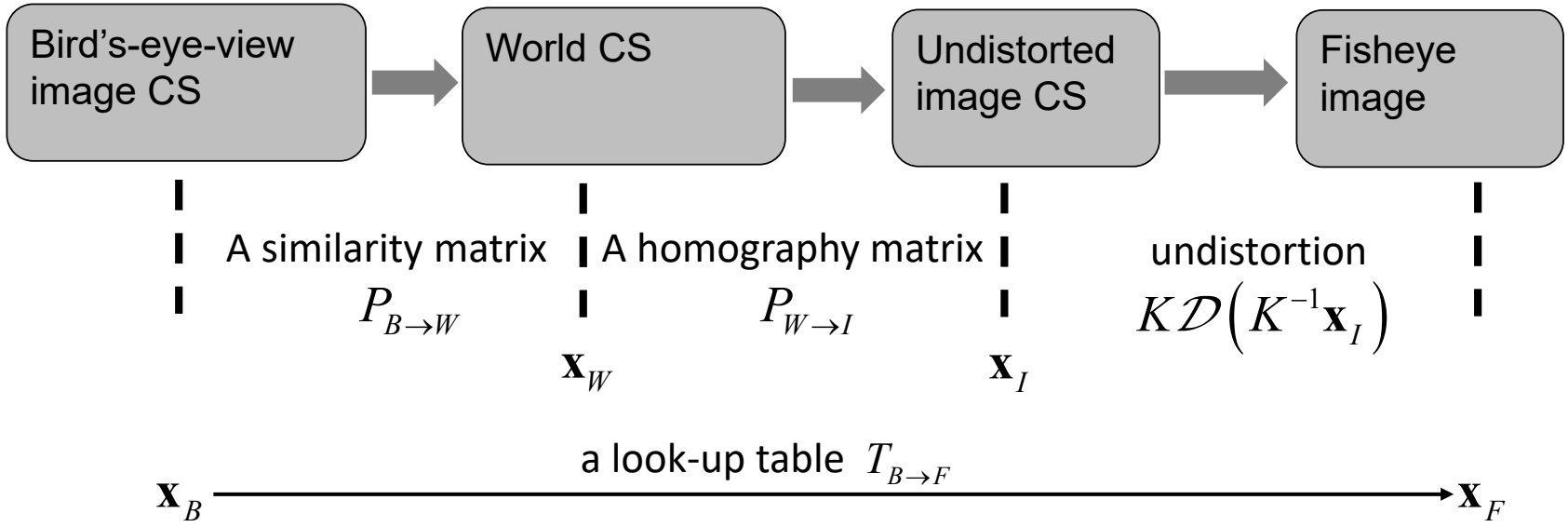
Bird's-eye-view Generation

- Our task is to measure the geometric properties of objects on a plane (e.g., conveyor belt)
- Such a problem can be solved if we have its bird's-eye-view image; bird's-eye-view is easy for object detection and measurement

Bird's-eye-view Generation

- Three coordinate systems are required
  - Bird's-eye-view image coordinate system
  - World coordinate system
  - Undistorted image coordinate system
  - Original fisheye image



Bird's-eye-view Generation

- Basic idea for bird's-eye-view generation

Suppose that the transformation matrix from bird's-eye-view to WCS is $P_{B\to W}$, the transformation matrix from WCS to the undistorted image is $P_{W\to I}$, and the camera intrinsics are known

Then, given a position $(x_B, y_B, 1)^T$ on bird's-eye-view, we can get its corresponding position in the original fisheye image as

$$\mathbf{x}_F = K\mathcal{D}\left(K^{-1}P_{W\to I}P_{B\to W}\begin{pmatrix} x_B \\ y_B \\ 1 \end{pmatrix}\right)$$

Then, the intensity of the pixel $(x_B, y_B, 1)^T$ can be determined using some interpolation technique based on the neighborhood around $\mathbf{x}_F$ on the fisheye image

Bird's-eye-view Generation

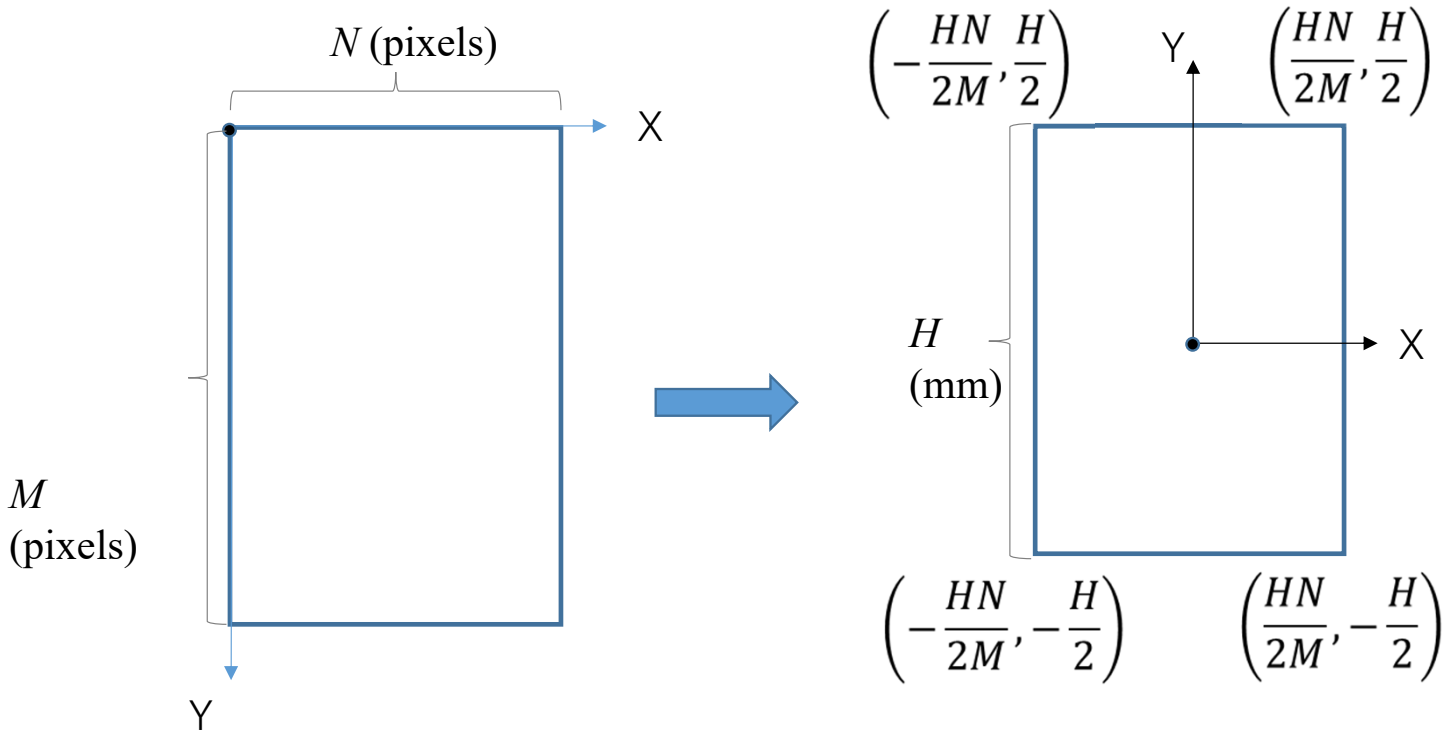
- Basic idea for bird's-eye-view generation

Suppose that the transformation matrix from bird's-eye-view to WCS is $P_{B\to W}$, the transformation matrix from WCS to the undistorted image is $P_{W\to I}$, and the camera intrinsics are known

The key problem is how to obtain $P_{B\to W}$ and $P_{W\to I}$?

Bird's-eye-view Generation

- Determine $P_{B\to W}$



Note: It is valid only when you think the origin of the world CS is at the center of the bird's-eye-view image

Bird's-eye-view Generation

- Determine $P_{B \to W}$

For a point $(x_B, y_B, 1)^T$ on bird's-eye-view, the corresponding point on the world coordinate system is,

$$\begin{pmatrix} x_W \\ y_W \\ 1 \end{pmatrix} = \begin{bmatrix} \frac{H}{M} & 0 & -\frac{HN}{2M} \\ 0 & -\frac{H}{M} & \frac{H}{2} \\ 0 & 0 & 1 \end{bmatrix} \begin{pmatrix} x_B \\ y_B \\ 1 \end{pmatrix} \equiv P_{B \to W} \begin{pmatrix} x_B \\ y_B \\ 1 \end{pmatrix}$$

Please verify!!

Bird's-eye-view Generation

- Determine $P_{W \to I}$

The physical plane (in WCS) and the undistorted image plane can be linked via a homography matrix $P_{W \to I}$

$$\mathbf{x}_I = P_{W \to I} \mathbf{x}_W$$

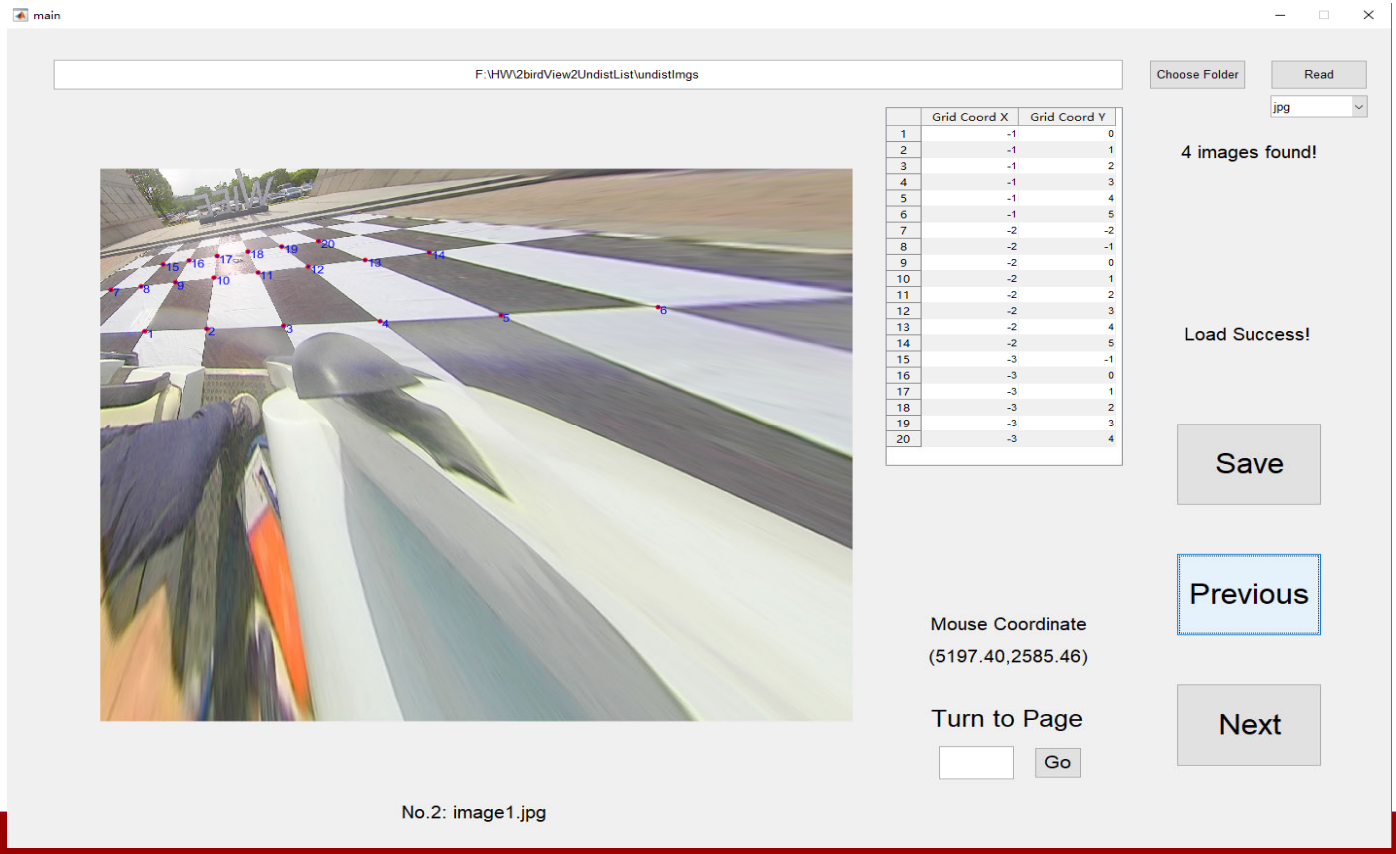
If we know a set of correspondence pairs $\{\mathbf{x}_{Ii}, \mathbf{x}_{Wi}\}_{i=1}^{N}$,

$P_{W \to I}$ can be estimated using the least-square method

Bird's-eye-view Generation

- Determine $P_{W \to I}$

A set of point correspondence pairs; for each pair, we know its coordinate on the undistorted image plane and its coordinate in the WCS



Bird's-eye-view Generation

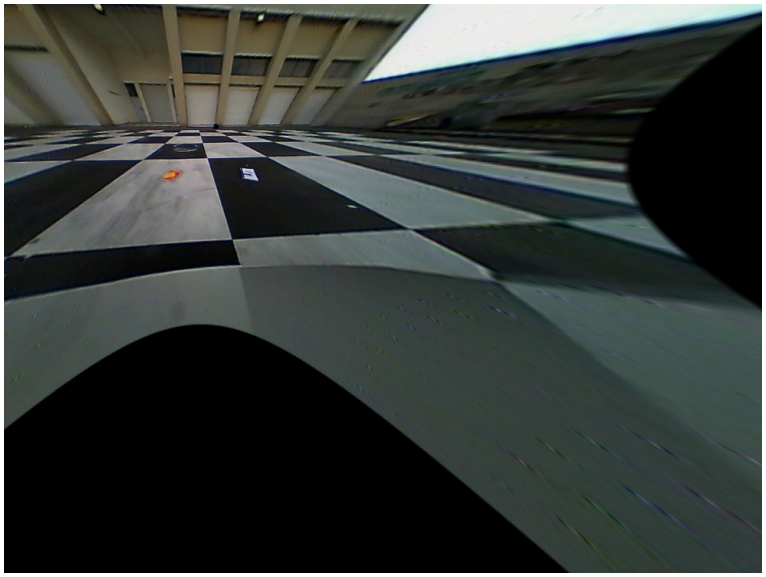
When $P_{B\to W}$ and $P_{W\to I}$ are known, the bird's-eye-view can be generated via,

$$\mathbf{x}_F = K\mathcal{D}\left(K^{-1}P_{W\to I}P_{B\to W}\begin{pmatrix} x_B \\ y_B \\ 1 \end{pmatrix}\right)$$

Bird's-eye-view Generation

Another example

Original fish-eye image

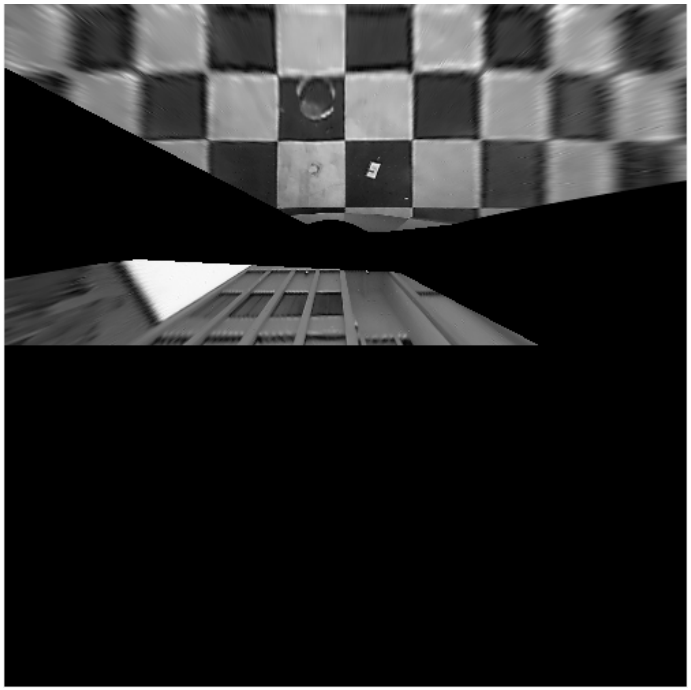


Undistorted image

Bird’s-eye-view Generation

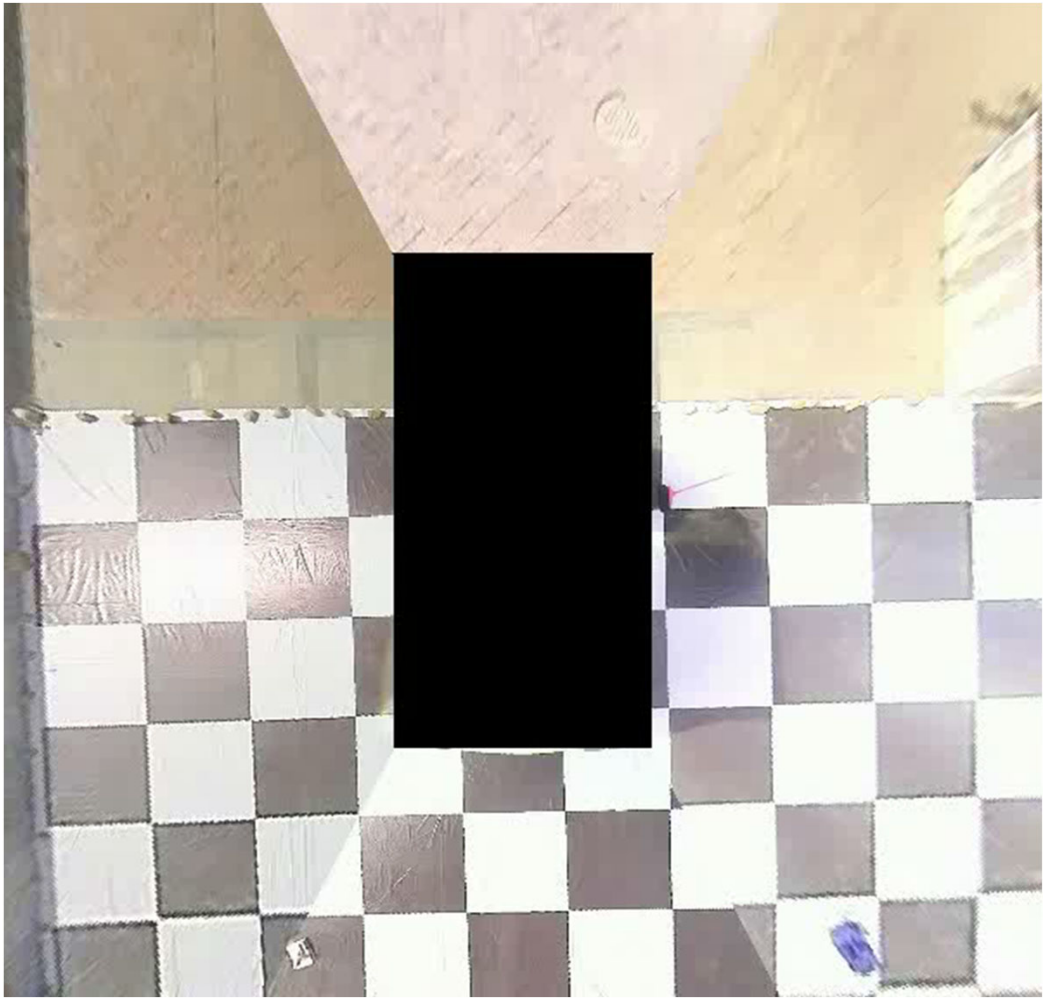
Another example

Original fish-eye image



Bird’s-eye-view

Bird’s-eye-view Generation



With multiple bird’s-eye-view from multiple cameras, a surround-view can be synthesized


Q+A