# Single Image Rolling Shutter Rectification

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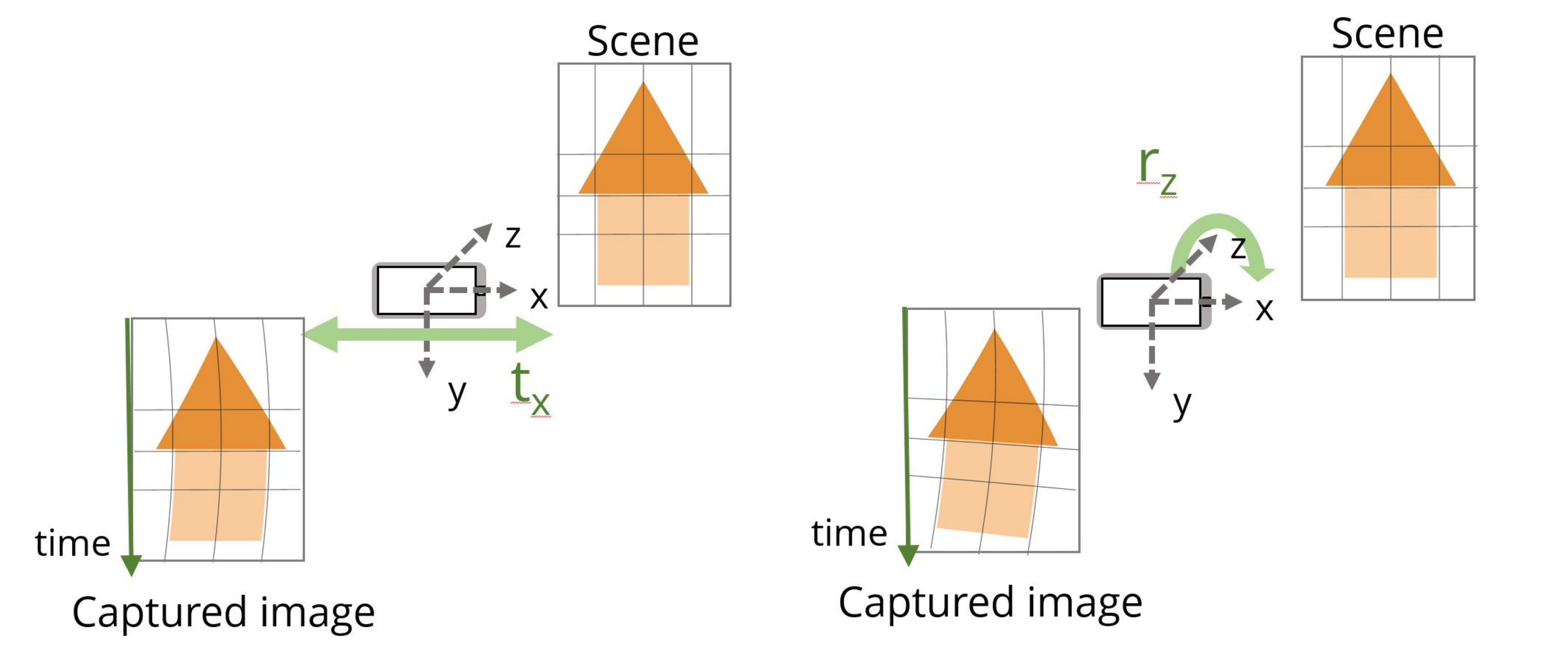
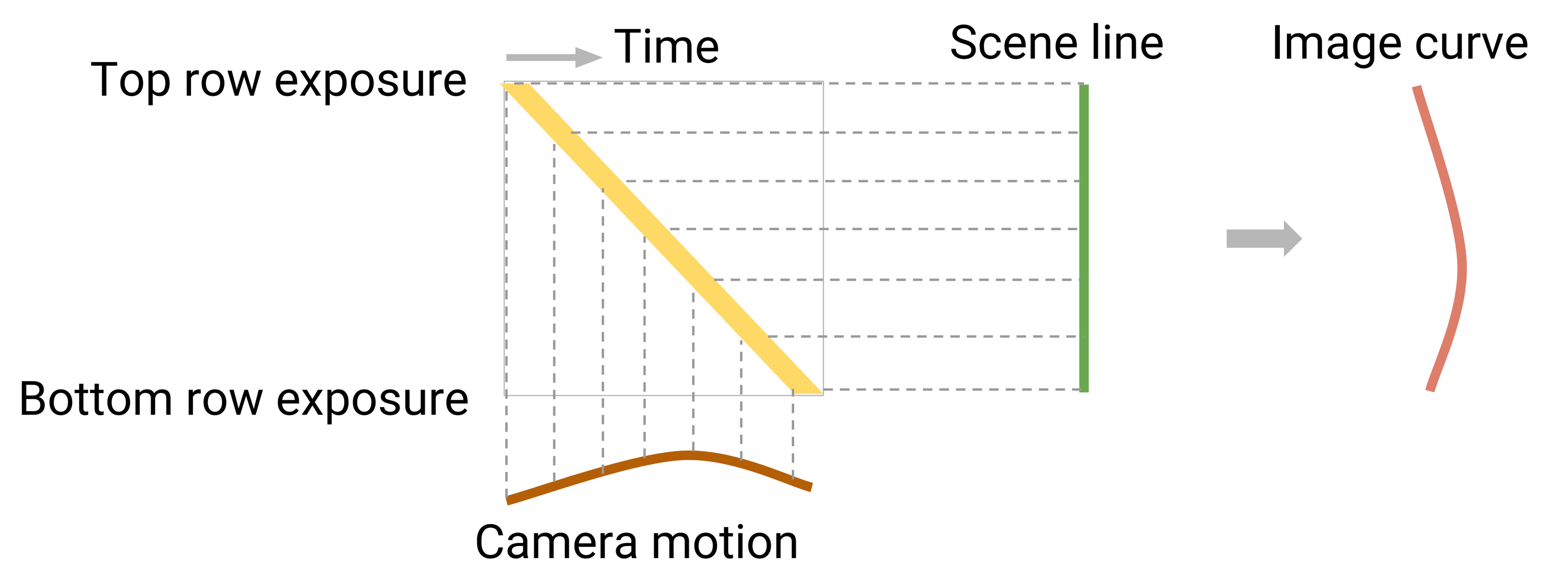
## Correct Rolling Shutter Distortions From A Single Image




Most mobile phone (CMOS sensor) cameras employ row-wise light acquisition

Camera motion even during short exposure causes local geometric distortions known as the *rolling shutter effect*

### Each image row is associated with a camera pose




### Challenges

Lack of multiple images to exploit correspondences

What image features to extract to decode camera trajectory?

### Polynomial motion model

For $i \in \{x, y, z\}$,

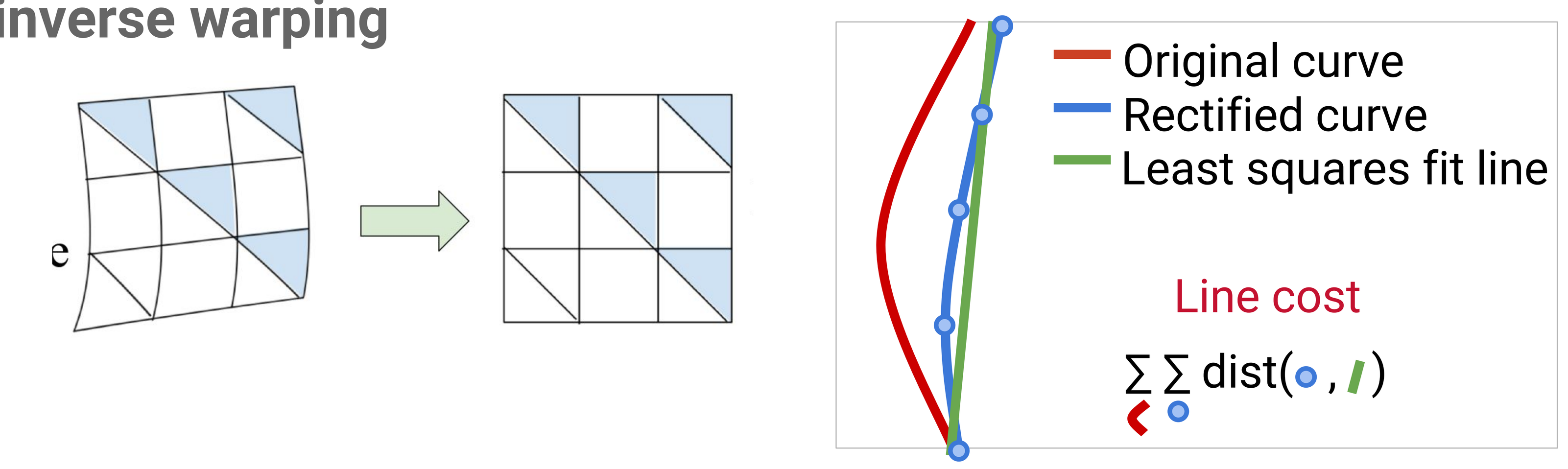
$$r_i(y) = \alpha_{i0} + \sum_{j=1}^{n} \alpha_{ij} \left(\frac{y-1}{M}\right)^j$$

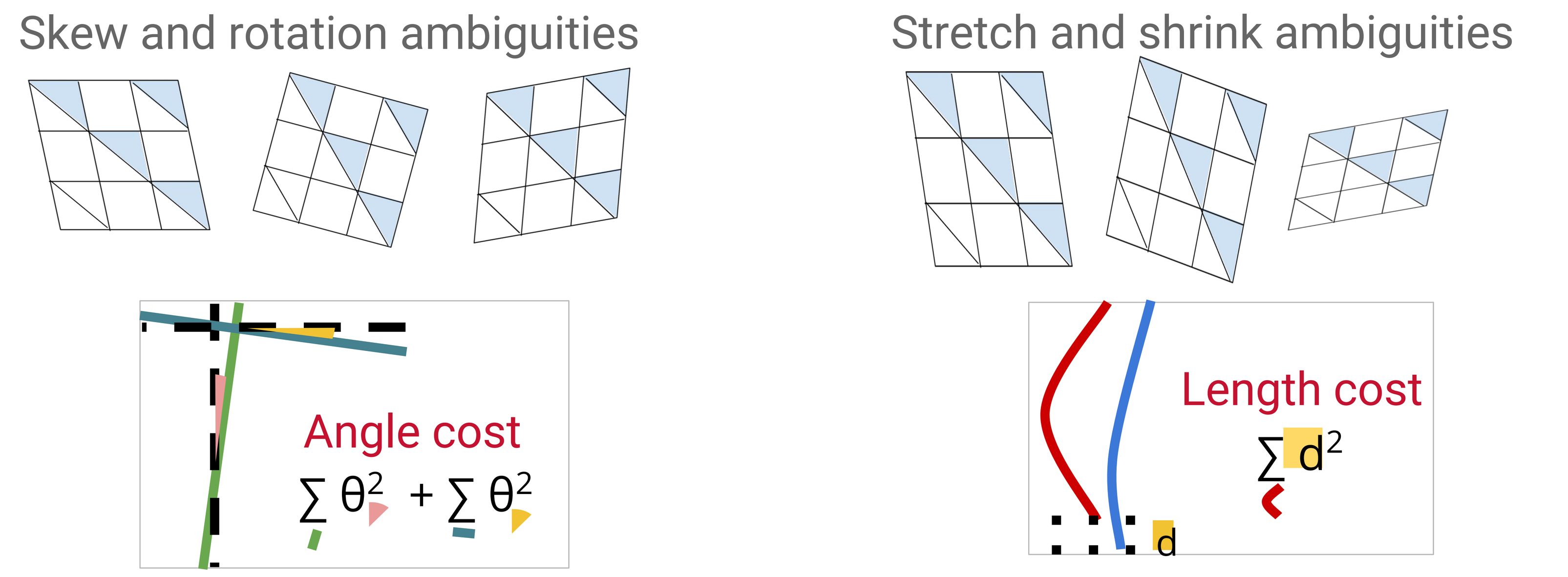
$y$ : row index $\in [1, M]$ $\quad$ $M$ : number of rows

$\alpha_{ij}$ : $j^{\text{th}}$coefficient for the $i^{\text{th}}$axis motion

## Geometry-Based Approach

### A desirable motion trajectory transforms curves to lines on inverse warping



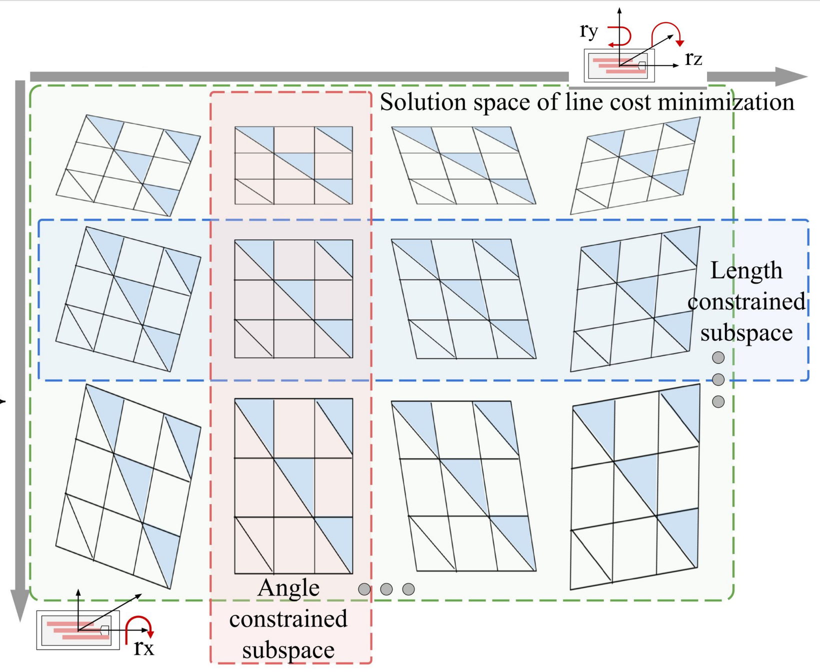




### Estimate polynomial coefficients

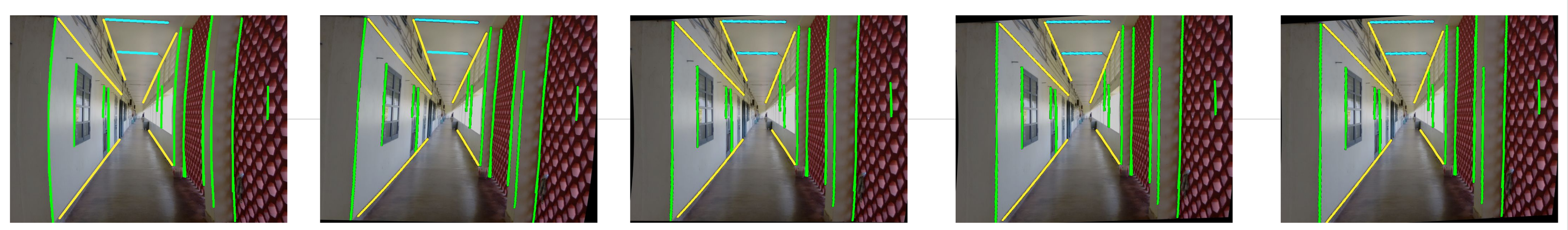
of motion that result in minimum line cost subject to desirability constraints

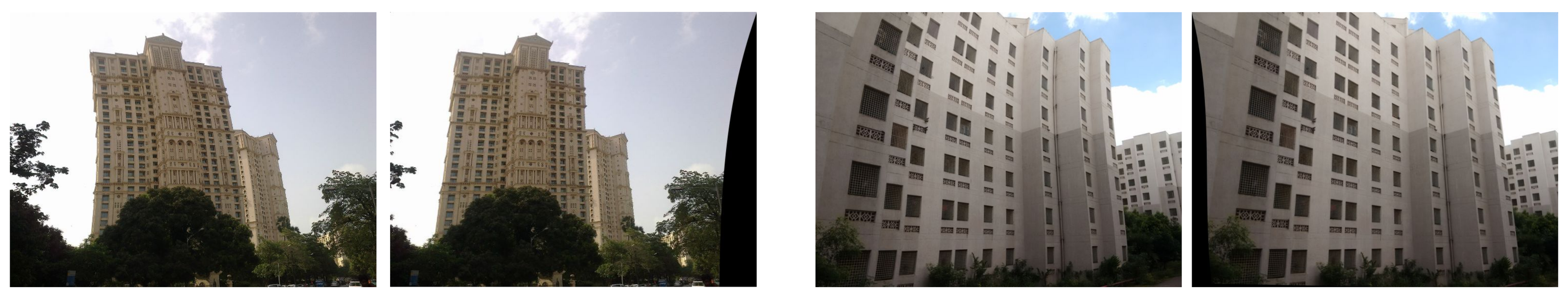
$$\{\hat{\alpha}_{ij}\} = \arg\min_{\alpha_{ij}} \{\ \text{Line cost}\ \}$$

$$\text{subject to} \begin{cases} \text{Angle cost} & < \epsilon_1 \\ \text{Length cost} & < \epsilon_2 \end{cases}$$




Intermediate results over iterations





*Distorted* *Corrected* *Distorted* *Corrected*

*Vijay Rengarajan, A.N. Rajagopalan, and R. Aravind, "From Bows to Arrows: Rolling Shutter Rectification of Urban Scenes," Proceedings of International Conference on Computer Vision and Pattern Recognition (CVPR), June 2016

## Learning-Based Approach

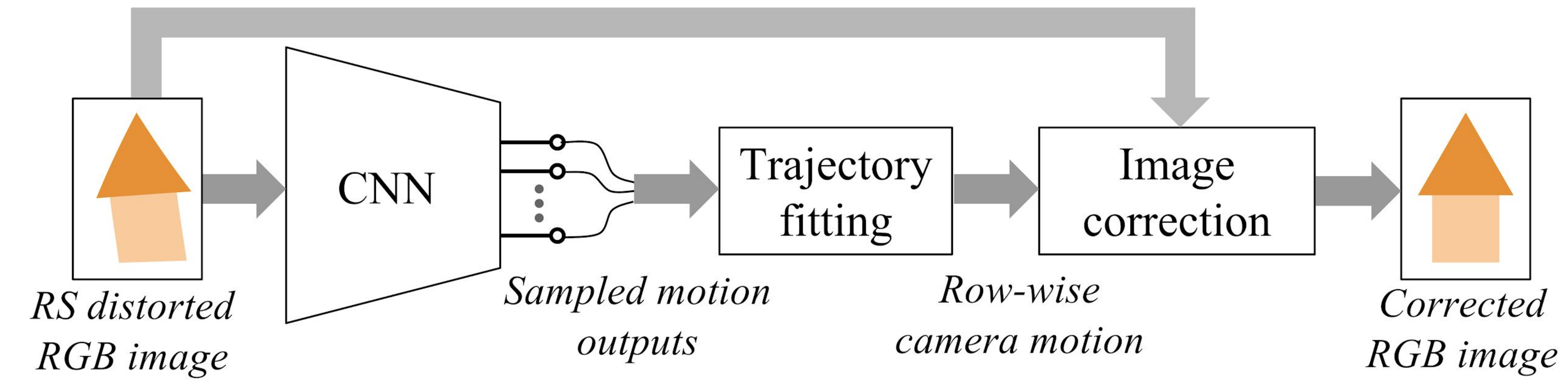
### Use a CNN to map the distorted image space to the motion space

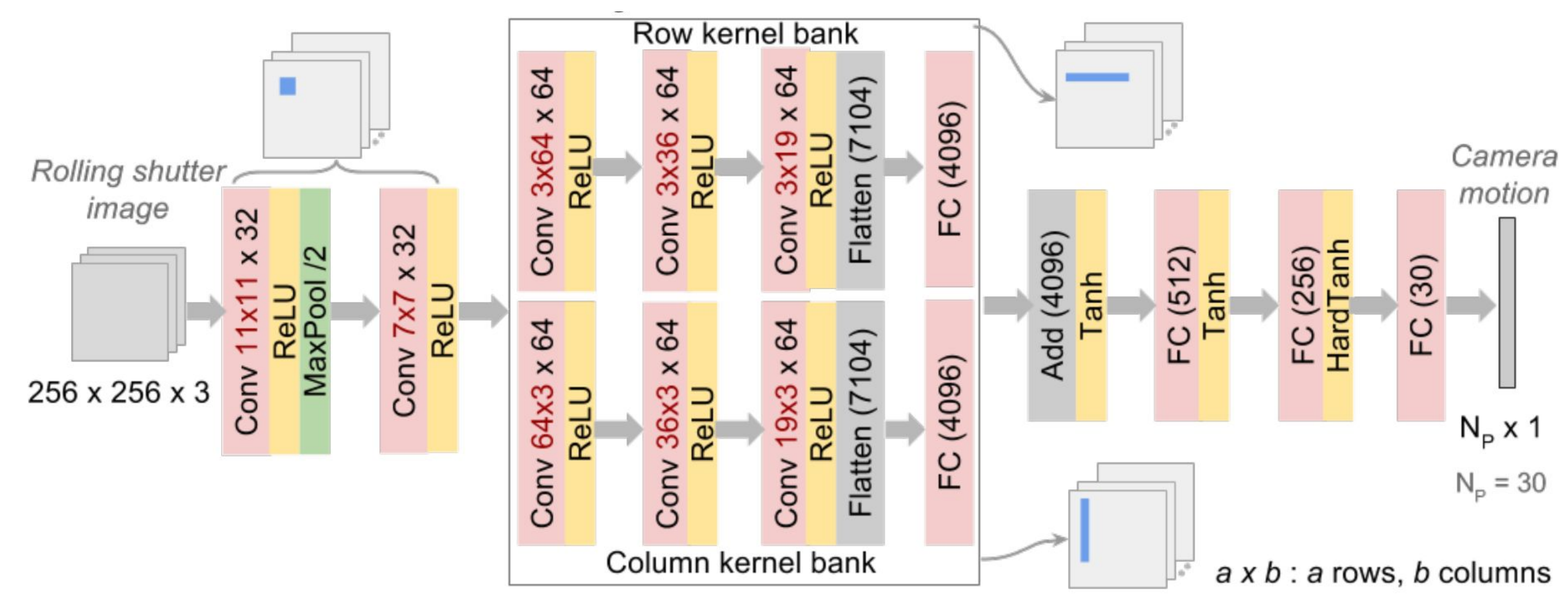
CNN input: Rolling shutter image (256x256 RGB)

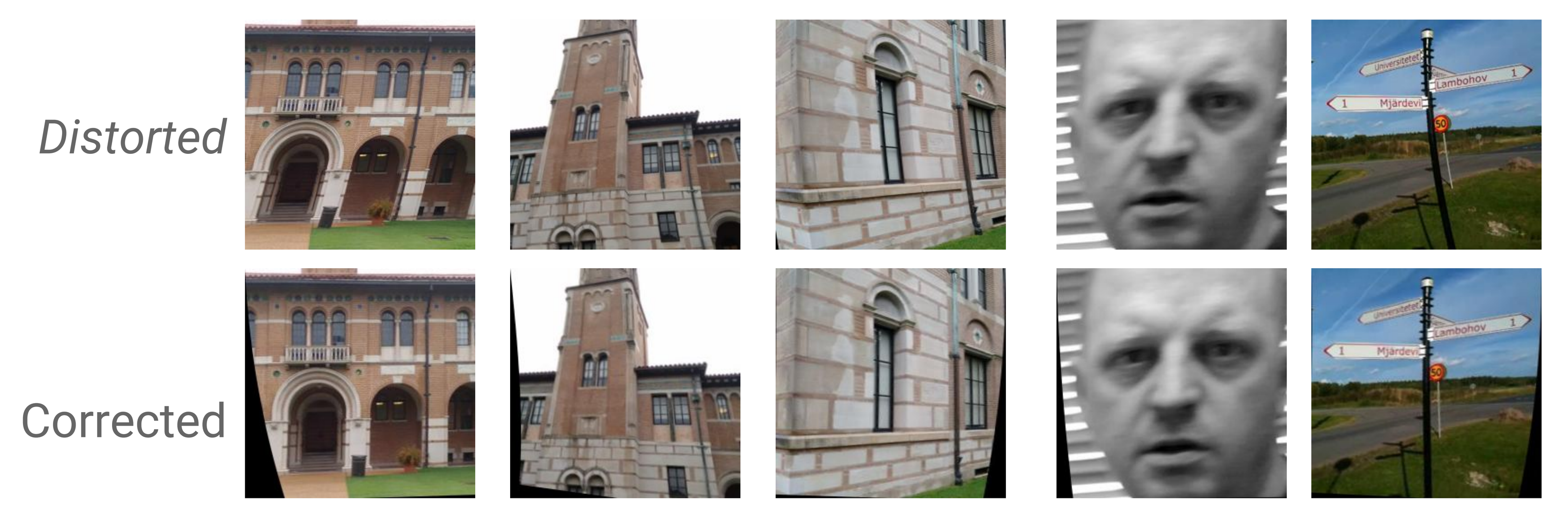
CNN output: Motion values (15 tx samples, 15 rz samples corresponding to equally spaced rows)

Fit a polynomial trajectory to get row-wise camera poses

Correct the distorted image using inverse warping




*Vijay Rengarajan, Yogesh Balaji, and A.N. Rajagopalan, "Unrolling the Shutter: CNN to Correct Motion Distortions," Proceedings of International Conference on Computer Vision and Pattern Recognition (CVPR), July 2017