Sub-Pixel Layout for Super-Resolution with Images in the Octic Group

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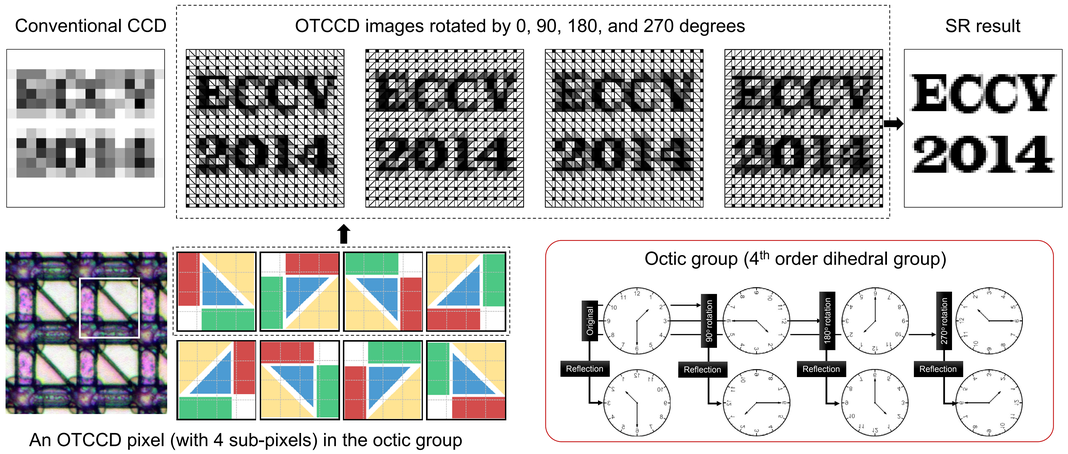
❑ Idea illustration



This paper presents a novel super-resolution framework by exploring the properties of non-conventional pixel layouts and shapes. We show that recording multiple images, transformed in the octic group, with a sensor of asymmetric sub-pixel layout increases the spatial sampling compared to a conventional sensor with a rectilinear grid of pixels and hence increases the image resolution. The example above shows OTCCD (Orthogonal-Transfer CCD, MIT Lincoln Lab) images under 4 rotations can perform 4x Super-Resolution (SR).

❑ Contributions

- A **novel view** to the SR problem by using an asymmetric sub-pixel layout to form multiple images in the octic group
- The **theoretical bound** of SR performance w.r.t. the number and distribution of sub-pixels
- A **sub-pixel layout selection** algorithm to choose good layouts for well-posed SR
- A simple yet effective **SR reconstruction** algorithm

❑ Key proposition

Given a group of pixels with t poses in the octic group $\mathcal{G}$ with each pixel containing r sub-pixels, for a designated magnification factor $\mathcal{M}$, rank($\mathbf{P}^{\Gamma}$) is bounded as

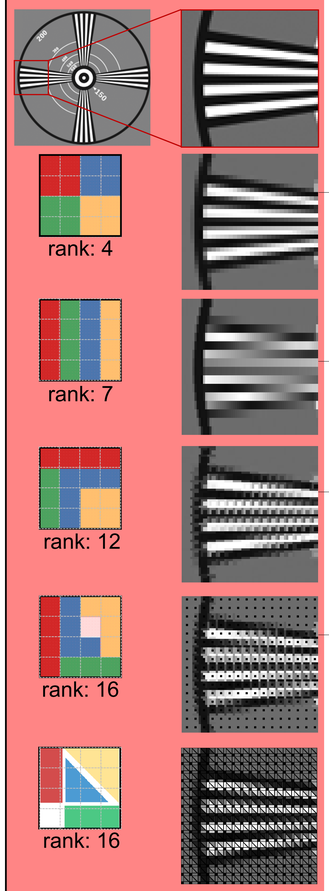
$$\text{rank}(\mathbf{P}^{\Gamma}) \leq \min(\mathcal{M}^2, t(r-1)+1)$$

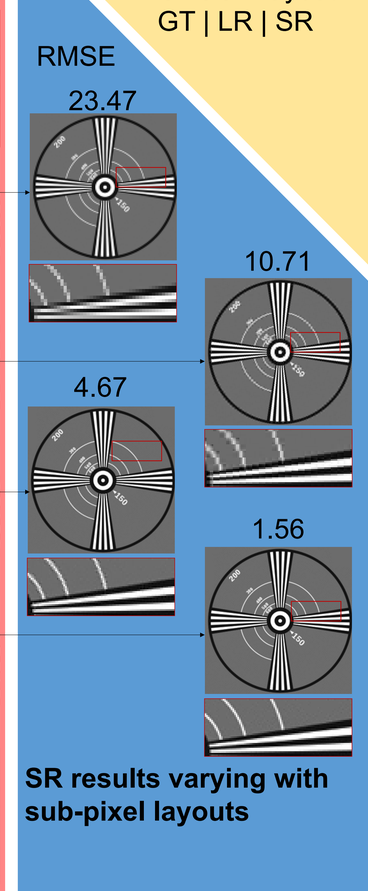
rank($\mathbf{P}^{\Gamma}$) is determined by number and distribution of sub-pixels; It evaluates the well-posedness of SR reconstruction.

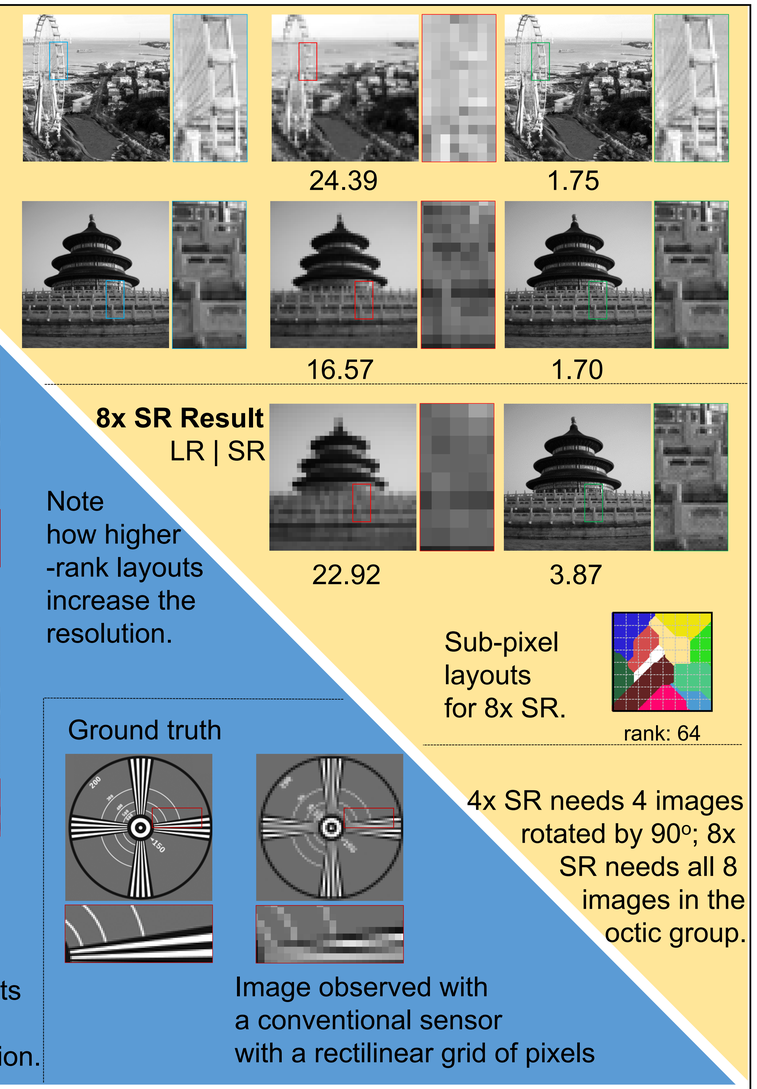
❑ Potential hardware

OTCCD + Dove prism + rotation mount

❑ Result







This is the gap among sub-pixels (treat as a dumb pixel). It also contributes to SR.

Real-simulation result for 4x (left) and 8x (right) SR

❑ **Take-home message:** "Rotation-asymmetric sub-pixel layout + rotated images" play an important role in increasing spatial sampling to break the limit of reconstruction-based super-resolution.