Low Light Enhancement (LLE): Enhance a poorly illuminated input image into a well-lit result.

Simulated Exposure Fusion (SEF): Render virtual exposure stack from the single image → global enhancement → merge using Exposure Fusion (EF) algorithms.

**QFSEF:** Iterative Quaternion RPCA factorization for progressive specularity removal & SEF.

**Layer Factorization:** Split image into multiple illumination consistent layers.

\[ I = I_{\text{specular}} + I_{\text{diffuse}} \]

**Robust Principle Component Analysis (RPCA):**

\[ I = E + A \]

where \( A \): low-rank & \( E \): sparse

argmin \( \| A \|_* + \lambda \| E \|_1 \) s.t. \( I = A + E \)

Solved by Quaternion Principle Component Pursuit

**Iterative Factorization:**

\[ I = E_1 + A_1 = E_1 + (E_2 + A_2) = E_1 + E_2 + (E_3 + A_3) = \cdots = \sum_{i=1}^{K} E_i \]

**Stack Simulation:** Clean & Combine factors.

**Post Processing:**

a) Layer Grouping: (r = 1% of I energy)

b) Outlier Removal: (>99.9 & <0.1% of I)

c) Luminance Normalization: (0 mi)

**Combine**

\[ S_{i+1} = (1 - \alpha) S_i + \alpha E_i, \text{ where } i \in [0, K] \& S_0 = I \]

**Exposure Fusion:** Fuse simulated stack images.

- **Direct (I_D)**
- **Laplacian Pyramid Fusion (I_L)**
- **Generalized Random Walk Fusion (I_G)**

**Summary:**

- Novel single image exposure fusion method.
- Novel iterative quaternion RPCA factorization scheme for exposure stack simulation.
- Qualitative & quantitative SOTA comparisons on multiple datasets.
- Ablation analysis with multiple variants.

**Future Work:**

- Simulations for LLE self-supervision.
- End-to-end unrolled LLE.
- Beyond LLE: relighting, shadow removal, white balancing, object compositing, image harmonization etc.