**Automatic Design of High-Sensitivity Color Filter Arrays With Panchromatic Pixels**


**Abstract:**

In most of existing digital cameras, color images have to be reconstructed from raw images, which only have one color sensed at each pixel, as their imaging sensors are covered by color filter arrays (CFAs). At each pixel, a CFA usually allows only a portion of the light spectrum to pass through, and thereby reduces the light sensitivity of pixels. To address this issue, previous works have explored adding panchromatic pixels into CFAs. However, almost all existing methods assign panchromatic pixels empirically, making the designed CFAs prone to aliasing artifacts. In this paper, based on a mathematical model, we propose a fully automatic approach to designing high-sensitivity CFAs using panchromatic pixels. By the frequency structure representation of CFAs, we formulate high-sensitivity CFA design as a continuous multi-objective optimization problem, where robustness to aliasing artifacts and percentage of panchromatic pixels are simultaneously maximized. We analyze the characteristics of our new formulation. According to the analysis, we develop a new method to propose frequency structure candidates, which can produce CFAs that reach a desired percentage of panchromatic pixels. Then for each candidate, we optimize parameters to obtain the final CFA, which is an appropriately balanced solution to the multi-objective optimization problem. We formulate the two design procedures as constrained optimization problems and solve them using the alternating direction method. Extensive experiments confirm the advantage of the proposed method in both low-light and normal-light conditions.