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DISSERTATION TITLE: *Multispectral imaging: Fast acquisition, capability extension, and quality evaluation*

Multispectral imaging (MSI) has been shown to be beneficial for a wide range of applications such as medical imaging, cultural heritage, biometrics, etc., but still its use was limited in part due to slow speed, high complexity and cost. In this dissertation, we have proposed three new promising fast, practical, and inexpensive multispectral imaging solutions that opens up for new applications maybe even to the consumer level. Our focus was on three different multispectral imaging systems and technologies: multi-camera (MCMSI), filter array (FAMSI), and LED (Light Emitting Diode) illumination (LEDMSI) based systems. We have also proposed a novel framework and methodology based on MCMSI and FAMSI technologies that enable multispectral imaging in an arbitrary illumination condition, which otherwise require to follow complicated and constraining calibration methods. We have shown two new applications: spectral film scanner and density measurements in photographic paper manufacturing process, where our proposed LEDMSI systems can be used effectively.

Digital color imaging, which is so far the most commonly used imaging technology, acquires a color image of a scene as a 3-band (usually red, green, and blue) image. Most of the digital cameras, mobile phones, tablets etc. employ this technology. Digital color imaging has several limitations such as metamerism, environment dependency, and sensitivity only in the visible spectral range. Multispectral imaging provides an effective solution to these by extending the number of imaging channels beyond the conventional three (in general, 4 to 20 bands), which enables the capture of unique physical properties of objects in the form of their spectral reflectances, and it can include even invisible information from ultraviolet and infrared regions.

The proposed MCMSI system, which joins two or more (say, n) digital cameras with their lenses covered with optimally chosen optical filters, enables acquisition of a $3\times n$-band image in a single exposure. FAMSI extends the conventional three-color filter mosaic pattern (e.g. the Bayer pattern) using more than three (n) filters, enabling acquisition of an n-band image in a single exposure. Our proposed LEDMSI system, which uses an RGB camera along with a combination of three optimally selected non-overlapping narrow band LED lights in each of the n exposures, enables capture of $3\times n$-band image very fast.

Each of the three proposed multispectral imaging systems has its own advantages and disadvantages, which we have analyzed in detail through simulations and experiments. We have also provided a spectral quality evaluation and comparison framework and methodology which helps choose an appropriate system for a given application.