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Challenges in design and development of Compressive Sensing based Single pixel optical Camera System for Spaceborne missions

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Evolution of CCD and CMOS sensors as prime imaging technology has enabled development of efficient and compact remote sensing systems for spaceborne missions. These imaging systems typically sample the ground scenes by means of a linear or area array of photon detectors. The quest for resolving higher spatial frequencies over large ground area with better radiometric accuracies results in huge data volume constraining the transmission bandwidth. This necessitated the development of complex on-board compression systems in digital domain with power and weight constraints. Recently, compressive sensing (CS) has emerged as potential signal processing technique for efficiently acquiring and reconstructing the signals. The main advantage of this technique is that it compresses the signal during sensing process, thereby reducing burden on on-board processing electronics systems. Based on the CS concept, conceptual framework for single pixel optical camera systems have been extensively studied as it has potential to significantly revolutionize commercial digital camera systems. However, there has not been any systematic studies towards using the CS based single pixel camera systems for spaceborne missions.

In this paper, we discuss feasibility of using CS based single camera systems from spaceborne platforms. In the process, we highlight various challenges in design and realization of these camera systems. The proposed camera system is based on digital light modulator, which acts as a sparse sampling device and a single pixel photodetector that provides under-determined measurements. We also present performance evaluation of reconstruction algorithms of compressive sampling (CS). Figure 1 provides a conceptual diagram of a single pixel camera system. The potential of this imaging system lies in the fact that it enables usage of single pixel, which offers unprecedented spectral coverage, lessens burden on onboard electronics systems and eliminates PRNU effects.

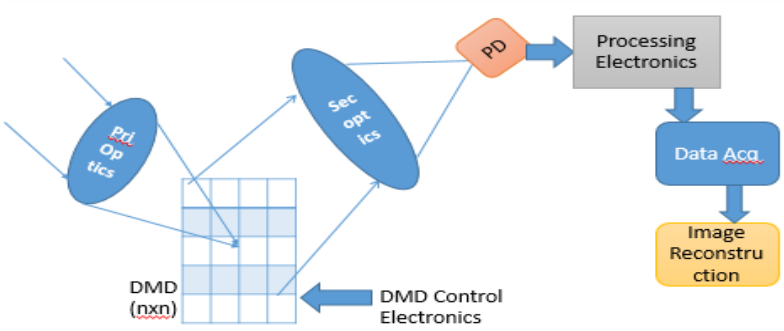

Figure 1. A Design Concept of a single pixel camera system

1. Dharmpal Takhar, Jason N. Laska, Michael B. Wakin, Marco F. Duarte, Dror Baron, Shriram Sarvotham, Kevin F. Kelly, Richard G. Baraniuk, "A New Compressive Imaging Camera Architecture using Optical-Domain Compression".

2. Emmanuel Cand`es and Justin Romberg, Caltech, "1-magic: Recovery of Sparse Signals via Convex Programming".