Compressive Light Field Photography using Overcomplete Dictionaries and Optimized Projections

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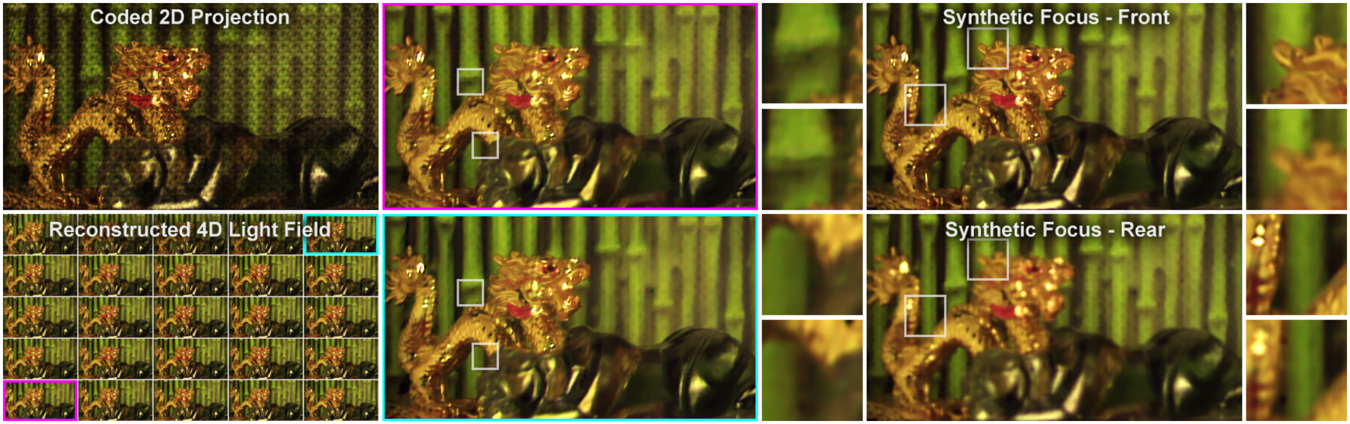

Figure 1: *Light field reconstruction from a single coded projection. We explore sparse reconstructions of 4D light fields from optimized 2D projections using light field atoms as the fundamental building blocks of natural light fields. This example shows a coded sensor image captured with our camera prototype (upper left), and the recovered 4D light field (lower left and center). Parallax is successfully recovered (center insets) and allows for post-capture refocus (right). Even complex lighting effects, such as occlusion, specularity, and refraction, can be recovered, being exhibited by the background, dragon, and tiger, respectively.*

Abstract

Light field photography has gained a significant research interest in the last two decades; today, commercial light field cameras are widely available. Nevertheless, most existing acquisition approaches either multiplex a low-resolution light field into a single 2D sensor image or require multiple photographs to be taken for acquiring a high-resolution light field. We propose a compressive light field camera architecture that allows for higher-resolution light fields to be recovered than previously possible from a single image. The proposed architecture comprises three key components: light field atoms as a sparse representation of natural light fields, an optical design that allows for capturing optimized 2D light field projections, and robust sparse reconstruction methods to recover a 4D light field from a single coded 2D projection. In addition, we demonstrate a variety of other applications for light field atoms and sparse coding techniques, including 4D light field compression and denoising.

Keywords: computational photography, light fields, compressive sensing

Links: DL PDF WEB VIDEO DATA CODE

1 Introduction

Since the invention of the first cameras, photographers have been striving to capture moments on film. Today, camera technology is on the verge of a new era. With the advent of mobile digital photography, consumers can easily capture, edit, and share moments with friends online. Most recently, light field photography was introduced to the consumer market as a technology facilitating novel user experiences, such as digital refocus, and 3D imaging capabilities, thereby capturing moments in greater detail. The technological foundations of currently available light field cameras, however, are more than a century old and have not fundamentally changed in that time. Most currently available devices trade spatial resolution for the ability to capture different views of a light field, oftentimes reducing the final image resolution by orders of magnitude compared to the raw sensor resolution. Unfortunately, this trend directly counteracts increasing resolution demands of the industry—the race for megapixels being the most significant driving factor of camera technology in the last decade.

We propose a computational light field camera architecture that allows for high resolution light fields to be reconstructed from a single coded camera image. This is facilitated by exploring the co-design of camera optics and compressive computational processing; we give three key insights into both optical and compu-