

# Ultrafast Imaging Using Spatiotemporal Encoding and Deep Learning

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**Abstract:** High speed optical imaging is a critical tool for the observation of highly transient, nonrepeatable phenomena. In this study, we introduce a compact, spatiotemporally encoded, deep – learning enabled ultrafast imaging system. Our approach involves encoding ultrafast events using nano – scribed spatiotemporal masks and reconstructing them into a sequence of femtoseconds frames via a U – net based deep learning model. This model, trained on simulated ultrafast events including geometrical shapes and handwritten digits with random positions and velocities, exhibits high accuracy and noise tolerance in reconstructing multi – frame ultrafast events from single – shot measurements captured by a standard camera. We also present preliminary results of the fabrication and characterization of spatiotemporal masks, as well as a novel implementation of FT spectroscopy based on this system. Our work provides a straightforward and cost – effective approach for the investigation of nonrepetitive ultrafast transient processes.