Real-time Super-resolution Imaging Using a Single Sensor

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We develop a novel concept for real-time super-resolution imaging using a single sensor, which benefits from the use of spatio-temporal resonant aperture and sparse reconstruction.

Conventionally, there are two types of popular active imaging systems for data acquisition: the real-aperture (RA) system and synthetic-aperture (SA) system. The SA system relies on the mechanical movement of a single sensor to form virtually a large scanning aperture via post-processing, which is typically inefficient in data acquisition. On the contrary, the RA system is composed of a large number of antenna elements, which has more flexibility in measurement modes, but sacrifices the size, weight, power, and price advantages of the single sensor system. Now, a natural question arises: *is it faithful to get a subwavelength image from a single sensor with fixed location*? The answer is encouraging. We have shown that for a given finite operational bandwidth, the resonant aperture antenna can increase the information capacity of measurements efficiently in far fields due to strong Fabry-Perot resonance, leading to the far-field imaging beyond the diffraction limit. A set of proof-of-concept investigations has been performed to verify the proposed theory. It is expected that such imaging concept can find real applications for subwavelength imaging by using more specialized spatial-temporal aperture and efficient reconstruction solver. In addition, the proposed imaging system amounts to encode the spatial details of the probed targets into temporal domain, which mathematically leads to a measurement matrix well matched to compressive sensing (CS), and serves as an easy-implementation apparatus for compressive measurements.

This work proposes a novel concept of real-time subwavelength imaging using a single sensor in combination with a spatio-temporal resonant aperture, where the resonant aperture is placed in the vicinity of probed object, and the single sensor is far from both resonant aperture and probed object. The resonant aperture is filled by the dispersive Drude metamaterial. We provide three-fold theoretical results to demonstrate that the proposed imaging system is capable of producing super-resolution imaging without using any near-field scanning, mechanical movement, and antenna array. In particular, (a)For the aperture filled with such dispersive material, there are two mechanisms of resonances: one is due to the aperture itself, and the other from the structure of “air- medium-air”. (b) The information capacity of the proposed imaging system can be efficiently driven up by the resonant aperture, in combination with the broadband illumination. (c)such resonant aperture manages efficiently the conversion of evanescent waves into propagating waves. Finally, above theories are verified by full-wave numerical simulations with the use of CST Microwave Studio Package.