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A Scalable Laplacian Pyramid Reconstructive Adversarial Network for Flexible Compressive Sensing Reconstruction

Background

Compressive sensing (CS) is a transformative sampling technique that allows sparse signals to be sampled in compressed form at a rate much lower than the Nyquist rate. However, conventional CS reconstruction techniques, based on either convex optimization or iterative methods, come with three drawbacks in imaging applications: (1) High complexity of iterative signal reconstruction, (2) the dependency on known signal sparsity which often does not apply to natural images, and (3) rigid, fixed-resolution reconstructions.

Deep neural networks (DNNs) have been explored for CS image reconstruction but result quality typically does not exceed that of conventional CS optimization techniques. Furthermore, fixed-resolution outputs remain unaddressed by current DNN methods.

Invention Description

Researchers at Arizona State University have developed a scalable Laplacian pyramid reconstructive adversarial network (LAPRAN) that enables high-fidelity, flexible, and fast CS image reconstruction. LAPRAN progressively reconstructs an image using the concept of the Laplacian pyramid through multiple stages of reconstructive adversarial networks (RANs). At each pyramid level, CS measurements are used with a contextual latent vector to generate a high-frequency image residual. Consequently, LAPRAN can produce hierarchies of reconstructed images, each with incremental improvements in resolution and quality. The scalable pyramid structure of LAPRAN thus delivers high-fidelity CS reconstruction with adaptive resolution and compression ratios (CRs), neither of which are achievable with current methods. Experiments on multiple public datasets demonstrate that LAPRAN outperforms model-based and data-driven baselines: peak signal-to-noise ratio (PSNR) improved by an average of 7.47 dB and 5.98 dB, respectively, and structural similarity (SSIM) improved by an average of 57.93% and 33.20%, respectively.

Potential Applications

- Biomedical imaging
- Communication systems
- Pattern recognition
- Speech and sound processing
- Video processing

Benefits and Advantages

- Flexible – Reconstructs images at desired resolutions across a wide range of compression ratios, with or without knowledge of signal sparsity
- Efficient – Demonstrates improved image quality over competing techniques while prioritizing reconstruction speed
- Innovative – Pyramidal layering of reconstruction processes reduces CS inversion problem to incremental stages which lowers error accumulation

Laboratory Homepage of Professor Fengbo Ren

Related Publication (PDF)