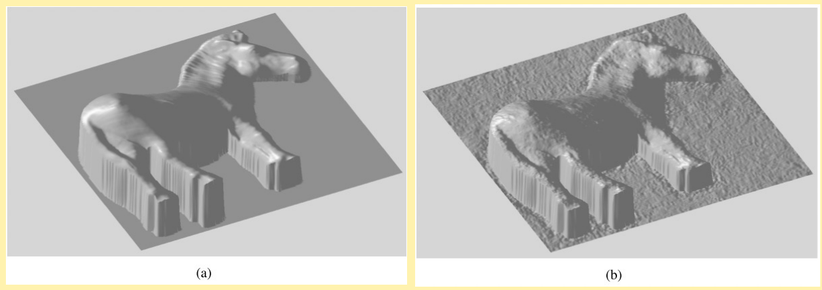
Hyperparameter Tuning for the Derivative Compressive Sampling

Md Fazle Rabbi
Fordham University

Problem Statement

- Derivative compressive sampling (DCS) is a signal recovery method to reconstruct a source signal using sub-Nyquist sampling rates when the signal gradients are measured.
- The DCS recovery algorithm is sensitive with respect to hyperparameters. Good results depend on tuning the hyperparameters properly.
- We study the sensitivity of DCS with respect to the algorithm hyperparameters and draw guidelines for the user to set up the values of the hyperparameters.



(a) (b)

Problem Description

- DSC has been used to recover a surface (x) from measurements (y) using sub-Nyquist sampling rates.

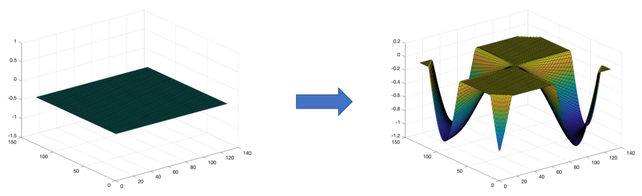


Image (x): Peak Valley (Before Reconstruction)

Image (y): Peak Valley (After Reconstruction)

- If we use the wrong hyperparameter values for Lambda (λ) and Delta (δ) for the DCS recovery algorithm, the reconstructed image will be blurry:

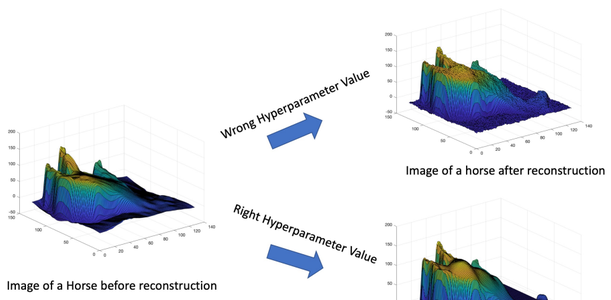


Image of a Horse before reconstruction

Image of a horse after reconstruction

Image of a horse after reconstruction

- The reconstruction quality is conditioned on tuning the hyperparameters properly.

Hyperparameter Tuning

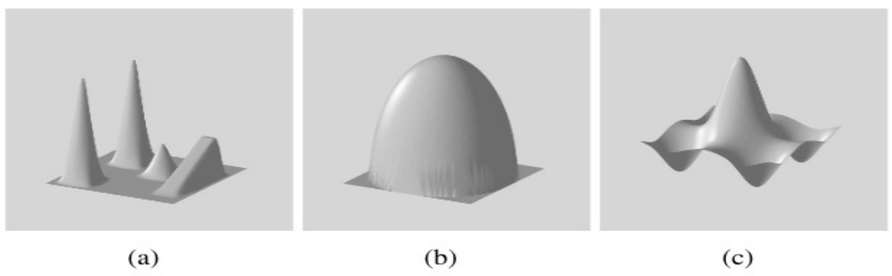
- The user should set the hyperparameter values in advance, but the challenge is the reference signal is not available in advance.
- If the values of the hyperparameters are not appropriately set, the recovery quality will be poor.

Brute-Search Sensitivity Analysis

- We study the performance sensitivity with respect to the hyperparameters by varying their values and then check the algorithmic recovery performance by adding noise to a reference signal and then recover it using the DCS algorithm.
- We conclude guidelines to setup values for the hyperparameters.

Results

- **The brute-search values:**
  - Lambda, λ = [0, 0.0001, 0.001, 0.01, 0.1, 1, 10]
  - Delta, δ = [0.1, 1, 2, 5, 10]
- **Three noise types:**
  1. Gaussian
  2. Laplacian
  3. Salt and Pepper
- **Nine Surfaces:**

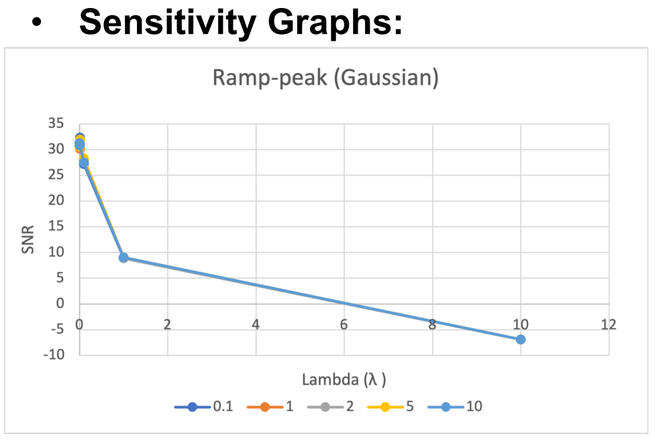


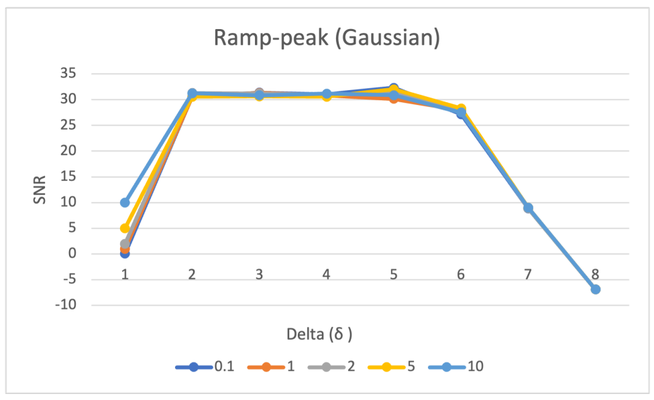
(a) (b) (c)

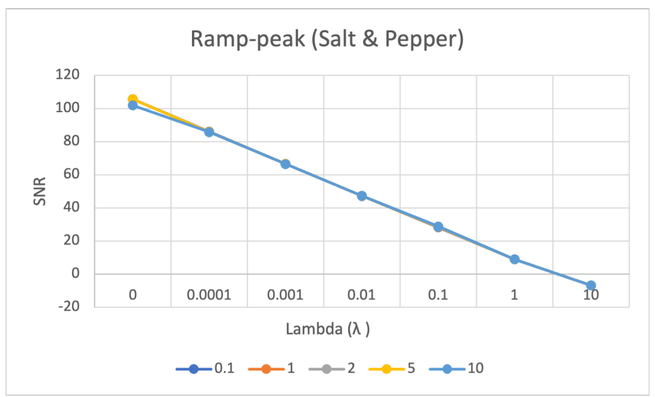
(d)

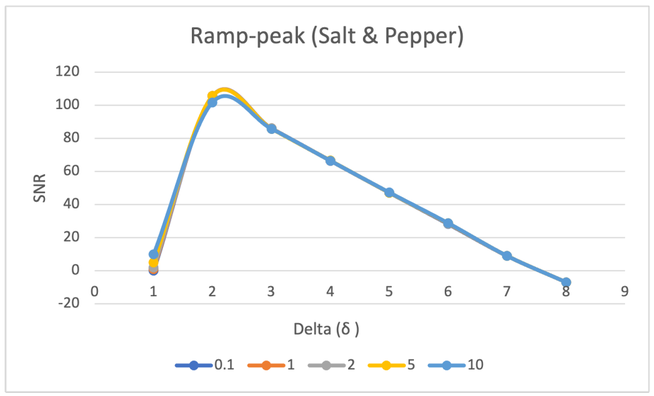
Fig. 2. Synthetic surfaces (a) Ramp-peak (b) Sphere, (c) Peak-valley, and (d) sample photos of 6 real objects. (Top from left to right: Cat, Rock, and Horse. Bottom from left to right: Gray, Owl, and Buddha.)

- **Sensitivity Graphs:**









- **Conclusions:**
  - The values Lambda, λ = 0 and Delta, δ = 2 leads to the best average performance

Contact <Md Fazle Rabbi> mrabbi@fordham.edu
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USC Viterbi School of Engineering
Information Sciences Institute