

NEL-BITA

类脑智能技术及应用国家工程实验室

National Engineering Laboratory for Brain-inspired

Intelligence Technology and Application

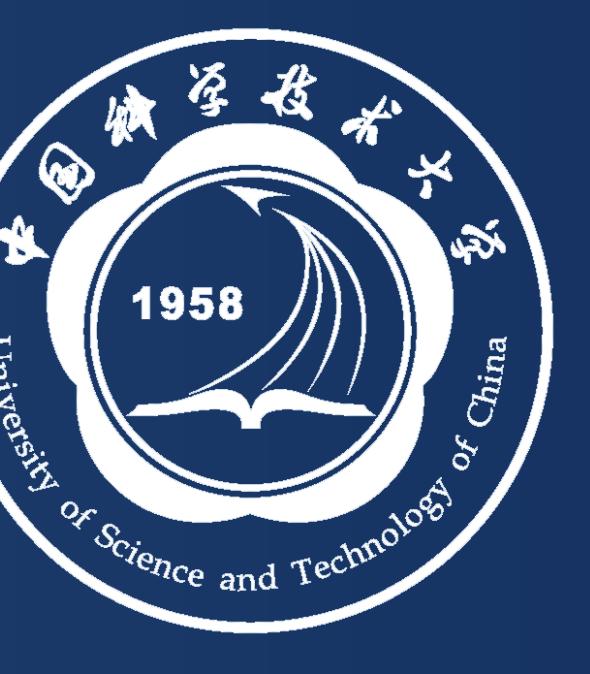
# On The Classification-Distortion-Perception Tradeoff

Dong Liu, Haochen Zhang, Zhiwei Xiong

University of Science and Technology of China, Hefei, Anhui 230027, China

Email: dongeliu@ustc.edu.cn

National Engineering Laboratory for Brain-inspired Intelligence Technology and Application

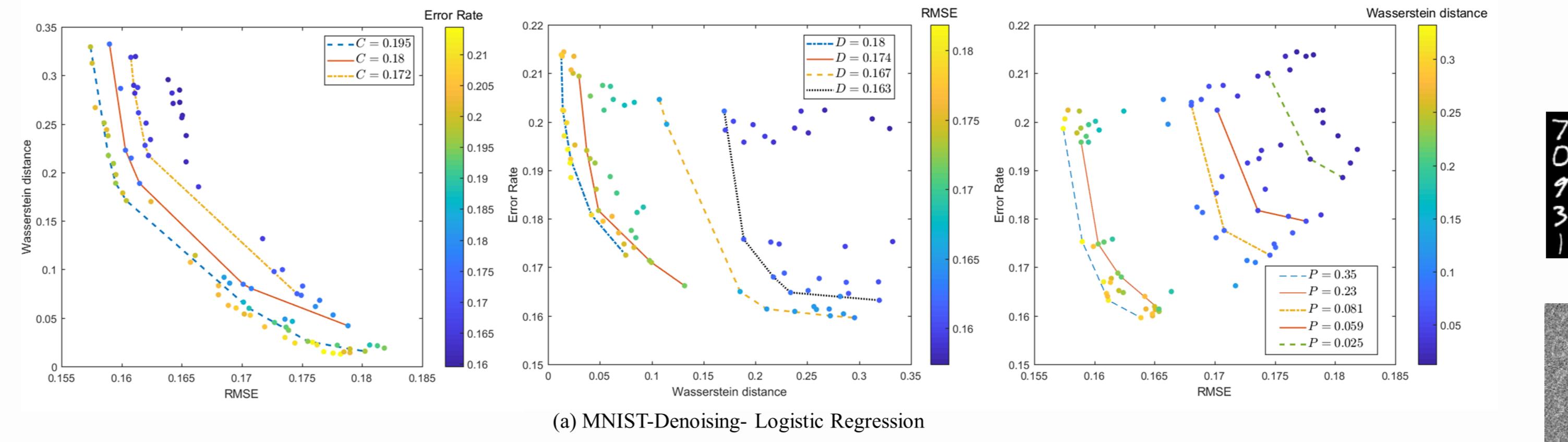


## Introduction

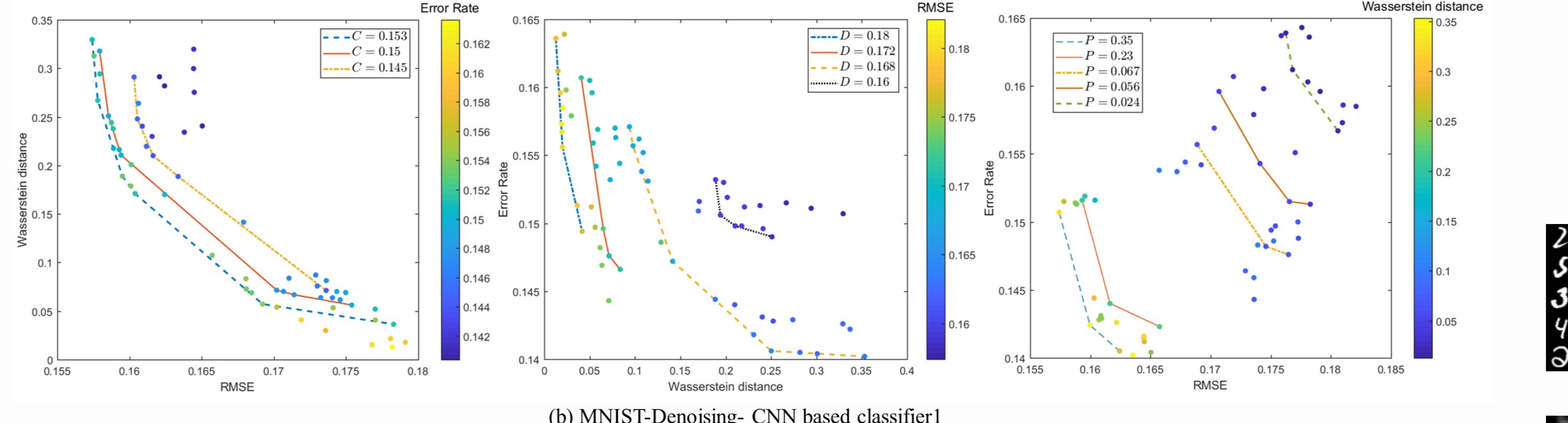
- Different restoration tasks have various objectives.
- *Signal fidelity metrics* that evaluate
- *Perceptual naturalness metrics* that evaluate
- *Semantic quality metrics* that evaluate how
- When semantic quality is defined as the classification error rate achieved on the restored signal using a predefined classifier, we provide a rigorous proof of the existence of the classification-distortion-perception (CDP) tradeoff, i.e. the distortion, perceptual difference, and classification error rate cannot be made all minimal simultaneously.

## Formulation

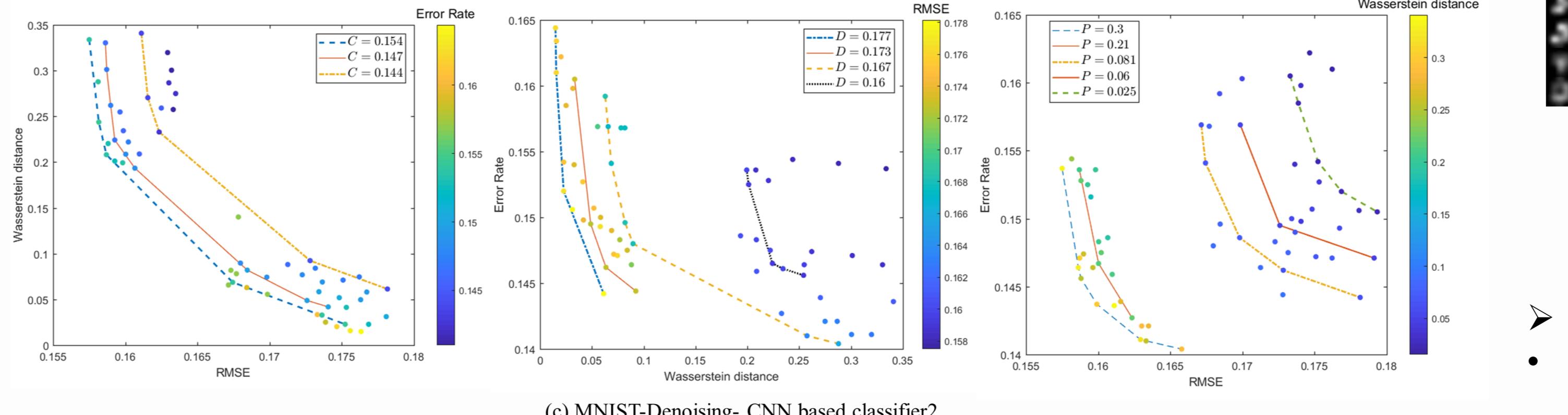
## Profiles of the CDP Function



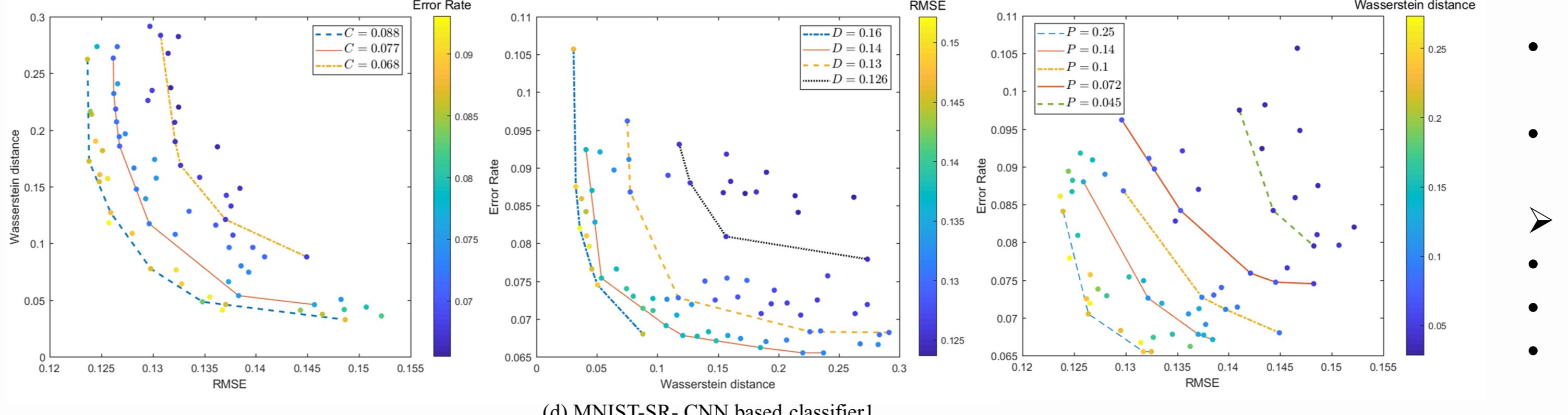
(a) MNIST-Denoising- Logistic Regression



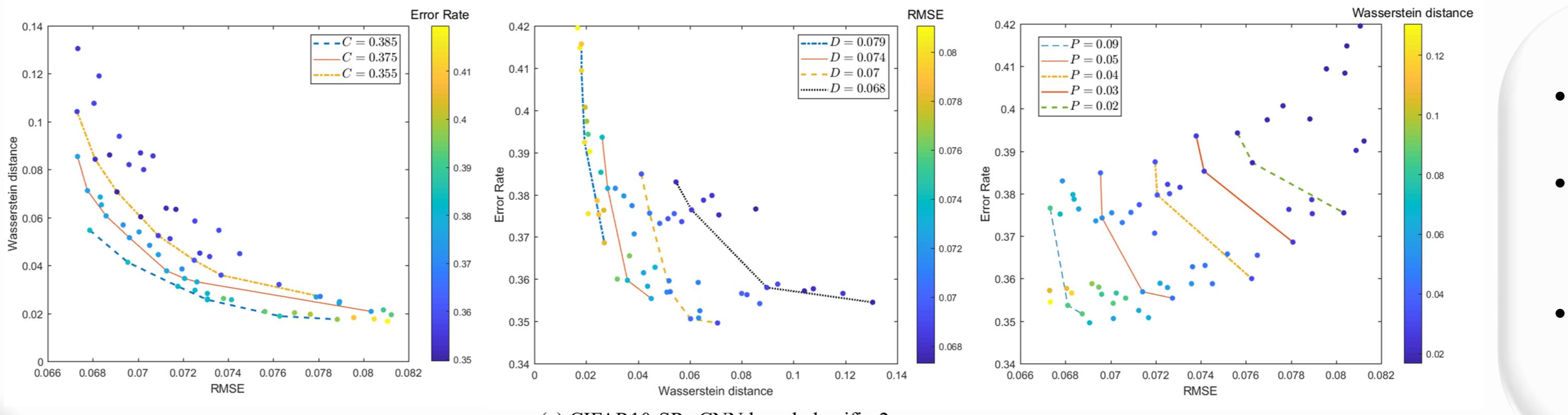
(b) MNIST-Denoising- CNN based classifier1



(c) MNIST-Denoising- CNN based classifier2

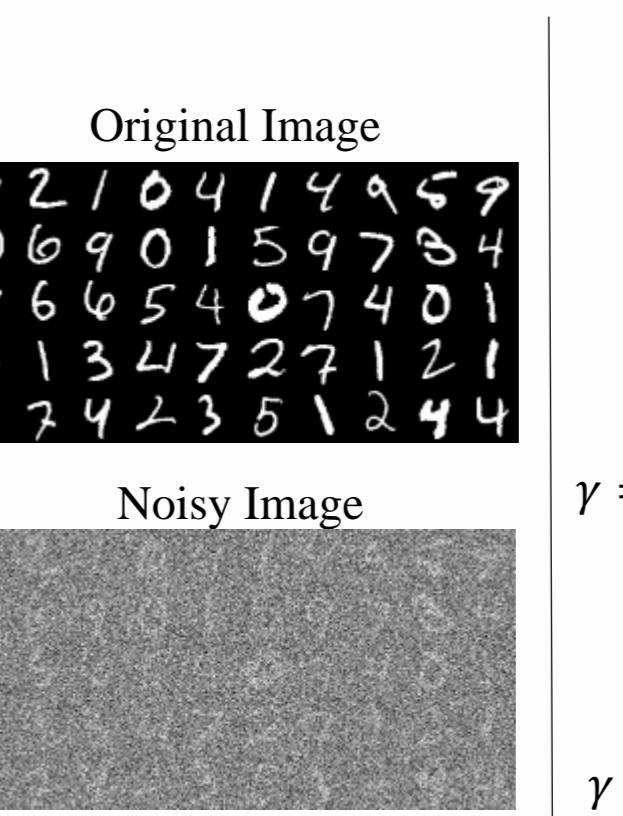


(d) MNIST-SR- CNN based classifier



(e) CIFAR10-SR- CNN based classifier2

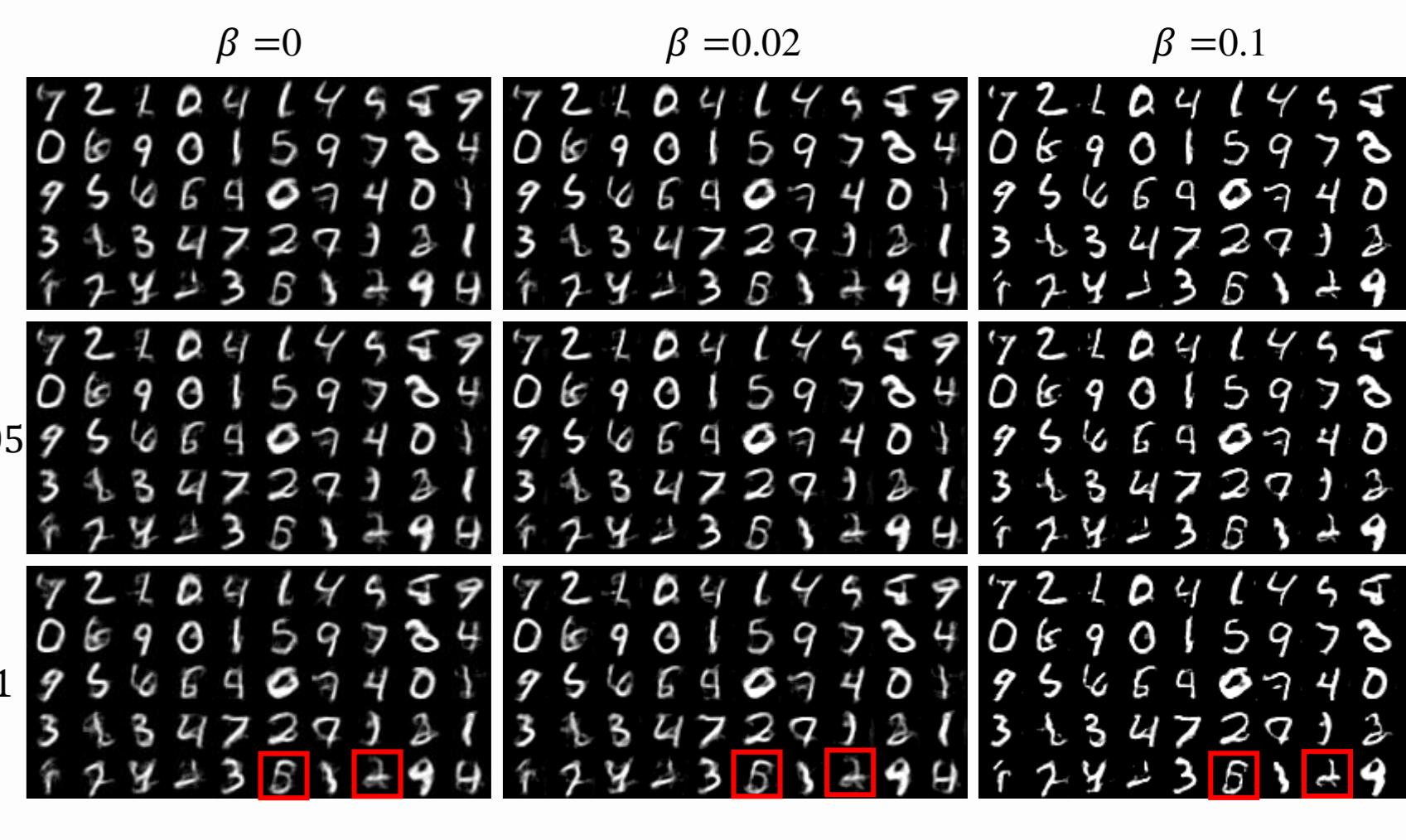
## Experiments



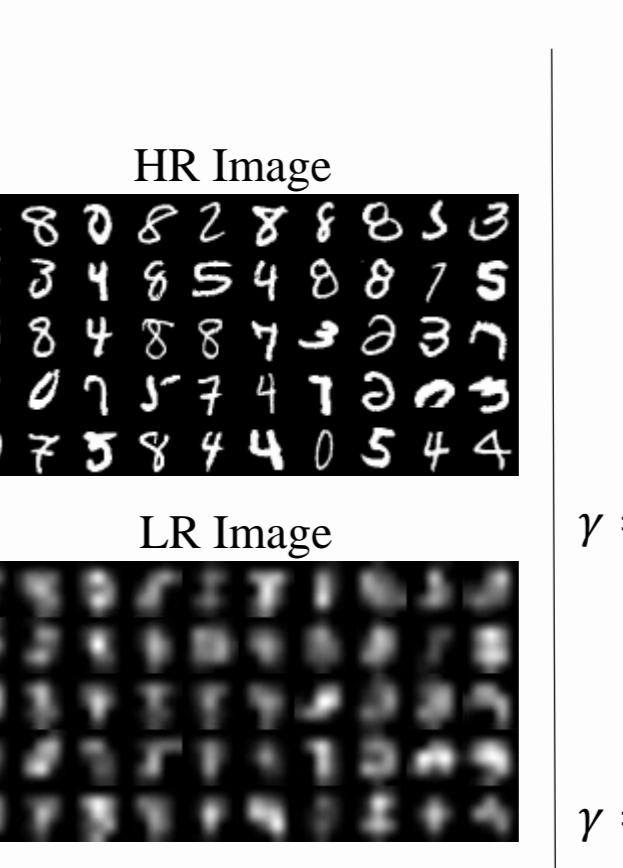
Original Image

Noisy Image

## Visual Results

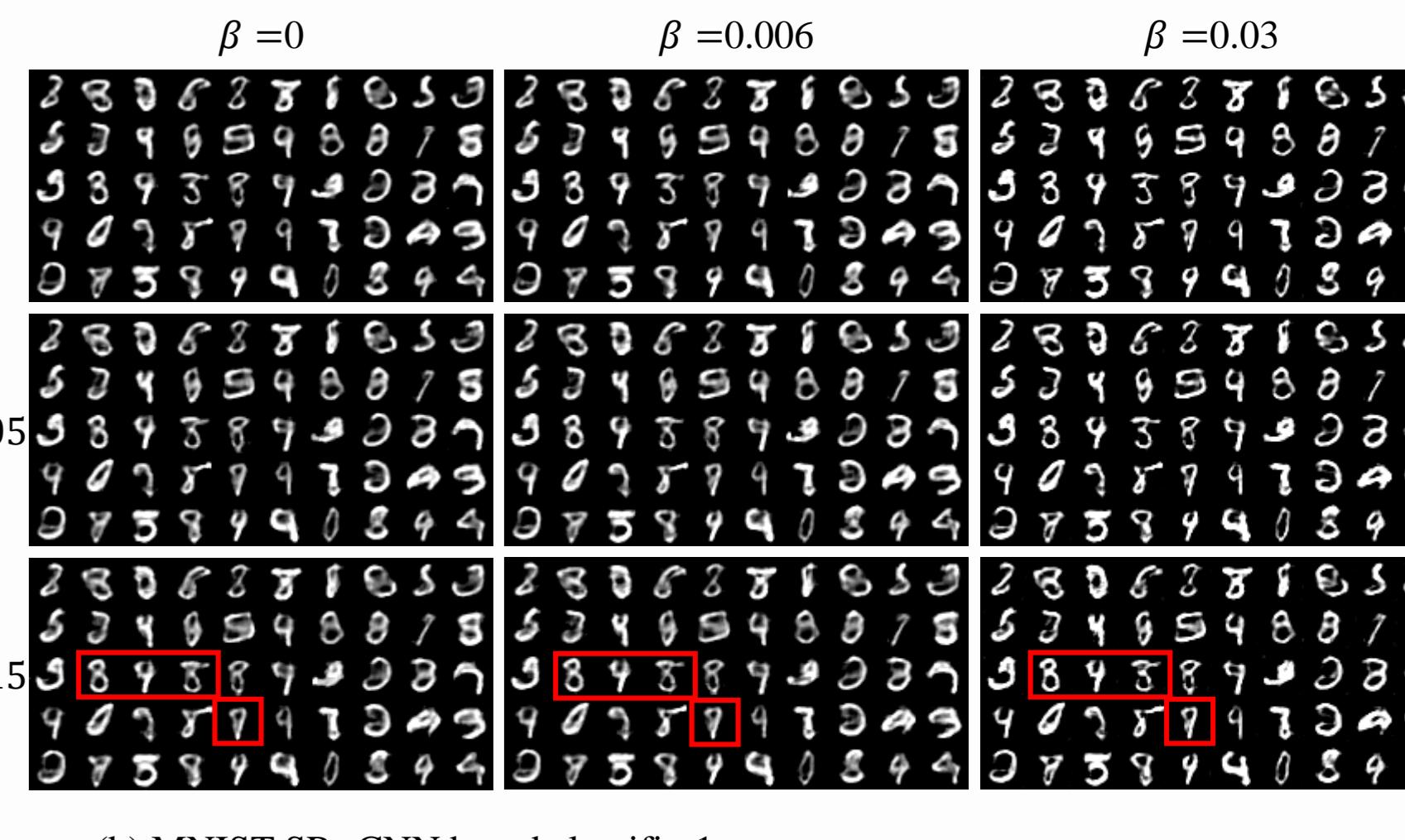


(a) MNIST-Denoising- CNN based classifier1



HR Image

LR Image



(b) MNIST-SR- CNN based classifier1

## Discussion

### Profiles of CDP function

- In the first column, when  $C$  is sufficiently large, there is a tradeoff between  $P$  and  $D$ . Once  $C$  is smaller, the  $P$ - $D$  curve elevates, indicating that better classification performance comes at the cost of higher distortion and/or worse perceptual quality.
- Similarly in the other two columns, and the relations of  $C$ - $P$  and  $C$ - $D$  are convex as the theorem forecasts.
- Comparing (a), (b) and (c), although the error rates differ much in number, the trends of the CDP tradeoff are similar.

### Visual result

- The visual quality of restored images in general increases along with the weight  $\beta$ .
- Given the same  $\beta$ , when increasing  $\gamma$ , the visual quality decreases.
- There seems a positive correlation between classification and human recognition

## Conclusion

- We have investigated the classification-distortion-perception tradeoff theoretically and experimentally.
- Regardless of the restoration algorithm, the classification error rate on the restored signal evaluated by a predefined classifier cannot be made minimal along with the distortion and perceptual difference.
- The CDP function is convex, indicating that when the error rate is already low, any improvement of classification performance comes at the cost of higher distortion and worse perceptual quality.