**Semih Barutcu - Research Statement**

My areas of interest are image processing, inverse problems, and deep learning. The goal of my research is to apply advancements in machine learning techniques to standing challenges in computational imaging and image processing, and to develop algorithms for such problems as well as improving the current methodology.

**Research Contributions**

**Improvement in an Iterative Reconstruction by Combining two Inverse Models [1]**: In this research, we addressed the so called ptycho-tomography problem and introduced a 3D reconstruction method that uses gradient descent. 3D ptychography overcomes the resolution limitation of lens-based imaging method and it is significant to get high resolution reconstructions. Here, we re-design the inverse problem and solve the ill-posedness of the problem by exploiting the redundancy in the forward model which makes the reconstruction to be easily accessible via gradient descent. Then, we apply our gradient descent algorithm to show significant improvements over the state-of-the-art methods.

**Covid-19 Detection using Chest X-Ray Images [2]:** In this work, we have developed classification networks to detect different aspects of findings in the lungs for subtle effects of Covid-19 which are hard to differentiate from other pneumonias. Due to the small amount of training data available, networks are pre-trained on a general chest x-ray dataset and fine-tuned with clinical images from Northwestern Medicine. To ensure to get the best accuracy, networks are ensembled via a probabilistic approach and the resulting model performed similar to a consensus of experienced radiologists which allow the method to be used as pre-screening tool in hospitals.

**Physics-Based Deep Image Prior Approach to Computed Tomography [3]:** Computed tomography has been studied well and methods have been developed to get 3D image of a structure. However, in some cases, whole structure cannot be scanned resulting in an ill-posed problem, namely missing-wedge. Unlike the traditional methods, we approach the challenge with a physics-based deep network and solve it without training with the inspiration from “Deep Image Prior”. That is, we construct a generative network taking projections as the input and modifies the 3D output to minimize the loss between the input projections and results of the physical projection model of the output. This approach does not require any training data as it transforms the projections into 3D reconstruction directly using a combination of fully connected and convolutional layers. In order to incorporate the regularization for noise, we have self-trained the network in an Alternating Direction Method of Multipliers (ADMM) framework.

**Improving X-Ray Imaging Method through Regularization and Automatic Position Correction [4]:** In this project, we improve an x-ray imaging method by decreasing dependency on exact measurements via regularization and learned position correction. In x-ray ptychography, projection acquisition process is usually not precise in nanometer domain and resulting reconstructions generate significant errors. We have improved the results via two methods: incorporating regularization via image priors and correcting position via automated self-learning. We show that improvements via learned scan positions with the help of regularization are significant compared to the existing methods in the literature.

**Future Work and Collaboration with Netflix**

I have been in image and video processing field with a focus on inverse problems for several years. In the recent projects, my focus has shifted towards the applications of deep learning in new inverse imaging fields and towards the improvements on the current challenges. My intention is to continue working on the application of machine learning methods to various existing problems in this field and Netflix Research is a well-suited environment for me to pursue this goal.

In many applications, with the background knowledge of the traditional methods significant improvements can be made to deep learning compared to experimental applications. Netflix Research has been in the image processing field for a long time and many of the well-studied methods in image processing can be applied to deep learning methods currently being employed in its products. If I am given the chance, I desire to work on specific inverse problems in computational imaging or image processing in Netflix Research where the methods can be improved by using the well-studied image processing literature.

**References**

[1] **S. Barutcu** et al., “Simultaneous 3D X-Ray Ptycho-Tomography with Gradient Descent,” *Proceedings of the* *IEEE International Conference on Image Processing (ICIP)*, *Oct. 2020*, doi: 10.1109/icip40778.2020.9190775

[2] R. M. Wehbe, **S Barutcu** et al., “DeepCOVID-XR: An Artificial Intelligence Algorithm to Detect COVID-19 on Chest Radiographs Trained and Tested on a Large US Clinical Dataset,” *Radiology, p. 203511, Nov. 2020*, doi: 10.1148/radiol.2020203511

[3] **S. Barutcu** et al., “Computed Tomography reconstruction via Deep Image Prior and ADMM,” *Nature - Scientific Reports (In review)*

[4] P. Shedligeri, **S. Barutcu** et al., “Improving Acquisition Speed of X-Ray Ptychography through Spatial Undersampling and Regularization,” *Proceedings of the* *IEEE International Conference on Image Processing (ICIP)(In review)*