Motivation

- Detect dark matter particle candidates
- Detectors are semiconductor crystals instrumented with sensors
- Extract positional information reliably from the sensor data
- Improve background rejection using fiducial cuts
- An effective fiducial cut can improve the signal-to-background ratio by up to 20x

Dataset & Features

- Output voltage traces of 12 sensors
- Sensor response for energy hits at inputted positions (x, y, z)
- Generated by simulations
- Sensor voltage normalized to range from 0 to 1

- Input vector: 12 sensors * 1000 time steps = 12000 row-vector
- Output/Label: 3 row-vector representing x, y, z coordinates

Model

- Supervised Learning
- Fully connected neural network
- Layers, hidden units as hyperparameters
- Modified MSE cost:
  \[ L = \sum_{i} (y_i - \hat{y}_i)^2 + \lambda \left( \sum_{i} |y_i - \hat{y}_i|^2 \right) \]

Results

Sub-problem: single coordinate (output = [z])

- layers: [12000, 16, 20, 16, 18, 3]
- lambda_bias: 1.0

All coordinates (output = [x, y, z])

- batch_size: 32
- epoch: 200

Future

- Investigate the position and voltage dependence of the resolution
- Try other neural network models like convolutional neural network to include effects such as time offsets and pile-ups present in real data
- Train and test the model with real sensor data

References