Applying Deep Neural Network Techniques for LArTPC Data Reconstruction

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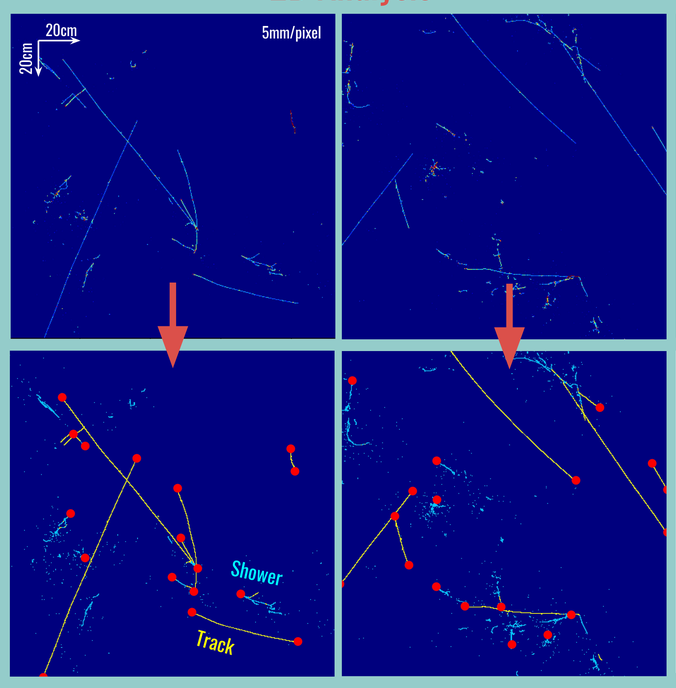
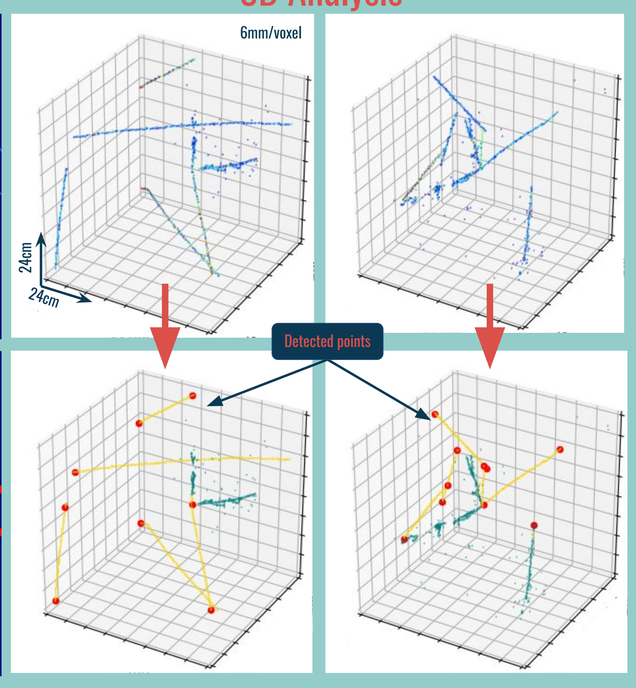
2D Analysis



Top 2 example input 2D images
Bottom Results of 2D UResNet + PPN

3D Analysis



Top 2 example input 3D volumetric images
Bottom Results of 3D UResNet + PPN

MOTIVATIONS

Develop a full 2D & 3D reconstruction chain for Liquid Argon Time Projecting Chambers (LArTPC) detectors using deep learning

DEMONSTRATION

First steps demonstration: semantic segmentation (UResNet) and track/shower edge point detection (Pixel Proposal Network)

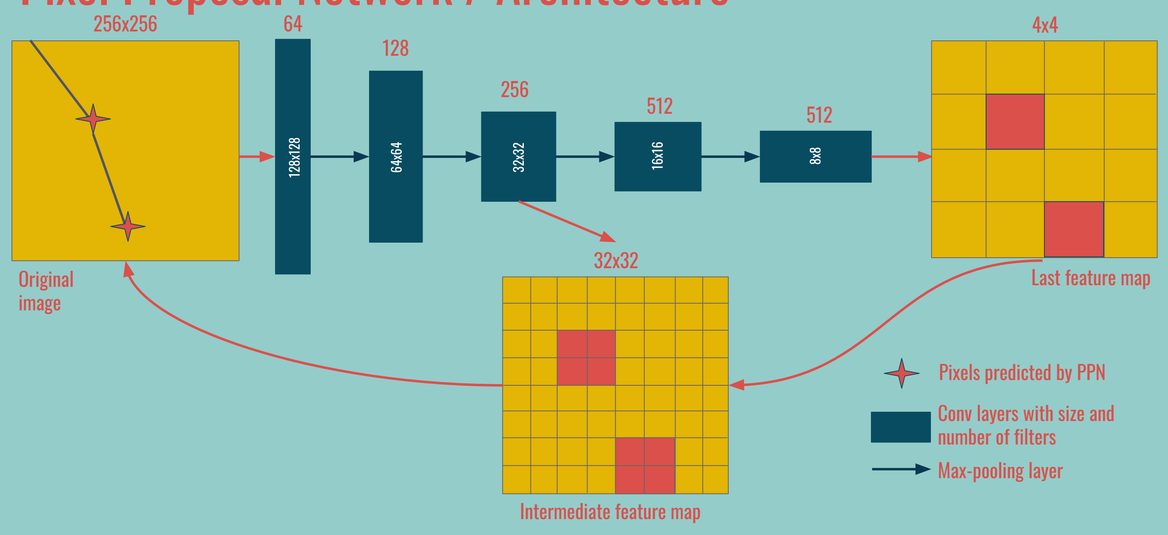
DATASET

Trained on DeepLearnPhysics open LArTPC simulation samples 2D & 3D

ROADMAP

Track/shower start point detection (Pixel Proposal Network) → Semantic segmentation (UResNet) → Clustering of energy deposits → Particle ID and energy estimate

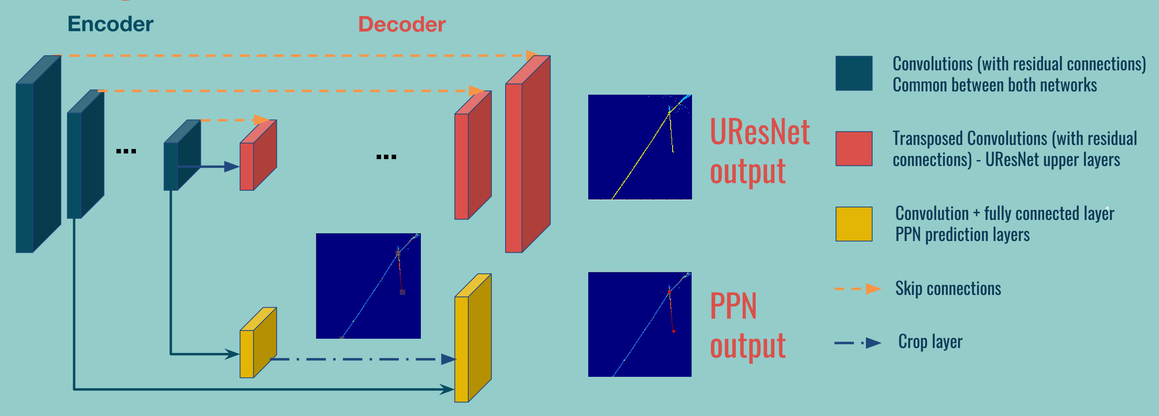
Pixel Proposal Network / Architecture



Semantic Segmentation with UResNet

- UResNet is an encoder-decoder network which performs pixel-wise classification between track / shower / background. ... See K. Terao's poster #117 for more details!
- Share computation of convolutional layers with PPN !
- Training scheme: train UResNet first, freeze the lower layers then train PPN.

Training UResNet + PPN / Architecture



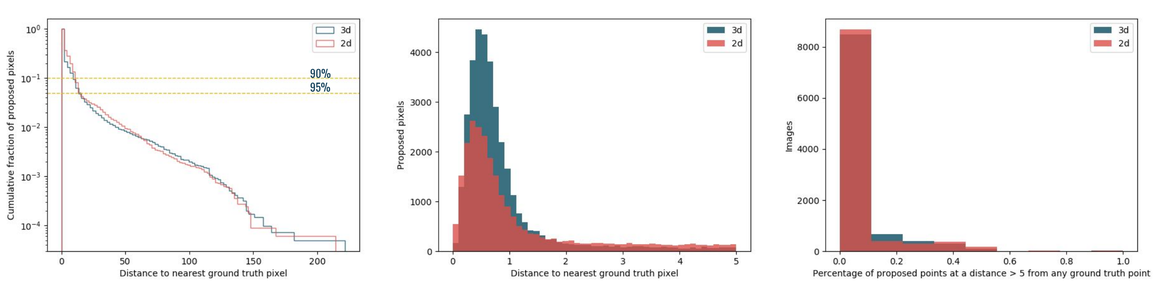
Vertex finding with Pixel Proposal Network (PPN)

GOAL Determine shower/track edge points with pixel precision

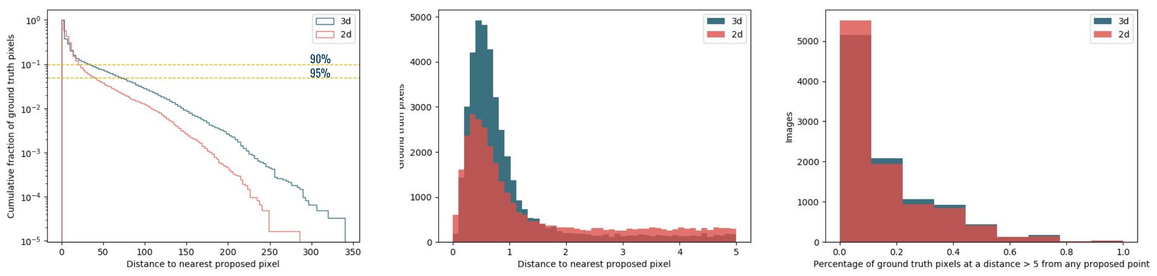
IDEA 2-stages network inspired by Faster-RCNN, an object detection and classification network

- ➢ Stage 1 = select some pixels of interest from the last feature map
- ➢ Stage 2 = propose points within these pre-selected pixels from an intermediate feature map
- ➢ Run DBSCAN clustering algorithm for the final selection of points

METRICS Distance from PPN proposed points to ground truth points (in pixels) *10,000 images*

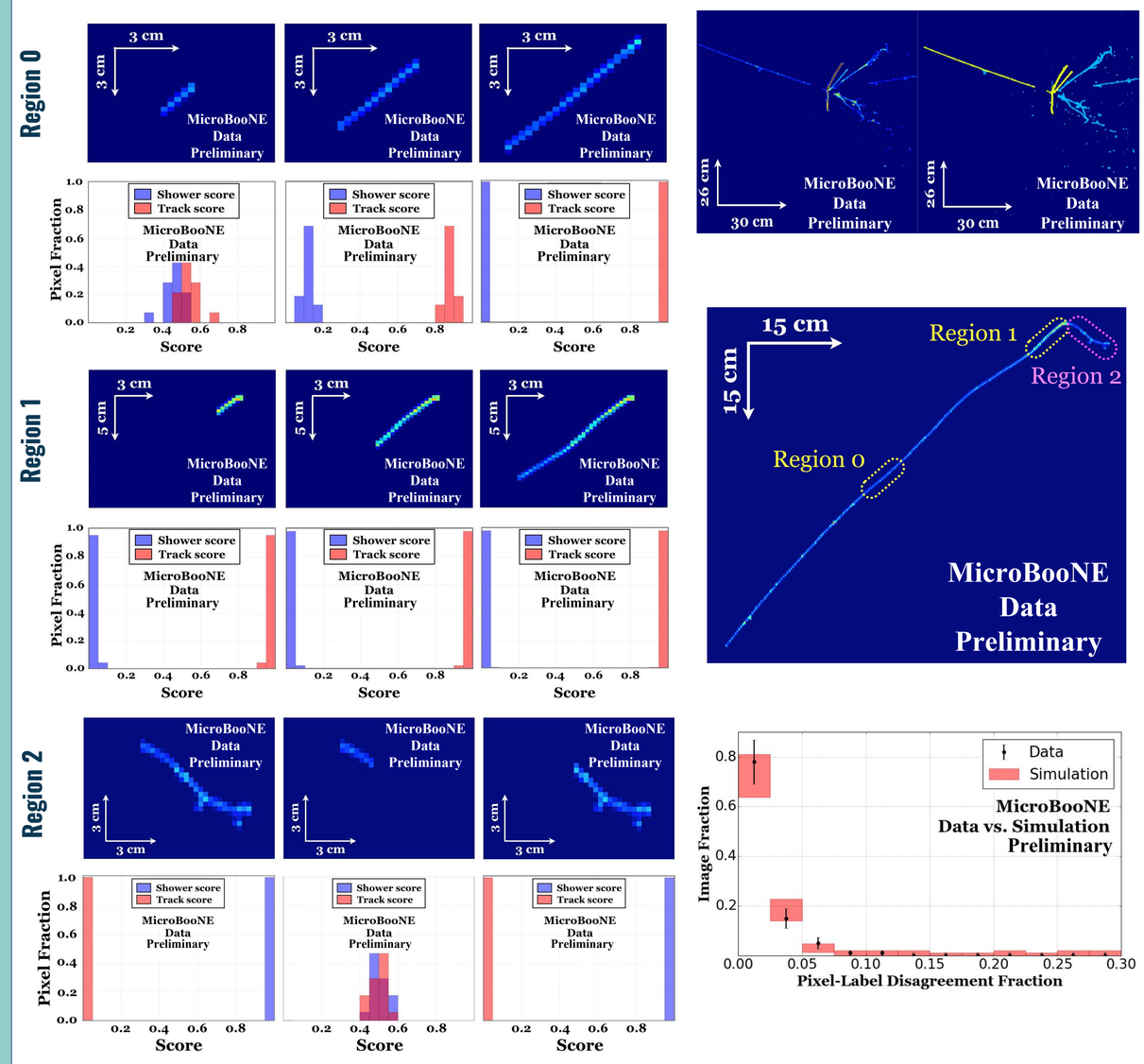


METRICS Distance from ground truth points to PPN proposed points (in pixels) *10,000 images*



PERFORMANCE ❖ 74.7% (84.2%) of proposed points are within 5 pixels of a ground truth point.
2D (3D) ❖ 96.6% (97.1%) of proposed points are within 20 pixels of a ground truth point.

MicroBooNE Data validation study (UResNet)



Next steps

- ❖ Clustering of energy deposits based on UResNet + PPN output (use predicted points as seeds)
- ❖ Hierarchical reconstruction (primary / secondary vertex)

References

[1] Ren, Shaoqing, et al. "Faster r-cnn: Towards real-time object detection with region proposal networks." *Advances in neural information processing systems*. 2015.
[2] Ronneberger, Olaf, Philipp Fischer, and Thomas Brox. "U-net: Convolutional networks for biomedical image segmentation." *International Conference on Medical image computing and computer-assisted intervention*. Springer, Cham, 2015.
[3] He, Kaiming, et al. "Deep residual learning for image recognition." *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2016.
[4] JINST P03011.12
[5] http://higgstan.com/

Source code available on https://github.com/Temigo/faster-particles