Pandora track/shower discrimination via semantic segmentation

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Roadmap

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- Overview and project goal
- Model architecture and inputs
 - Changes since Daresbury
- Updated performance figures

Overview and project goal



- Assign track and shower probabilities to every hit in U, V and W planes
- Train a neural network to calculate the probabilities
- Pass these probabilities to downstream Pandora algorithms for cluster creation, merging, etc
 - Currently cluster property-based cuts



Architecture

- U-Net architecture developed for biomedical image segmentation in 2015
- Convolutions form the downsampling part of the U
- Transpose convolutions form the up-sampling part of the U
- Skip connections add images from down-sampling path to upsampling path
- Track and shower probabilities assigned to each pixel



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https://arxiv.org/abs/1505.04597

Architecture

- Building on work started by Steven Green
- PyTorch implementation
- Two key blocks in the network
 - Down-sampling convolution block
 [Conv, ReLU, BatchNorm, Conv, BatchNorm]
 [MaxPool]
 - Up-sampling transpose convolution block [ConvTranspose, ReLU, BatchNorm] [Conv, ReLU, BatchNorm, Conv, BatchNorm]
- Loss: Categorical cross-entropy $loss = -lny_{true_class}$
- Accuracy: Fraction classified == truth

WARWICK **Rectified Linear Unit** 1 0 -1 0 1

Batch normalisation





- Multiple input pixels map to one output pixel
- Each layer increases number of kernels to build more complex features
- Stride 2 down-samples to reduce computational overhead

- Each input pixel maps to multiple output pixels
- Effective stride 1/2 up-samples to return to original image size

Inputs

- Trained on a 980 MCC11 DUNE FD 1x2x6 events
- Hit positions and PDG codes output to text from Pandora
- Simple MC tagging (e/γ = shower, other = track)
 - Candidate for optimisation
- Generate mosaic of event, select non-empty tiles
 - Want ~1-to-1 correspondence between hits and pixels
 - 256² pixel tile covering 128² cm² region achieves this
 - 80% training, 20% validation
 - Split into batches of 96 images



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Activations



Activations





DS Layer 2



DS Layer 3





DS Layer 3

US Layer 4

Performance

- Overall accuracy 92% (87%)
 - Track accuracy 91% (82%)
 - Shower accuracy 93% (94%)
- * (Daresbury)



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Summary and future plans

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- Further network refinements:
 - Architectural tweaks (e.g. ResBlocks, depth)
 - Leaky ReLU activation
- Data set refinement
 - Improved MC tagging
 - Image augmentation (e.g. randomly rotate images in each batch)
 - Train on a much larger data set
- Integrate outputs into Pandora

Backup

