

Segmentation Using CNN

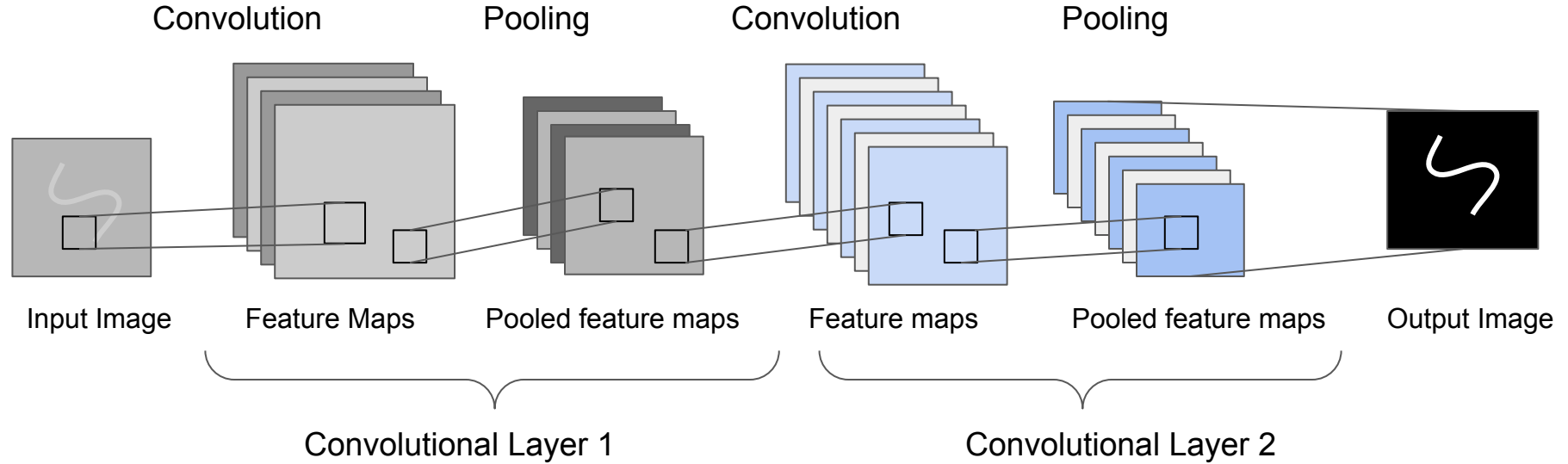
A. Prajapati

24/02/2022

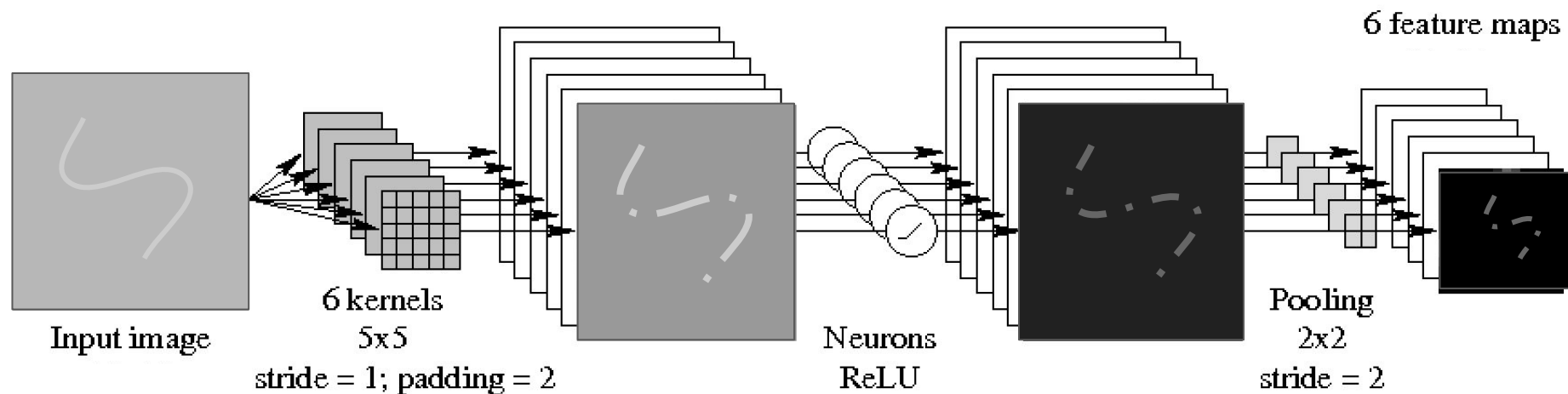
Intro

1. CNN
2. UNet
3. ResNet
4. Attention ResNet
5. Data preparation
6. Results

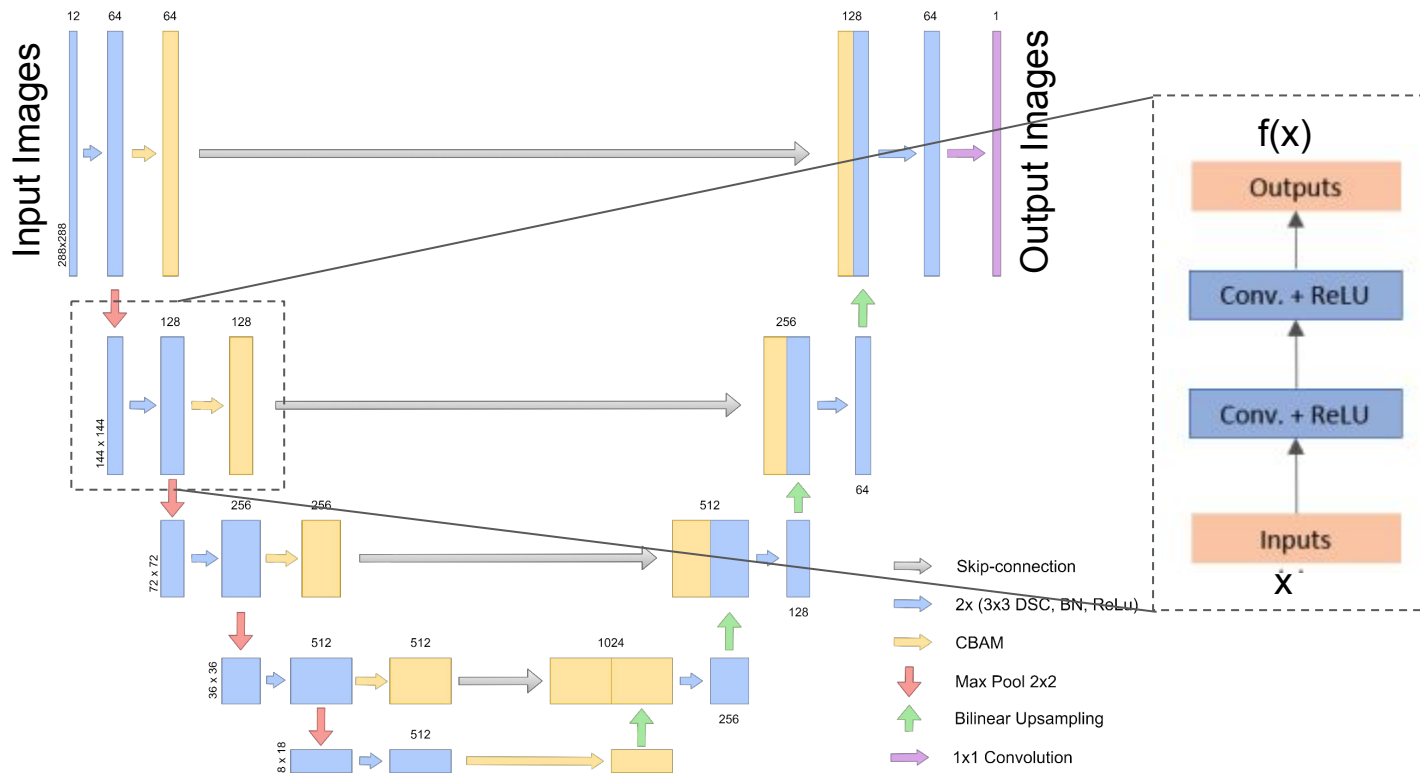
Convolutional Neural Networks (CNN)



Convolutional Layer 1



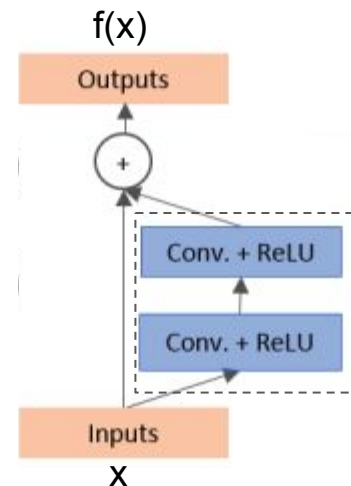
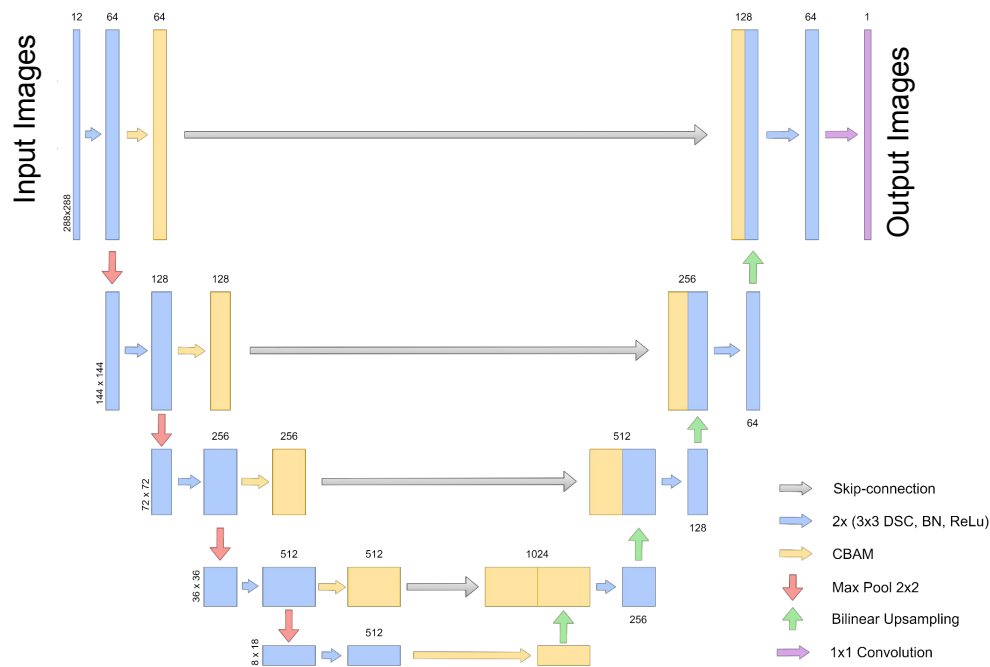
UNet



Layers are trying to learn $f(x)$ for the given input x .

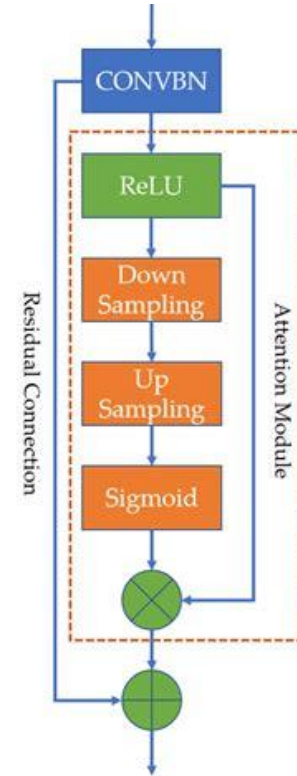
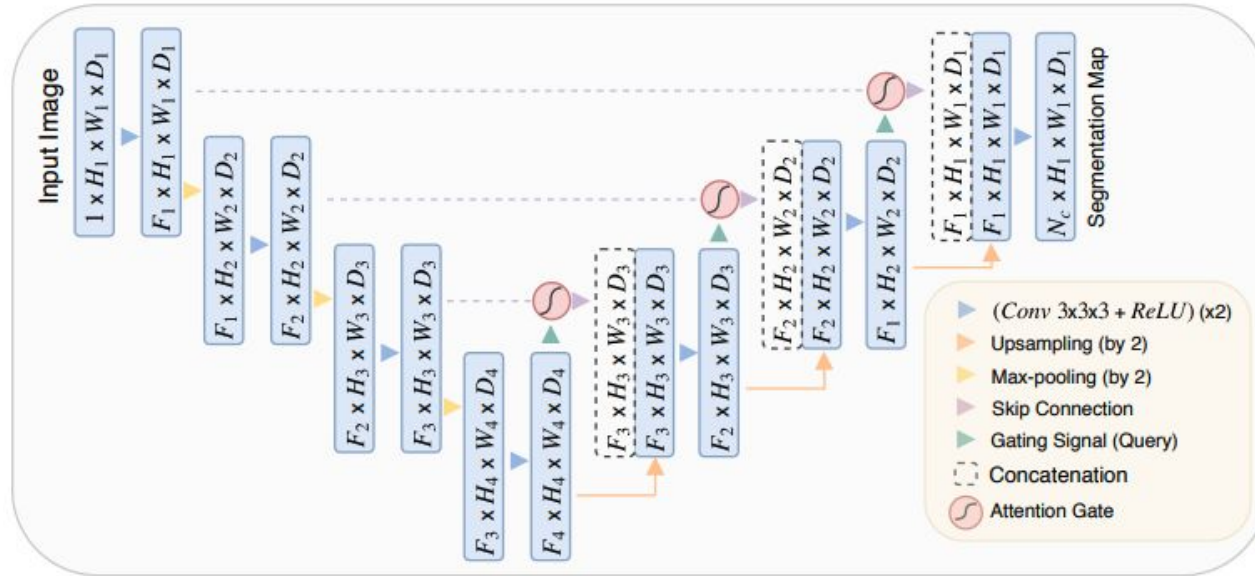
Recurrent Residual Convolutional Neural Network based on U-Net (R2U-Net) for Medical Image Segmentation
<https://arxiv.org/pdf/1802.06955.pdf>

ResNet



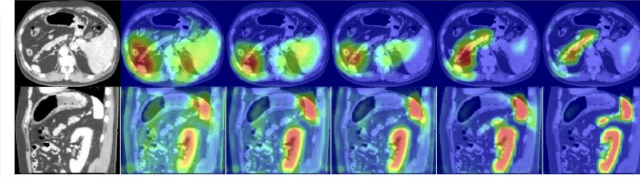
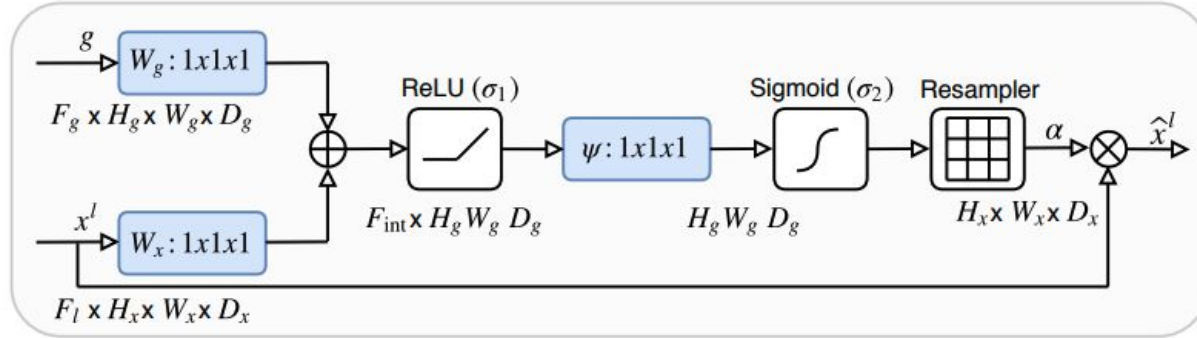
Here, Layers are trying to learn the residual unlike UNet where they try to learn $f(x)$. ResNet helps in solving the problem of vanishing gradients and also of overfitting to an extent.

Attention ResNet

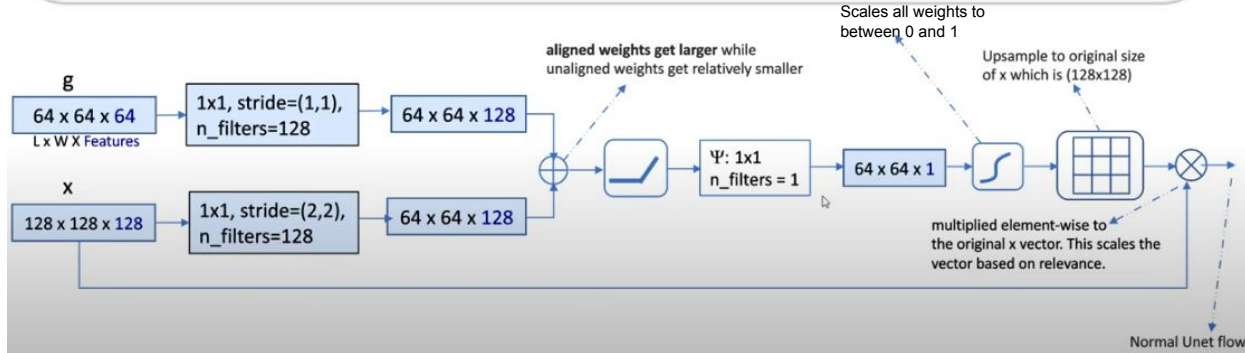


Architecture is very similar to ResNet, except there is an extra block called attention block. Attention in U-Nets is a method to highlight only the relevant activations during the training.

Attention Block

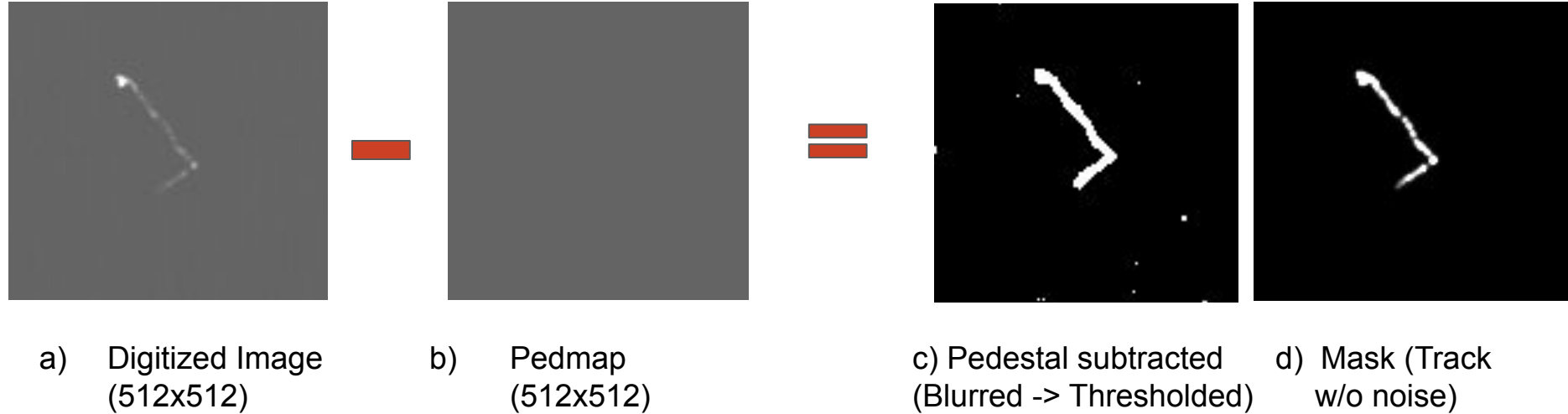


Attention U-Net: Learning Where to Look for the Pancreas
<https://arxiv.org/pdf/1804.03999.pdf>



It reduces computation resources wasted on irrelevant activations and provides better generalization of the network.

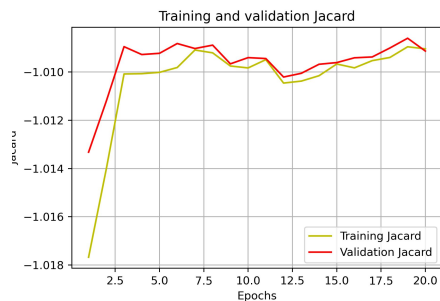
Data Preparation



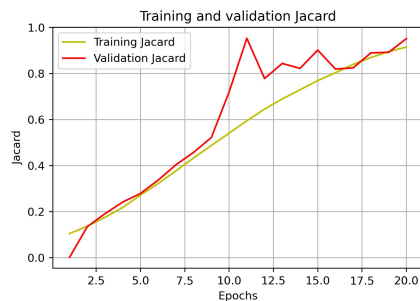
Pedestal map is subtracted from the digitized image. Pedestal subtracted image is then passed through a median filter with a kernel size of 3. Blurred image is thresholded with a threshold of 1 (pixels with intensity more than 1 becomes 255 and rest 0). These images are input for the network.

Masks are produced by digitizing the tracks without noise. Network is trained to produce images similar to masks.

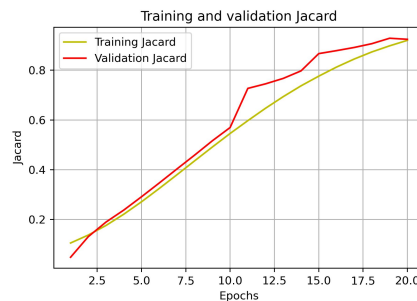
Training and Validation accuracy



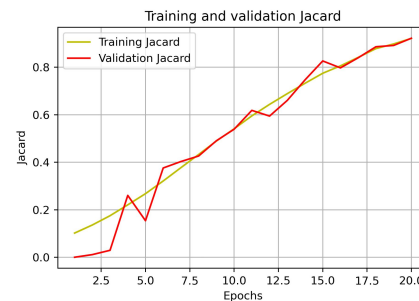
(a) CNN



(b) UNet



(c) Att-Net

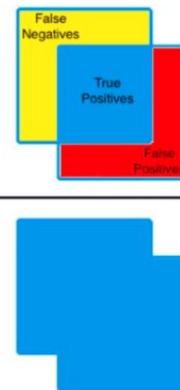


(d) Att-ResNet

Jaccard Coefficient = Intersection over Union

Jaccard Coefficient measures the similarity between two sets of data. The closer to 1 means more similar data.

$$\text{IoU} = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$



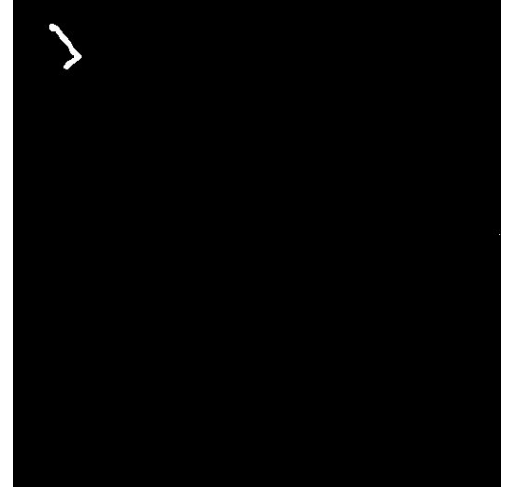
Prediction from the Network



a) Input Image



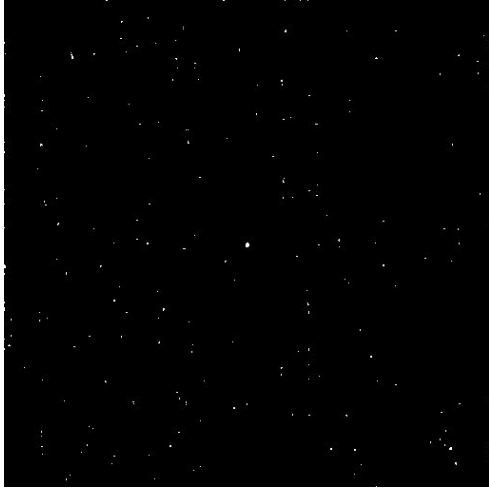
b) Mask



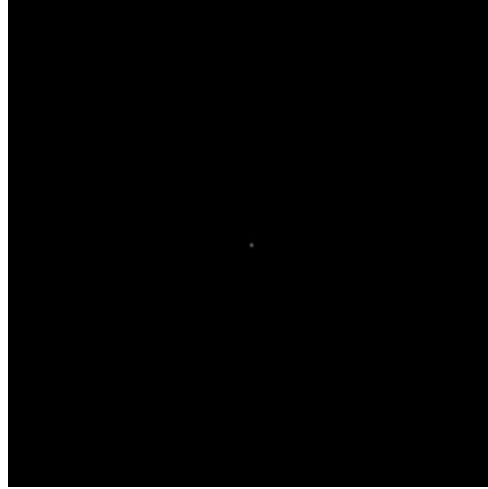
c) Prediction of the Network

Example shown here is for a 60 keV ER.

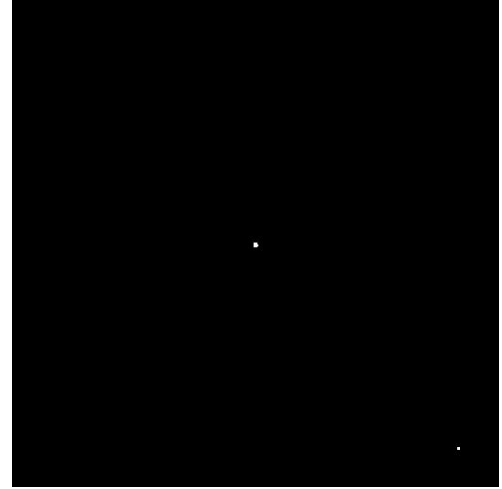
Prediction from the Network



a) Input Image



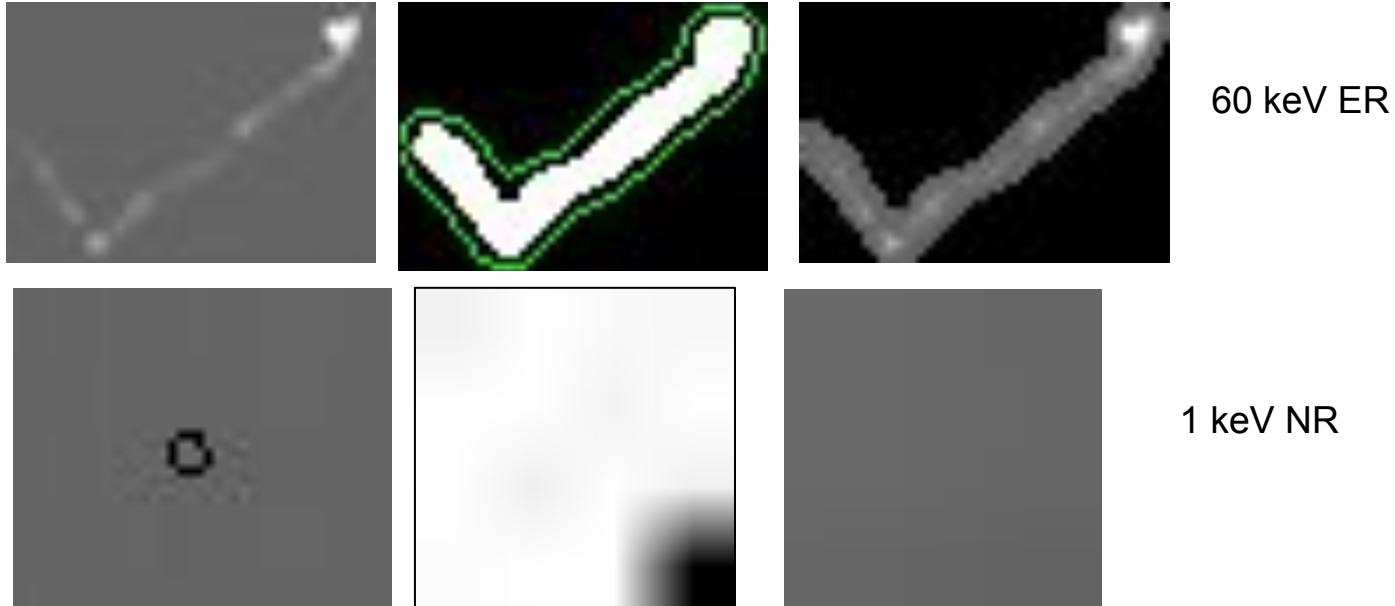
b) Mask



c) Prediction of the Network

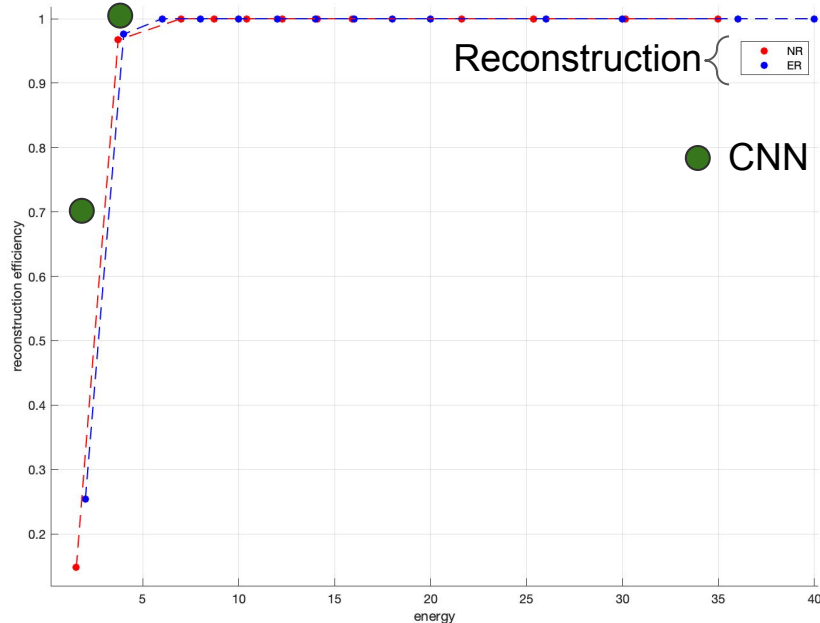
Example shown here is for a 1 keV NR.

Instance Segmentation



Clusters are found using OpenCV module.

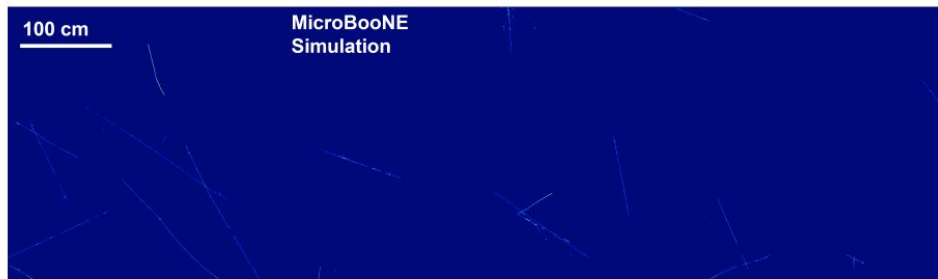
Reconstruction Efficiency



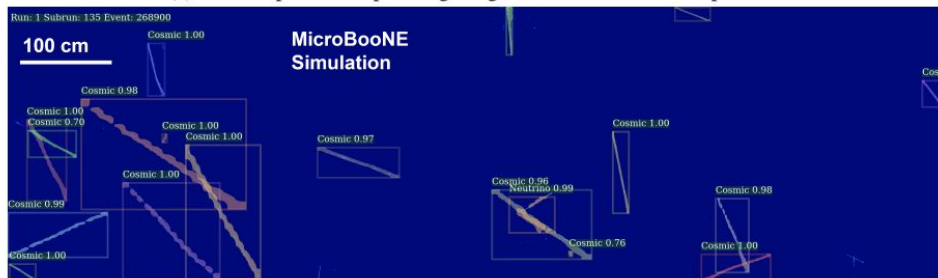
Only 100 events of each energy were used to check the efficiency of CNN.

Reconstruction efficiency at 1 keV of NR is around 70% and at 3 keV NR is 100%.

Plan:



(a) An example of an input image as given to sMask-RCNN to process



(b) A simulated neutrino interaction overlaid on cosmic ray muons from data, labeled by sMask-RCNN

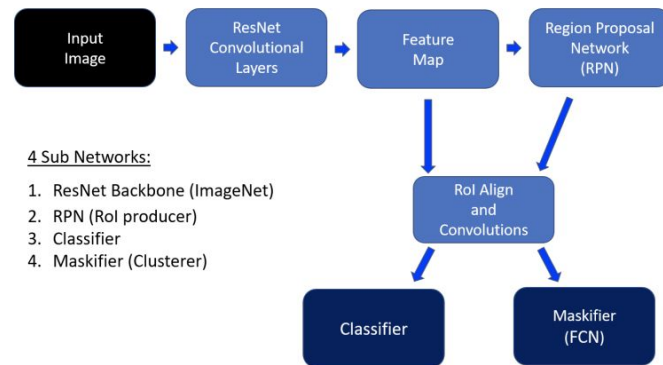


Figure 3: Network Architecture for Mask-RCNN in MicroBooNE.

Cosmic ray muon clustering for the MicroBooNE liquid argon time projection chamber using sMask-RCNN
<https://arxiv.org/pdf/2201.05705.pdf>