Guy's and St Thomas' NHS Foundation Trust

KING'S College LONDON

U-Net: Segmenting Images With Deep Learning

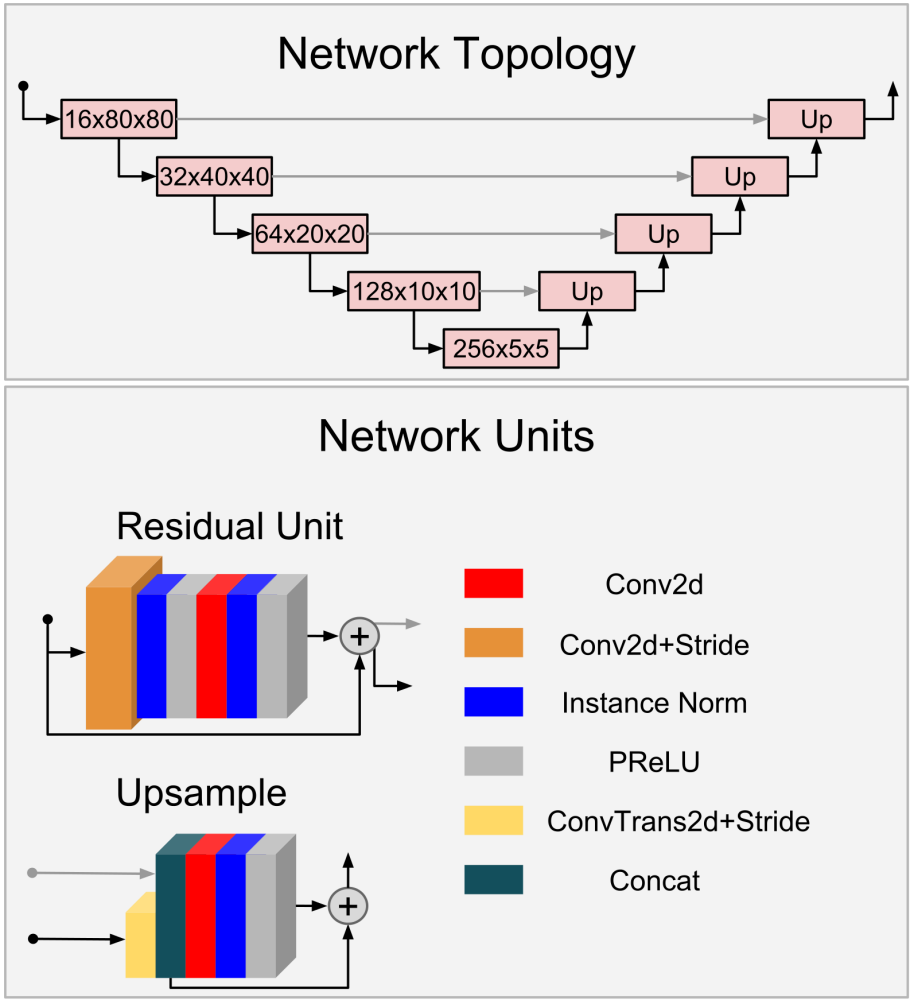
Slides adapted from the Machine Learning for Biomedical Application course from King's College of London

U-Net Overview

- Convolutional neural network used for segmentation, ie. catgorizing individual pixels/voxels in an input
- Follows a similar architecture to autoencoders, where input is encoded into a latent representation then decoded again into the result
- Data transferred between encode/decode paths
- Key detail is downsampling at each layer, convolutions then cover larger feature areas
- Allows information about features at low resolutions to be combined with those at high

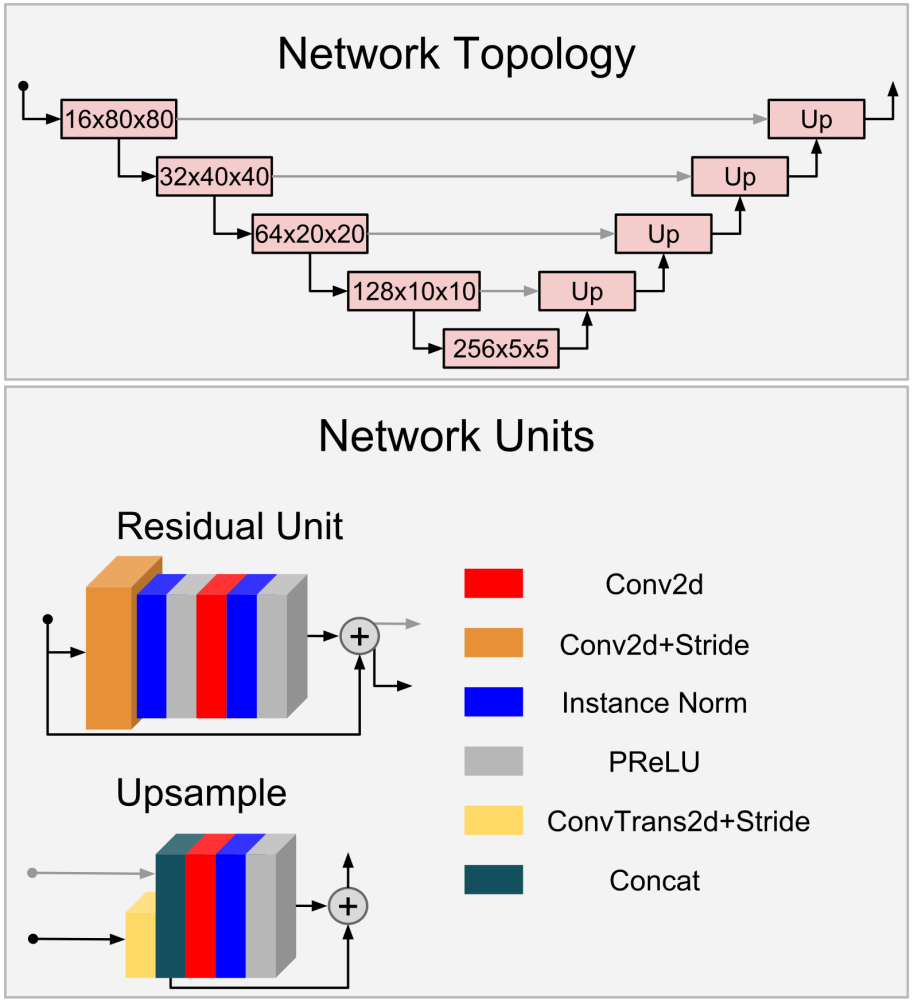
Example Architecture

- 5 layers composed of residual blocks
- Downsampling and upsampling done with pooling/unpooling or convolutions
- Features from one layer passed to next and horizontally between encode/decode paths

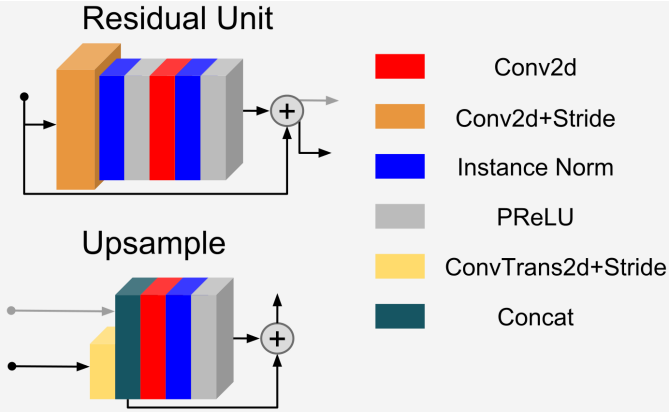


Example Architecture

- Each block consists of convolutions, normalization, and activation components
- Convolutions correlate features
- Normalization keeps values in controlled ranges
- Activation filters out values below a threshold



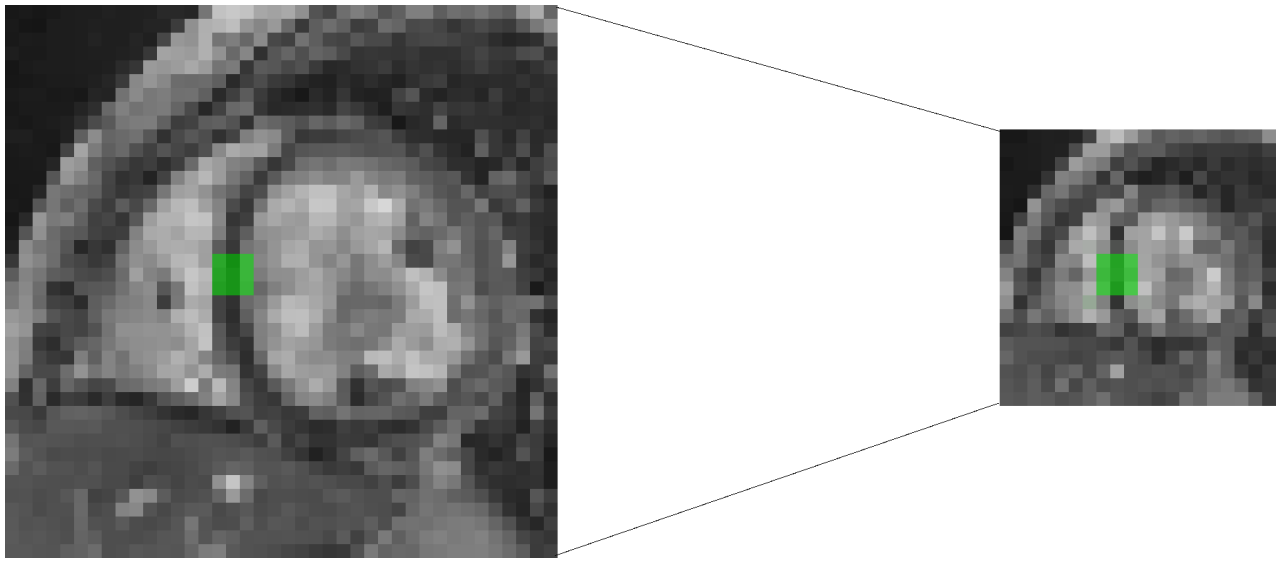
Residual Units



- Blocks of convolution,
- normalization, and activation
- layers
- Input into block is added to
- output of last layer
- This allows combination of input and output information
- Behaves like a smoothing function
- Loss space is smoothed out, easier for optimizers to find minima and move between them

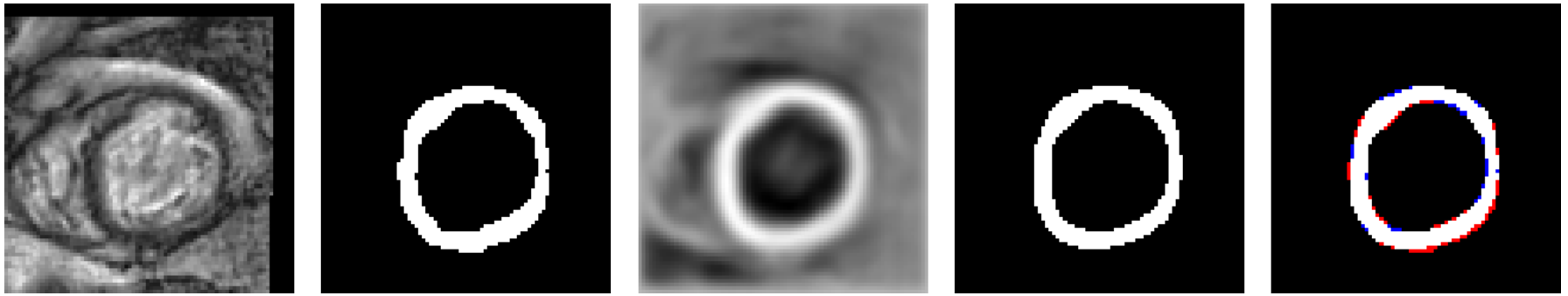
Downsampling

- For a 80x80 image a 3x3 convolution covers a small area and correlates only with small features
- After downsampling to 40x40, a 3x3 convolution covers a greater equivalent area in the image
- Roughly equivalent of using a 6x6 convolution on original image



Segmentation

- Typically U-net is used to segment images, ie. identify structures by assigning categories
- Eg. segmenting the left ventricle in MR images:



Input image Ground Truth Logits Output segment Difference

Application

- LV segmentation can be used to assess a range of biomarkers:
  - Wall thickness
  - Myocardial volume
  - Myocardial strain
  - Chamber volume, thus stroke volume and ejection fraction
  - Chamber dimension
- These can be used to diagnose various types of heart failure, dissynchrony, hypertrophy, etc.