NiftyNet

An open-source community-driven framework for neural networks in medical imaging

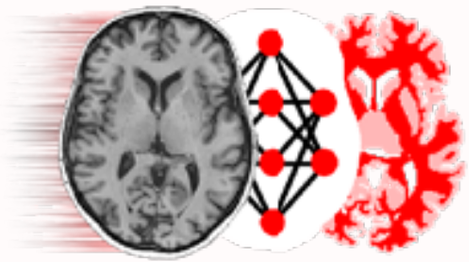
www.niftynet.io

EPSRC Engineering and Physical Sciences Research Council

wellcome

What is NiftyNet?

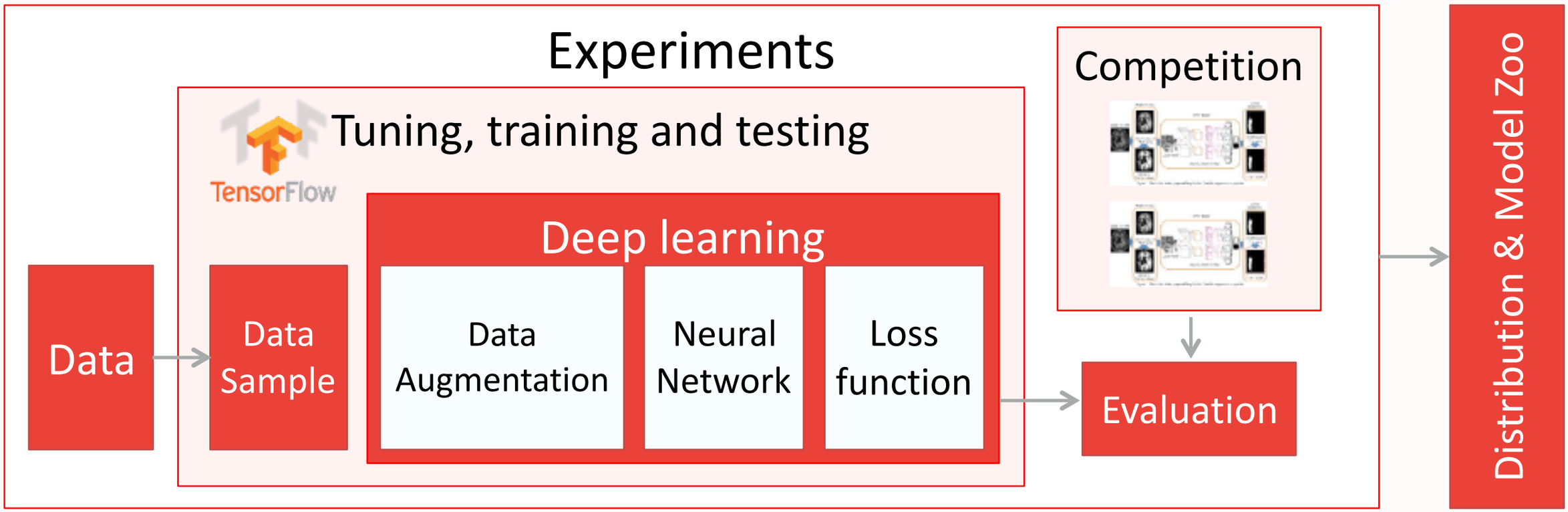
- An open-source library for convolutional networks in medical image analysis



= × Medical image domain knowledge

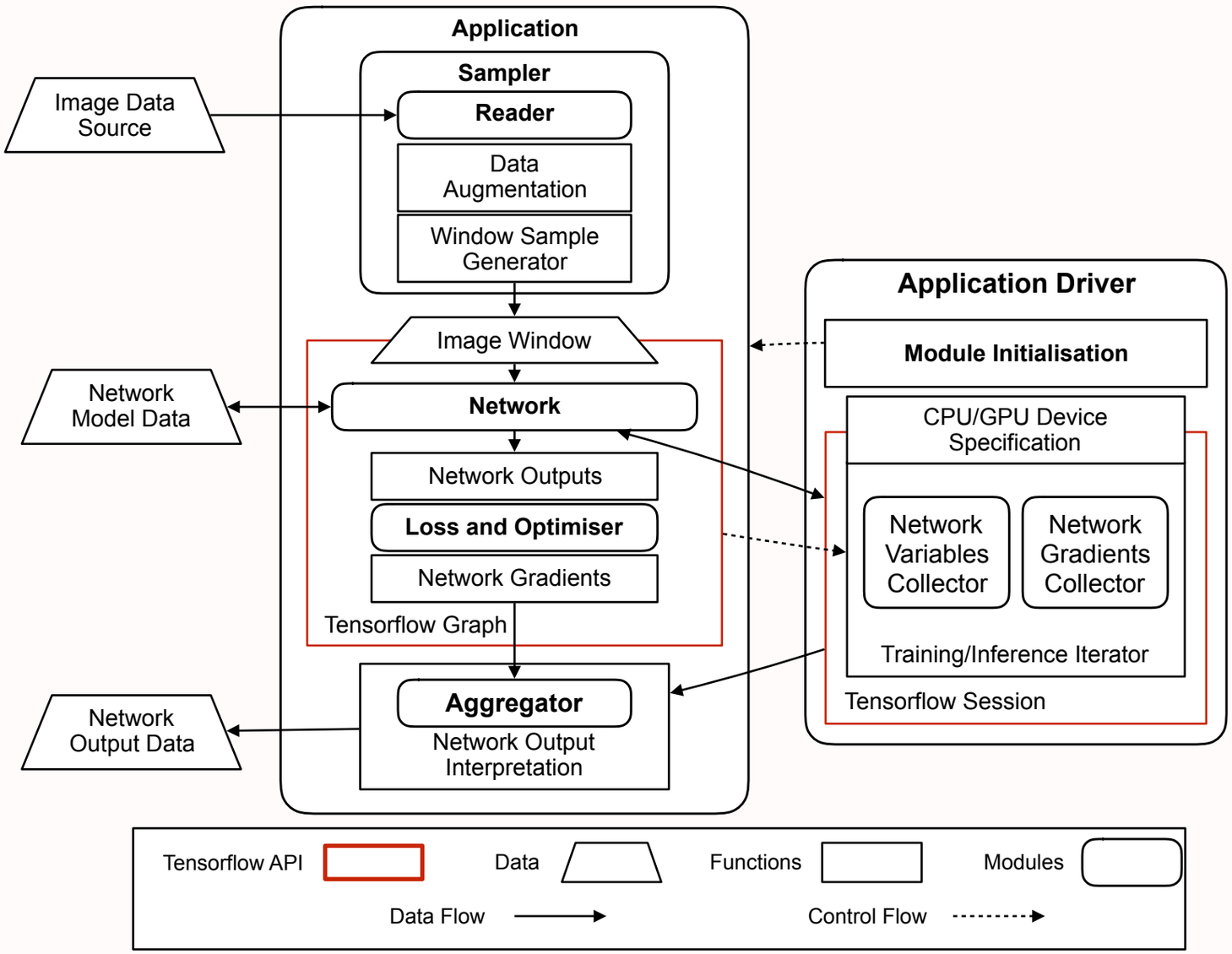
- Apache-2.0 licensed
- Easy-to-customise interfaces of network components
- Dissemination of architectures and pre-trained models
- Support for 2-D, 2.5-D, 3-D, 4-D inputs
- Multiple-GPU and tensorboard support
- Implementation of SOTA networks, loss functions, samplers, etc

What is NiftyNet?



TOC

- MultiGPU Driver
- I/O
  - Volume loader
  - Augmentation
  - Patch sampling
  - Outputs Aggregation
- Network model
  - Params. management
  - Layer operations
  - Loss functions
- Evaluation
- Applications
- Model Zoo



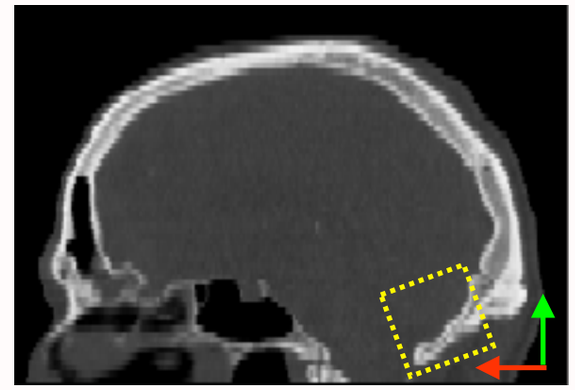
I/O: Image Loader

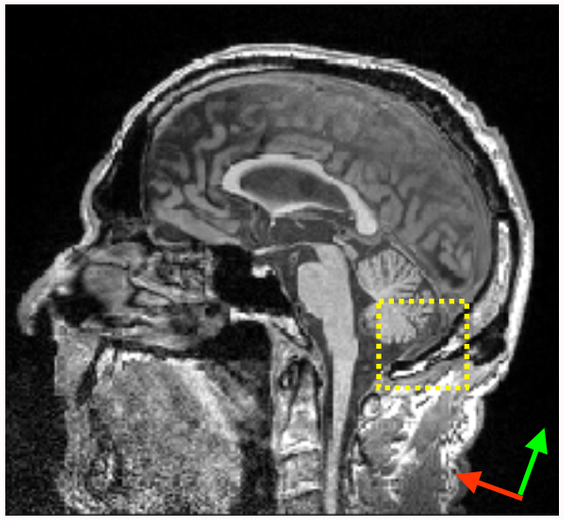
- Multi image-format loader
  - Uses tf.data API

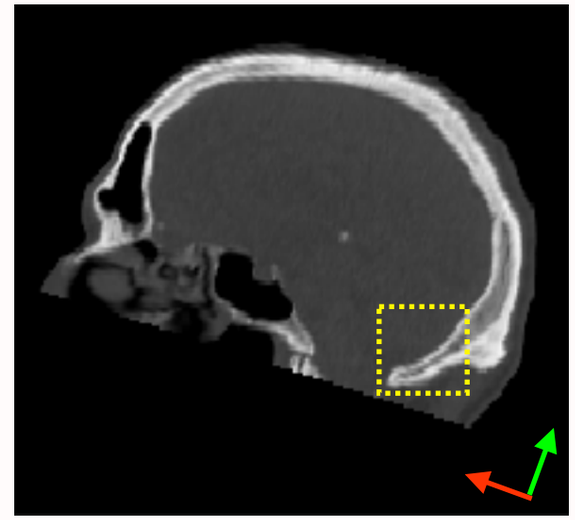
- Supports multimodal inputs
  - Internally or externally
  - Resolution matching

- Handling a set of image volumes
  - Subject or filename grouping
  - Handling missing modalities

- Preprocessing
  - Handling NIfTI/MHD/DICOM file headers
    - Resampling
    - Reorientation
    - Lazy Sampling
  - Intensity normalisation

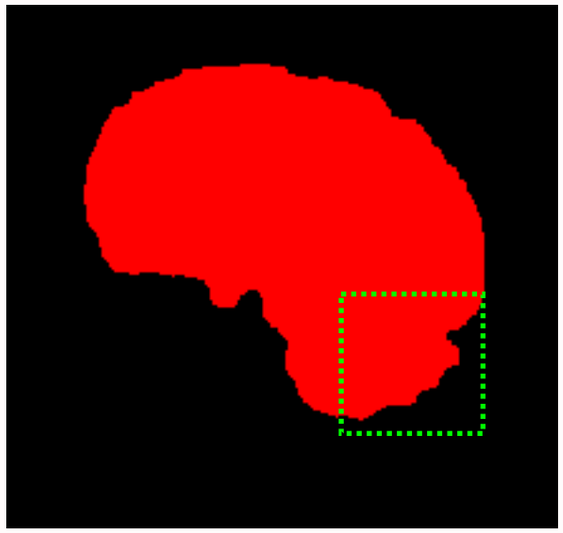






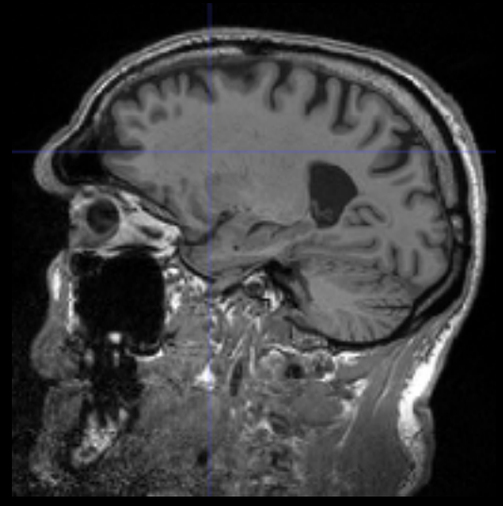
I/O: Window Sampling and Output Agregation

- Window properties
  - Size in “voxels”
  - Size in “mm”
  - Augmentation by composition
- Sampling
  - Uniform
  - Label Constrained
    - Sample only from areas with specific labels
    - Prescribe certain label sampling rates
  - Frequency Sampler
    - Sample a location given an externally defined map
    - Sample from locations with large errors
- Aggregation
  - Uniform & Overlapping (Effective Receptive Field)
  - Uncertainty Sampling

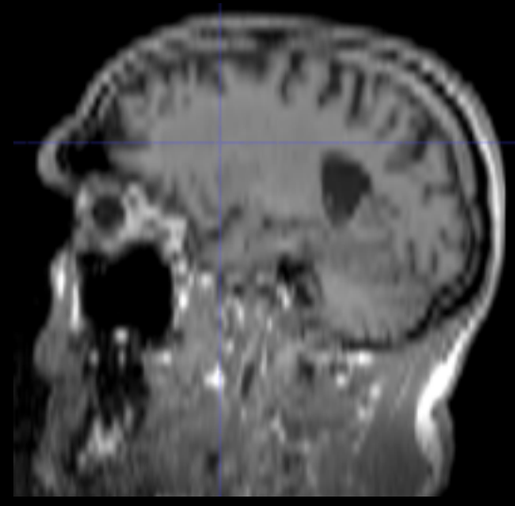


I/O: Data augmentation

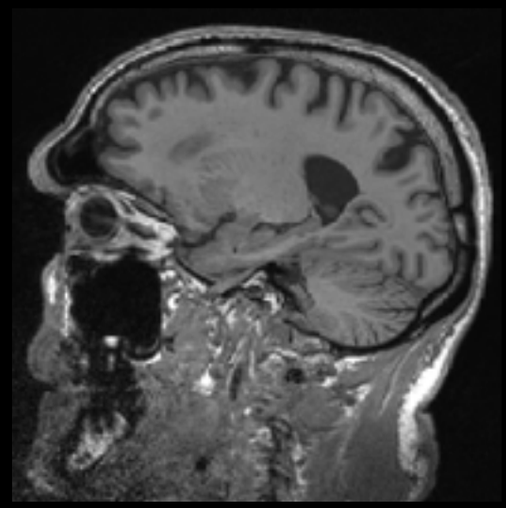
- Training with data augmentation
  - Application-dependent
- Geometrical augmentation
  - Rotation, Translation, Mirror
  - Random elastic deformation
  - Biologically-inspired elastic deformation
- Intensity augmentation
  - Histogram/Physics
  - Noise
  - Point-spread-function
  - Artefacts
  - Pathology/lesions



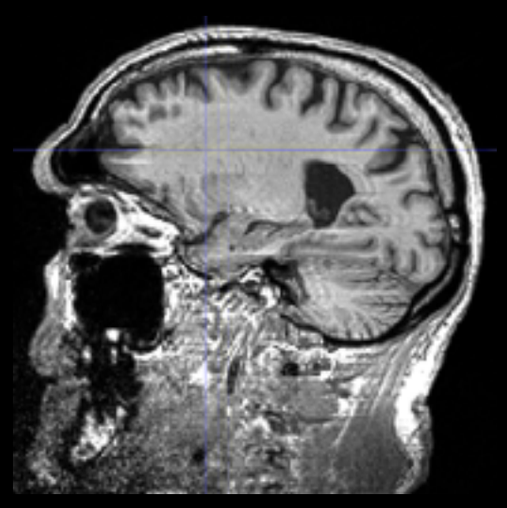
Original



PSF - Slice Thickness



Random Elastic

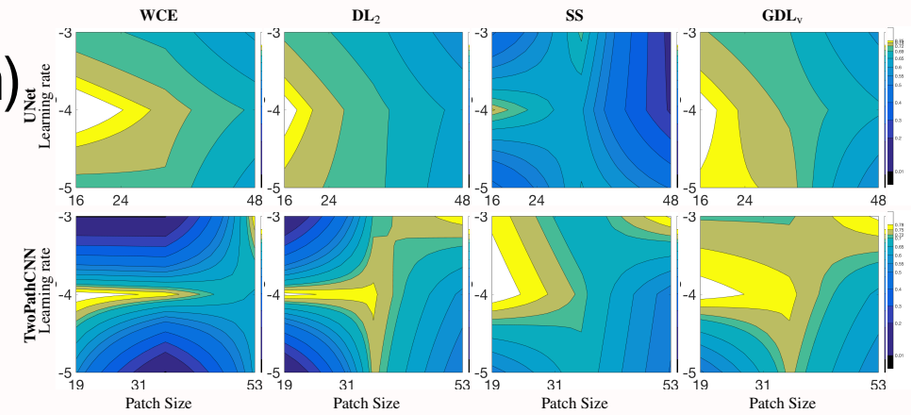


Movement Artefacts

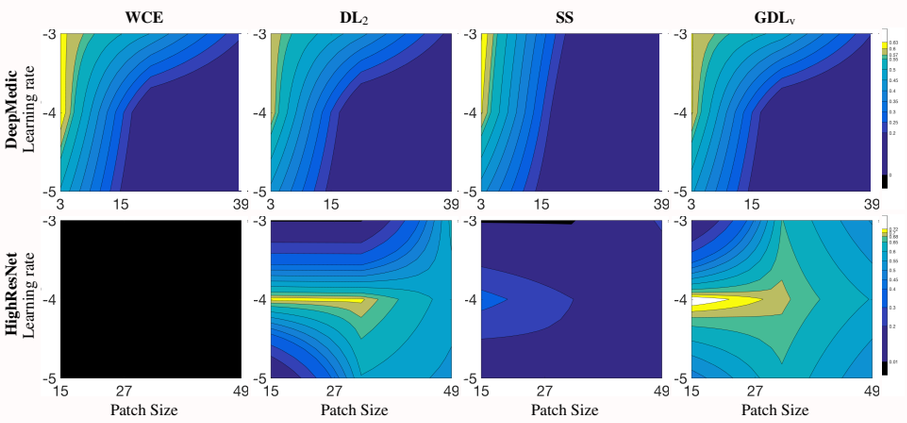
Network: Designing loss functions

- Losses:
  - Categorical
    - Cross-Entropy
    - Dice (Standard, Generalised, Wasserstein)
    - Sensitivity/Specificity
  - Continuous
    - L2/L1
    - Huber
  - Adversarial
  - Variational
    - KLD
- Metrics
  - Image-wide
  - Voxel-wise
  - Weighted & probabilistic losses

2D

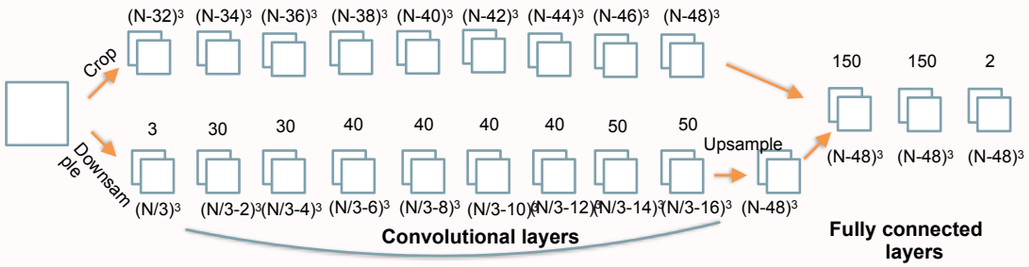


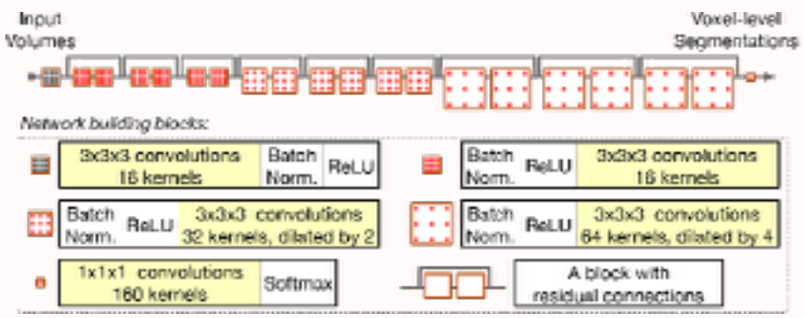
3D

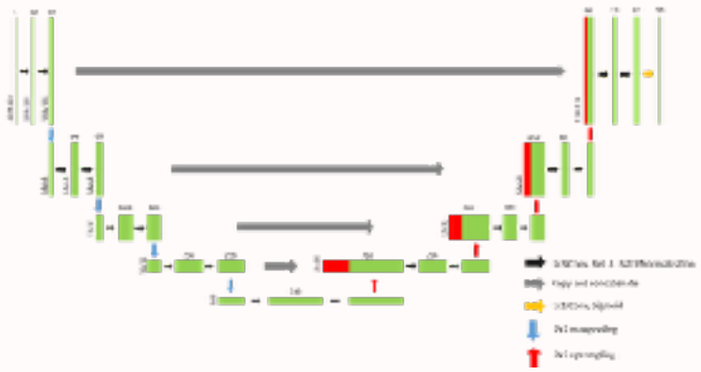


Network: Architectures

- Image-to-image: 2D, 3D, 4D (multimodal)
  - UNet
  - VNet
  - Highway Network
  - DeepMedic
  - HighResNet
- Generative/AutoEncoders
  - AE, dAE, VAE
  - GAN
- Image-to-label
- Multi-task

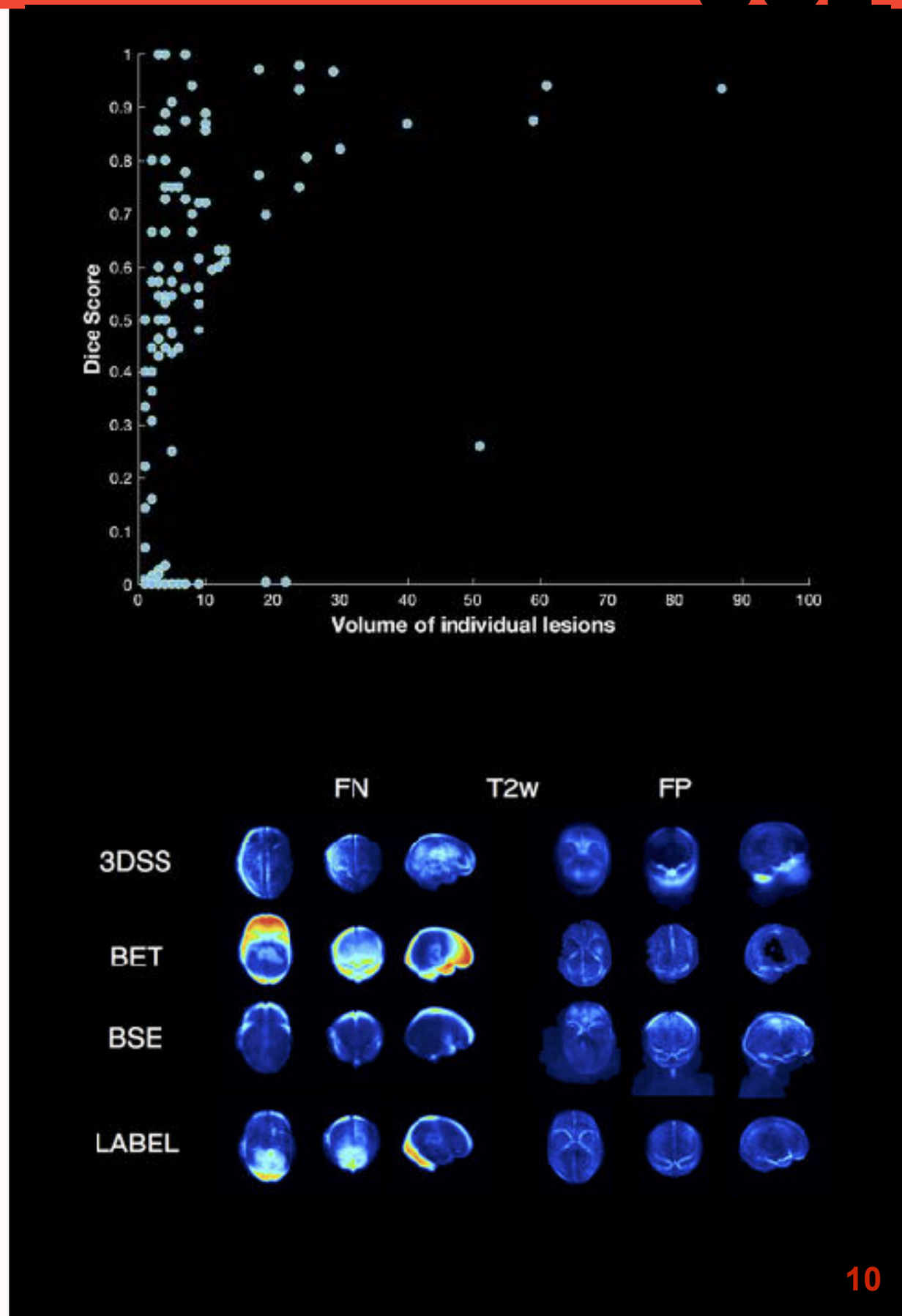






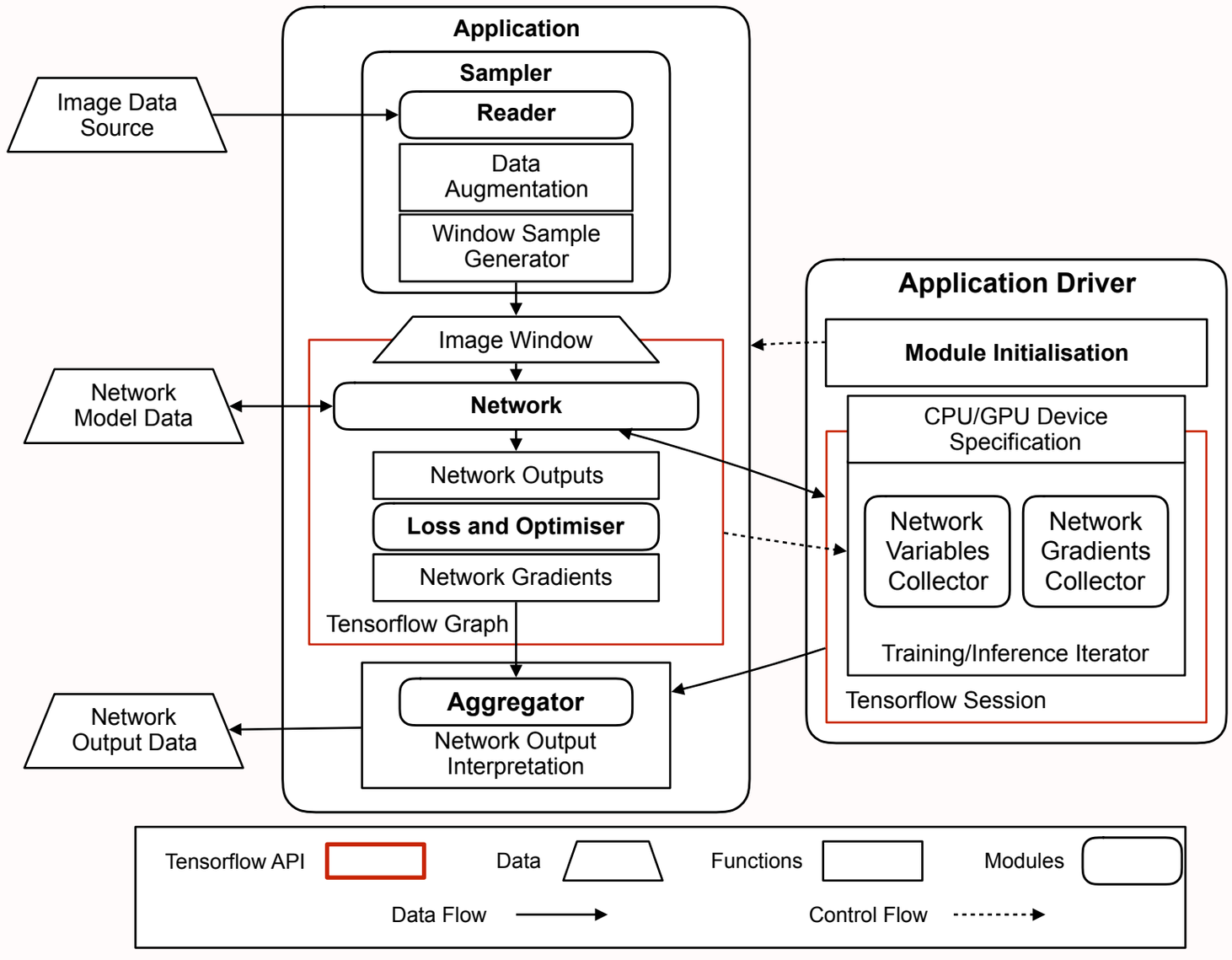
Evaluation: Standardised and Validated

- Tensorboard Integration
- Image-level
  - Categorical
    - Overlap: Dice/Jaccard
    - Distance: Hausdorf/MSD
    - Statistical: Sensitivity/Specificity/Recovery
  - Continuous
    - Direct: Mean Absolute Error/L_2
    - Perceptual: PSNR/SSIM
- Object Level (Categorical)
  - Volume: Size
  - Overlap, Distance and Statistical metrics
  - F1 stats
- Pixel-level
  - Generation of error maps
- Hyperparameter Optimisation
  - Grid, Random and Divide-and-Conquer Search



Application: Definition

- Define task-specific elements
  - loss functions
  - window sampling schemes
  - augmentation models
  - networks
  - aggregators
- Connect data stream
- Define behaviour during
  - Training
  - Inference
  - Evaluation



Long-term goal

- A popular repository of successful deep learning models
  - Model zoo (under construction)
  - Integration into popular pipeline infrastructures, e.g NiPype
  - Offer a baseline general-purpose implementation for “simple” segmentation, regression classification tasks

- Training general medical image convnet models on large medical image repositories
  - Medical ImageNet

- NiftyNet as a consortium of research groups
  - WEISS, CMIC, HIG
  - Other groups are planning to join

Further information

- Website: www.niftynet.io
- Slack: niftynet.slack.com
- Mailing List: nifty-net@live.ucl.ac.uk

- Paper
  - Gibson and Li et al., (2017); NiftyNet: a deep-learning platform for medical imaging;
  - arXiv: 1709.03485

NiftyNet: a deep-learning platform for medical imaging

Abstract

Questions?