Machine Learning in Medical Imaging

Machine Learning for computational sciences

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Medical Imaging in Healthcare

Symptoms
or
Screening

QUALY

Symptoms
Family History
Blood Pressure
Wearables
Electronic Health Records
Epidemiology
Genetics
Fluidics
Medical Imaging (X-ray, **MRI**, CT, PET, Ultrasound, Retinal Scans, …)

Optimal management
- lifestyle
- medication
- surgery
- monitoring

Magnetic Resonance Imaging

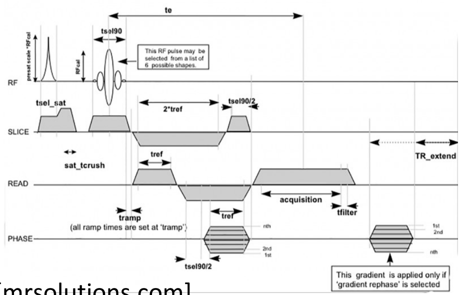
Acquisition

- Sequence of RF, gradients
  - many parameters
- K-space data received
- Time consuming
- Prone to artefacts

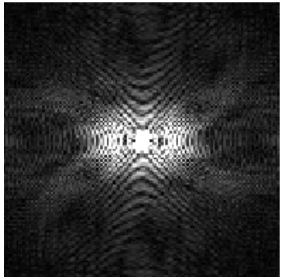
Image reconstruction

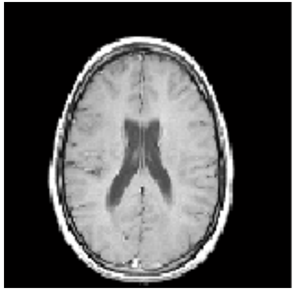
- Fourier Transform
  - (fully sampled)

- Iterative reconstructions
  - (under sampled)



[mrsolutions.com]



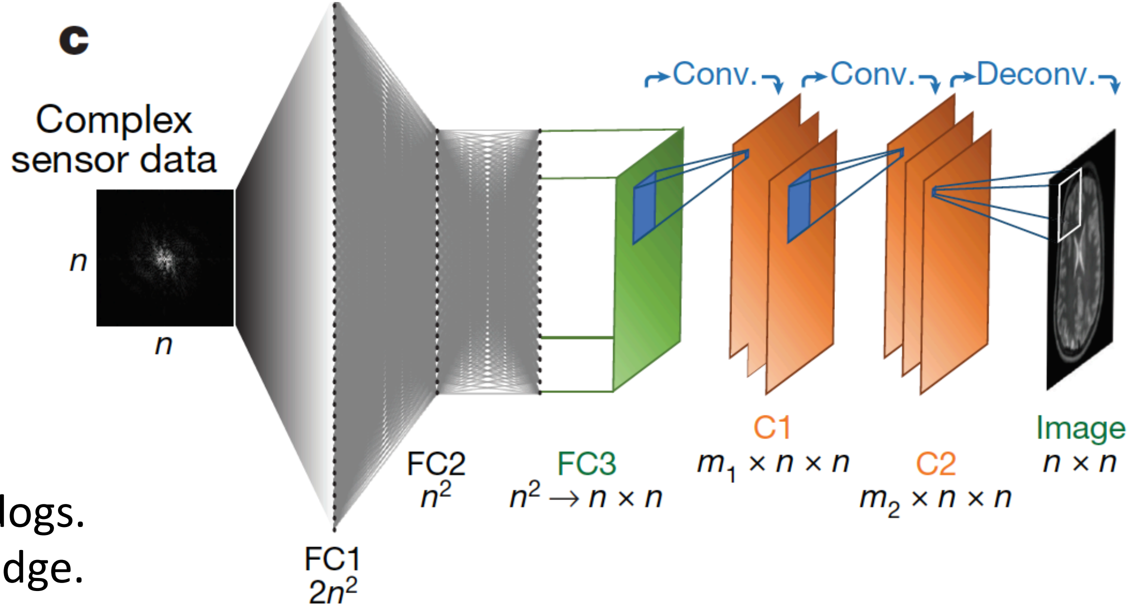


Machine Learning Strengths

- Convolutional Neural Networks
  - Suited to images (computer vision, self-driving cars…).
- NNs as universal function approximators.
  - Reconstruction is a ‘function’.
- Learn from data
  - Avoid ‘hand-crafted’ algorithms.
- Reinforcement Learning
  - potential for ‘move 37’ leaps in sequence design.
- Inference is Fast

[image removed of AlphaGo playing against world leader

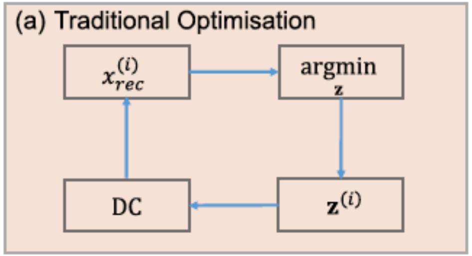
AUTOMAP
MR reconstruction

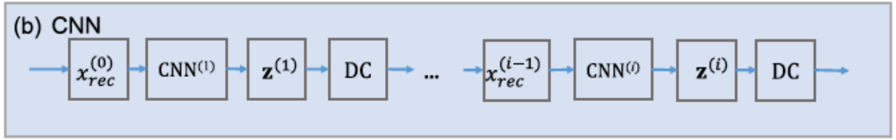


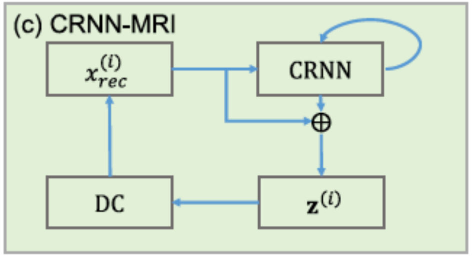
- Trained on cats and dogs.
- Little domain knowledge.
- Learnt FT!
- Large - hard to scale
- FAST

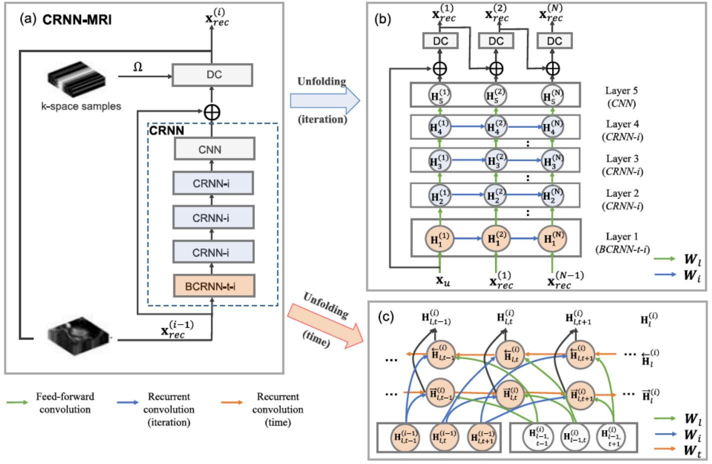
Zhu *Nature* **555**, pages 487–492 (2018)

Iterative Reconstruction as a Network









- Unroll iterations as a network.
- Uses domain knowledge
- Uses CNNs with feed forward links as appropriate
- Better explainability?
- Feels ‘hand-crafted’ again …

Qin *IEEE TMI* **38** p280 (2018)

Potential Discovery Tool

Pulse sequences have very many parameters and permutations.

Design trade-offs based in-part on experience and intuition.

Physics is known (Maxwell’s and Bloch equations).

Design a ‘game score’ and use reinforcement learning to find a faster/better strategy?

Discussion Themes

How to use AI to enhance, rather than replace, computational models

- Selectively replace: “data” parts of models, e.g. regularization parameters, de-noising steps, hand-crafted filters.
    - Iterative unrolling example.
- Train against human quality scores to learn to quantify image artefacts?

Balancing 1st principles approaches vs using machine learning

- AUTOMAP “wasteful”, but fast and generalizable?
- ‘move 37’ uses 1st principles (game rules / physics) but might teach us new strategies.

How to promote the application of novel theoretical mathematical models to research challenges

- Flip ‘Kaggle’ challenges to encourage 1st principles approaches?

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Thanks