# **Quantitative Neuroradiology**

# **Machine Learning for Improved Patient Care**

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Inpainting

Network Analysis

ANOINSIS



\*\*\*\*\*

#### ...... Multiple Sclerosis





Muscoskeletal

## **Image Analysis**

















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- Neuroradiologists interpret or "read" the acquired images and produce a report of their findings and impression or diagnosis.
- Referring physician reinterprets the findings against symptoms to obtain the final integrated diagnosis.
- Neuroradiology has a problem:
  - MRI & CT increase 10-12% per year compounded
  - Radiologists increase 1-3% per year
  - Limited NHS funding, no increase in training rates,
  - escalating data complexity

# **Classic Neuroradiology**





## Challenges of quantitative neuroradiology

- Normally small training datasets
- Very variable input data
- Accuracy is paramount
- Speed is not important (with exceptions)
- Ability to extrapolate
- Problem specific solutions
- No ground truth
- Large unstructured data
- Ethics and clinical adoption













- 300.000 sessions +2.5M Volumes
  - Many images & follow-up data
  - 2.5M Volumes
  - 14k "different" sequences
  - 15+ different scanners
  - From 0.5 7T (mostly 1.5T and 3T)
- **RIS** Radiological reports
- CDR ICD-10 codes
- Blood tests













- What questions can we ask?
  - •Epidemiology and learning disease structure
  - •Service optimisation:
    - •Workflow: Triage, Prioritisation, Recall
    - Management: Auditing, Bed usage, Cost-code optimisation, etc.
  - •Surveillance/Diagnosis/Prognosis

How do we learn from an unbalanced pool of pathologies given

a largely non-overlapping set of sequences?





### **Parameterising Clinical Reports**



#### + ValidationGUIr1

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• Deep Autoencoding - Low dimensional (2D) projection of Rad Report vs "Ataxia" - Reporting is consistent with regards to "appearance" and non-trivial (Cerebellum vs Sensory)



## Big Data @ UCL









- 20000 radiologically normal → 6207 Asserted Normals
- Do standard Neuro pipelines work? -... with this "beautiful" data



### **Big Data @ UCL**

![](_page_9_Picture_6.jpeg)

![](_page_9_Picture_9.jpeg)

![](_page_10_Picture_0.jpeg)

![](_page_10_Picture_1.jpeg)

- 40000 radiologically normal
  - 6207 Asserted Normals

![](_page_10_Picture_4.jpeg)

# **Population Analysis**

![](_page_10_Picture_6.jpeg)

![](_page_10_Figure_7.jpeg)

#### Age: R=0.897, RMSE=6.246 years

![](_page_10_Figure_9.jpeg)

#### Sex: 95.97% accuracy

![](_page_10_Picture_11.jpeg)

![](_page_11_Picture_0.jpeg)

- 40000 radiologically normal
  - 6207 Asserted Normals
- Region statistics

#### MRI Imaging

![](_page_11_Picture_5.jpeg)

![](_page_11_Picture_7.jpeg)

#### Delineation

#### **Population Distribution**

![](_page_11_Figure_10.jpeg)

![](_page_11_Picture_11.jpeg)

- Gaussian process (GP) Probabilistic classification/predictions
- Variational/Denoising Auto-encoders for abnormality detection

![](_page_12_Figure_3.jpeg)

![](_page_12_Figure_4.jpeg)

# ssification/predictions abnormality detection

![](_page_12_Figure_6.jpeg)

![](_page_12_Picture_7.jpeg)

![](_page_13_Figure_1.jpeg)

![](_page_13_Figure_3.jpeg)

![](_page_13_Picture_5.jpeg)

![](_page_14_Picture_0.jpeg)

- Patient-specific phenotyping tools for clinical data
- The Data
  - Can be low resolution (slice thick. 3/5/7mm)
  - Artefacts
  - Inconsistent scanning parameters
    - 1400 different "sequences"
  - Inconsistent availability of modalities
- Homogenising data acquisition across sites
  - Quality Control/Assurance, data identification
- Extracted metadata is integrated into a clinical report
- Collaboration with ION & NHNN

#### **Quantitative Neuroradiology Initiative**

![](_page_14_Picture_13.jpeg)

![](_page_14_Figure_14.jpeg)

![](_page_14_Picture_16.jpeg)

### **Translation to Clinical Usage**

![](_page_15_Picture_1.jpeg)

![](_page_15_Picture_2.jpeg)

1 - Image Acquisition

![](_page_15_Picture_4.jpeg)

2 - Automated quality control & biomarker estimation

![](_page_15_Picture_6.jpeg)

![](_page_15_Picture_10.jpeg)

3 - Automated clinical report & comparison to healthy population

![](_page_15_Picture_12.jpeg)

4 - Quantitative neuroradiology & improved patient care

Early Alzheimer's Disease

Alzheimer's Disease 16

![](_page_15_Picture_16.jpeg)

### **Translation to Clinical Usage**

![](_page_16_Picture_1.jpeg)

1 - Image Acquisition

![](_page_16_Picture_3.jpeg)

2 - Automated quality control & biomarker estimation

![](_page_16_Picture_5.jpeg)

![](_page_16_Picture_6.jpeg)

![](_page_16_Picture_7.jpeg)

![](_page_16_Picture_9.jpeg)

3 - Automated clinical report & comparison to healthy population

![](_page_16_Picture_11.jpeg)

4 - Quantitative neuroradiology & improved patient care

![](_page_16_Figure_13.jpeg)

Early Alzheimer's Disease

Alzheimer's Disease 17

![](_page_16_Picture_16.jpeg)

### **Translation to Clinical Usage**

![](_page_17_Picture_1.jpeg)

1 - Image Acquisition

![](_page_17_Figure_3.jpeg)

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![](_page_17_Figure_4.jpeg)

Healthy

![](_page_17_Picture_6.jpeg)

VHL

![](_page_17_Picture_7.jpeg)

![](_page_17_Picture_8.jpeg)

2 - Automated quality control & biomarker

MFG

![](_page_17_Picture_10.jpeg)

3 - Automated clinical report & comparison to healthy population

![](_page_17_Picture_12.jpeg)

4 - Quantitative neuroradiology & improved patient care

![](_page_17_Figure_14.jpeg)

Early Alzheimer's Disease

Alzheimer's Disease 18

![](_page_18_Picture_0.jpeg)

- Translation to Clinics: Neuroradiological workflow •
  - Deploy results into reporting platform
    - Disease specific biomarkers
    - Available at reporting time (HPC)
  - Push to patient health care record
    - Available to referring physician
    - Retrievable for longitudinal analysis
- Translation to industry: BrainMiner
  - UCL spinoff
  - Translate TIG/QNI beyond UCL
  - SBRI award £1.1M
  - Build CE marked/FDA approved software

#### **Translation to the Real World**

![](_page_18_Picture_14.jpeg)

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# **Questions?**

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