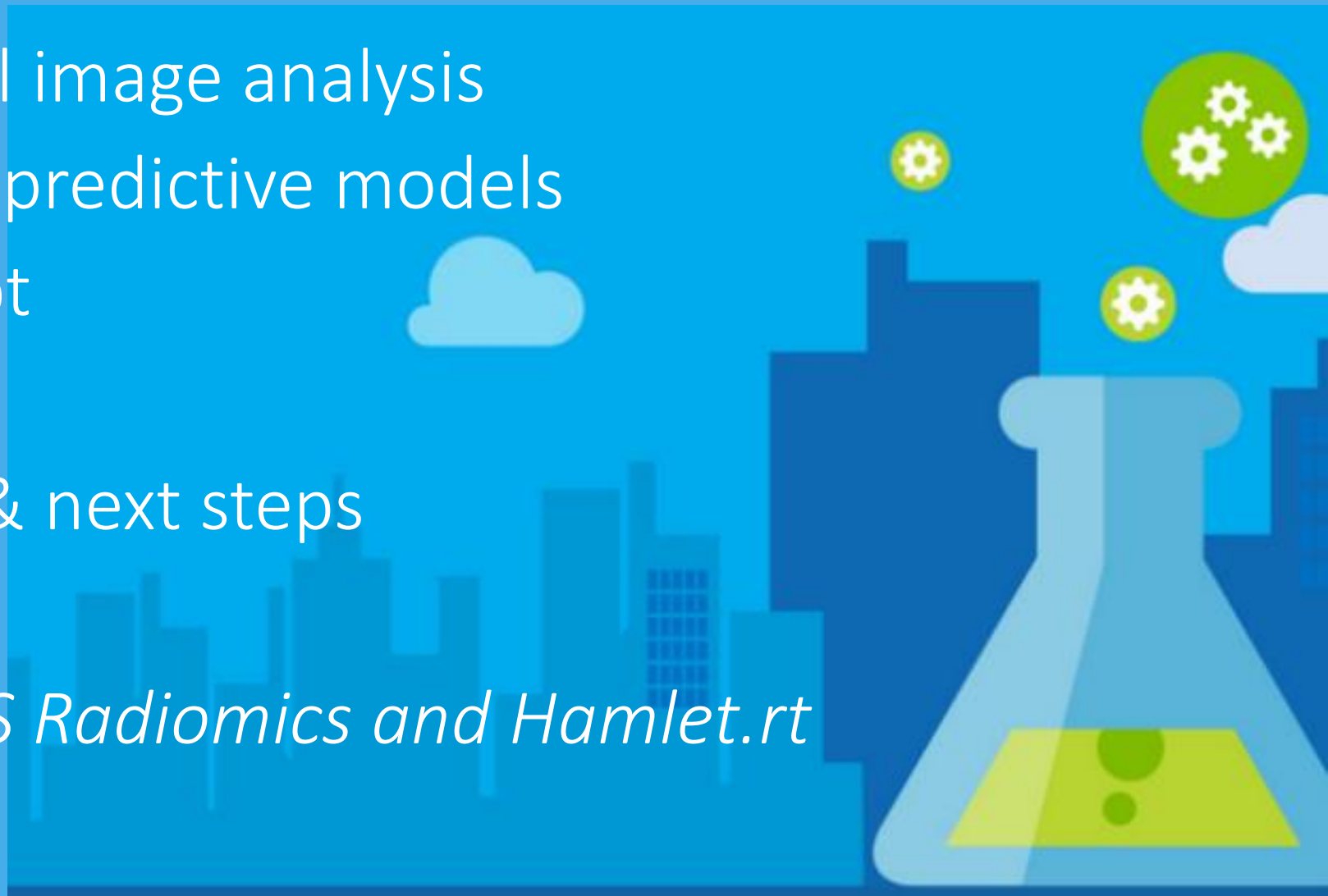
Hamlet.rt

Machine learning and predictive radiomics

Overview

- MSRC and medical image analysis
- CMIH and patient predictive models
- Hamlet-RT concept
- Project overview
- Current progress & next steps

NDA in place for MS Radiomics and Hamlet.rt

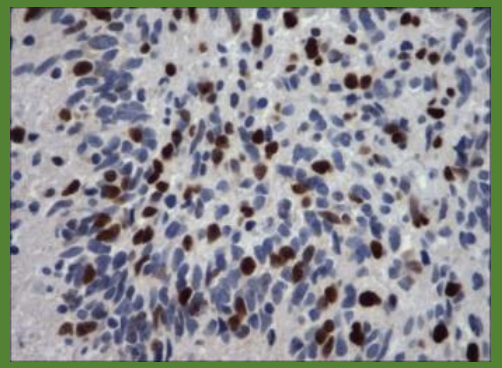


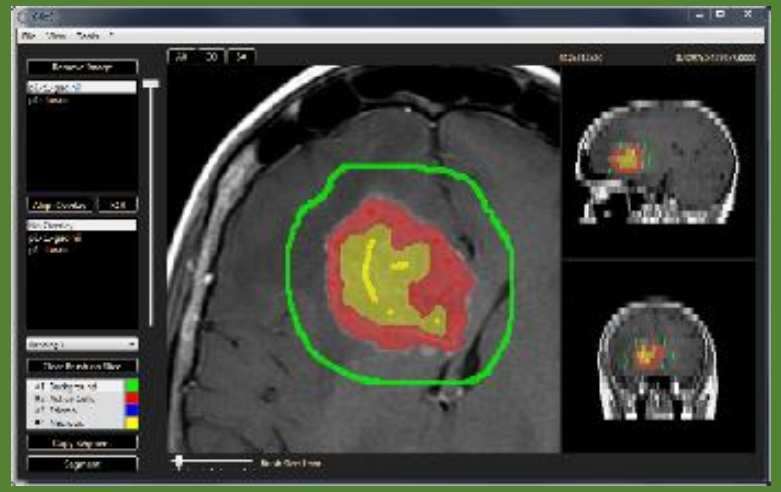
MSRC Lab

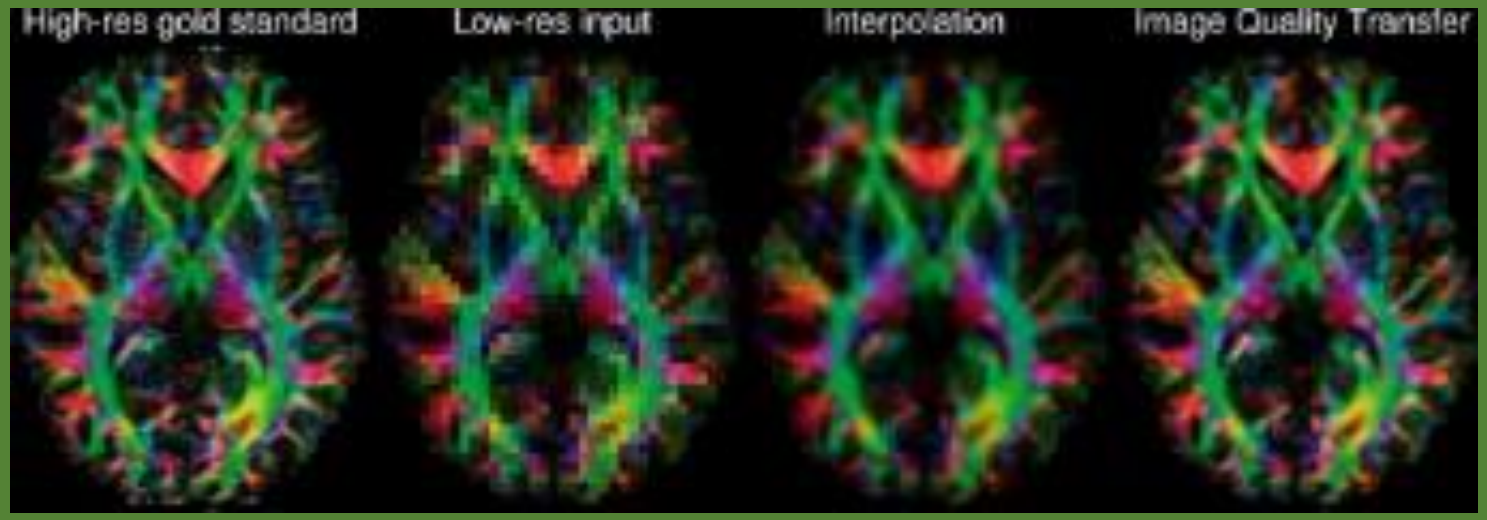
- One of seven research centres
- Areas of interest
  - Machine Learning
  - Formal methods
  - Computational Biology
  - Language Development (F#)
  - HXD

Innereye : ML for medical image analysis

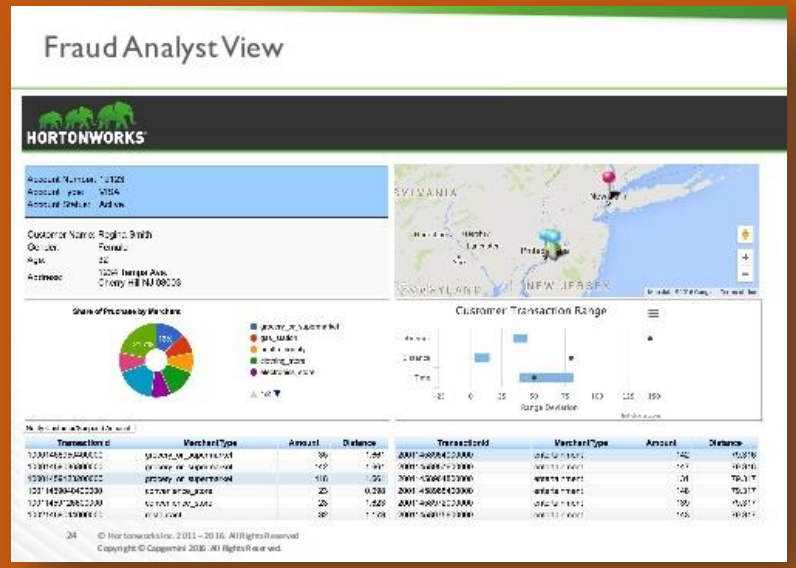
- Computer vision background
- Multimodal image applications





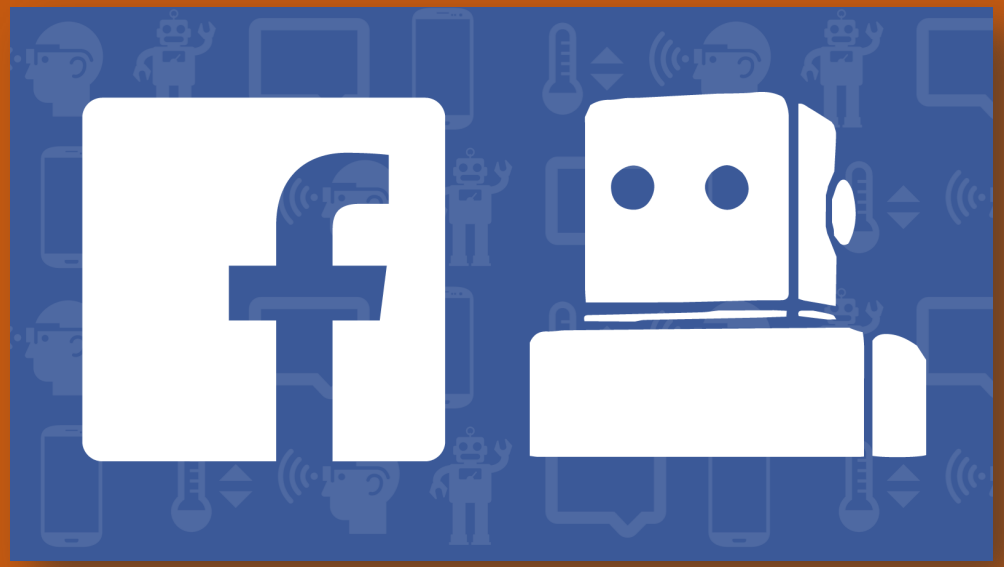


ML reached a tipping point in 2012…



Credit card analytics

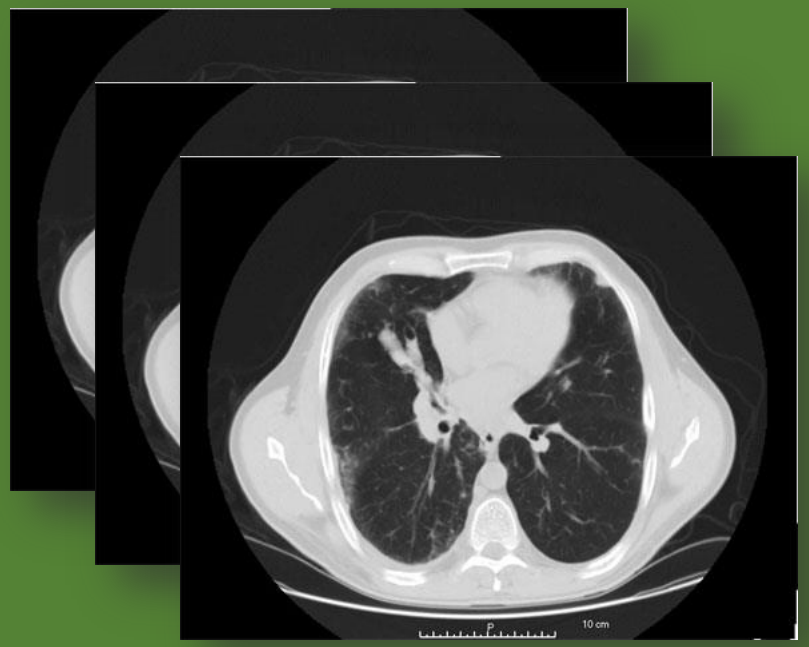
Virtual assistants



Social media & advertising

Potential of ML in 2017

- Automatic segmentation in single and multiple timepoint image data
- Feature recognition in multi-modal image data
- Radiomics – link image features to non-image data
  - **Delta** radiomics
  - **Predictive** radiomics



DICOM CT
RTSTRUCT
RTDOSE

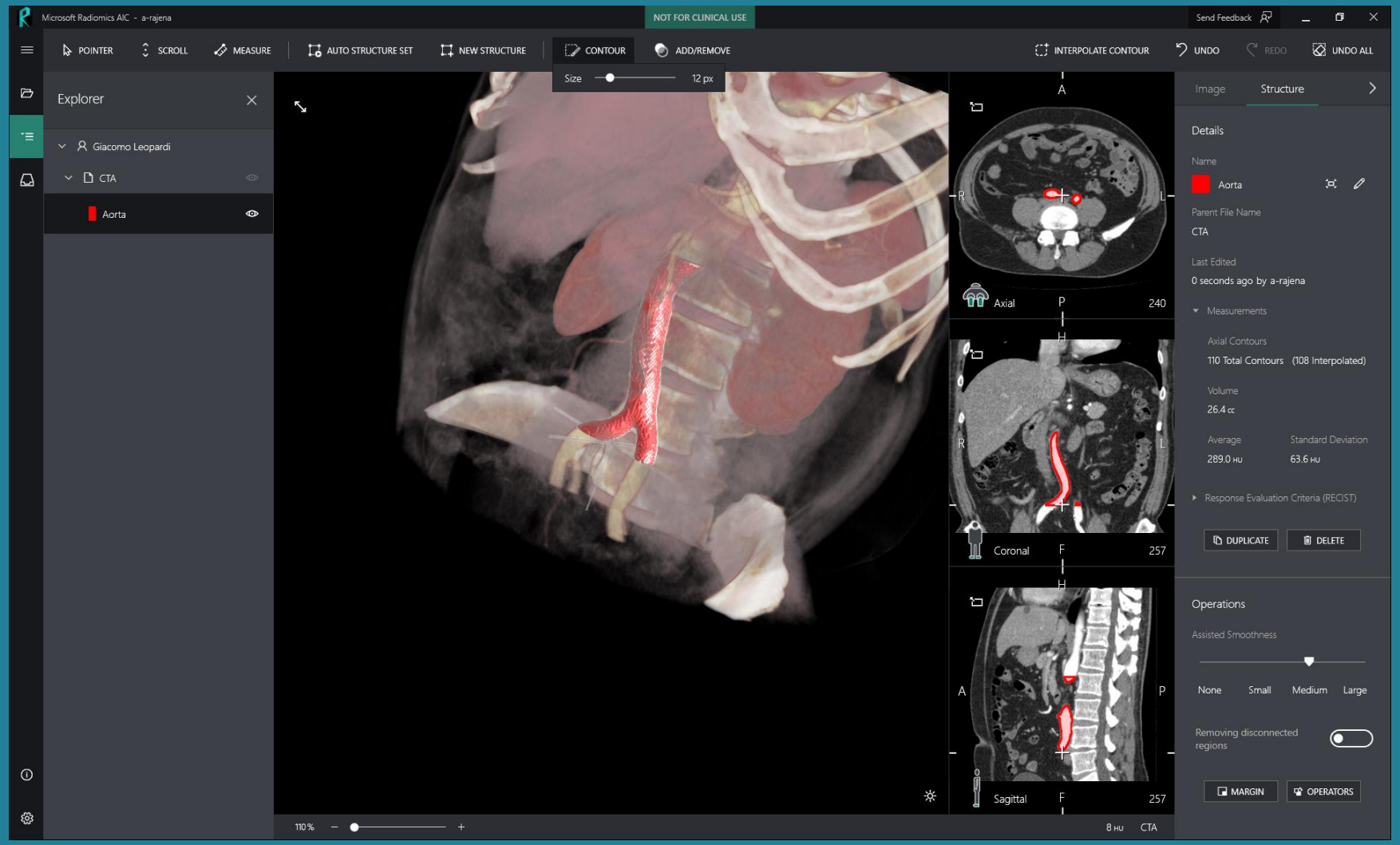
Radiomics AI for Contouring

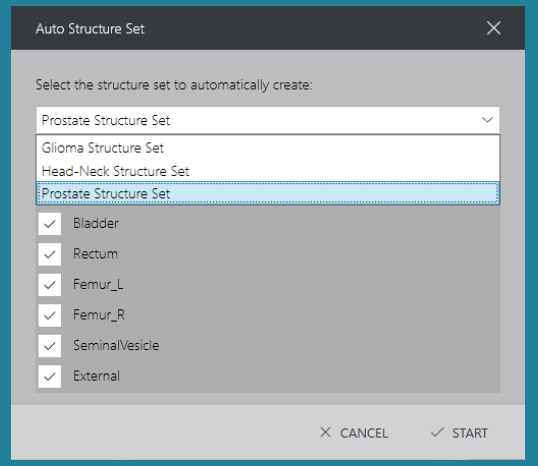
Building a cloud accelerated commercial application for Radiation Oncology

Radiomics App

- RT workflow acceleration tool (<1 min on workstation)
- ML models for
  - Prostate
  - HNC
  - Glioblastoma
  - Kidney
  - Breast + IMN
  - Lung
- Rapid fixup using assisted segmentation

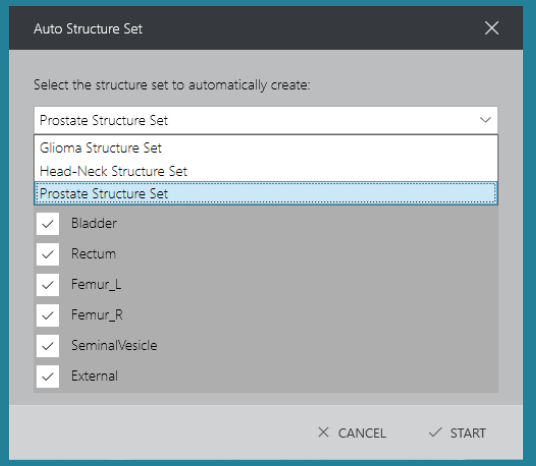
Prepare datasets for ML models in radiomics app

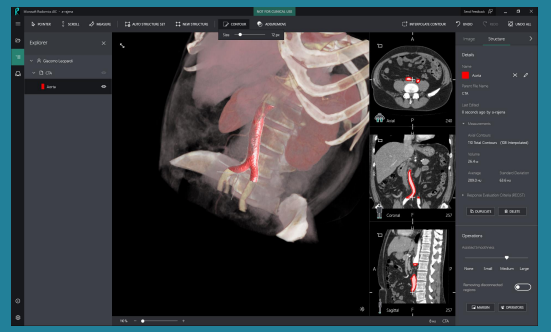




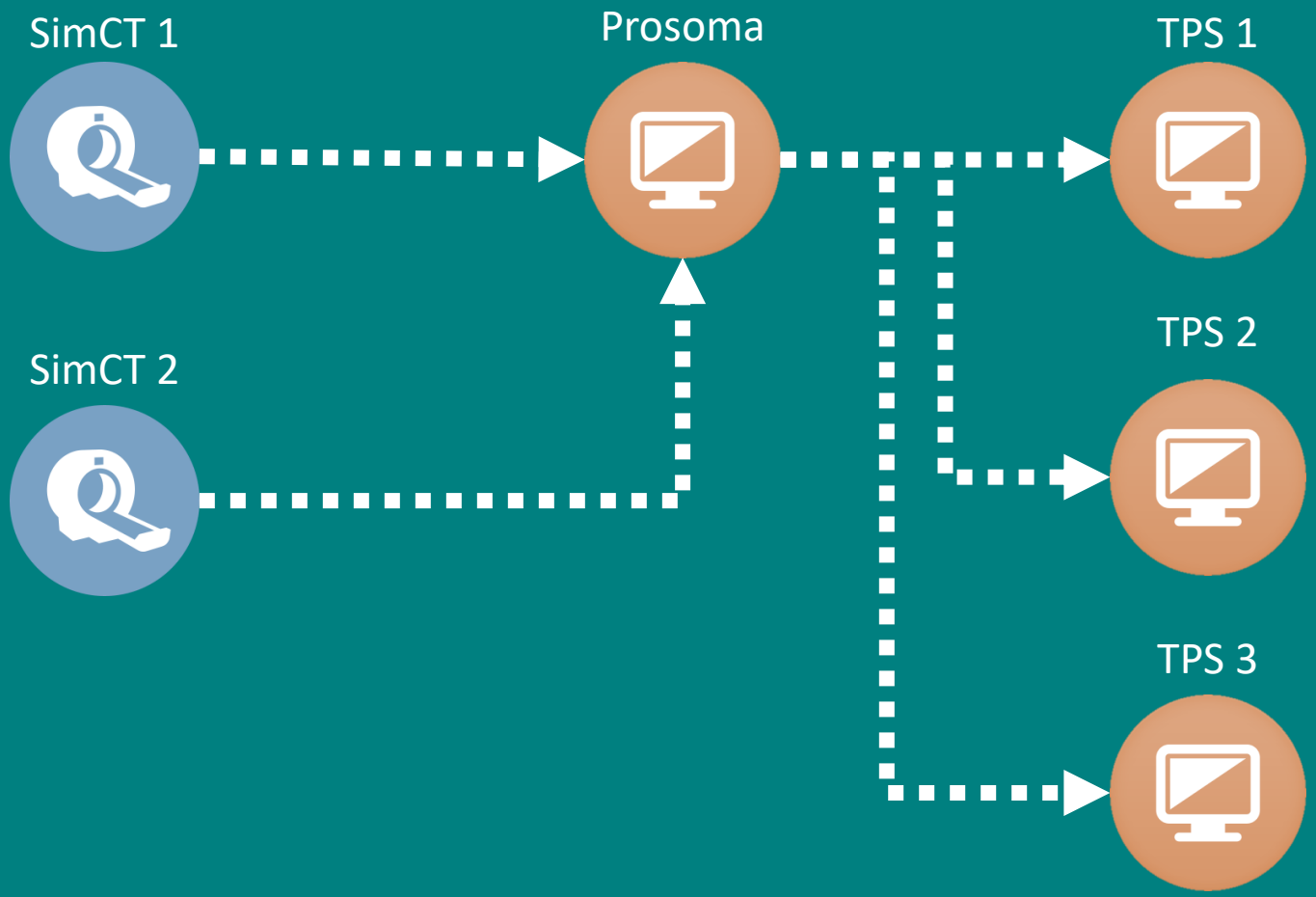
Microsoft Research Cambridge

R-AIC in action

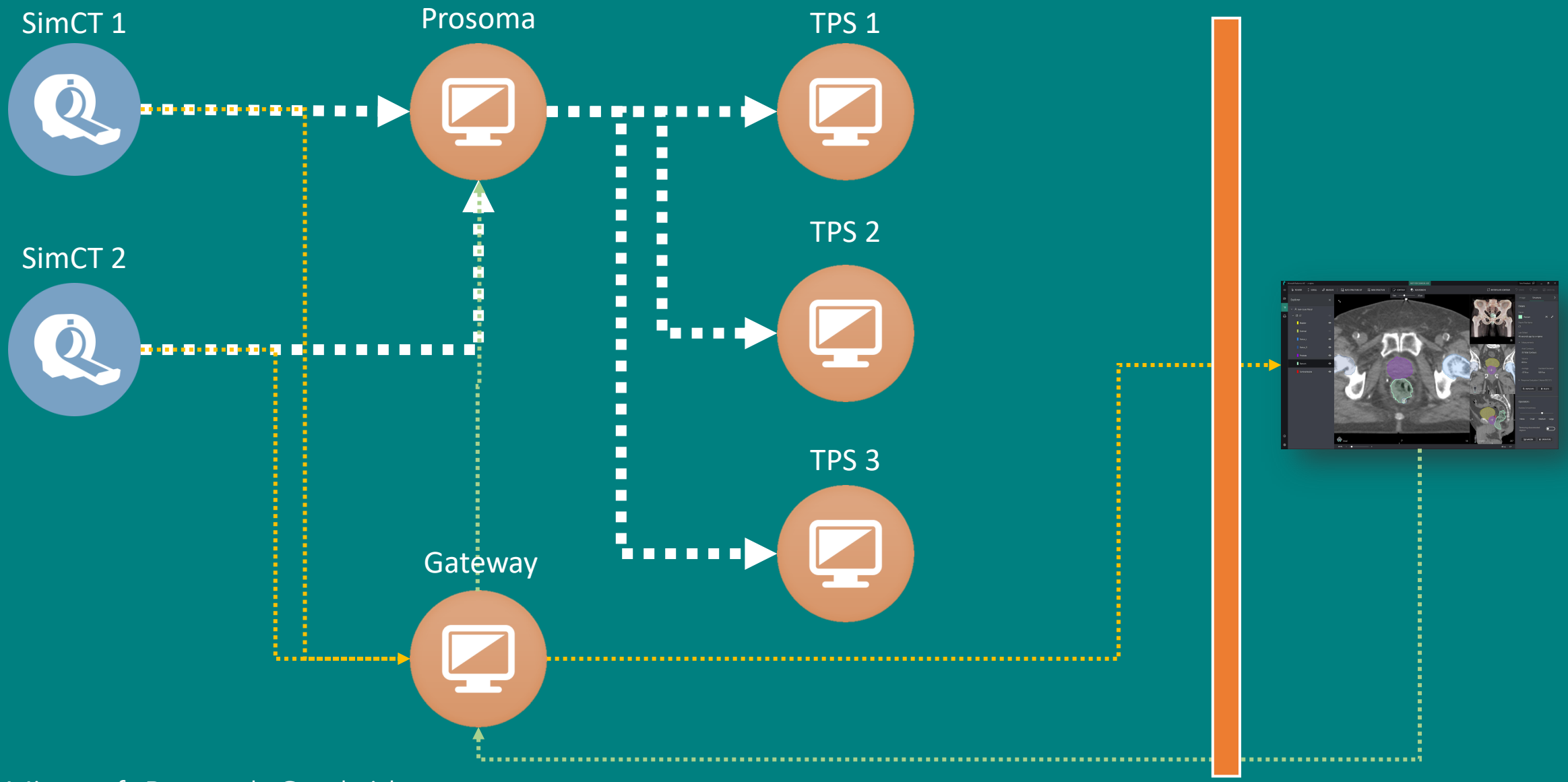




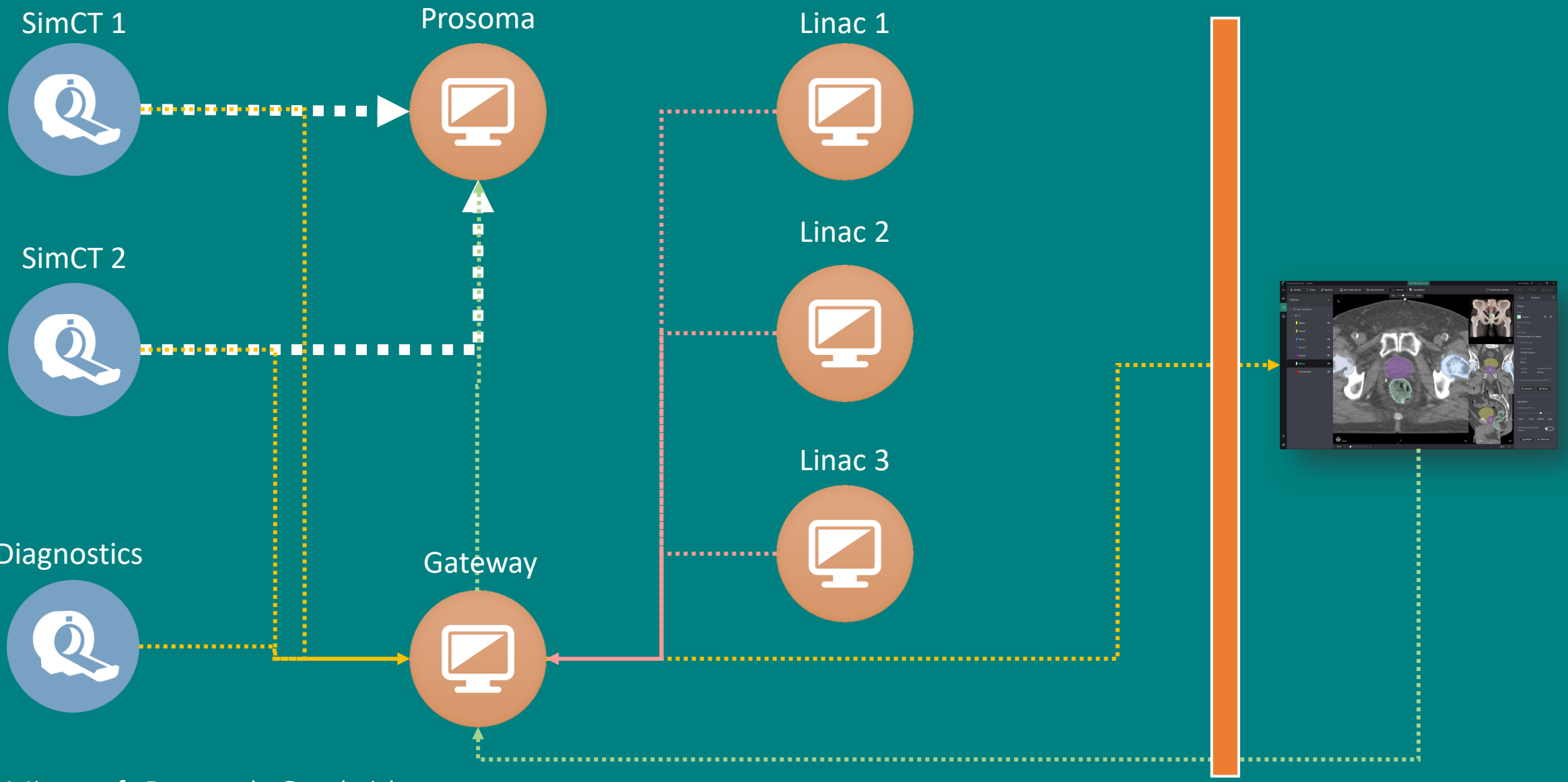
Radiomics gateway / listener



Radiomics gateway / listener



Hamlet gateway / listener



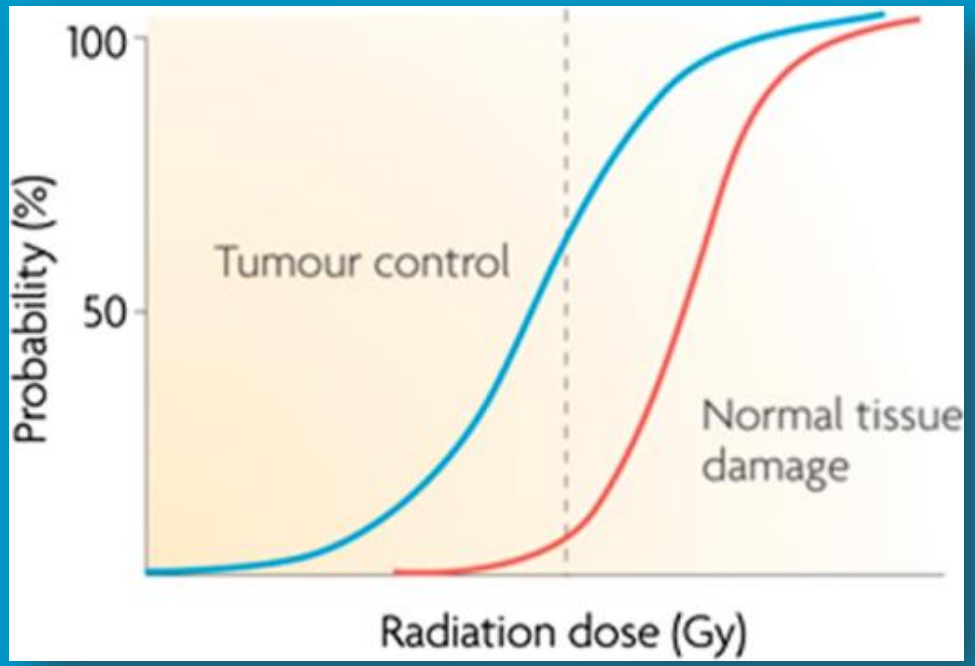
cmih
centre for mathematical
imaging in healthcare

Predictive mathematical models & clinical trials

Predicting NT treatment effects

- VoxTox – Delivered dose better predictor of NT outcome than planned dose

- NT event rate is low(!)
- NT dose effect models are population based
- Complex interplay of non-dosimetric factors



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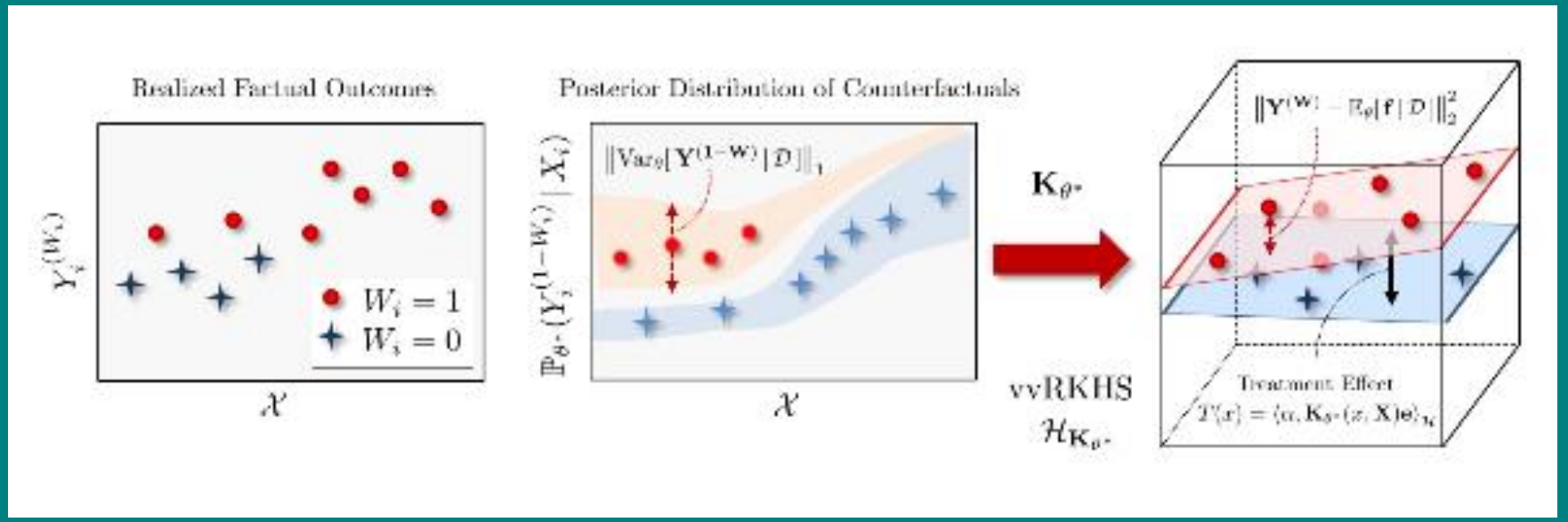
Multitask Gaussian Process models

- Alternative way to model patient-level data using Bayesian models
- Event = observation of presence *or absence* of toxicity
- Build a continuously refined prior distribution of toxicity event
- CNNs used to train models of posterior (predictive) distribution



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Hamlet.rt

Hamlet-RT concept

- Build and validate ML and mathematical models for RT radiomics
- Then build **predictive** models of treatment toxicity using imaging, dose, baseline clinical and treatment toxicity data together

MSRC - Criminisi

- ML Segmentation models
- Image based predictive models
- Software engineering *(Radixact / CBCT VNA)*

Oncology Centre

- Patient recruitment
- Data curation
- Model testing & validation

CMIH - Schonlieb

- MTG models
  - Non-image data
  - With image data

CCI - Drumright

- Clinical informatics for research
- Data release from EPIC for radiomics

Anonymised image data (Image / dose / structures)

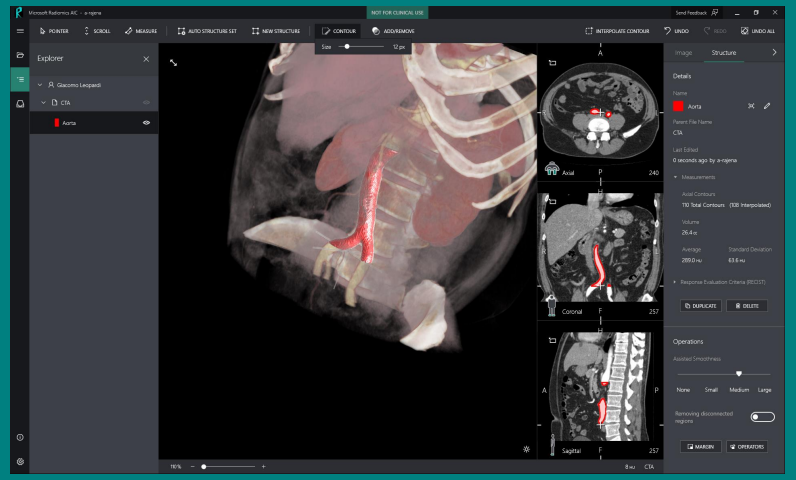
Baseline and late toxicity data from EPIC

Mosaiq acute toxicity data

Predictive ML image signatures

Overview

- Prospective data collection study – no interventions
- Aim to recruit 1000 patients over 3 years for imaging workstream
  - Prostate
  - Head & Neck
  - Breast
  - Lung
  - Brain
- MTG models will focus on Prostate & HNC only
- Start development of MTGs with **VoxTox** consolidation cohort



Short and longer term goals

- Short term
  - Build **ML segmentation** tools for disease sites that work for planning CT, CBCT/MVCT
  - Build 1st generation **multimodal ML tools** for radiomics (image, segmentation and dose) and response evaluation
  - Build **predictive MTG** models of acute toxicity from VoxTox cohorts
- Longer term
  - Utilise & validate ML models for predictive radiomics
  - In view of low event rate, mine toxicity endpoints from EPIC

Consent & commercial use

- Patient consent at start of RT preparation
- Explain 3 way partnership between Trust, Microsoft and University
  - Clinical investigator led study
  - Sharing of non-identifiable image data
  - GDPR 2018 compliance (restriction / rectification / retraction)
  - No commercial use of image data permitted, only image derivatives (knowledge derived from images) can be commercialised
  - Allowed to acknowledge beenfits to the study, and to the trust!
  - Working with Hilary Stobart (ICPV) to get this right.

Innereye help

- Part of high-level collaboration with CUH
- SDE's (Application Dev | Azure | DICOM integration & VNA)
  - Help build integration tools for KVCT & MVCT VNA
- ML Experts (DF & DCNN)
  - Develop customised ML applications
- **Unlimited** CUH licenses of co-developed applications
- Free Azure compute & storage resources for research

Microsoft Research Cambridge

People

Antonio Criminisi
Principal Researcher

Javier Alvarez-Valle
Senior Software Engineer

Aditya Nori
Principal Researcher

Kenji Takeda
Director, Azure for Research

Richard Lowe
Software Engineer

Ivan Tarapov
Senior Software Engineer

Michelle Li
User Experience Designer

Rajesh Jena
Radiation Oncology Consultant

Loic Le Folgoc
Visiting Researcher

Governance issues

- Research collaboration agreements with MSR and University in place which permit commercial use. Will be extended for Hamlet.rt
- R&D will take on Sponsorship issues
- CCTC will have trial oversight but there are no CRFs, no monitoring requirements
- Funding and Trust sponsorship will confer CRN badging
- Application for NCRN portfolio status

Thanks to Hamlet.rt's *dramatis personae*…

ACT I

- Yvonne Rimmer
- Charlotte Coles
- Amy Bates
- Duncan Jodrell
- Louise Grybowicz
- Andrew Hoole

ACT II

- Antonio Criminisi
- Javier Alvarez-Valle
- Richard Lowe
- Aditya Nori
- Laurence Bourn
- Kenji Takeda
- Iain Buchan
- Chris Bishop

ACT III

- Carola Schönlieb
- John Aston
- James Rudd
- Angelica Aviles-Rivero
- Evgeny Dmitriev
- Stephen Kelleher

ACT IV

- Michael Simmons
- Lydia Drumright
- Hilary Stobart