

The Cancer Phenomics Toolkit (CaPTk)

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Overview

Center for Biomedical Image Computing and Analytics (CBICA)

Neuroinformatics and Computational
Clinical Neuroscience

(Neurodegenerative diseases,
neurodevelopmental and
neuropsychiatric disorders, MS,...)

Oncologic Image Analysis

Brain
Cancer

Breast
Cancer

Lung
Cancer

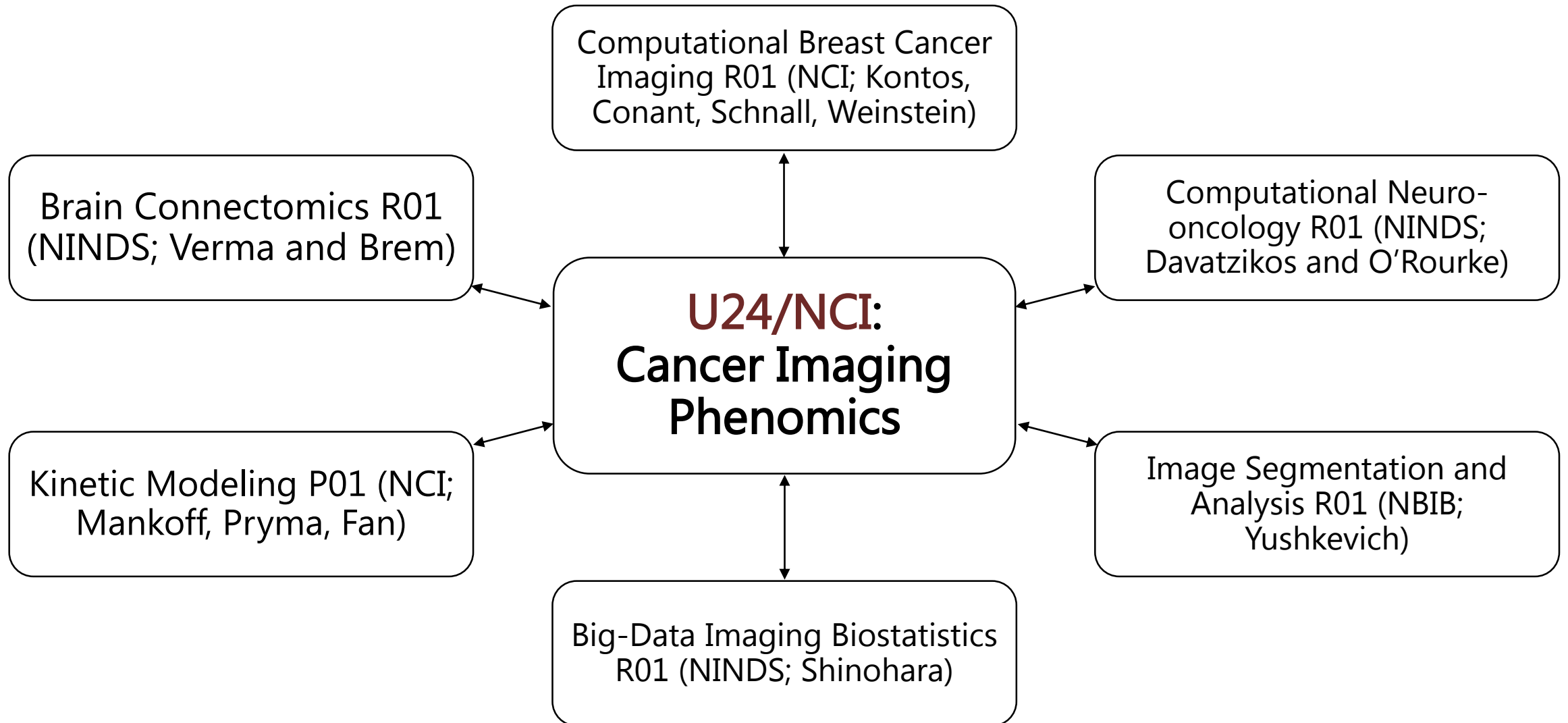
"If you cannot measure it, then it is not science"

From lecture to the Institution of Civil Engineers, London (3 May 1883)

Lord Kelvin, 1824-1907

Lots of Interface with
the TCE's of the ACC

Oncologic Imaging Analytics



Two Major Foci of CapTk Program

- To leverage a rich family of advanced image computing algorithms
- To leverage extensive and long-standing collaborations with clinical teams who have provided input in the development of the algorithms, as well as data for training and validation of models

U24/ NCI: Cancer Imaging Phenomics

Multi-parametric
Imaging Features

Genomic Data

Demographic and
Clinical Variables

Complex Data Analysis

Precision Diagnostics
and Prognostics
Local Tissue → Whole
Tumor → Patient

Main Elements of CaPTk

Image Analysis Algorithms: Extraction of rich set of multi-parametric imaging features; image segmentation and co-registration

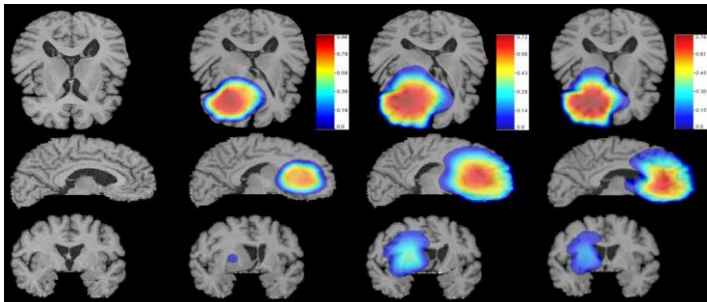
Precision Diagnostics Using Machine Learning: Risk for cancer development, risk for recurrence, prediction of survival, imaging genomics

Personalized Treatment Planning: Guide tumor resection and targeted radiation, estimate functional loss based on connectomic features...

1. Neurosurgical planning workstation: from precision diagnostics to personalized treatment
2. Precision diagnostics workstation of breast cancer

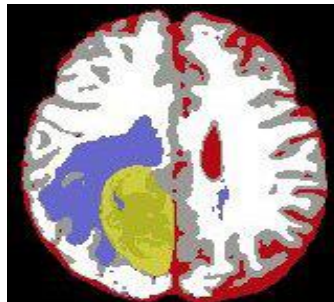
Computational Neuro-Oncology

Modeling tumor growth



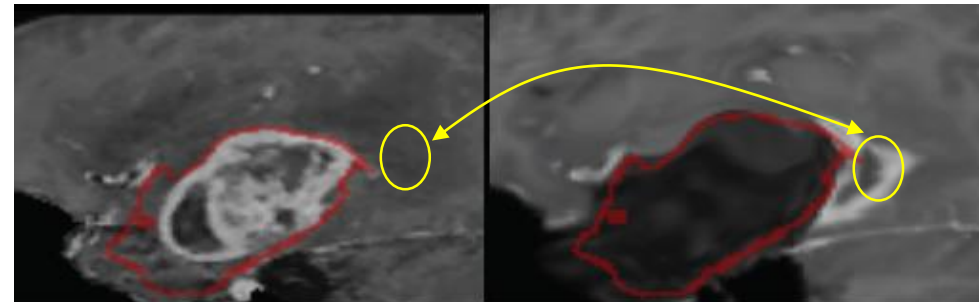
Hogea et al., J. Math. Biol., 2008

Segmentation



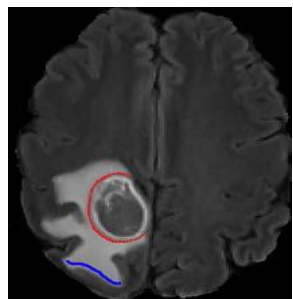
Gooya et al., TMI, 2012
Bakas et al., MICCAI BRATS 2015 **1st prize**

Pre-operative to Post-Recurrence Registration

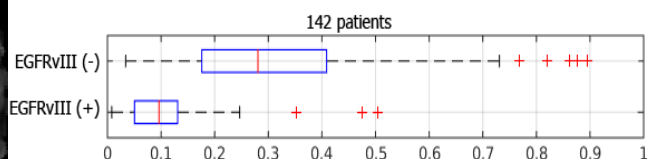


Kwon et al., TMI, 2014

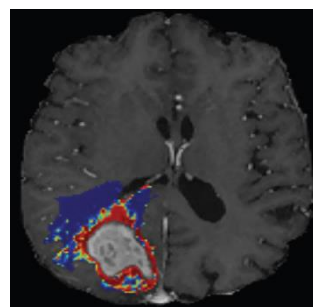
Imaging Signatures of Molecular Characteristics



Bakas et al., SNO 2015

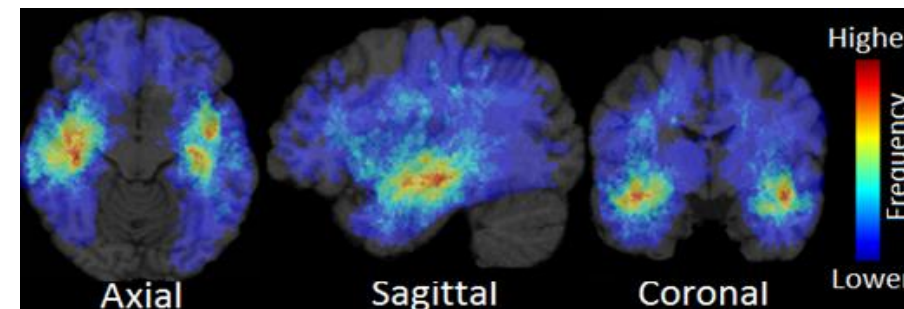


Predicting Recurrence



Akbari et al., Radiology, 2014
Akbari et al., Neurosurgery, 2016

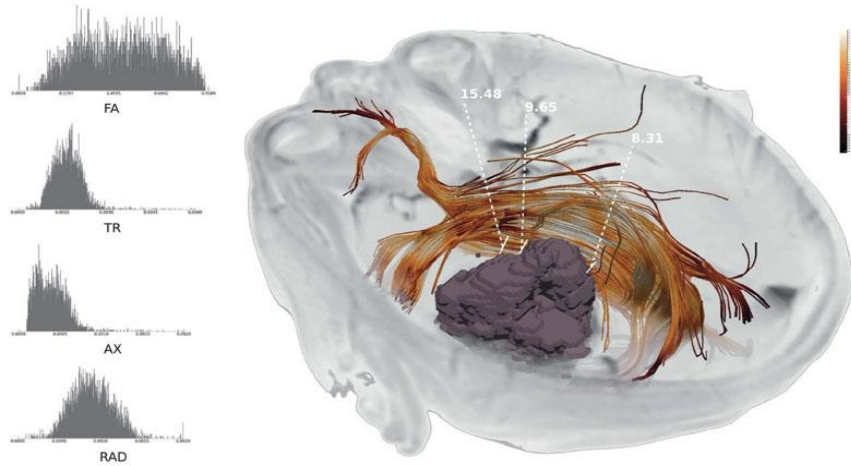
Spatial Distribution Atlases



Bilello et al., NeuroImage: 2016

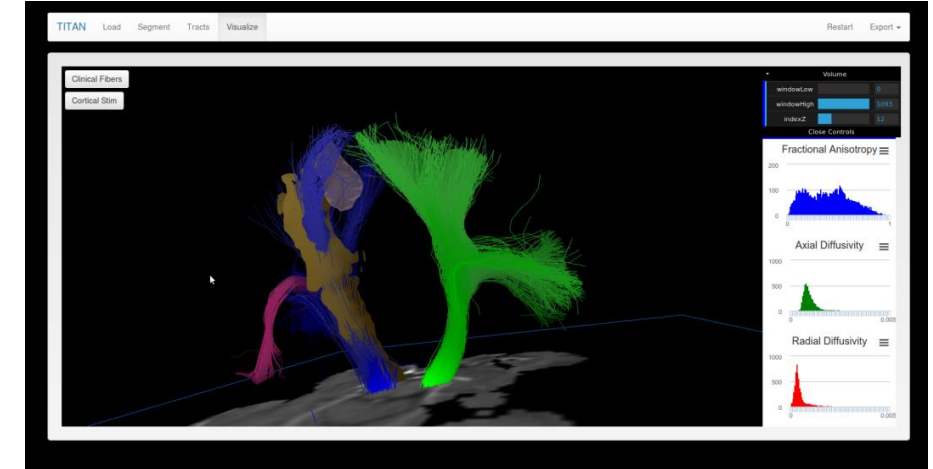
Computational study of Brain Connectivity

Peri-lesional Effects of GBMs

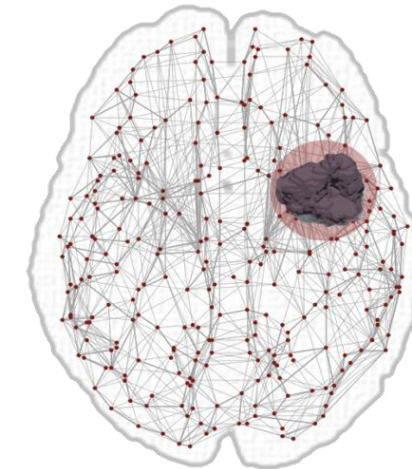


- Automated atlas-based tract extraction (using connectivity signatures instead of shape help address mass effect)
- Edema invariant tractography (using multicompartment models fitted to multishell imaging)
- Tumor connectome (effect of tumor on distant regions, regional vulnerability and functional rerouting)

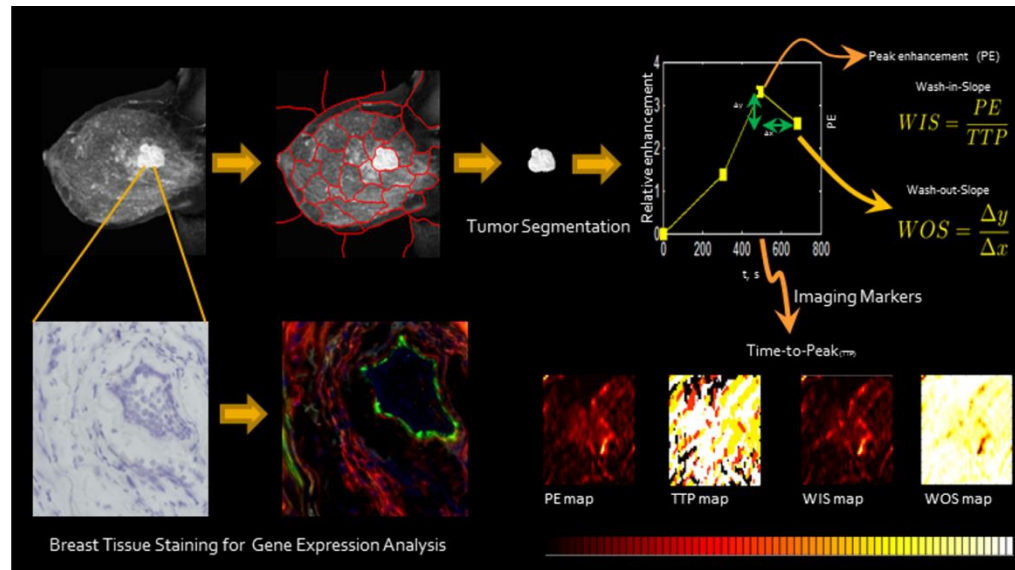
Web-based Integrated Surgical Planning Environment



Global Effects of GBMs



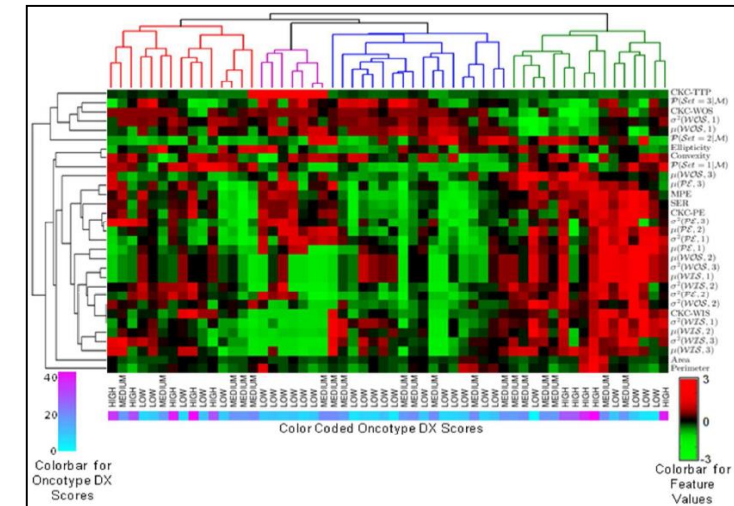
Radiomic Breast Cancer Phenotypes



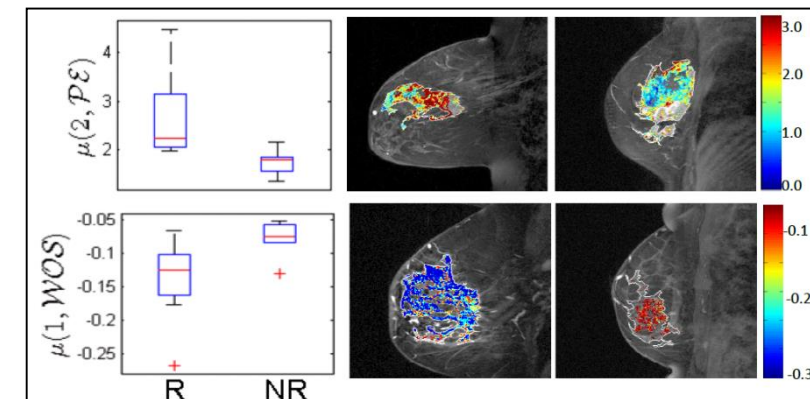
Ashraf et al., IEEE TMI 2013; Mahrooghy et al. IEEE TBME 2015

Breast Cancer Phenotyping via Imaging:

- Segmentation and multi-parametric feature extraction
- Identification of intrinsic phenotype patterns
- Prognostication and treatment response prediction



Intrinsic Imaging Phenotypes for Breast Cancer Prognostic and Predictive Value



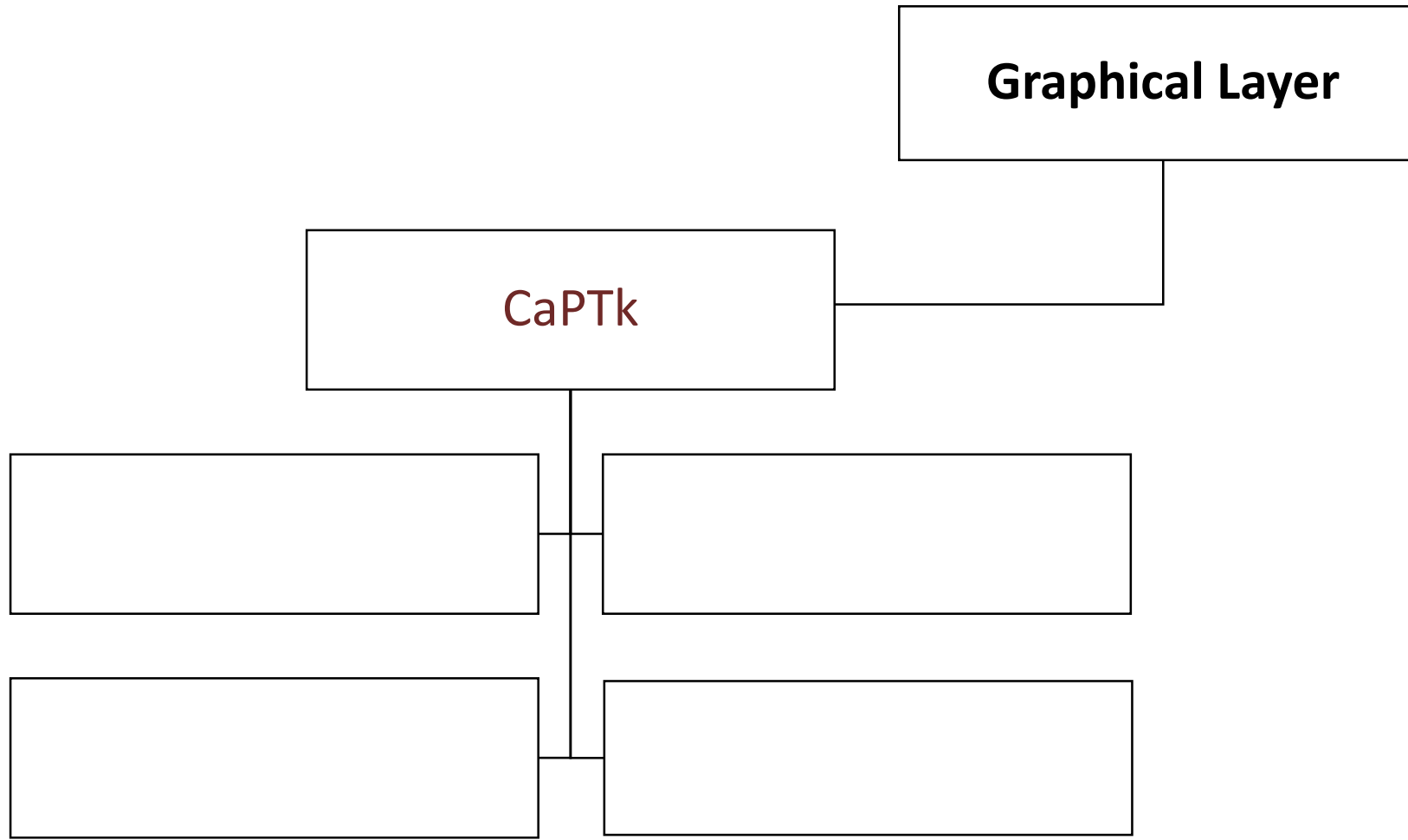
Goals

- Enable the larger scientific community (radiologists, clinicians, neuro-scientists and other researchers who don't deal with **command line interfaces**) to use cutting edge algorithms from computational research centers for clinically relevant studies through a user-friendly, platform-independent interface.

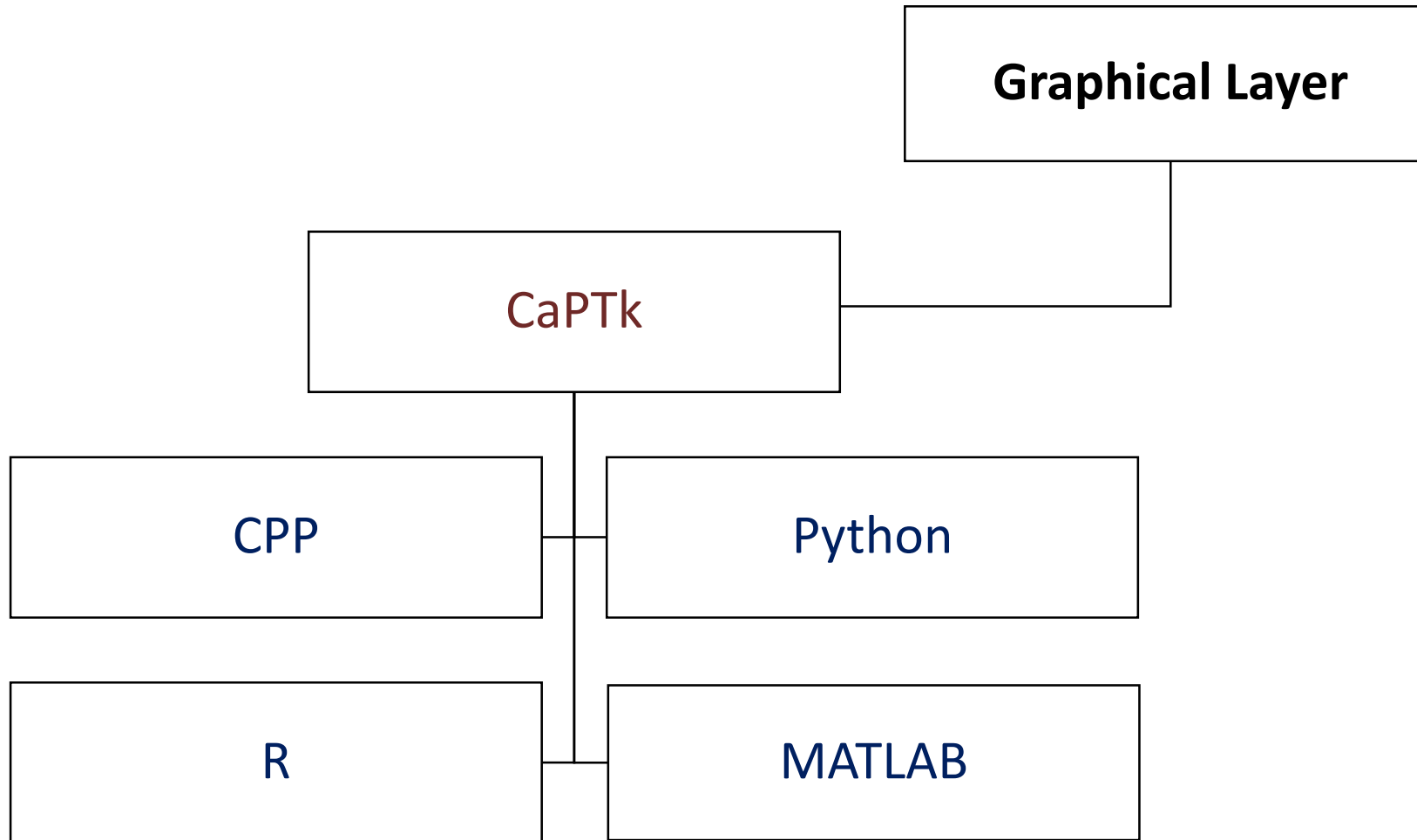
Goals

- Enable the larger scientific community (radiologists, clinicians, neuro-scientists and other researchers who don't deal with command line interfaces) to use cutting edge algorithms from computational research centers for clinically relevant studies through a user-friendly, platform-independent interface.
- Provide a platform for researchers from computational centers to incorporate their algorithms in a form which can be used to target the larger scientific community as quickly as possible.

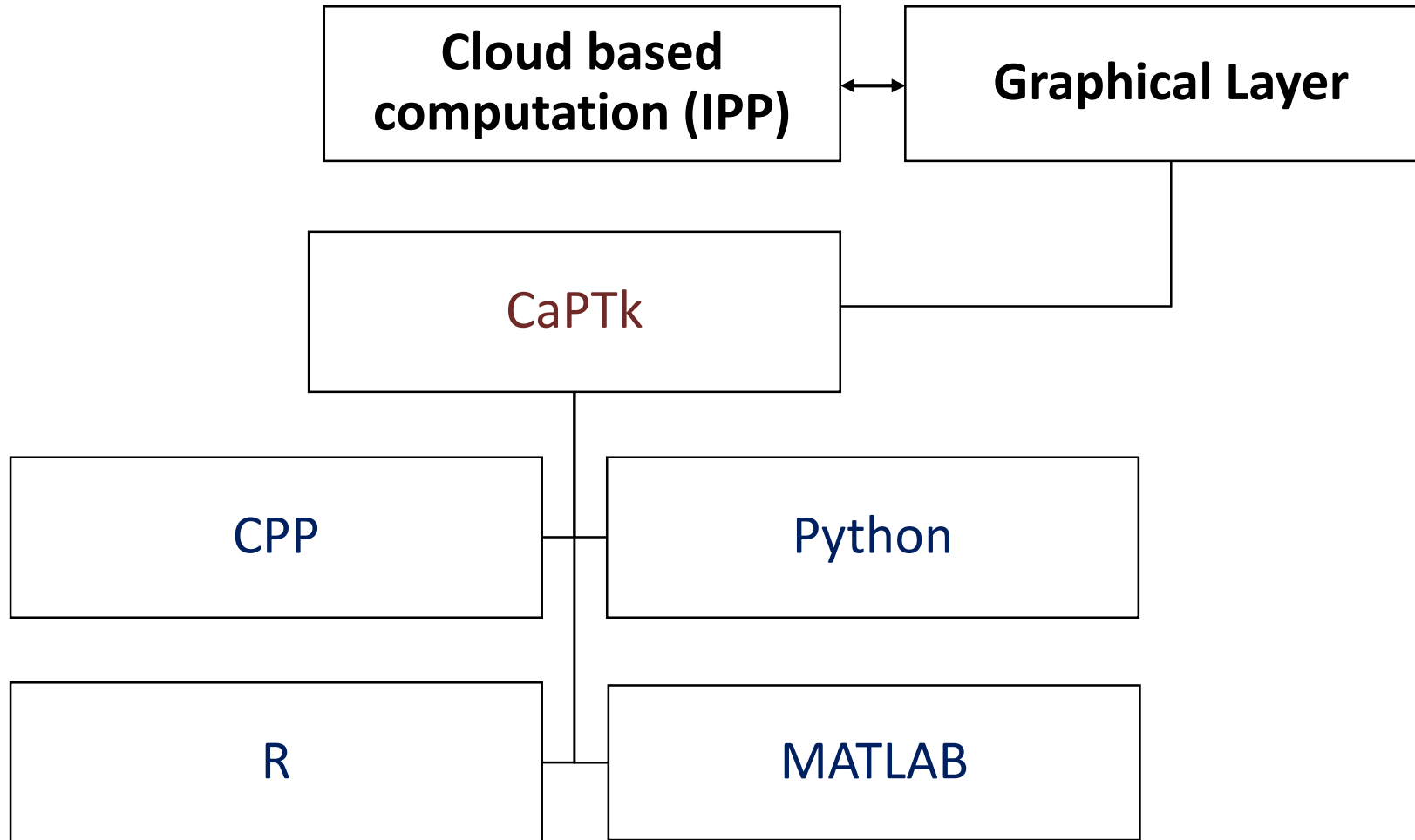
Overview of Architecture



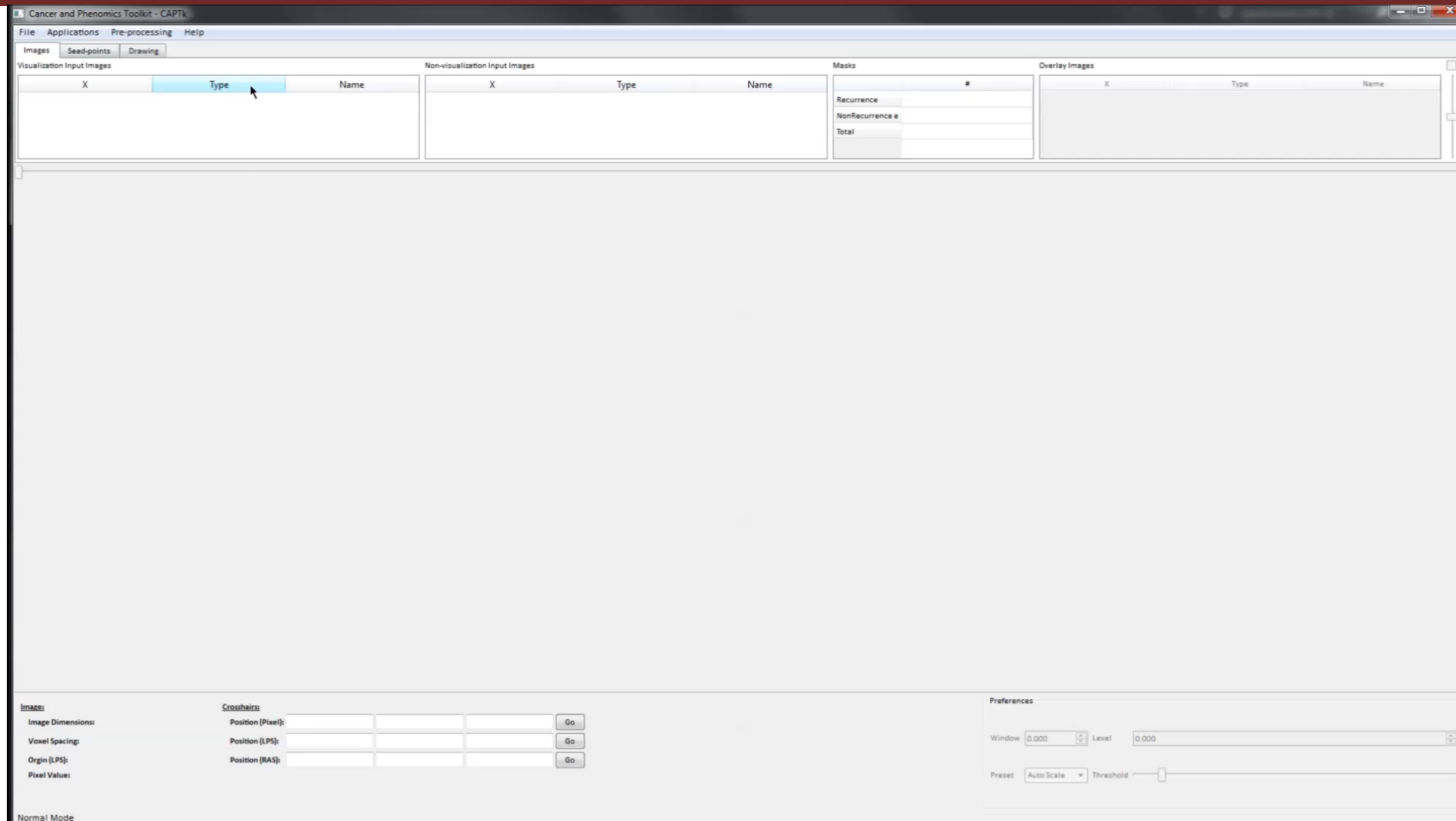
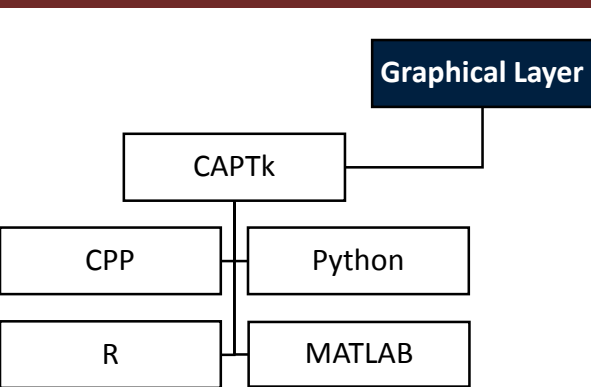
Overview of Architecture



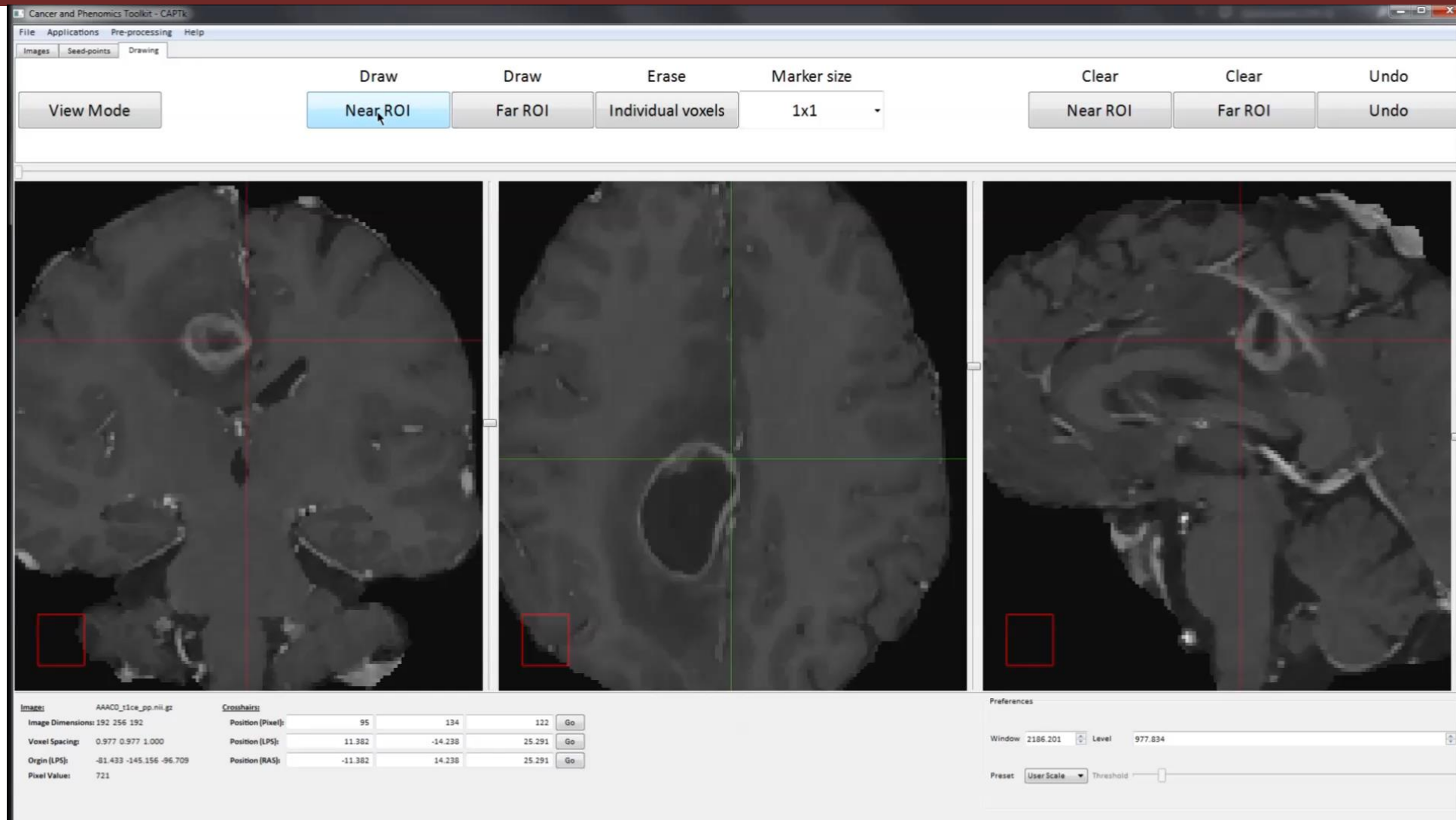
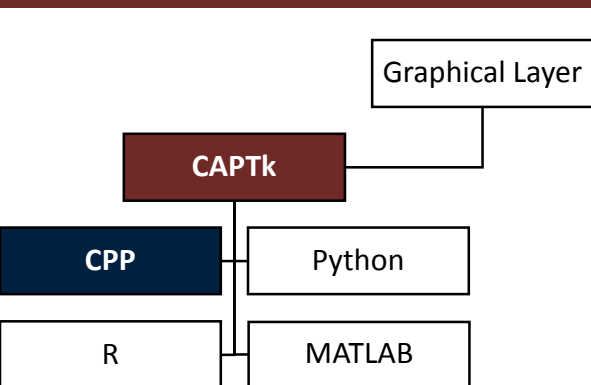
Overview of Architecture



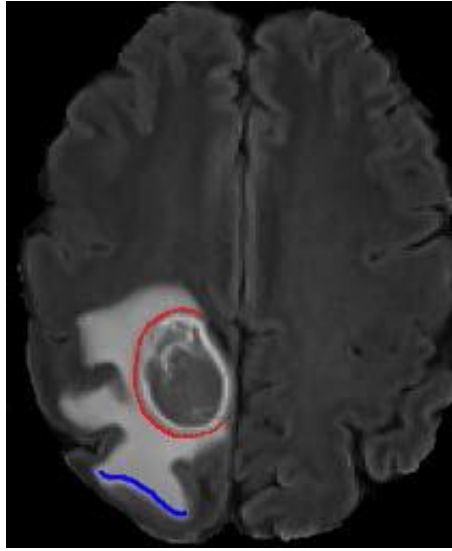
Graphical Layer & GLISTR



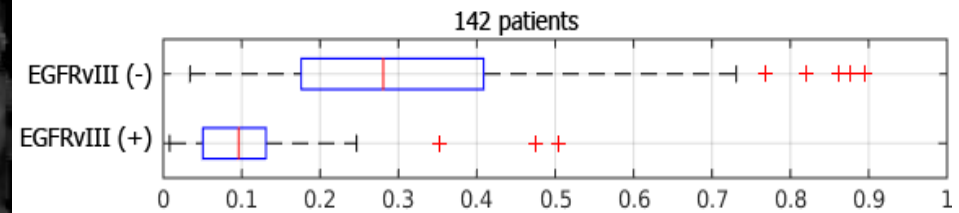
Graphical Layer & EGFR



EGFR Results



Bakas et al., SNO 2015



Geodesic Segmentation using CaPTk

Graphical Layer

CAPTk

CPP

Python

R

MATLAB

Cancer and Phenomics Toolkit - CAPTk

File Applications Pre-processing Help

Images Seed-points Drawing

Draw Draw Erase Marker size

View Mode Near ROI Far ROI Individual voxels 1x1

Clear Clear Undo

Near ROI Far ROI Undo

Draw near ROI points in the image

Image: AAC0_flair_pp.nii.gz

Image Dimensions: 152 256 152

Voxel Spacing: 0.977 0.977 1.000

Origin (LPS): -81.433 -145.156 -96.709

Pixel Value: 487

Crosshairs:

Position (Pixel): 95 134 122 Go

Position (LPS): 11.382 -14.238 25.291 Go

Position (RAS): -11.382 14.238 25.291 Go

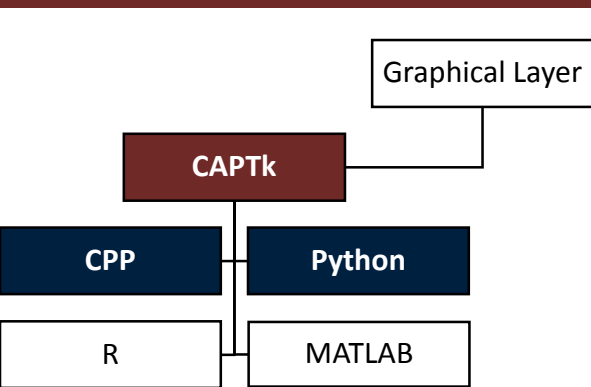
Recurrence Drawing Mode

Preferences

Window 747.000 Level 373.500

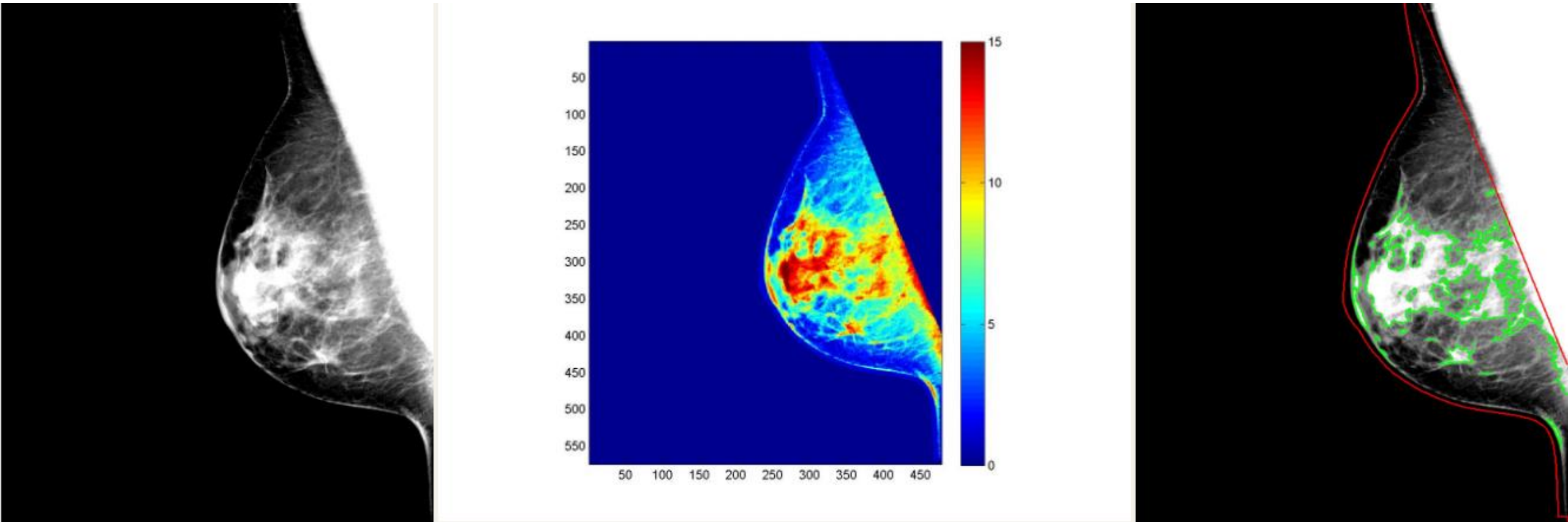
Preset Auto Scale Threshold

TITAN – Edema Invariant Tractography



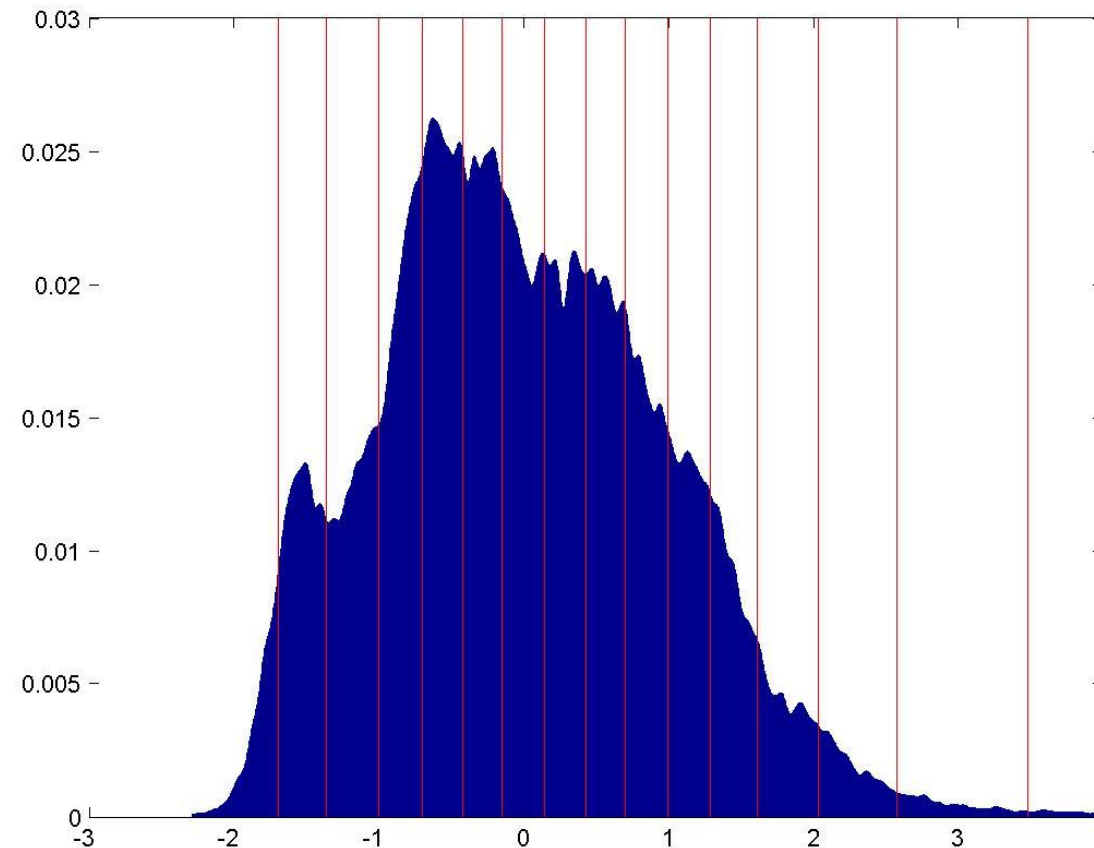
The screenshot shows the TITAN web interface. The top navigation bar includes 'TITAN', 'Load', 'Segment', 'Tracts', and 'Visualize'. On the right side of the bar are 'Restart' and 'Export' buttons. The main content area is dark blue. A light gray box in the center contains the text 'Please select the subject to load'. Below this text is a dropdown menu labeled 'Subjects ...' and a 'Submit' button.

LIBRA: Fully-automated Breast Density Estimation



The breast density maps using an adaptive multi-class fuzzy c-means segmentation with SVM classification

LIBRA: Adaptive Histogram-based Clustering



The breast region gray-level intensity histogram (z-scored) and FCM-cluster centers

LIBRA being called from CAPTk

Diagram illustrating the architecture of LIBRA being called from CAPTk:

- CAPTk (Central Hub)
- Graphical Layer
- Programming Languages: CPP, Python, MATLAB

LIBRA-1.0.3 (Revision: 487) interface components:

- Images / Seed-points tabs
- Visualization Input Images
- Image: AAAC0...
- Image Dimensions: 192 256
- Voxel Spacing: 0.977
- Origin (LPS): -81.433
- Pixel Value: 160
- Preferences: Window 747.000, Level 373.500, Preset Auto Scale, Threshold

