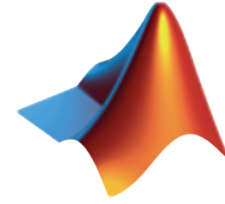




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TROG
CANCER RESEARCH



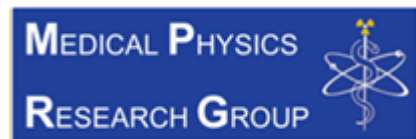
MathWorks®

Associating 3D Radiation Dose with Treatment Failure in Prostate Cancer Radiotherapy Patients

Presented by Marco Marcello

MATLAB Conference 10/05/17

Acknowledgements



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Supervisors – **Professor Martin Ebert**
and **Dr Pejman Rowshan Farzad**



Trial Chairperson – **Professor Jim Denham**
Trial Contact – **Mrs Allison Steigler**

Breakdown

1) Introduction

⇒ Cancer and radiotherapy **basics**

⇒ Research **problem** and **aims**

2) Aim 1: Locating Regions where Dose is Correlated with Failure

⇒ Using MATLAB for **3D visualisation**

⇒ Using MATLAB for **locating significant regions**

3) Aim 2: Classification Modelling

⇒ What is **classification modelling**?

⇒ Live demo of **MATLAB Classification Learner App**

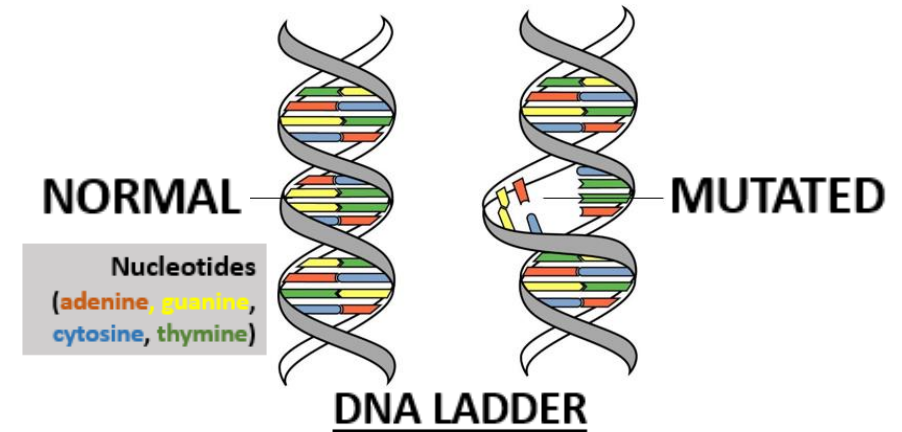
4) Potential Impact of Research

⇒ How MATLAB helps **impact** radiotherapy through this project

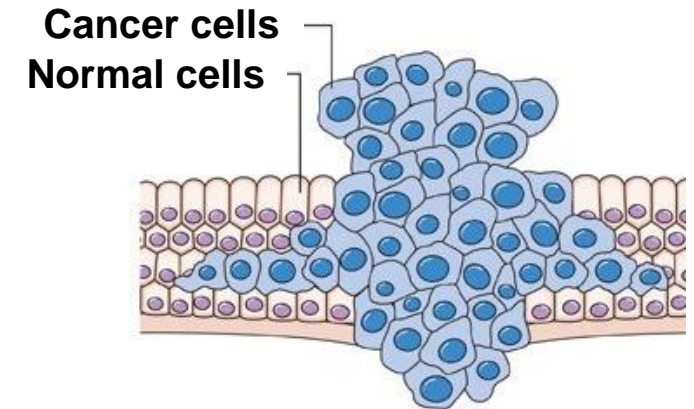
Cancer and Radiotherapy Basics

↳ What is cancer?

⇒ Cancer results from **genetic mutations** that occur naturally or result from external influences.



⇒ Particular mutations stimulate **out-of-control cell growth** of cells without normal functionality.



⇒ Groups of these cells are what we call **tumours**, and can destroy healthy function in many **crucial organs**.



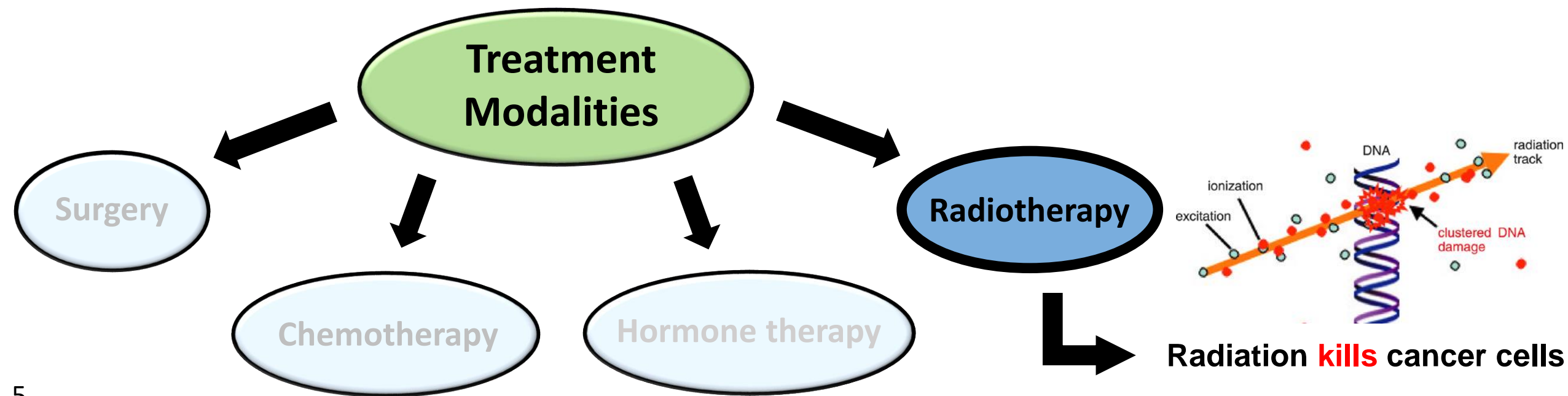
Cancer and Radiotherapy Basics

↳ Is cancer prominent? How's it treated?

⇒ **Cancer** is the **leading cause of death** in Australia, with 1 in 2 men and 1 in 3 women diagnosed by the age of 85

⇒ **Prostate cancer** is the **most commonly diagnosed cancer** in Australia, with 1 in 8 men diagnosed within their lifetime

Prostate cancer is typically **treated** with a combination of the following **modalities**:

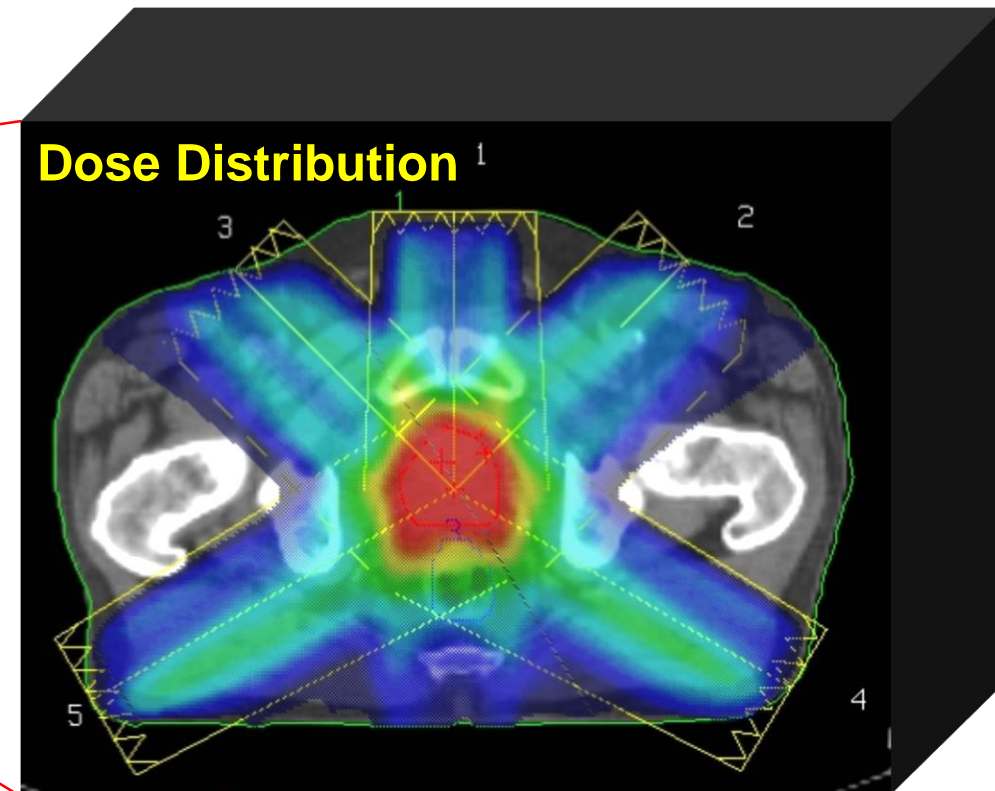
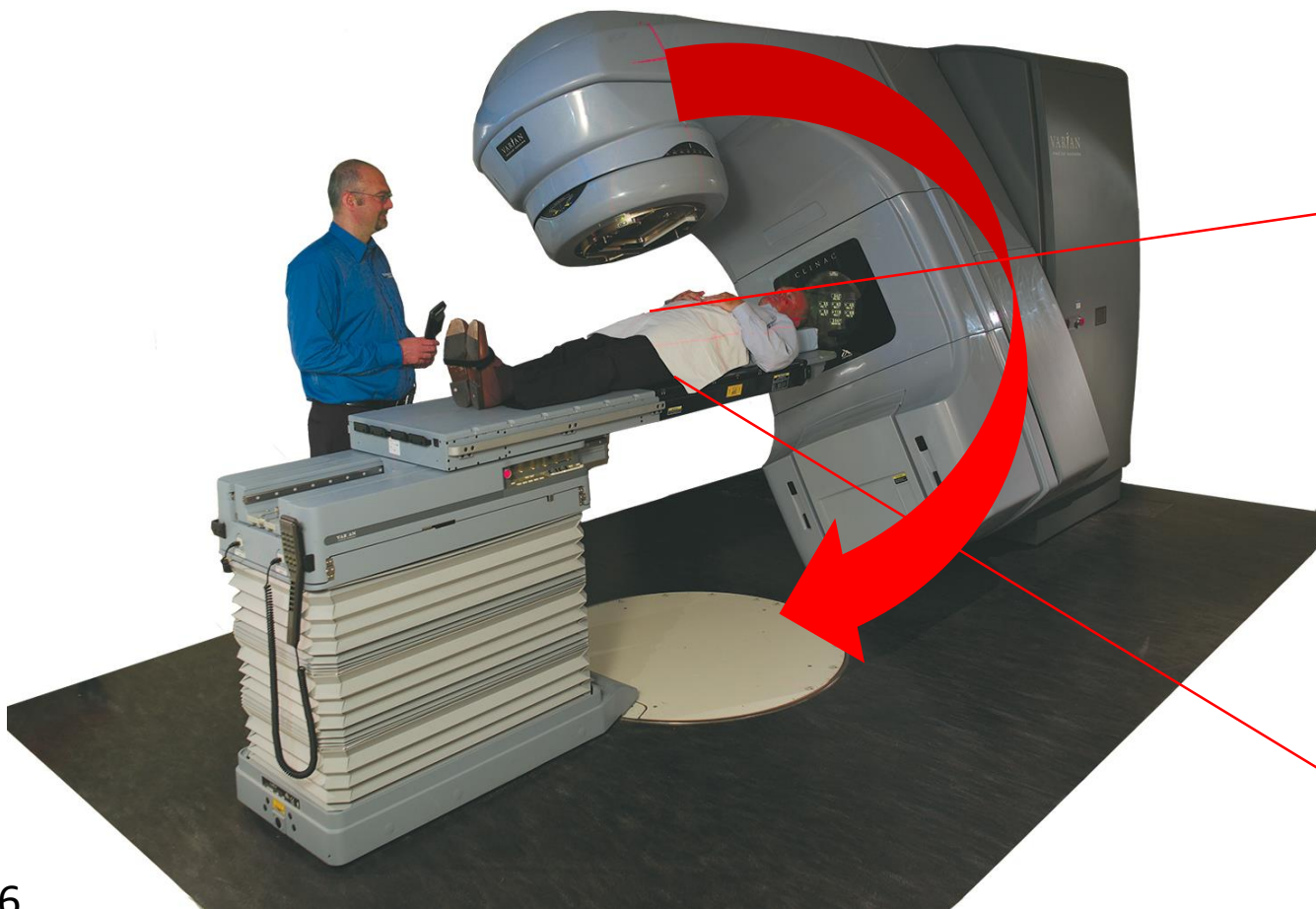


Cancer and Radiotherapy Basics

↳ What's External Beam Radiotherapy (EBRT)?

EBRT: radiation (high energy photons) **externally** delivered to tumour via linear accelerator.

'The Goal': to **maximise** dose (energy deposition) to **tumour** and **minimise** dose to **healthy tissues**.

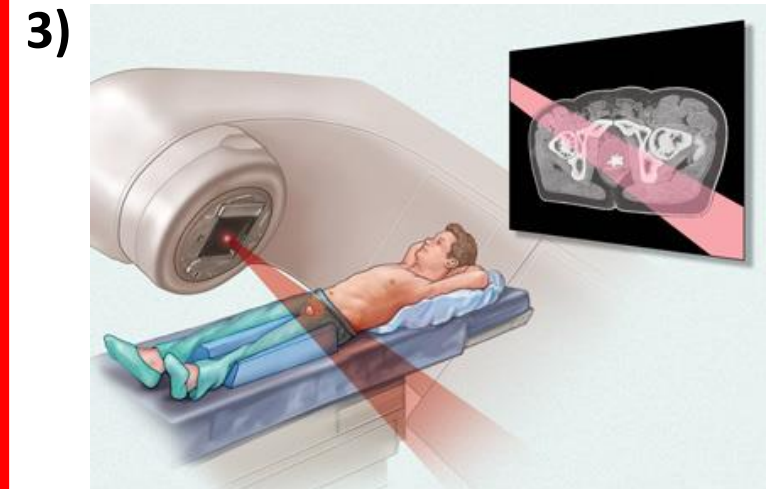
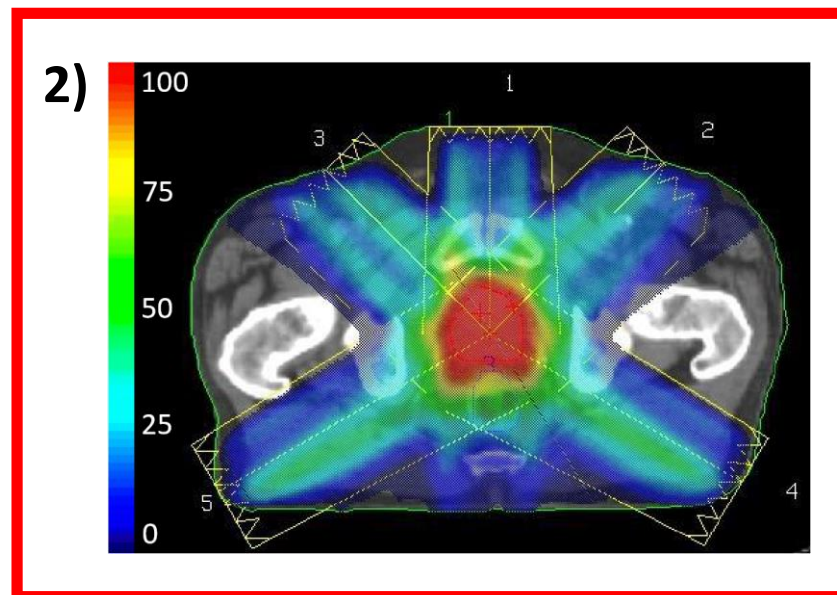
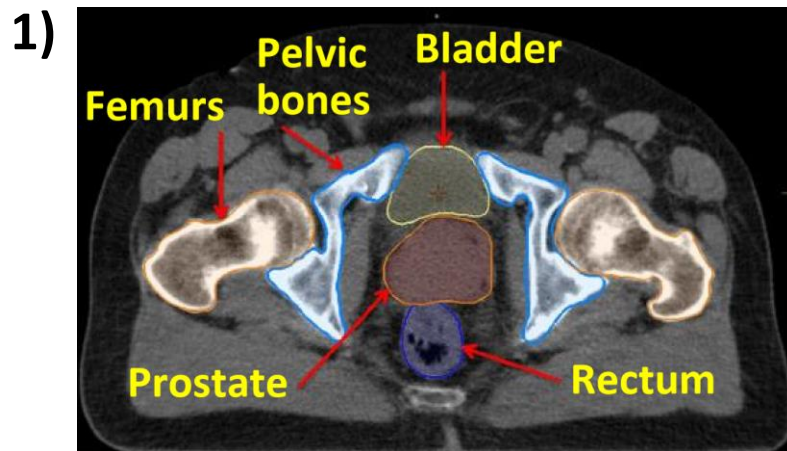


Cancer and Radiotherapy Basics

↳ What's the EBRT process?

Prostate cancer external beam radiotherapy (EBRT) involves **three major stages**:

- 1) Produce a high-quality **3D image** of the treatment region.
- 2) Produce a treatment plan, including a **3D radiation dose distribution**.
- 3) Accurately **deliver** the planned **radiation dose** via **linear accelerator**.



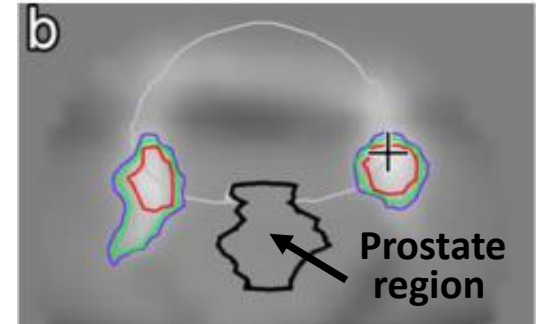
Research Problem and Aims

↳ Issues addressed? Project aims?

The project addresses a major unresolved issue in prostate EBRT:

⇒ The **distribution of cancer** around the prostate is **difficult to locate** due to potential microscopic **disease spread**.

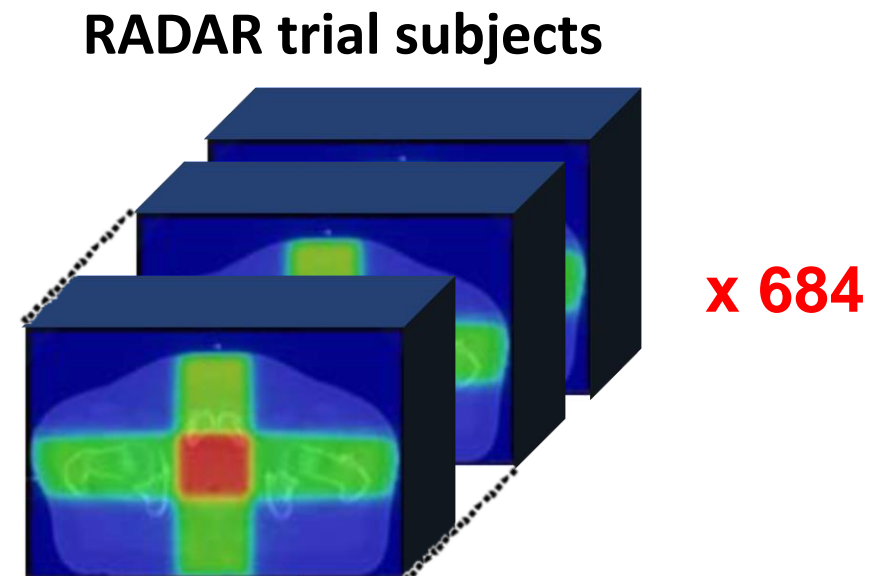
⇒ Therefore, there could be **regions** that are **under-dosed**.



Witte, M. G. *et al.* Relating Dose Outside the Prostate With Freedom From Failure in the Dutch Trial 68 Gy vs. 78 Gy. *Int. J. Radiat. Oncol. Biol. Phys.* **77**, 131–138 (2010).

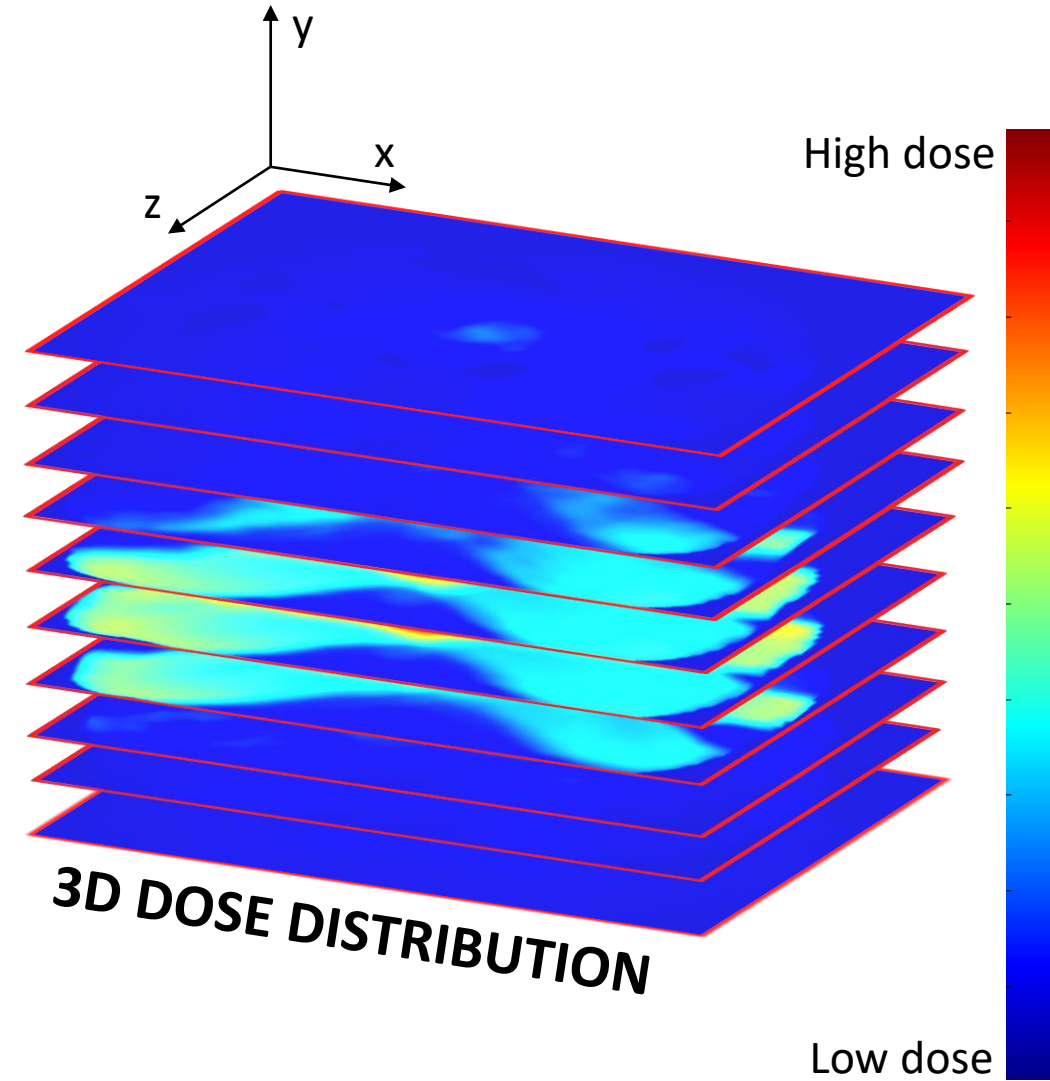
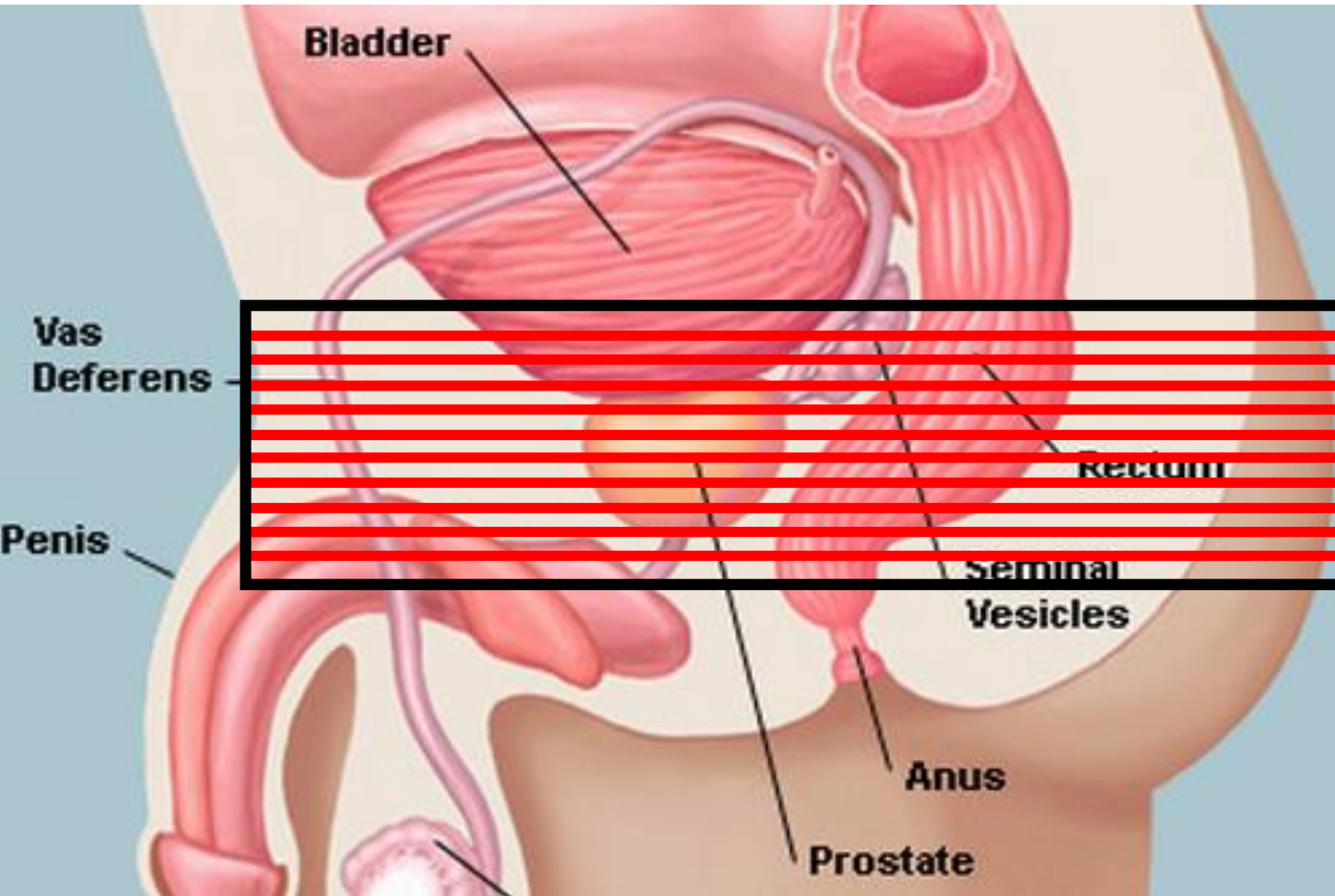
Project aims:

- 1) To find regions where **dose variation** is **correlated** with treatment **failure**.
- 2) To produce a **classification model** capable of **predicting failure** based on a subject **dose distributions**.



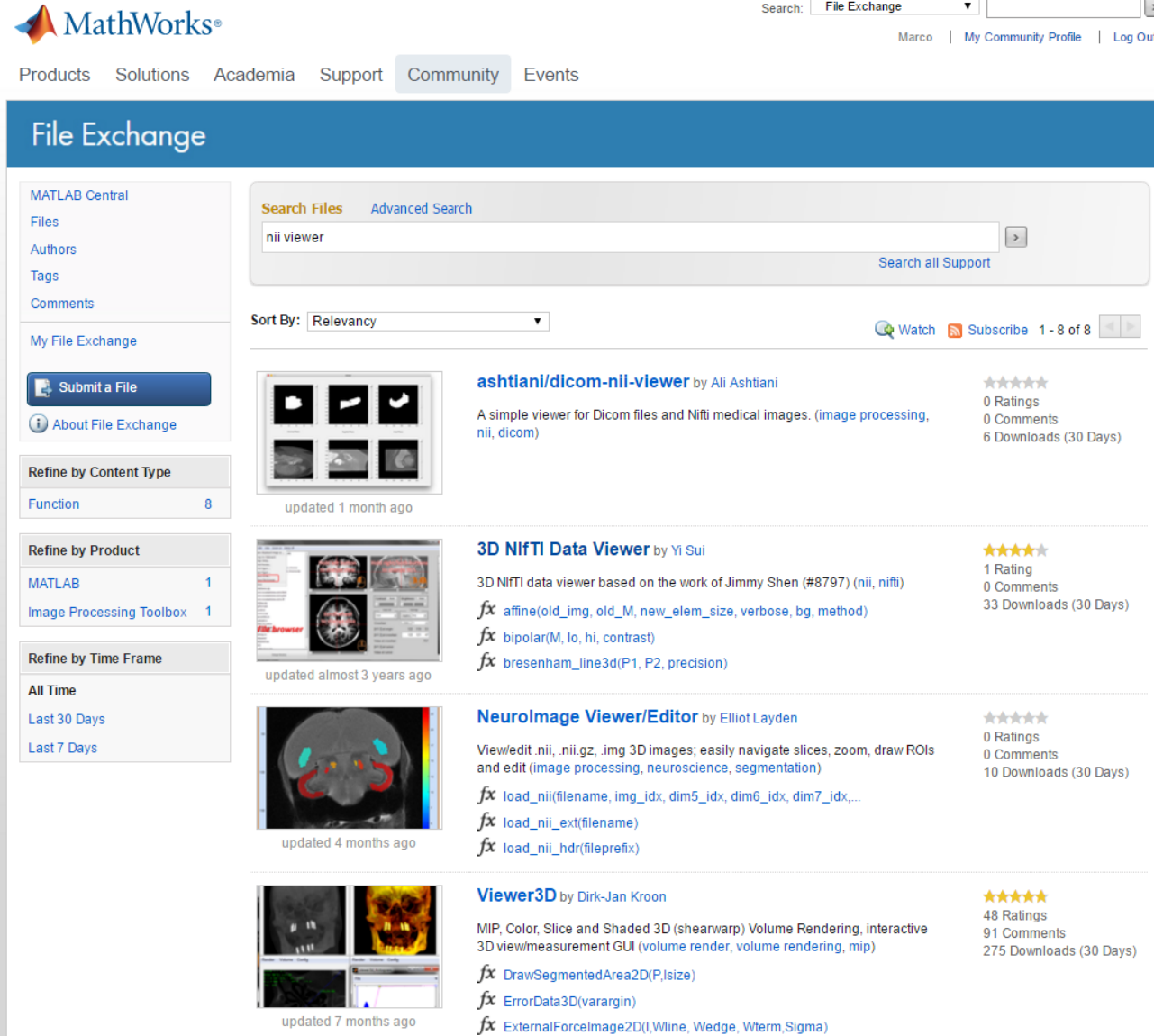
Aim 1: Locating Significant Regions

↳ What's a prostate EBRT 3D dose distribution?



Aim 1: Locating Significant Regions

↳ 3D Visualisation on MATLAB?



The screenshot shows the MathWorks File Exchange interface. At the top, there is a search bar with 'File Exchange' selected and a search button. Below the search bar, there are navigation links for 'Products', 'Solutions', 'Academia', 'Support', 'Community', and 'Events'. The main content area is titled 'File Exchange' and contains a search bar with 'nii viewer' entered. Below the search bar, there are sorting options ('Sort By: Relevancy') and a 'Watch' button. The search results are displayed in a list format, showing the title of the file, the author, a description, and statistics (ratings, comments, downloads). The first result is 'ashtiani/dicom-nii-viewer' by Ali Ashtiani, described as a simple viewer for Dicom files and Nifti medical images. The second result is '3D NIFTI Data Viewer' by Yi Sui, described as a 3D NIFTI data viewer based on the work of Jimmy Shen. The third result is 'NeuroImage Viewer/Editor' by Elliot Layden, described as a viewer/edit .nii, .nii.gz, .img 3D images; easily navigate slices, zoom, draw ROIs and edit. The fourth result is 'Viewer3D' by Dirk-Jan Kroon, described as MIP, Color, Slice and Shaded 3D (shearwarp) Volume Rendering, interactive 3D view/measurement GUI (volume render, volume rendering, mip).

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Last 7 Days

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nii viewer

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ashtiani/dicom-nii-viewer by Ali Ashtiani

★★★★★
0 Ratings
0 Comments
6 Downloads (30 Days)

A simple viewer for Dicom files and Nifti medical images. (image processing, nii, dicom)

updated 1 month ago

3D NIFTI Data Viewer by Yi Sui

★★★★★
1 Rating
0 Comments
33 Downloads (30 Days)

3D NIFTI data viewer based on the work of Jimmy Shen (#8797) (nii, nifti)

`fx affine(old_img, old_M, new_elem_size, verbose, bg, method)`
`fx bipolar(M, lo, hi, contrast)`
`fx bresenham_line3d(P1, P2, precision)`

updated almost 3 years ago

NeuroImage Viewer/Editor by Elliot Layden

★★★★★
0 Ratings
0 Comments
10 Downloads (30 Days)

View/edit .nii, .nii.gz, .img 3D images; easily navigate slices, zoom, draw ROIs and edit (image processing, neuroscience, segmentation)

`fx load_nii(filename, img_idx, dim5_idx, dim6_idx, dim7_idx, ...)`
`fx load_nii_ext(filename)`
`fx load_nii_hdr(fileprefix)`

updated 4 months ago

Viewer3D by Dirk-Jan Kroon

★★★★★
48 Ratings
91 Comments
275 Downloads (30 Days)

MIP, Color, Slice and Shaded 3D (shearwarp) Volume Rendering, interactive 3D view/measurement GUI (volume render, volume rendering, mip)

`fx DrawSegmentedArea2D(P, lsize)`
`fx ErrorData3D(varargin)`
`fx ExternalForceImage2D(L, Wline, Wedge, Wterm, Sigma)`

updated 7 months ago

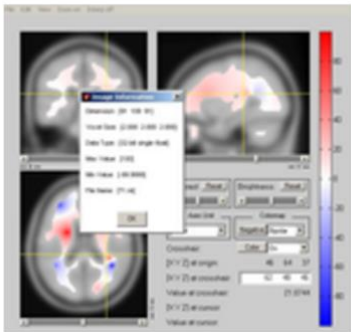
Aim 1: Locating Significant Regions

↳ 3D Visualisation on MATLAB?



File Exchange

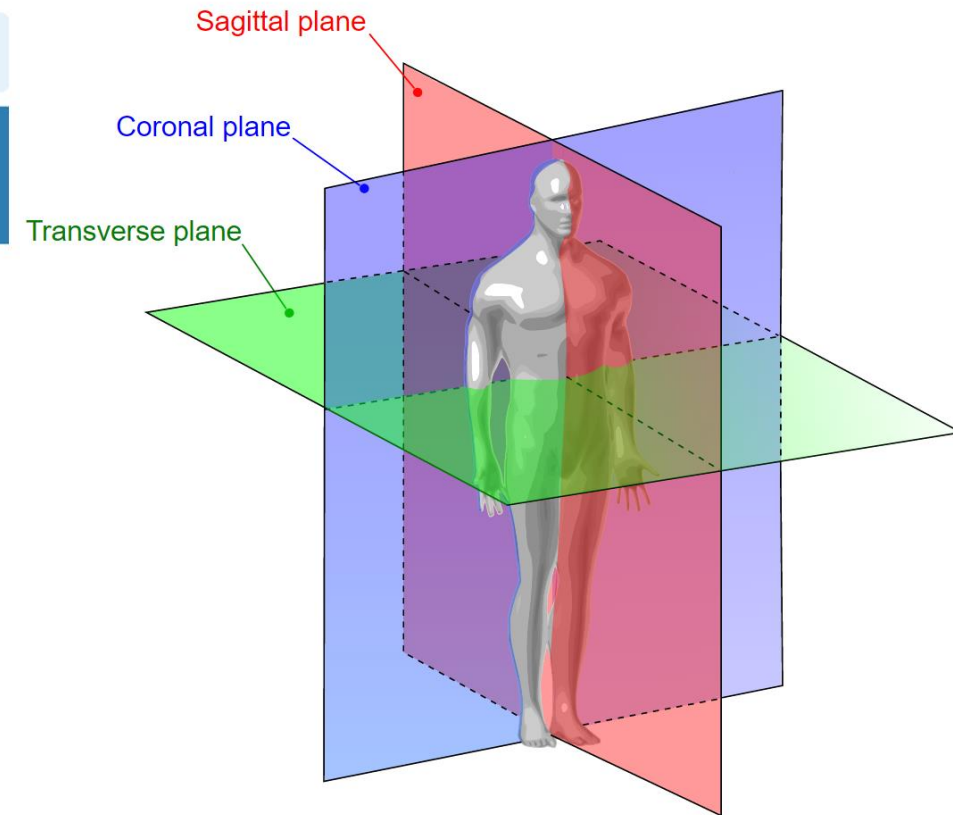
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About



Tools for NifTI and ANALYZE image

version 1.27 (426 KB) by Jimmy Shen

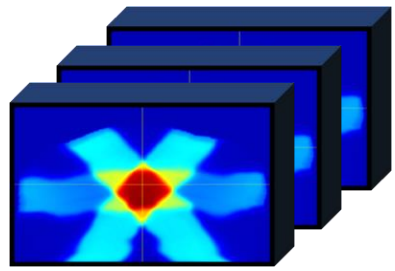
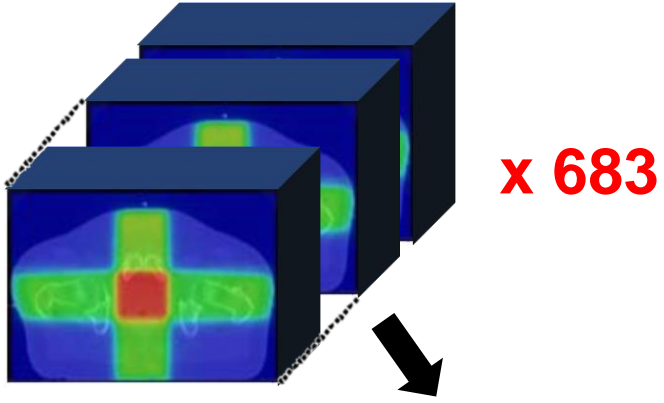
Load, save, make, reslice, view (and edit) both NifTI and ANALYZE data on any platform



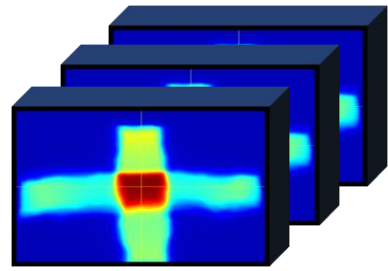
Aim 1: Locating Significant Regions

↳ Analysis: Dose-difference testing

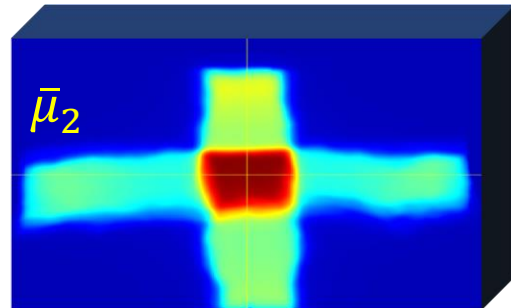
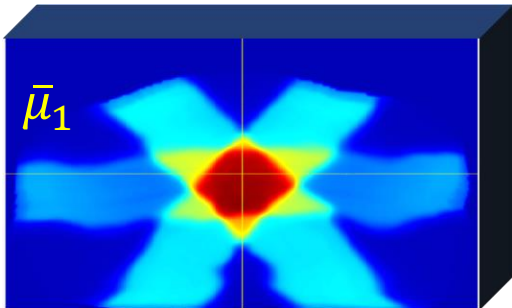
RADAR trial
subjects



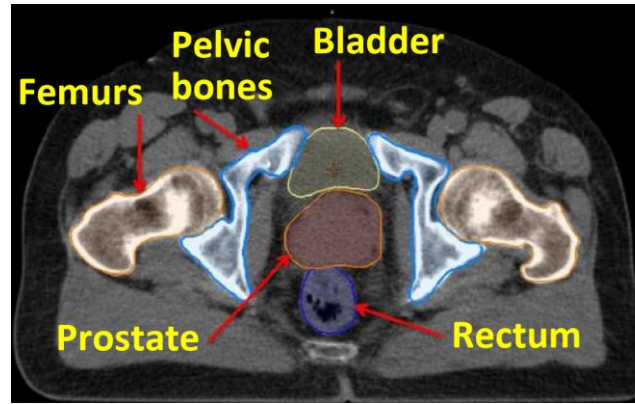
1: Treatment failed



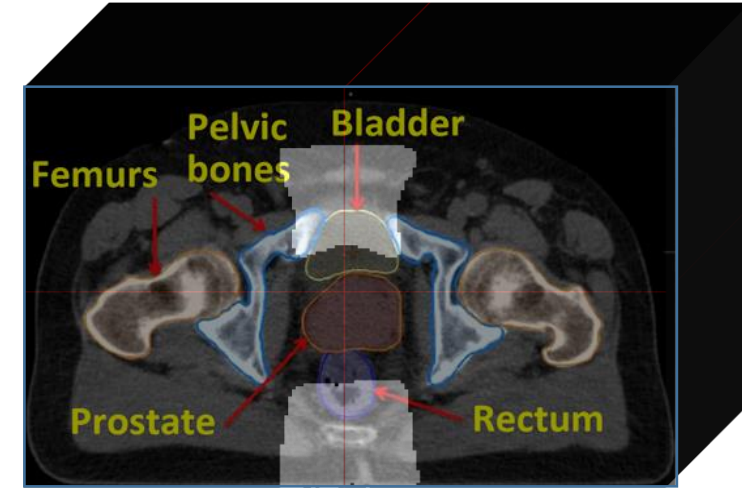
2: Treatment succeeded



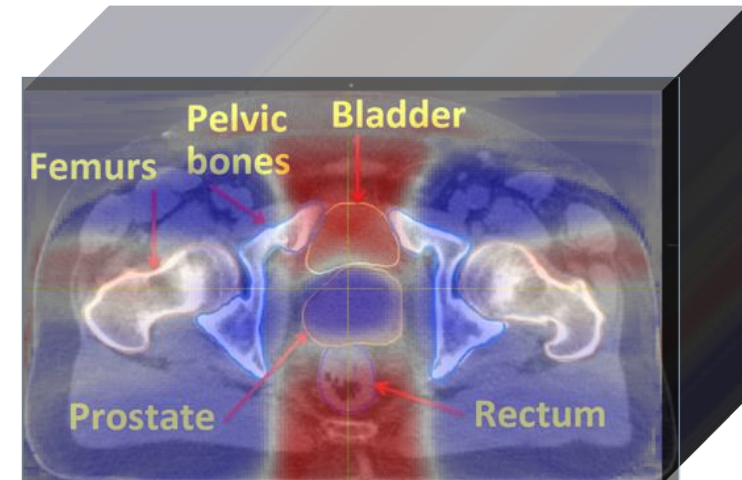
Local anatomy



$p < 0.01$ threshold dose-difference map



↑ 'Locally normalised'
dose-difference map



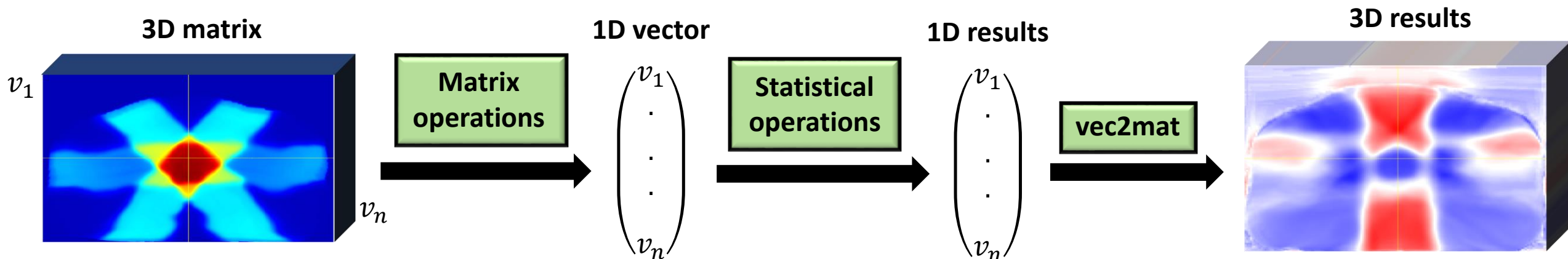
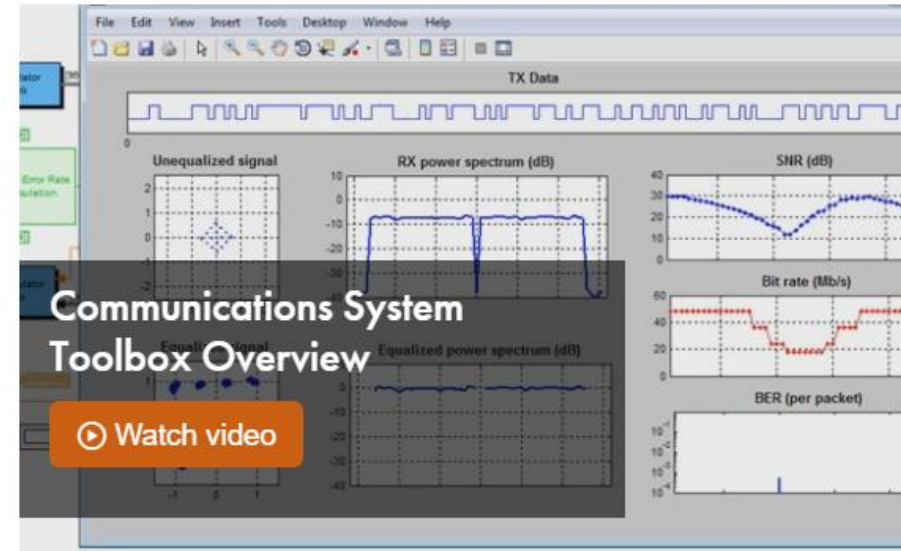
'Multiple comparisons'
dose-difference test

Aim 1: Locating Significant Regions

↳ Analysis: How did MATLAB help?

The **entire analysis** was performed on MATLAB

- ⇒ All dose distributions are 3D matrices
- ⇒ MATLAB's matrix manipulation was very helpful
- ⇒ Using the **'vec2mat'** function from the **Communications System Toolbox**



Aim 1: Locating Significant Regions

↳ Analysis: How did MATLAB help?

The analysis involved a lot of data crunching!

⇒ Each dose distribution is about **2.3 Mb**

⇒ The analysis includes over **680** distributions

Parallel Computing Toolbox allows running multiple core's at once

⇒ **Reduces processing time**, very helpful!

⇒ Especially '**for loops**', frequently used in code



Aim 2: Classification Modelling

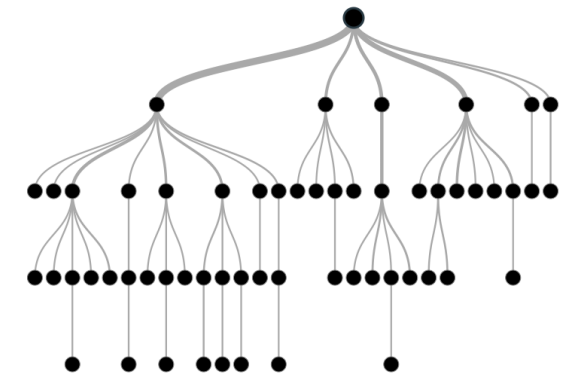
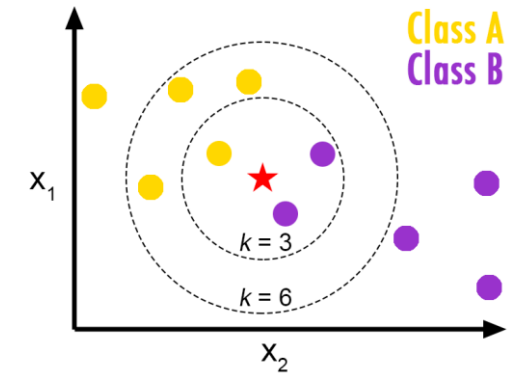
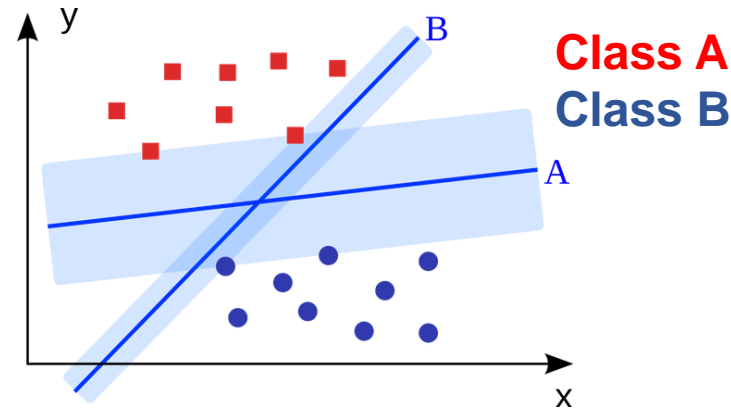
↳ What is 'machine learning' based classification?

A number of machine learning **algorithms** are used for classification:

⇒ K-nearest neighbour

⇒ Support vector machine

⇒ Decision tree

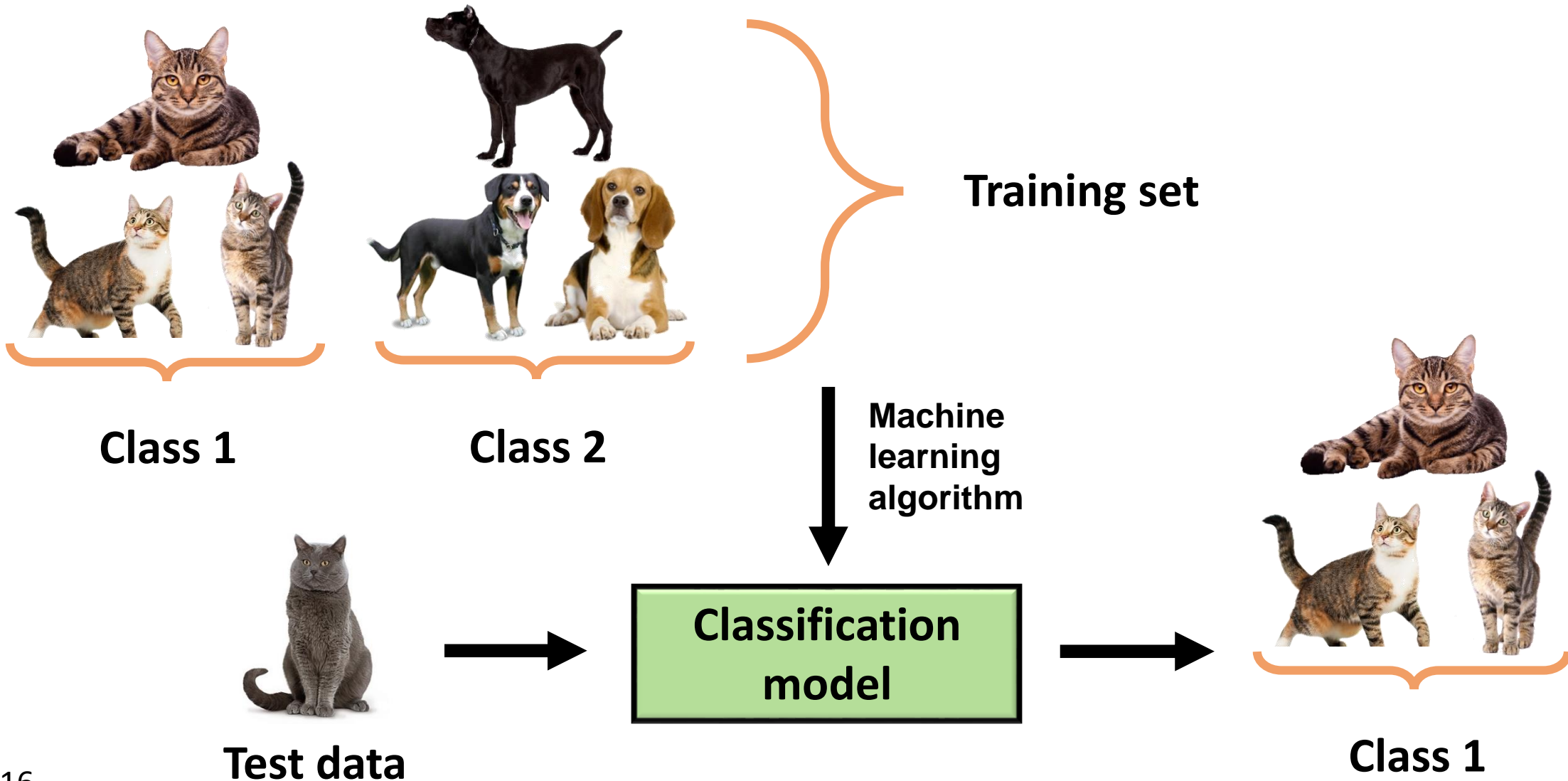


Two major steps:

- 1) Use an algorithm to **'train'** a model using a data set made up of **classes** (subgroups).
- 2) **Classifying** external data into a **class** of the training set.

Aim 2: Classification Modelling

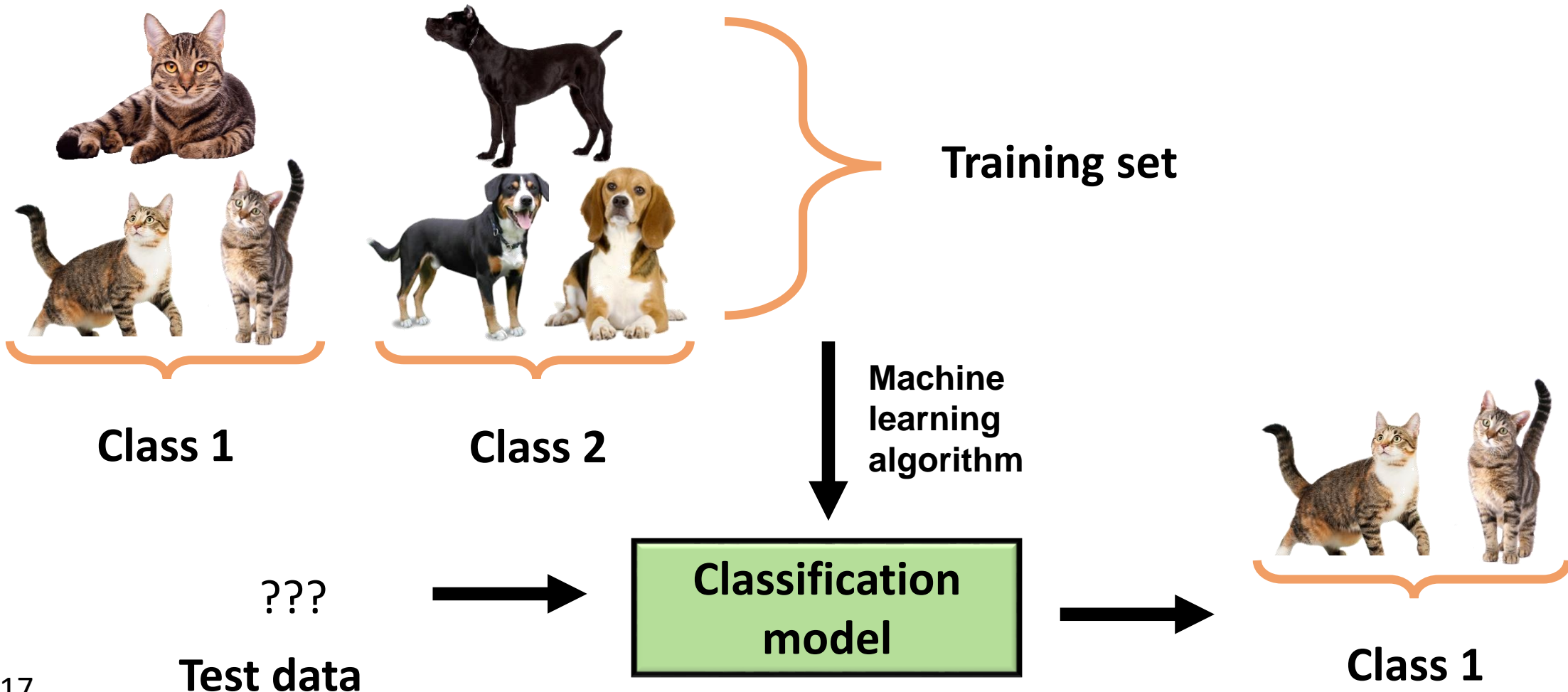
↳ What is 'machine learning' based classification?



Aim 2: Classification Modelling

↳ What is 'machine learning' based classification?

How do we test our model without test data? Can use **cross-validation**...



Aim 2: Classification Modelling

↳ What is 'machine learning' based classification?

Testing the model...

Three basic **statistics** help us **test** the model's **per**

Accuracy:

$$Acc = \frac{\# \text{ correctly classified}}{\text{total number}}$$

E.g. 10 cats, 10 dogs
7 cats and 9 dogs
correctly classified

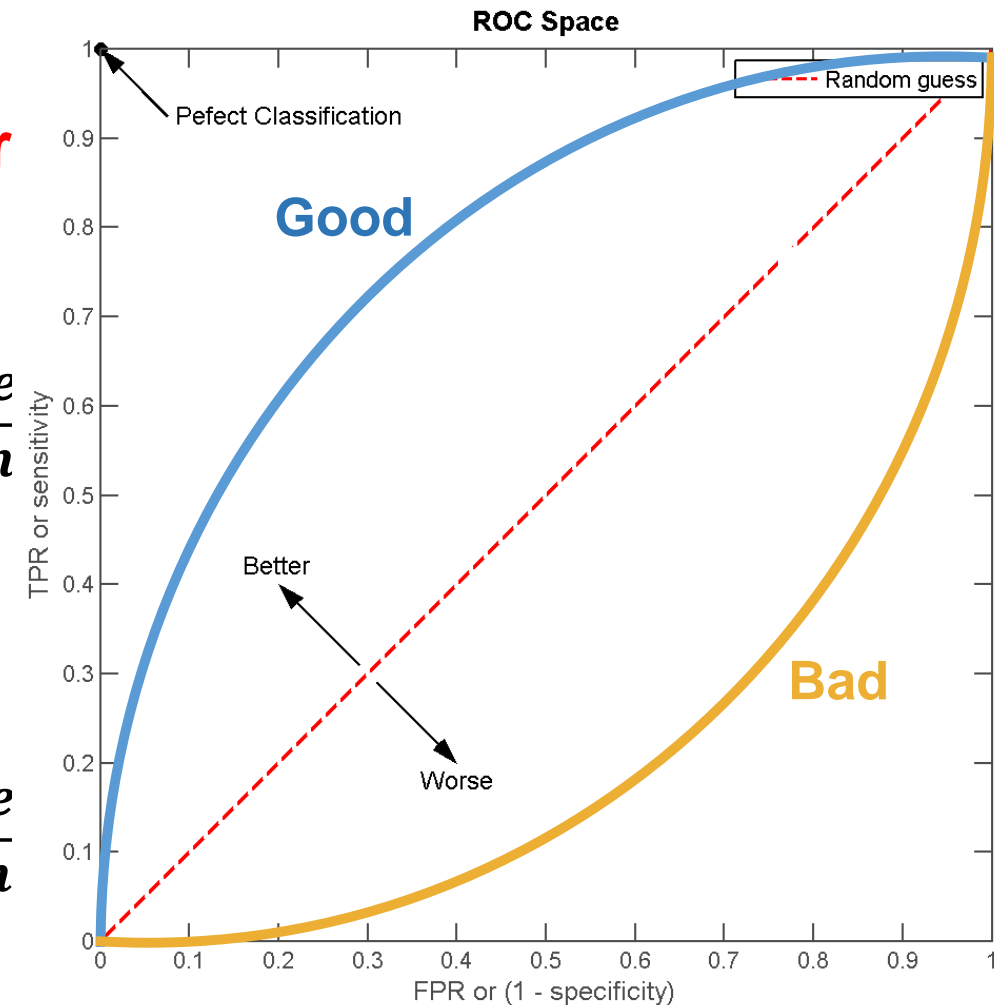
$$\Rightarrow Acc = \frac{7+9}{20} = 80\%$$

Sensitivity:

$$Sen = \frac{\# \text{ correctly classified}}{\text{total number in}}$$
$$\Rightarrow Sen = \frac{9}{10} = 90\%$$

Specificity:

$$Spe = \frac{\# \text{ correctly classified}}{\text{total number in}}$$
$$\Rightarrow Spe = \frac{7}{10} = 70\%$$

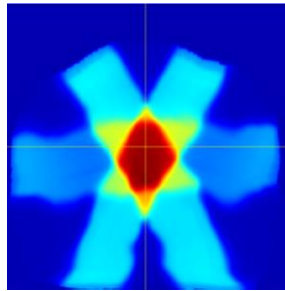


Aim 2: Classification Modelling

↳ Live demo example

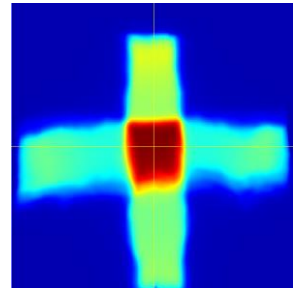
E.g. Classifying RADAR data according to **number of beams**:

Not 4 beams



X 273

4 beams



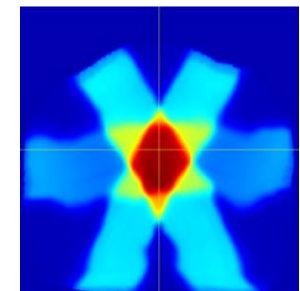
X 367

Training set

Machine
learning
algorithm

Classification
model

Not 4 beams



X 273

Class 1

'15-fold'
cross
validation

Aim 2: Classification Modelling

↳ Benefits of the MATLAB Classification Learner App

Benefits:

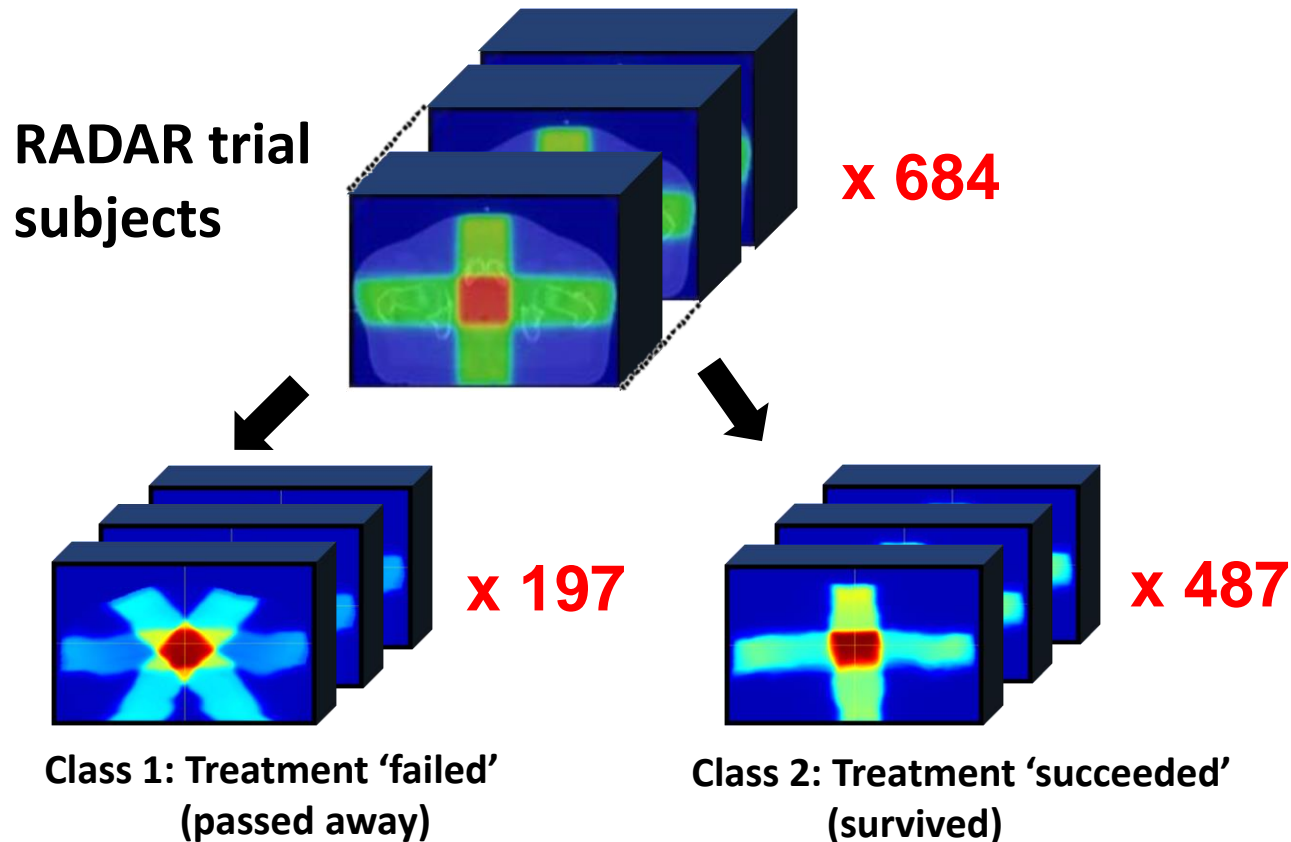
- ⇒ Running **multiple** machine learning algorithms simultaneously is extremely powerful
- ⇒ Implement **cross validation** easily
- ⇒ Activate **PCA** easily
- ⇒ Generate **performance statistics** easily



Aim 2: Classification Modelling

↳ Classification to predict failure

Goal: to build a model capable of predicting treatment failure in a patient based on their planned dose distribution



Aim 2: Classification Modelling

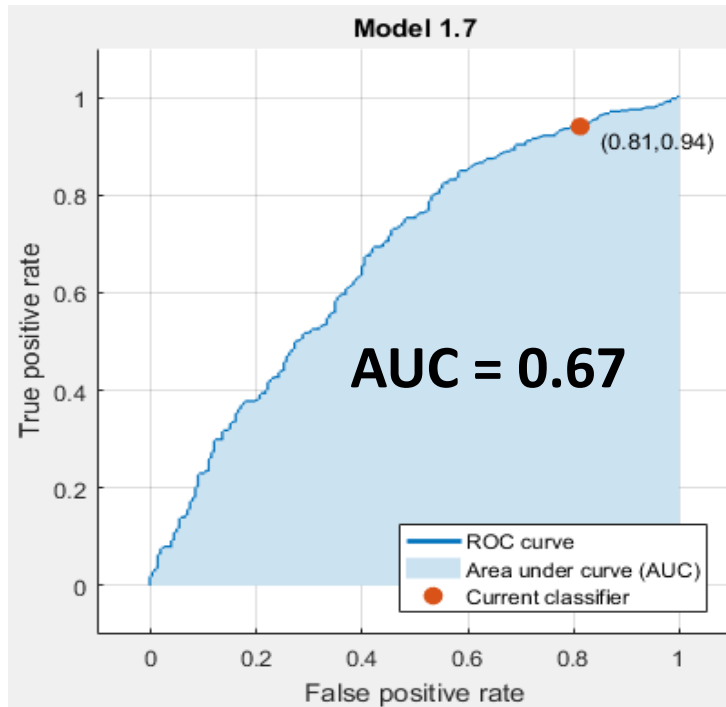
↳ Classification results

⇒ Classified the two groups:

- **197** died within 6.5 years
- **487** death free

⇒ **1 in 8** sampled data

⇒ **15-fold** cross validation



1.1	☆ Tree	Accuracy: 68.4%
Last change: Complex Tree		10752/10752 features
1.2	☆ Tree	Accuracy: 70.8%
Last change: Medium Tree		10752/10752 features
1.3	☆ Tree	Accuracy: 71.9%
Last change: Simple Tree		10752/10752 features
1.4	☆ Linear Discriminant	Accuracy: 67.4%
Last change: Linear Discriminant		10752/10752 features
1.5	☆ Quadratic Discriminant	Accuracy: 67.4%
Last change: Quadratic Discriminant		10752/10752 features
1.6	☆ Logistic Regression	Accuracy: 48.4%
Last change: Logistic Regression		10752/10752 features
1.7	☆ SVM	Accuracy: 72.4%
Last change: Linear SVM		10752/10752 features
1.8	☆ SVM	Accuracy: 70.5%
Last change: Quadratic SVM		10752/10752 features
1.9	☆ SVM	Accuracy: 69.2%
Last change: Cubic SVM		10752/10752 features
1.10	☆ SVM	Accuracy: 70.6%
Last change: Fine Gaussian SVM		10752/10752 features
1.11	☆ SVM	Accuracy: 72.4%
Last change: Medium Gaussian SVM		10752/10752 features
1.12	☆ SVM	Accuracy: 71.1%
Last change: Coarse Gaussian SVM		10752/10752 features

1.13	☆ KNN	Accuracy: 65.8%
Last change: Fine KNN		10752/10752 features
1.14	☆ KNN	Accuracy: 71.3%
Last change: Medium KNN		10752/10752 features
1.15	☆ KNN	Accuracy: 71.9%
Last change: Coarse KNN		10752/10752 features
1.16	☆ KNN	Accuracy: 71.1%
Last change: Cosine KNN		10752/10752 features
1.17	☆ KNN	Accuracy: 69.7%
Last change: Cubic KNN		10752/10752 features
1.18	☆ KNN	Accuracy: 70.5%
Last change: Weighted KNN		10752/10752 features
1.19	☆ Ensemble	Accuracy: 70.0%
Last change: Boosted Trees		10752/10752 features
1.20	☆ Ensemble	Accuracy: 72.1%
Last change: Bagged Trees		10752/10752 features
1.21	☆ Ensemble	Accuracy: 60.5%
Last change: Subspace Discriminant		10752/10752 features
1.22	☆ Ensemble	Accuracy: 63.9%
Last change: Subspace KNN		10752/10752 features
1.23	☆ Ensemble	Accuracy: 66.5%
Last change: RUSBoosted Trees		10752/10752 features

Potential Impact of Research

↳ How can these MATLAB based analyses impact radiotherapy?

Impact of these analyses:

1) Identifying **anatomical regions** prone to **under-dosing** is helpful because:

⇒ Valuable for clinicians identifying the **optimal treatment region**

⇒ It helps determine **where** and **why** the **treatment is failing**

⇒ Correcting this can directly **improve patient outcomes!**

2) A robust model capable of **predicting treatment failure** is helpful because:

⇒ It can help us determine particular **geometric dose patterns** associated with treatment failure

⇒ Predicting treatment failure before treatment can indicate need for **replanning and improvement**

Questions...

