Silesian University of Technology

RESEARCH UNIVERSITY
EXCELLENCE INITIATIVE
Ministry of Science and Higher Education

APPLICATIONS OF AI IN MEDICINE

Achievements of

The Silesian University of Technology

Artificial Intelligence and Machine Learning for diagnostic and prognostic applications

Scope:

- **Large Scale Data processing**
  - **Classification, data clustering**
  - **Feature selection and diagnostic tests design (patent awarded)**
- **Neural Networks For Data Mining**
- **Deep learning in biomedicine**
- **Biological and medical data analysis**

Projects:

MILESTONE

Molecular diagnostics and imaging in individualized therapy for breast, thyroid and prostate cancer

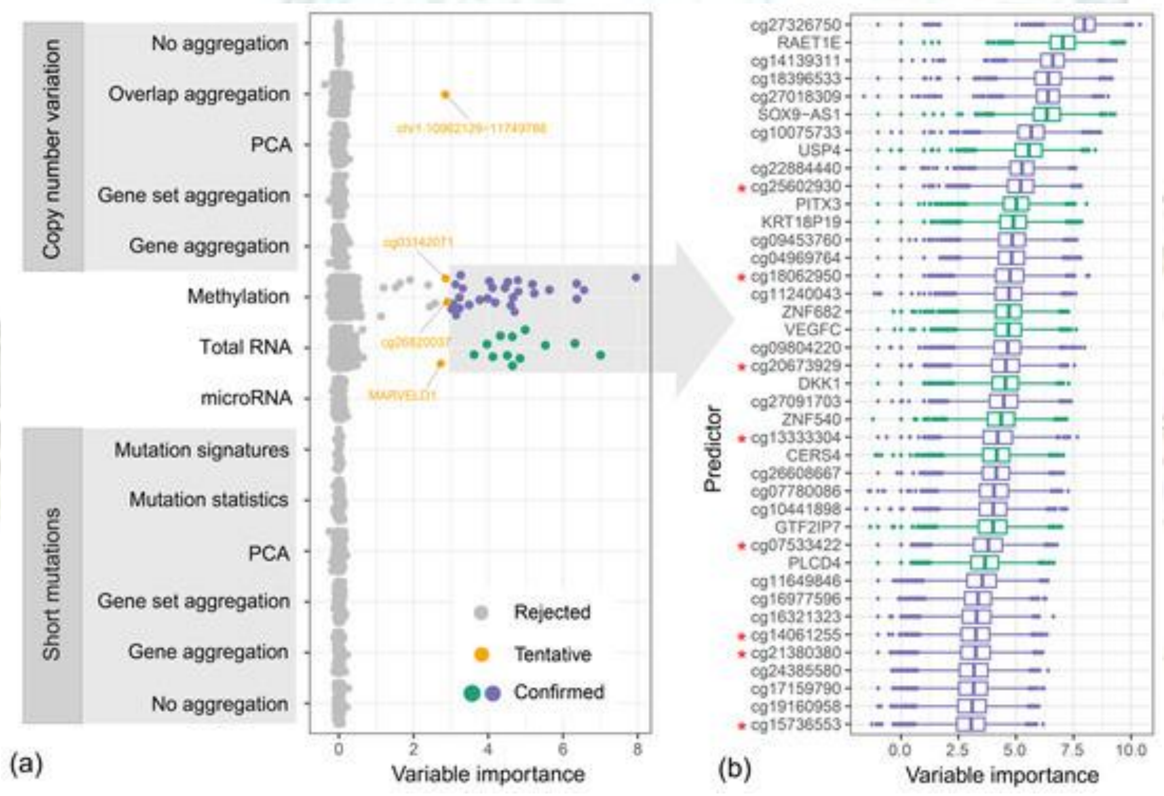
BioTest

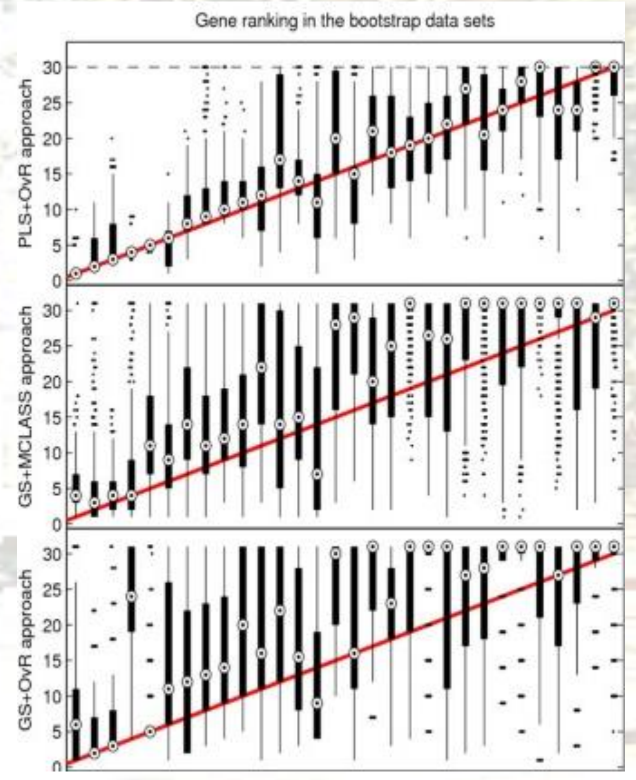
syscancer

Integrated informatics system for the support of cancer research of environmental origin

CoMPASS-NMD

Computational Models for new Patients Stratification Strategies of Neuromuscular Disorders

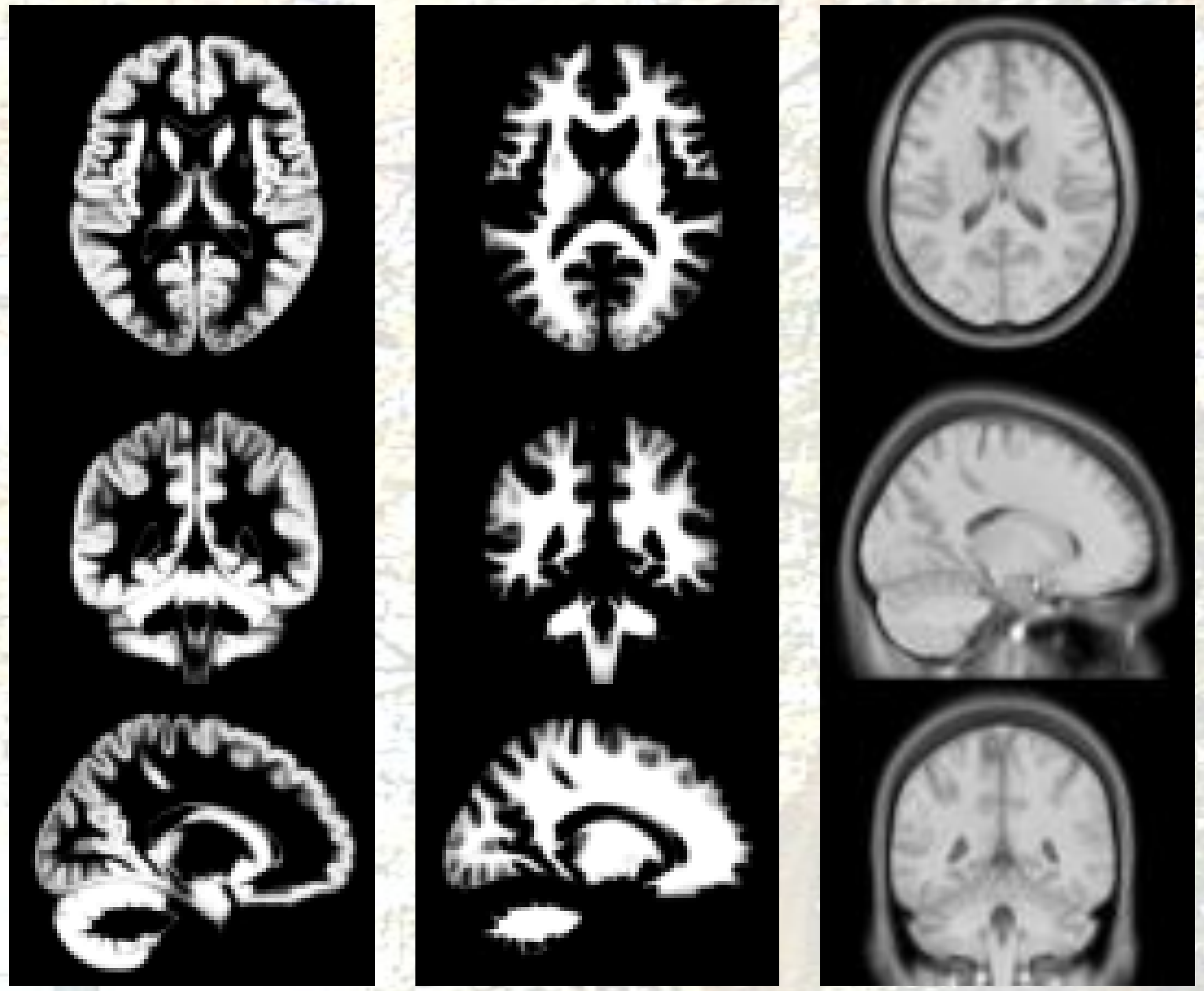




AI-supported medical image analysis

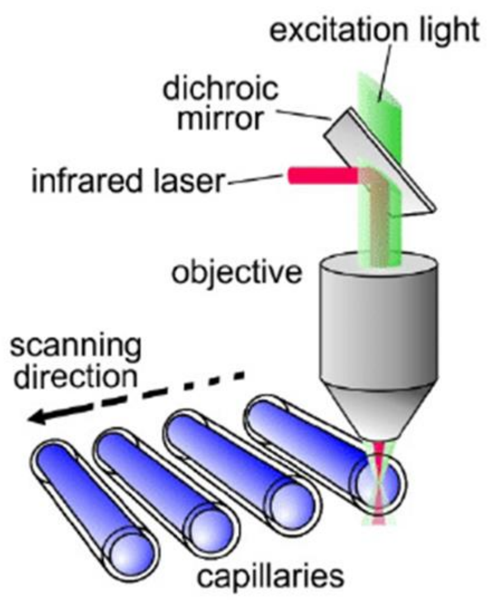
Scope:

- Multimodal image processing: MRI, CT, PET, ultrasound, angiography (MRA, CTA), dermatoscopy - including: image registration, fusion, segmentation, transformation
- Radiomics feature extraction for cancer diagnostics

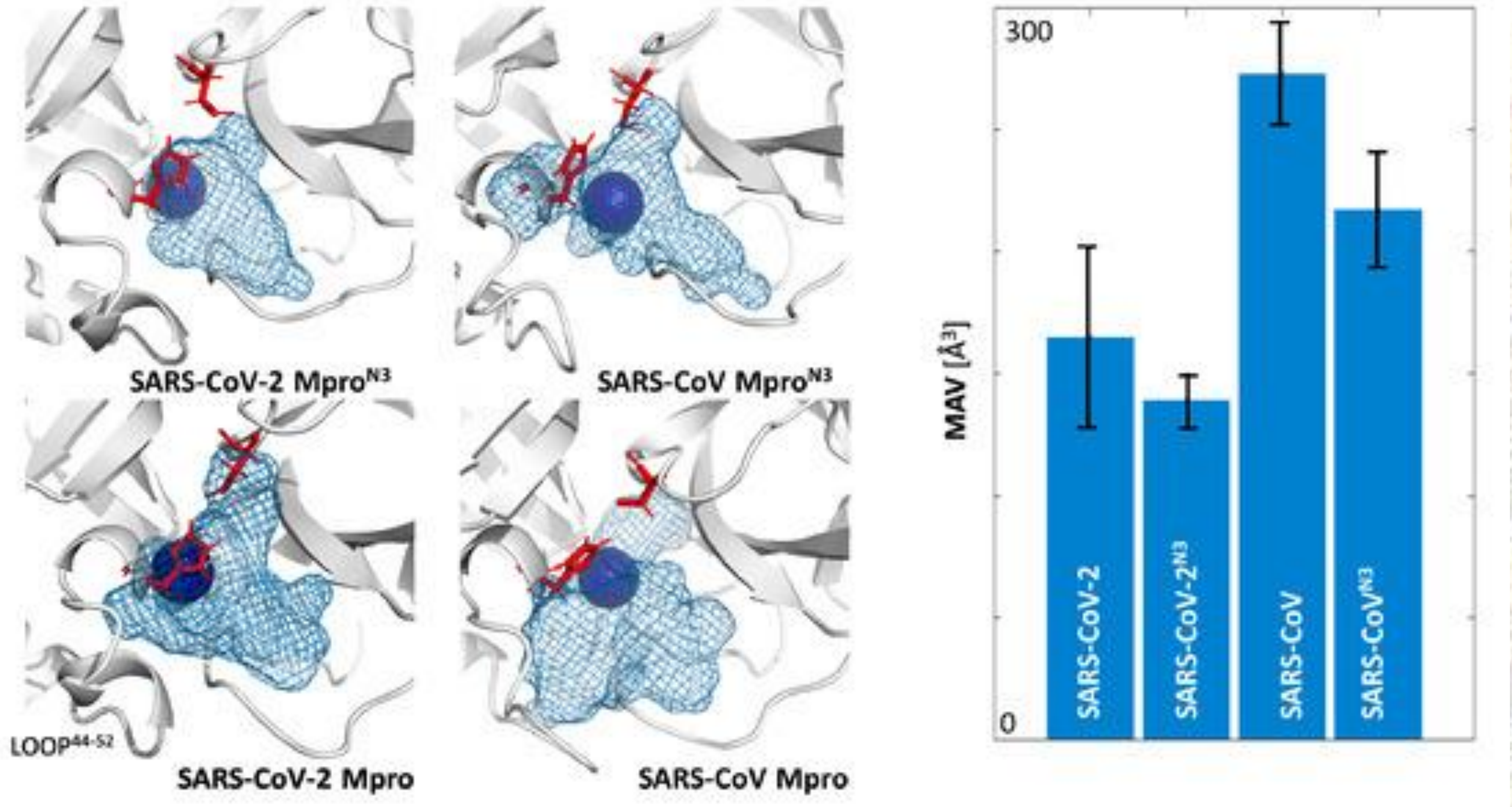


SARS-CoV2 and MST

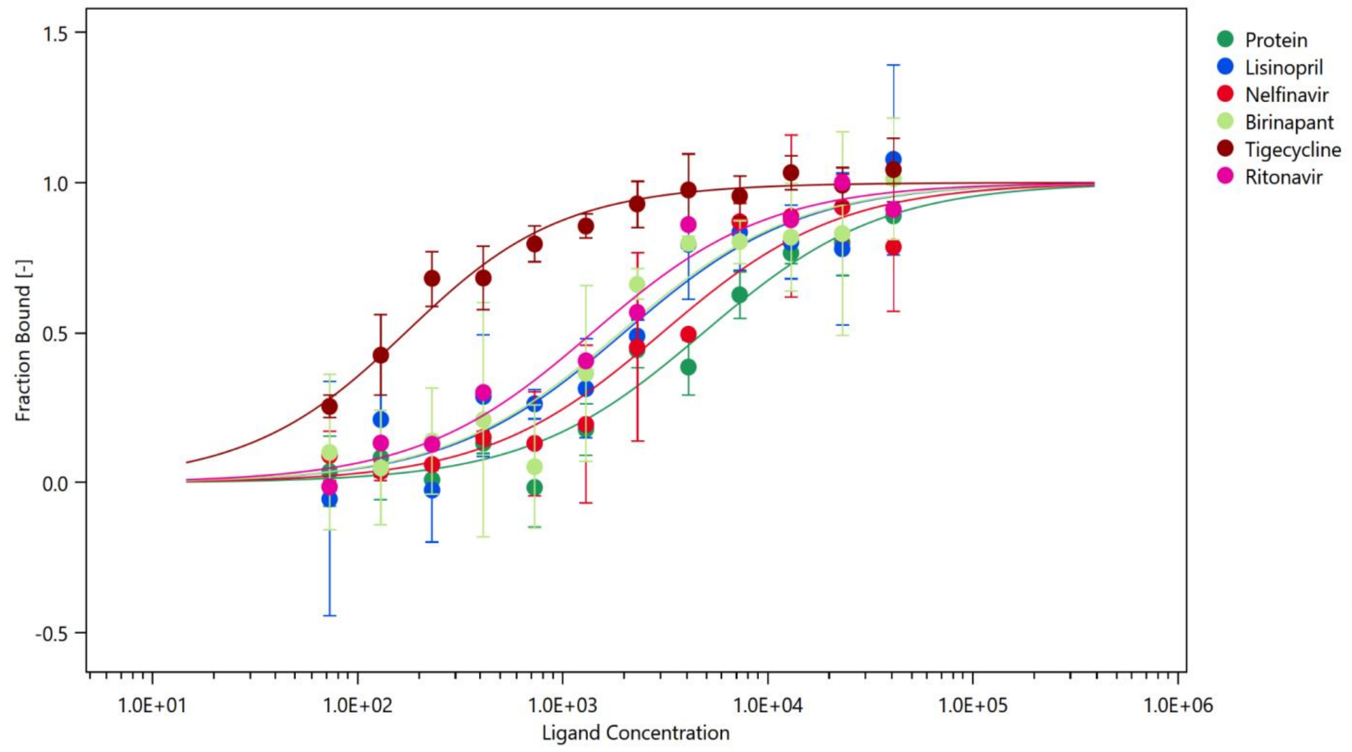
Monolith NT.Automated



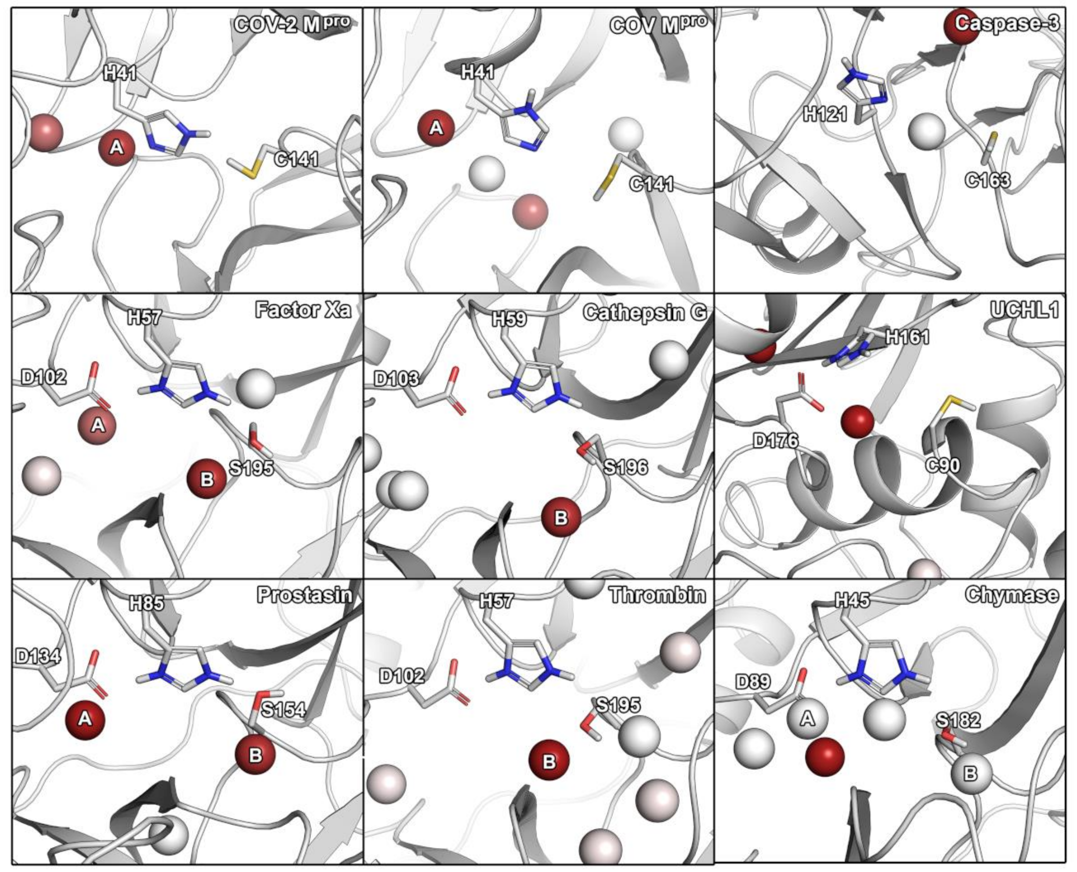
Schematic representation of MST optics

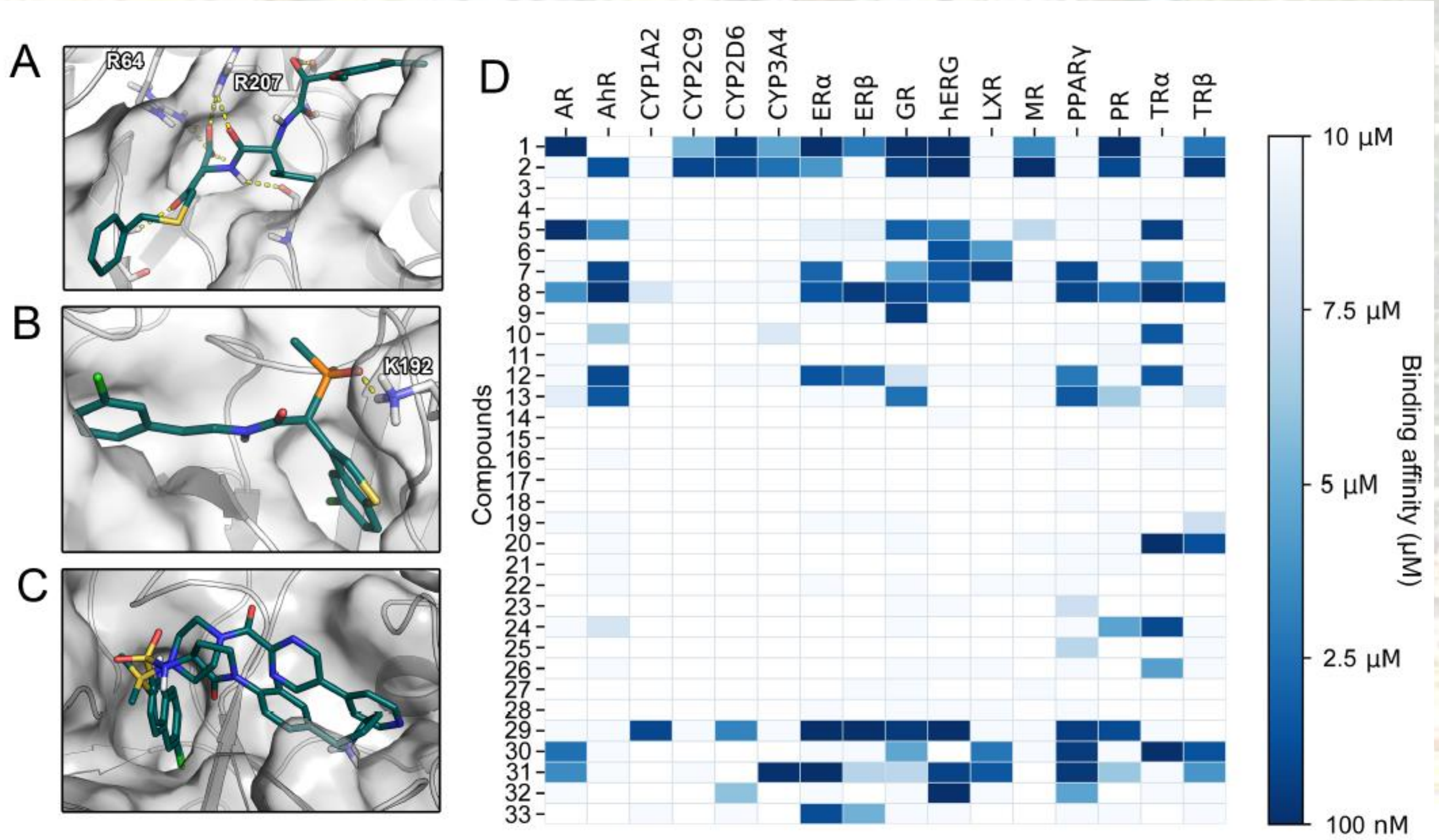


Analysis of the binding site’s conformational changes. Indication of pocket’s flexibility and plasticity, which may dash hopes for rapid and reliable drug design.



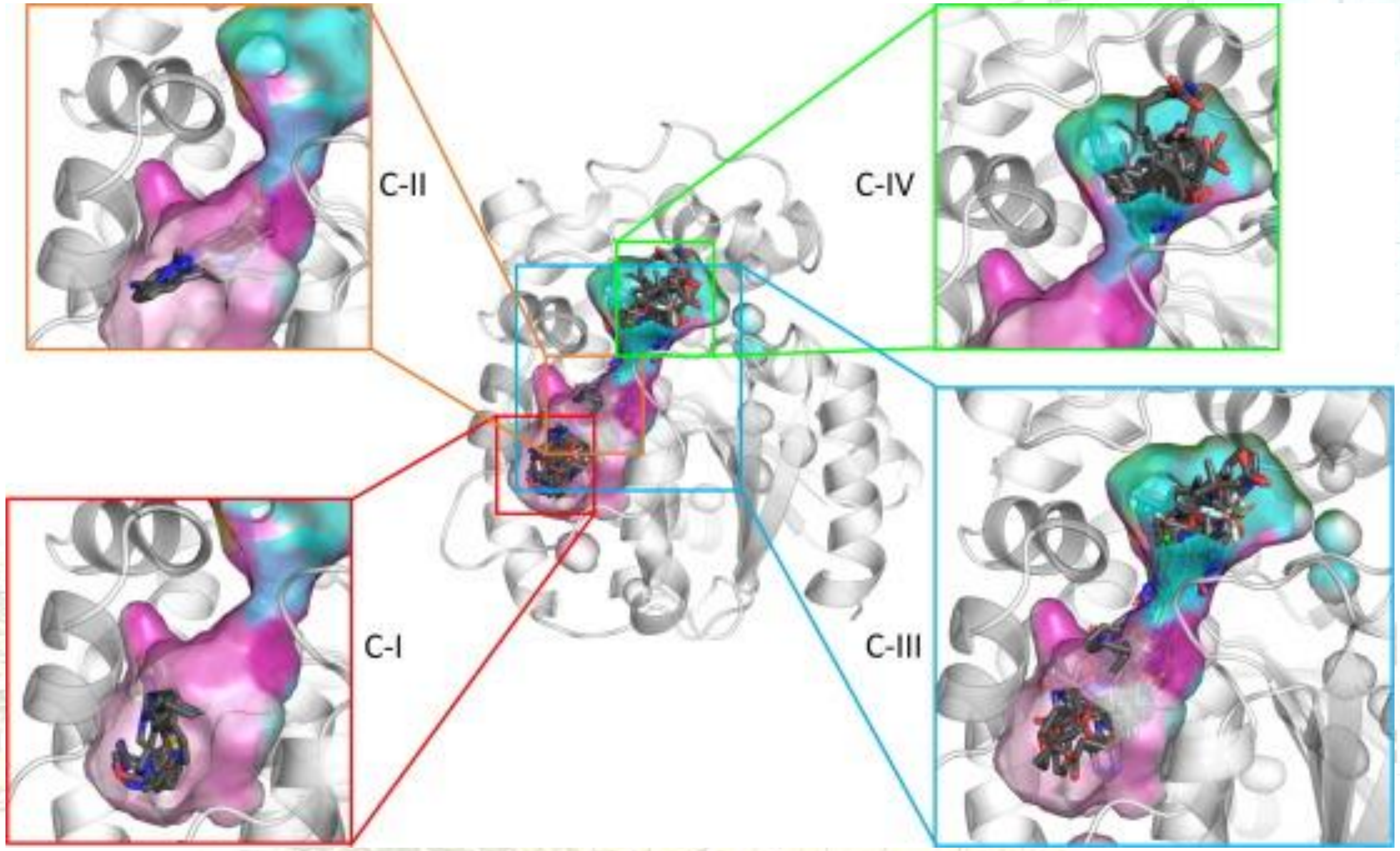
The comparison of the curves of the dimerization process of the SARS-CoV-2 M^{pro}: native process (dark green curve) and process influenced by tested compounds.

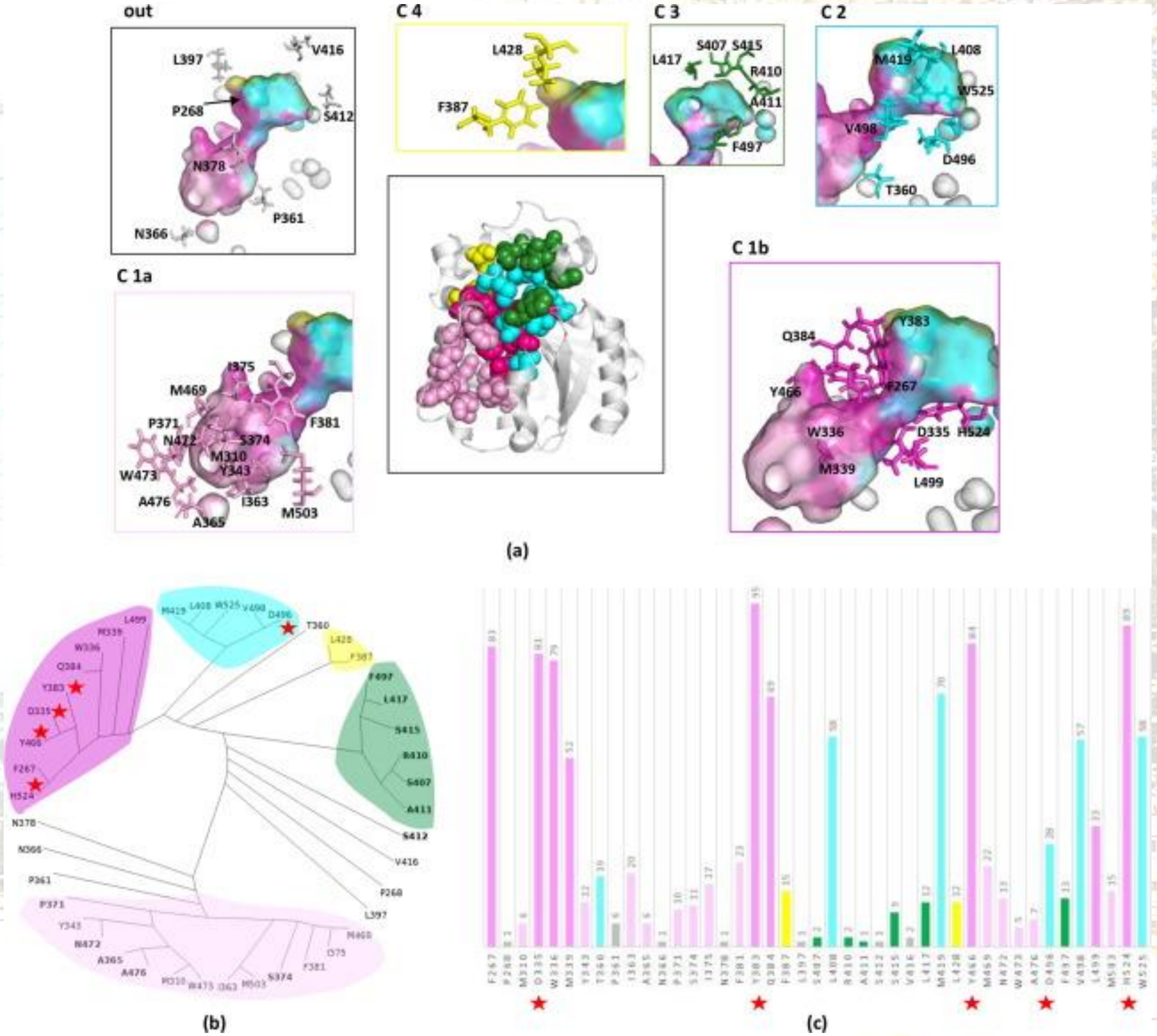




Characterisation and comparison of hydration and small–molecule hotspots in selected proteases. Potential problem: high risk of off-target binding.

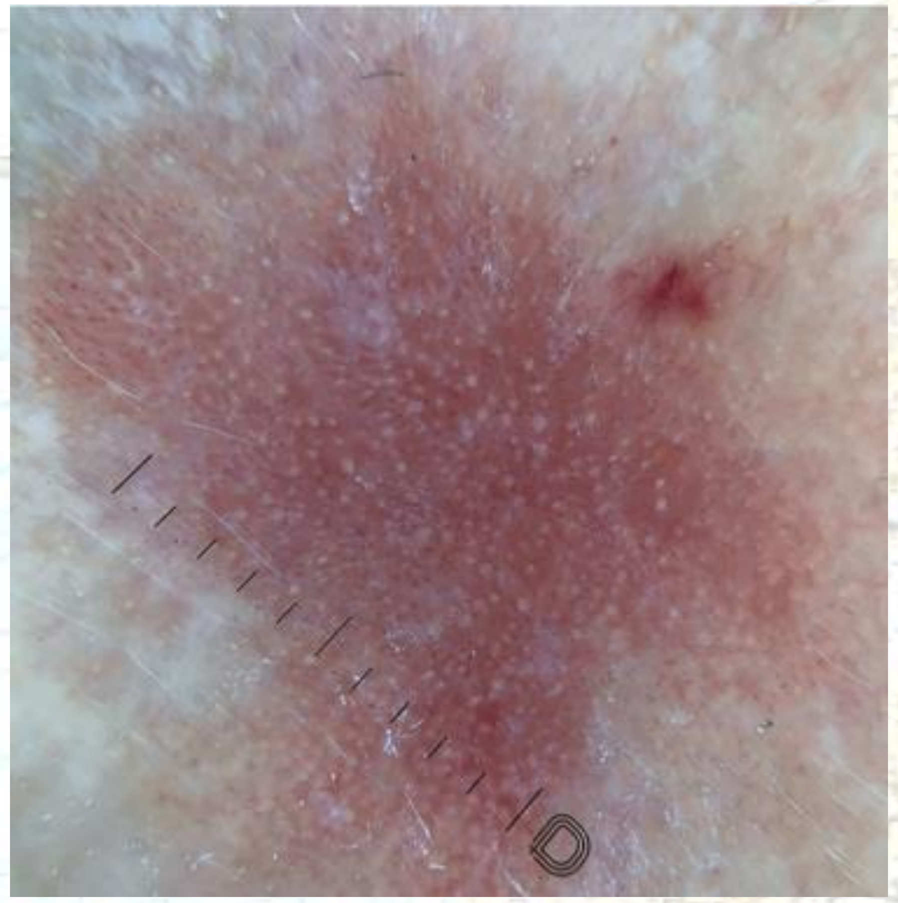
Drug Design: hsEH inhibitors

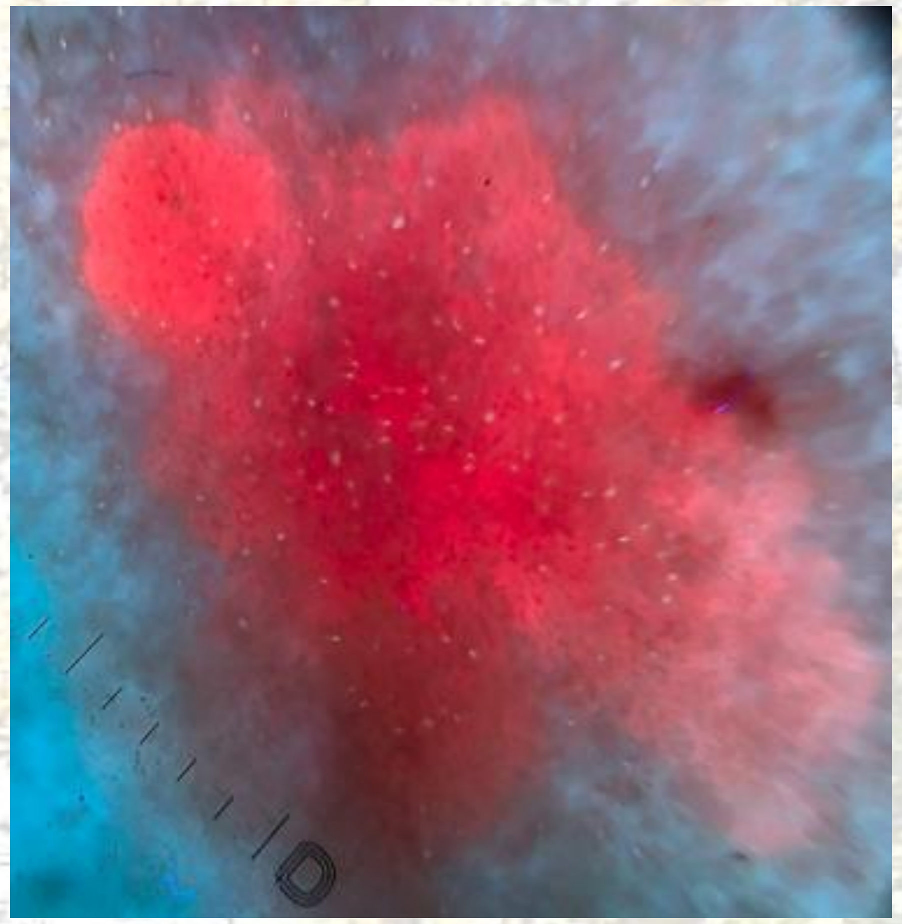


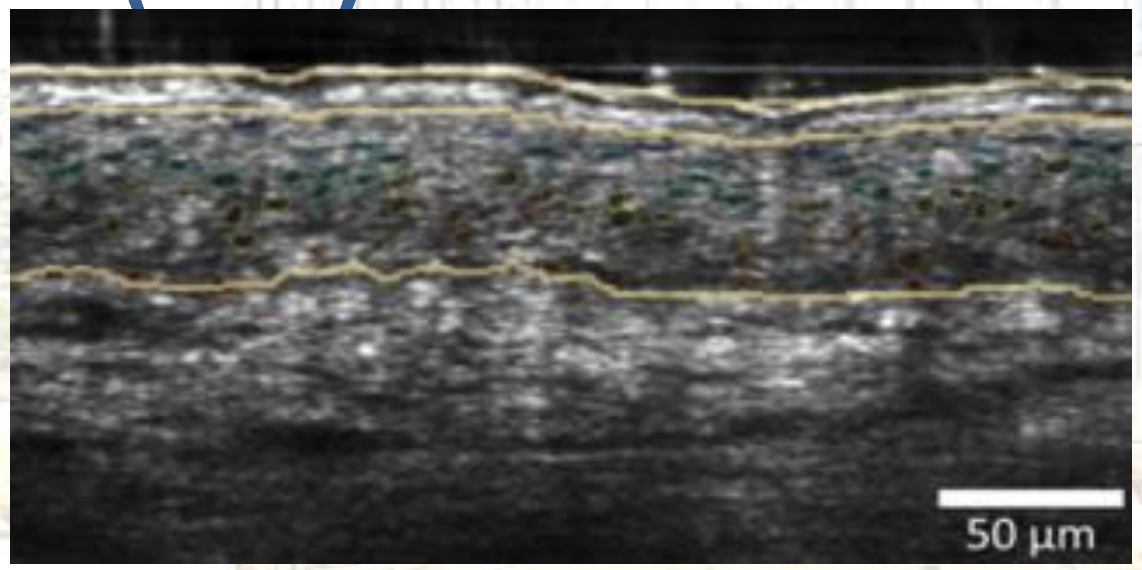


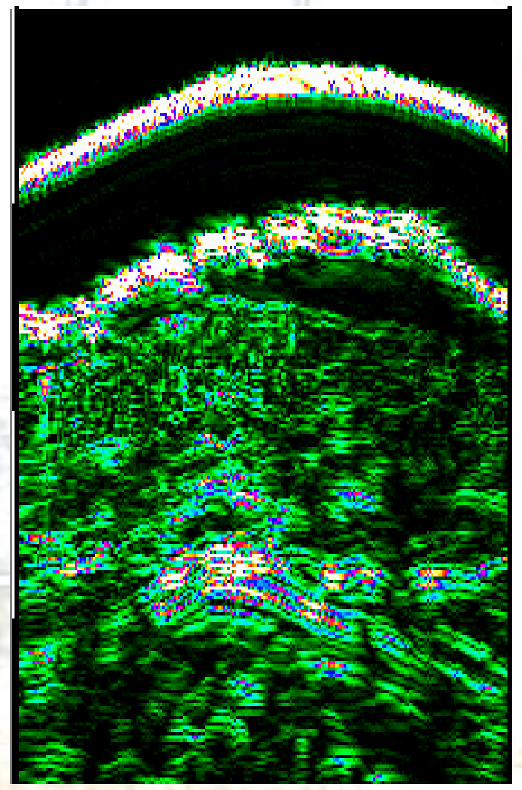
Application of artificial intelligence (AI) in dermatology

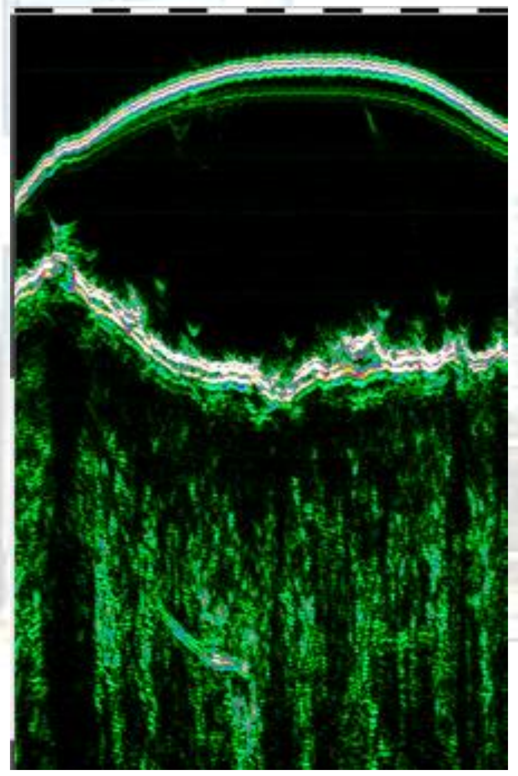
Development in imaging techniques:
- Clinical imaging
- Dermatoscopy
- Dermatoscopy with polarized light (UVFD)
- High-frequency ultrasound (HFUS)
- Optical coherence tomography (OCT)







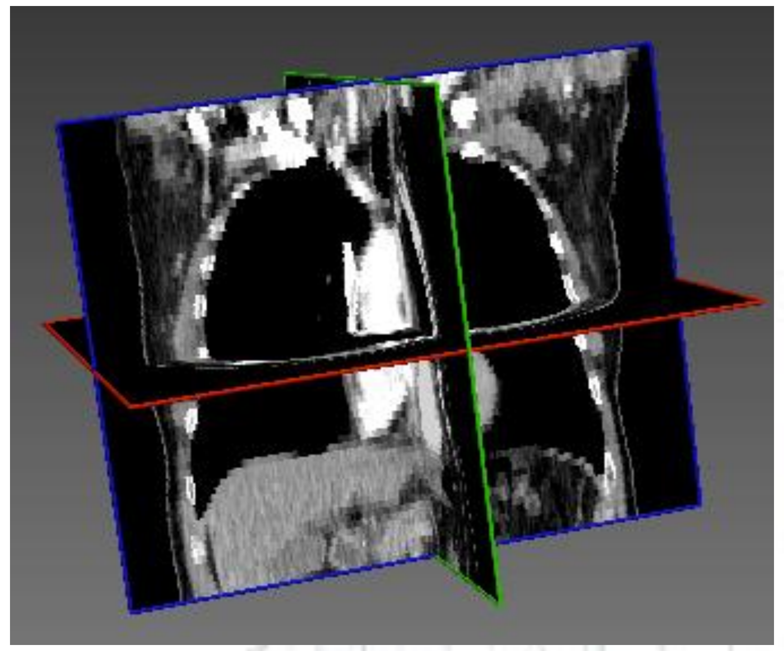
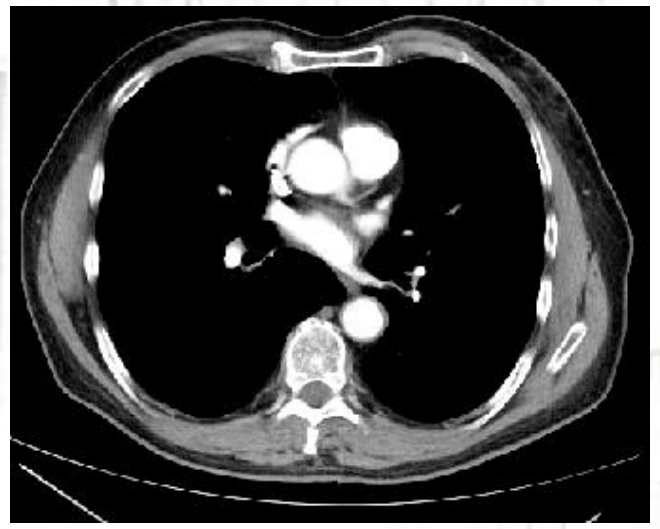




Applications:
- Determining the severity of the lesion
- Monitoring the progress of therapy

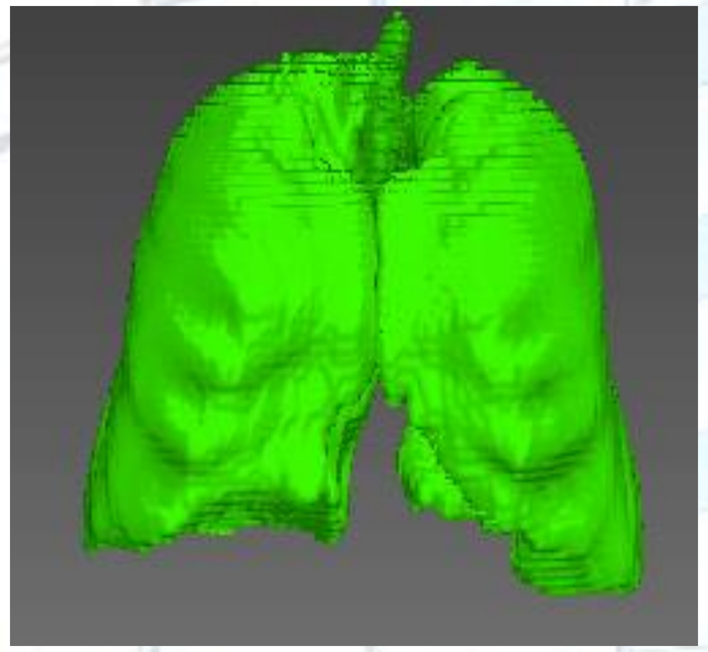
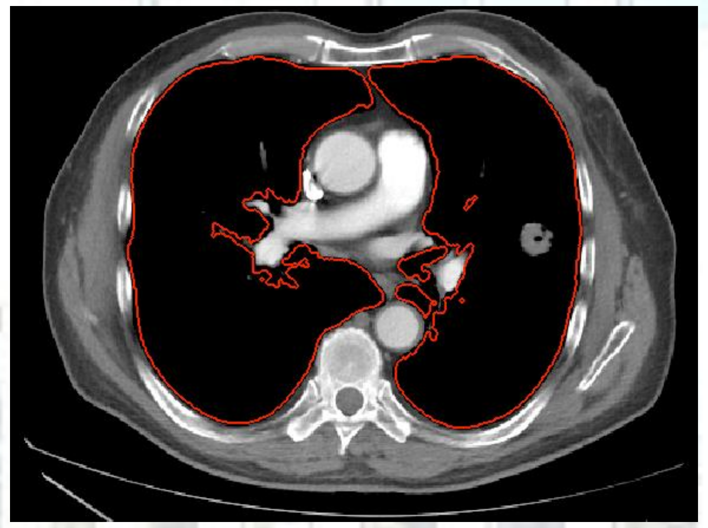
Public databases:
- Clinical images: DermNet
- Dermatoscopic images: ISIC, HAM10000, BCN20000
- HFUS: DOI 10.17632/5p7fxjt7vs.1

CARLOTA - Automatic detection of early stage lung cancer in LDCT

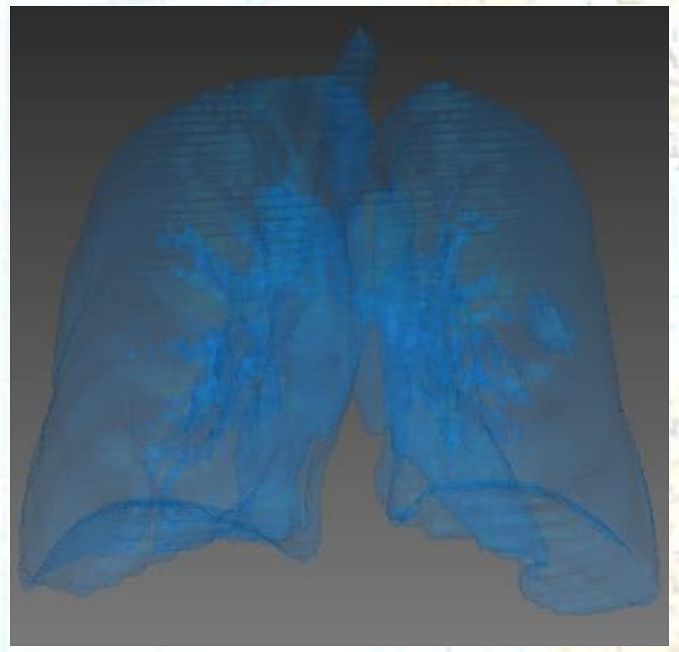
CT scans

Step I

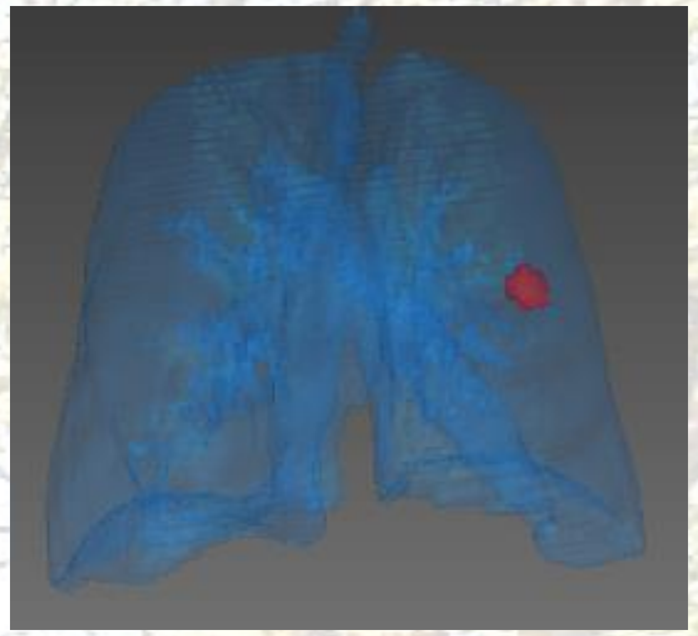
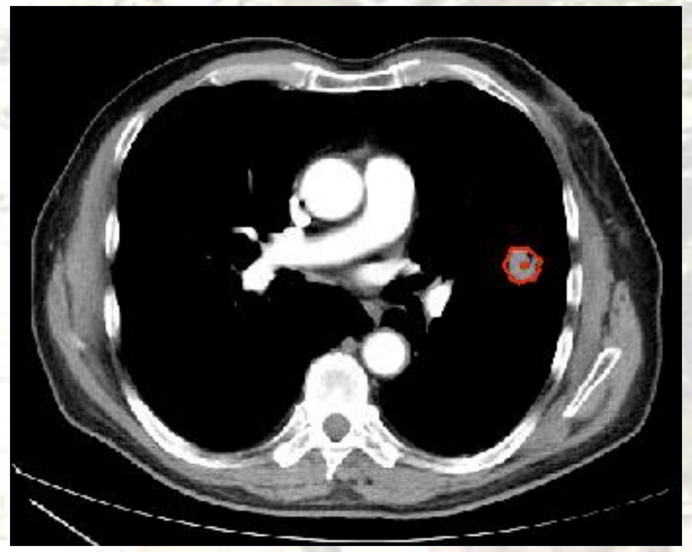
ROI detection

Step II




Modelling of the bronchial tree

Step III

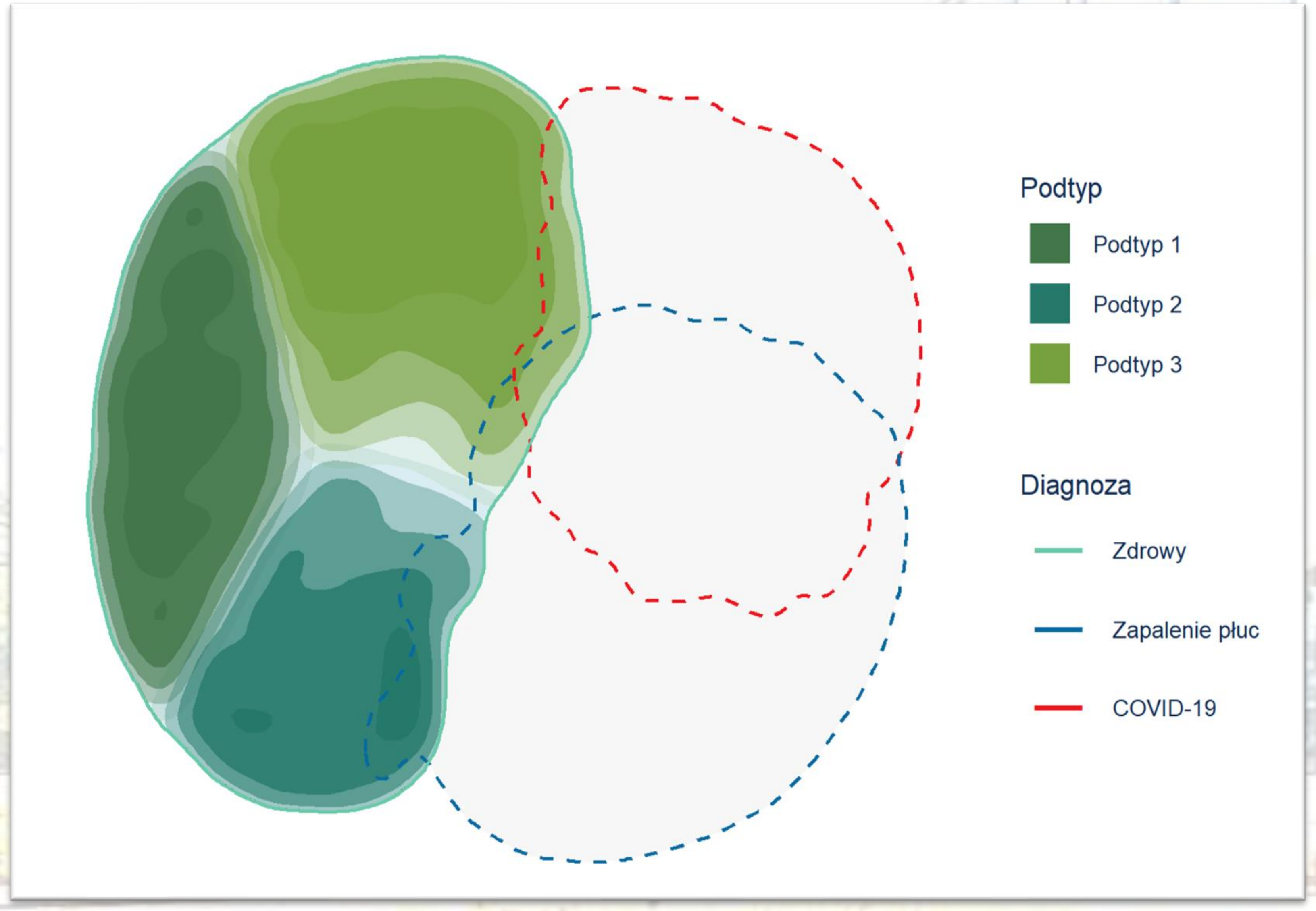



Lesion segmentation and classification

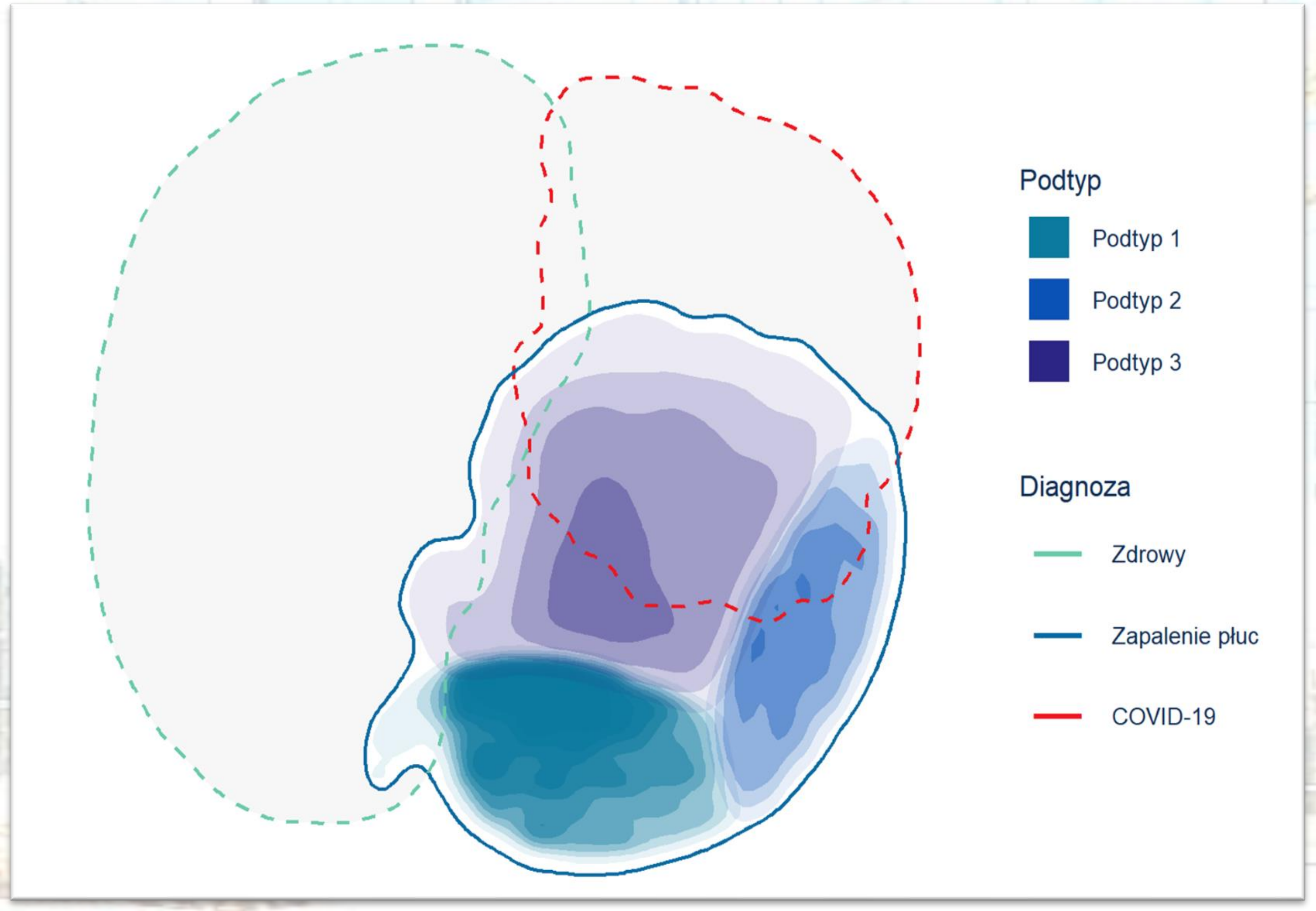
CIRCA – AI-supported of image-based COVID-19 diagnosis

Data heterogeneity – subpopulation definitions

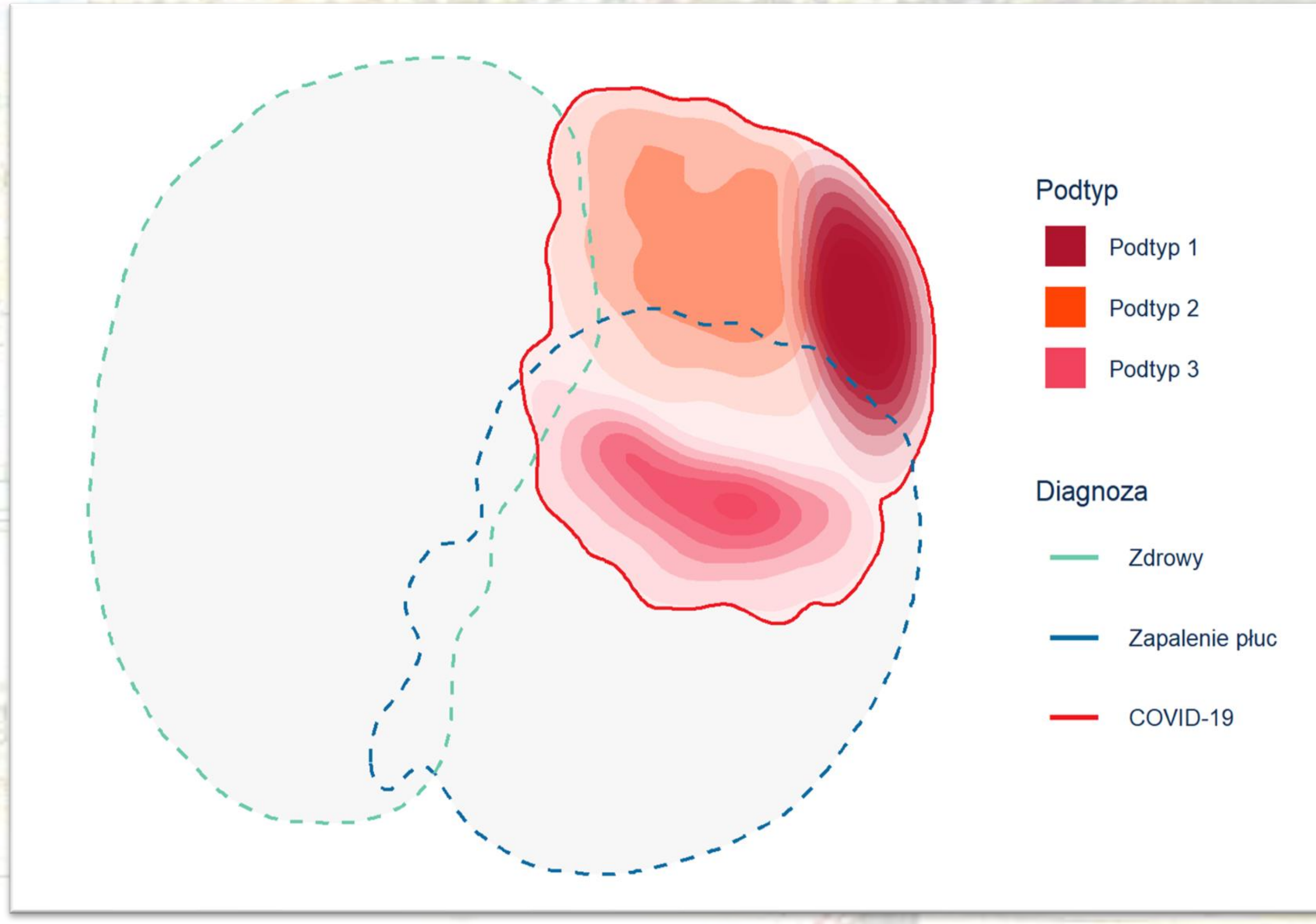
Healthy



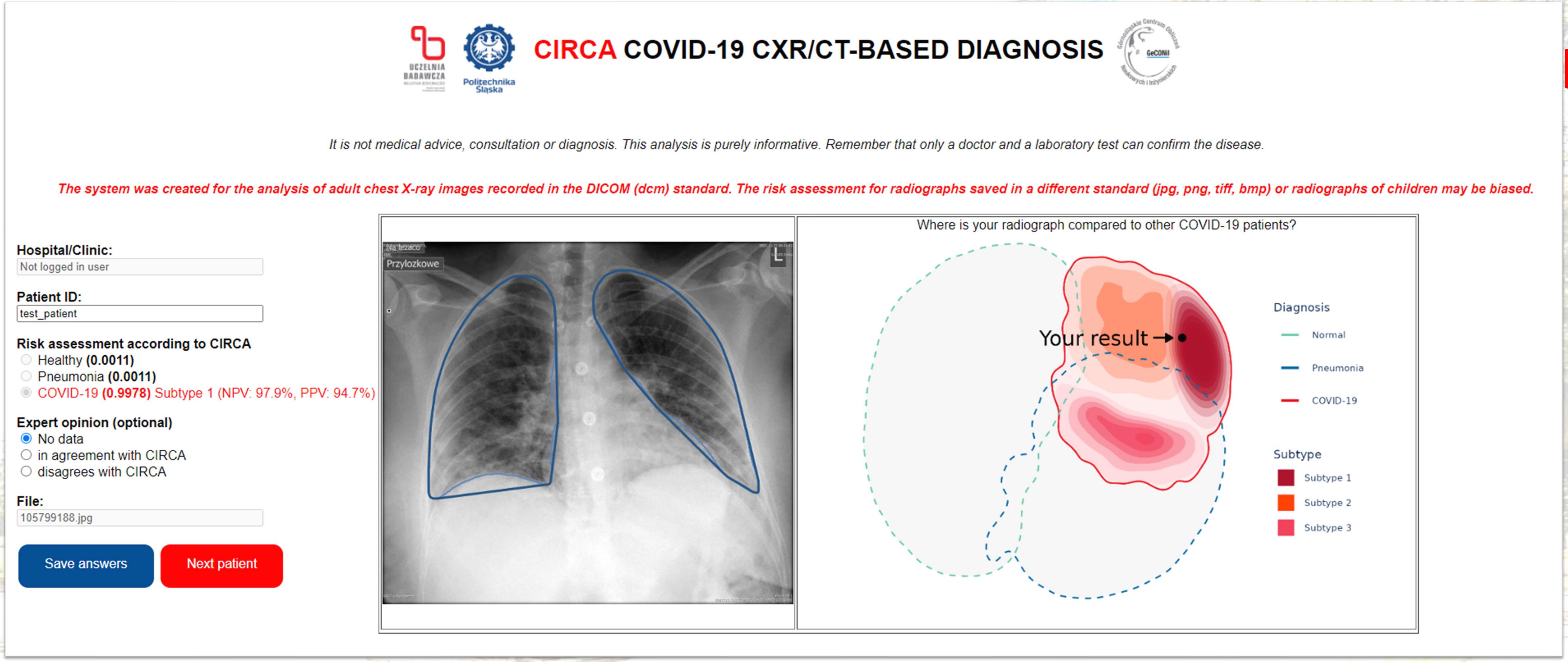
Other lung diseases



COVID-19



CIRCA – AI-supported of image-based COVID-19 diagnosis



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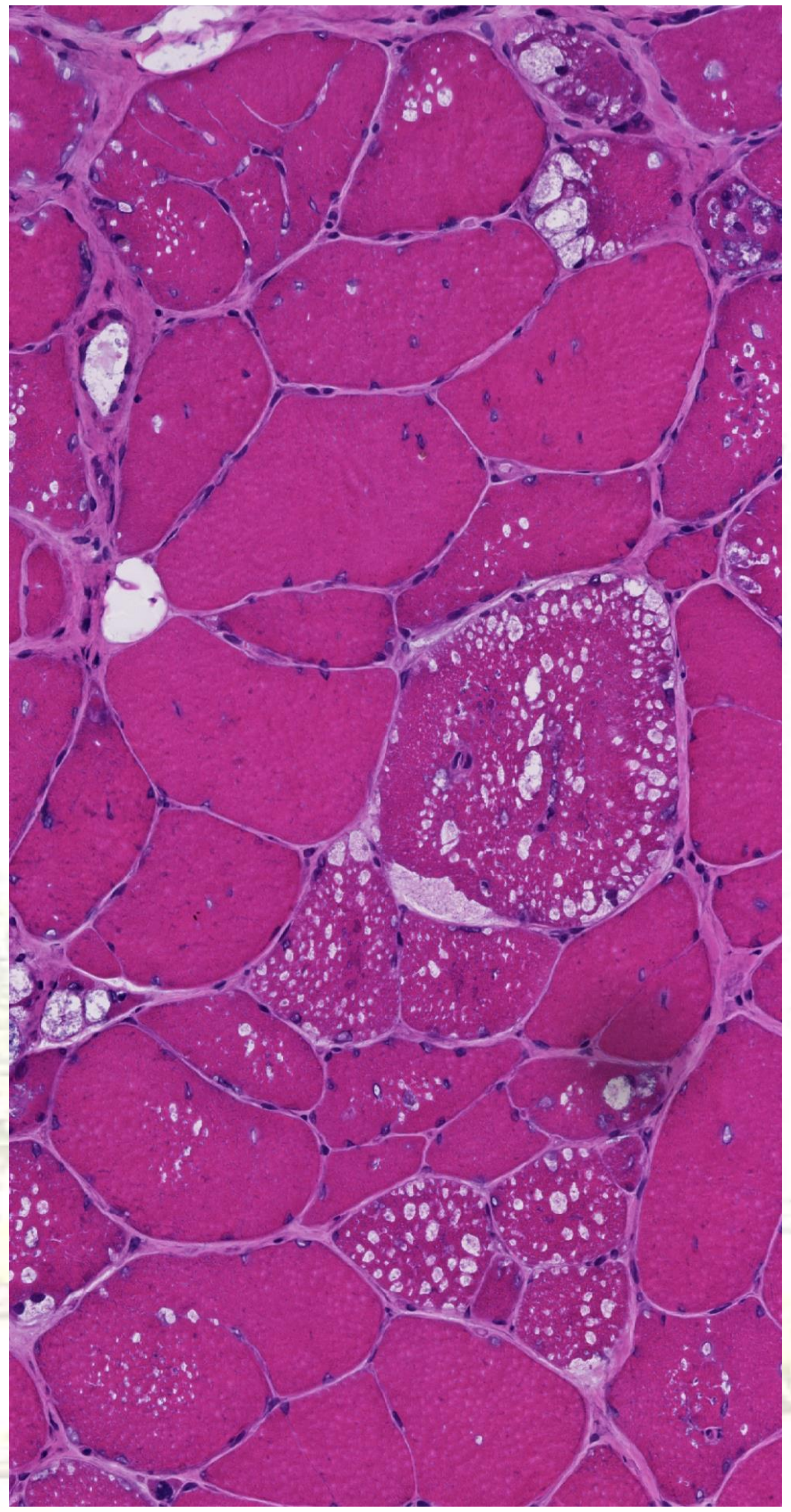
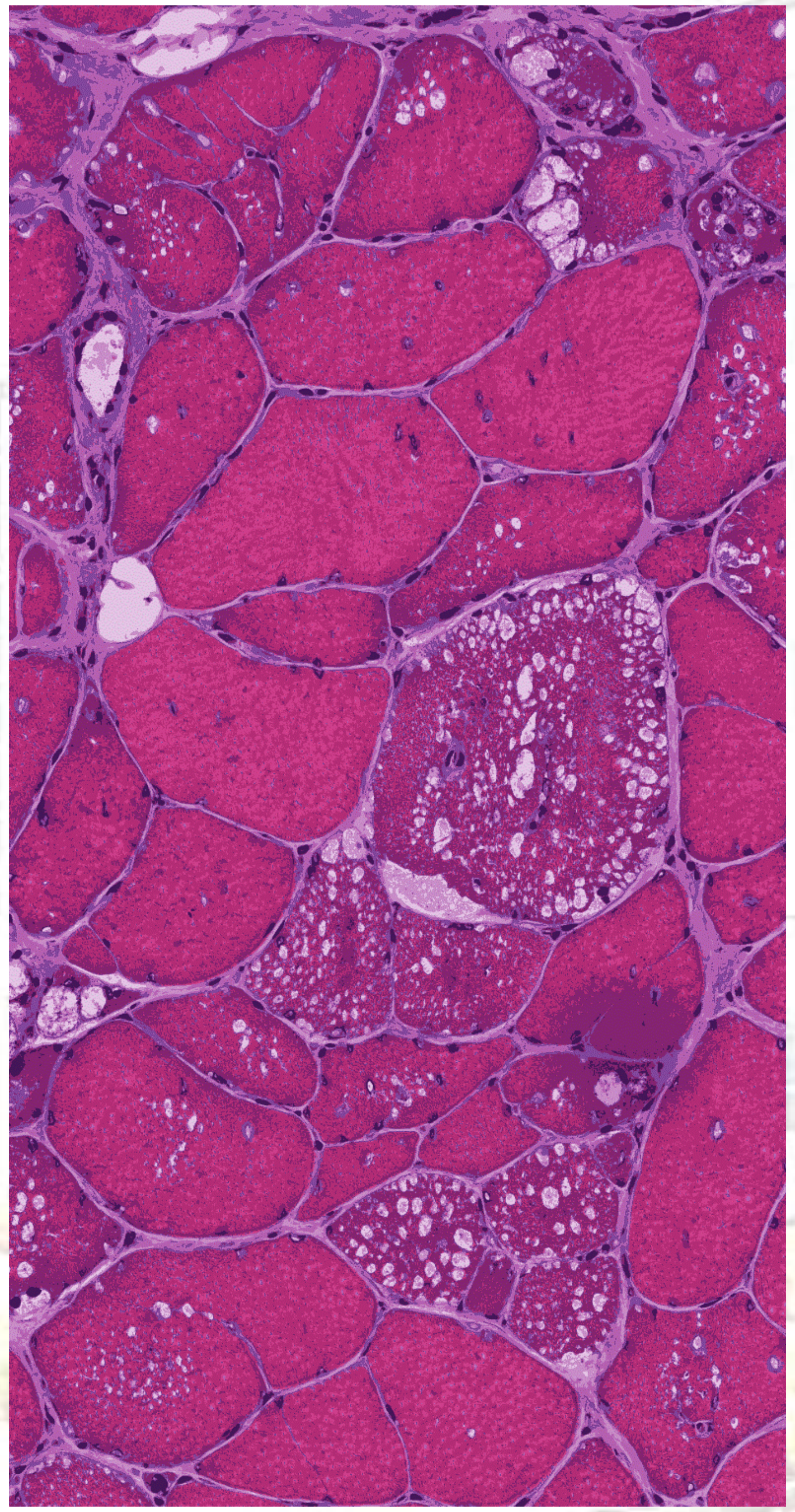
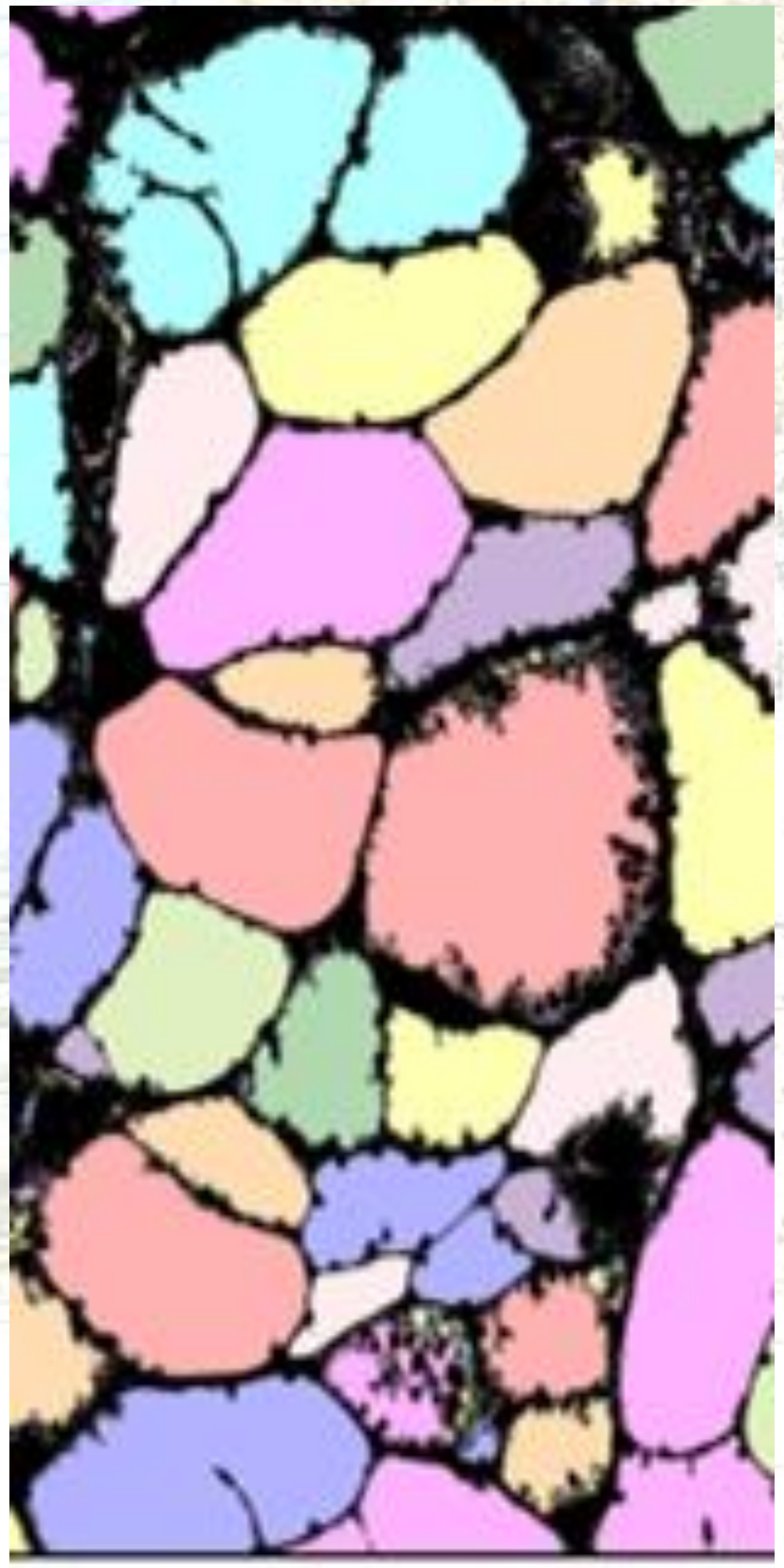
Virtual Pathologist – muscle tissue damage assessment

Tissue extraction → Staining quantisation → Image binarisation → Cell segmentation → Morphometrics



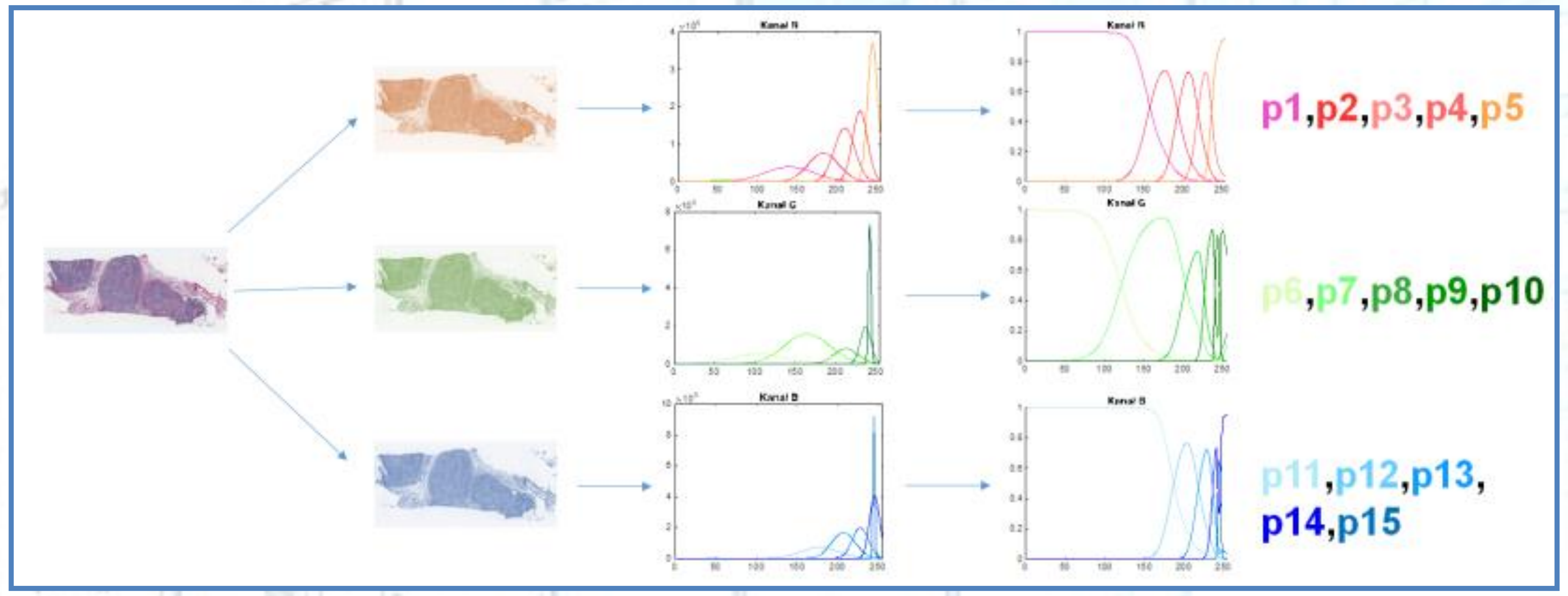


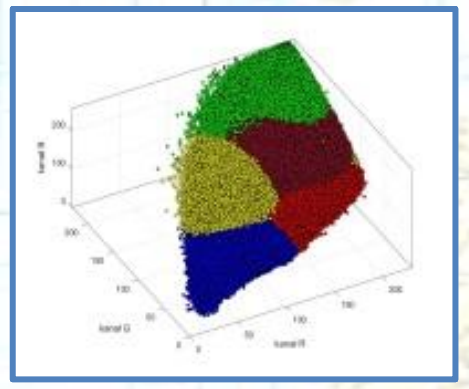


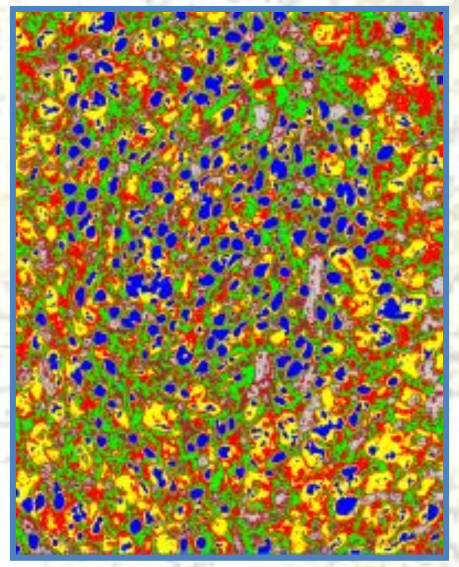
Area	Circularity	Equivalent Diameter	Fractal Dimension	Minor Major Axis Ratio
409411	0,304	722,00	1,12	0,73
410208	0,226	722,70	1,08	0,30
413320	0,477	725,43	1,08	0,82
415696	0,341	727,52	1,08	0,86
415946	0,332	727,74	1,06	0,25
417424	0,380	729,03	1,09	0,53
418369	0,143	729,85	1,06	0,28
425025	0,065	735,63	1,26	0,60
428740	0,084	738,84	1,21	0,66
431947	0,311	741,60	1,08	0,40
433229	0,170	742,70	1,13	0,26
434725	0,094	743,98	1,21	0,99
437113	0,239	746,02	1,15	0,74
446811	0,318	754,25	1,07	0,34
450076	0,333	757,00	1,10	0,52
453429	0,103	759,82	1,17	0,35
456413	0,376	762,31	1,05	0,49
456528	0,409	762,41	1,09	0,36
460398	0,091	765,63	1,21	0,34
465324	0,356	769,72	1,10	0,49
468219	0,026	772,11	1,36	0,86
468723	0,221	772,53	1,09	0,50
474137	0,232	776,97	1,07	0,38
482287	0,239	783,62	1,06	0,31
482862	0,358	784,09	1,08	0,54
482875	0,103	784,10	1,19	0,68
490850	0,262	790,55	1,14	0,75
494949	0,219	793,84	1,13	0,44
499841	0,289	797,76	1,10	0,51
502628	0,391	799,98	1,04	0,60
504005	0,272	801,07	1,10	0,57

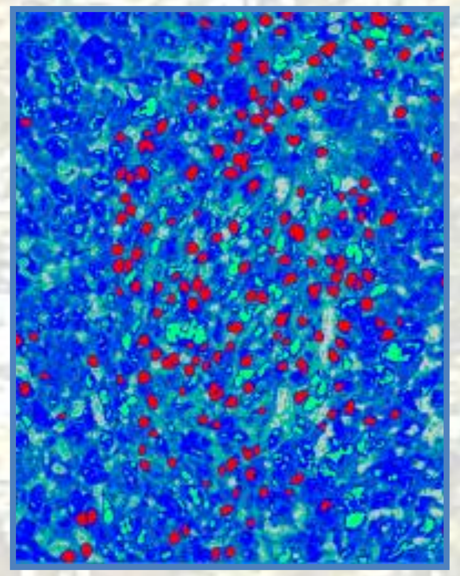
LISI - Automated TIL scoring of H&E stained images

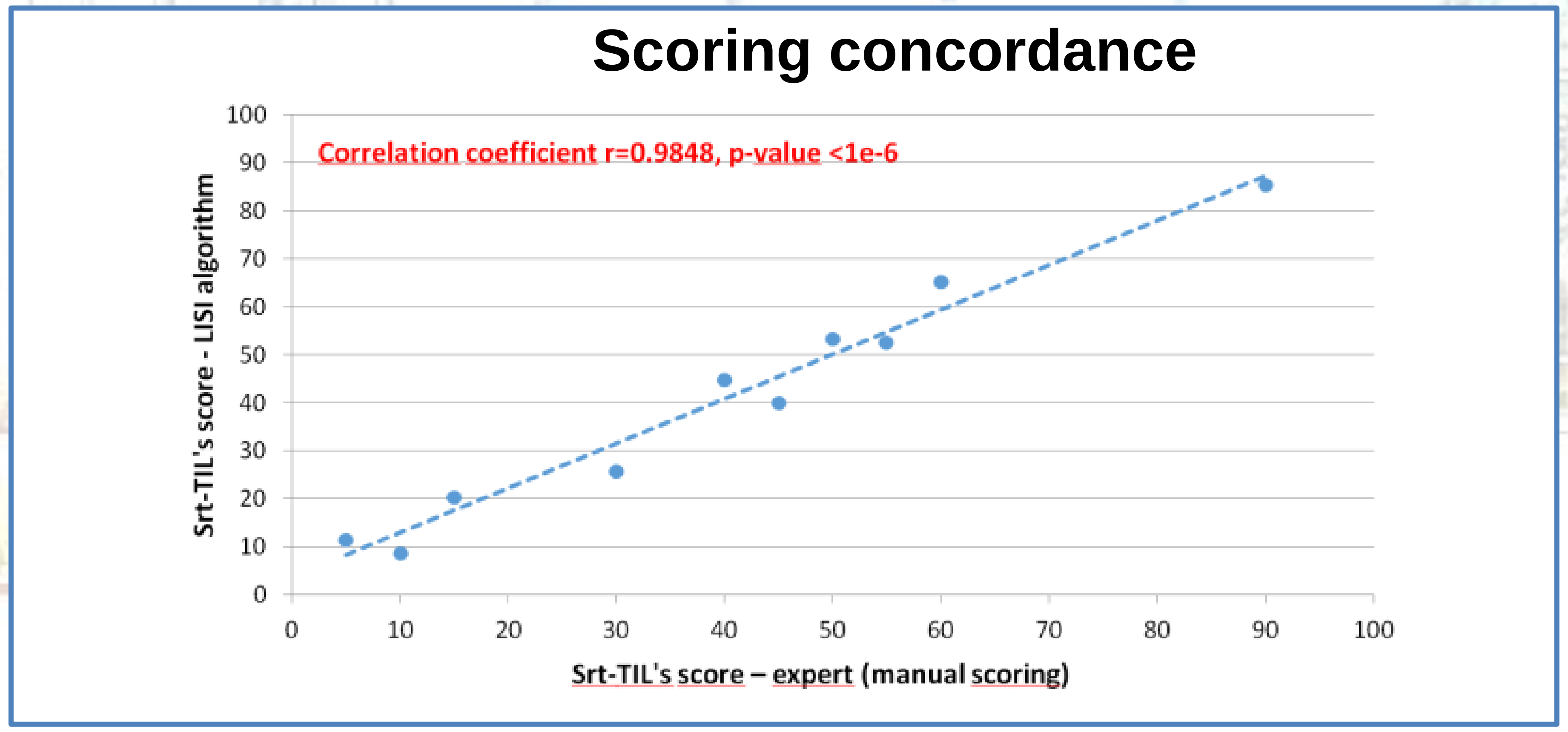
H&E stained tissue sample → Modeling of signal distribution for each RGB channel → Feature engineering → Clustering → Image quantization / segmentatio n → Tumor-infiltrating lymphocytes detection and scoring

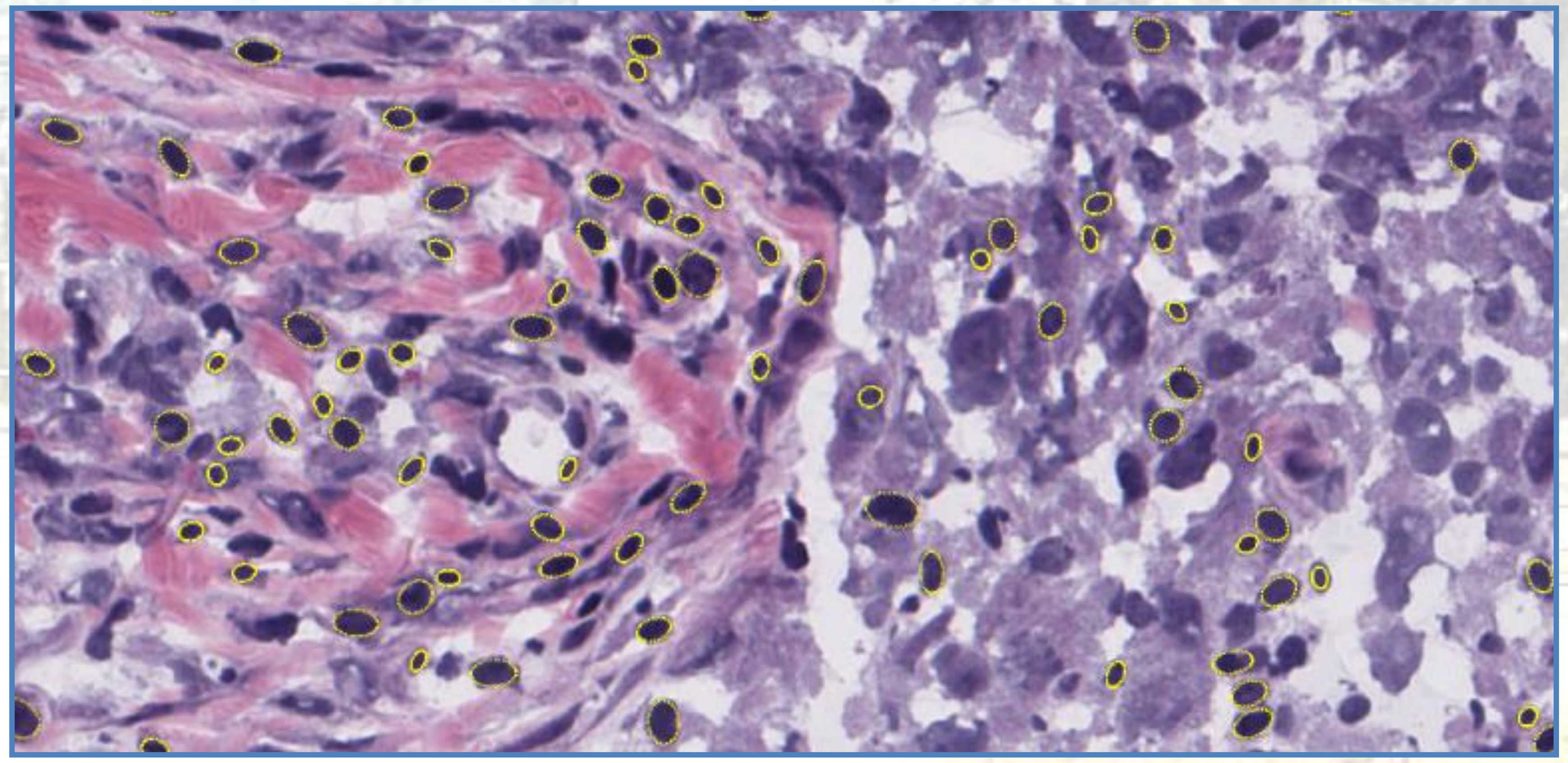












Functional bioinformatics

Zyla *et al. BMC Bioinformatics* (2017) 18:256
DOI 10.1186/s12859-017-1674-0

BMC Bioinformatics

RESEARCH ARTICLE — Open Access

Ranking metrics in gene set enrichment analysis: do they matter?

Bioinformatics, 2019, 1–9
doi: 10.1093/bioinformatics/btz447
Advance Access Publication Date: 4 June 2019
Original Paper

OXFORD

Gene expression

Gene set enrichment for reproducible science: comparison of CERNO and eight other algorithms

Joanna Zyla [1,2], Michal Marczyk[1,3], Teresa Domaszewska[2], Stefan H. E. Kaufmann[2], Joanna Polanska[1] and January Weiner 3rd [2,*]

[1]Data Mining Group, Faculty of Automatic Control, Electronic and Computer Science, Institute of Automatic Control, Silesian University of Technology, Gliwice, Poland, [2]Department of Immunology, Max Planck Institute for Infection Biology, Berlin, Germany and [3]Yale School of Medicine, Yale Cancer Center, New Haven, CT 06510, USA

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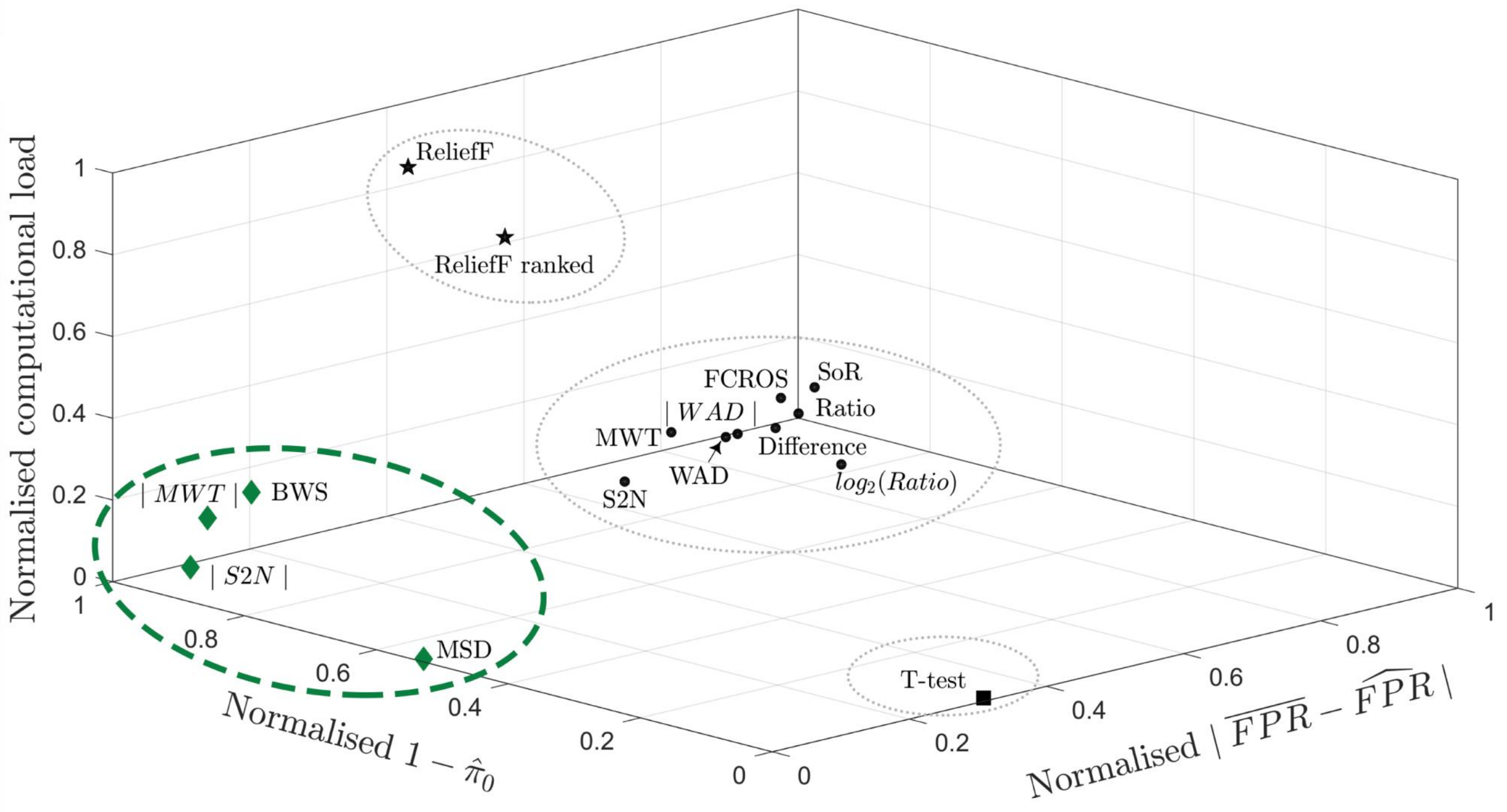
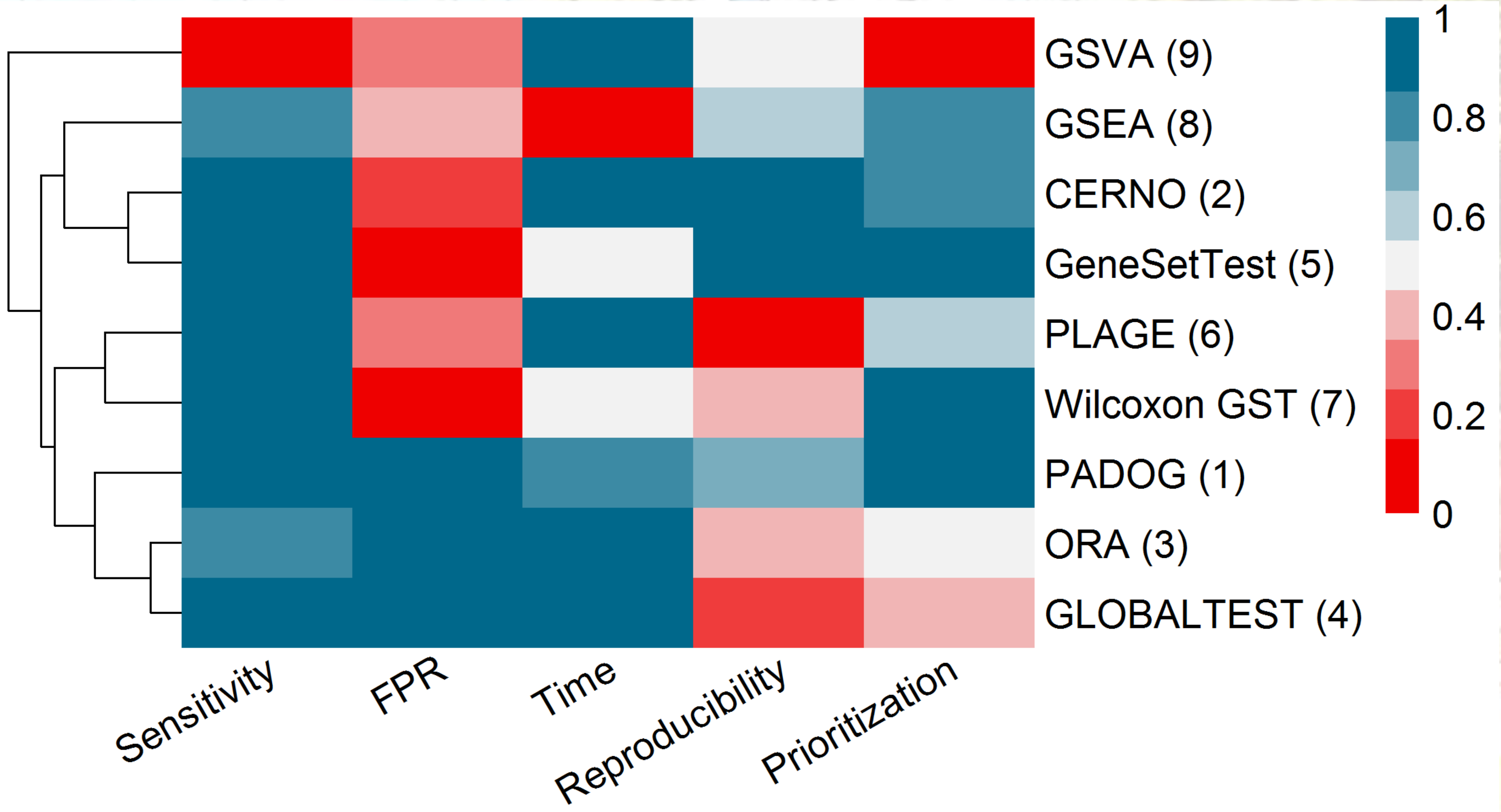
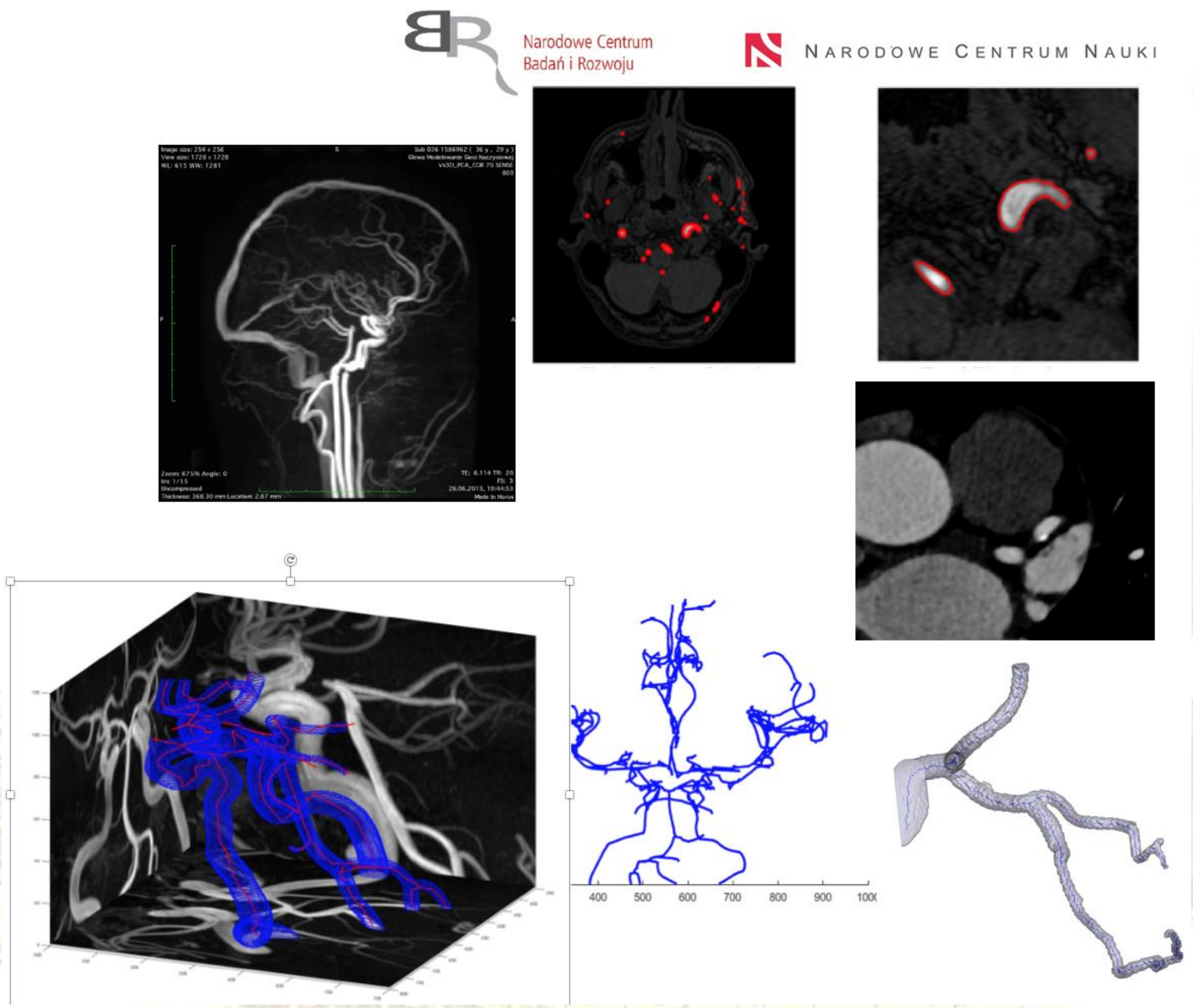
Associate Editor: Jonathan Wren

Received on December 10, 2018; revised on May 8, 2019; editorial decision on May 22, 2019; accepted on June 10, 2019



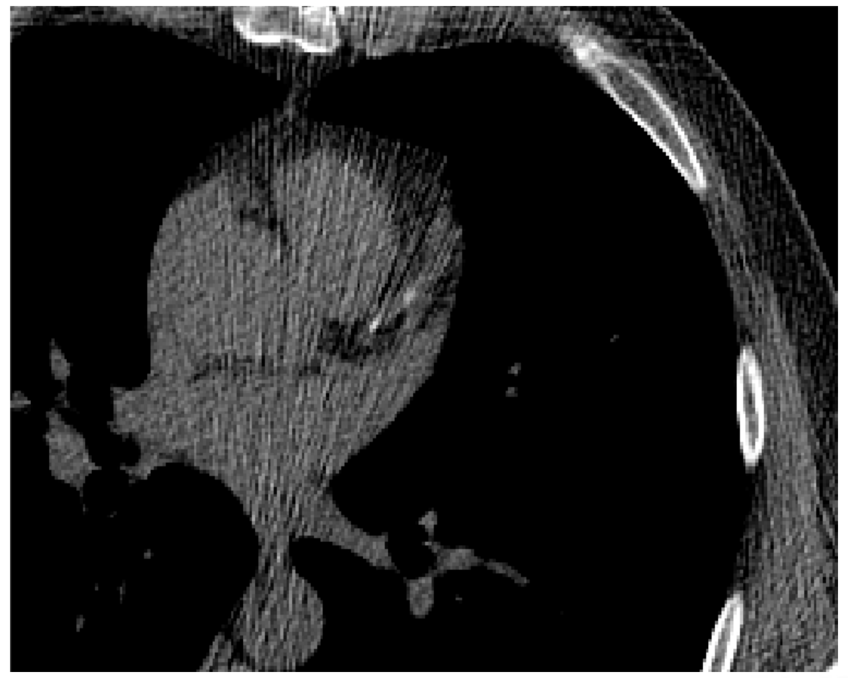


Applications of three-dimensional vascular network models



The aim of the project is to explore the commercialisation potential of an application to assist in the detection of cardiovascular lesions (the so-called CAD system or computer-aided diagnosis) based on the analysis of angiographic images from different modalities (i.e. CTA, contrast and non-contrast MRA).

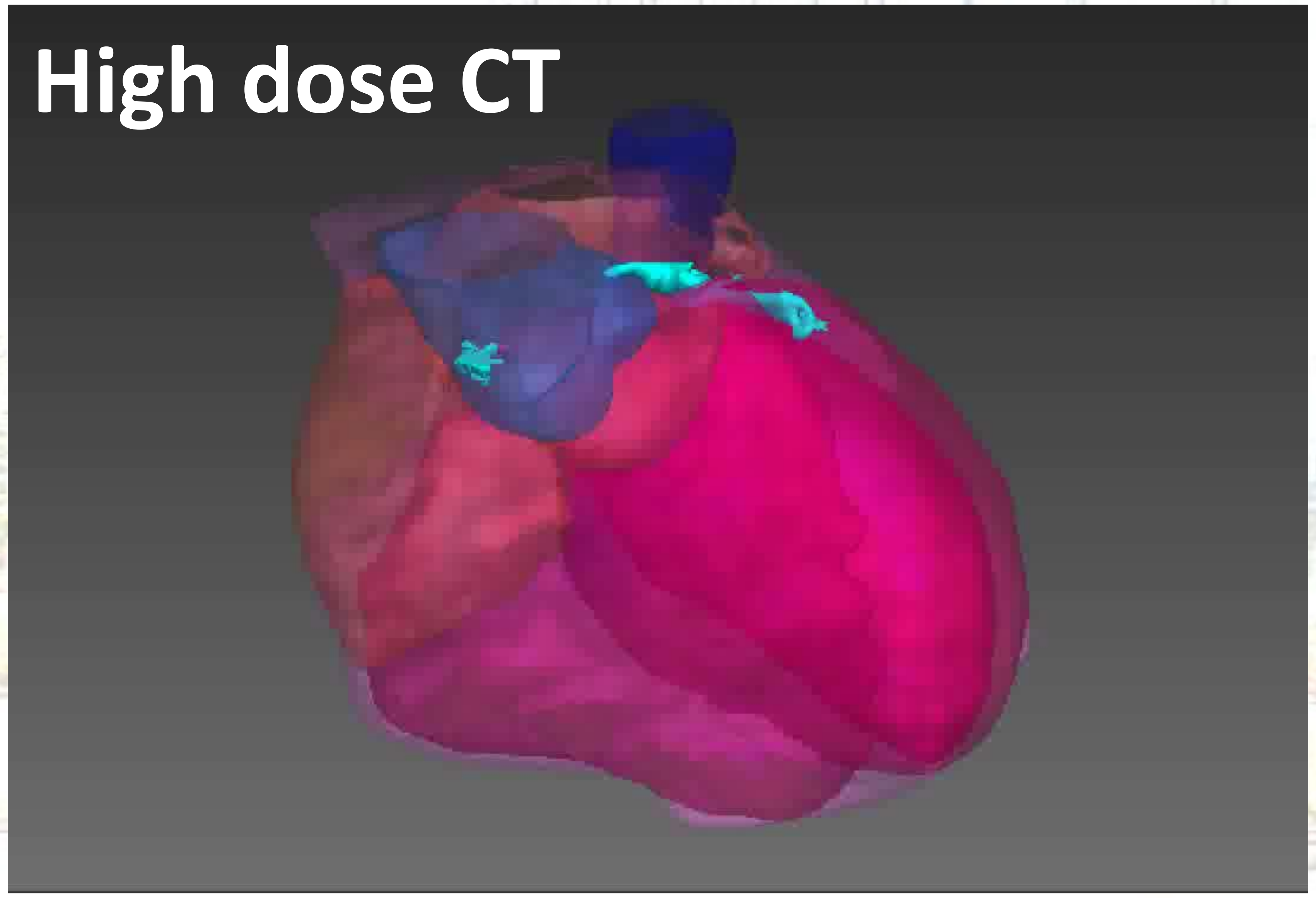
CASPER - 3D model of the calcification in the cardiovascular system

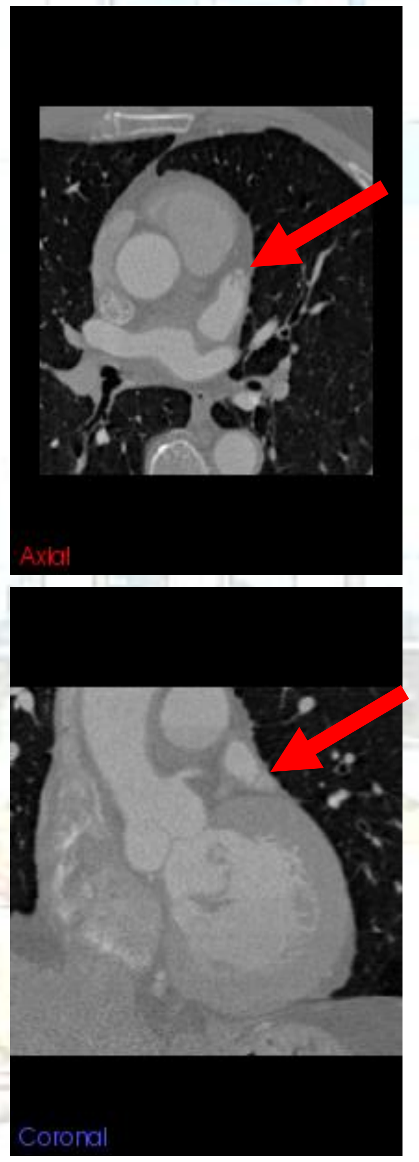


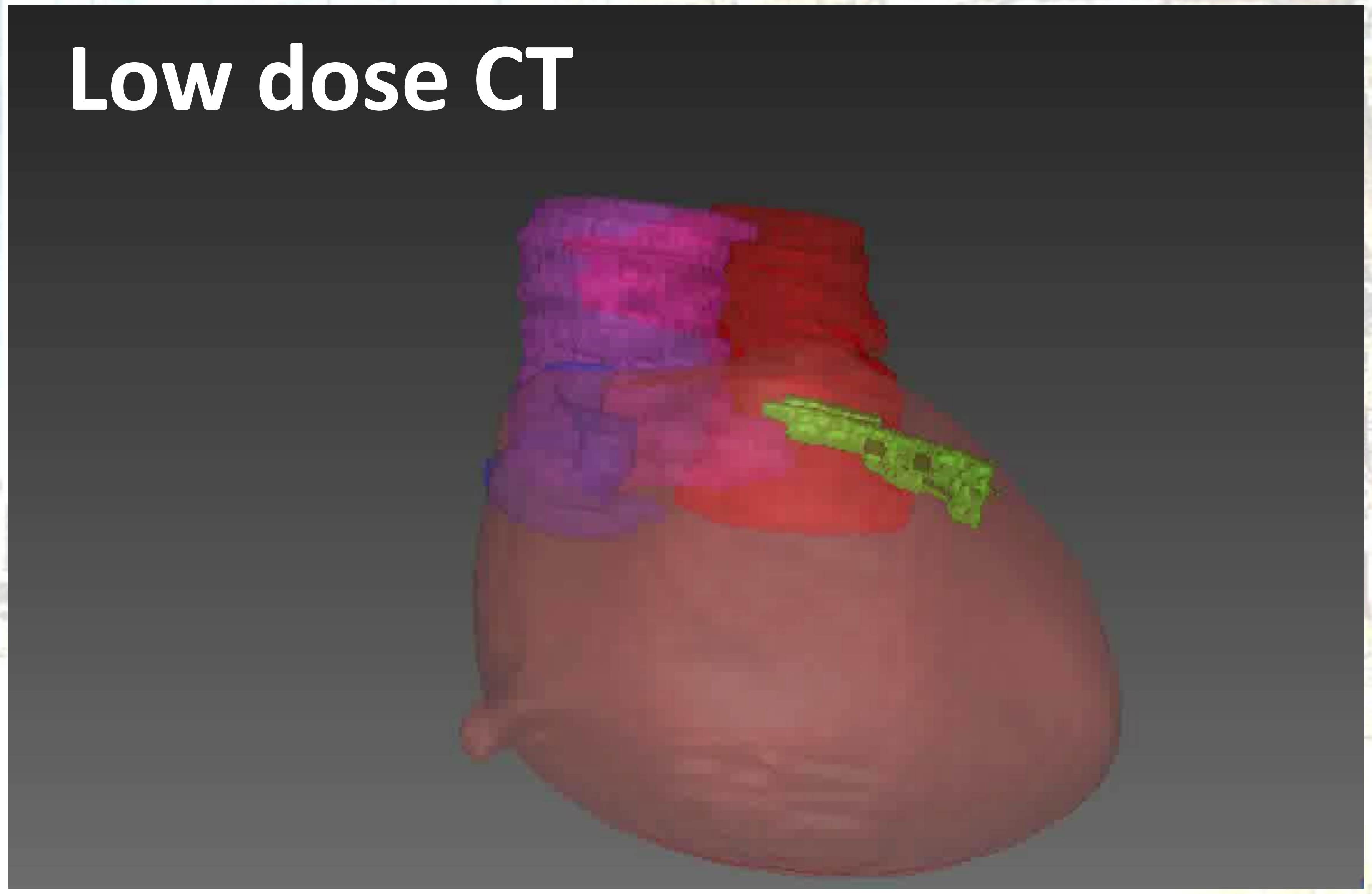
Sequence of morfological operations

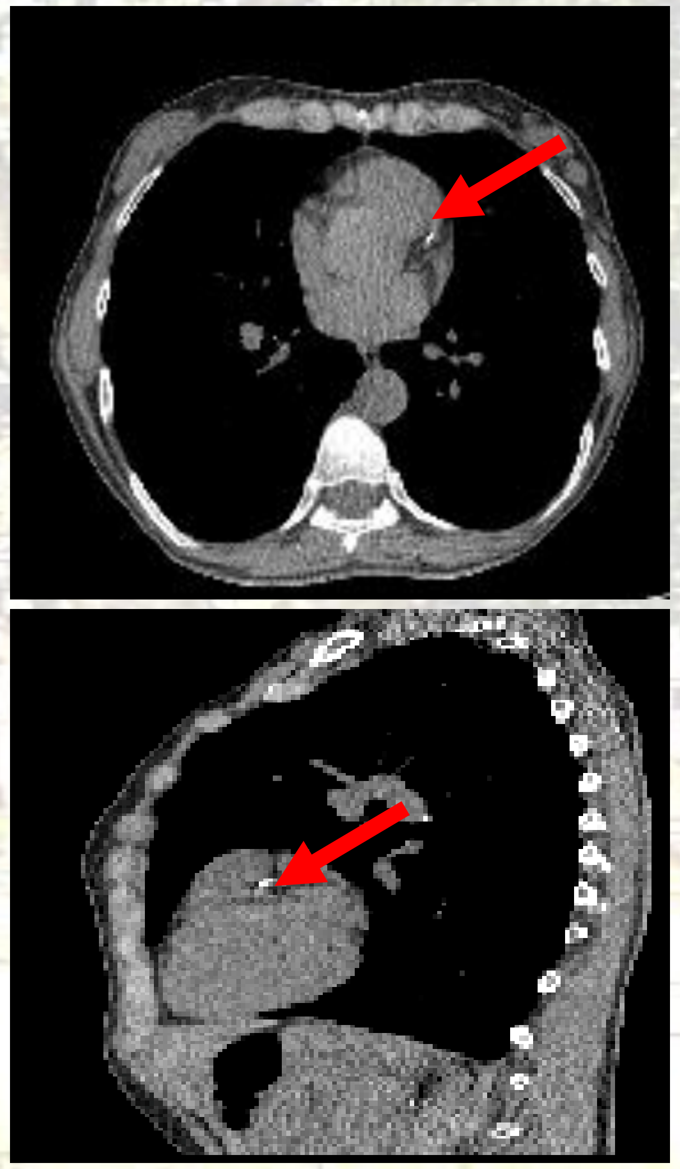
3D modelling of cardiovascular system

CAC Score estimation



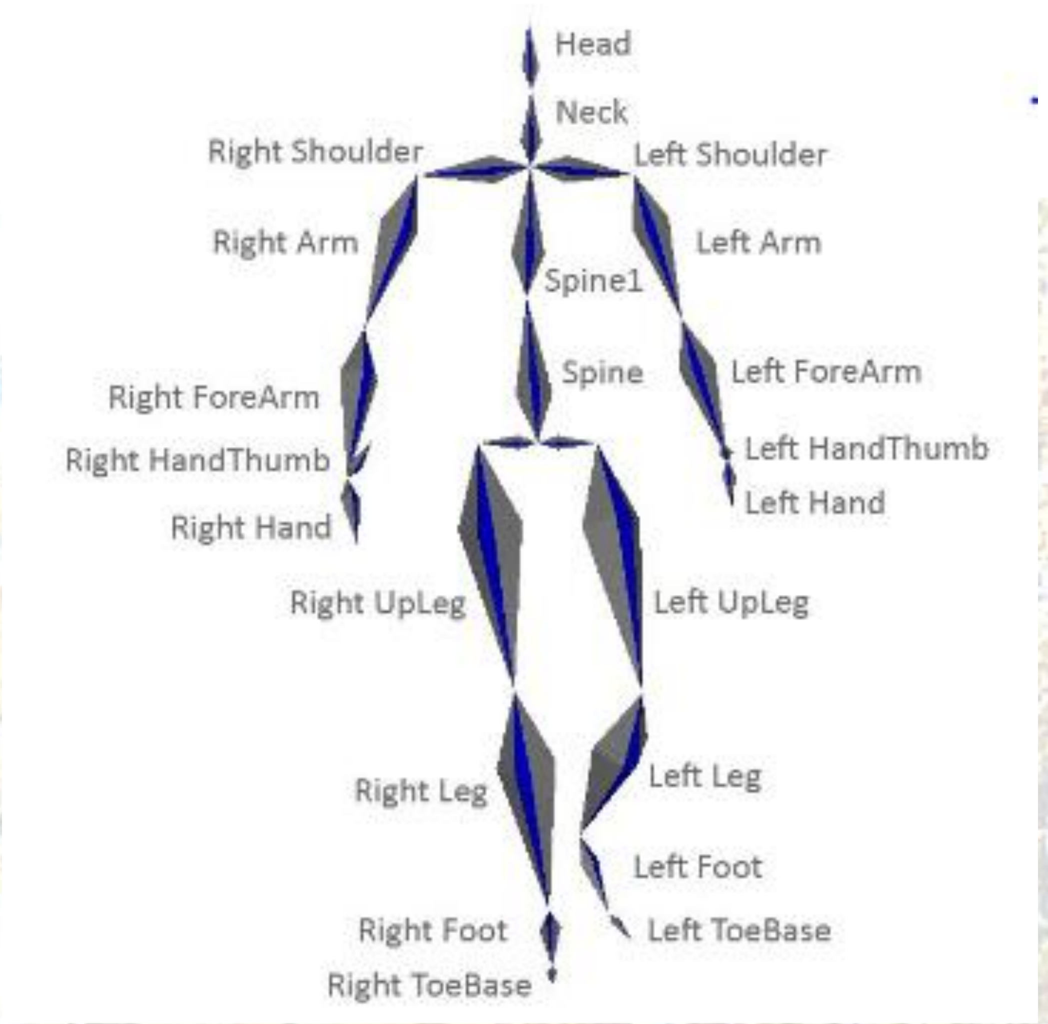


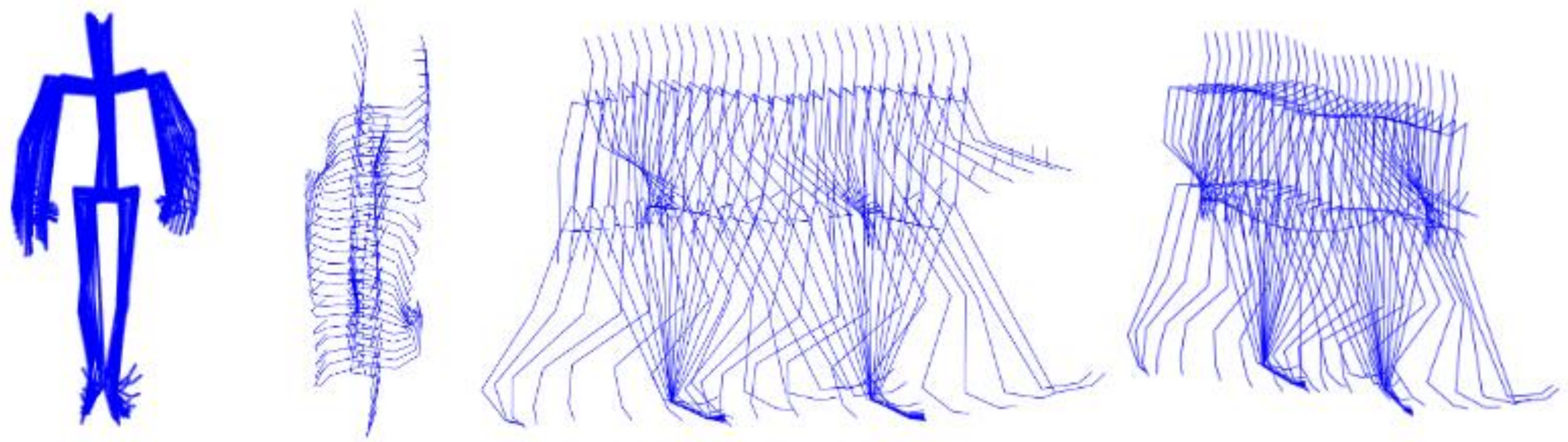




AI in motion data analysis

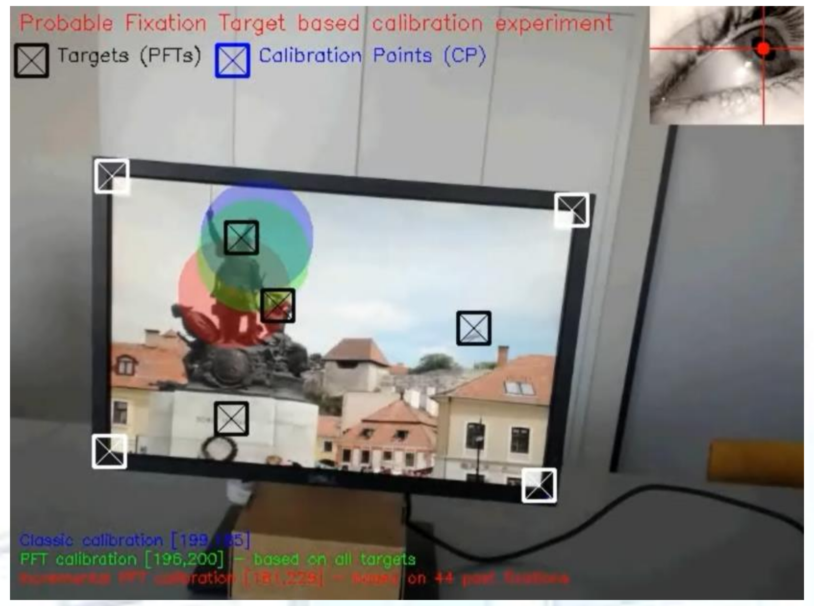
- Multivariate time series with parameters of human skeleton model
  - Marker-based and markerless acquisition
- Applications
  - Detection of gait abnormalities
  - Unmasking motion anomalies
  - Medical rehabilitation assistance

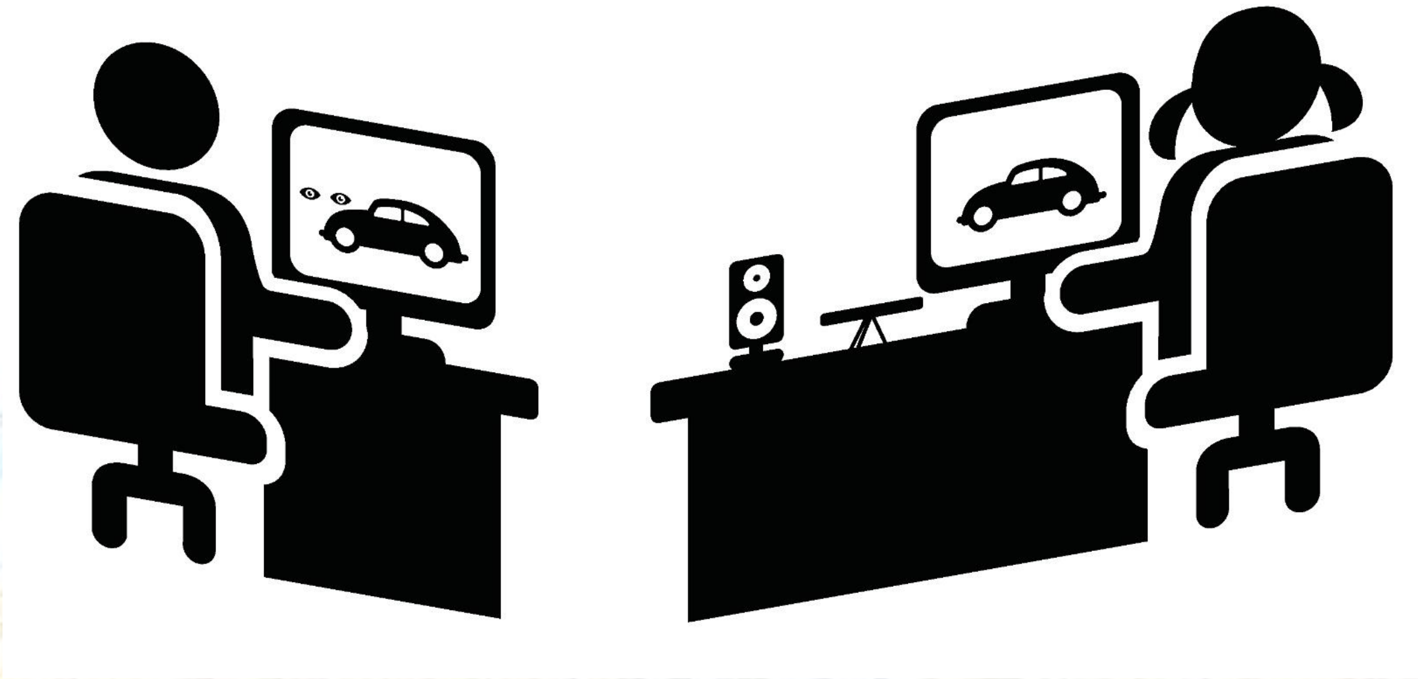


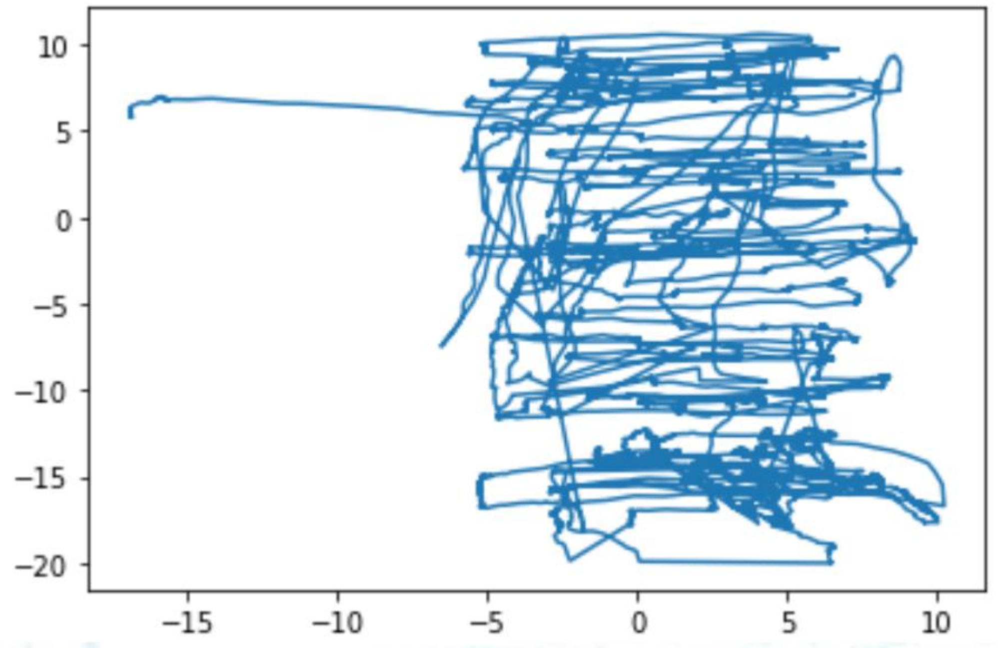


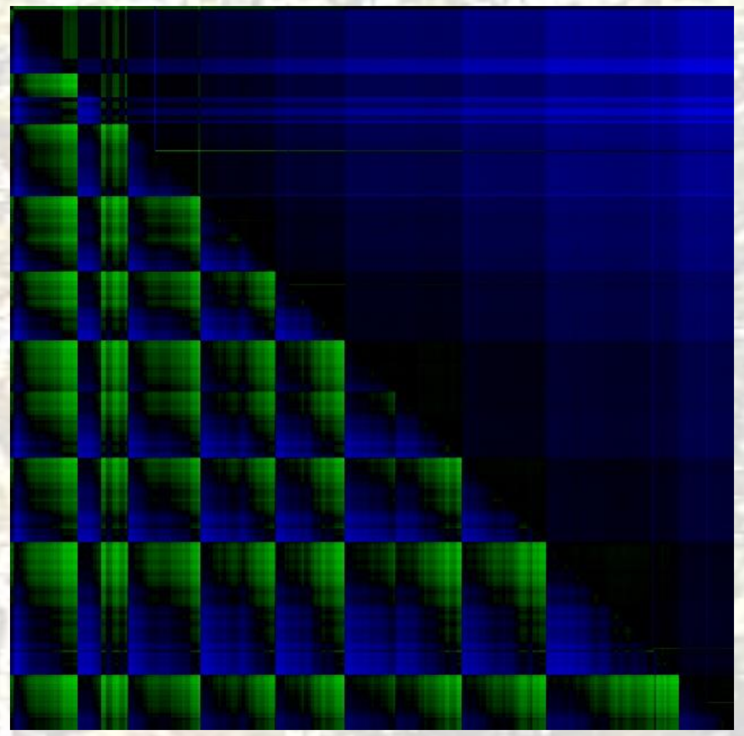
Eye movement analysis

- Diagnosing diseases
  - dyslexia
  - schizophrenia
  - Alzheimer's disease
- Therapy
  - amblyopia
  - strabismus
- Treatment
  - locked-in syndrome
  - brain damage

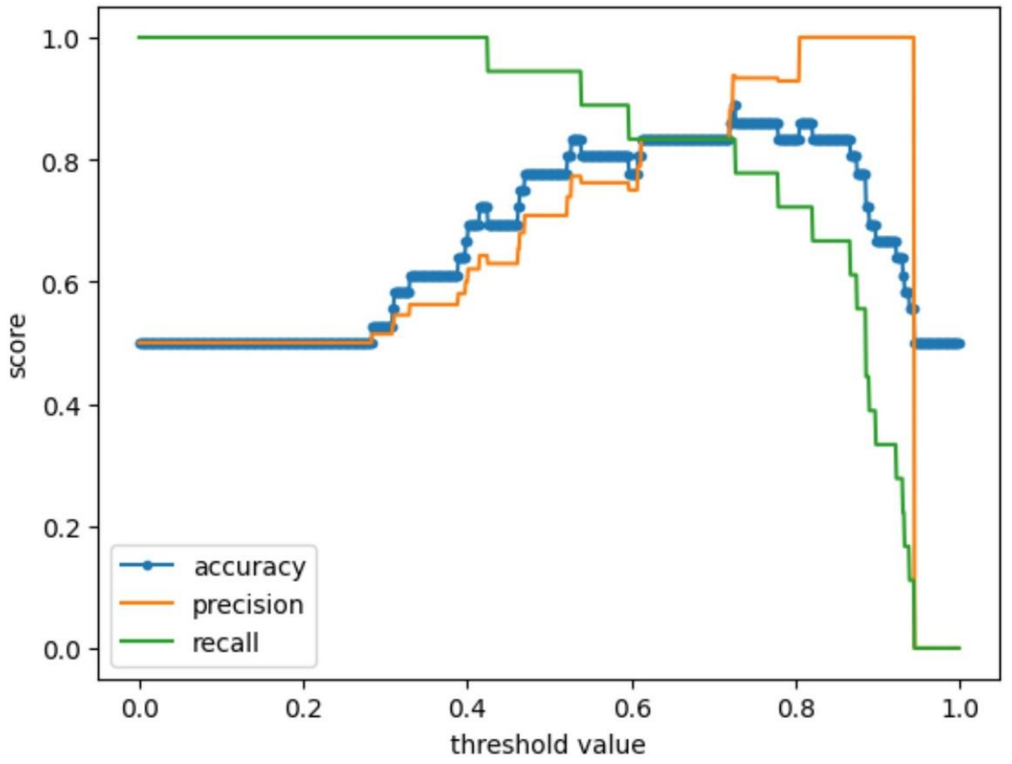








Tools:
- **Classic Machine Learning**
- **Convolutional Neural Networks**
- **Long Short-Term Memory Networks**
- **Generative Adversarial Networks**



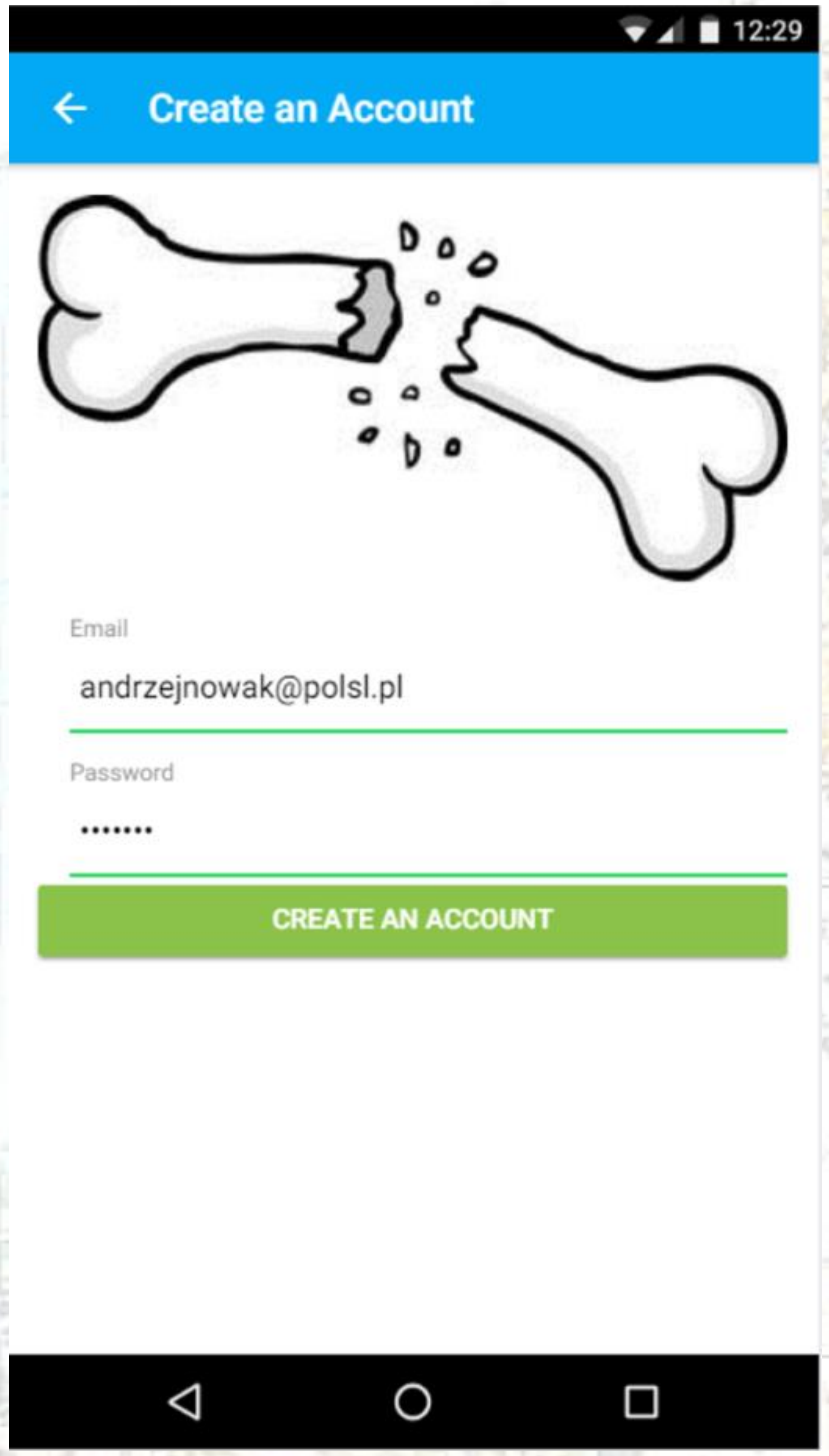
Calculator for patients at risk of osteoporosis

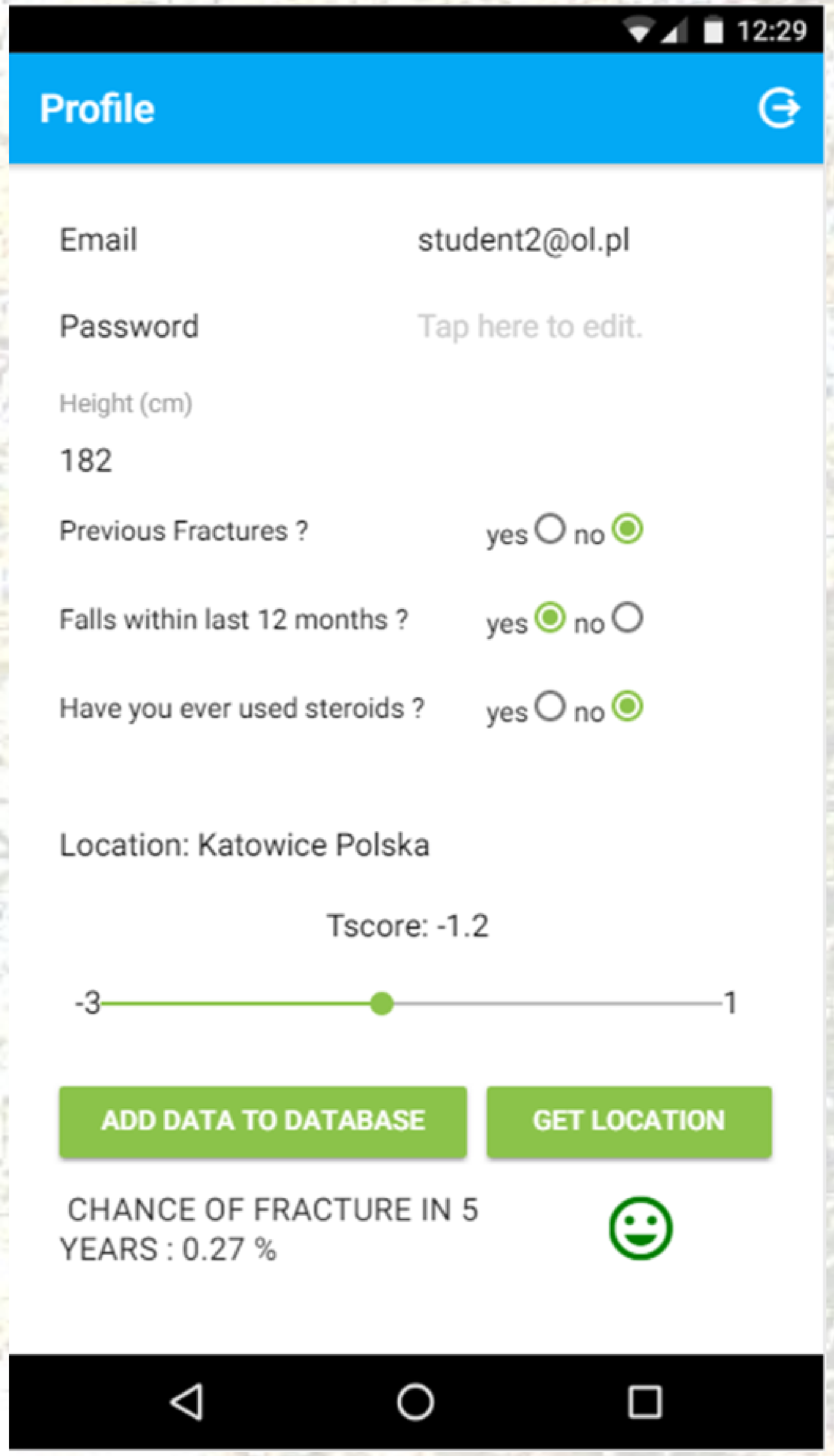
Research results:

- POL-RISK – the first osteoporosis calculator based on the Polish population, which helps clinicians and patients assess the risk of osteoporotic fracture in a 5- and 10-year perspectives.

Research challenges:

- Analysis of medical data with highly skewed data class distribution, which was referred to as the imbalanced classification problem.
- The problem of high dimensionality of medical data, which increased computational complexity and degraded the generalization of the detection model.
- The problem of cleaning the decision surface, reducing class overlapping, and removing noisy examples due to their interference with the learning process.

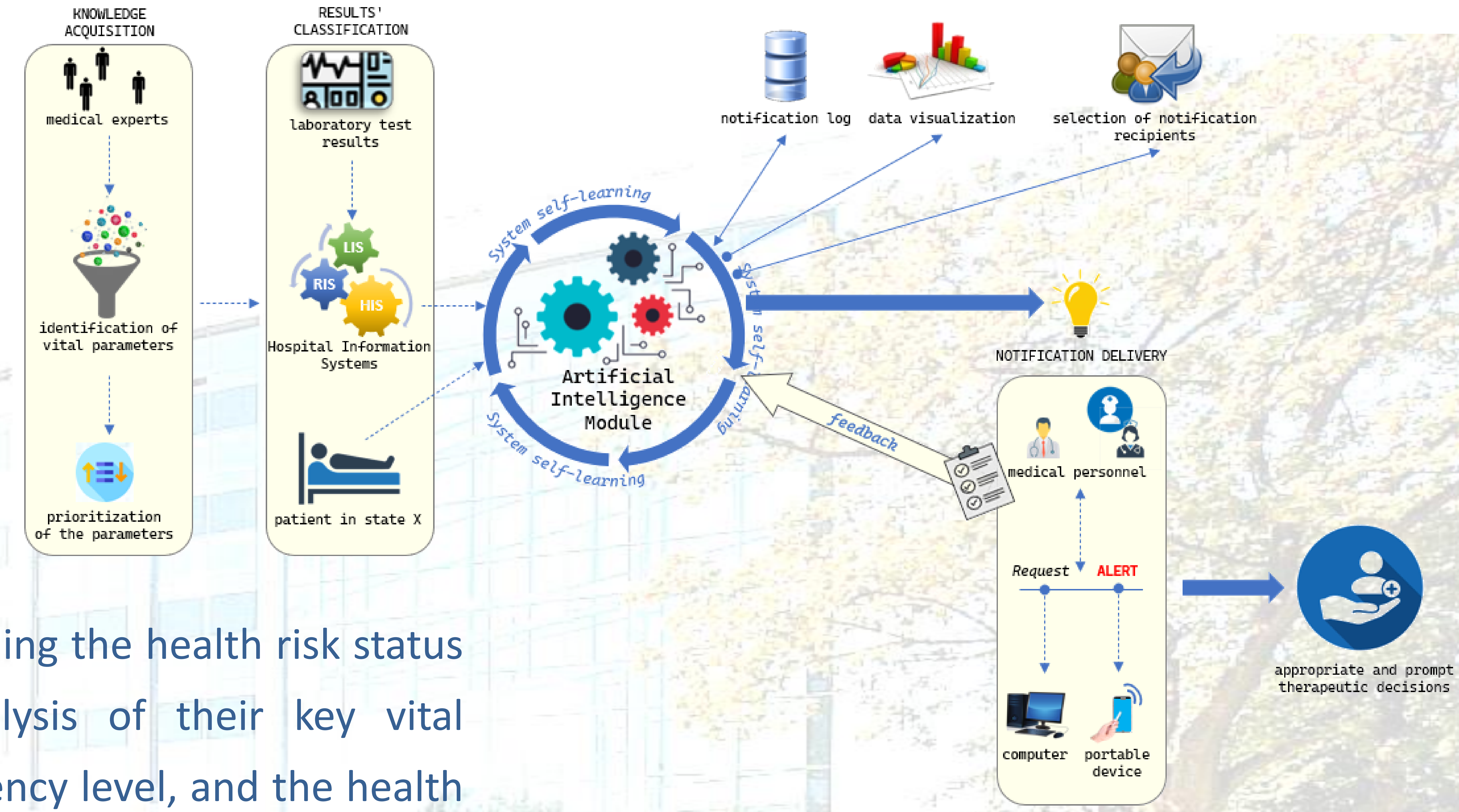




https://ryzyko-zlaman.pl/

MedAlert project

Development of Intelligent Algorithms for Selecting and Routing Critical Notifications in Hospital Medical Processes



System key features:

- Generation of real-time notifications regarding the health risk status of hospital patients, based on the analysis of their key vital parameters obtained from HIS and LIS, urgency level, and the health risk category.
- The automation of notification communication pathways – sending notifications to mobile work devices that inform a contextually selected narrow group of recipients about the availability of patient test results in the information system.
- Self-adaptive interface mechanism enabling the display of an appropriately organised list of results.

Summary

- Scientists from the Silesian University of Technology actively participate in AI technology development
- The intelligent tools they have developed are used in research in many omics
- They are working on many projects concerning AI applications in medicine
- We cordially invite you to get in touch with us!

Silesian University of Technology

RESEARCH UNIVERSITY
EXCELLENCE INITIATIVE