BioMedAI TWINNING

RationAI

BioMedAI · RationAI

Clinically Focused AI

Ostrava, 2024-12-21

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Institute of Comptuter Science · MUNI

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RationAI – BioMedAI

- **RationAI**
  - laboratory focusing on rational application of AI with focus on explainability and trustworthiness
  - founded in 2019 as a shared laboratory between FI and ICS
    - FI focuses on core research
    - ICS focuses on development of infrastructure for AI, provides project management and back-office

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RationAI – BioMedAI

- **BioMedAI**
  - center bringing together RationAI with a image analysis, visualization, and NLP laboratory for **eXplainable AI (XAI) research in biomedical applications** with specific focus on **digital pathology**
  - partnering with Masaryk Memorial Cancer Institute, Medical University Graz, and Technical University Berlin
  - founded in 2023 as a consequence of BioMedAI Twinning project

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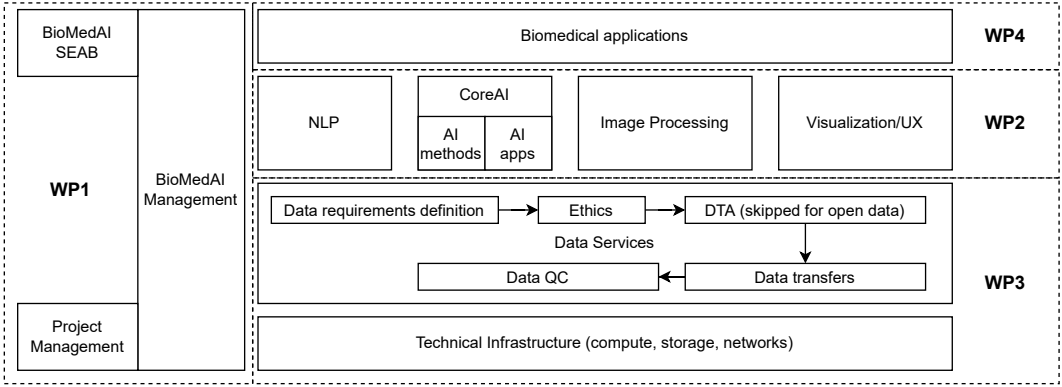
BioMedAI Structure



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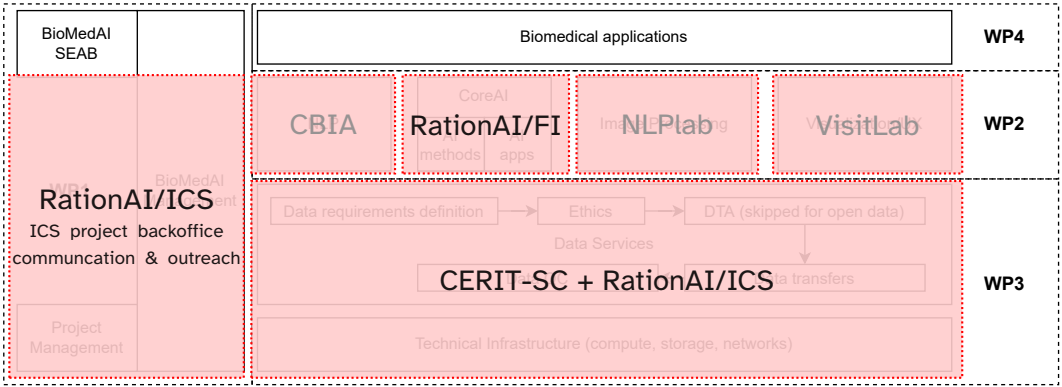

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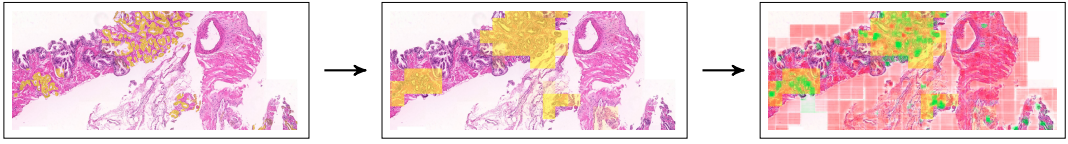
XAI Research Domains - I

- **Digital pathology – primary focus**
  - XAI analysis of large-scale imaging
  - screening and diagnostic applications
  - application of explainability to develop trust by medical professionals and to understand boundary conditions of applicability

https://doi.org/10.1016/j.nbt.2023.09.008
ELSEVIER
New Biotechnology
Volume 78, 25 December 2023, Pages 52-67

Shedding light on the black box of a neural network used to detect prostate cancer in whole slide images by occlusion-based explainability

Matej Gallo [a 1], Vojtěch Krajňanský [a 1], Rudolf Nenutil [b], Petr Holub [c], Tomáš Brázdil [a]



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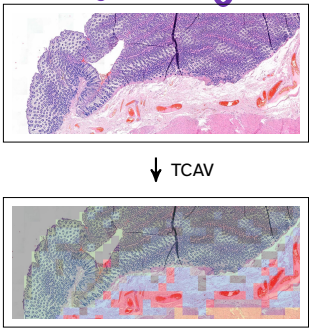
XAI Research Domains - II

- **Focus topics**
  - **fast and efficient training** of AI models to different problems in digital pathology – **transfer learning** and **domain adaptation**
  - **active learning** mechanisms – including novel visualization and HCI methods
  - **post-hoc model-independent explainability** methods
  - **extracting "knowledge"** from models (e.g., Testing with Concept Activation Vectors – TCAV)
  - **anomaly detection** models – quality control, data synthesis
  - feature extraction of **efficient discovery** of data in large data sets



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XAI Research Domains - III

- **collaborations:**
  - Masaryk Memorial Cancer Institute: Dept. of Pathology
  - Medical University Graz: Human Centered AI Group, Zatloukal Group
  - Charité Berlin + EMPAIA International
  - Technical University Berlin: Distributed Artificial Intelligence Laboratory (DAI Labor)
  - Faculty Hospital Brno: Inst. of Pathology
  - Institute for Clinical and Experimental Medicine (IKEM)
  - BBMRI-ERIC: European Research Infrastructure on Biobanking and Biomolecular Resources

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XAI Research Domains - IV

- **Obesitology & laboratory medicine**
  - analysis and predictions of time series data
  - **collaborations:** (i) 1st Medical Faculty at Charles University, and (ii) Institute of Laboratory Medicine at Faculty Hospital Brno
- **Public health**
  - data-quality analysis of national medical registers
  - **collaborations:** ÚZIS (Institute of Health Information and Statistics of CZ)

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Infrastructure R&D Domains - I

- **Co-initiated development of SensitiveCloud**
  - ISO 27001 certified environment for hosting and processing sensitive data
  - Kubernetes-based processing environments, piloting feasibility using RationAI group
- **Development of Kubernetes-based RatioAI pipeline and RatioViz visualization**
  - support for interactive development and batch HPC mode
  - setup of reproducible AI pipeline management based on MLflow and visualization
  - close collaboration between pipeline/visualization developers and infrastructure developers – architectural co-design

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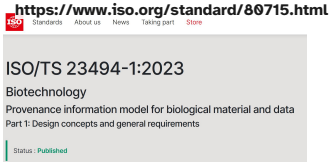
Infrastructure R&D Domains - H

- **Provenance modeling and standardization**
  - collaboration with BBMRI-ERIC on standardization of provenance in ISO TC/276 (Biotechnology) WG5 (Data Integration) – ISO 23494 Series
  - provenance model for sensitive data in distributed environments
  - application of provenance to the whole digital pathology chain: patient → sample → histopathological slide → whole-slide image → training of AI model → testing of AI model → clinical validation



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Infrastructure R&D Domains - HI

- **Privacy risks of privacy sharing**
  - analysis of risks of digital pathology imaging sharing
  - development of guidelines for anonymization of digital pathology imaging

- **Optimizations of imaging formats**
  - collaboration with Comprimato spin-off on using JPEG 2000 compression for substantial reduction of data volumes in digital pathology
  - development of DICOM support

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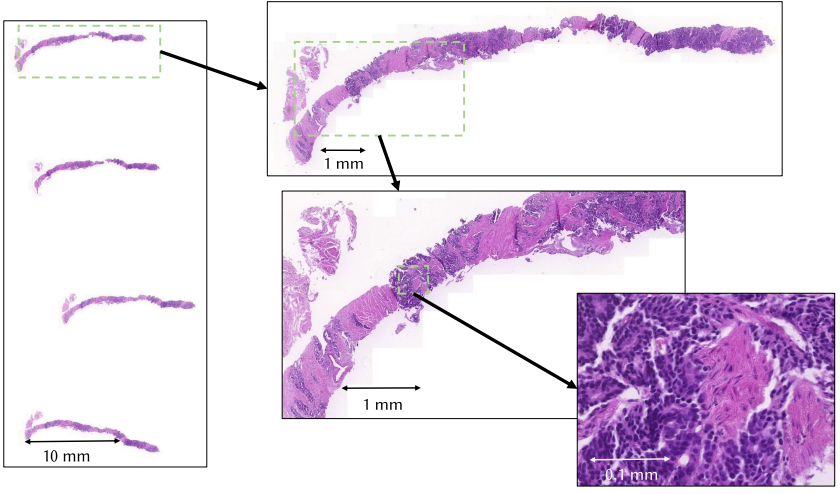
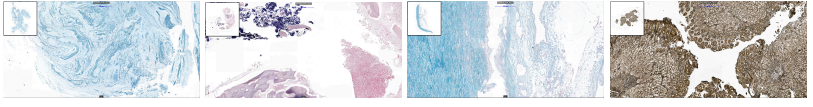


(a)



(b)

Data Management - I

- **Setup of contracting with new data/research partners**
  - ongoing expansion of collaborating hospitals: national and international
- **Development of FAIR/FAIR-Health data management plans**
  - FAIR: findability, accessibility, interoperability, reusability
  - FAIR-Health: quality (starting from traceability :)), (effective) privacy protection, incentives

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Data Management - II

- **Routine data management**
  - contracting access to data in large organizations
  - implementation of secure compartmentalization of storage
  - optimization of storage performance
    (TB–PB range of datasets)
  - infrastructural monitoring of compliance
  - operational data management done within RationAI group

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Data Management - III

- **Data pipeline:**
  - tiling → labeling → loading → training ...all captured in mlFlow
  - loading and processing in SensitiveCloud storage
- **Examples of data sets**
  - 123 TB biobank data set (MMCI/BBMRI)
  - 3 TB prostate data set (MMCI/BBMRI)
  - 1.5 PB colorectal cancer data set (MUG/BBMRI)

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Output Focus

- **Applied research results**
  - RationPath pathology toolset
    - efficient in adapting to different problems
  - RatioViz
    - xOpat client visualization with different compatible servers, “case viewer’, annotation tooling
    - integrated in BBMRI-ERIC toolset with cBioPortal
  - software developed as open source (https://github.com/RationAI/ once published)
- **Trained models in internal clinical validation at MMCI**

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International Leadership

- **EOSC**
  - PH: lead of Health Data Task Force, writer of EOSC Handbook, WP6 lead of EOSC-Life (FAIR data services)
- **European Health Data Spaces**
  - PH: consultant to EHDS architect since 2020, leader of WP8 of EHDS2Pilot (data quality, privacy/security, and processing), contributor to TEHDAS2 and QUANTUM
- **ISO**
  - PH: initiator and project lead of ISO 23494, contributor to ISO 20691

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INTEREST IN OPEN SCIENCE II

Topics - I

- **Traceability and quality of health-related data**
  - provenance of data sets back to source
  - provenance of AI models
  - including support for sensitive medical data (provenance not leaving source organizations)
    - provenance not leaving source organizations
  - quality checking (piloted on clinical and imaging data)
  - compliant with ISO 23494

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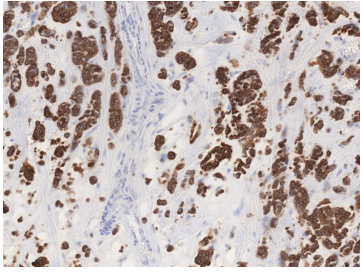
Topics - II



epithelium

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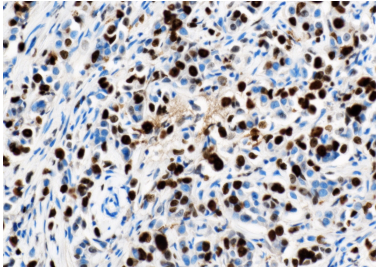

Ki67-positive nuclei

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Topics - III

- **Alignment to development of European Health Data Spaces**
  - working on behalf of Czech Ministry of Health in TEHDAS2
  - privacy-preserving data sharing (anonymization/pseudonymization)
  - discovery and access management
  - provisioning of Secure Processing Environments (SPEs)

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Topics - IV

- **Licensing of AI models**
  - what is legaly ’an AI model’?
  - open licensing mechanisms
  - contract clauses with employees and students contributing to AI models

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Topics - V

- **Repositories for AI-ready data with controlled access**
  - metadata models
    - information extracted from data
    - information extracted from provenance
  - interfacing repositories to SPEs (e.g., Kubernetes-bases in CERIT-SC)
  - focusing on ’our domains’ – clinical data ((un)structured, imaging, clinical, omics)

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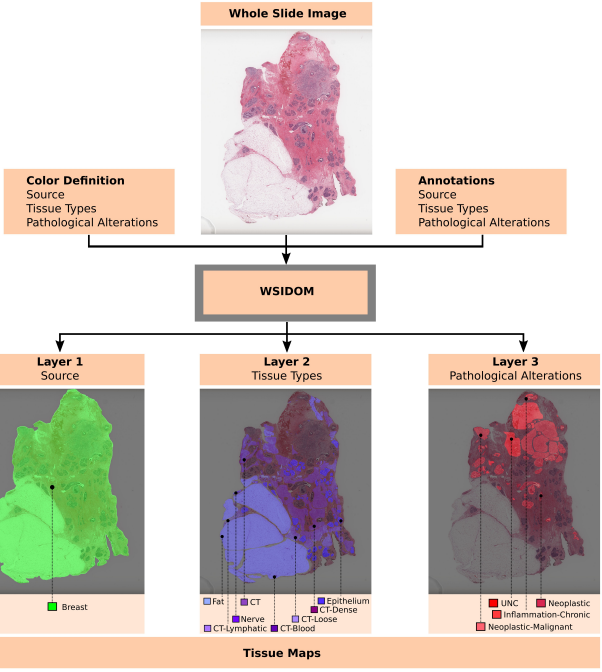
Topics -



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Topics - VII

- **Repositories for AI models**
- **Effective storage of large-volume data in specific domains**
  - histopathological and other large-scale imaging data
  - time series and clinical data

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