UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

Artificial Intelligence and Intelligent Systems
cini National Lab

PICUS lab
PATTERN ANALYSIS AND INTELLIGENT COMPUTATION FOR MULTIMEDIA SYSTEMS

AI in healthcare: Activities of the University of Naples Federico II node of the CINI-AIIS Lab

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Workshop: AI per la Medicina e la Salute

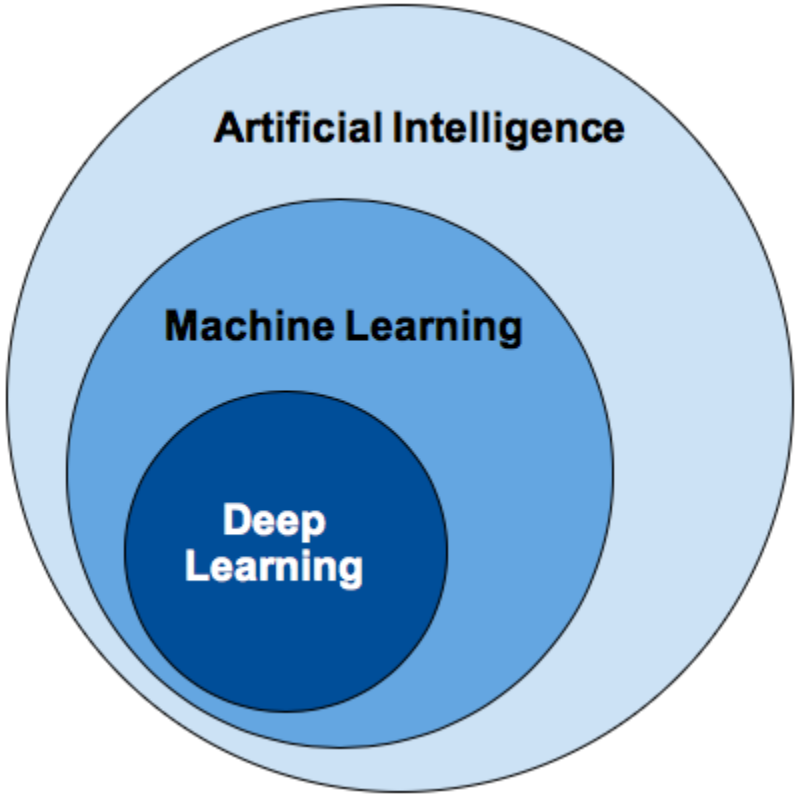
Artificial Intelligence in Healthcare

- Healthcare is considered one of the most promising applications of AI

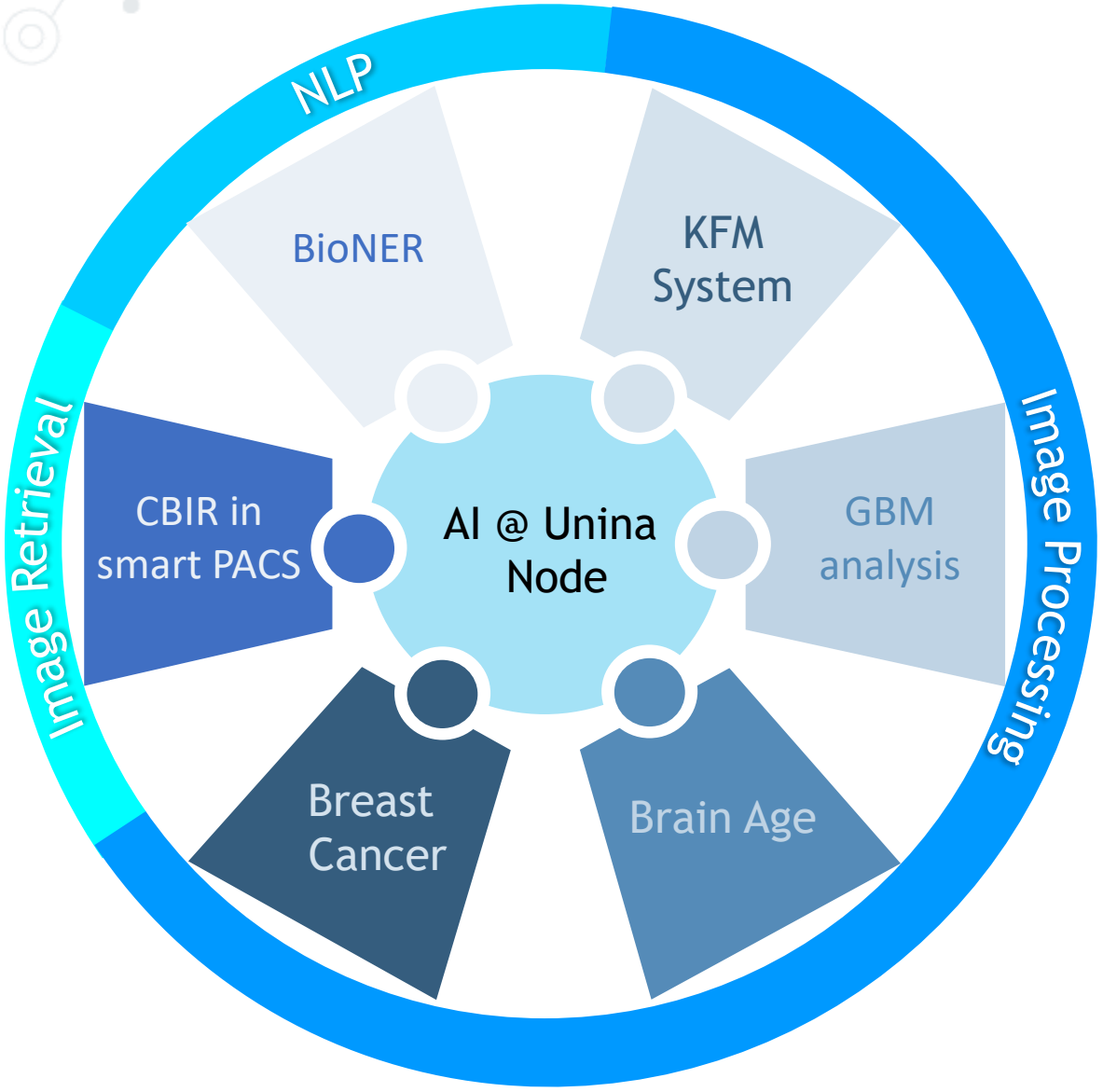
- AI in healthcare can be used to:
  - ✓ support patients and physicians
  - ✓ transform patient care and administrative processes
  - ✓ analyze patient data to identify potential health risks
  - ✓ help physicians make more accurate diagnoses

- The most common application of traditional ML is precision medicine:
  - ✓ predicting what treatment protocols are likely to succeed on a patient

- DL applications:
  - ✓ Medical images analysis:
    - ➢ the aim is to extracting clinically relevant features from images that go beyond what can be perceived by the human eye.
  - ✓ Natural Language Processing:
    - ➢ the creation, understanding and classification of clinical documentation
    - ➢ Analysis of unstructured clinical notes on patients



AI Applications of the University of Naples Federico II



People at the University of Naples Federico II

Breast Cancer

KFM System

GBM Analysis

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PATTERN ANALYSIS AND INTELLIGENT COMPUTATION FOR MULTIMEDIA SYSTEMS

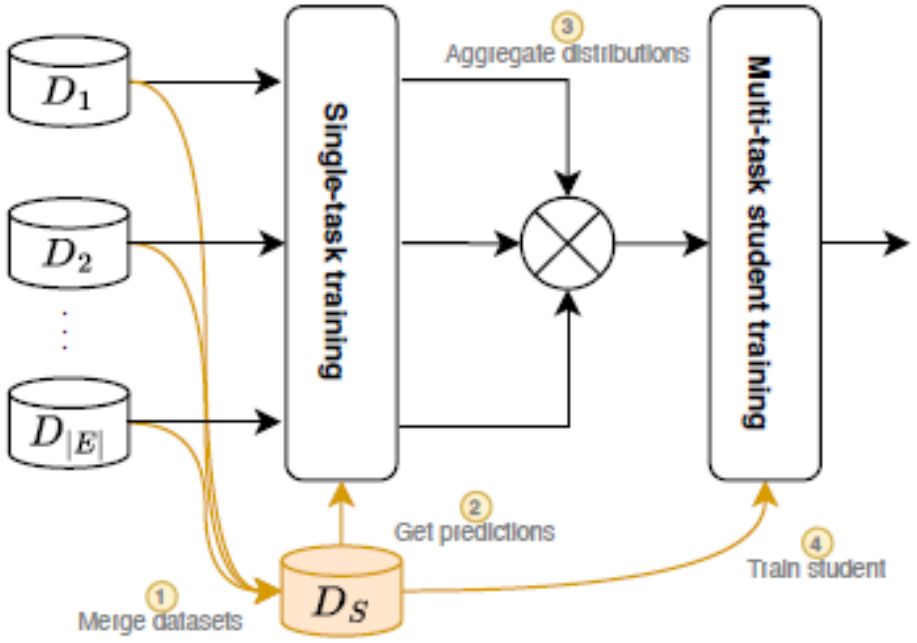
BioNER

Brain Age

GBIR in Smart PACS

Multi-task BioNER

- Biomedical Named Entity Recognition (BioNER) involves identifying mentions of biomedical entities from unstructured text
- Developing a BioNER system is still difficult due to the high frequency of synonyms, alternate spellings, polysemous words, and privacy issues.
- We propose TaughtNet a multi-task framework based on knowledge distillation that fine-tunes a single transformer architecture to recognize multiple entity types.



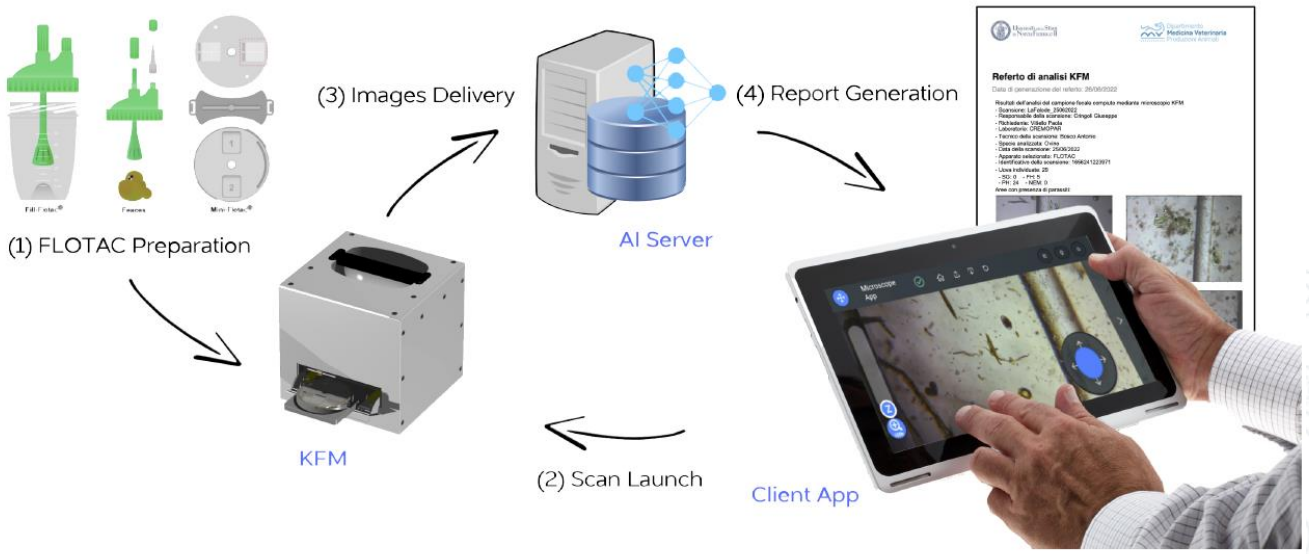
- Methodology:
  - ✓ *Datasets aggregation*. The available single-entity datasets are merged together to build an aggregated multi-entity dataset D_s.
  - ✓ *Retrieval of Teacher predictions*. Each sample in D_s is provided to each teacher as input and the resulting output distributions are stored.
  - ✓ *Distributions aggregation*. A single output distribution is generated by integrating the output distributions from each teacher
  - ✓ *Student Training*. A Student is trained by taking both the ground truth and the knowledge of Teachers into consideration.

Kubic FLOTAC Microscope (KFM)

- The Kubic FLOTAC Microscope (KFM) is a compact, low-cost, versatile, and portable digital microscope designed to autonomously analyze faecal specimens prepared with FLOTAC or Mini-FLOTAC.

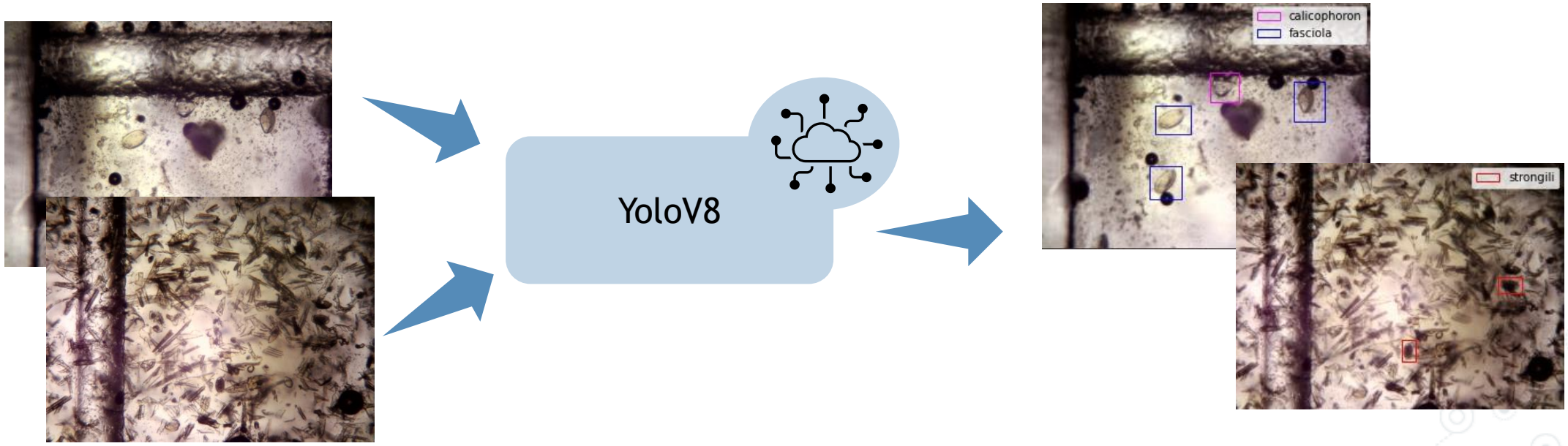
- The KFM is composed of
  - ✓ electro-mechanical components
  - ✓ A firmware that allows remote interactions
  - ✓ external agents which enable users to connect with the KFM hardware

- The device can be remotely controlled by any user with external devices, like smartphones, tablets or PCs, through a dedicated web interface and app



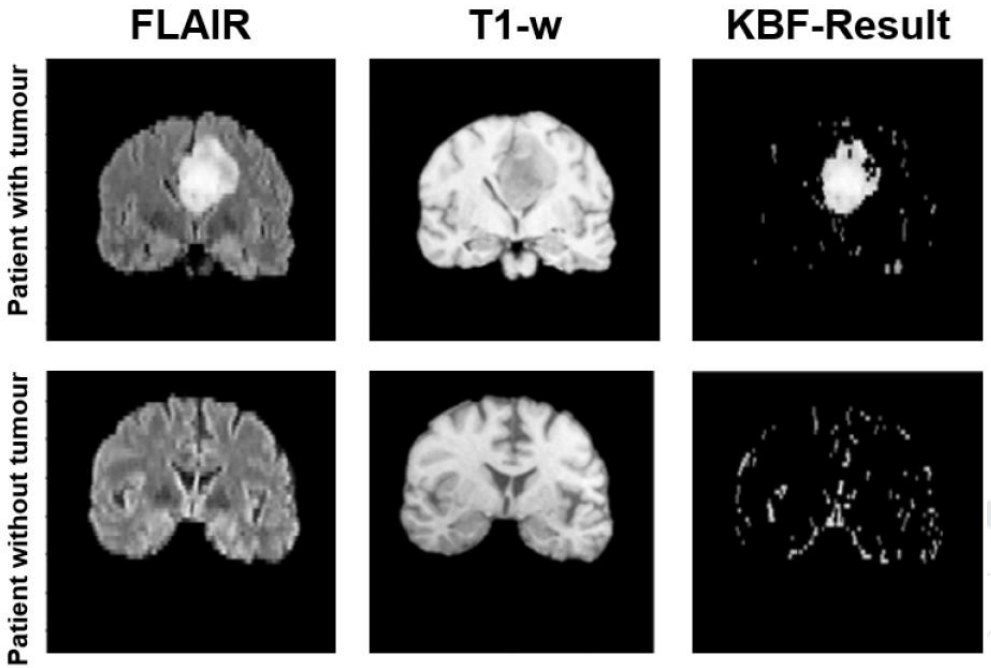
AI Server for Parasites Egg Detection

- Images collected with the KFM can be stored in the KFM AI server and/or transmitted to diagnostic hubs in order to have a quick diagnosis or a parasitological consultation.



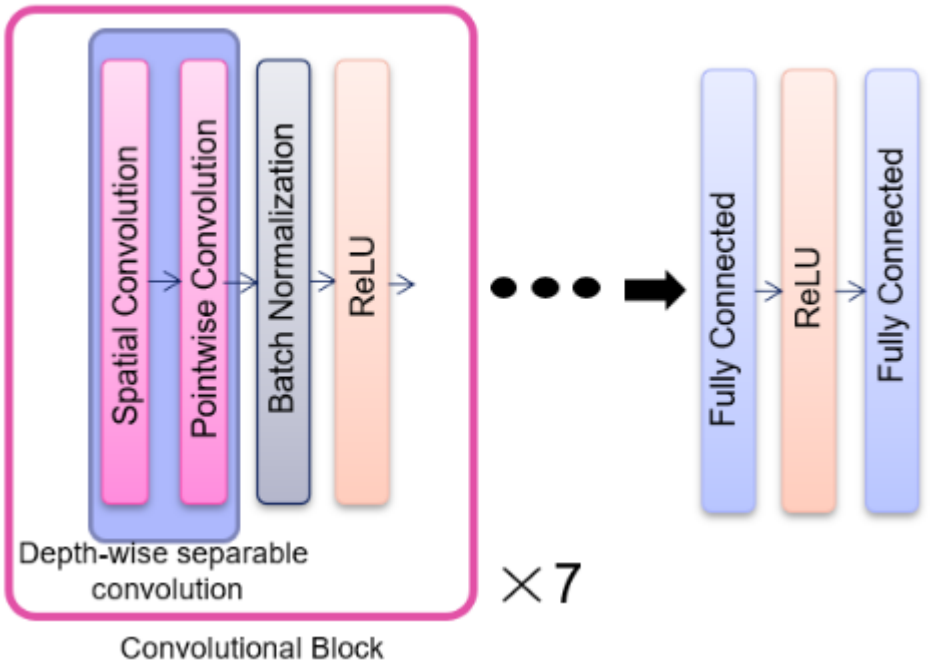
MGMT Promoter Methylation Identification

- Glioblastoma Multiforme (GBM) is known for its extremely low survival rate.
- Alkylating chemotherapy may result inefficient since the O(6)-methylguanine-DNA methyltransferase (MGMT) enzyme repair abilities counter the cytotoxic effects of alkylating agents.
- MGMT promoter regions may be subject to a phenomenon called methylation, a biological process preventing MGMT enzymes from destroying the alkyl agents
- We proposed to select the area of interest in an unsupervised manner, leveraging past medical experience for tumour recognition:
  - ✓ in T1-W slices, tumour areas have pixels whose intensity is higher than cerebrospinal fluids (CSF) but lower than any other kind of tissue
  - ✓ in FLAIR slices, pixels with the highest intensity belong to the tumour region



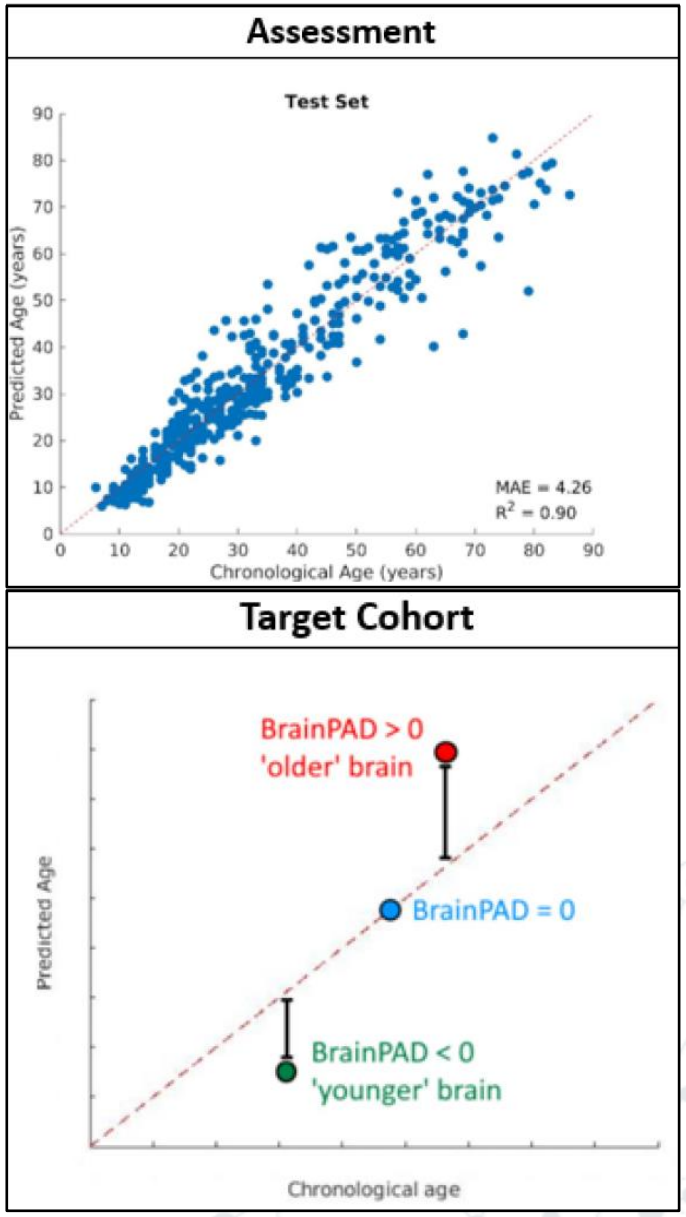
Convolutional Neural Network for identification

- We chose the FLAIR sequence for the good performance shown in the literature
- We adopted a Convolutional Neural Network (CNN) to face the task of MGMT promoter methylation identification.
  - ✓ We built a sequential network from the ground called MGMTClassifier composed of seven Convolutional Blocks and two fully connected layers separated by Rectified Linear Unit (ReLU) as an activation function.
- To reduce the number of training parameters and avoid overfitting at the same time, we adopt depth-wise separable convolution
- This simple but effective DL-based approach is able to outperform state-of-the-art solutions while consisting of less than 0.29% of their parameters (about 10 million of typical CNNs versus 40561 of the proposed approach).



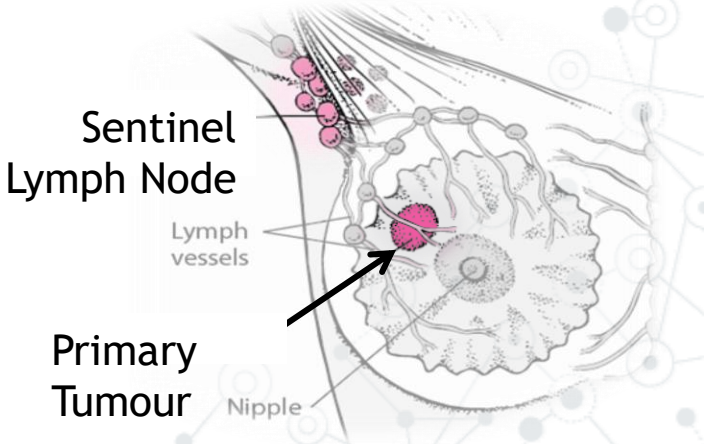
Assessing Brain Health with the Brain-Age Paradigm

- Machine Learning methods are used to model chronological age as a function of structural brain MRI scans in healthy people
- The extent to which each subject deviates from healthy brain-ageing trajectories, expressed as the difference between predicted and chronological age (brain-predicted age difference, brain-PAD), has been proposed as an index of structural brain health, sensitive to brain pathology in a wide spectrum of neurological and psychiatric disorders.
- We applied the brain age paradigm to a target clinical population of patients with Fabry Disease (FD), a rare genetic multisystemic disorder that also involves the brain but lacks quantitative neuroimaging biomarkers.
- Our brain-age model was based on the DenseNet architecture



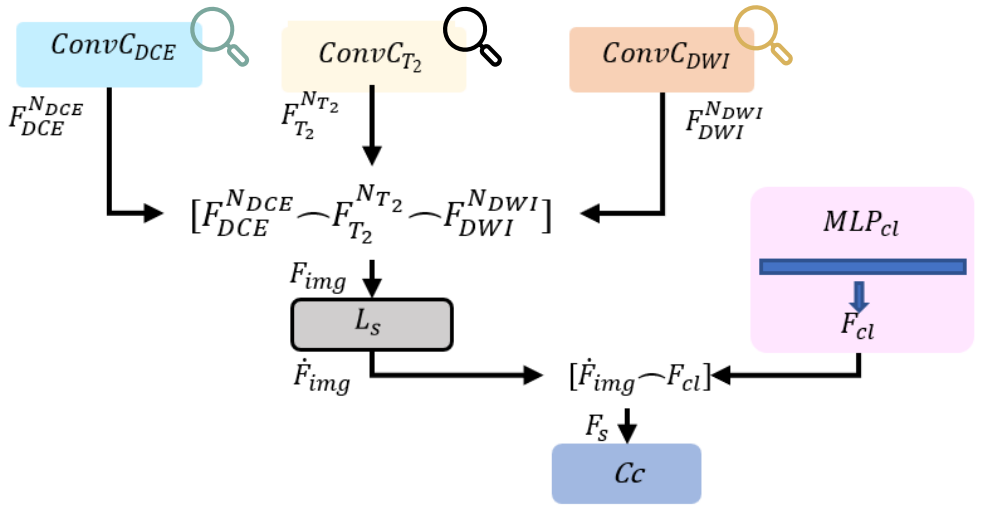
Axillary Lymph Node Status Assessment in Breast Cancer

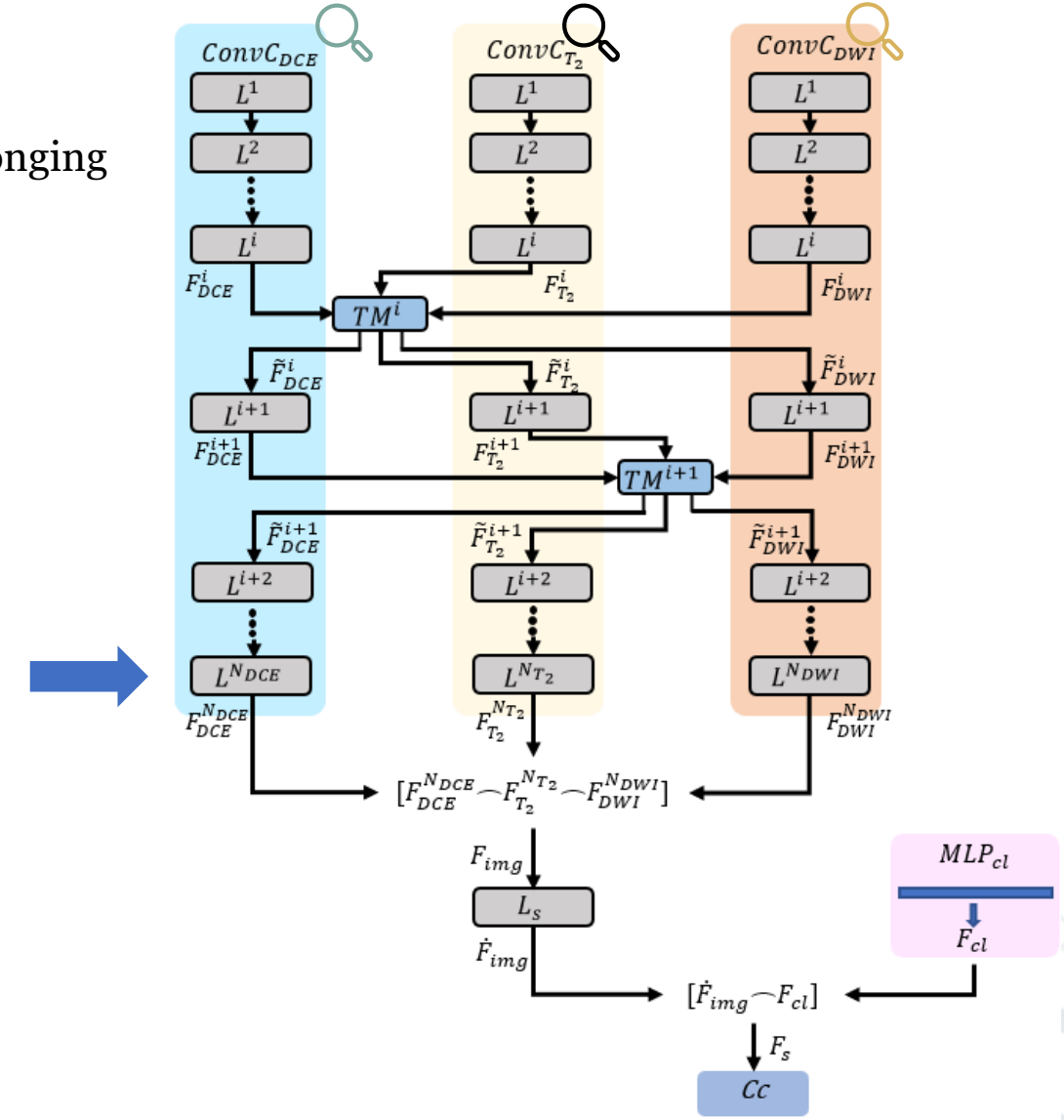
- Breast cancer (BC) is the most diagnosed cancer among women worldwide
- Axillary lymph nodes metastatic involvement, is one of the most important prognostic factors
- Axillary lymph nodes histological exam is the gold standard to determine their involvement in the BC patients:
  - ✓ It is an invasive procedures with complications
- The research activity is in collaboration with Università Campus Bio-Medico of Rome
- Multimodal dataset:
  - ✓ Different Magnetic Resonance Imaging (MRI) sequences:
    - ➢ Dynamic Contrast Enhanced (DCE)
    - ➢ Diffusion Weighted Imaging (DWI)
    - ➢ T2 Weighted
  - ✓ Clinical and Histological features



Multimodal Approach

- Multi Input – Single Output CNN
  - ✓ 4 different inputs: DCE, T2, DWI, CL
  - ✓ The Transfer Module (TM) is inserted between layers belonging to different convolutional cores to take into account the complementary characteristics of the images



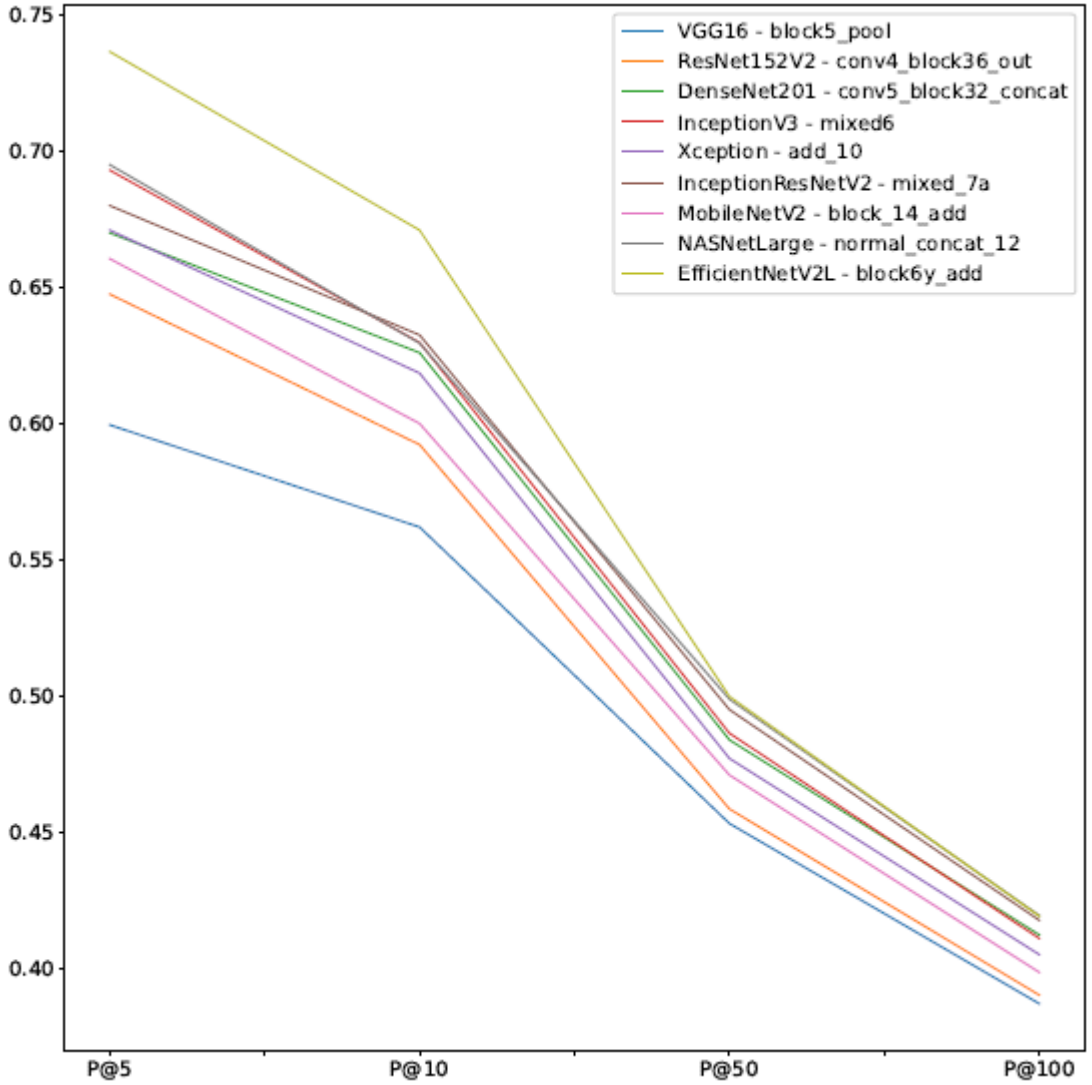


Deep Feature representation for CBIR in smart PACS

- Picture Archiving and Communication Systems (PACSs) represent an actual possibility to archive and organize the growing amount of data in Pathological Anatomy

- The Content-Based Image Retrieval (CBIR) methodology can be involved in the PACSs using a query-by-example task.
  - ✓ One of many crucial points of CBIR concerns the representation of images as feature vectors

- Our study explored different representations by features extracted from pretrained CNNs:
  - ✓ We valuated features extracted from different layers using different dimensionality reduction techniques.
  - ✓ we analyzed intend to understand which dataset category is not correctly retrieved.



Thank you for your attention!