DEEPHEALTH

Deep-Learning and HPC to Boost Biomedical Applications for Health

# Pipelines for Medical Imaging Use Cases & Requirements for Benchmarking

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Evaluation schemes for Big data and AI Performance of high Business impact

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*The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825111.*

# About DeepHealth

## Aim & Goals

- **Put HPC computing power at the service of biomedical applications** with DL needs and apply DL techniques on large and complex image biomedical datasets to support **new and more efficient ways of diagnosis, monitoring and treatment of diseases.**
- Facilitate the daily work and **increase the productivity of medical personnel and IT professionals** in terms of image processing and the **use and training of predictive models** without the need of combining numerous tools.
- Offer a **unified framework** adapted to exploit underlying heterogeneous **HPC and Cloud architectures** supporting state-of-the-art and next-generation **Deep Learning (AI) and Computer Vision algorithms** to enhance European-based medical software platforms.

## Key facts

**Duration:** 36 months
**Starting date:** Jan 2019

**Budget** 14.642.366 €
**EU funding** 12.774.824 €

**22 partners** from **9 countries:**
Research centers, Health organizations, large industries and SMEs

**Research Organisations**

Universitat Politècnica de València · Barcelona Supercomputing Center · list · UNIMORE · Karolinska Institutet · CRS4 · Università degli Studi di Torino · Otto von Guericke Universität Magdeburg

**Health Organisations**

Azienda Ospedaliero-Universitaria Città della Salute e della Scienza di Torino · Fundación para el Fomento de la Investigación Sanitaria y Biomédica de la Comunitat Valenciana · CHUV · Spitalul Clinic Prof. Dr. Theodor Burghele București · Stockholms läns landsting

**Large Industries**

everis (an NTT DATA Company) · PHILIPS · THALES · SIMAVI Software Imagination & Vision

**SMEs**

WINGS ICT Solutions · TREE Technology · prodesign electronic gmbh · security Stelar law research



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# Developments & Expected Results

- **The DeepHealth toolkit**
  - Free and open-source software: 2 libraries + front-end.
    - ***EDDLL**: The European Distributed Deep Learning Library*
    - ***ECVL**: the European Computer Vision Library*
  - Ready to run algorithms on Hybrid HPC + Cloud architectures with heterogeneous hardware (Distributed versions of the training algorithms)
  - Ready to be integrated into end-user software platforms or applications
- **HPC infrastructure** for an efficient execution of the training algorithms which are computationally intensive by making use of heterogeneous hardware in a transparent way
- Seven enhanced **biomedical and AI software platforms** provided by EVERIS, PHILIPS, THALES, UNITO, WINGS, CRS4 and CEA that integrate the DeepHealth libraries to improve their potential
- Proposal for a structure for anonymised and pseudonymised data lakes
- **Validation** in 14 use cases (*neurological diseases, tumor detection and early cancer prediction, digital pathology and automated image annotation*).



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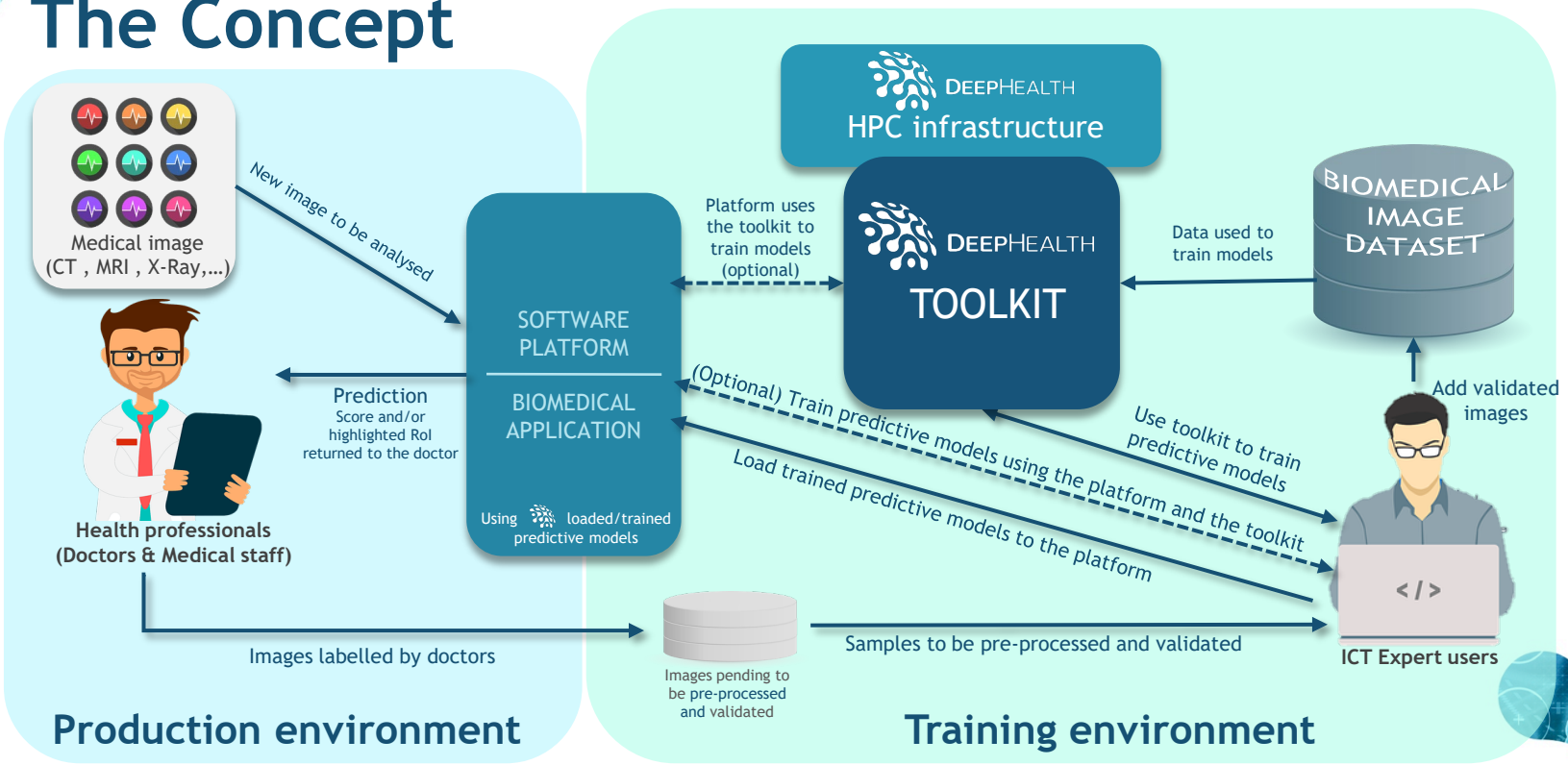
# The Concept



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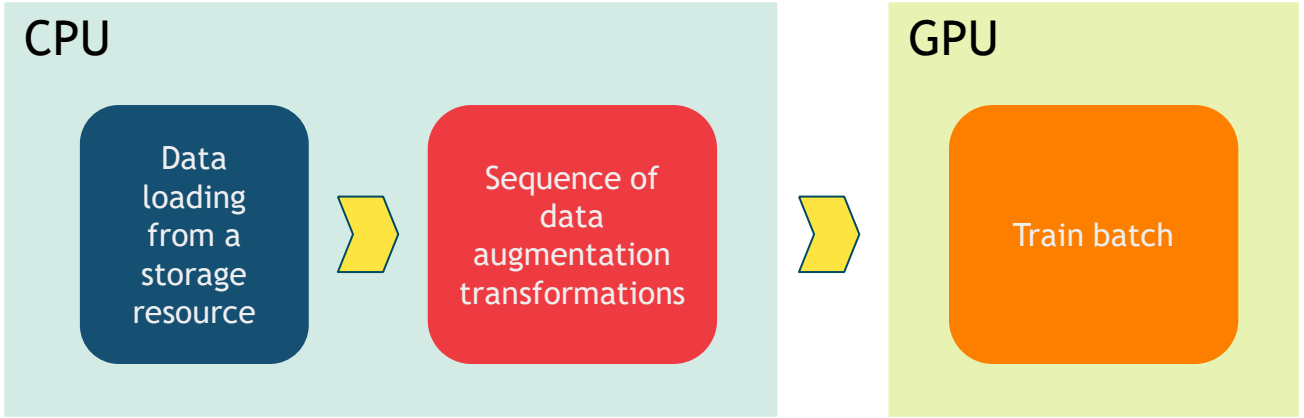
# Pipeline Definition

What do we understand by pipeline in this context?

A **pipeline** is a set of operations **sequentially applied** to a data block (subset of samples)



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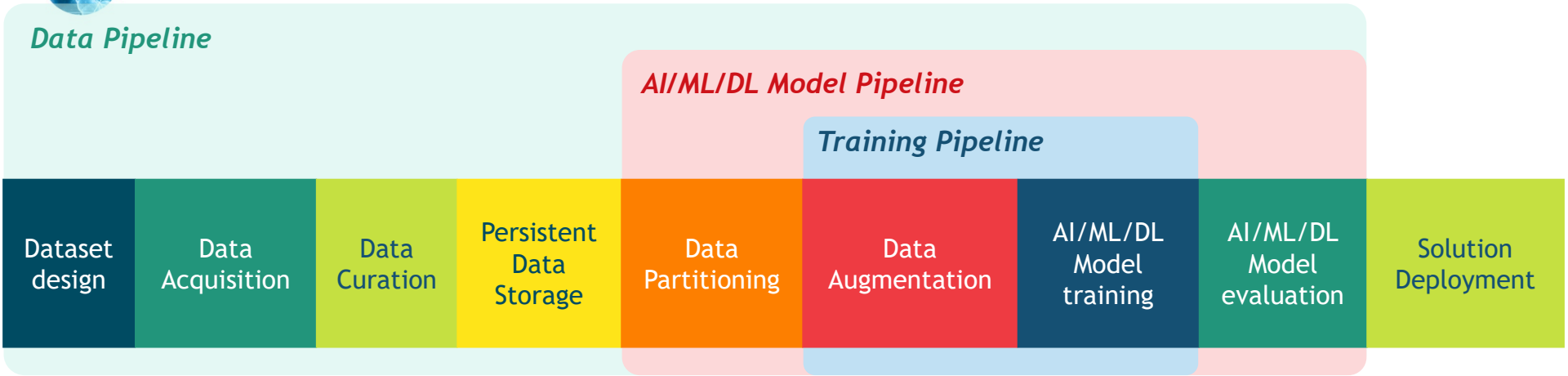
# Data & Model Pipelines




***Training Pipeline*** *is at the core of the* ***Model Pipeline*** *which in turn* is considered part of the ***Data Pipeline***

Both pipelines are suitable for business and research applications

The whole ***Data Pipeline*** is applicable to any sector. Our project is focused on the Health sector



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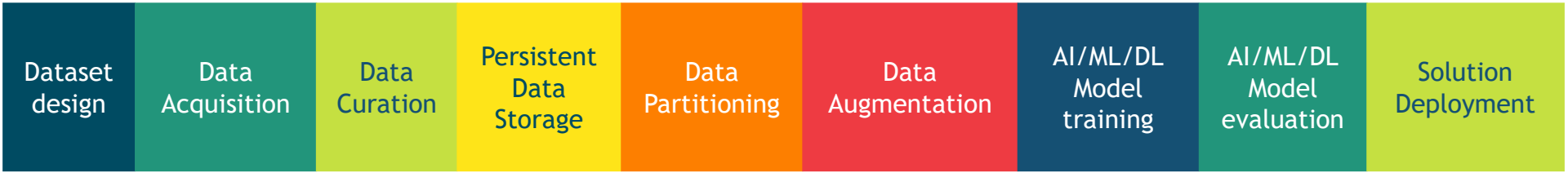
# Data & Model Pipelines – Dataset Design




- Data types and formats –identification and definition
- Metadata definition
- Data Lake structure definition
- Guidelines / HOW-TOs
- Etc.



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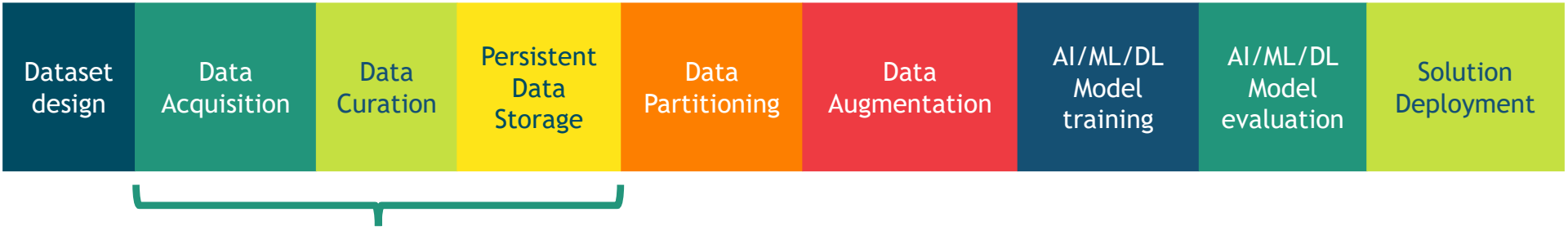
# Data & Model Pipelines – Acquisition + Curation + Storage




- Data acquisition continuum
- Data cleansing/cleaning/wrangling/crunching
- Aggregated data/values computation
- Implementation of the data-lake definition
- Creation of users and permissions or make data public



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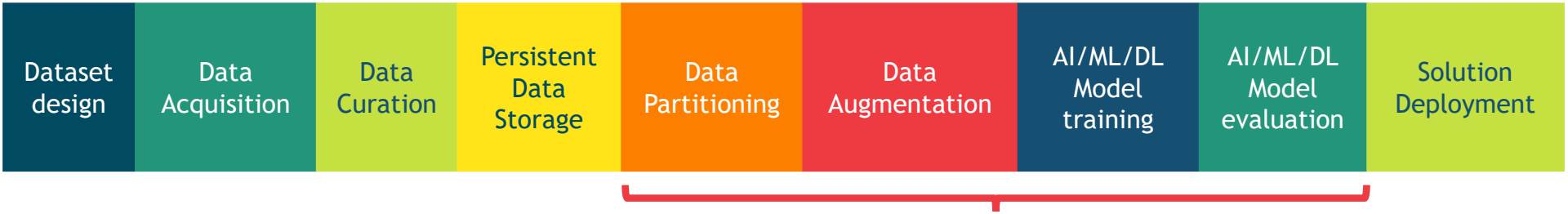
# Data & Model Pipelines – Model Pipeline




Model training loop:

- Partitioning in training/validation/test subsets
- Data augmentation on-the-fly
- Training and evaluation of models
- Cloud & High Performance Computing requirements



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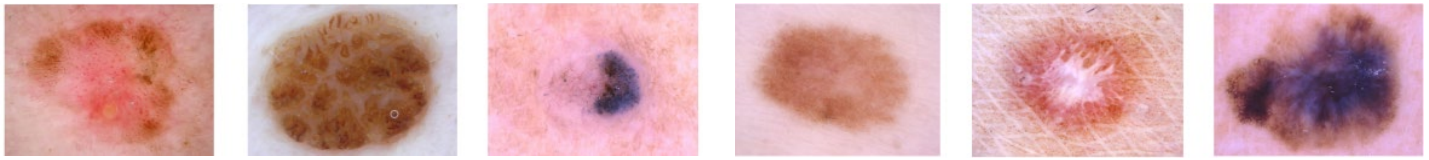
# Skin Lesion Detection and Classification

- Use case nº 12 of the DeepHealth project is based on the International Skin Imaging Collaboration dataset
- Aims: identification (**segmentation**) and diagnosis (**classification**) of skin lesion images among different classes



*Actinic Keratosis* | *Benign Keratoses* | *Basal Cell Carcinoma* | *Nevus* | *Dermatofibroma* | *Melanoma*

- Dataset design
- Data Acquisition
- Data Curation
- Persistent Data Storage

- Retrospective acquisition
- 23.906 annotated images
- Publicly available on the ISIC archive website
- jpeg data format

- Data Partitioning
- Data Augmentation
- Model training
- Model evaluation

- Training 19.000
- Validation 906
- Test 4.000



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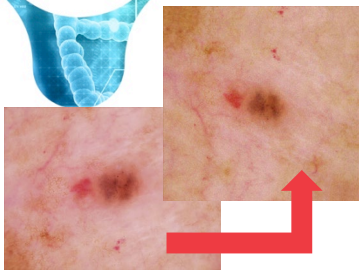
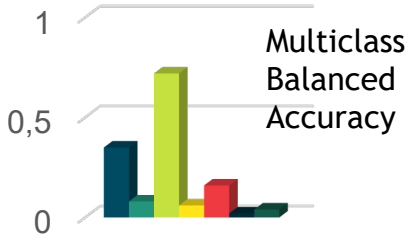
# Skin Lesion Detection and Classification



Performed using the DeepHealth toolkit. Models are already available in the front-end.

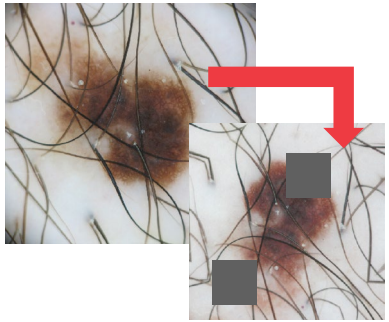
ECVL DEEPHEALTH EDDL



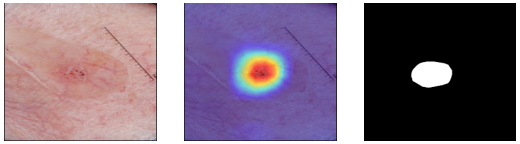

Data Augmentation

AI/ML/DL Model training

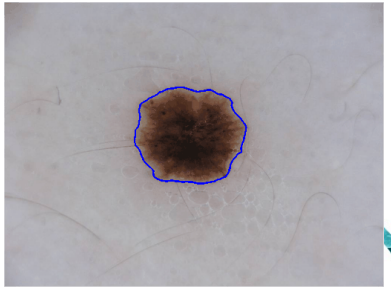
AI/ML/DL Model evaluation



**Explainability** plays a fundamental role in this context. Ensuring **Confidence Calibration** and providing a **Visual Explanation** of the models is essential to support clinicians.



Jaccard Index
(Intersection over Union)





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# Needs & Requirements

**Evaluate datasets in terms of**

1. **Findability** – where should a data scientist search for the dataset?
2. **Availability** – how long does a data scientist need to start the initial exploratory data analysis?
3. **Interoperability** – how long does a data scientist need to start training AI/ML/DL models with a dataset?
4. **Reusability** – are previously obtained results with a dataset public and available to other researchers / data scientists?
5. **Privacy / Anonymisation** – can the dataset be made public without compromising the identity of individuals?
6. **Quality** – is the dataset biased or unbalanced? What procedure has been followed to validate annotations?



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# Needs & Requirements

**Evaluate Deep Learning libraries in terms of**

1. **Speed-up** – is distributed learning really efficient?
2. **Convergence** – does the distributed learning reach the same model accuracy in less time?
3. **Usability** – how long does a developer need to use the libraries effectively?
4. **Integrability** – how difficult is it to integrate the libraries as part of solutions to deploy?
5. **KPIs**: time-of-training-models (**totm**), performance/power/accuracy trade-off, etc.
6. **Others** – can you help us to evaluate other aspects?



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# Needs & Requirements

**Evaluate Software Platforms in terms of**

1. **Usability** – how long does a domain application expert need to manage the software tool effectively?
2. **Completeness** – does the application platform provide all the algorithms/procedures/functions to allow domain application experts to easily define the sequences of steps to implement the data and/or model pipelines?
3. **Compatibility** – how many data formats does the platform admits to import/export data and models from/to other frameworks?
4. **KPIs**: time-to-model-in-production (**ttmip**), time-of-pre-processing-images (**toppi**), etc.
5. **Others** – can you help us to evaluate other aspects?



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# Questions?


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**https://deephealth-project.eu**

@DeepHealthEU


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