CHUV use case E-Brainscience

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E-Brainscience: Team

Ferath Kherif, PhD
Brain researcher
Expertise in:
   Cognitive science
   Computer science
   Neuroscience

Adeliya Latypova, PhD
Biomedical researcher
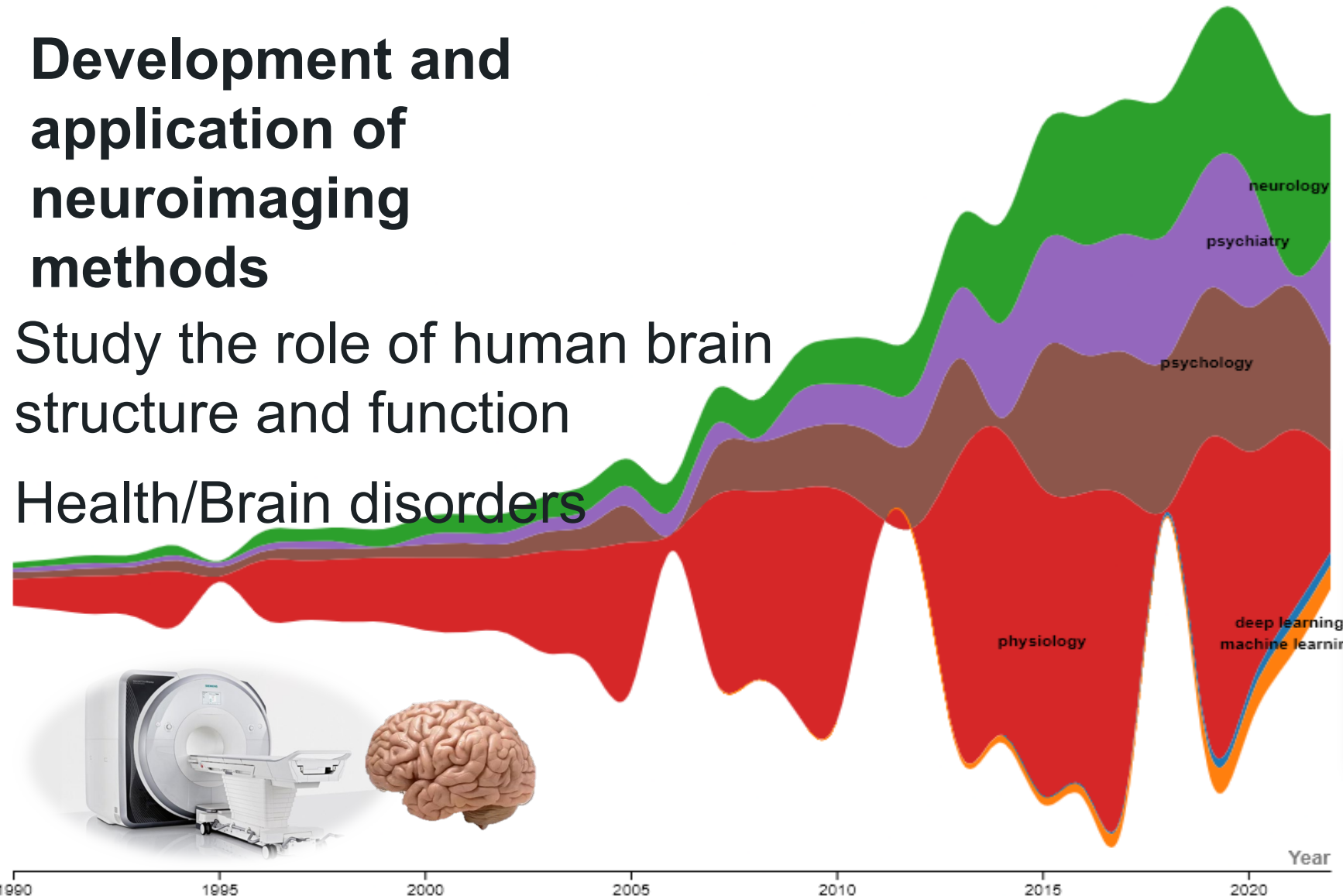Expertise in:
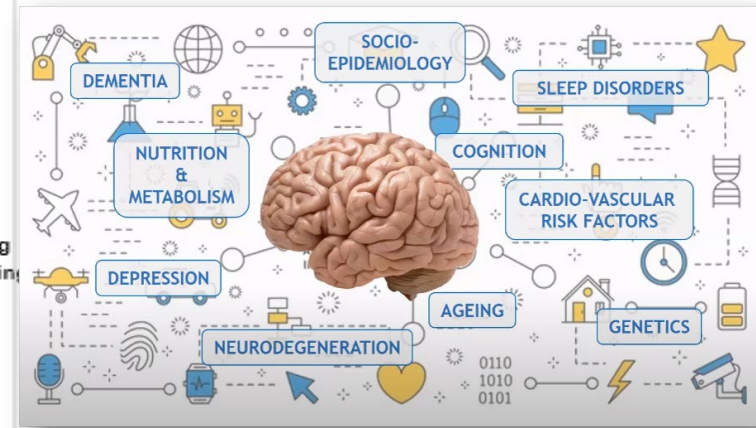   Biomechanical Engineering
   Computer science
   Bioinformatics

E-Brainscience

Development and application of neuroimaging methods

Study the role of human brain structure and function

Health/Brain disorders

Challenges

➤ Significant increase in the number of **complex data sets**.

➤ Data processing applications are **fragmented** and desktop-based.

➤ **Lack of** standardized scalable easy-to-use **preprocessing workflow**

➤ Difficulty conduct collaborative studies & ensure privacy

The **infrastructure** is not considered, and neither are the **deployment** strategies

E-Brainscience

Users

Neuroscientists in research labs

Clinical researchers in Hospitals

Large research data centres

UC1 - Image preprocessing App

- Workflow aimed on image preprocessing and **brain feature generation** for futher analysis and model building
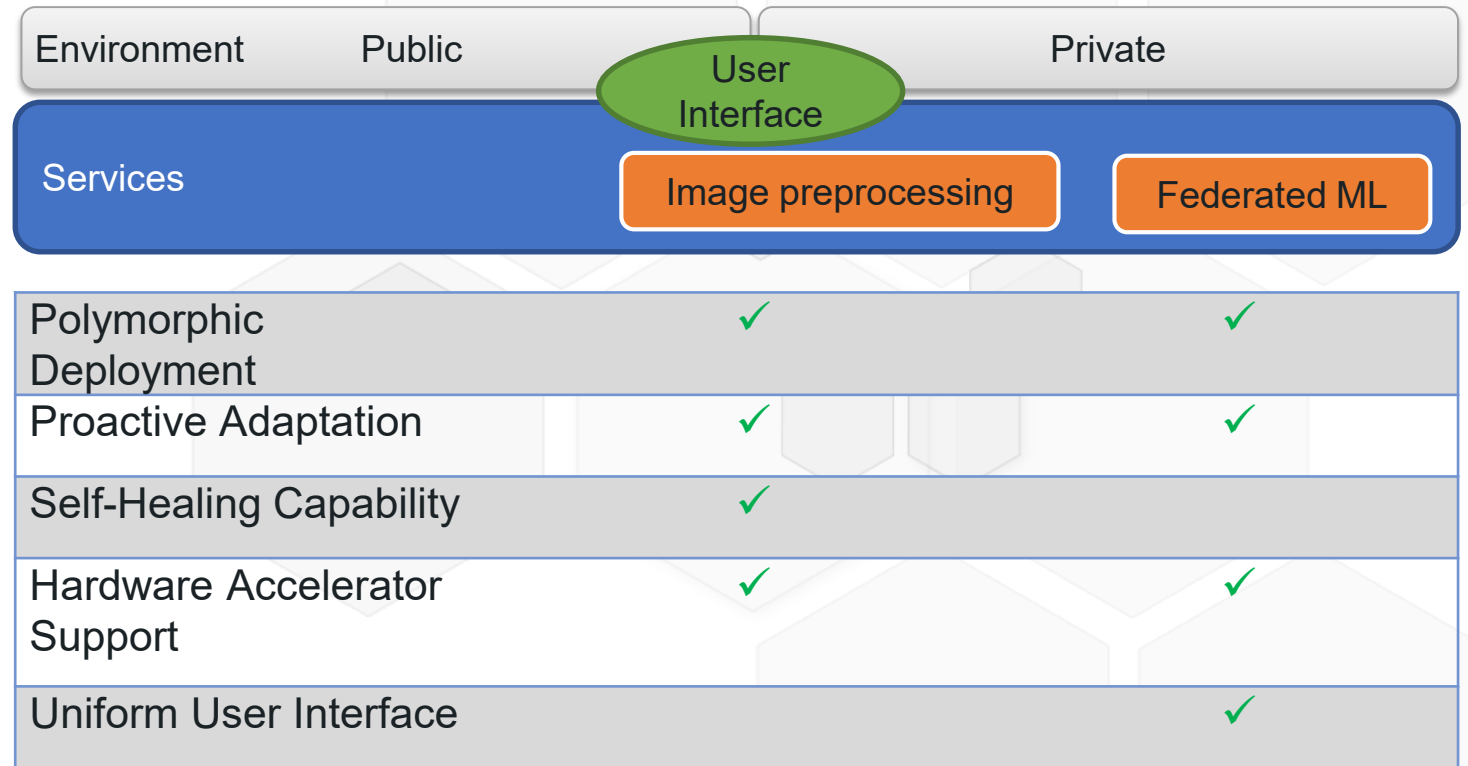
UC2 – Federated ML

- Building, estimation and comparson of **ML models on distributed data** in security and privacy preserving mode
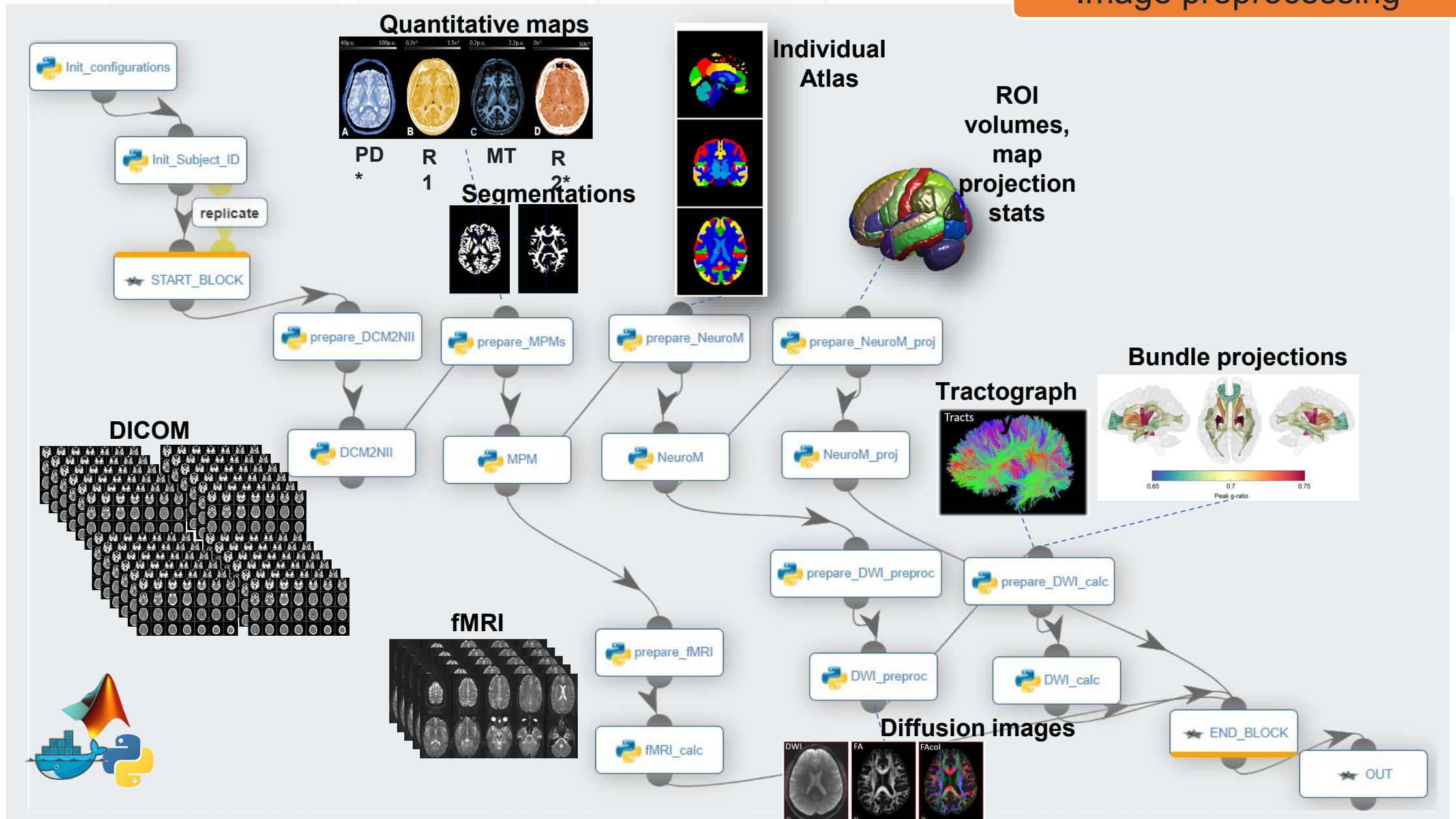
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E-Brainscience with MORPHEMIC
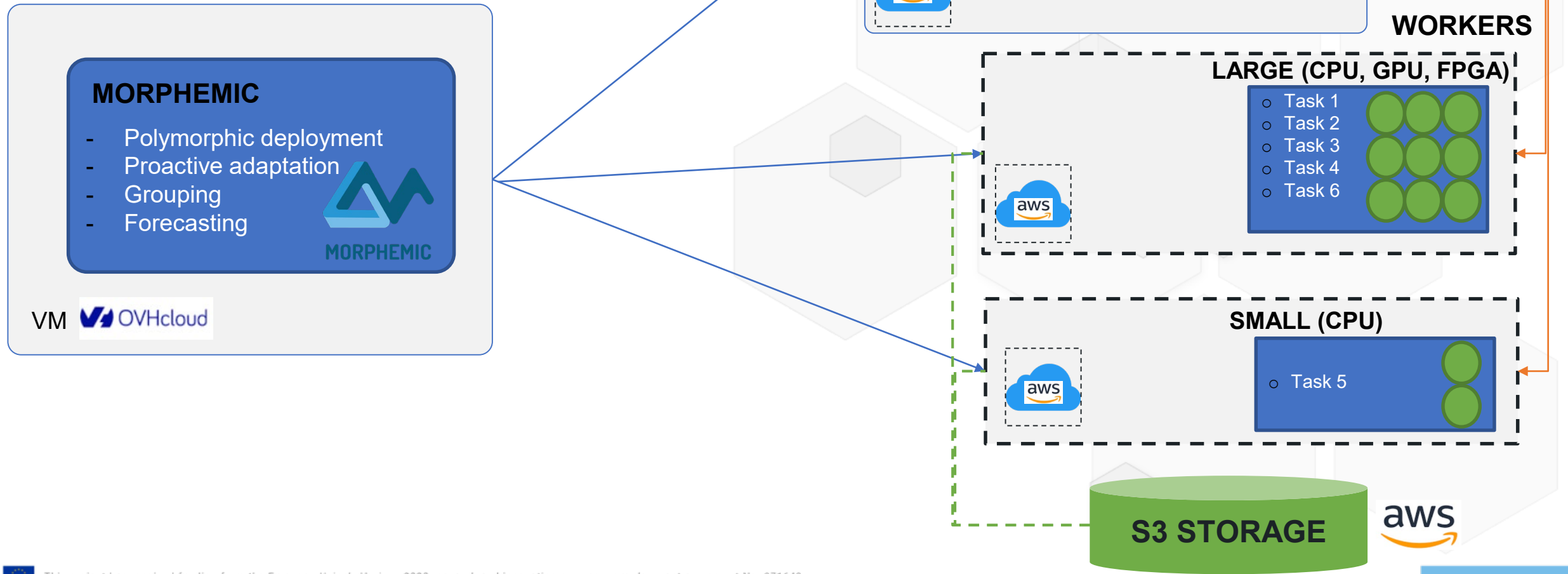
Our requirements

- Optimal application deployment: time vs cost

- Possibility to deploy different type of hardware (e.g. CPU, GPU, FPGA)

- Easy management

- Security

MORPHEMIC features

Environment	Public		Private
		User Interface	
Services		Image preprocessing	Federated ML
Polymorphic Deployment	✓		✓
Proactive Adaptation	✓		✓
Self-Healing Capability	✓		
Hardware Accelerator Support	✓		✓
Uniform User Interface			✓

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MORPHEMIC

Init_configurations

Init_Subject_ID

replicate

START_BLOCK

Quantitative maps

PD* R1 MT R2*

Segmentations

Individual Atlas

ROI volumes, map projection stats

prepare_DCM2NII

prepare_MPMs

prepare_NeuroM

prepare_NeuroM_proj

Bundle projections

Tractograph

Tracts

Peak g-ratio
0.65 0.7 0.75

DICOM

DCM2NII

MPM

NeuroM

NeuroM_proj

prepare_DWI_preproc

prepare_DWI_calc

fMRI

prepare_fMRI

DWI_preproc

DWI_calc

fMRI_calc

Diffusion images

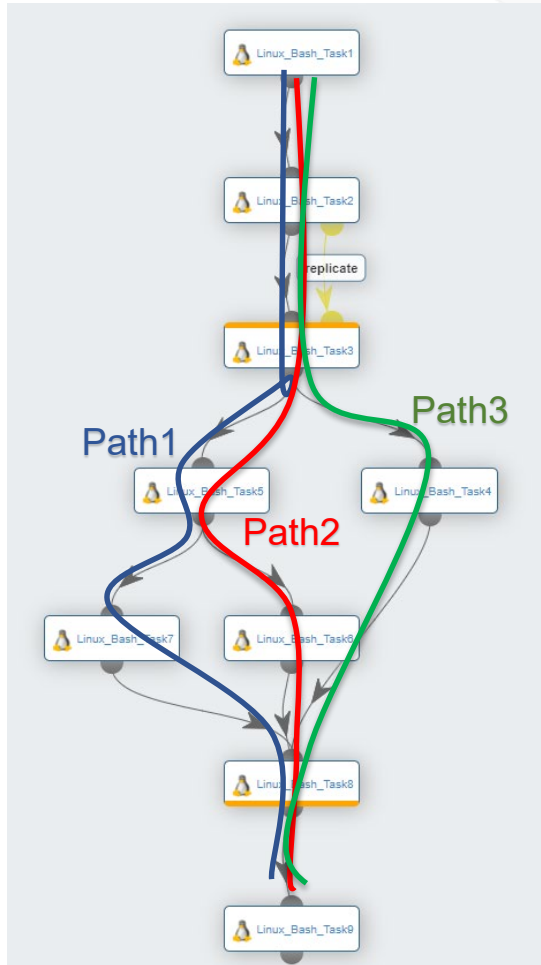DWI FA FAcol

END_BLOCK

OUT

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App architecture

Optimization: Metrics and Utility modelling

Workflow_duration

- Workflow duration in ideal case (infinite node available, no tasks pending) : critical path method
  - `Ref_workflow_duration`

- `Deadline` is a desired time to finish the job (e.g. 5 hours) or «ASAP» (= `Ref_workflow_duration`)

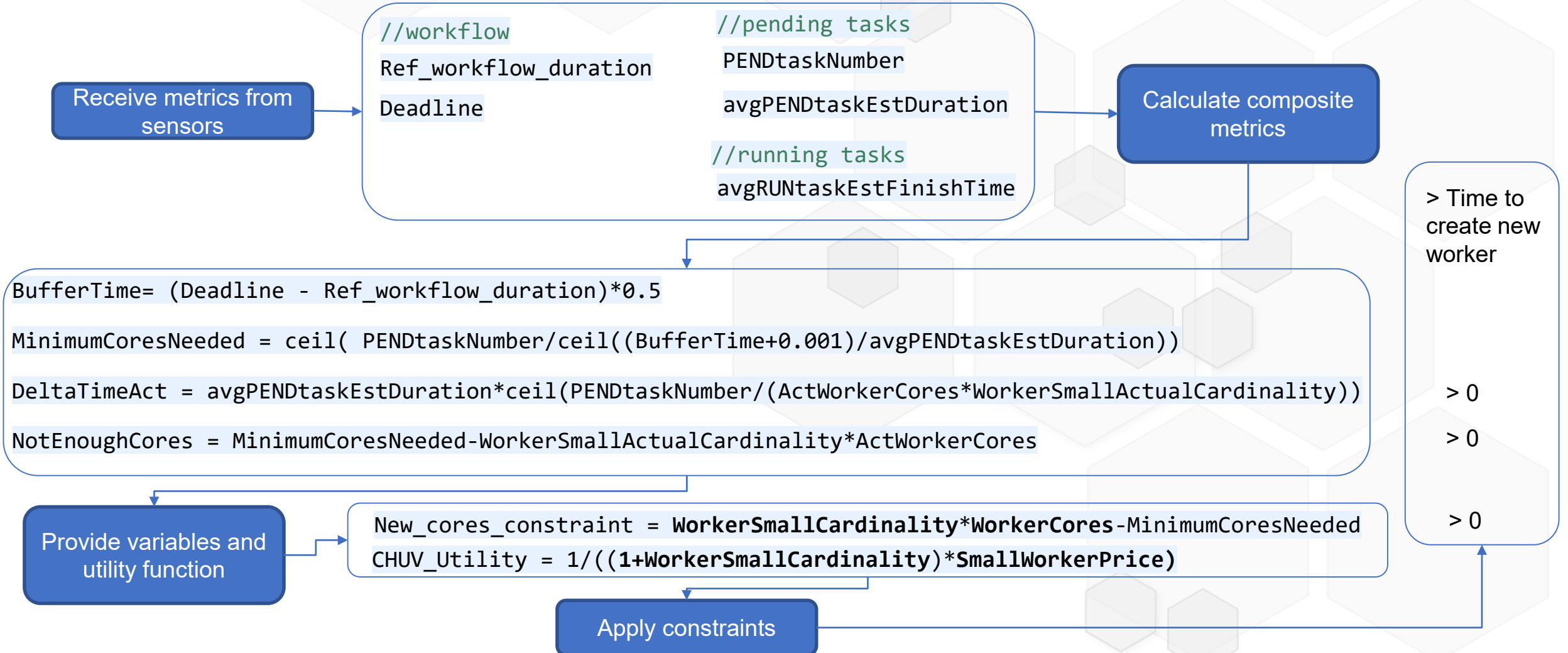- *BufferTime* = `Deadline - Ref_workflow_duration`

On runtime:

```
//running tasks
avgRUNtaskEstFinishTime
//pending tasks
PENDtaskNumber
avgPENDtaskEstDuration
```
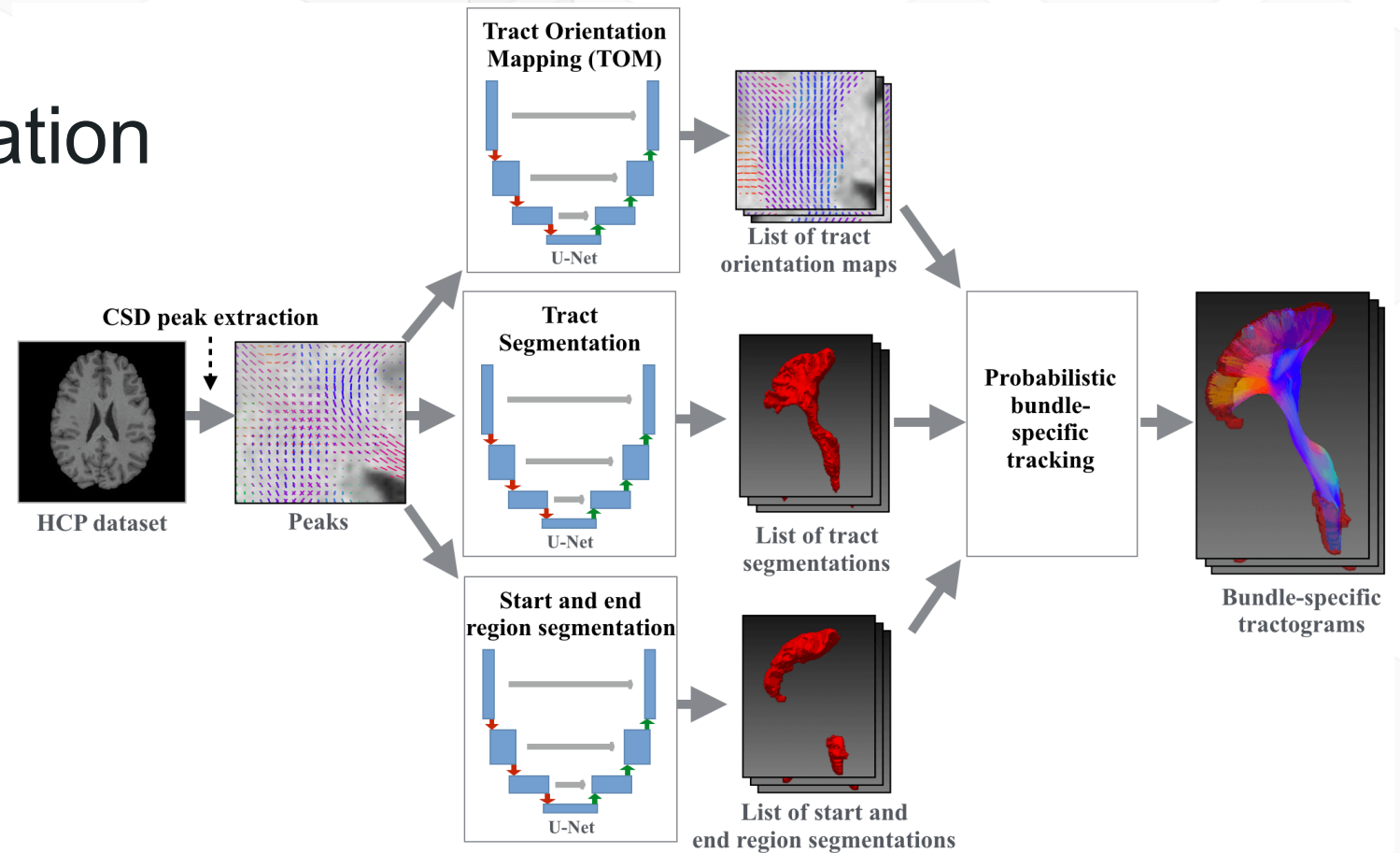
- Aim : estimate /predict/ forecast

Minimum cores needed to run without delay
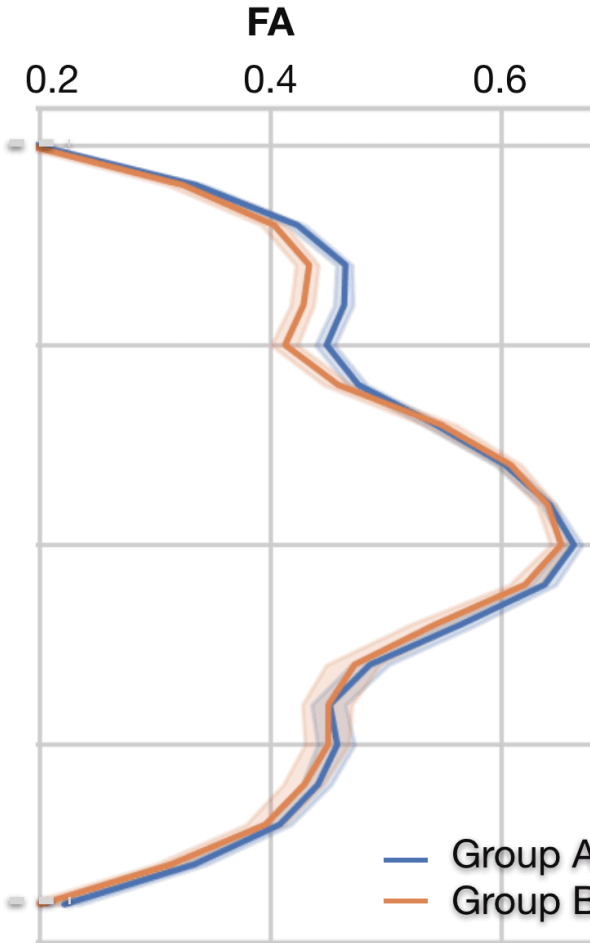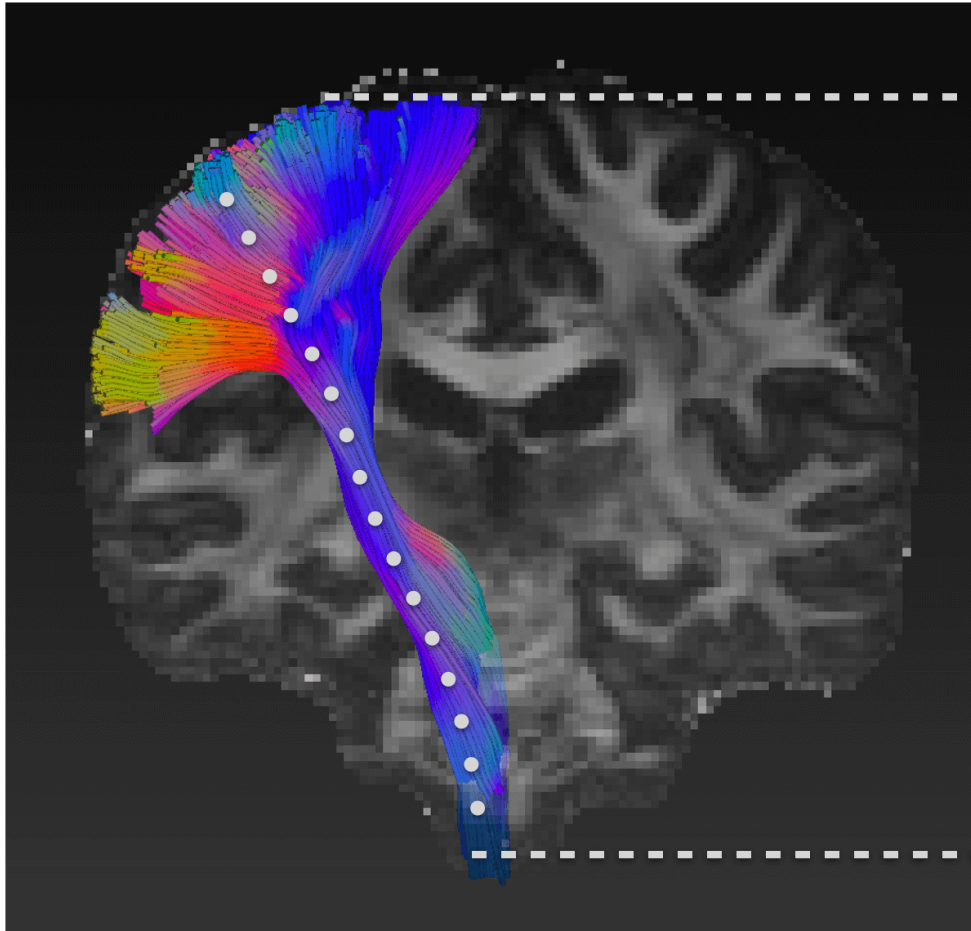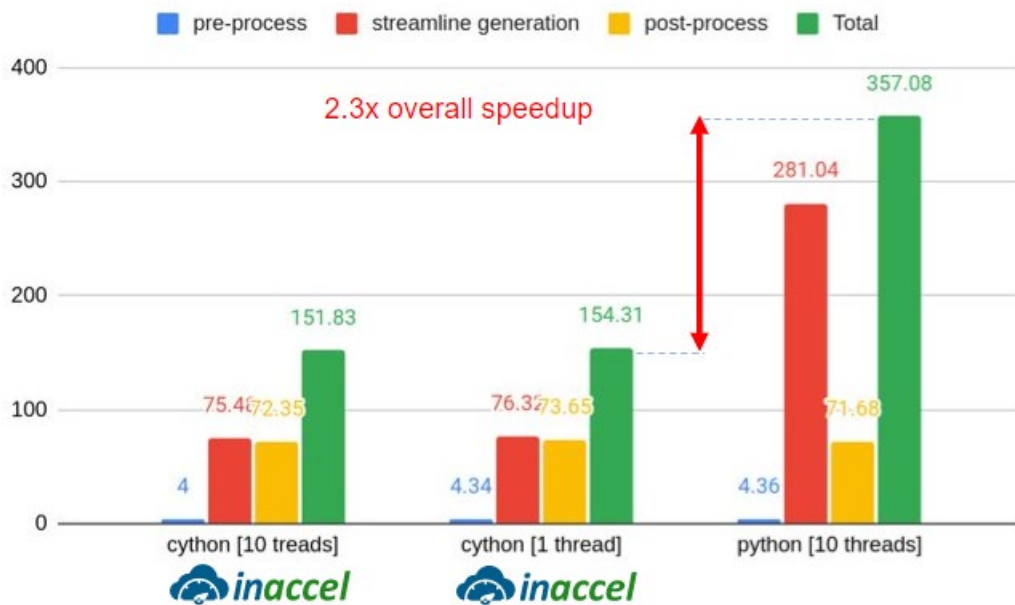
Strategy: Reconfiguration

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```
//workflow
Ref_workflow_duration
Deadline
```

```
//pending tasks
  PENDtaskNumber
  avgPENDtaskEstDuration
```

```
//running tasks
  avgRUNtaskEstFinishTime
```

Receive metrics from sensors

Calculate composite metrics

```
BufferTime= (Deadline - Ref_workflow_duration)*0.5

MinimumCoresNeeded = ceil( PENDtaskNumber/ceil((BufferTime+0.001)/avgPENDtaskEstDuration))

DeltaTimeAct = avgPENDtaskEstDuration*ceil(PENDtaskNumber/(ActWorkerCores*WorkerSmallActualCardinality))

NotEnoughCores = MinimumCoresNeeded-WorkerSmallActualCardinality*ActWorkerCores
```

> Time to create new worker

> 0

> 0

> 0

Provide variables and utility function

```
New_cores_constraint = WorkerSmallCardinality*WorkerCores-MinimumCoresNeeded
CHUV_Utility = 1/((1+WorkerSmallCardinality)*SmallWorkerPrice)
```

Apply constraints

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Acceleration

TractSeg: White matter segmentation

https://github.com/MIC-DKFZ/TractSeg#tractseg

TractSeg: Tractometry

➢ Projection of bundles on the quantitative maps

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Acceleration

➤ White matter tractometry with TractSeg
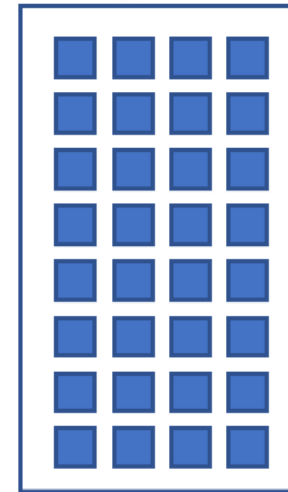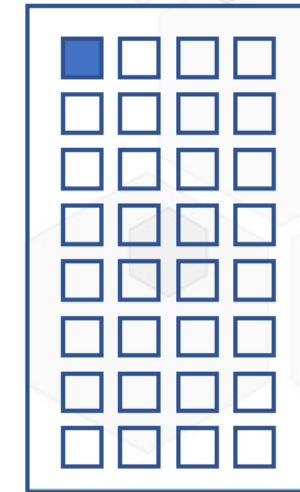
➤ 2 times speedup!

Conclusions

➢ We contributed MORPHEMIC EU project by building E-BRAINSCIENCE tools

➢ Tools support heavy pipelines or federated learning across hospitals and clinics

➢ Minimizing costs and energy consumption

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