Use of **Generative Models** in **Biomedical** Imaging

Telecom Paris, Dpt Image-Data-Signal (France)

Collège de **l'Académie Nationale de Médecine**

Columbia University, Dpt of Biomedical Engineering, (New York, USA)

Imperial College London, Faculty of Medicine (UK)

Our BIOMED Group

Biomed Team & Collaborators


Elsa Angelini


Pietro Gori


Loic Le Folgoc


Maxime Di Folco

- Within the **Image-Data-Signal Department**
- 3 faculty + ~15 PhD students + ~3 post-docs/RE focused on health data
- Several **co-supervisions within Telecom faculties**.
- External co-supervisions: hospitals, imaging manufacturers, startups, big pharma, others
- Strong **international** network of collaborators

AI Algorithms + …. fundamental **models** on anatomical/biological knowledge + image **physics** + "smart" **mathematical** formulation of a given task:

Collaborators

SKAIROS Simulate all, keep the best
Primaa
PHILIPS Healthcare
BIOSPACE LAB
INCEPTO
Guerbet
INSTITUT PASTEUR
NeuroSpin
IMT Atlantique
Institut Langevin
Centre hospitalier Sainte-Anne

International

Columbia University in the City of New York
Imperial College London
Harvard Medical School
Politecnico di Torino
Stevens

PARIS-SACLAY CANCER CLUSTER
FRANCE INNOVATION CANCER

AI Tasks

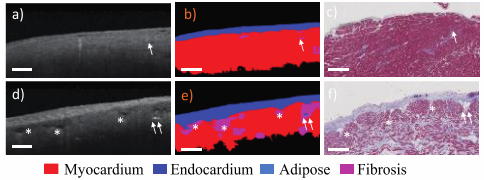
Deep Learning in Medical Imaging

➔ **The deep-fake for good intentions!**

Segmentation

Angelini. MICCAI'20

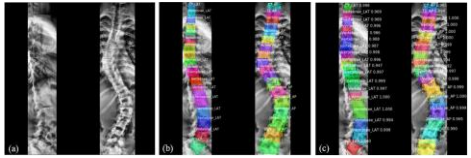
Cardiac fibrosis



OCT

Angelini. ESJ'19

Scoliosis

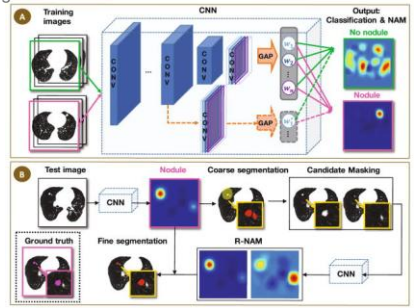


X-rays

Angelini. MICCAI'17

Lung tumor

CT scans



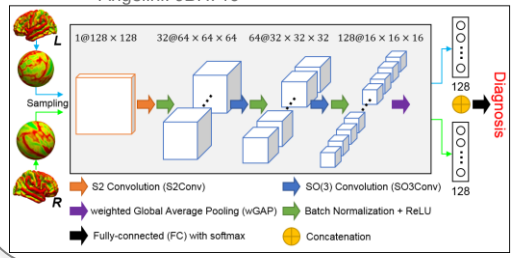
Classification

- classification in 3 classes: AD, MCI, HC

Alzheimer's disease

MRI

Angelini. JBHI'19

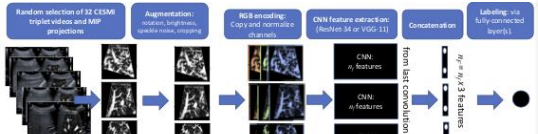


Disease Scoring

Liver fibrosis

Ultrasound videos

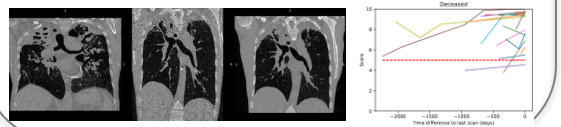
Angelini, ISBI'19



Angelini, ISBI'19

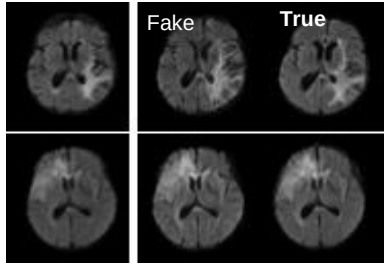
CT scans

Lung fungal disease



Generative models

Predict an "unseen" exam



Brain tumor

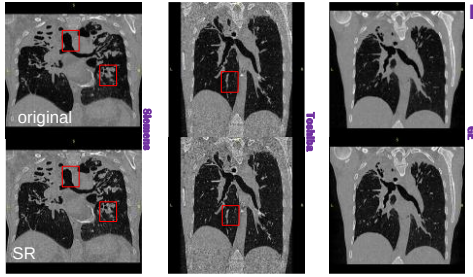
MRI

Case #1

Case #2

T0 **T0+3months = progression?**

Predict Super-Resolution version



Lung disease

CT scans

Angelini, ISBI'19

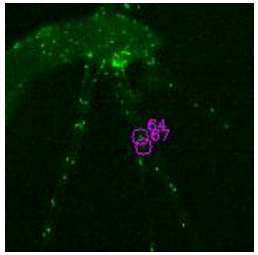
AI Tasks

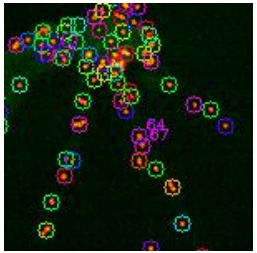
Deep Learning in Biological Imaging

Particle tracking

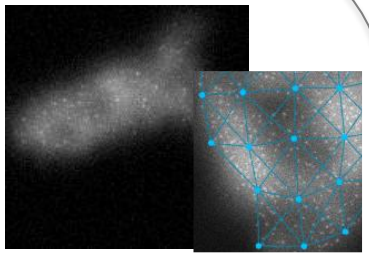
Live animal: Hydra Vulgaris

Fluorescence on neurons



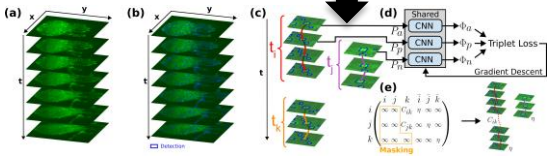


[Lack of manual gt]



Simulator with realistic deformations

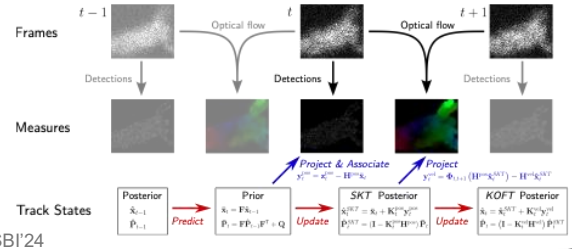
Contrastive **SSL**



Angelini. ISBI'23

DL

Kalman
Optical Flow
Tracking

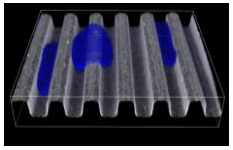


Angelini. ISBI'24

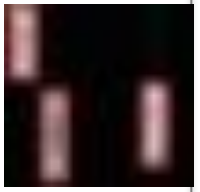
Phenotyping

Micro-groove cell imaging

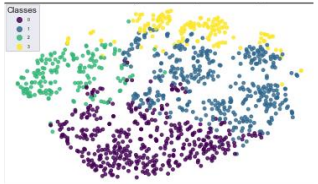
Fluorescence on nuclei

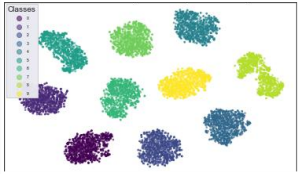


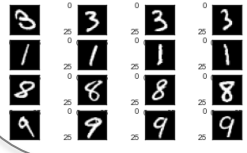
DL **Cellpose** Segmentation

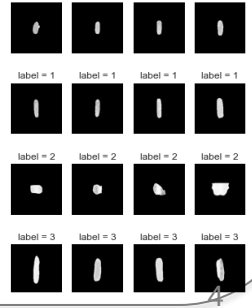


cVAE for WT vs mutants cells phenotyping

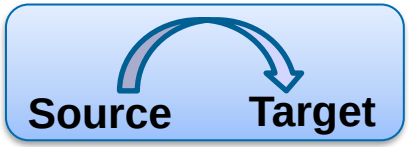








FOCUS: AI Generative Modeling to infer non-acquired medical image modality



?

- No hallucinations ?
- Clinical benefits ?

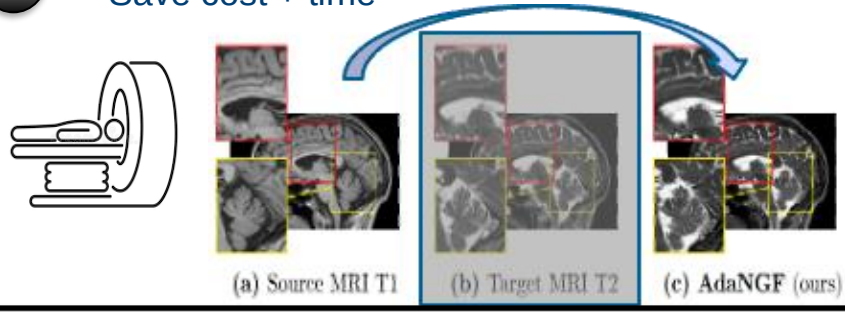
PhD thesis - IMT F&R
Kevin Giraldo Paniagua.
Sup: E. Angelini +,
(+ PH Conze et V. Jaouen)

IMT Atlantique

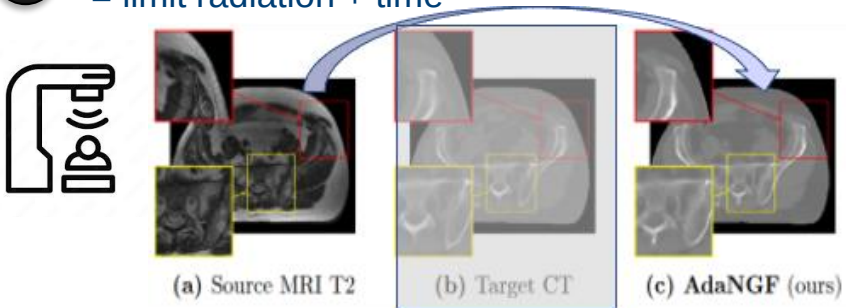
All using open-access data + unpaired training

2 paper presentations @IEEE ISBI'26:

1 → **MRI -> MRI**: infer T2 from T1 sequence
= Save cost + time



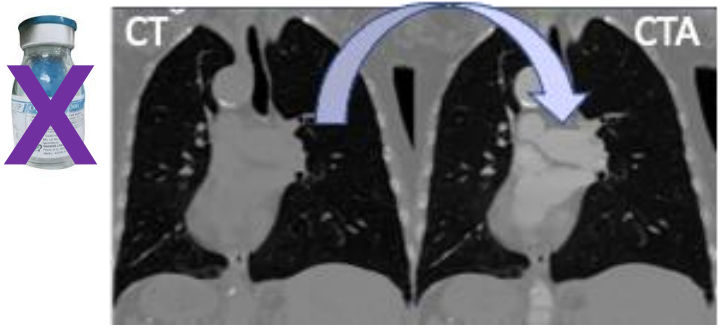
2 → **MRI -> CT**: infer complementary modality
= limit radiation + time



Specificities of our AdaNGF method:

- **Edge-Aware** GAN with « smart » enhancement of fine anatomic structures from source to target imaging modality. .
- Fully unsupervised: Easier to setup [but more challenging to trai

3 → **CT -> CTA**: infer **contrast agent** in blood vessels
= limit patient's risks + costs



FOCUS: AI Generative Modeling to infer Super-Resolved biological images

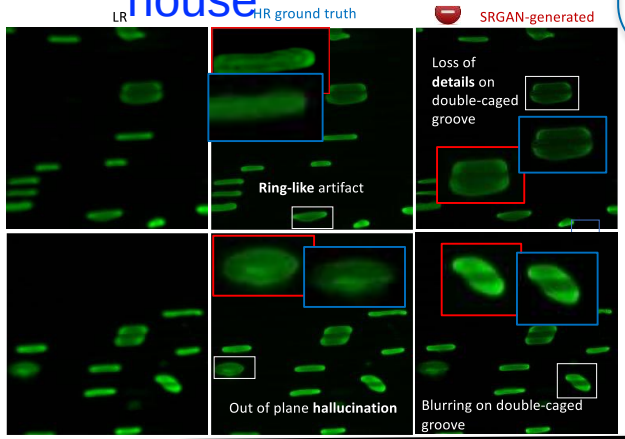
PhD thesis – IPParis ED
Xingjian Zhang.
Sup: E. Angelini +,
(+ A. Barakat

1 paper presentation @IEEE ISBI'26

LOG-SPACE FREQUENCY LOSS FOR BIOIMAGE RESTORATION

- **ESRGAN** Generator
- **PatchGAN** Discriminator

Acquired in-house

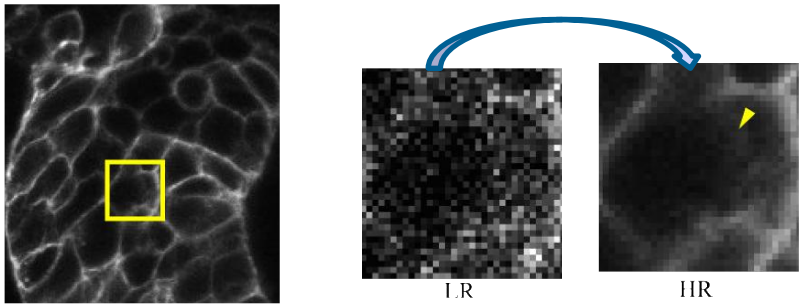


1 Out-of-focus **deformed nuclei**

➔ **Harmonise** "Screening conditions" (user + batch effect)

➔ Need for **translation** to lower image quality => portable device

2 Noisy **zebrafish** embryo

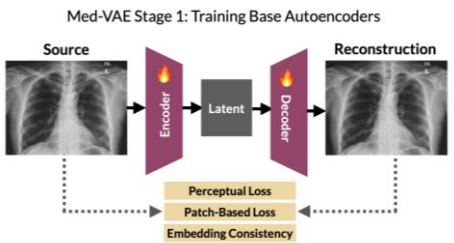


FOCUS: Other current usage of AI Generative Modeling

Auto-encoders

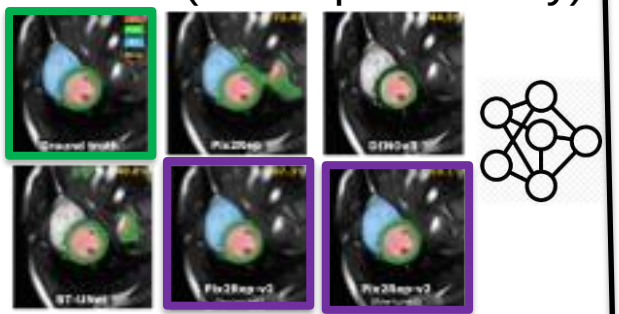
1 Augment **training** data

MedVAE



Stanford Univ. 2025 + 1M images

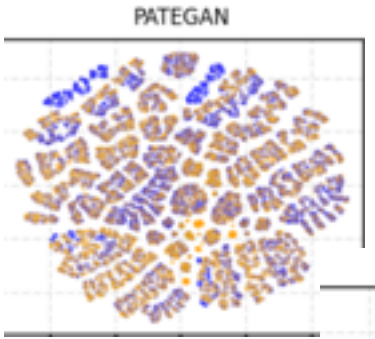
2 **Constrain** segmentation results (**XAI** = plausability)

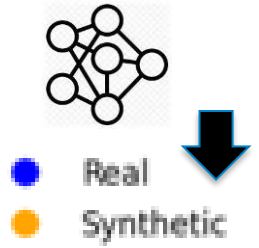


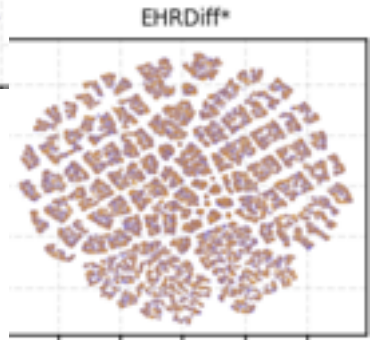
Pix2Rep

3 **Share** "anonymised" copy of health cohorts (Neonatal EHR)

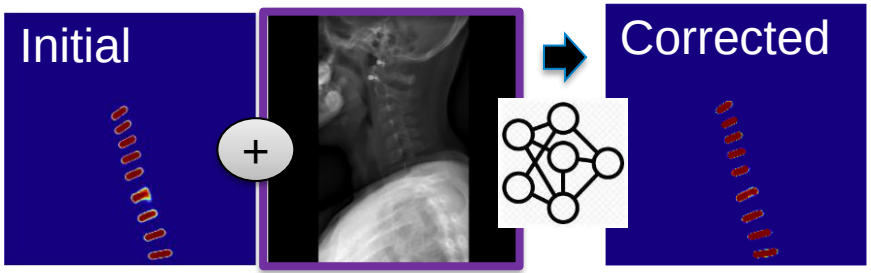
Imperial College London







Spine digital twin ➔ correct heatmaps



- **Diffusion**
- **GAN**

➔ Our vision for tomorrow

Research:

Upstream research topics:
Low-annotations regime
+ Multi-omics + Cancer

Frugal AI

Within a community:
Foundational Models
+ Robust & **Fair** & **Open** AI
+ Benchmark with open cohorts
+ learn/replicate on **private cohorts**.

Remain competitive with private cohorts

➔ **Industrial partners needed for:**
- Phd **CIFRE** fellowships
- **Chairs** + costs = cloud + access to data
- **Sponsoring** Data **Challenges** for students
- **Contributions** to MSc courses and use-cases

Computing:

Hi! PARIS — PARIS ARTIFICIAL INTELLIGENCE FOR SOCIETY

GENCI — Le calcul intensif au service de la connaissance

Translation:

Joint Lab with **GHSJ**

Antoine Agathon
Head of Medical R&D

Georges Huchard
Head of IT

PROOF OF CONCEPT

Students: 2nd IPPMed Data Challenge on Cancer Imaging

March-June 2026

OVHcloud

PARIS-SACLAY CANCER CLUSTER — FRANCE INNOVATION CANCER

⇒ Attract students = talents
⇒ Opportunities to sponsor prizes

New TP and MSc teaching track on AI for Biomed Data

Extra Slides

ML Tasks

Deep Learning in Histopathology

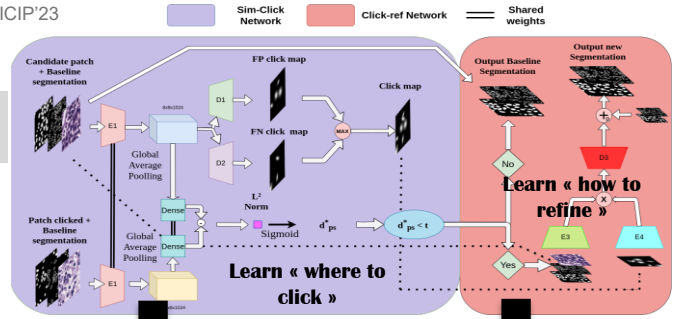
→ Frugal AI

IP PARIS

"Smart" segmentation corrections on large WSIs

Nuclei segmentation H&E WSI

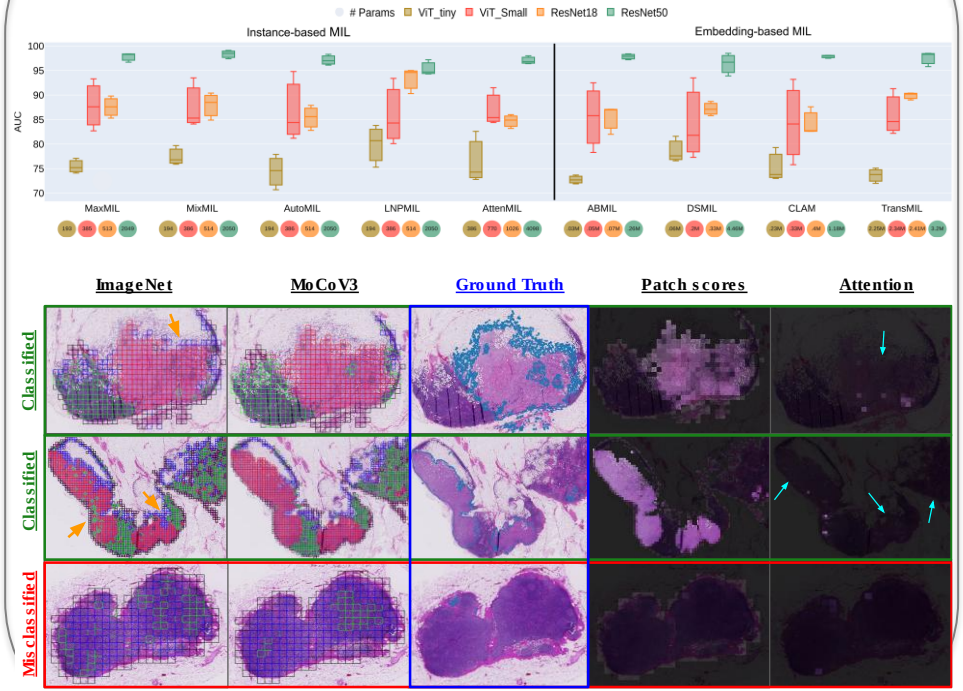
Angelini. ICIP'23



Simple & Interpretable MIL methods for Diagnosis

Gori. ECCV '24 (under review)

segmentation H&E WSI



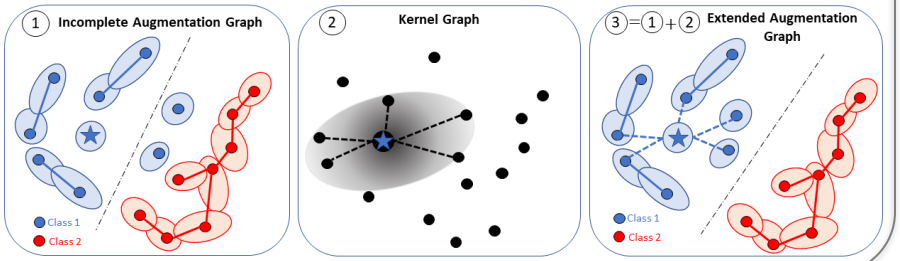
ML Tasks

Generic Methodological ML Approaches

➔ Fair AI

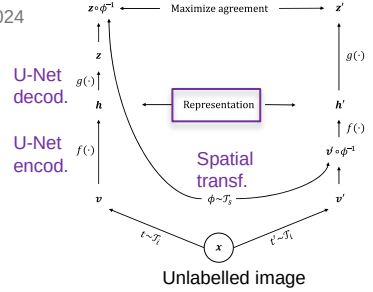
Integrating Prior Knowledge in Contrastive Learning with Kernel

Gori.ICML'23

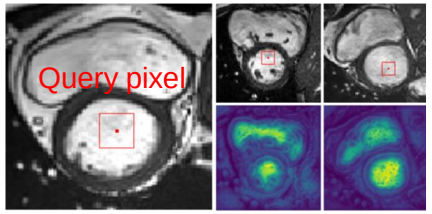


Dense Self-Supervised Learning for Medical Image Segmentation

MIDL 2024



closest pixel

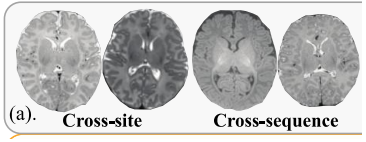


Pixel embedding similarity maps

MAPSeg: Unified Unsupervised Domain Adaptation for Heterogeneous Medical Images Segmentation Based on 3D Masked Autoencoding and Pseudo-labeling

Open-access cohorts

Angelini. CVPR'24



3 domain shifts in infant brain MRI