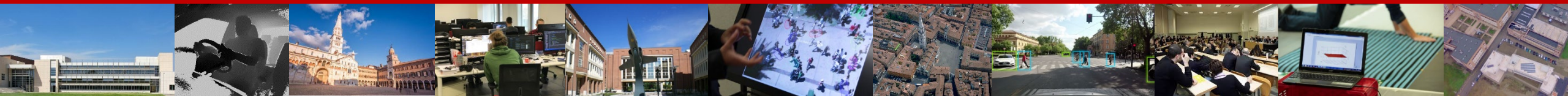
Intelligenza Artificiale: Prospettive in Campo di Ricerca nel Medical Imaging



Federico Bolelli

federico.bolelli@unimore.it

University of Modena and Reggio Emilia, Italy

UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

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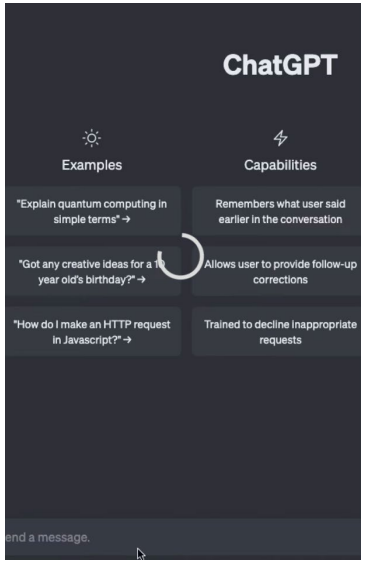
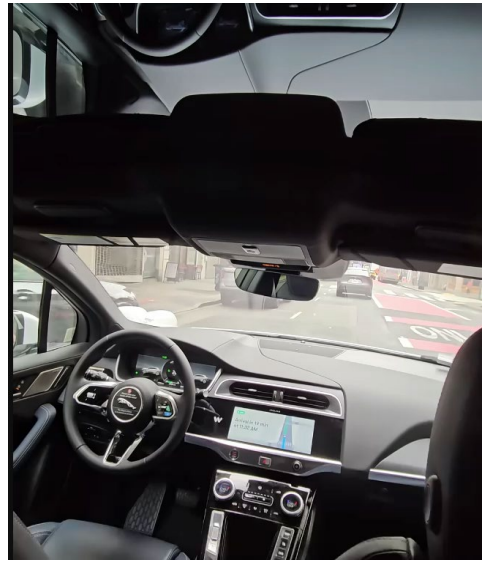
Today's AI "Magic" Capabilities





AI in Medical Imaging

Can we do the same in Medicine? Automotive, coding, game development, video generation, market analysis, robotics: AI is already a reality in all these fields. In medicine, not yet. Why?

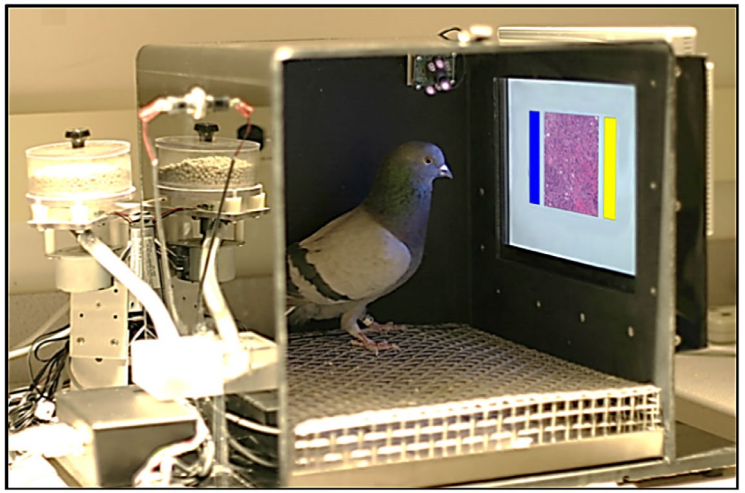
- Scarce and Non-Standardized Data
- Privacy and GDPR
- Complexity and Expert Annotations
- Complex Data (WSI, 3D Volumes)

Do we Need Clinicians Anymore?

When tasks are well-defined and data/labels exist, AI can act as a strong second reader, reducing errors and workload:

- **Pathology (WSI) — Breast Cancer.** Deep learning algorithms achieved **AUC = 0.994 (best model)** vs **AUC = 0.884 (best pathologist)** in a *time-constrained* diagnostic setting. **7/32** algorithms exceeded the panel of **11 pathologists** in that setting [1];
- **Dermoscopic Melanoma Recognition.** In a reader study with **58 dermatologists**, the CNN showed higher overall discrimination with **CNN ROC AUC: 0.86** vs **mean dermatologists: 0.79** [2];

Do you want pigeons making life-or-death treatment decisions about your tumor? [3]



[1] Ehteshami Bejnordi B, Veta M, van Diest PJ, et al. JAMA (2017).
[2] Haenssle HA, et al. Annals of Oncology (2018).
[3] Pigeons (Columba livia) as Trainable Observers of Pathology and Radiology Breast Cancer Images. PLoS ONE 10(11): e0141357. https://doi.org/10.1371/journal.pone.0141357 .

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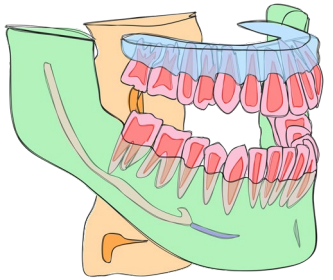
Our Public Datasets

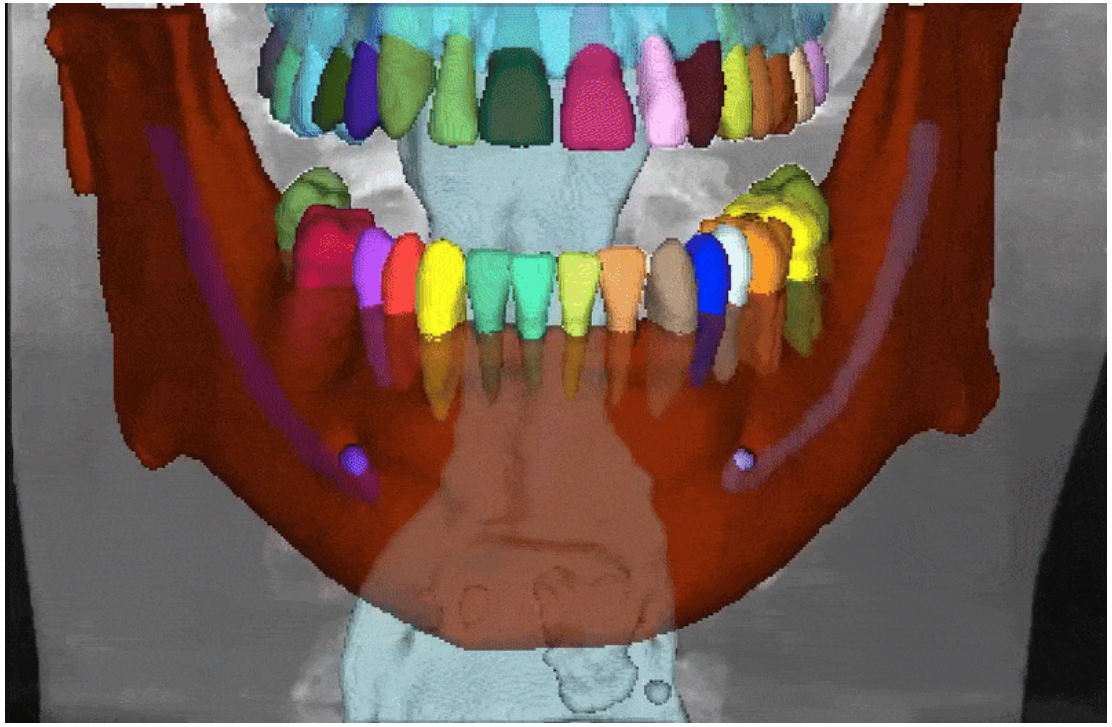
ToothFairy includes **500+ CBCT scans** with **expert manual segmentations**, covering **70+ anatomical regions**.

It is **a multi-scanner, multi-center dataset** involving multiple centers across the world.

Through **3 segmentation challenge editions (2023, 2024, 2025)**, we progressively expanded **anatomical classes** and **structural complexity**, building **one of the largest public datasets** in maxillofacial imaging.

TOOTH FAIRY





[1] Cipriano, M., et al. (2022). Deep Segmentation of the Mandibular Canal: a New 3D Annotated Dataset of CBCT Volumes. ***IEEE Access****, 10, 11500-11510.*

[2] Cipriano, M., et al. (2022). Improving segmentation of the inferior alveolar nerve through deep label propagation. ***CVPR****.*

[3] Bolelli, F., et al. (2024). Segmenting the Inferior Alveolar Canal in CBCT Volumes: the Toothfairy Challenge. ***IEEE Transactions on Medical Imaging****, 44(4), 1890-1906.*

[4] Bolelli, F., et al. (2025). Segmenting Maxillofacial Structures in CBCT Volumes. ***CVPR****.*

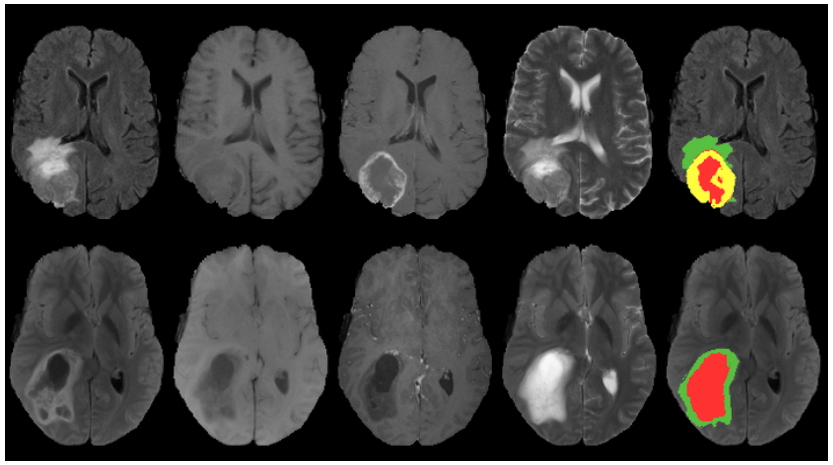

A. Anesi

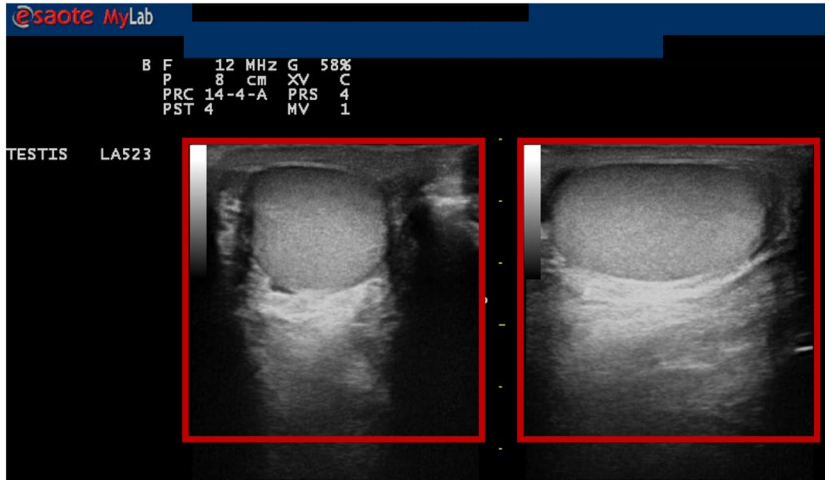

P. Minafra

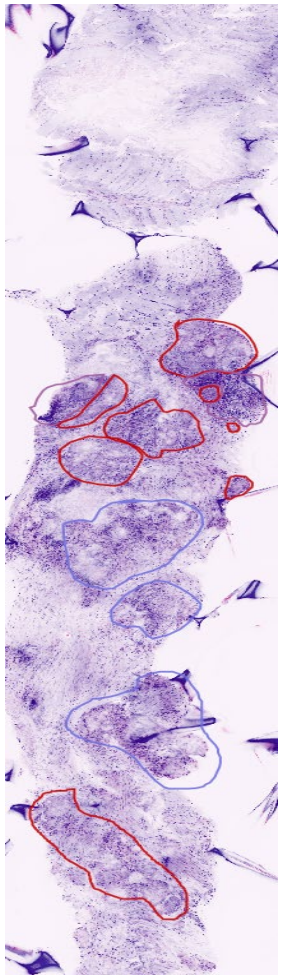

M. Di Bartolomeo


A. Pellacani

Our (Almost) Public Datasets







Brain (MRI) — Multimodal Reality [1]


F. Benuzzi


F. Lui


G. Sprugnoli


F. Farioli

Ultrasound — Noisy [2]


D. Santi


G. Spaggiari

Urology (FCM ex vivo) — Confocal Microscopy Histopathology (Breast, Prostate, and Kidney [3])


G. Bianchi


L. Bertoni


S. Puliatti


R. Magistroni


G. Besutti

[1] Pipoli, V., et al. (2025). IM-Fuse: A Mamba-based Fusion Block for Brain Tumor Segmentation with Incomplete Modalities. ***MICCAI****.*

[2] Marchesini, K. et al. (2026). Too Big to Fail? Not Quite: FiLM-UNet Beats Foundation Models in Cross-Domain Ultrasound Segmentation. ***ISBI*** *(Under Review)*

[3] Fondo di Ateneo per la Ricerca (FAR) 2023, Grana, C., et al. "Deep Learning for Renal Pathology Prognosis Prediction"

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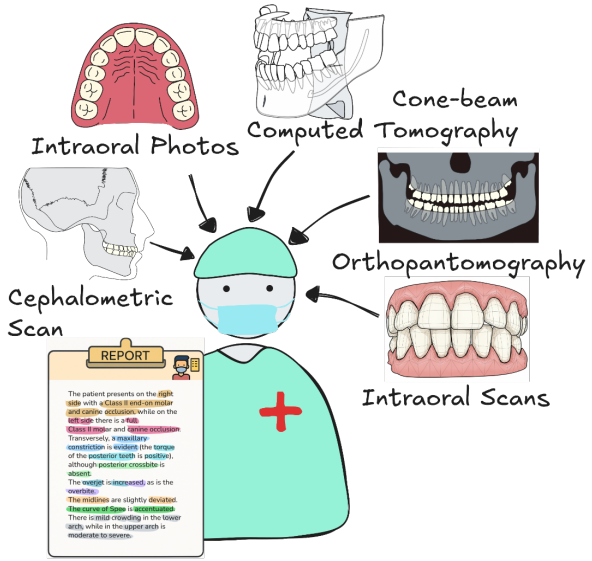
Multimodal Data

Clinical data is inherently multimodal

A patient record combines **heterogeneous sources**

- **Text:** radiology reports, clinical notes
- **Structured data:** demographics, coded clinical variables
- **Labs:** blood tests and biomarkers
- **Imaging:** histology, X-ray, CT, MRI, ultrasound
- **Signals (sometimes):** e.g., ECG



Two key requirements to unlock multimodal AI:

- **Standardize** acquisition + annotation (protocols, labels, metadata)
- **Organize data per patient** (longitudinal, cross-modality linkage)

Outcome: more efficient multimodal training + **better generalization** to real-world data

[1] Lumetti, L., et al (2026). Do Multimodal LLMs Understand Intraoral Dental Data? Dataset, Platform, and Baselines. ***CVPR*** *(Under Review)*

[2] ODIN Challenges: Multimodal Text Report Generation for Oral and Dental Image Analysis, ***MICCAI challenge*** *(Under Review)*

L. Lombardo

F. Cremonini

Standardazing Data Collection and Labeling

ToothFairy4M: a platform for multimodal (dental) data collection

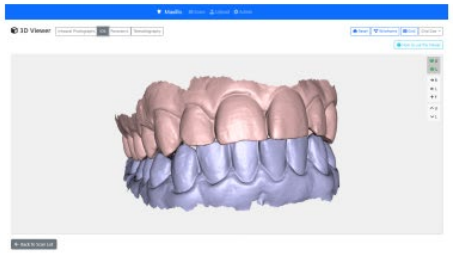
Digital platform to support in collecting **patient-centered multimodal data**

Joint visualization of available modalities to support a comprehensive clinical overview

Structured annotation workflow (labels + regions of interest) to create datasets usable for **multimodal models**

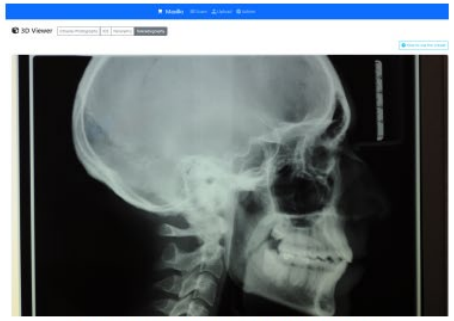
Next step: extend to additional modalities (e.g., **MRI, WSI**)

(a) Intraoral photographs (IOP).

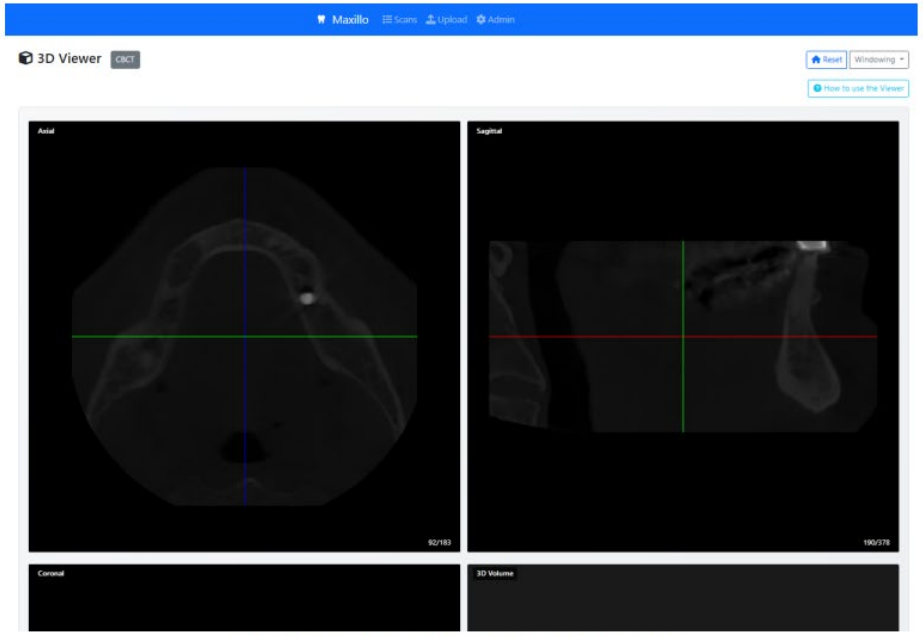


(b) Intraoral scan (IOS) meshes.

(c) Panoramic radiograph (OPG).



(d) Lateral teleradiography (CEPH).



(e) CBCT viewer with synchronized MPR panes.

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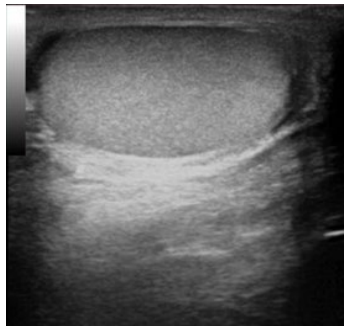
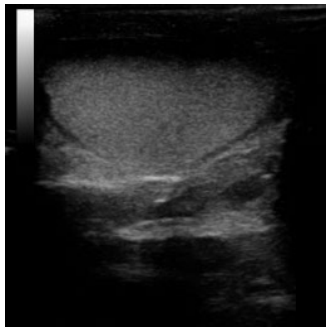
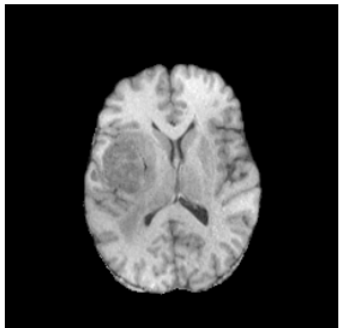
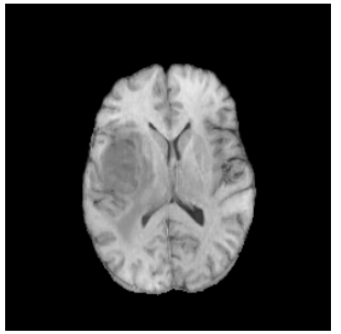
Privacy Preserving Data Enanchment

Medical data is highly sensitive and identifiable

Risks: unauthorized access, re-identification, uncontrolled reuse/sharing

Synthetic data: **generate realistic-like samples via generative AI trained on real data**

Benefits: **safer sharing/testing**, fewer access limits, **more data for model training**

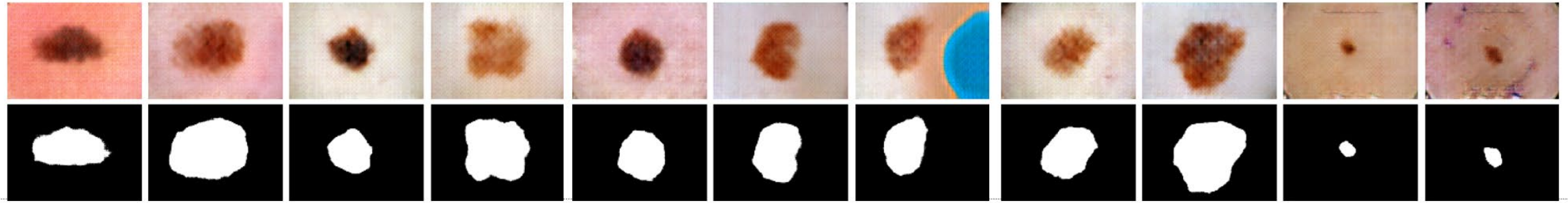
Real Synthetic


G. Pellacani


L. Bertoni


G. Besutti


A. Anesi



Generated skin lesion images

[1] Fondo di Ateneo per la Ricerca (FAR) 2024, F. Bolelli et al. "Synthetic Data: A Solution to Medical Imaging Limitations«

[2] Morelli, N., et al. (2025). Enhancing Testicular Ultrasound Image Classification Through Synthetic Data and Pretraining Strategies. In ICIAP.

Foundation Models + Agentic AI: what's next for Medical Imaging?

Foundation models:

- Pre-train on large multimodal corpora (images + reports + metadata)
- Enable transfer across tasks (segmentation, detection, report drafting)
- Key gaps: domain shift, calibration, bias, interpretability

Agentic AI (workflow-aware):

- Tool-using agents orchestrate pipelines: QC → triage → retrieve priors → draft report
- Human-in-the-loop guardrails: approvals, audit trail, safe escalation
- Measure end-to-end impact: safety, robustness, time-to-decision, outcomes

Take-home:

- Best path: data platforms (e.g., ToothFairy4M) + foundation models + validated, human-supervised systems in real workflows

AImage Lab

Team


C. Grana


E. Ficarra


F. Bolelli


L. Lumetti


K. Marchesini


V. Pipoli


E. Candeloro


O. Carpentiero


N. Morelli


E. Vezzali


G. Casari


A. Saporita


G. Rosati


Y. Assefa


M. Lugli


D. Santoli

Thank You!

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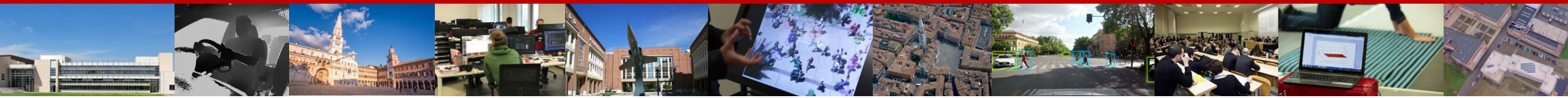

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