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PIANO NAZIONALE DI RIPRESA E RESILIENZA
Future Artificial Intelligence Research

Spoke 8
Pervasive AI

Michela Milano
Università di Bologna

20 Ottobre 2023 Maker FAIR

Future Artificial Intelligence Research

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Spoke leader
ALMA MATER STUDIORUM
Università di Bologna

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA A.D. 1088

AFFILIATES

INFN
Istituto Nazionale di Fisica Nucleare

Consiglio Nazionale delle Ricerche

People

UNIBO 26 people

Michela Milano
Paola Mello
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INFN 2 people

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Rita Cucchiara
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Cosimo Distante
Marco Leo
Silvia Zuffi
Daniela Giorgi
Roberto Marani
Paolo Paradisi

Spoke 8 - Critical Mass
37 permanent staff
3 person/months per year
333 person/months total

RTDA:
14 recruited by UNIBO
2 INFN 5 CNR

8 PhD on the National PhD on AI
3 research fellowships

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Pervasive AI

Pervasivity	Artificial intelligence solutions and systems are becoming ubiquitous, pervading intelligent objects and artificial infrastructure, socio-technical, perceptive and multi-modal environments and impacting social, economic and legal endeavours thus requiring public awareness and social acceptance.

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Features of pervasive AI systems

Seemless integration of different temporal and spatial scales

Seemless integration of heterogeneous data sources, also from multi-modal perception

Seemless integration of heterogeneous computing and storage resources

Seemless integration of operational, tactical and strategic planning

Pervasive AI

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Seemless integration of operational, tactical and strategic planning

WP1 (Milano, Rovatti)
Multi-scale learning and reasoning

WP2 (Bonacorsi, Contucci)
Founding principles for controllable and explainable Ai systems

WP3 (Cucchiara, Zuffi)
Vision and multi-modal perception

Contexts touched by pervasive AI systems

Cognitive and Social modeling

WP4 (Esposito, Sartori) Social Implications of AI

Legal and ethical aspects

WP5 (Floridi, Sartor) Computable law and ethics

Education, Awareness, Acceptance and Trust

WP6 (Panciroli, Gabbrielli) Education and

Human/artificial creativity

WP7 (Musolesi, Presutti) Artificial and Human creativity

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How to experiment?

WP8 Experimental studies on Pervasive AI systems

	Society			Economy			Culture		
	Bologna Digital twin	Healthcare	Commu nication	Industry 5.0	Finance	Labor market	Music/ visual media	Cultural & software heritage	Edu
WP1: Multi-scale learning and reasoning	●	●		●	●		●		
WP2: Founding principles of ML for controllable and explainable AI		●							
WP3: Visual and Multimodal Perception	●	●		●	●		●	●	
WP4: Social implications of generative AI and ADMs		●	●		●	●			
WP5: Methods for computable law and ethics	●	●		●	●	●	●		
WP6: **Education and awareness tools**	●			●				●	●
WP7: **Artificial and Human creativity**							●		

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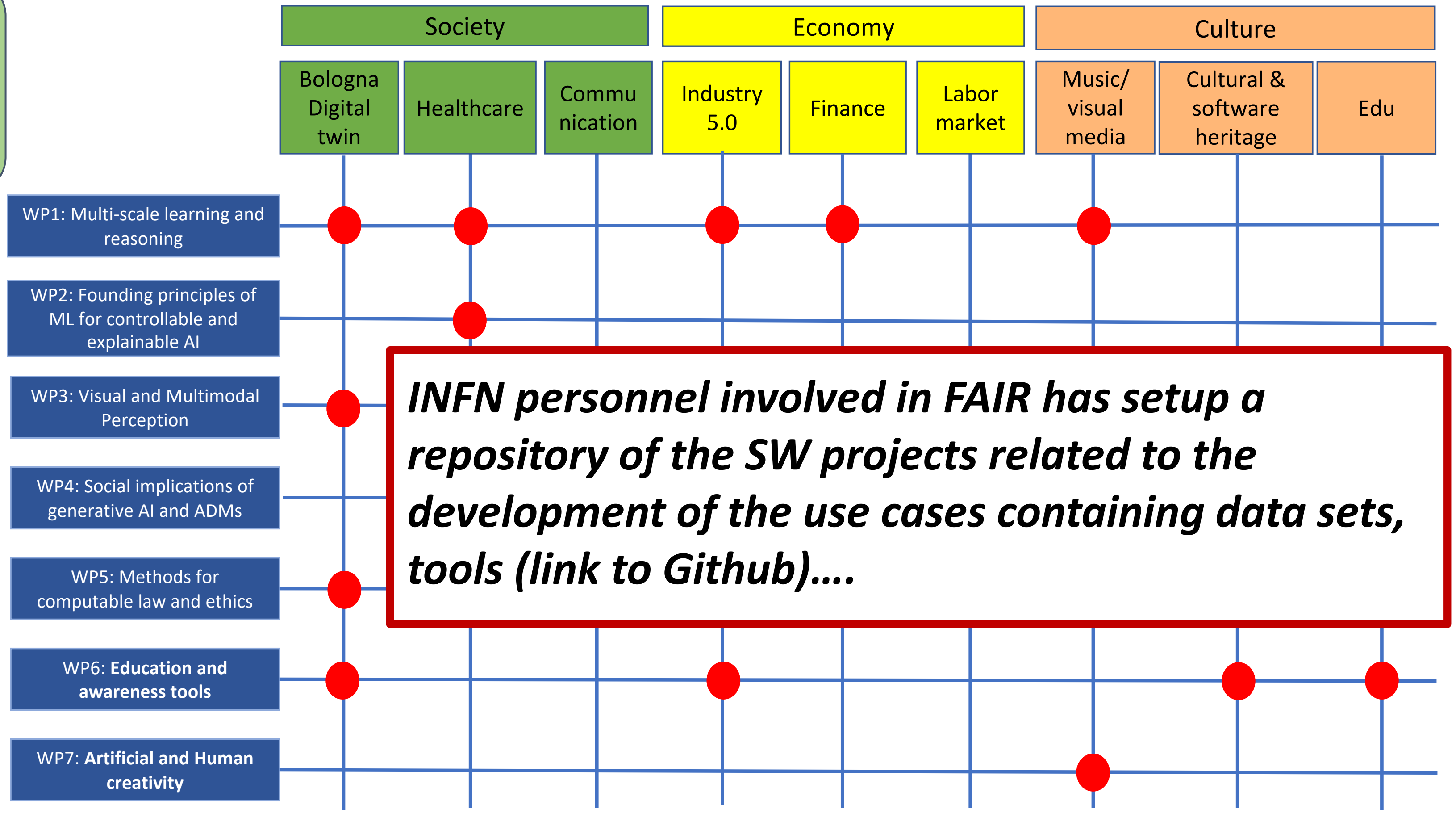
How to experiment?

WP8 Experimental studies on Pervasive AI systems



INFN personnel involved in FAIR has setup a repository of the SW projects related to the development of the use cases containing data sets, tools (link to Github)….

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Brain tumor study

We have recently carried out a study of glioma grading by means of a

Radiomics + Machine Learning approach

DOI: 10.1016/j.ejmp.2023.102538

Physica Medica 107 (2023) 102538

Contents lists available at ScienceDirect

Physica Medica

journal homepage: www.elsevier.com/locate/ejmp

Deriving quantitative information from multiparametric MRI via Radiomics: Evaluation of the robustness and predictive value of radiomic features in the discrimination of low-grade versus high-grade gliomas with machine learning

Leonardo Ubaldi [a,b], Sara Saponaro [c,d,*], Alessandra Giuliano [e], Cinzia Talamonti [a,b], Alessandra Retico [d]

[a] National Institute for Nuclear Physics (INFN), Firenze Division, Firenze, Italy, Firenze, Italy
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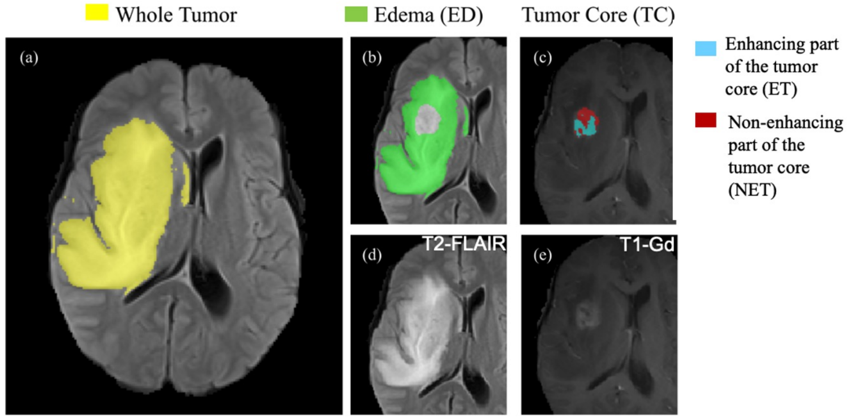
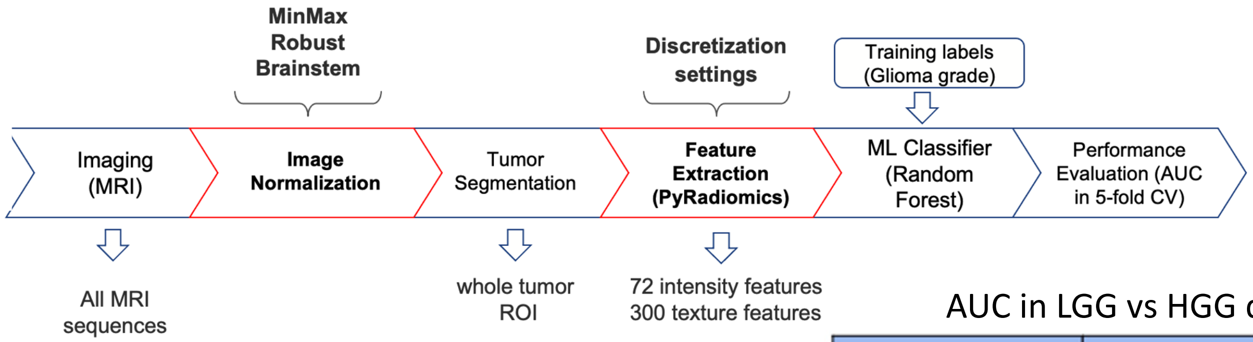
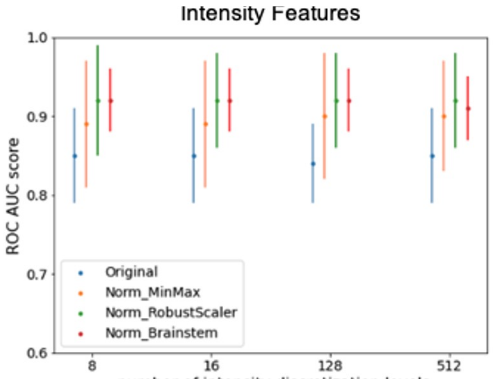
[d] National Institute for Nuclear Physics (INFN), Pisa Division, Pisa, Italy
[e] Medical Physics Department, San Luca Hospital, Lucca, Italy

BraTS

61 patients with Low-Grade Gliomas (**LGG**)
97 patients with High-Grade Gliomas (**HGG**)







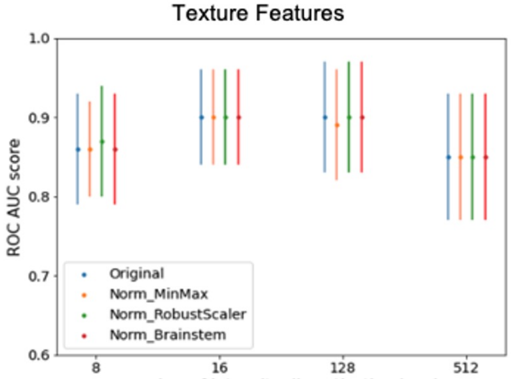


Image normalization and intensity discretization have an impact on the performance of ML classifiers based on radiomic features.

The complementary information of multimodal MRI should be taken into account

AUC in LGG vs HGG discrimination

Modality	Raw feature Set (372 Features complessive per le 4 modalità)	MRI-reliable feature Set (372 Features) [Norm_Brainstem] (bin counts = 128)
T1	0.73 ± 0.05	0.69 ± 0.04
T1-Gd	0.89 ± 0.05	0.93 ± 0.05
T2	0.76 ± 0.08	0.75 ± 0.06
T2 FLAIR	0.76 ± 0.08	0.76 ± 0.06
All sequences	0.88 ± 0.08	0.93 ± 0.05

Roadmap for the “brain tumor” use case

Technical challenges:

- impact of lesion segmentation on robustness and reproducibility of radiomic features and on classification performance
- definition of suitable ML/DL architectures for multiple inputs [ML vs. DL approaches]
- dependence on dataset size:
  - generalization ability of the Decision Support System (DSS)
  - performance of ML/DL approach and dependence on training set size
  - generative methods for data augmentation
  - is transfer learning useful/feasible?
- Explainable AI (XAI) [what is relevant for the prediction?]: radiomic + ML approach vs. DL approach

Sociological aspects of this use case:

- study of the equity of the algorithm with respect to patients’ gender/age
- confidence in the use of AI-based DSS by clinicians/patients and its dependence on the clinical center characteristics

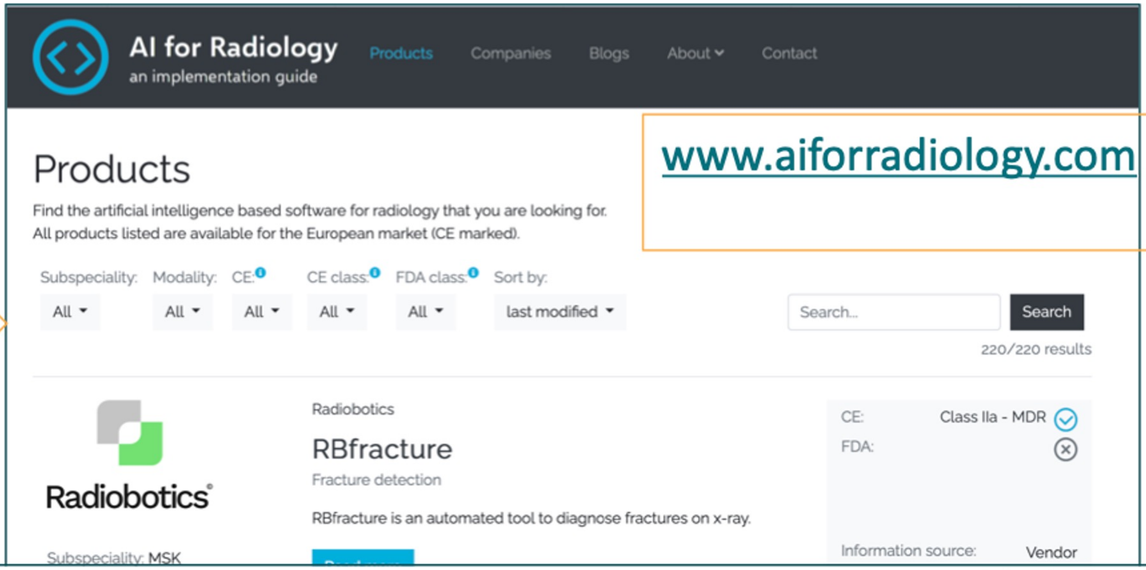
Legal/Ethical implication:

- false negative vs. false detection: weights and criteria
- accountability issues and risk management

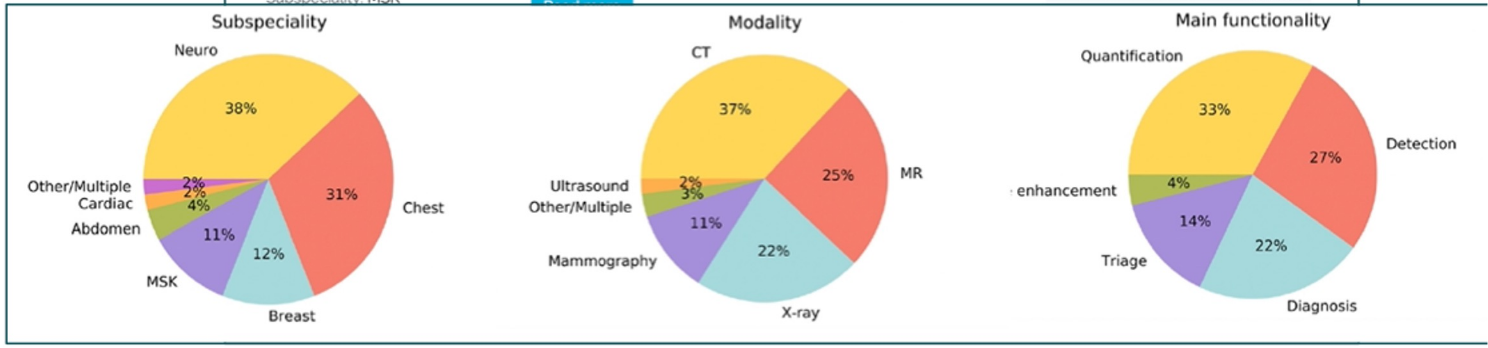
Prodotti basati su AI con marchio CE disponibili sul mercato

[van Leeuwen, K. G., Schalekamp, S., Rutten, M. J. C. M., van Ginneken, B., & de Rooij, M. (2021). Artificial intelligence in radiology: 100 commercially available products and their scientific evidence. *European Radiology*, *31*(6), 3797–3804. https://doi.org/10.1007/s00330-021-07892-z]

- E' stata effettuata una rassegna di **100 prodotti software marcati CE** e resa consultabile online
- Un'ampia ricerca bibliografica sulle evidenze scientifiche della validità di questi prodotti ha evidenziato che:
  - Per 64 prodotti su 100 non è stata pubblicata nessuna evidenza di efficacia su rivista peer-review.
  - Solo 18 prodotti su 100 hanno dimostrato un (potenziale) impatto clinico rilevante con studi su: impatto sul pensiero diagnostico, sul percorso diagnostico/terapeutico del paziente o sui costi.



www.aiforradiology.com



AI in Medical Image Analysis: performance and impact

Comparison between **DL models** and **health-care professionals (HCP)** in the same sample [14 studies/82, different diseases]:

- a sensitivity of **87.0%** for **DL** models and **86.4%** for **HCP**
- a specificity of **92.5%** for **DL** models and **90.5%** for **HCP**

➔ DL models and HCP show **equivalent performance**

[Liu et al. A comparison of deep learning performance against health-care professionals in detecting diseases from medical imaging: a systematic review and meta-analysis. **Lancet Digit Heal** 2019;1:e271–97]

Radiologists can guide the introduction of AI into healthcare. They **will not be replaced by AI**, which, in turn will:

- standardize the level of reporting across different clinical centres
- speed up the diagnosis process and allow radiologists to perform more value-added tasks

[Pesapane F, Codari M, Sardanelli F. Artificial intelligence in medical imaging: threat or opportunity? Radiologists again at the forefront of innovation in medicine. **Eur Radiol Exp** 2018;2]

AI algorithms for medical imaging **must be effectively evaluated** before they are used in clinical practice.
The performance obtained in the R&D stage is difficult to maintain in the clinical use.

➔ Both the generalizability of AI algorithms and the benefits of AI-assisted care relative to conventional care should be proved

[Park SH, Han K, Jang HY, Park JE, Lee J, Kim DW, et al. Methods for Clinical Evaluation of Artificial Intelligence Algorithms for Medical Diagnosis. **Radiology** 2022:1–12]

It is not enough for AI to efficiently detect image abnormalities/pathological conditions. **AI imaging studies** should be refined to **predict clinically meaningful endpoints**, e.g.: lesion malignancy, need for treatment, patient survival.

[Oren O, Gersh BJ, Bhatt DL. Artificial intelligence in medical imaging: switching from radiographic pathological data to clinically meaningful endpoints. **Lancet Digit Heal** 2020;2:e486–8.]

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FAIR FUTURE AI RESEARCH

Use case Healthcare

Two main projects are in progress:

- Set up of an NLP-inspired analysis of multimodal MRI data

  [Paolo Torroni, Andrea Galassi, Marco Lippi and the INFN team]

- Sociological study of trust towards AI-based tools by targeted users in a clinical environment

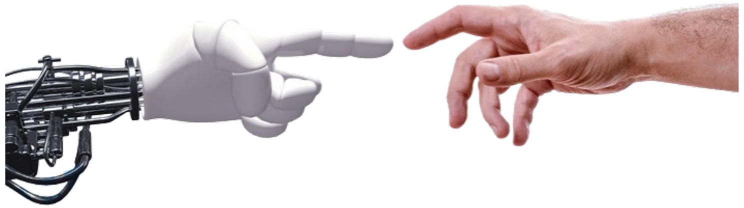
  [Laura Sartori, Chiara Binelli and the INFN team]

Use case Creative AI

experimenting the use of **generative AI** as an **assistant** for *co-creation tasks (music as a pilot)*

using **immersive adaptive environments** to *analyse, encourage* and *enhance* human creativity

tune the generative for a collaborative relationship



generate music that influences the artist's creative process *music situations*

Music generation co-creation

"Give me some exotic sounding drum rhythm as if it was played by the guy from the Police"

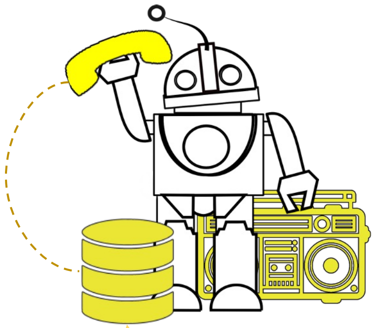
"Fill this spot with a F# chord that builds up tension and prepares for the next Lydian section."

"Create 14 variations of this flute melody in B. Use Bach's counter-point."

"Play something that fits with  *and sounds like this*  *"*

Note
Chord
Genre
Style
Instrument
…

music descriptions



Generative model

Adaptive memory

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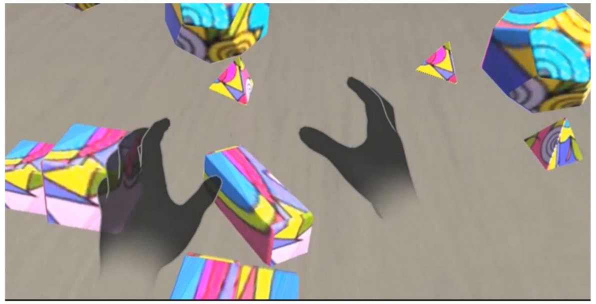
Enhancing Human Creativity using an Affective Stimulation in Virtual Reality



Virtual creativity:
interacting with 3D objects to build a "creative product"

↓

studying the degree of immersivity within the virtual world and the emotional involvement

VR Story cubes:
narrating a story based on multisensorial information

↓

studying the degree of immersivity within the virtual world and the emotional involvement

Virtual agent:
composing music while interacting with a virtual avatar

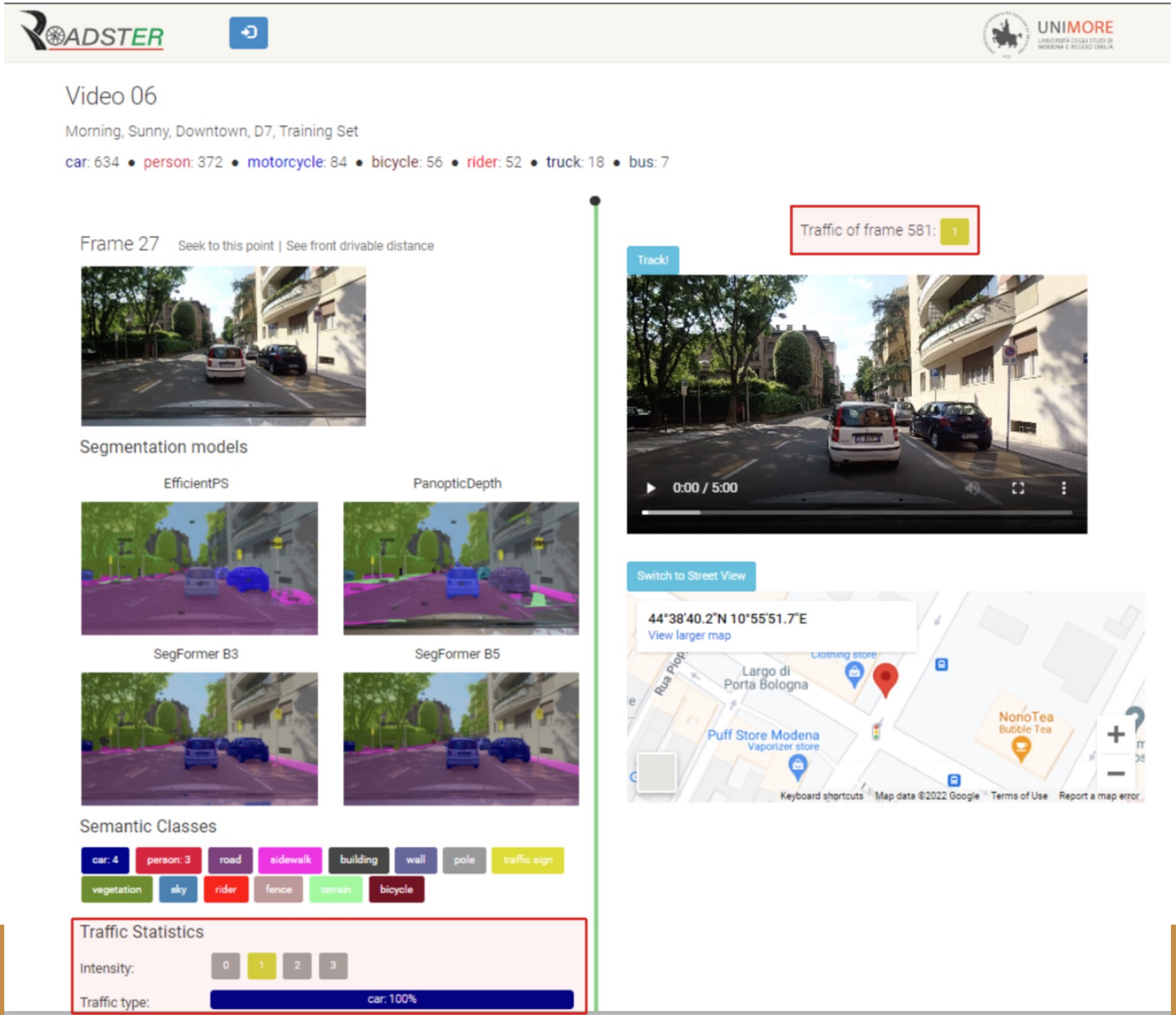
↓

studying the influence on personal creativity and personal creative skills

Understanding urban traffic conditions by camera-car

Use and comparison of State-of-the-art models of
Image open-word segmentation
Object labeling
traffic monitoring
text generation
and matching of car-based video with Google MAPS

the work is partially cofounded by IFAB
in collaboration with UNIMORE, UNIBO , UNIPR



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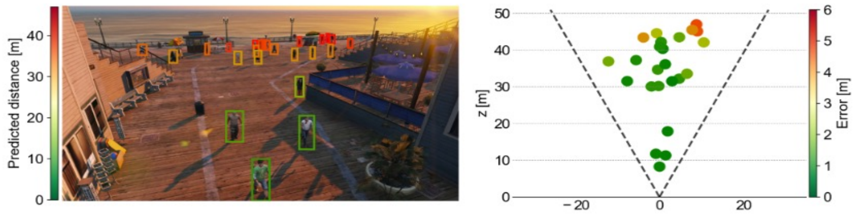
In collaborazione con
Comune di Modena
ecosister

People Analysis in Smart Cities

Distance estimation

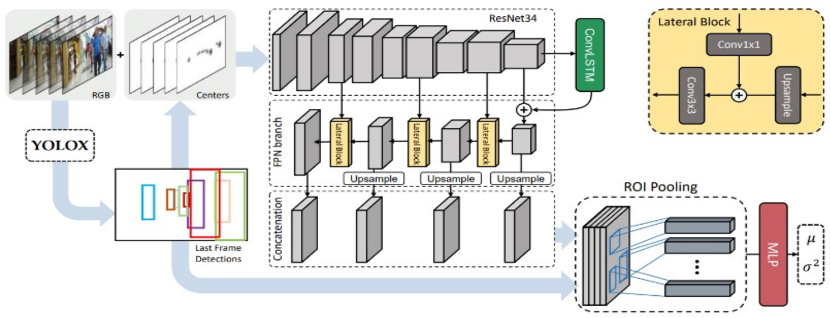
Accurate per-object distance estimation is crucial in safety-critical applications such as autonomous driving, surveillance and robotics.

→ **DistSynth** is only trained on **synthetic images** and can accurately estimate distances from a **monocular camera**.



Tracking pedestrians by levaraging multiple cues

Distance estimation can help distinguish pedestrians in a crowd.



Human pose, **depth maps**, or **thermal** data can encode a deeper and robust understanding of the scene.

→ **TrackFlow** can merge different information during multi-object tracking association using Normalizing Flows.

(MOTSynth)	Easy		Moderate		Hard	
Metrics	HOTA ↑	IDF1 ↑	HOTA ↑	IDF1 ↑	HOTA ↑	IDF1 ↑
SORT	63.48	79.40	50.31	62.11	37.48	45.13
+ **TrackFlow GT**	+4.37	+7.41	+5.33	+9.09	+6.54	+10.88
+ **TrackFlow**	+0.31	+0.97	+0.81	+1.63	+0.74	+1.56
ByteTrack	63.22	80.84	49.91	62.46	37.61	46.15
+ **TrackFlow GT**	+3.76	+2.82	+5.47	+5.51	+5.08	+4.60
+ **TrackFlow**	+0.13	+1.80	+0.47	+1.21	+0.88	+1.81

Mancusi, G., Panariello, A., Porrello, A., Fabbri, M., Calderara, S., & Cucchiara, R. - TrackFlow: Multi-Object Tracking with Normalizing Flows. ICCV 2023
Mancusi, G., Fabbri, M., Egidi, S., Verasani, M., Scarabelli, P., Calderara, S., & Cucchiara, R. - First Steps Towards 3D Pedestrian Detection and Tracking from Single Image. ICIAP2021

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VLM CHALLENGES in FAIR

TPVLMC – Transversal Project on Vision, Language and Multimodal Challenges

PIs: Rita Cucchiara, Roberto Navigli

Objectives

- Create a **large Italian framework for research on Visual, Language and Multimodal Challenges**, bringing together activities in Large Scale models, Generative AI solutions, Benchmarking, Image Processing and Computer Vision, NLP, Human signal understanding, and some Downstream Tasks concerning multimodal data.
- Define a new operative trustworthy-by-design architecture, open-source, oriented to multimodal data both in comprehension, generation and retrieval, state-of-the-art ad international level and (at least partially) trained on Italian multimodal documents and oriented to tasks, useful in national applications. We named ITALM2-a platform for Italian Large Scale Multimodal Model(s)
- Define, within the platform several benchmarks and benchmark challenges putting together the state-of-the-art international benchmarks
- Define a strategy for working at national level with many synergies between universities and research centers in collaboration with CINECA Leonardo and NVIDIA AI Nation, as well with EU platforms and EU projects of the researchers involved.

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VLM CHALLENGES in FAIR

TPVLMC – Transversal Project on Vision, Language and Multimodal Challenges

Activities

- May 2023: Workshop and kick-off meeting at Ital-IA (Pisa), with the presentation of the TP and collection of preliminary abstracts and interests
- 9/21/2023: Meetings in Modena with Victor Sanh (Huggingface), N. Sebe (UNITN), G. Fiameni (NVIDIA) and Cristian Canton Ferrer (Meta) on the creation of multimodal LLM
- 10/2023: Creation of a survey to collect expressions of interest
- 10/16/2023: Operational meeting in Rome, with NVIDIA and CINECA for the definition of the workplan and HPC needs
- Dialogues with potential stakeholders, including PCM, UCIMA and CINECA

Involved research groups:

- 12 groups (PIs: R. Cucchiara, R. Navigli, G. Semeraro, A. Lenci, A. Del Bue, P. Torroni, F. Cutugno, R. Bernardi, P. Soda, M. Esposito, F. Dell'Orletta, F. Falchi), for a total of 90 PM.

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Spoke 8
Pervasive AI

Michela Milano
Università di Bologna

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20 Ottobre 2023 Maker FAIR