



UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II

itee^{PhD}
information technology
electrical engineering



Francesco Longobardi

Graph neural networks for security applications

Tutor: prof. Daniel Riccio

Cycle: XXXIX

Year: Second

My Background

- M.Sc. degree in **Computer Science** (March 2023) @ DIETI – University of Naples Federico II
- Research group: **PRISCA Lab** – DIETI Unina
- PhD started in November 2023 – November 2026
- Scholarship type: PNRR - DM 118/2023 - Dottorati generici
- Periods abroad: 03/05/2025-29/10/2025 at University of Las Palmas de Gran Canaria (ULPGC), Department of Computer Engineering (EII), Gran Canaria, Spain. Supervisor: Prof. Modesto Fernando Castrillón Santana

Summary of study activities

	Courses	Seminars	Research	Tutorship
First Year	23	6.6	33	0
Second Year	14	4.9	43	0.3
Expected	10 – 20 (30-70 total)	5 – 10 (10-30 total)	30 – 45 (80-140 total)	0 – 1.6 (0-4.8 total)

- Courses attended
 - How To Boost Your PhD
 - Methodologies and Tools for conducting Systematic Literature Reviews and Systematic Mapping Studies
 - U3525 - Biometric Systems
 - 11 seminars for a total of 4.9 credits (24.5 hours)
- Conference attended
 - 21st International Conference in Computer Analysis of Images and Patterns. CAIP2025, 2025, Las Palmas de Gran Canaria, Spain, 22-25 September 2025
 - 4th International Workshop on Recent Advances in Digital Security: Biometrics and Forensics (BioFor2025), Rome, September 15th, 2025

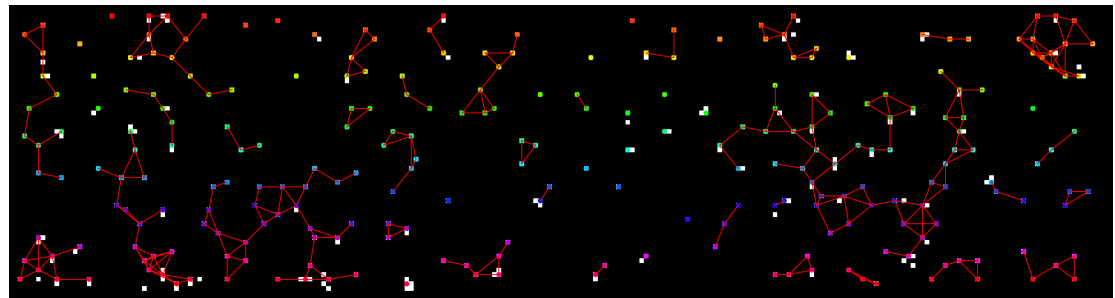
Research area

Application of Graph Neural Networks (GNNs) to security problems

GNNs follow the paradigm of *message passing*:

- Information stored in each node or edge of a graph is shared
- Combined with other nodes according to the connectivity
- Result: node or graph level representations

Crafting graphs with relevant node and edge features is important to effectively model a task

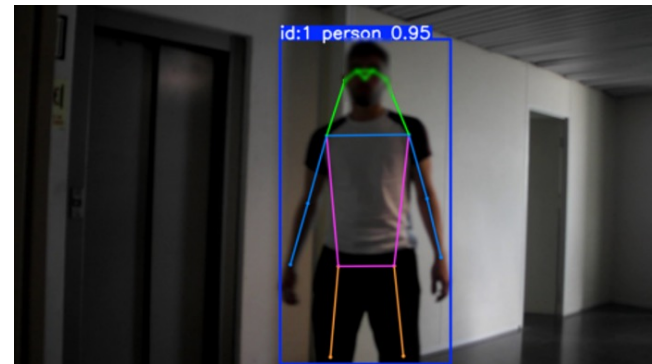
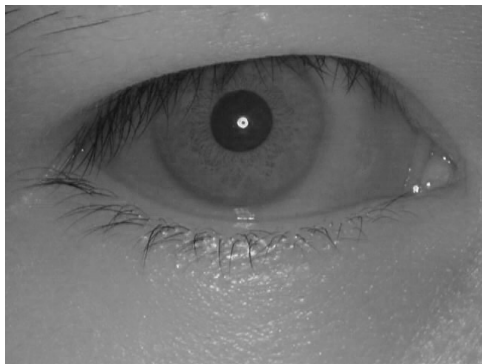


Research area

Application of Graph Neural Networks (GNNs) to biometrics

Biometric recognition deals with extracting meaningful descriptors to discern between subjects based on a biometric trait

During this year I have worked on Iris biometrics and Face-Body multi-biometrics



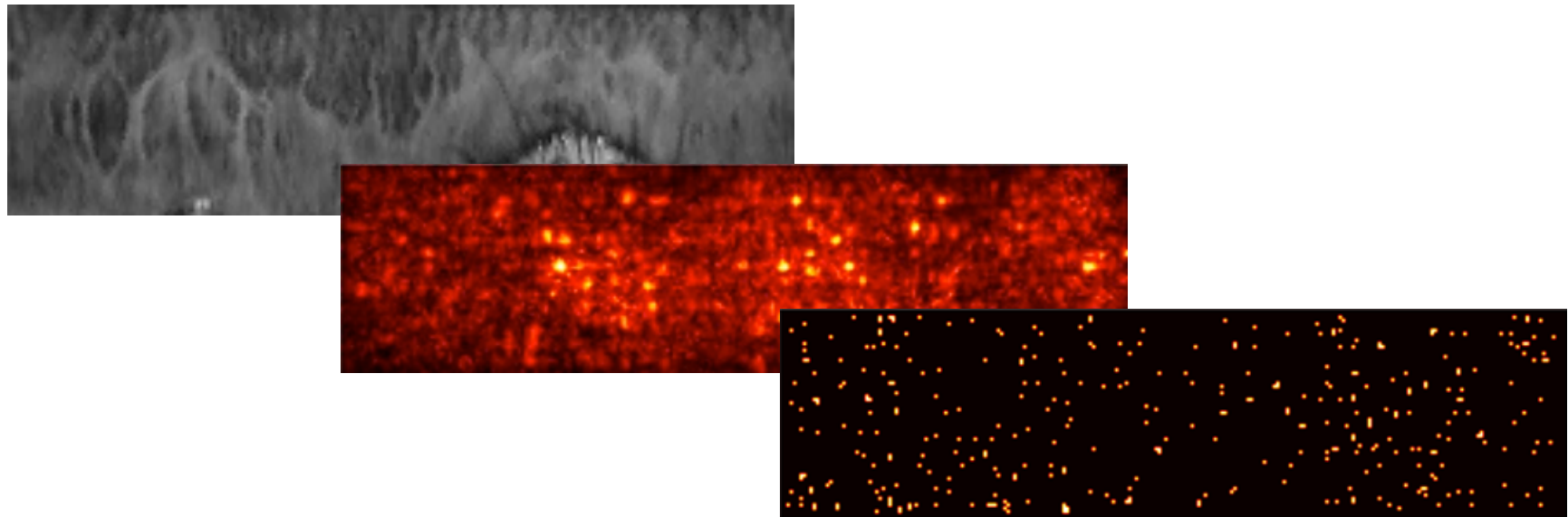
Research field of interest

- *Iris images biometrics*
 - VIS-to-NIR domain translation
 - Landmark extraction and evaluation
- **Multi-biometric systems**
 - Face-Body biometric signatures
 - Video and image processing in varying, realistic conditions
- **Graph Neural Networks**
 - Graph construction
 - GNN message passing operators
 - Deep metric learning with graphs

Research activity

Biometric systems: *Iris*

- Compute baseline, comparison-based landmarks in an iris image
- Train a ResNet-18 able to produce effective embeddings in a deep metric space
- Estimate landmarks from cumulative saliency maps

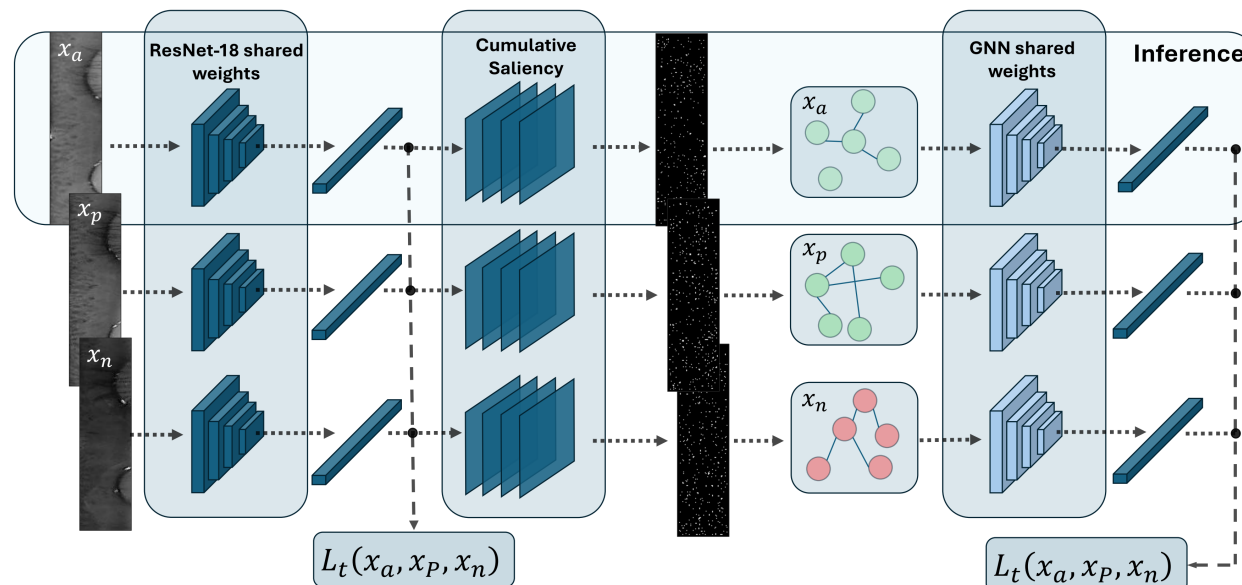


F. Longobardi et al., "I-LENS: Iris Landmark Extraction and Network-based Signatures", Submitted to IEEE Trans. on Biometrics, Behavior, and Identity Science (T-BIOM)

Research activity

Biometric systems: *Iris*

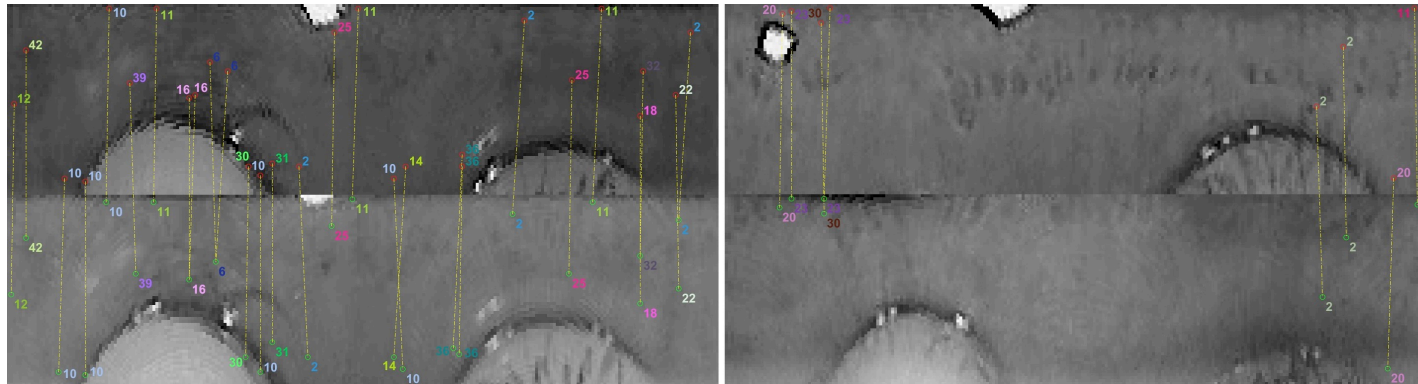
- Compute graphs over detected landmarks
- Train a GNN able to produce embeddings in a deep metric space
- Evaluate the stability and discriminability of detected landmarks



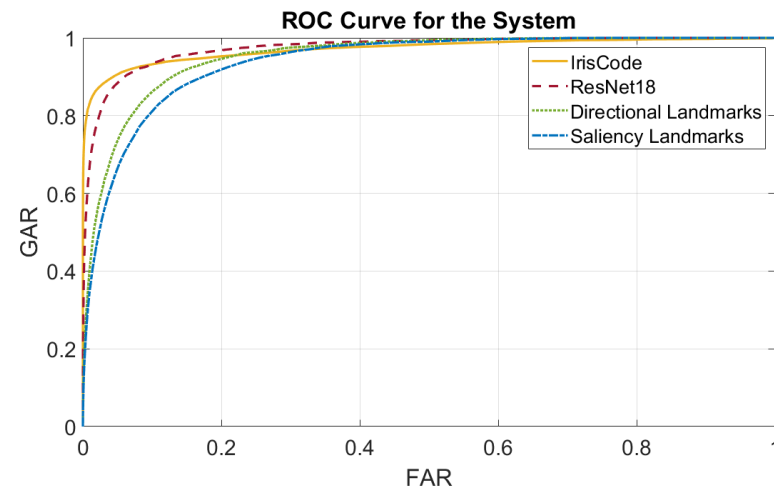
F. Longobardi et al., "I-LENS: Iris Landmark Extraction and Network-based Signatures", Submitted to IEEE Trans. on Biometrics, Behavior, and Identity Science (T-BIOM)

Research results

- Iris landmarks computed using the saliency method are stable and retain a good amount of biometric discriminability



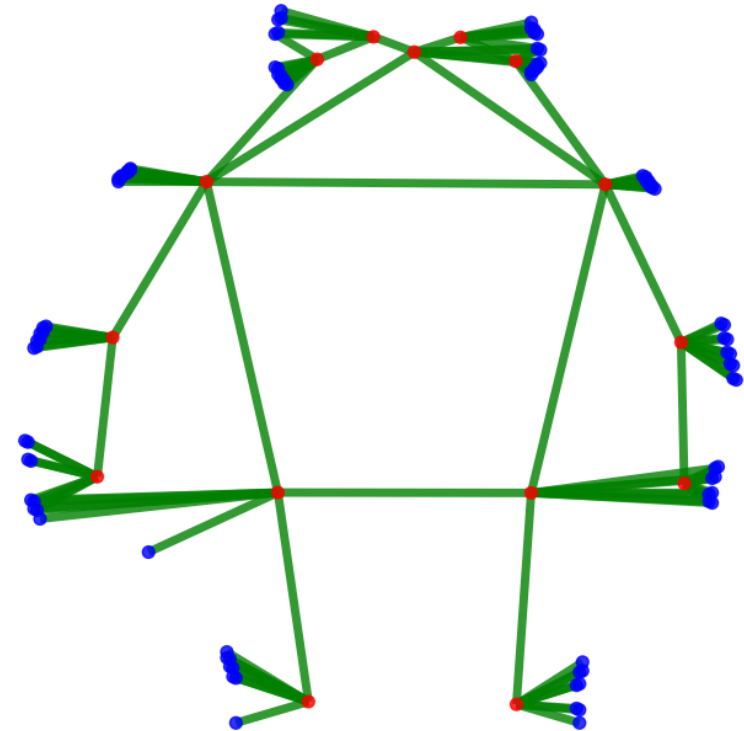
- Meaningful landmark regions can be identified purely by analyzing local directional patterns extracted through oriented filters



Research activity

Biometric systems: *Face-Body multi-biometrics*

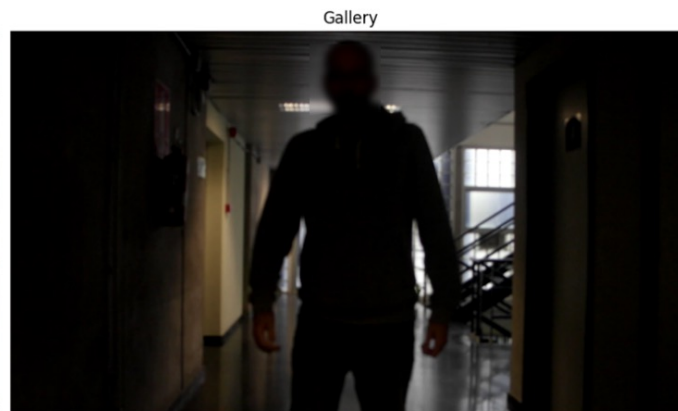
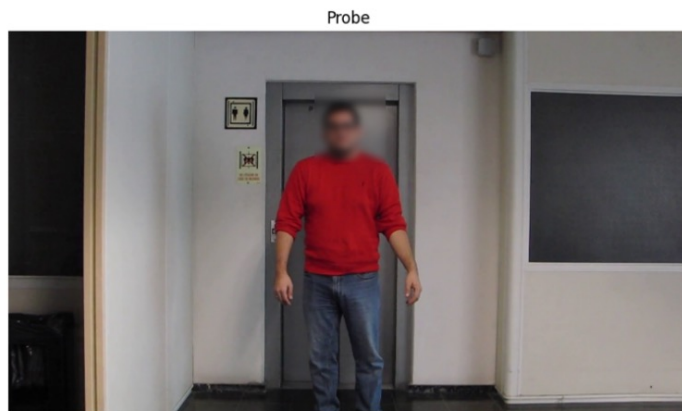
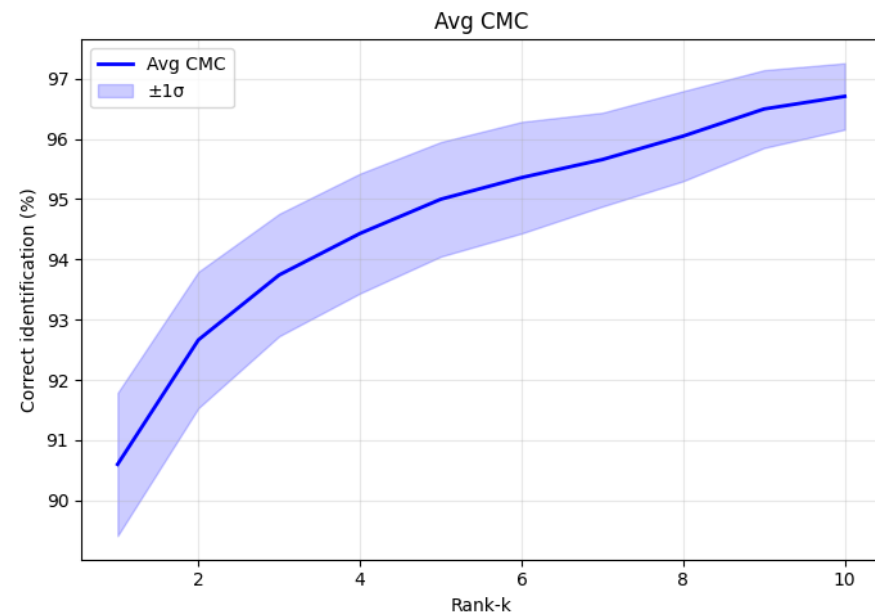
- Selection of best frame for face detection and best frame for body landmarks
- Segmentation of the person in the chosen frame
- Detection and segmentation is performed using YOLO and DeepLabV3



Research activity

Biometric systems: *Face-Body multi-biometrics*

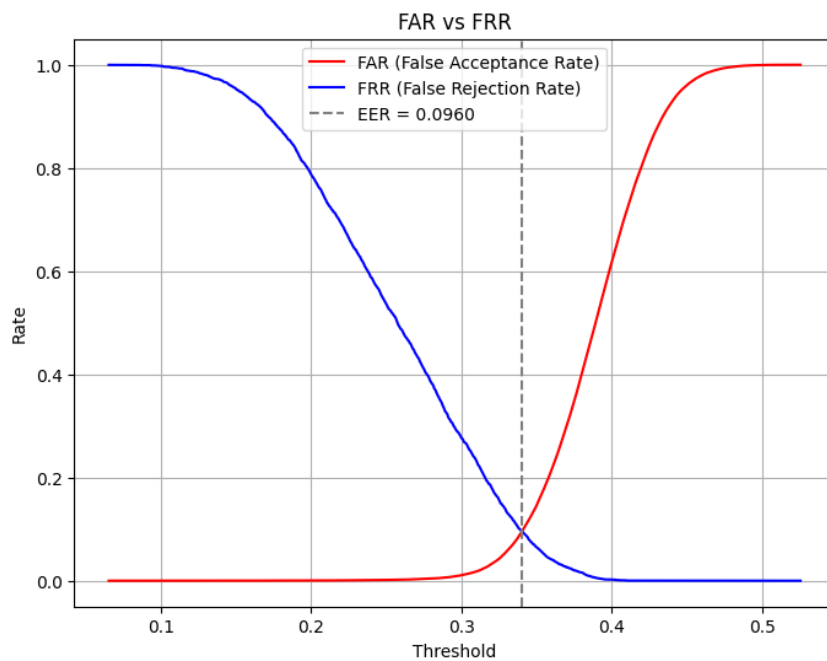
- Construction of graphs using anatomical and spatial edges
- Node-level features: normalized coordinates, information on node's nature, visual feature maps
- Graph-level features: visual information from face embedding neural networks



EER_threshold:
0.4887
False Accept with distance:
0.4554

Research results

- Incorporating descriptors of the body encapsulated in graphs can improve authentication performance in challenging conditions
- Learned attentional fusion combines descriptors of multiple biometric traits into an optimized embedding



		Mean	Std
Facenet-VggFace2	EER	0,1691	± 0,0090
	AUC	0,9073	± 0,0060
	RR	0,8802	± 0,0140
Facenet-CasiaWebface	EER	0,2117	± 0,0089
	AUC	0,8523	± 0,0074
	RR	0,8419	± 0,0191
GNN-FusionNet (ours)	EER	0,1262	± 0,0062
	AUC	0,9487	± 0,0032
	RR	0,8817	± 0,0083
Comparison PCA-100	EER	0,1320	± 0,0096
	AUC	0,9175	± 0,0083
	RR	0,9006	± 0,0146
GNN-FusionNet (ours) Comparison Descriptors PCA-100	EER	0,0883	± 0,0080
	AUC	0,9716	± 0,0038
	RR	0,9060	± 0,0119

Research products

[C1]	<p><i>D. Riccio, F. Longobardi, M. Sangiovanni, M. Frucci, N. Brancati, M. Staffa, L. D’Errico, A. Ciccarelli,</i> <i>“HEMERA: H&E-to-HER2 Encoding for Morphology-Enhanced Region Annotation”</i> <i>5th CINI National Lab AIIS Conference on Artificial Intelligence (Ital-IA 2025), Trieste, 23-24 June 2025 (accepted)</i></p>
[C2]	<p><i>F. Longobardi, S. D. Amodio,</i> <i>“Enhancing Iris Recognition through Advanced VIS-to-NIR Image Translation”</i> <i>4th International Workshop on Recent Advances in Digital Security: Biometrics and Forensics (BioFor2025), Rome, 15 September 2025 (accepted and presented)</i></p>
[C3]	<p><i>G. Rauso, M. Sangiovanni, S. Barra, D. Riccio, M. Staffa, L. D’Errico, F. Longobardi,</i> <i>“Increasing Resolution of MRI Volumes through Interleaved Slice Synthesis based on Generative Adversarial Networks”</i> <i>21st International Conference in Computer Analysis of Images and Patterns (CAIP2025), Las Palmas de Gran Canaria, 22 - 25 September 2025 (presented and published)</i></p>
[J1]	<p><i>D. Riccio, M. Sangiovanni, F. Longobardi, A. F. Scalella, V. Manfredi,</i> <i>“Hope: Histopathological Image Organization and Processing Environment”</i> <i>Image and Vision Computing</i> <i>(Submitted, currently under revision)</i></p>

Research products

[J2]	F. Longobardi, M. Sangiovanni, D. Riccio, <i>“I-LENS: Iris Landmark Extraction and Network-based Signatures”</i> <i>IEEE Transactions on Biometrics, Behavior, and Identity Science (T-BIOM)</i> <i>(submitted)</i>
------	---

Future Work

- Deploy the face-body recognition framework in a real-world, robotic awareness scenario
- Ensure privacy protection via cancellable biometric keys

Approach:

- Robot interacts with individuals without prior knowledge of their roles
- Use unsupervised methods to infer user roles
- Construct scene-based embeddings
- Perform clustering based on similarity and extracted features