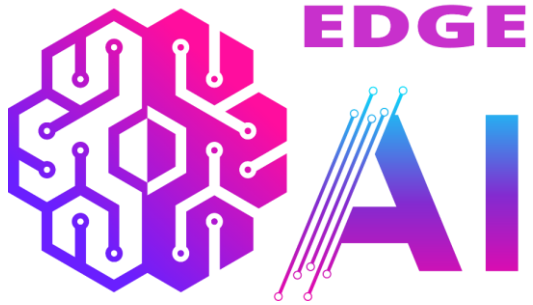
European Conference on EDGE AI Technologies and Applications - EEAI



On the Move Biometrics at the Edge: Security Meets Convenience

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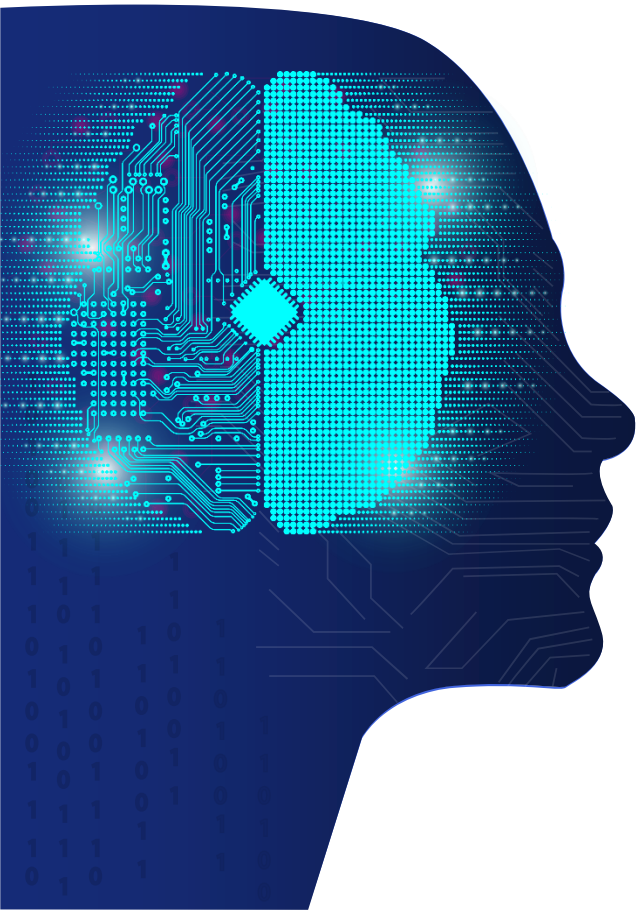
Presentation Outline



- Introduction
- State-of-the-art
- Research Goal
- Methodology
- Design and Implementation
- Demo
- Future Research
- Conclusion

Introduction

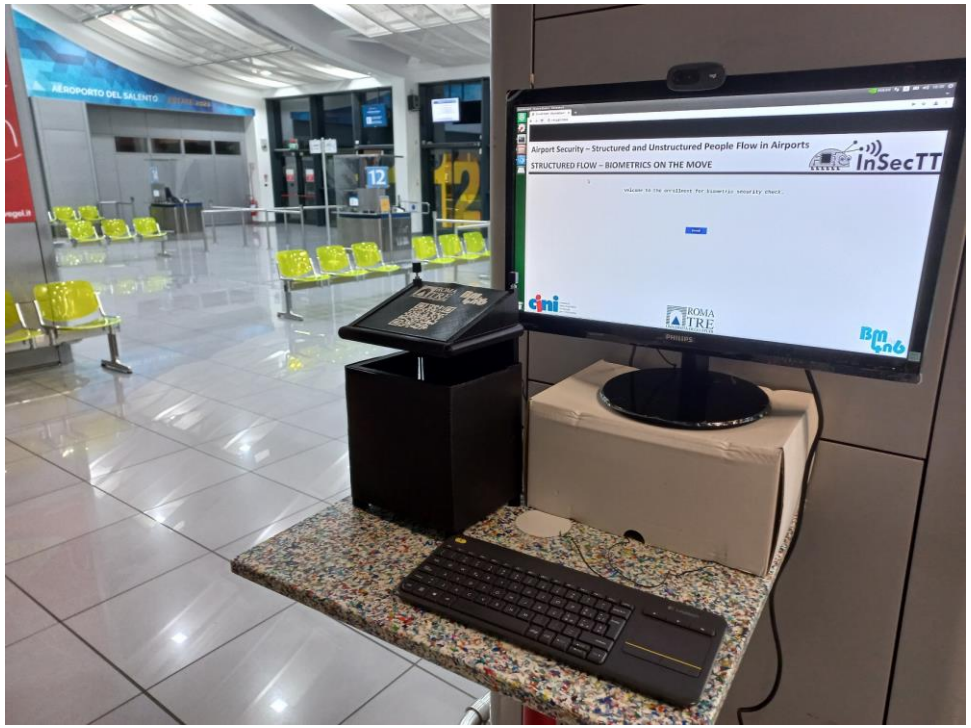
- Biometric recognition systems perform automatic user recognition exploiting physical or behavioral characteristics
  - desired properties
    - performance
    - acceptability
    - circumvention
  - advantages
    - cannot be lost or stolen
    - improved security
  - applications
    - access control
      - physical locations or logical services
    - forensics and law enforcement
      - criminal identification

State-of-the-art

- Biometrics can provide safe and convenient experience for passengers in airports
  - pros
    - some traits allow contactless way of identity verification
    - easily integrated in many processes
      - many states require biometric information in passports or during the VISA application process
    - some airports are trying new forms of biometric-based mobile check-in
      - e.g.: Heathrow Airport allows travellers to use their smartphones to verifying their identity
    - companies testing biometric boarding include Lufthansa (Miami), Finnair (Los Angeles), etc.
  - cons
    - commonly used traits (face, fingerprint) are exposed
      - easily spoofed traits, highly susceptible to attacks
      - dangerous morphing attacks

Research Goal

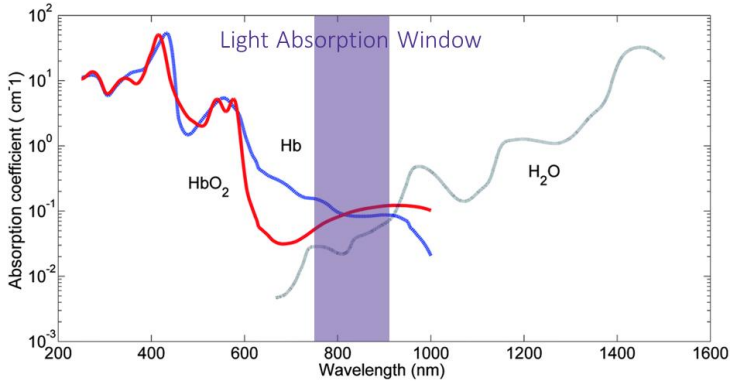
- Design a secure and convenient recognition system to be used in critical airport areas
  - requirements
    - security
      - robustness against spoofing attacks
    - convenience
      - recognition to be performed on-the-move
    - cost-effectiveness
      - on-board processing of the treated data

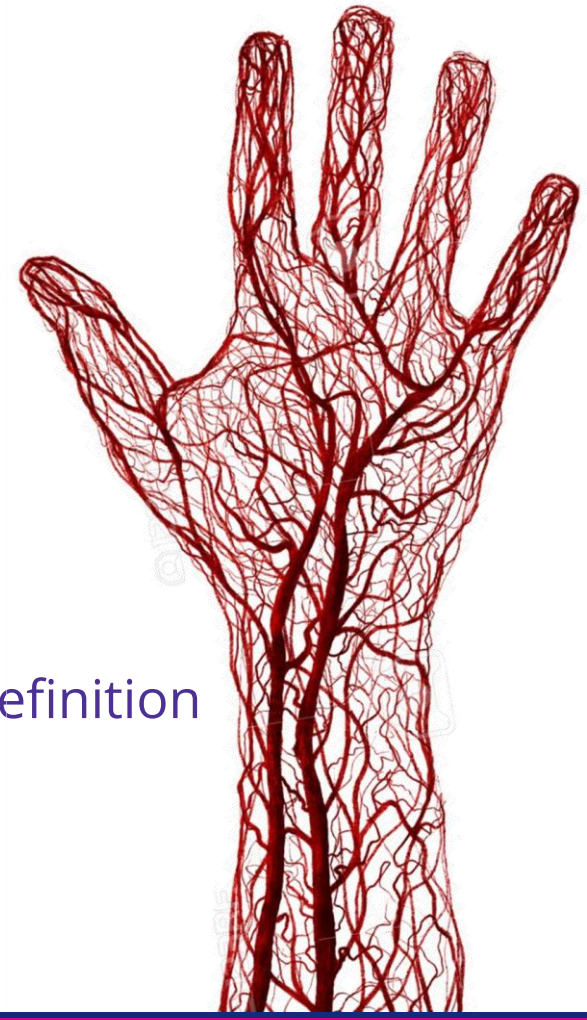


- Proposed approach
  - multi-modal biometric system relying on face and hand vein patterns
    - face recognition can be performed at a distance
    - vein patterns guarantee liveness detection, and prevent unauthorized acquisition
      - on-the-move recognition hard to accomplish

Methodology

- Most relevant innovation: vein patterns captured “on-the-move” as biometric identifiers
  - near-infrared (NIR) light is absorbed by deoxyhemoglobin
    - near-infrared cameras capture images with veins as dark pixels



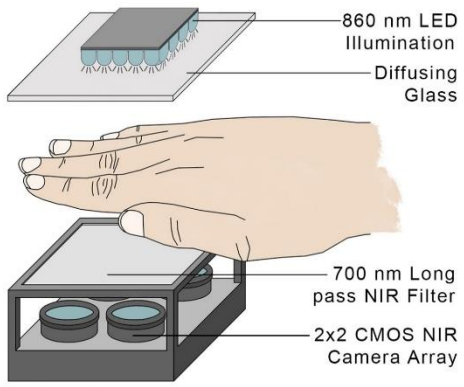


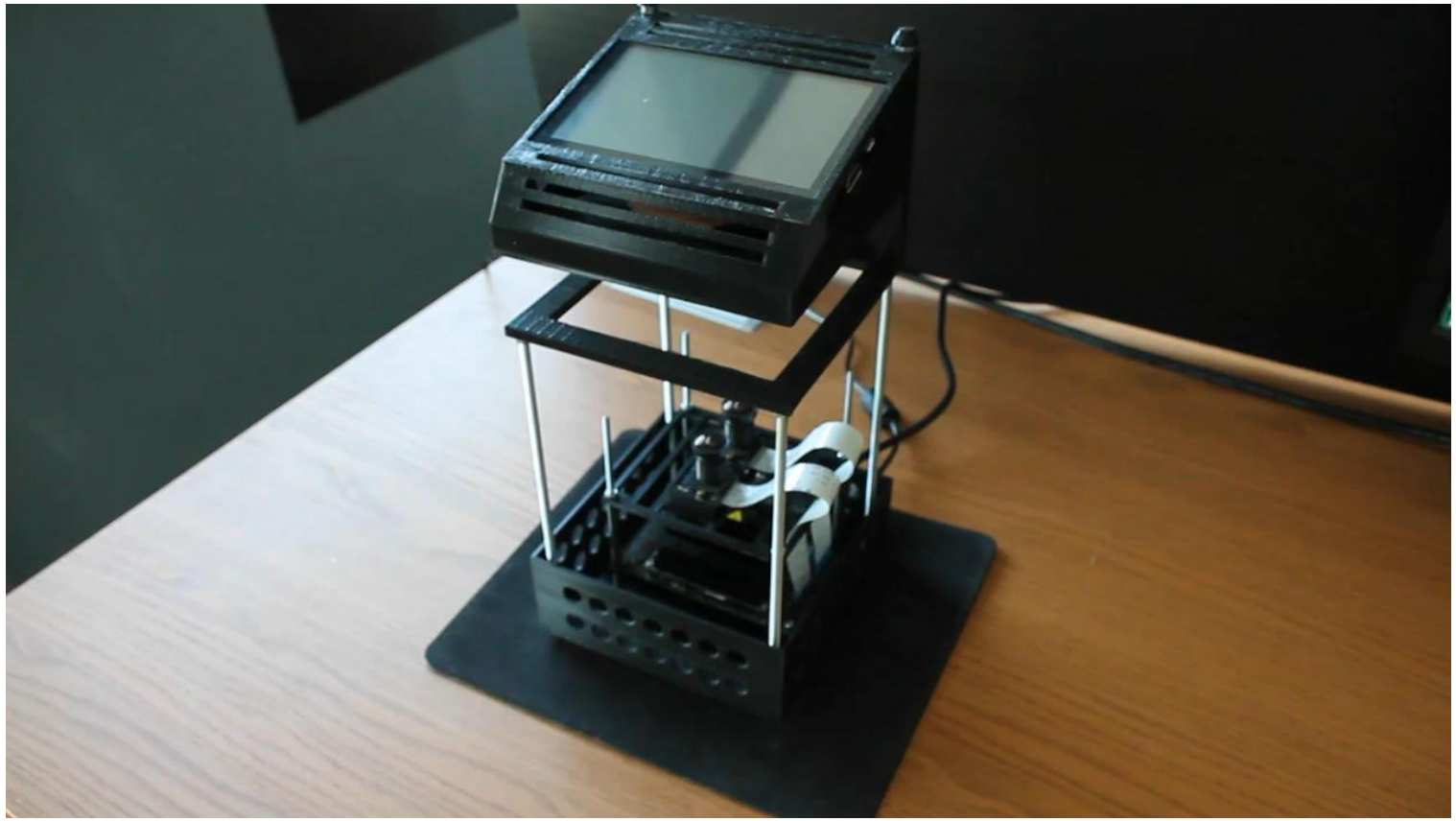
  - main issue
    - vein-pattern images often characterized by low contrast and poor definition
      - feature extraction is a challenging process

- Face and vein information fused at decision level
  - user authenticated if in the top-2 ranks for both modalities

Device Design

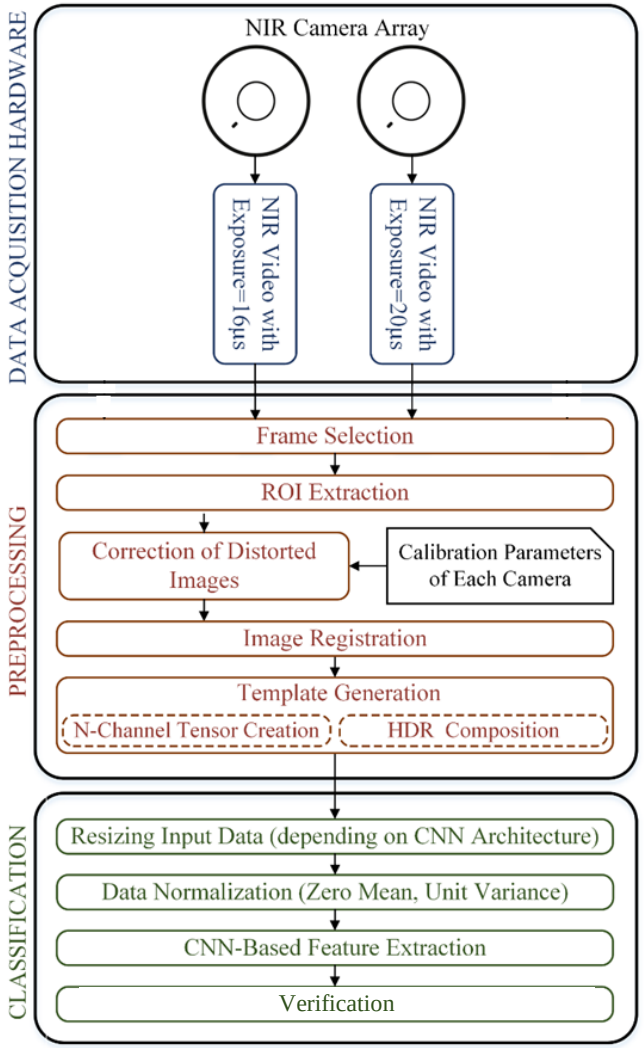
- Low-cost device based on 1 Nvidia Jetson Nano with 2 NIR cameras (+1 webcam)





Data Processing

- Pipeline



- Preprocessing
  - frames selection
    - high-contrast images
  - ROI extraction
  - image correction

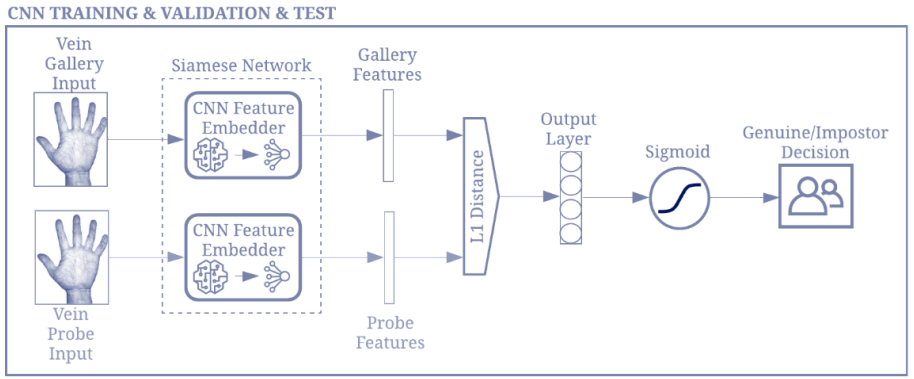
- Employed representation
  - use of conv. neural networks (CNNs)
  - transfer learning
    - modification of a Densenet-161 CNN
      - custom embedder layer

ers

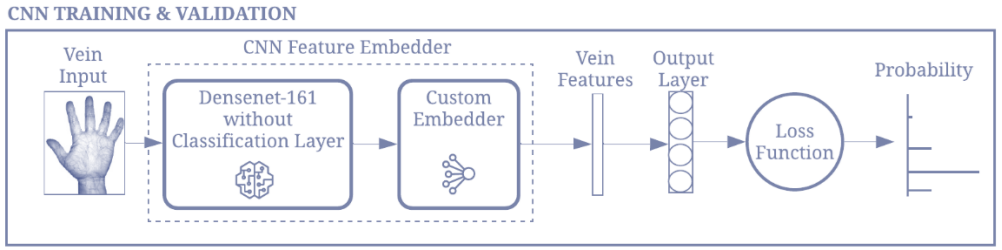
Layers		Input Size	Output Size
Convolution	7×7 conv, str.2	$224 \times 224 \times 1$	$112 \times 112 \times 96$
Pooling	3×3 max pool, str.2	$112 \times 112 \times 96$	$56 \times 56 \times 96$
Dense Block 1	$\begin{bmatrix} 1 \times 1 \text{ conv} \\ 3 \times 3 \text{ conv} \end{bmatrix} \times 6$	$56 \times 56 \times 96$	$56 \times 56 \times 384$
Transition 1	1×1 conv 2×2 avg pool, str.2	$56 \times 56 \times 384$	$28 \times 28 \times 192$
Dense Block 2	$\begin{bmatrix} 1 \times 1 \text{ conv} \\ 3 \times 3 \text{ conv} \end{bmatrix} \times 12$	$28 \times 28 \times 192$	$28 \times 28 \times 768$
Transition 2	1×1 conv 2×2 avg pool, str.2	$28 \times 28 \times 768$	$14 \times 14 \times 384$
Dense Block 3	$\begin{bmatrix} 1 \times 1 \text{ conv} \\ 3 \times 3 \text{ conv} \end{bmatrix} \times 36$	$14 \times 14 \times 384$	$14 \times 14 \times 2112$
Transition 3	1×1 conv 2×2 avg pool, str.2	$14 \times 14 \times 2112$	$7 \times 7 \times 1056$
Dense Block 4	$\begin{bmatrix} 1 \times 1 \text{ conv} \\ 3 \times 3 \text{ conv} \end{bmatrix} \times 24$	$7 \times 7 \times 1056$	$7 \times 7 \times 2208$
Custom Embedder	7×7 global avg pool batch normalization dropout (50%)	$7 \times 7 \times 2208$	1×2208
	fully connected layer batch normalization	1×2208	1×2048
Classifier	output layer	1×2048	$1 \times U$

Learning Process

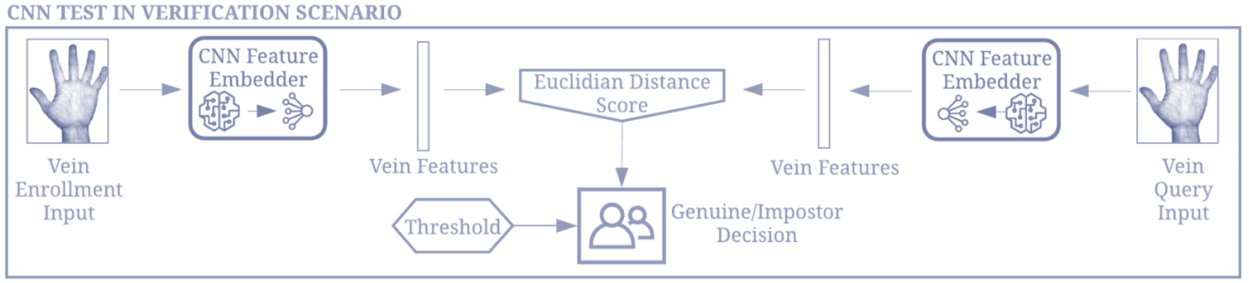
- Purpose
  - learn discriminative feature for users not in training (open-set conditions)
  - train a network valid for all possible subjects, instead of one for every user
    - possibilities
      - siamese network training



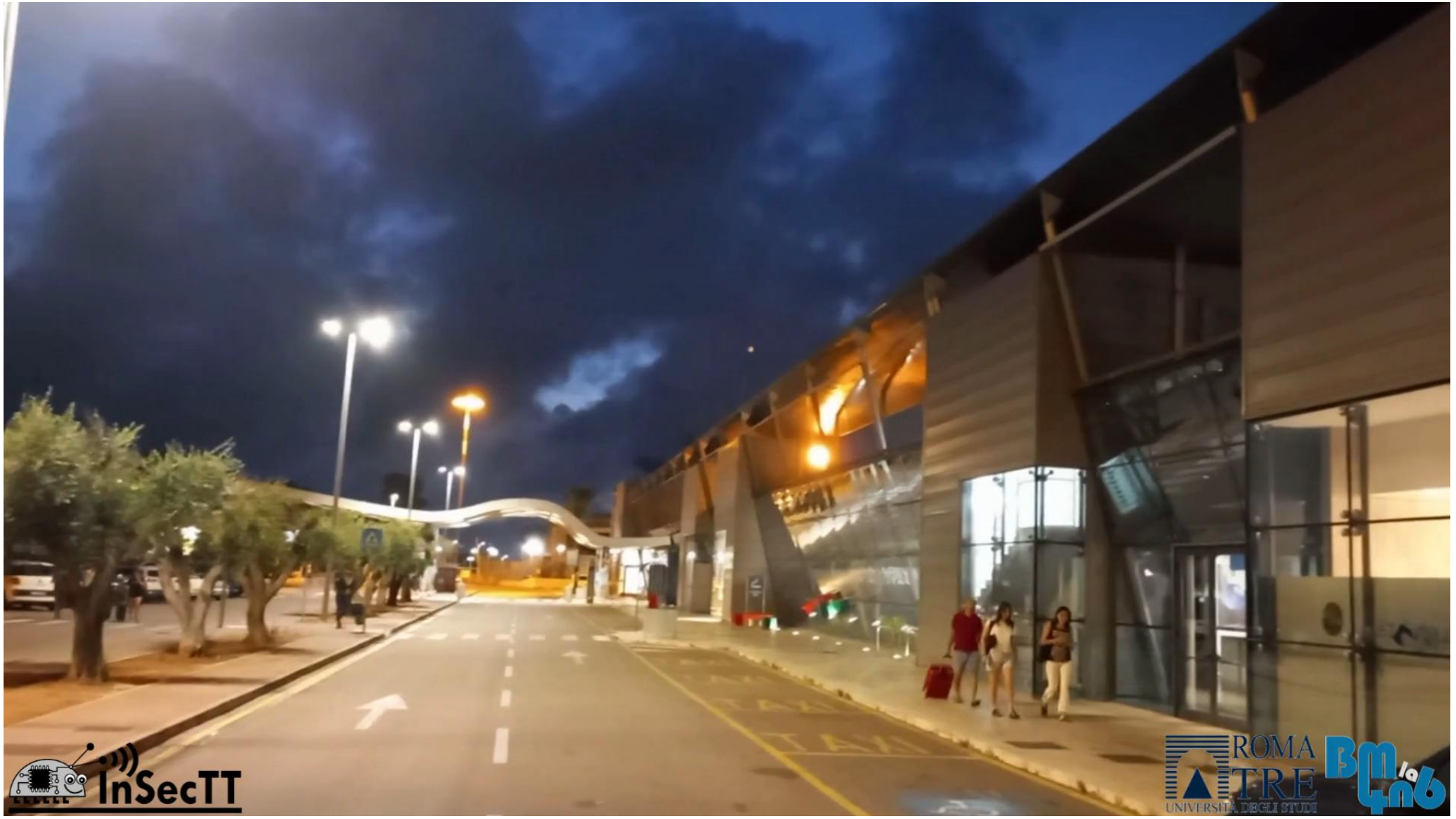
      - alternative loss function
        - additive angular margin penalty (AAMP)



      - verification (EER < 1%)

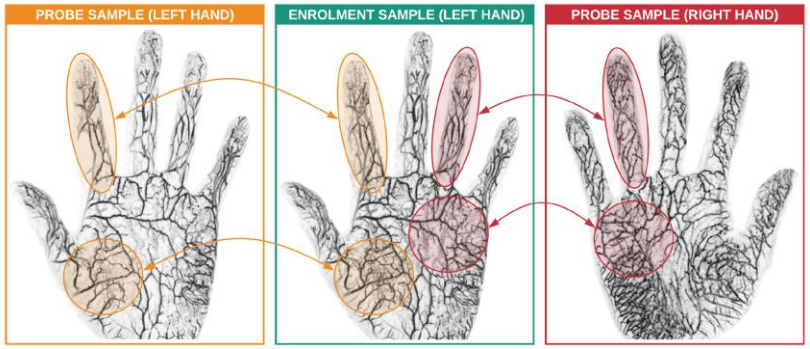


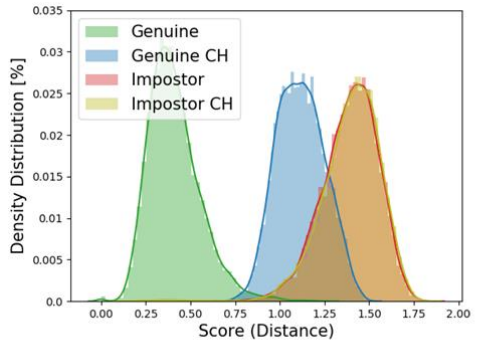
Demo



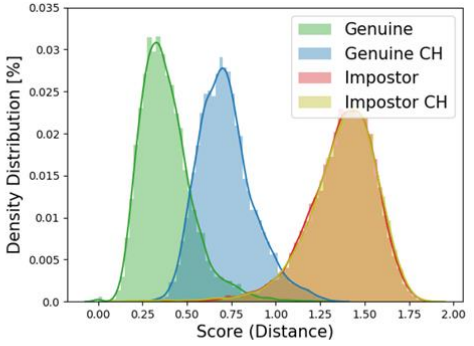
Future Research

- Hands interoperability
  - evaluation of same-subject cross-hand vein pattern similarity
    - training strategies allowing hand interoperability could increase user convenience



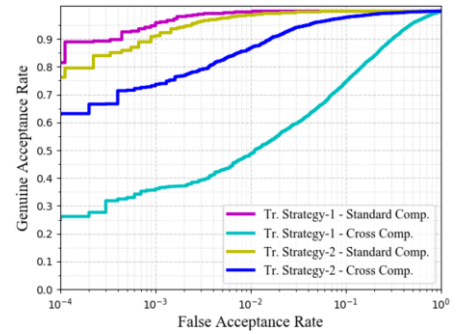


Training Strategy-1

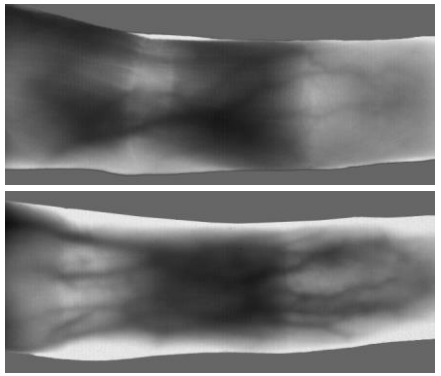


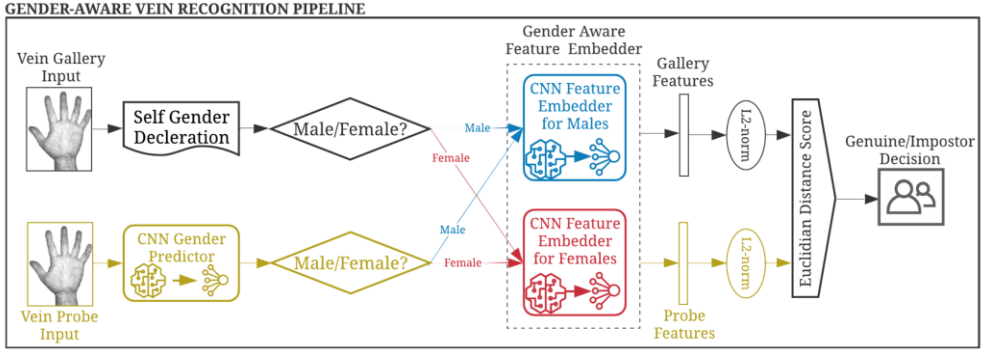
Training Strategy-2

Training Strategy-1		Training Strategy-2	
0.57%	17.6%	1.19%	4.46%

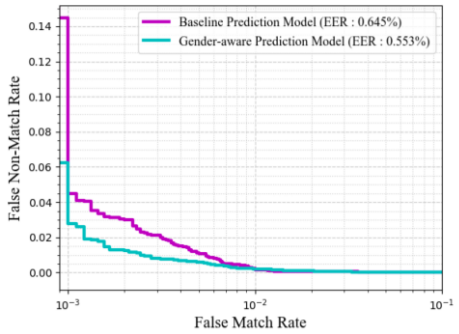


- Gender bias
  - differences in men/women vein patterns characteristics



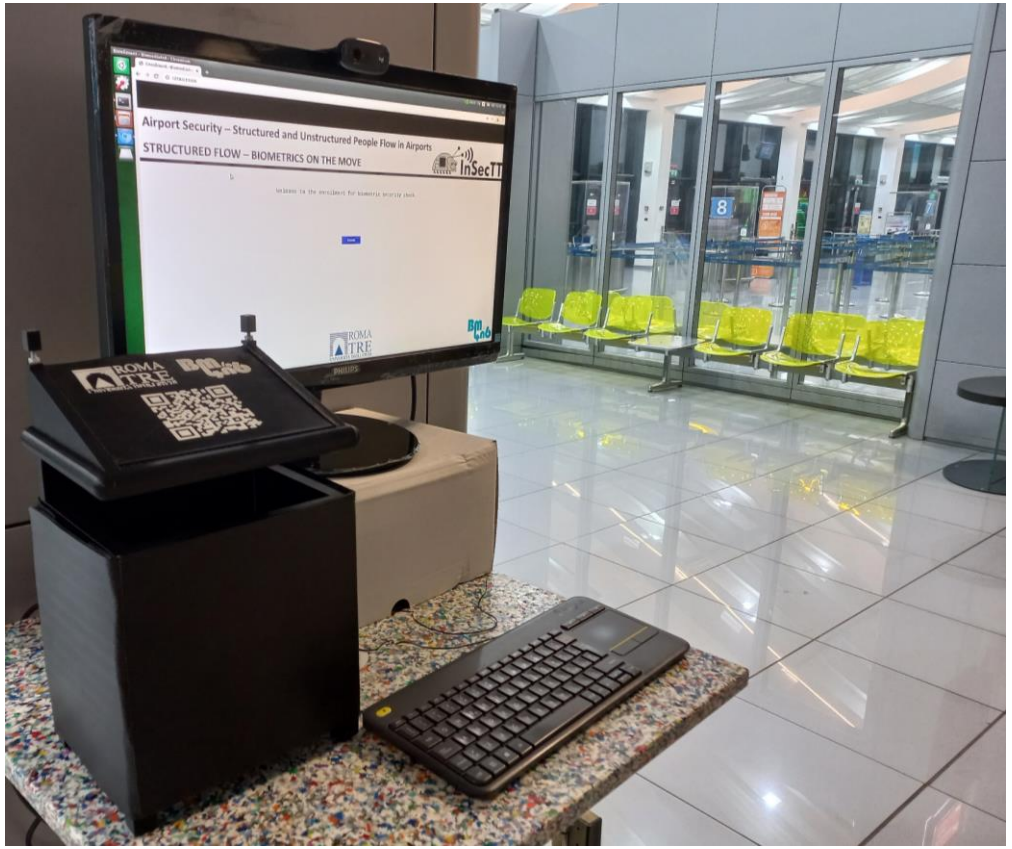


	Imbalanced Scenario			Balanced Scenario		
Class	Female	Male	W. Avg.	Female	Male	W. Avg.
Baseline	0.894%	0.612%	0.645%	1.339%	0.952%	1.160%
Gender-aware	0.879%	0.310%	0.553%	1.129%	0.883%	1.007%



Conclusion

- An “on-the-move” biometric recognition systems has been developed
  - suitable for critical airport areas
    - convenient
      - requires only minimal interaction
    - secure
      - vein patterns guarantee liveness detection
    - cost-effective
      - low-cost components and on-board processing



- Future research
  - vein patterns could represent a good alternative to fingerprints for biometric recognition

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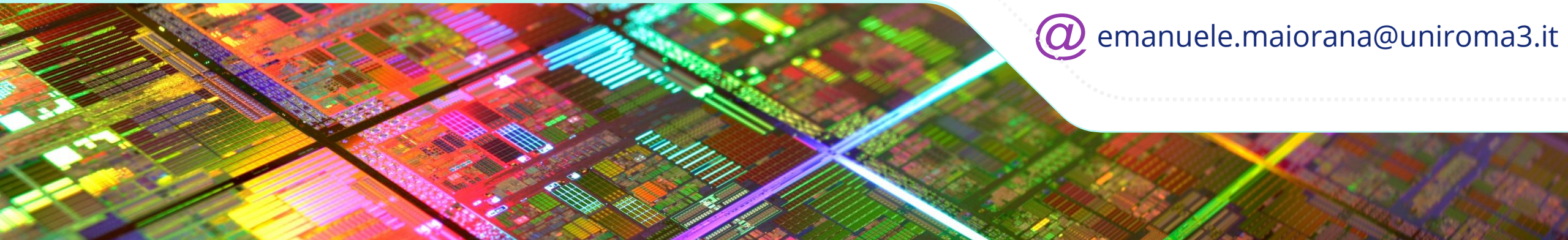
Thank You

For your attention



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