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Centre de Visió per Computador

# WEARABLE BIOMETRICS AND AUTOMATIC HUMAN BEHAVIOR ANALYSIS TECHNOLOGIES FOR ADAPTATION AND PERSONALIZATION OF THE SMART CITY TO THE SMART CITIZEN

**Oriol Pujol**, Sergio Escalera

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# Who we are ...

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# What do we do?

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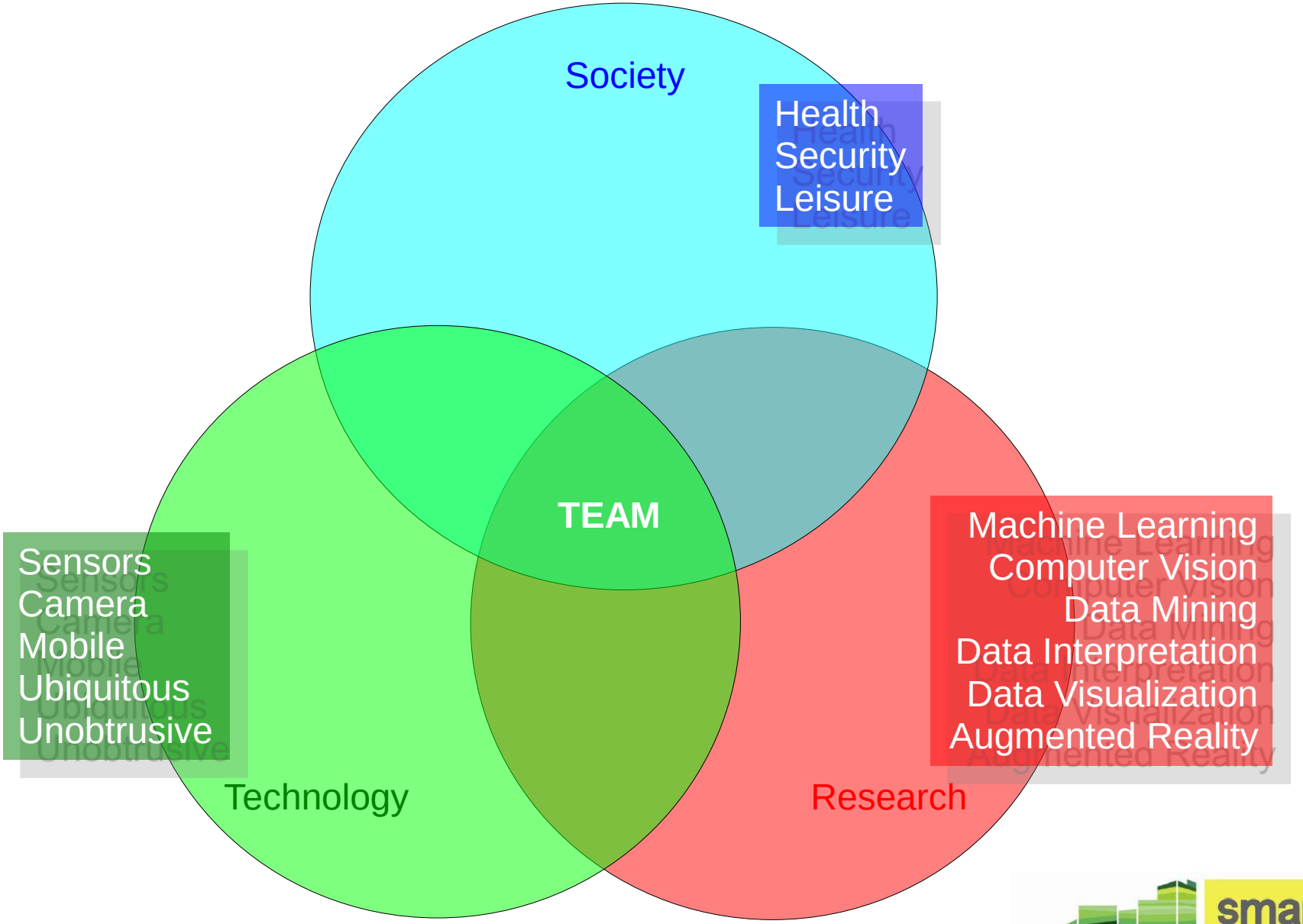


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# Outline

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- Smart citizen role in the smart cities scenario
- Soft-biometric systems for adaptation of the smart city
  - What
  - How
  - Experience
- Human behavior analysis in smart homes
  - What
  - How
  - Experience
- Conclusions

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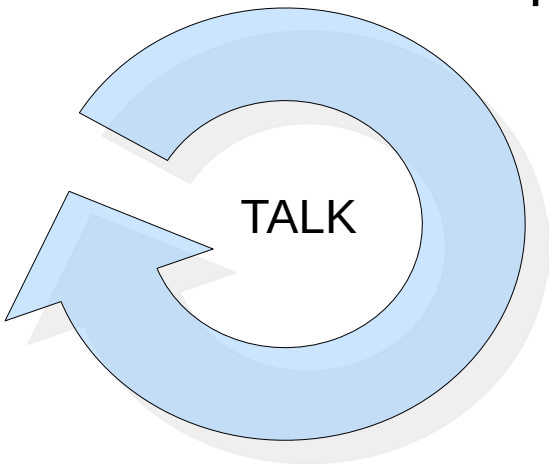
# Smart cities and … active citizens

Modern Transportation
Modern ICT Infrastructures
Sustainable economic development
High quality of life
“Green” cities
e-Governance




Preferences
Opinions
Choices
Location and behavior

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# Smart city layers

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FINAL USER APPS

PERSONALIZED FACILITIES

ENABLERS
Soft-biometrics
User Behavior Analysis
User Context Analysis
Preferences Modelling

ARTIFICIAL INTELLIGENCE
ML, CV, DM, DFusion

PAN + LAN + WAN

ENVIRONMENT
EGOCENTRIC

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# Biometrics in the Smart Cities scenario

FINAL USER APPS

PERSONALIZED FACILITIES

- CITY IS AWARE OF THE USER

- USER IDENTIFIES HIMSELF USING SOME WEARABLE DEVICE

CITIZEN LIVES IN THE CITY – COMMUNICATION AT ALL TIMES AND EVERYWHERE:

NEW REQUIREMENTS:

**CONTINUOUS and UNOBTRUSIVE**

**PROPOSAL: SOFT-BIOMETRICS FROM USER'S GAIT**

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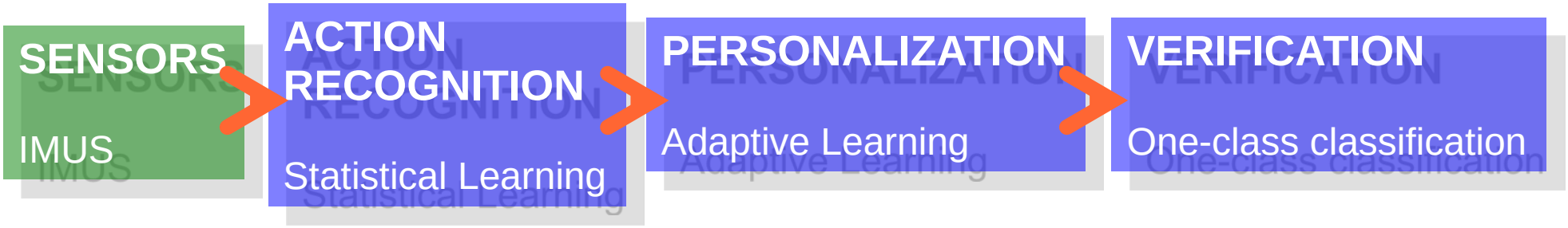
# How …
# general pipeline

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# How …

**SENSORS**

IMUS

**ACTION RECOGNITION**

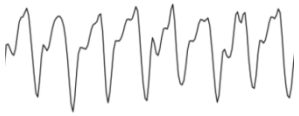
Statistical Learning

**PERSONALIZATION**

Adaptive Learning

**VERIFICATION**

One-class classification



**ACTION RECOGNITION**

Statistical Learning

Multi-class classifier:

Daily patterns:

- walking
- climbing stairs
- standing idle
- interacting with environmer
- working – office

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# How …

**SENSORS**

IMUS

**ACTION RECOGNITION**

Statistical Learning

**PERSONALIZATION**

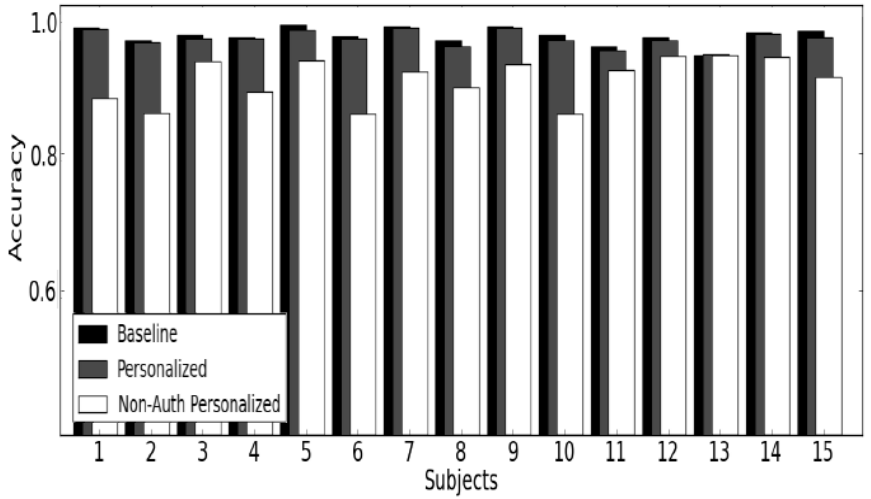
Adaptive Learning
Incremental techniques

**VERIFICATION**

One-class classification

GOAL: Bias the general action recognition system towards data of authorized users

- **Increase acceptance:** Improve recognition for authorized users
- **Filter out non-authorized users :** Reduce recognition for non-authorized users



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# How …

**SENSORS**

IMUS

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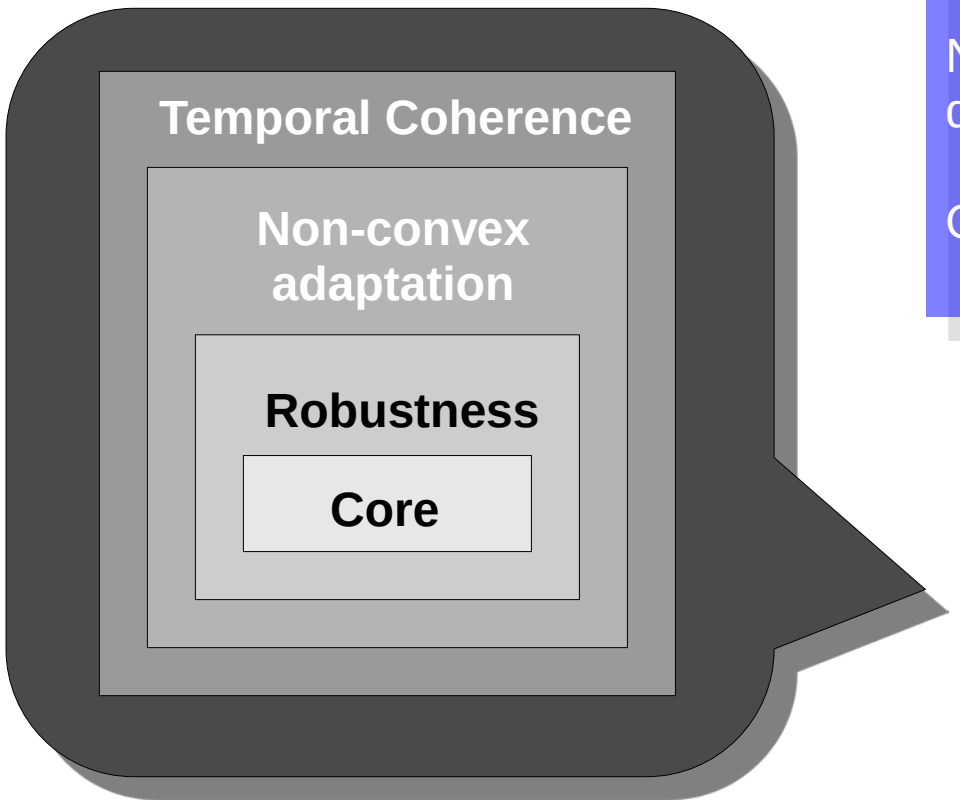
Adaptive Learning

**VERIFICATION**

One-class classification




**VERIFICATION**

Non-authorized users are difficult to model

One-class classification strategy

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# Experience ...

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## EXPERIMENTAL SETTINGS

**Android based smartphone**

20 users in 7 scenarios:

- Indoor corridors
- Outdoor street uphill and downhill
- Crowded flat urban street
- Free urban street
- Mixed scenarios with obstacles
- Rough floors

## PERFORMANCE MEASUREMENTS

**False Rejection Rate** – user is not verified as authorized user
**False Acceptance Rate** – a non-authorized user is verified as authorized

**Baseline SOTA results: 10% of EER**
**Our system:**
**FRR < 2%**
**FAR < 0.06%**

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# Human Behavior Analysis in Smart Environments

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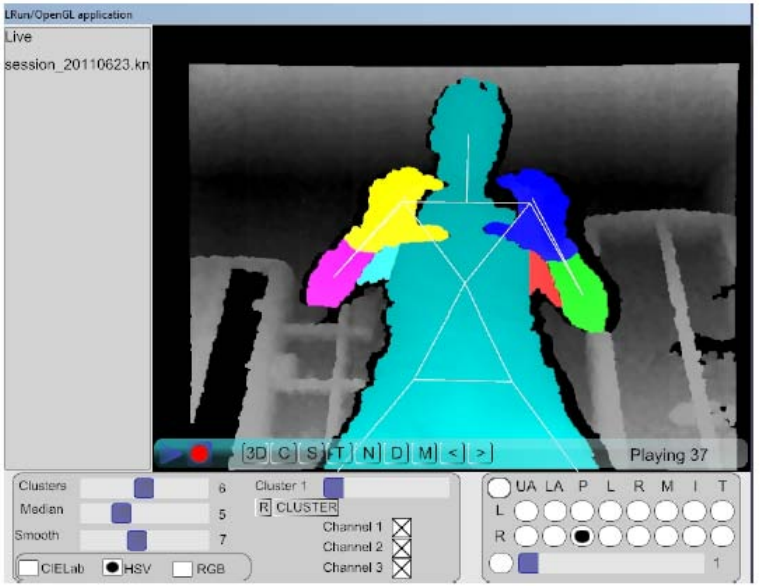
**PROPOSAL: NON-INVASIVE MULTI-MODAL HUMAN POSE RECOVERY AND BEHAVIOR MODELLING IN SMART ENVIRONMENTS**

INTERACTION WITH FACILITIES
- Proactive systems
- User direct activation
- Internet of Things

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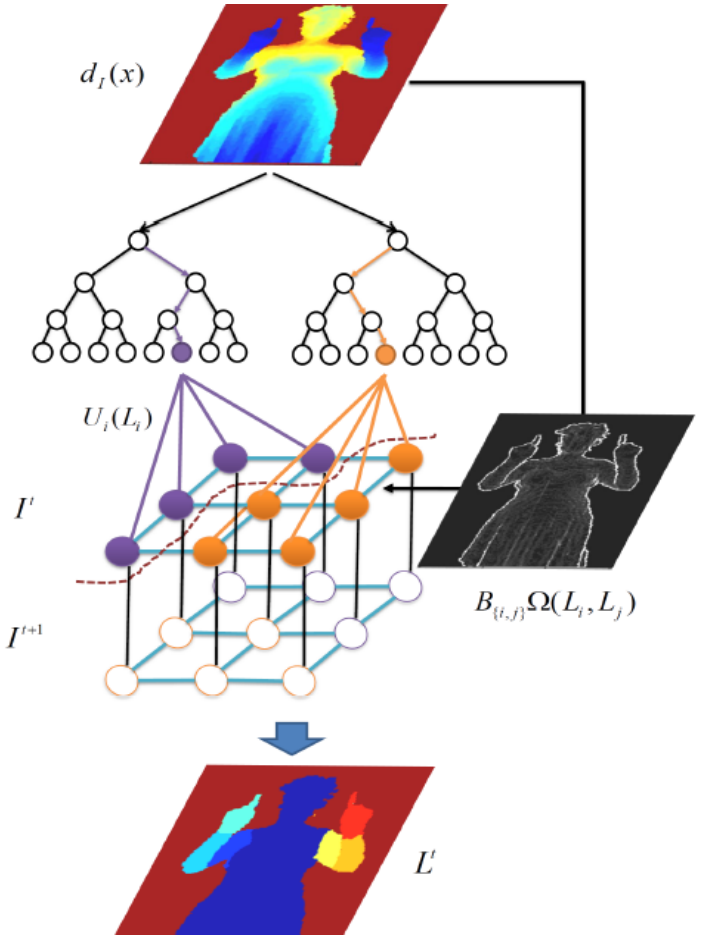
# How ...

**SENSORS**

RGB cameras
Depth sensors

**FUSION**

Ensemble Learning




**STATISTICAL LEARNING**

Probabilistic Graphical Models

**BEHAVIOR ANALYSIS**

Sequential Learning

**JOINT SEGMENTATION AND RECOGNITION**

Limb parts inference

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# Experience ...

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## Human Pose Recovery

- Indoor environments
- Several subjects free movements

**Baseline SOTA results: 80%**
**Our system: 90%**

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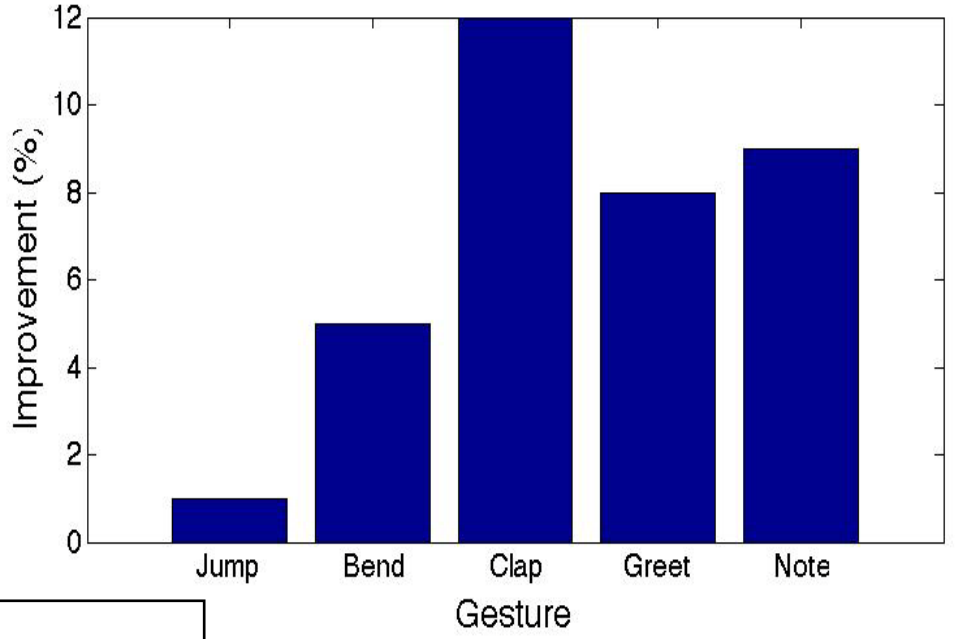
# Experience ...

Human Behavior Analysis

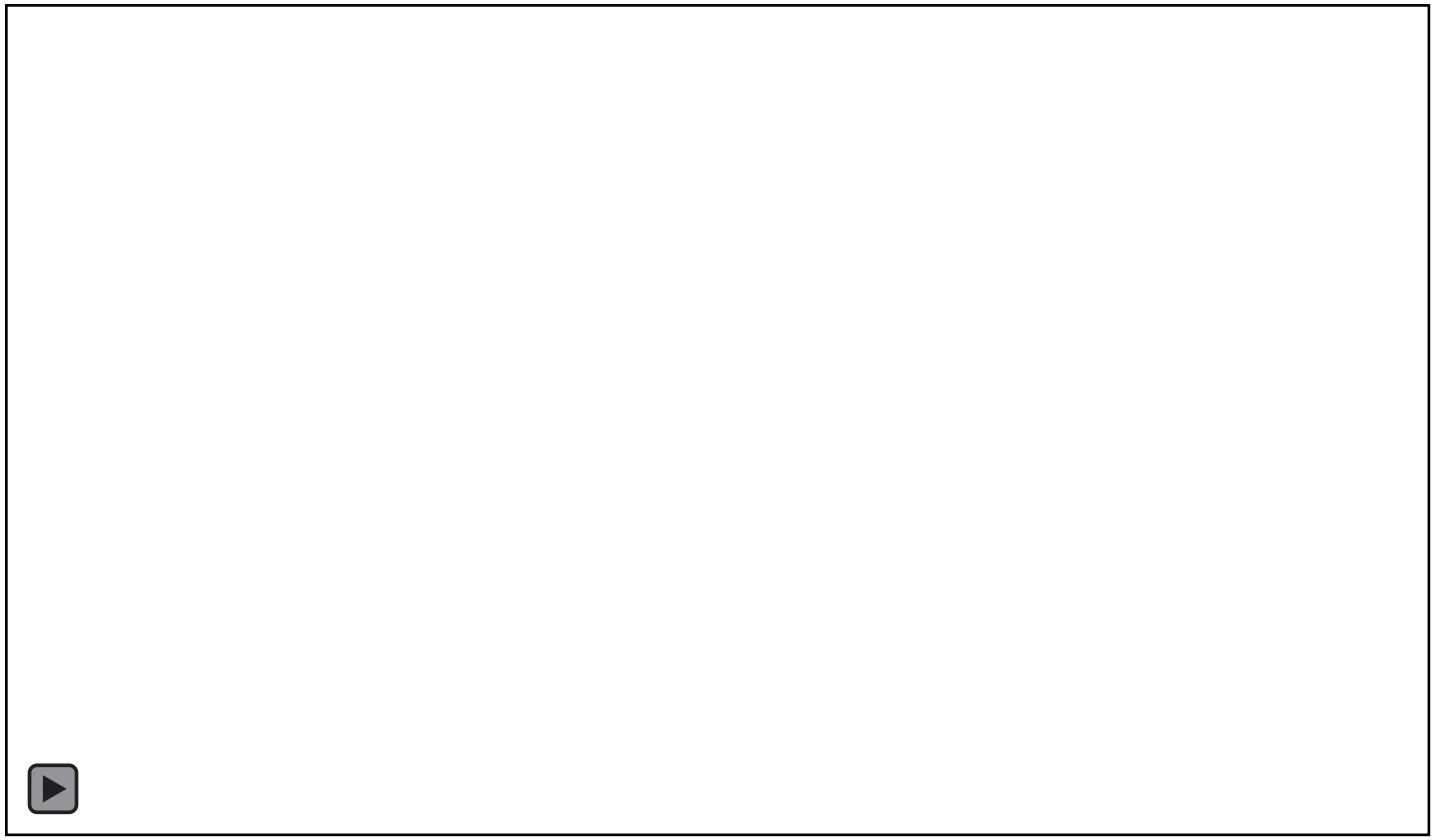
- Indoor environments
- Several subjects free movements
- Recognition of five behaviors
- Improved sequence aligment



# Experience ...

**Human-Object Interaction**

- Indoor corridors
- Joint modeling of citizen and objects
- Logging of objects / places / owners
- Quasi-Internet of Things



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# Conclusion

Effective communication channels between the city and the citizen

- Smart environments proactive sensing
- Unobtrusive egocentric sensing

Data fusion and artificial intelligence are key component in the Smart City reality

FUTURE is defined by a true collaboration among all stakeholders
from each architecture layer

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