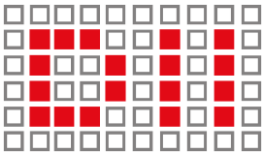
IEEE ICC 2015
Workshop on ICT-enabled services and technologies for
eHealth and Ambient Assisted Living

Human Activity Analysis for in-home Fall Risk Assessment

Daniele Liciotti, Gionata Massi, Emanuele Frontoni,
Adriano Mancini, and Primo Zingaretti*
* Università Politecnica delle Marche - Department of Information Engineering

UNIVERSITÀ
POLITECNICA
DELLE MARCHE



Talk layout

- Introduction
  - AAL (The falling problem)
  - Goals
- Overview of the System Architecture
  - Physical architecture
  - Software architecture
  - Movements Map
- Results
- Conclusion

The falling problem in elderly

- Falls are one of the major source of morbidity and mortality in the elderly population [1]
- As a result physical activity is reduced, leading to:
  - muscle atrophy
  - less social interactions
  - a reduced quality of life
- The elder should be urged to ”move”, encouraging the use of the residual motor capacities

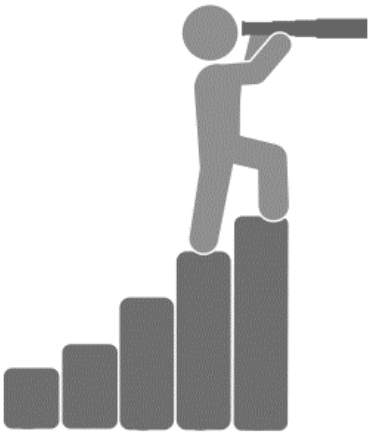
[1] Todd C, Skelton D. (2004) What are the main risk factors for falls among older people and what are the most effective interventions to prevent these falls?, Copenhagen, WHO Regional Office for Europe (Health Evidence Network report)

Goals

- Monitoring the degree of vitality of elderly users in their daily activities
- Designing a system less intrusive as possible
- Keeping complexity as low as possible

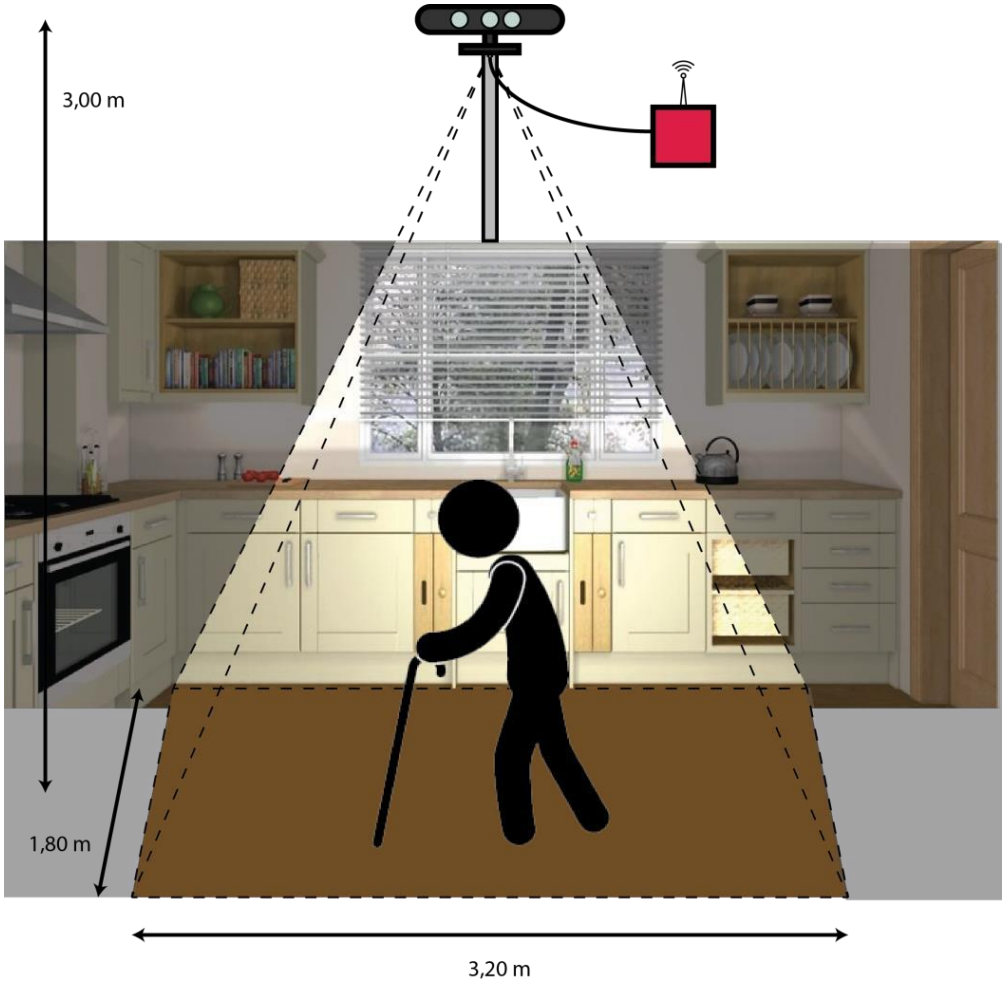
Goals

- The aim of the proposed project, is an intelligent low-cost embedded video system able to:
  - identify elderly users
  - analyse behaviors and posture
  - provide a large amount of data



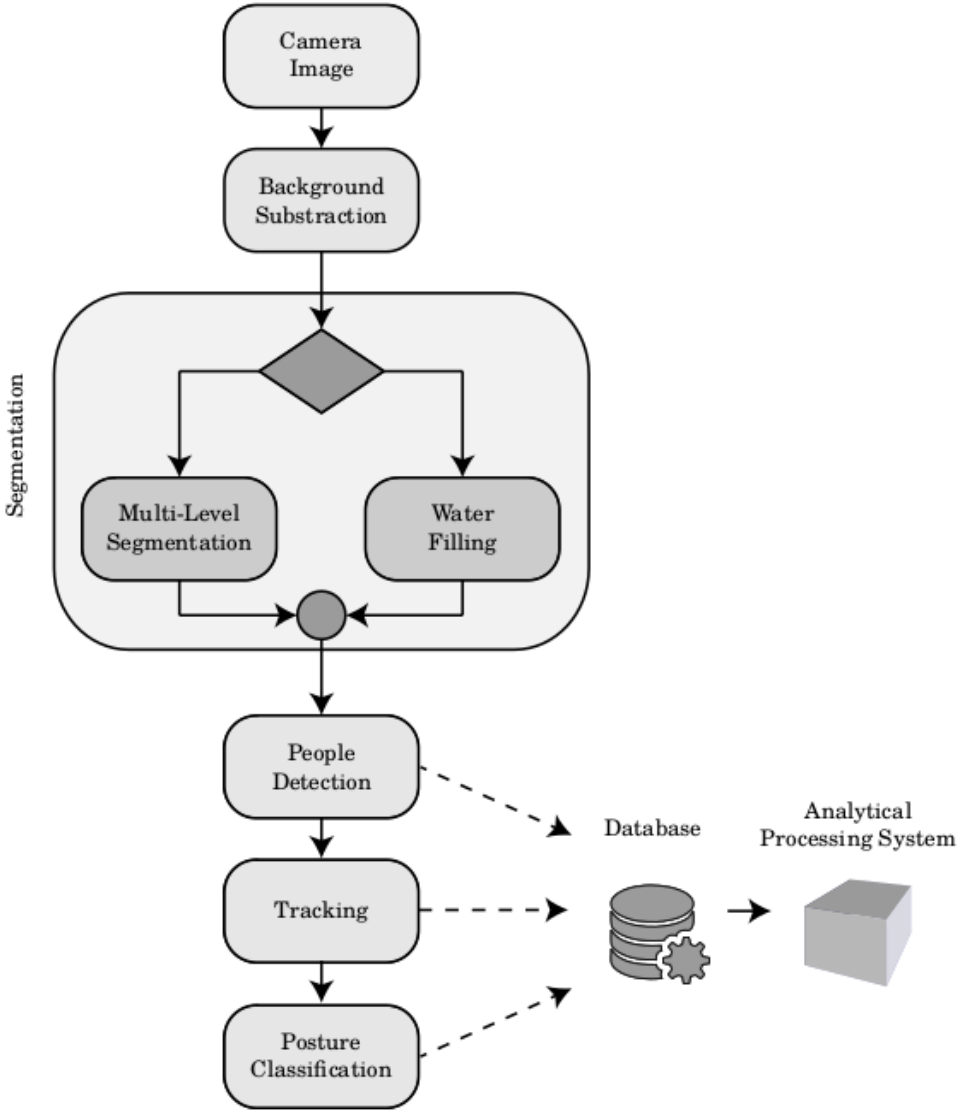
Physical Architecture

- RGB-D Sensor in a top-view configuration (Asus Xtion Pro Live)
- Embedded System (we choose the CubieBoard2)

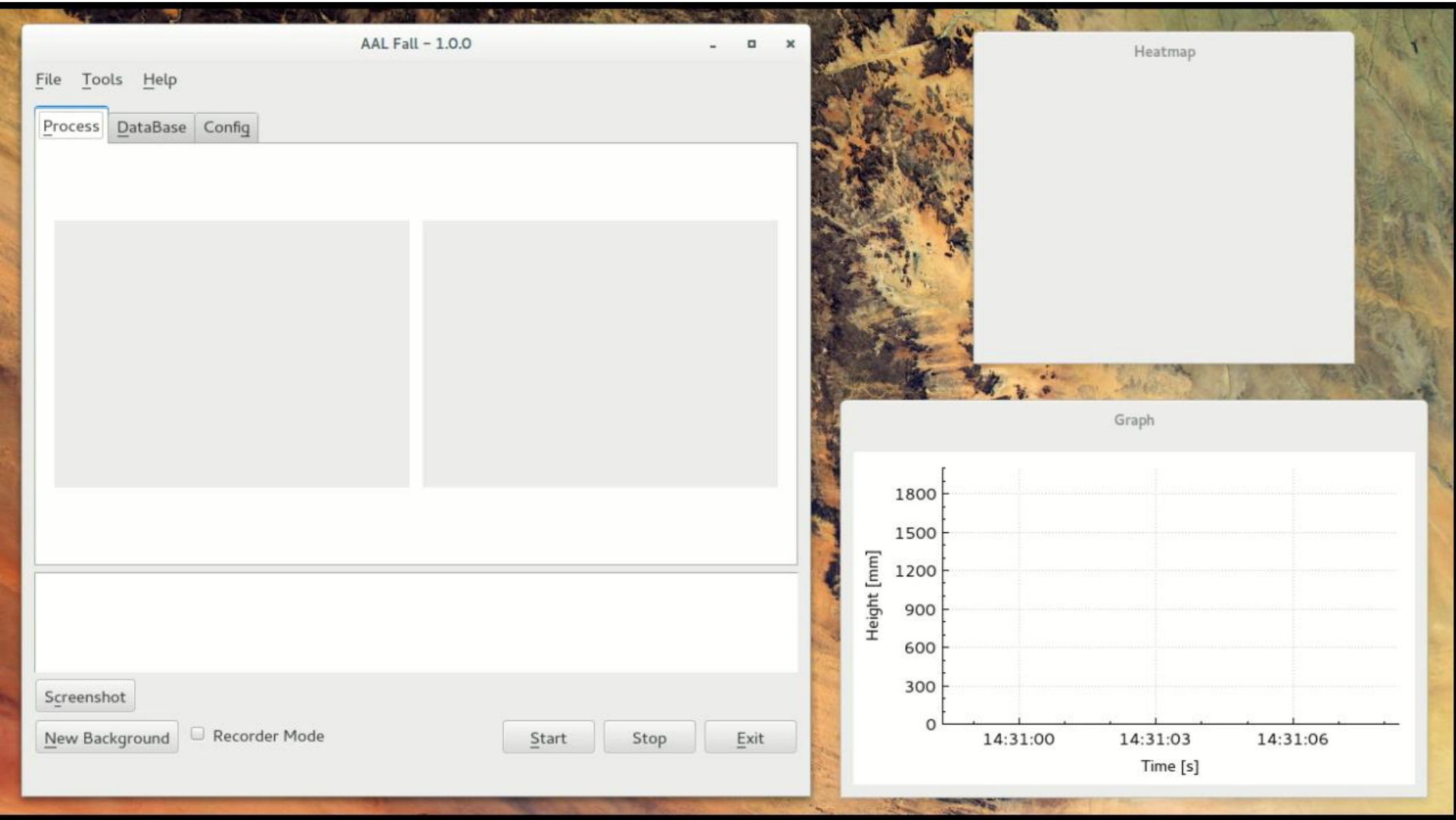


Software Architecture

- The main steps of algorithms



Demo


AAL Fall – 1.0.0
File
Tools
Help
Process
DataBase
Config
Screenshot
New Background
Recorder Mode
Start
Stop
Exit
Heatmap
Graph
1800
1500
1200
900
600
300
0
Height [mm]
14:31:00
14:31:03
14:31:06
Time [s]

Camera Image

Depth

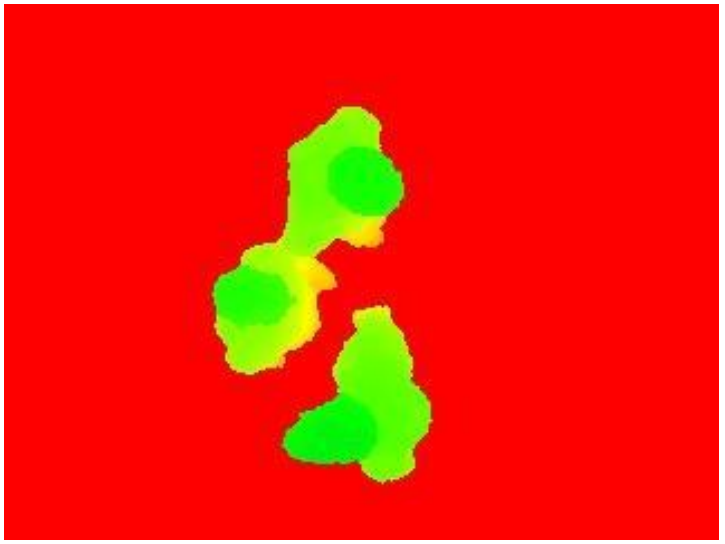
Depth stream
640x480

RGB

Color stream
640x480

Background Subtraction

Depth

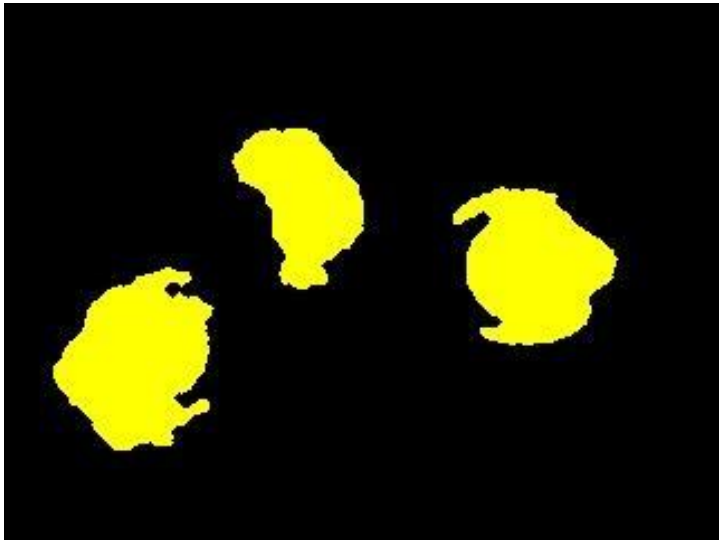


RGB

Foreground = new Frame - Background

Multi-Level Segmentation

Depth



RGB

Find contours of people

Multi-Level Segmentation

Depth

RGB

Multi-Level Segmentation Algorithm

Multi-Level Segmentation

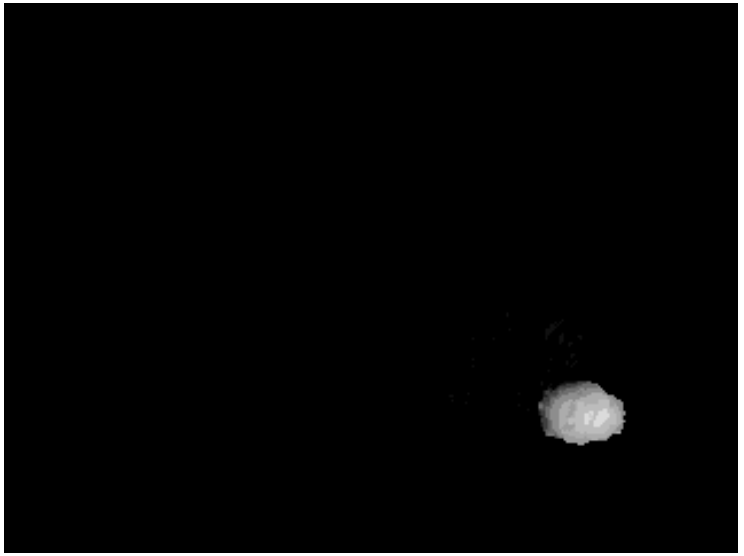
input : A depth image filtered $f(x, y)$
output: A vector of points $points$
max, $point_{max} \leftarrow minMaxLoc(f(x, y))$;
$level \leftarrow threshold$;
while $max - level > floor$ **do**
    $f_{level}(x, y) \leftarrow f(x, y) < (max - level)$;
    $contoursTemp \leftarrow findContours(f_{level}(x, y))$;
    filter contours by area;
    find $point_{max}$ for all contours;
    if $point_{max} \in points$ **then**
        $skip$;
    else
        $points.push\_back(pointpoint_{max})$;
    end
    $level \leftarrow level + threshold$;
end

Algorithm 1: Multi-level segmentation algorithm.

- In the segmentation procedure, new blob boundaries are detected and their maximum point (the highest point of each person) is determined.
- Only the new values are saved into a vector.
- The segmentation procedure ends when the last level analysed corresponds to the floor.

Water Filling*

Depth

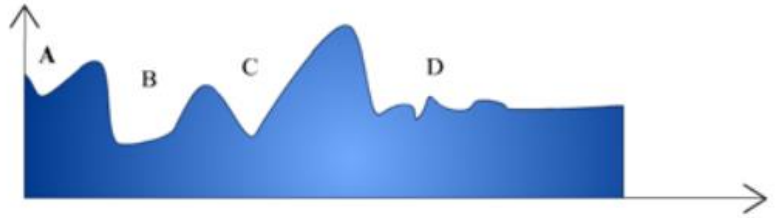


RGB

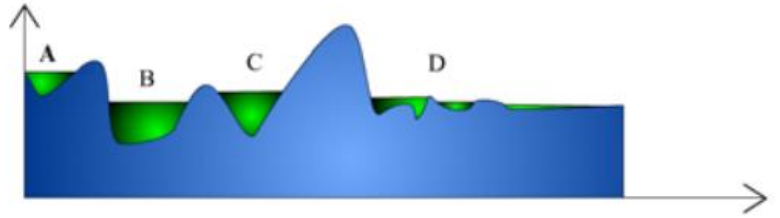
*Zhang, Xucong, et al. "Water filling: Unsupervised people counting via vertical kinect sensor." Advanced Video and Signal-Based Surveillance (AVSS), 2012 IEEE Ninth International Conference on. IEEE, 2012.

Water Filling

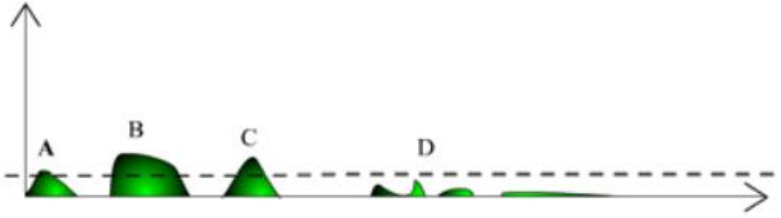
- Finds the local minimum regions simulating the rain and the flooding of ground. According to a uniform distribution, it simulates the rain with some raindrop.
- Moves the raindrops towards the local minimum points, but if a point is wet, it wets the point of the higher level.
- Then, puddles are formed because the water flows to some local minimum regions.



(a) $f(x, y)$: original depth image.



(b) $f(x, y) + g(x, y)$: result of water filling.

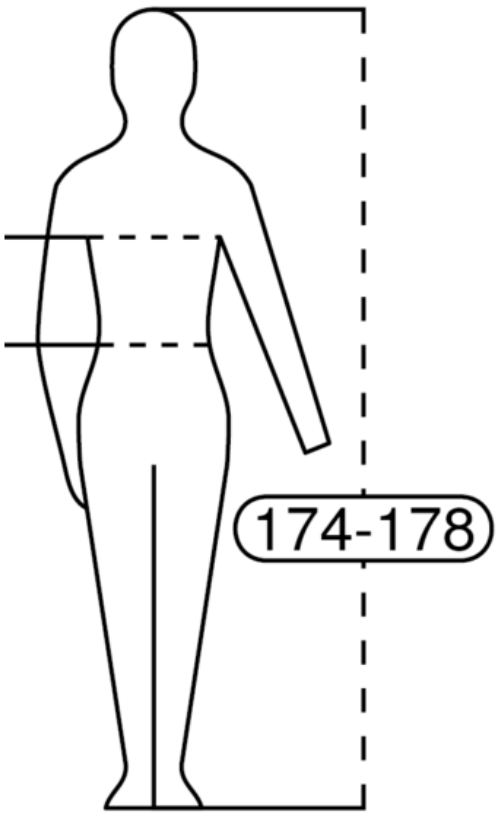


(c) $g(x, y)$: measure function

People Detection

Determines if a set of pixel represents a person or an object by using the following features:

- the height of each person, h_{height}
- the size of each head, A_{head}
- the head-shoulders distance, $d_{h/s}$

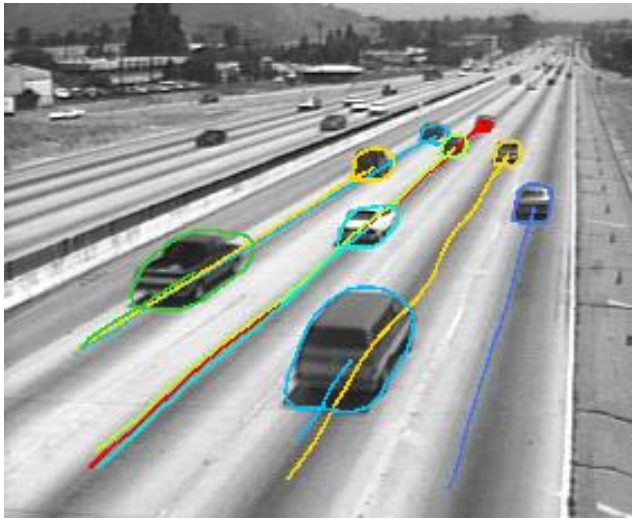


Tracking

The tracking algorithm recognizes if a person has been already identified by the system using the set of features:

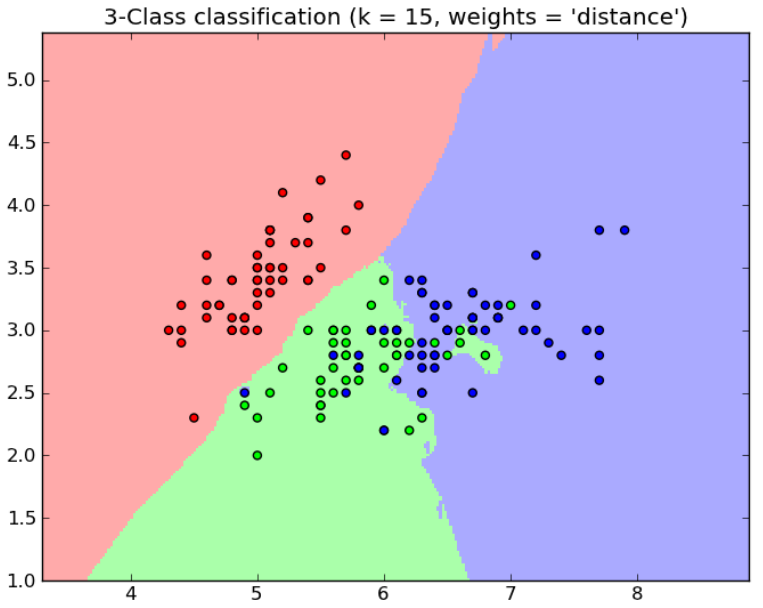
- the spatial positioning of the person;
- the recordings of people recognized in a set of previous frames.

If the person is recognized, the system associates to the person the previously generated identifying label, otherwise it generates a new label and marks the person.



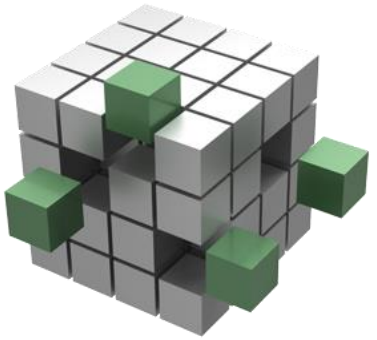
Posture Classification

- Measuring the height of the same person over the time, the posture classifier determines if a person:
  - stands up;
  - is sitting;
  - is falling.
- In the last scenario we take in account the robustness of this measurement and providing also an output signal that emits an alarm.



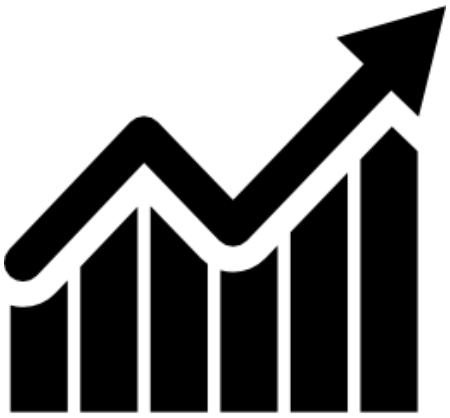
Analytical Processing System

- The information provided by the last procedures is recorded in a database.
- A separate process that accesses the data published on the database and extracts statistics and knowledge about the inhabits.



Results

- We tested the system in a simulated environment, the image acquisition and processing allow a processing rate of about 25 frames per second.
- The accuracy test, measured against the ground truth, consists of 30 recording of about one minute.
- The analysis software shows, in real-time, the number of people that pass in the room, the ones who are walking, sitting or falling. For each person in the room, a motion activity index is computed.



Conclusion

- In this work, we presented a novel method of fall detection, that is a useful tool to monitor the physical activities of the elderly at home.
- The major advantages of the proposed solution are that it is non-contact and ethically correct.

Thanks for your attention!

Daniele Liciotti
d.liciotti@univpm.it
Università Politecnica delle Marche - Department of Information Engineering

UNIVERSITÀ
POLITECNICA
DELLE MARCHE