

Fall detection algorithm: in development...

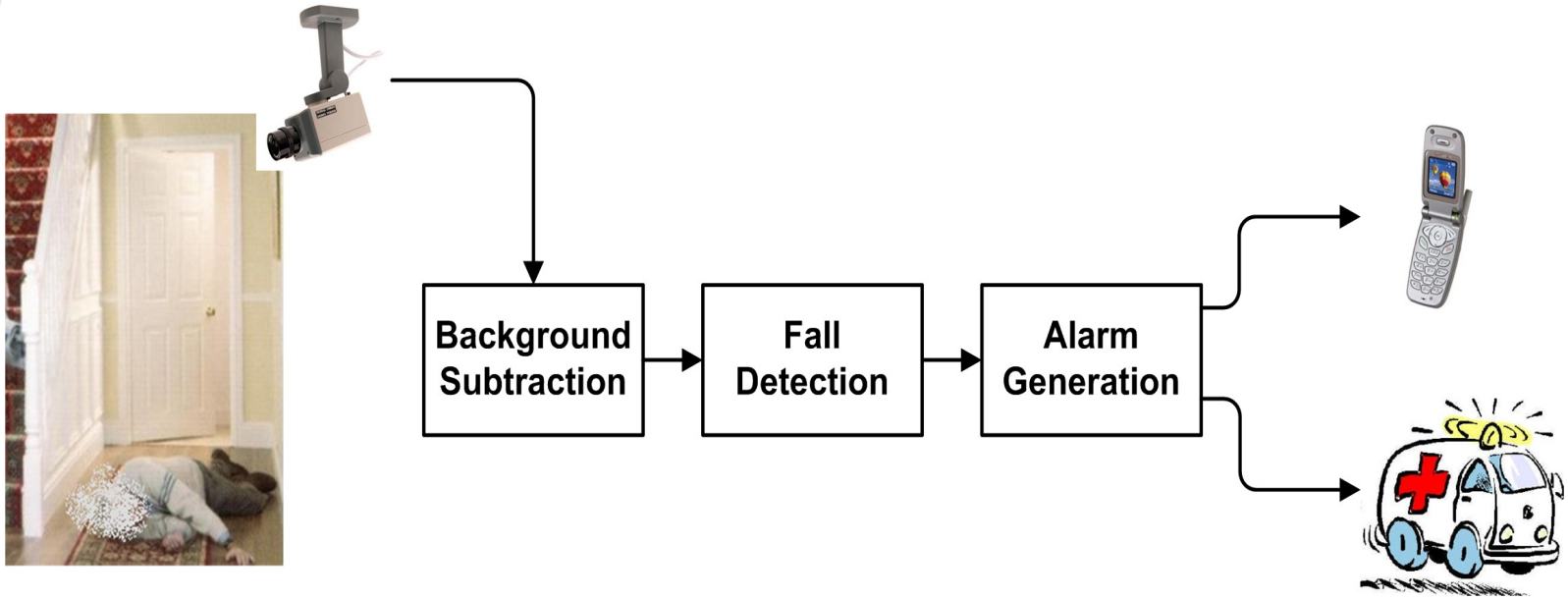
Toon Goedemé
(Jared Willems and Glen Debard)

www.fallcam.be

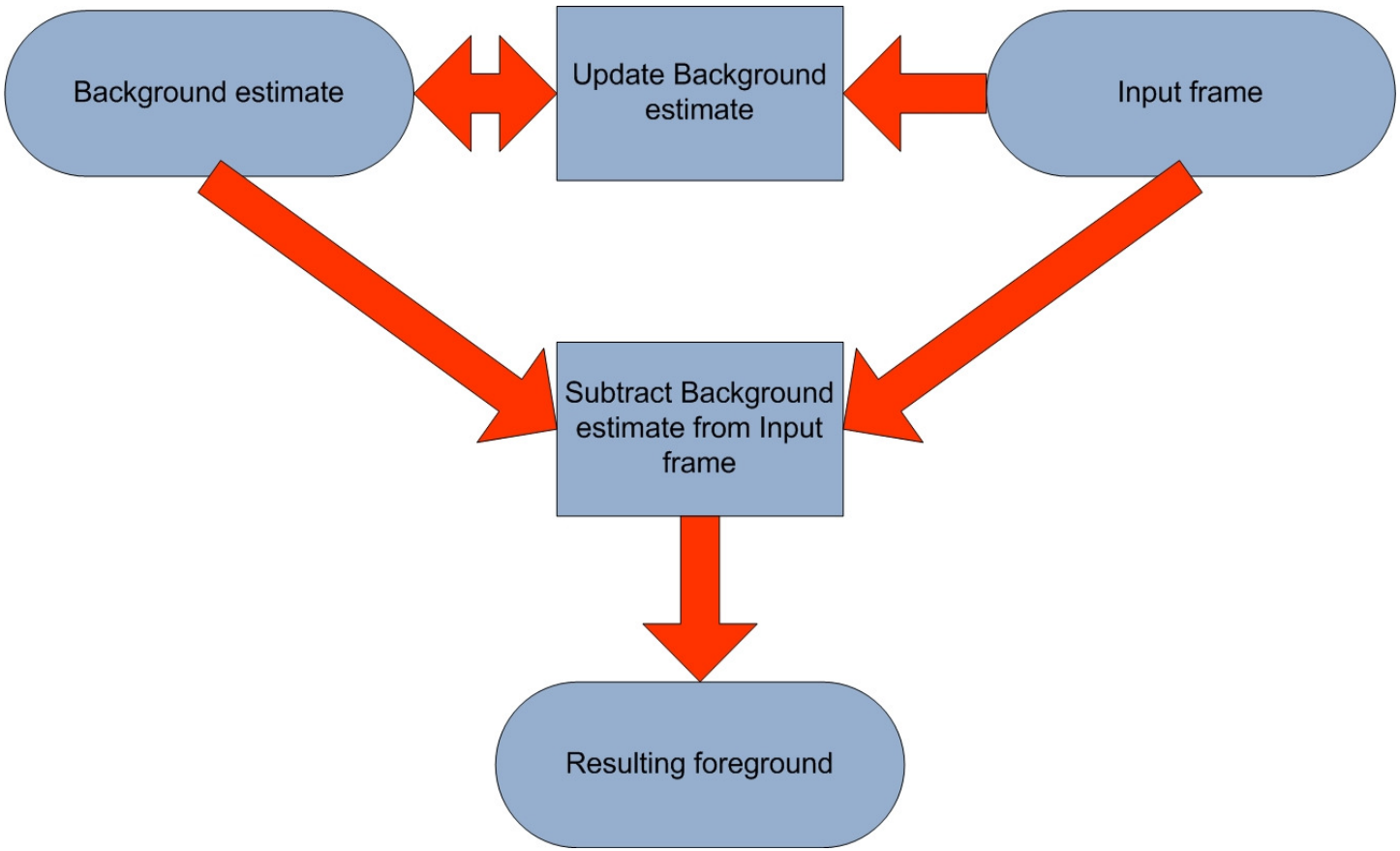
Summary

- Quick-and-dirty fall detector
- Advanced fall detector
- Alternative approach
- Discussion

Basic fall detection system



1. Background subtraction



1. Background subtraction

Non-recursive techniques

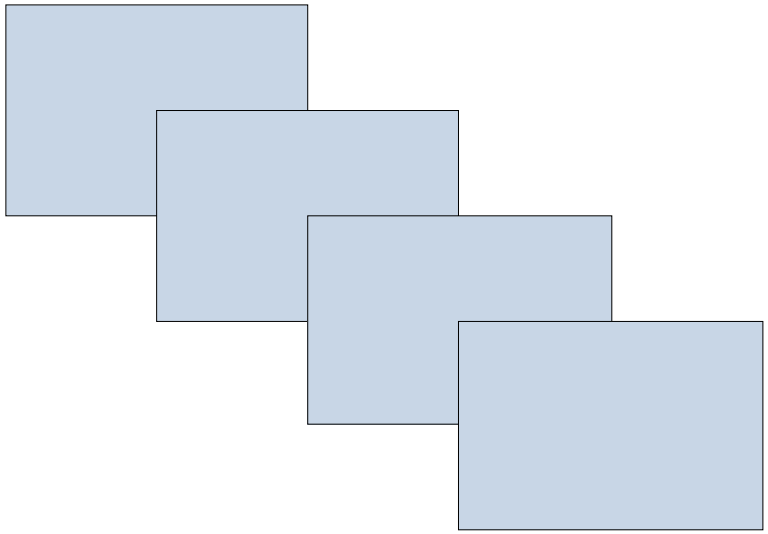
- Frame differencing
- **Median filtering**

Recursive techniques

- Running average
- **Approximated median filtering**
- Mixture of gaussians

Median filtering

Non-recursive method



Mediaan

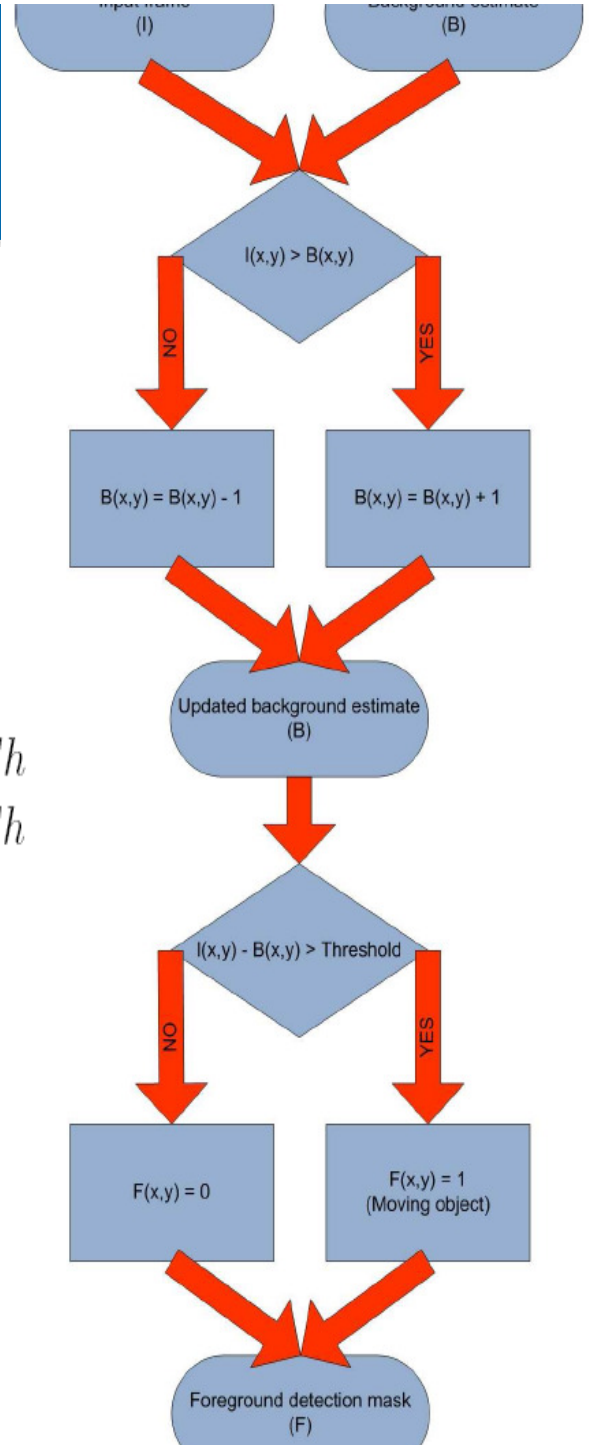
Berekende Achtergrond

Approximated median filtering

- Recursive technique

$$B(x,y) = B(x,y) + 1 \quad if \quad I(x,y) \geq B(x,y)$$
$$B(x,y) = B(x,y) - 1 \quad if \quad I(x,y) < B(x,y)$$

$$F(x,y) = 1 \quad (moving \quad object) \quad if \quad I(x,y) - B(x,y) \geq Th$$
$$F(x,y) = 0 \quad if \quad I(x,y) - B(x,y) < Th$$



1. Background subtraction

In our project median filtering and approximated median filtering → comparative study

Median filtering gives better results but is slower than approximated median filtering

(MF: 0,35 and AMF: 2,44 average pixel value difference)

(MF: 0,20 s/frame en AMF 0,097 s/frame)

Intel core 2 duo, T9400, 2,53Ghz dual core processor

Buffer of 40 frames, one frame added each 5 frames

1. Background subtraction



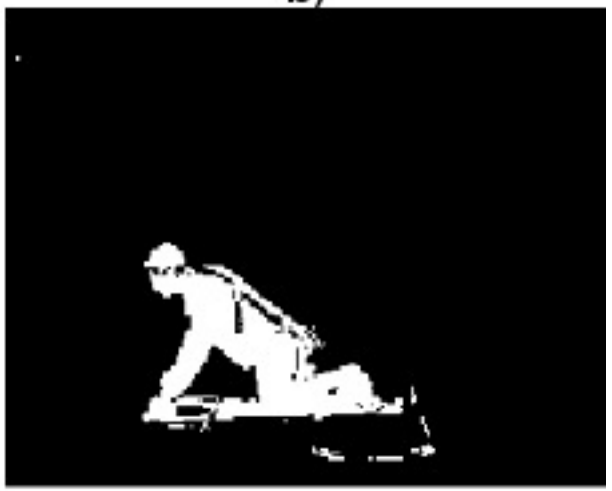
a)



b)



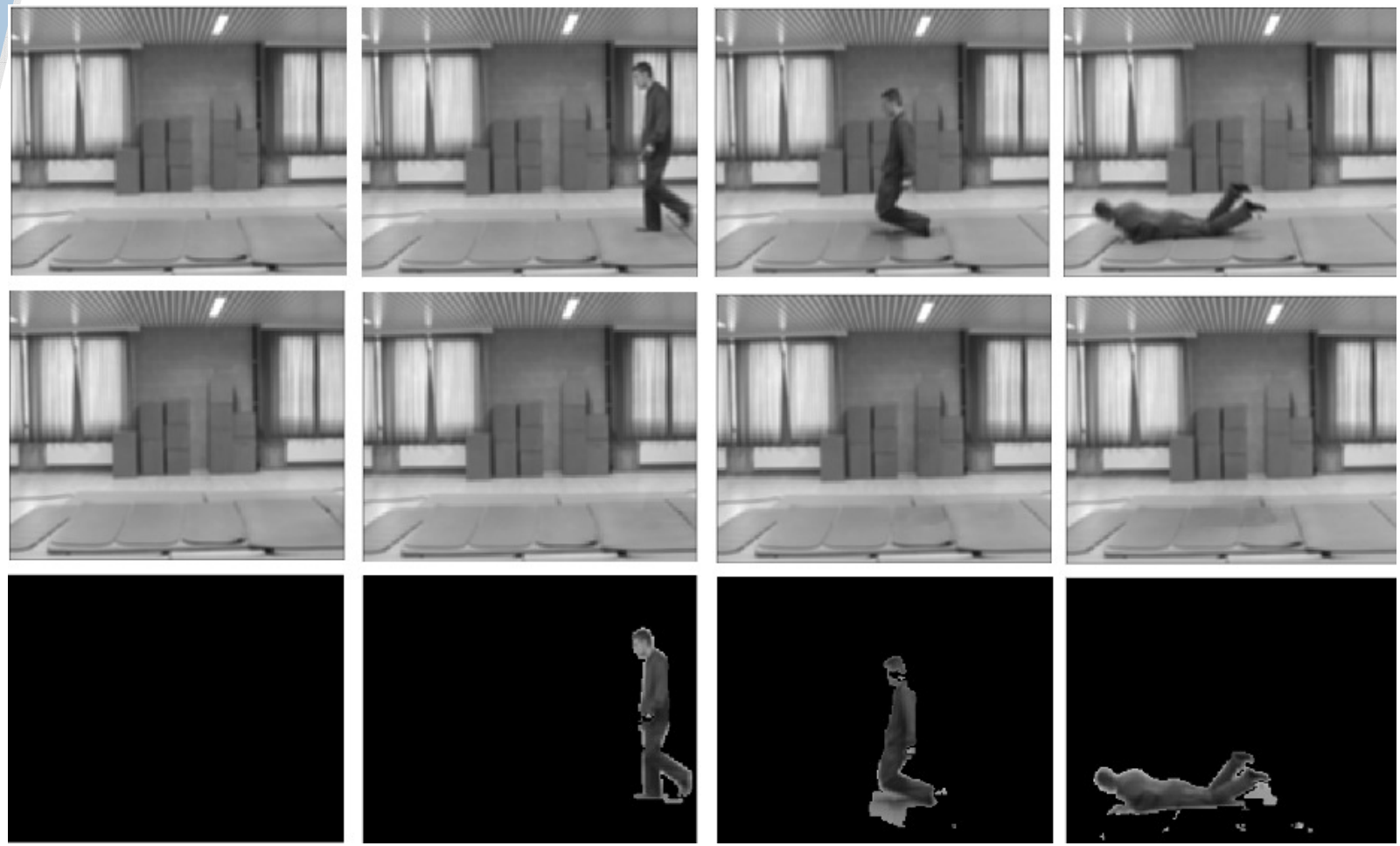
c)



d)

Example 1

1. Background subtraction



Example 2

1. Background subtraction



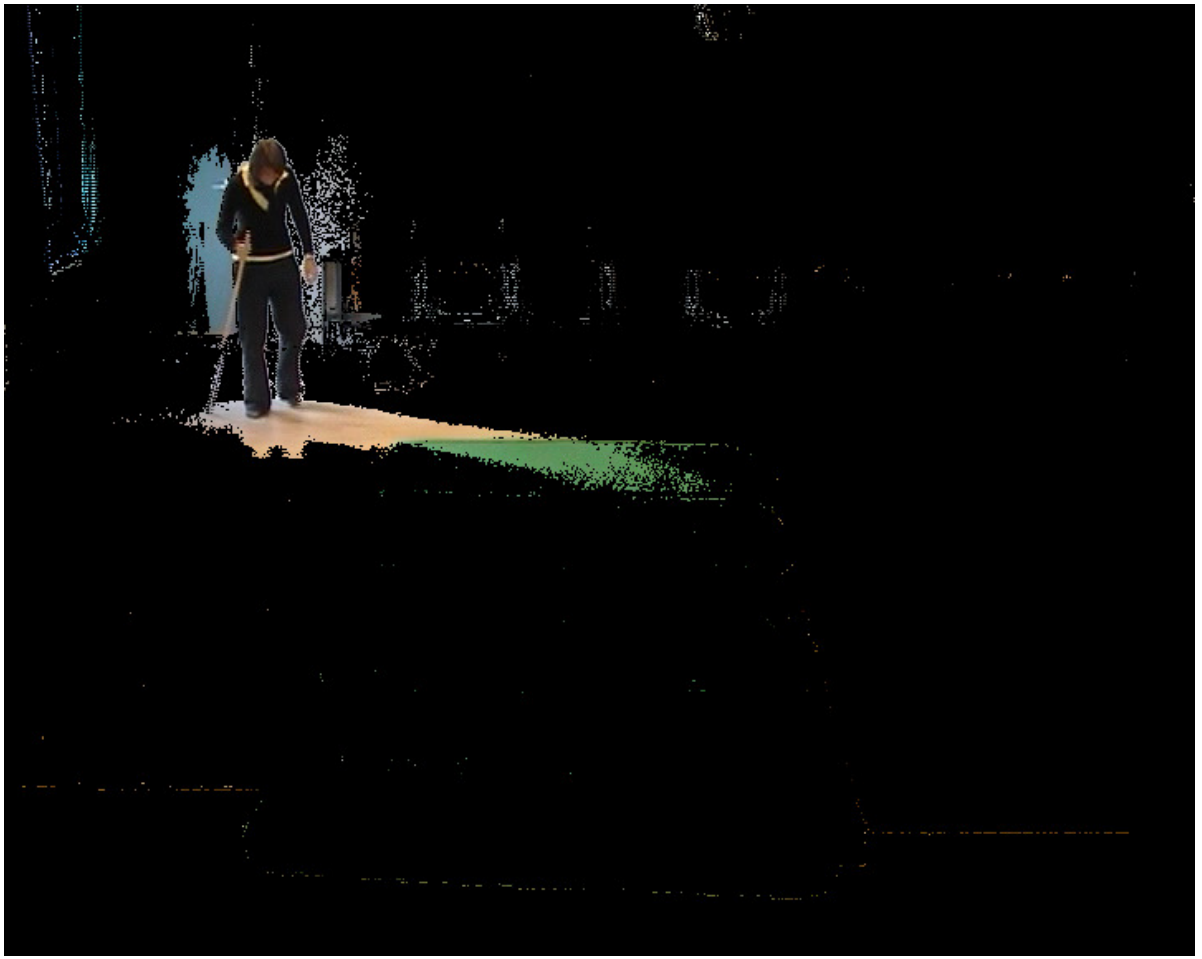
Example 3:
Input image

1. Background subtraction



Example 3:
Computed background

1. Background subtraction



Example 3:
foreground

1. Background subtraction



Example 3:
foreground

1B. Shadow removal

Shadow removal necessary:

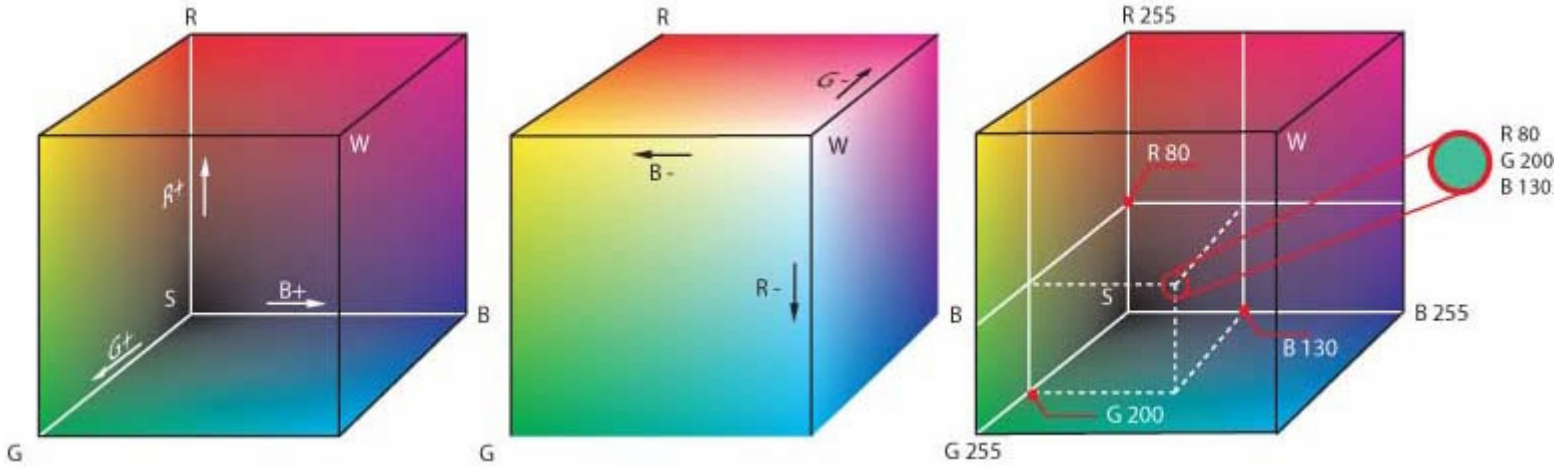
- Shadowed part is also different from background
- Included in foreground

Shadow removal principle:

- Colour of shadowed part stays identical
- Only brightness changes
- => compare with background based on hue

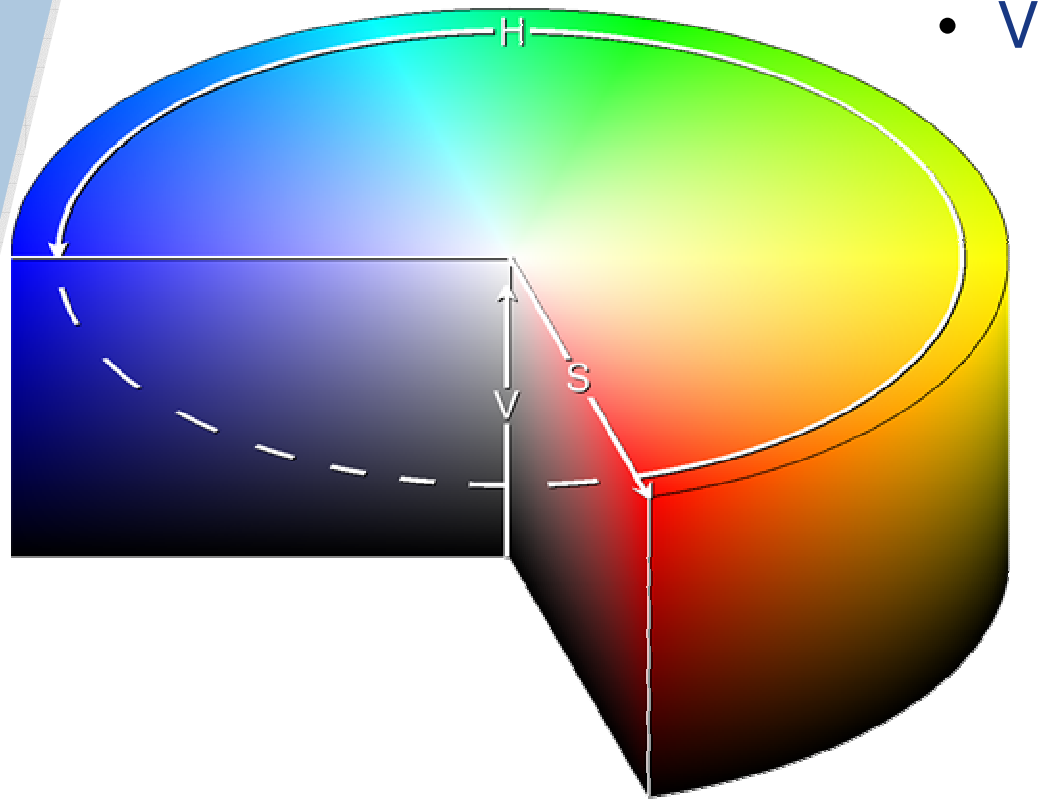
1^B. Shadow removal

- RGB color space
  - Red
  - Green
  - Blue



1B. Shadow removal

- HSV color space
  - Hue
  - Saturation
  - Value



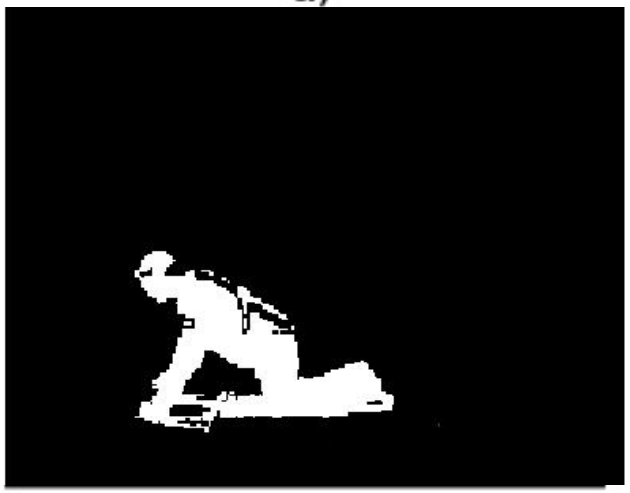
1B. Shadow removal



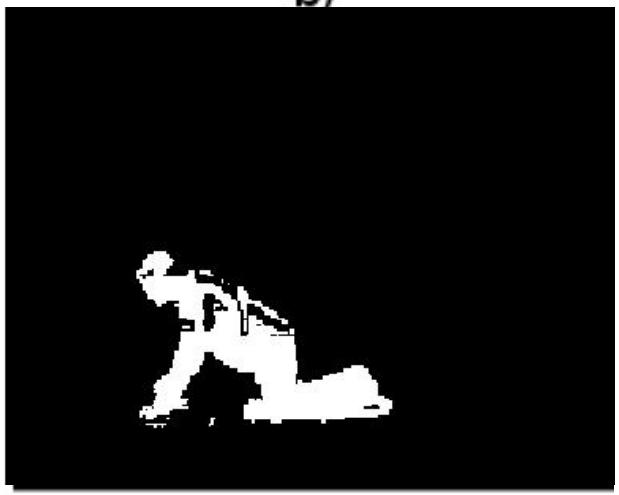
a)



b)



c)



d)

2. Fall detection

Fall detection:

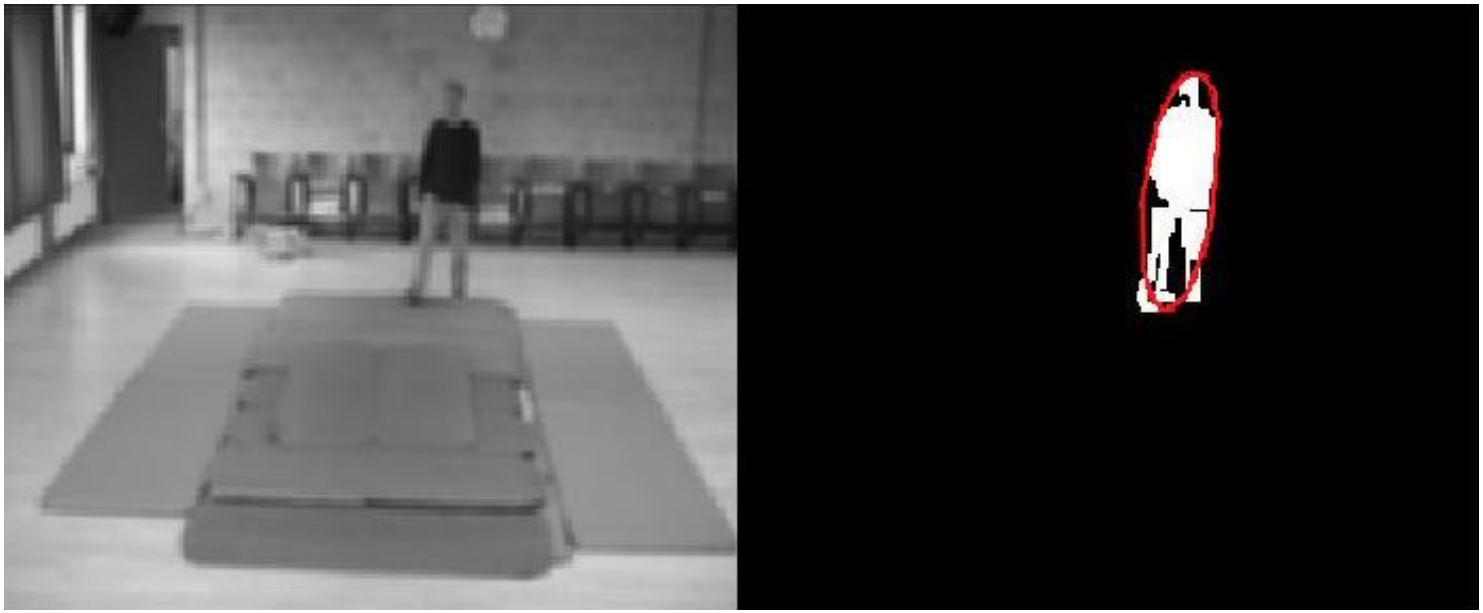
- Person modelling: Best Fit Ellipse
- Parameter extraction
- Fall Decision

We use 3 parameters in cascade:

- Aspect ratio
- Fall angle
- Vertical projection histograms

Feature extraction - ellipse fitting

Model person with best fit ellipse:



Compute center point using geometric moments

$$x_0 = \frac{M_{10}}{M_{00}} \qquad y_0 = \frac{M_{01}}{M_{00}}$$

Central moments μ needed to build covariance matrix

Ellipse fitting

$$C = \begin{bmatrix} \frac{\mu_{20}}{M_{00}} & \frac{\mu_{11}}{M_{00}} \\ \frac{\mu_{11}}{M_{00}} & \frac{\mu_{02}}{M_{00}} \end{bmatrix}$$

Square root of eigen values → length of each axis

Eigen vectors → orientation of ellipse

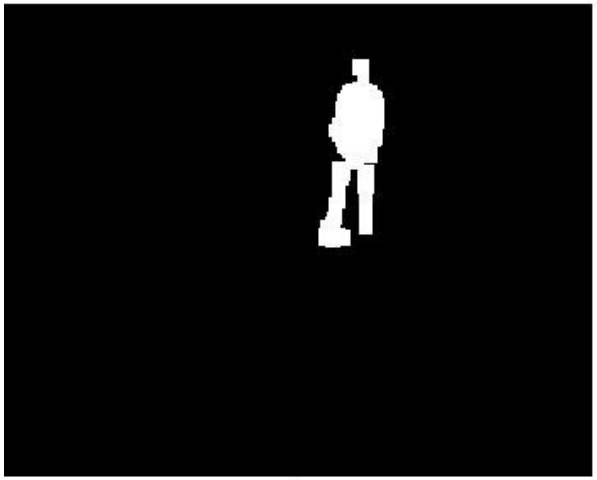
Ellipse fitting



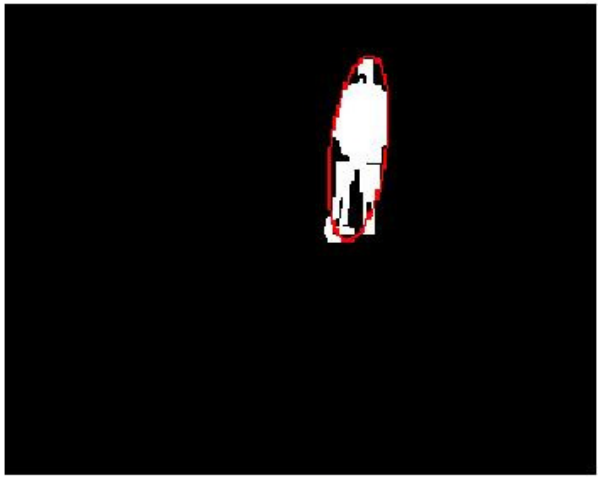
a)



b)



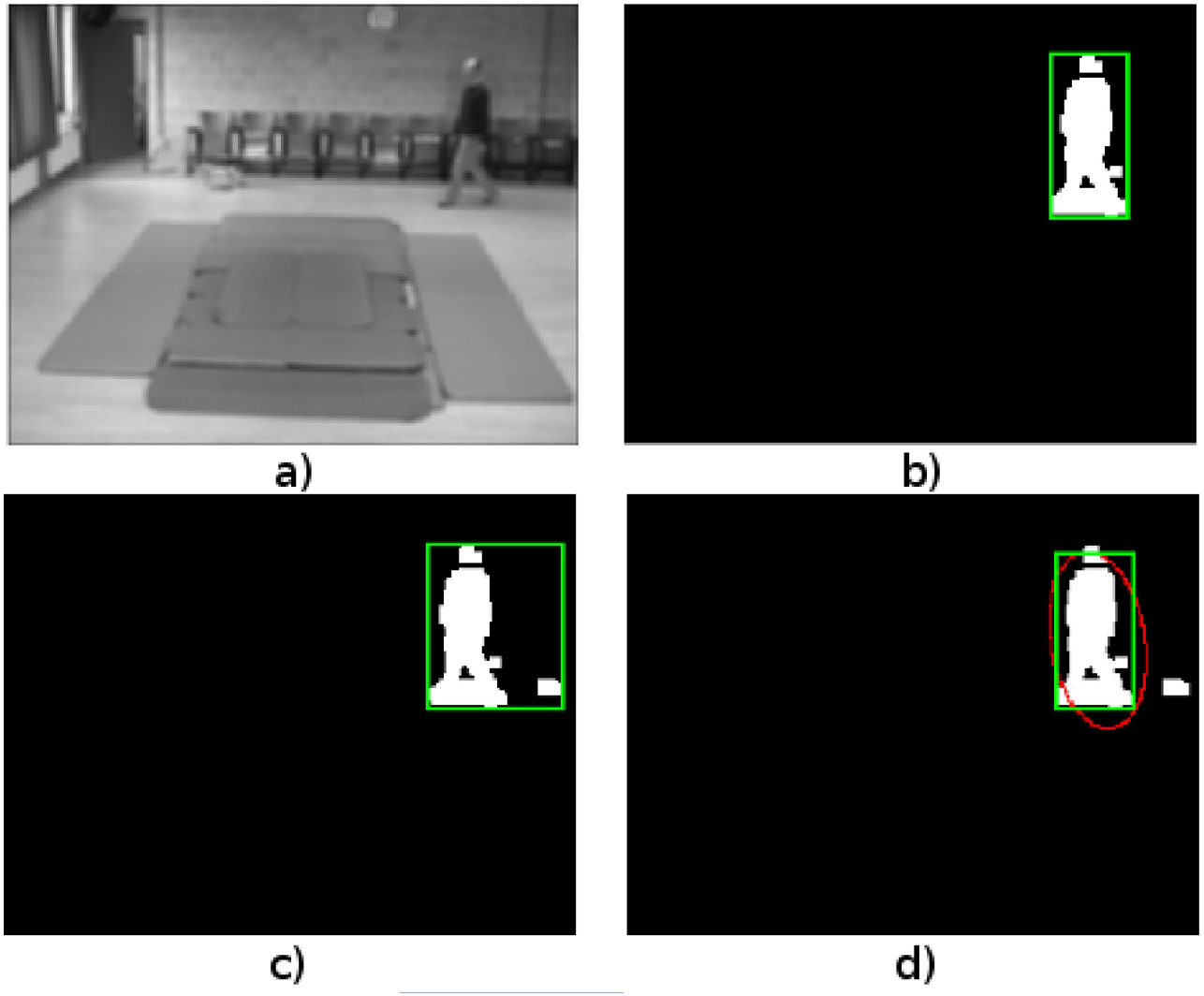
c)



d)

2. Fall detection: parameter extraction

Aspect ratio: hight/width ratio of person. <1 → fall

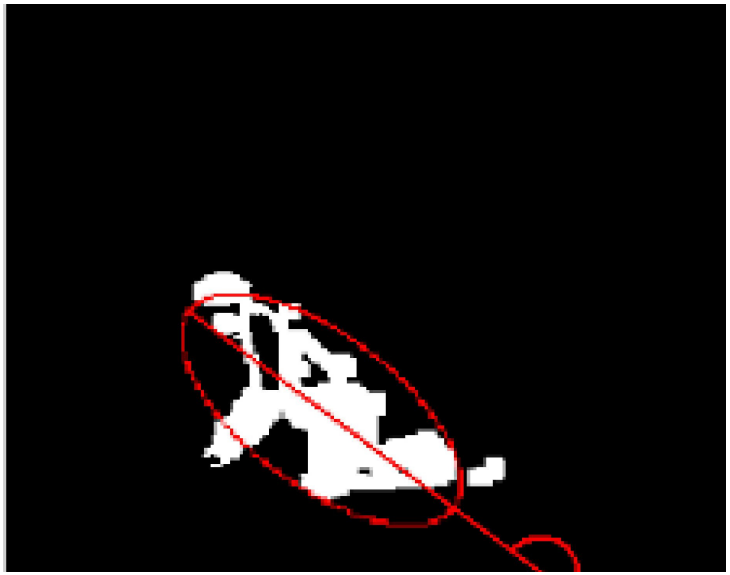


2. Fall detection: parameter extraction

Fall angle

angle between major axis of person and floor. <45° or >135° → fall

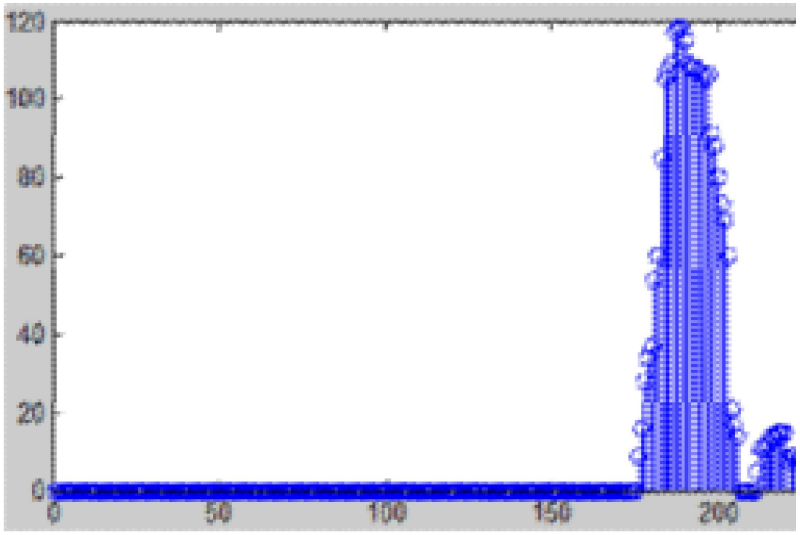




2. Fall detection: parameter extraction

Vertical projection histograms





- Significant change in case of a fall.
- How to compute difference of histograms?
  - Bhattacharyya distance
  - Lin et al. → compare maximum value
- Compute histogram one second before and at the present moment
- Histogram changes with distance to camera → normalisation

Results – basic algorithm

Accuracy:

Viewpoint	Correct	FP	FN
Side view	85%	0%	15%
Frontal view	78%	11%	11%

tested on 23 sequences

Speed in s/frame:

AMF	MF
0,36	0,43

Intel Core 2 Duo, T9400, 2,53 Ghz dual core processor

Demo

Summary

- Quick-and-dirty fall detector
- Advanced fall detector
- Alternative approach
- Discussion

Advanced fall detection algorithm

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Advanced fall detection algorithm

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Shortcomings basic system

- Shadow removal not 100% OK
- Limited to viewpoints
- Not robust to occlusions
- Not robust to multiple actors
- ...
- ... Not SMART enough!

Shadow removal

- Shadow removal based on intensity changes does not work well in practice.





Shadow removal

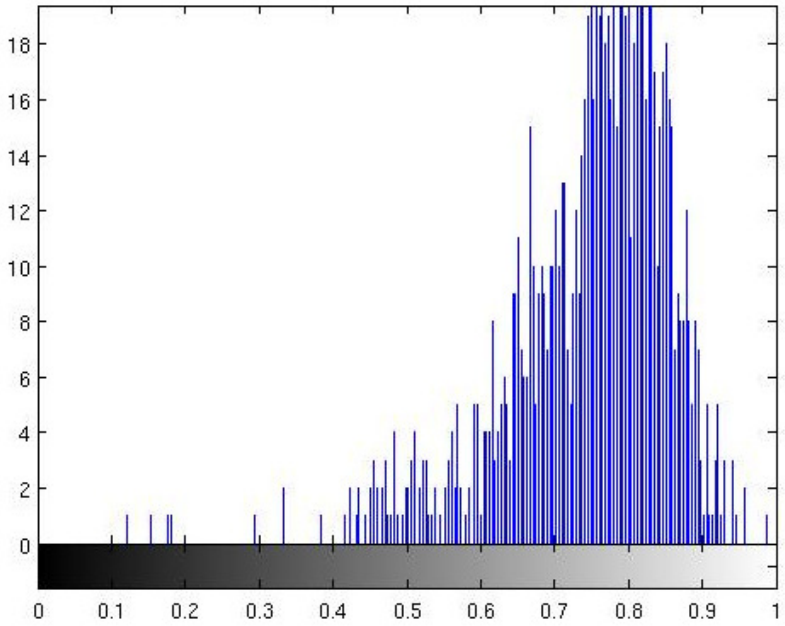
Zoom in on shadow



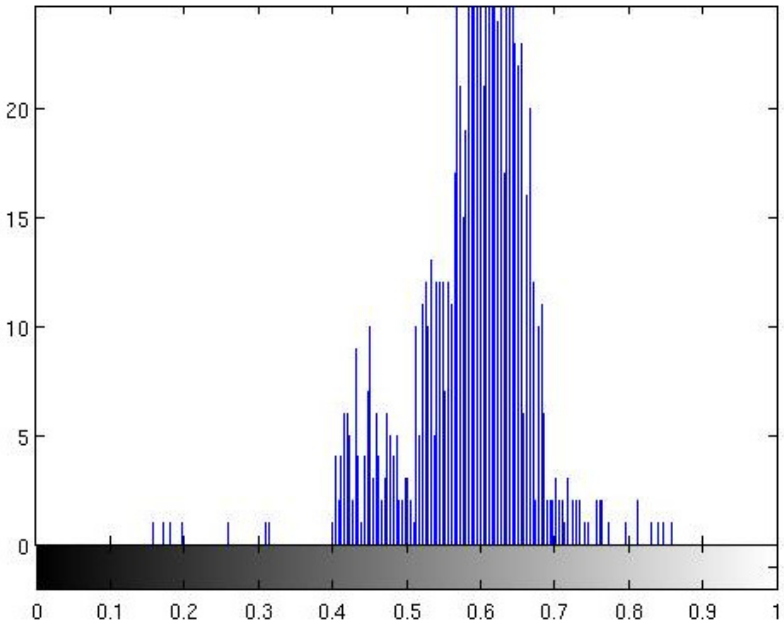


Shadow removal

Intensity change



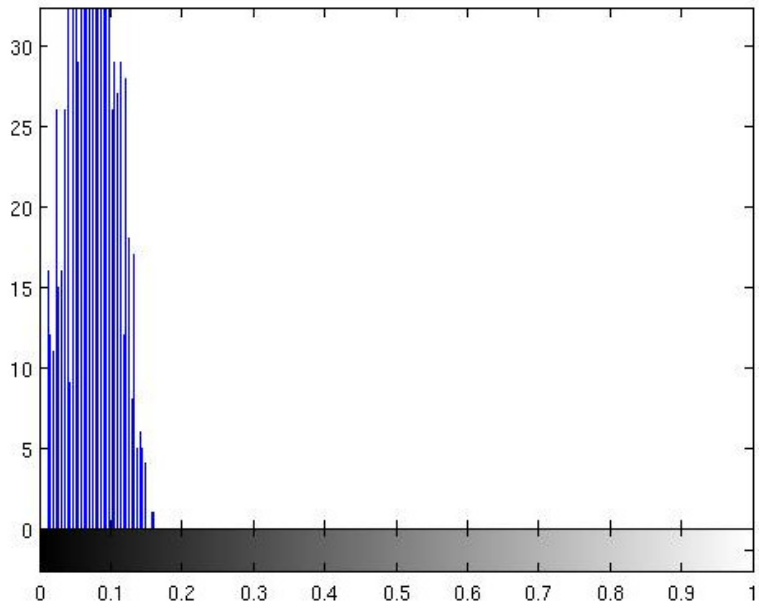
without shadow



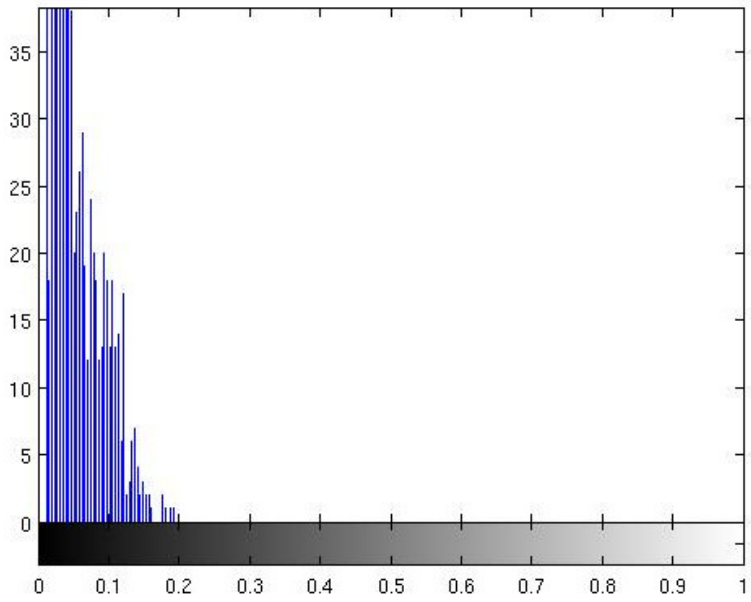
With shadow

Shadow removal

Saturation change



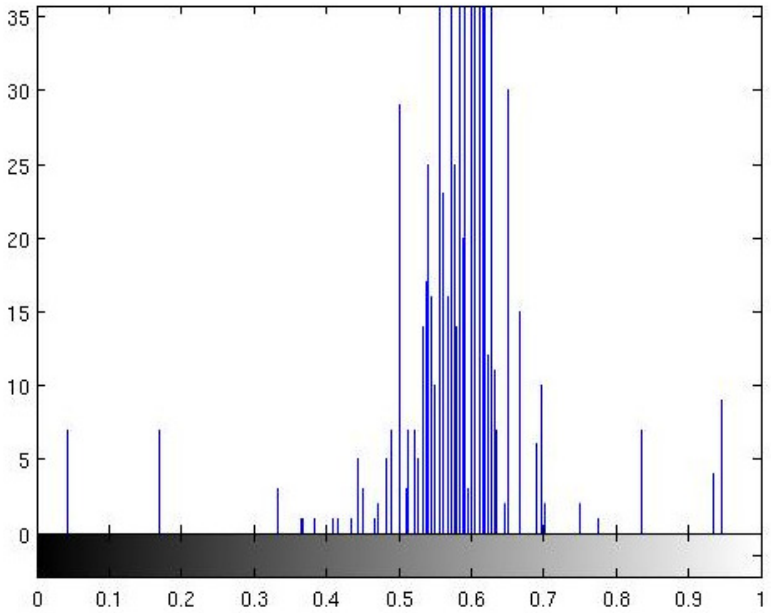
without shadow



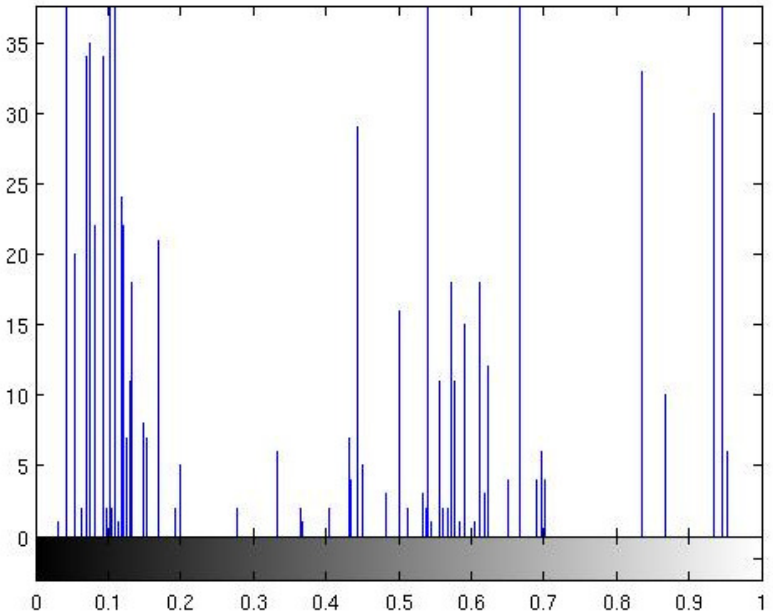
With shadow

Shadow removal

Hue change

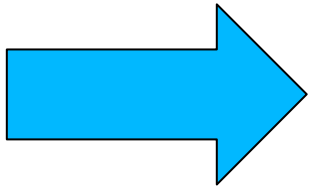


without shadow



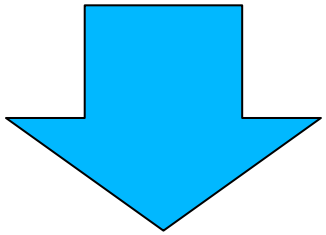
With shadow

Shadow removal



also significant hue changes

- Main reason is different color spectrum of indoor artificial light and outdoor light.
- Also color correction of camera can have impact.



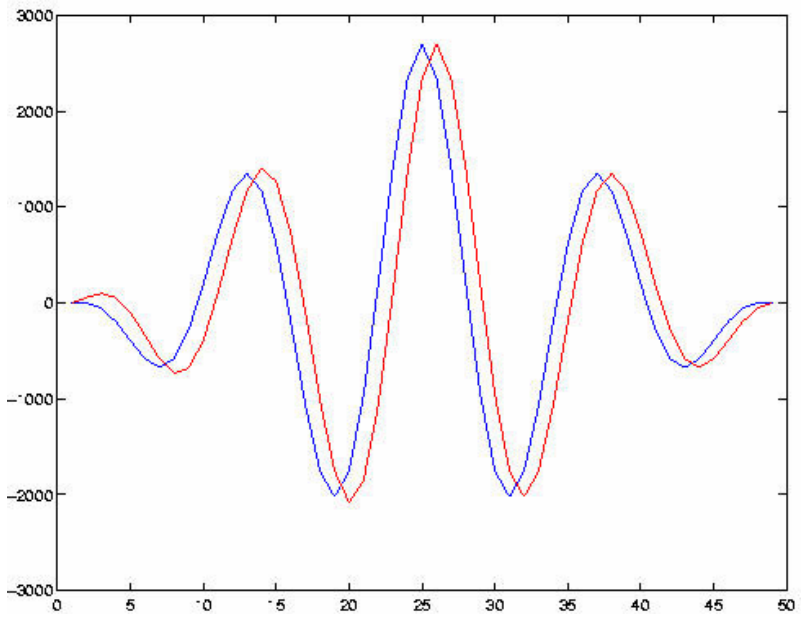
Possible solution:

Normalized Cross Correlation (NCC)

Shadow removal

- Method by J. Jacques, C. Jung en S. Musse
- Compares background and incoming frame using Normalised Cross Correlations (NCC).
- Compares texture, not only color values
- Refinement step based on standard deviation

Shadow removal



Correlation maximum if signals coincide

Normalized Cross Correlation: compares texture of foreground and background

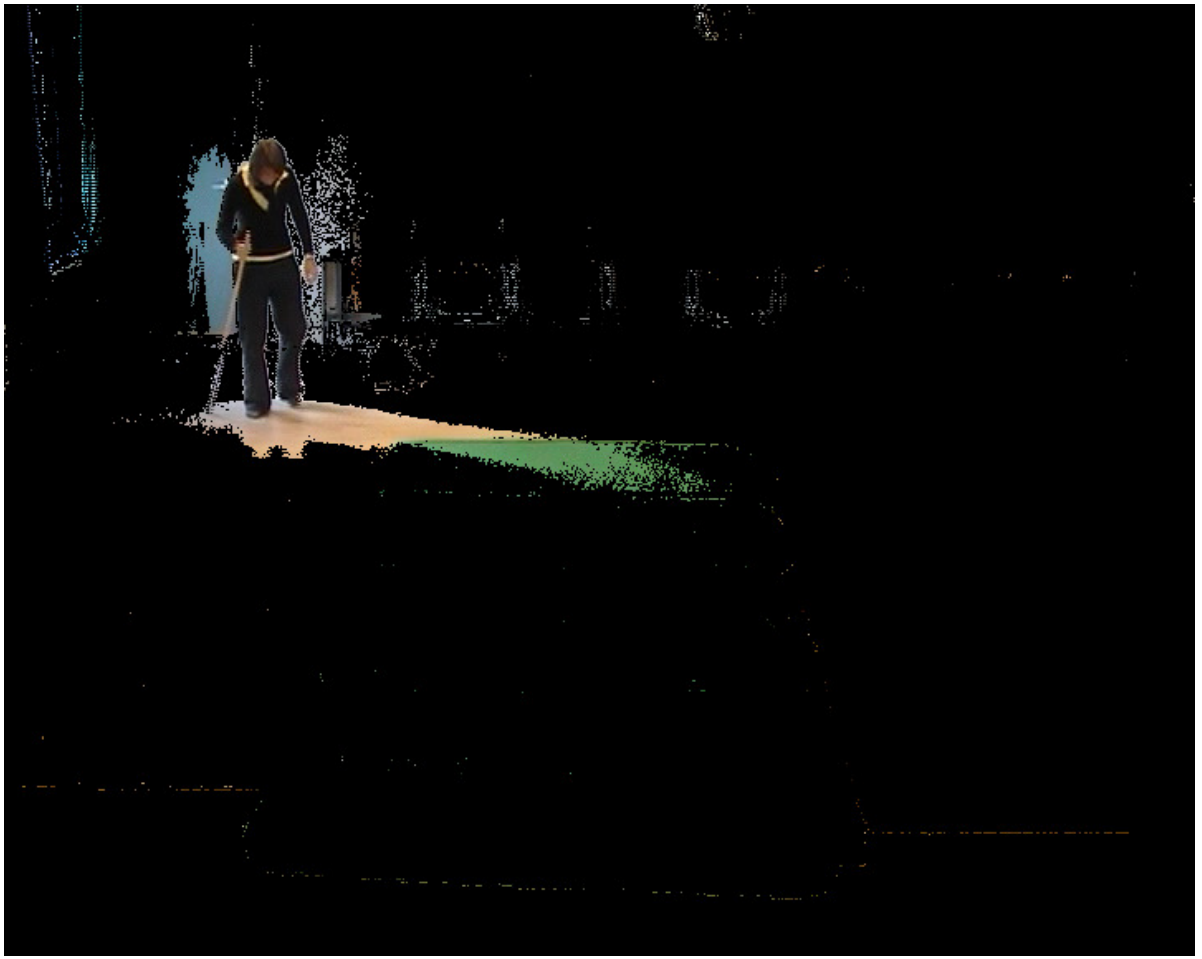
Start image



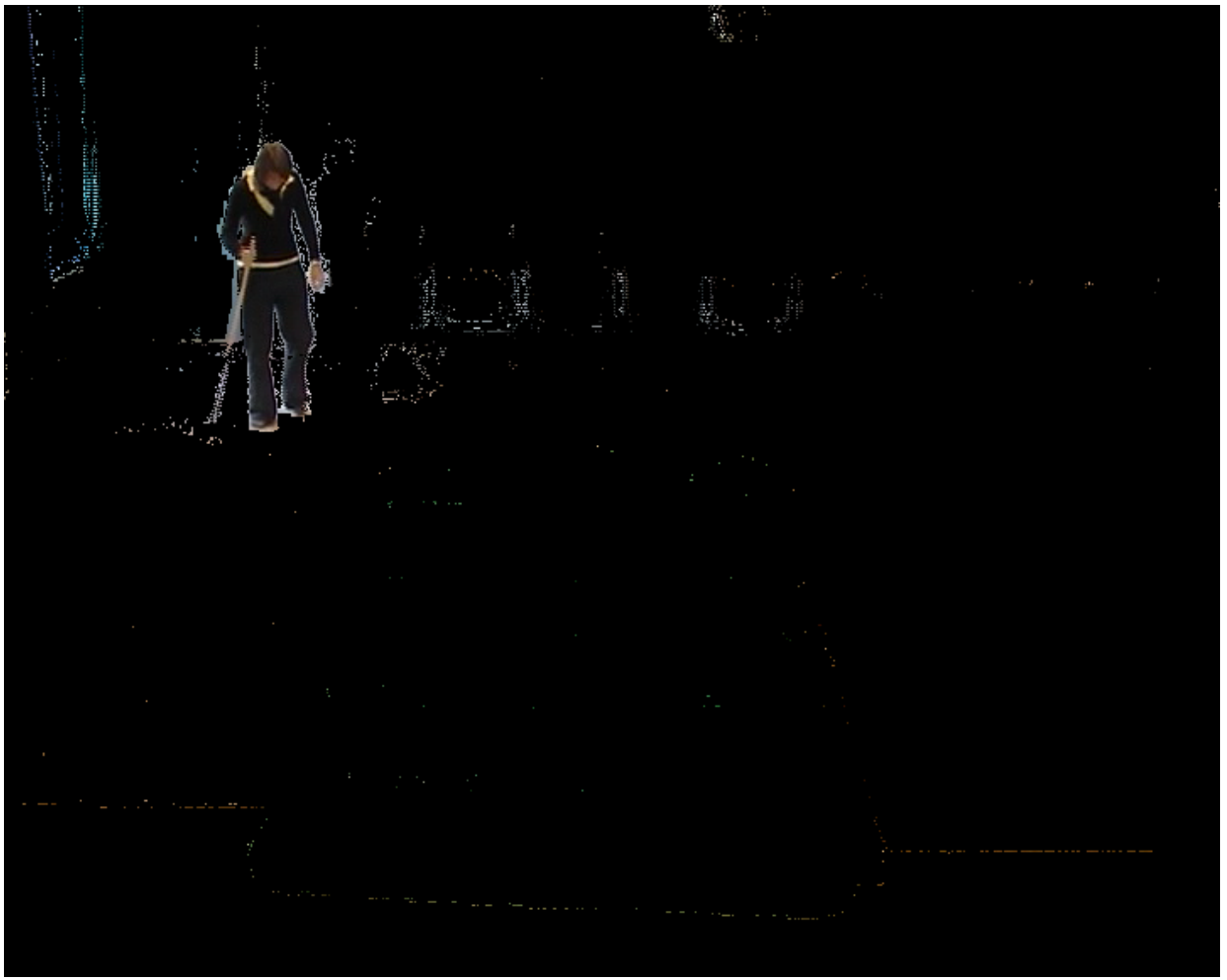
Background detection



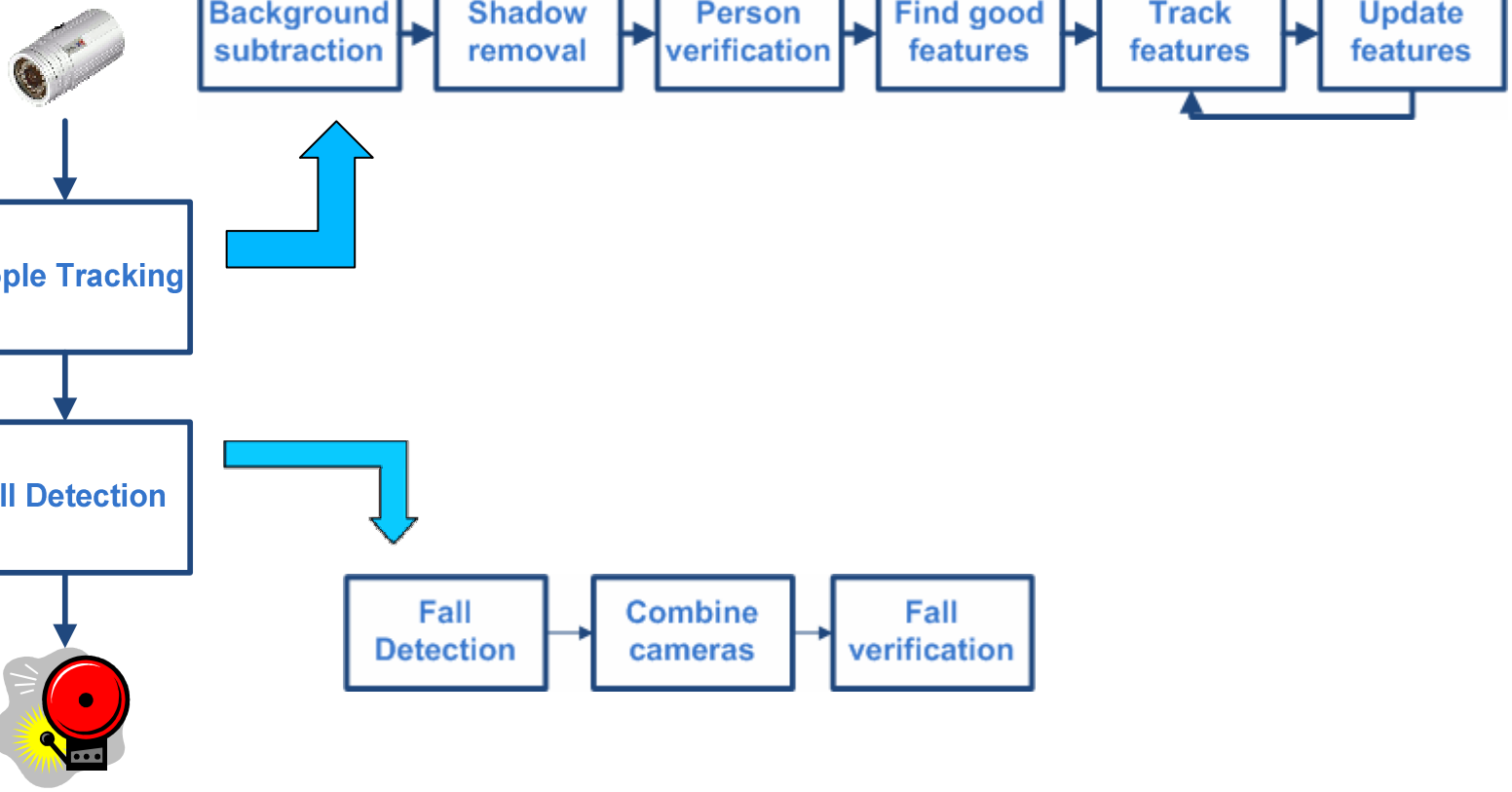
Foreground detection



Shadow removal



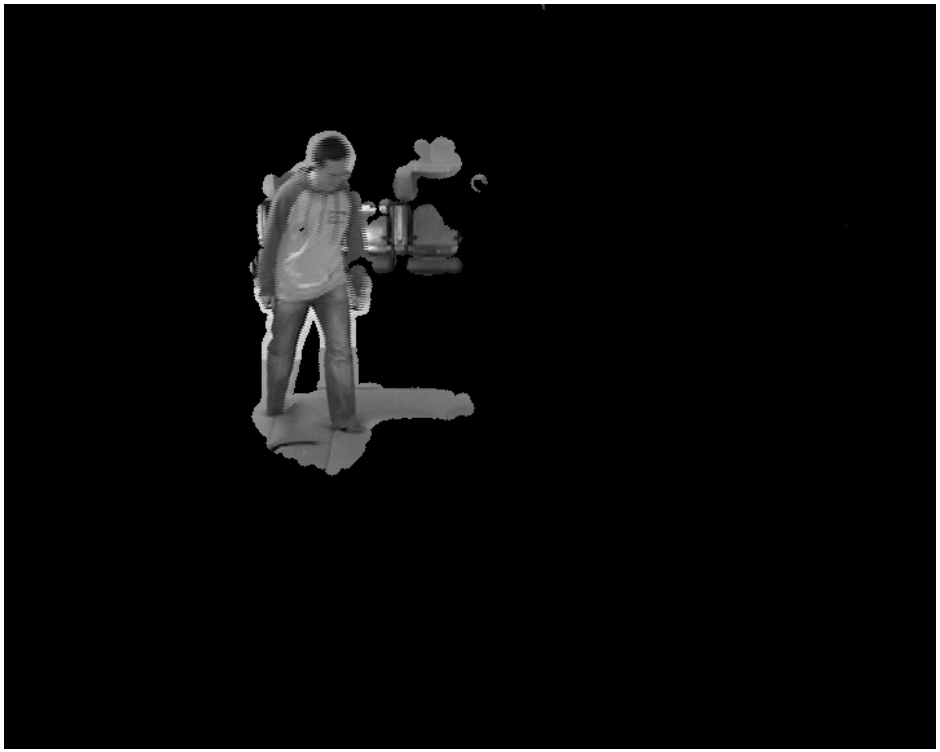
Advaced fall detector: overview



input image

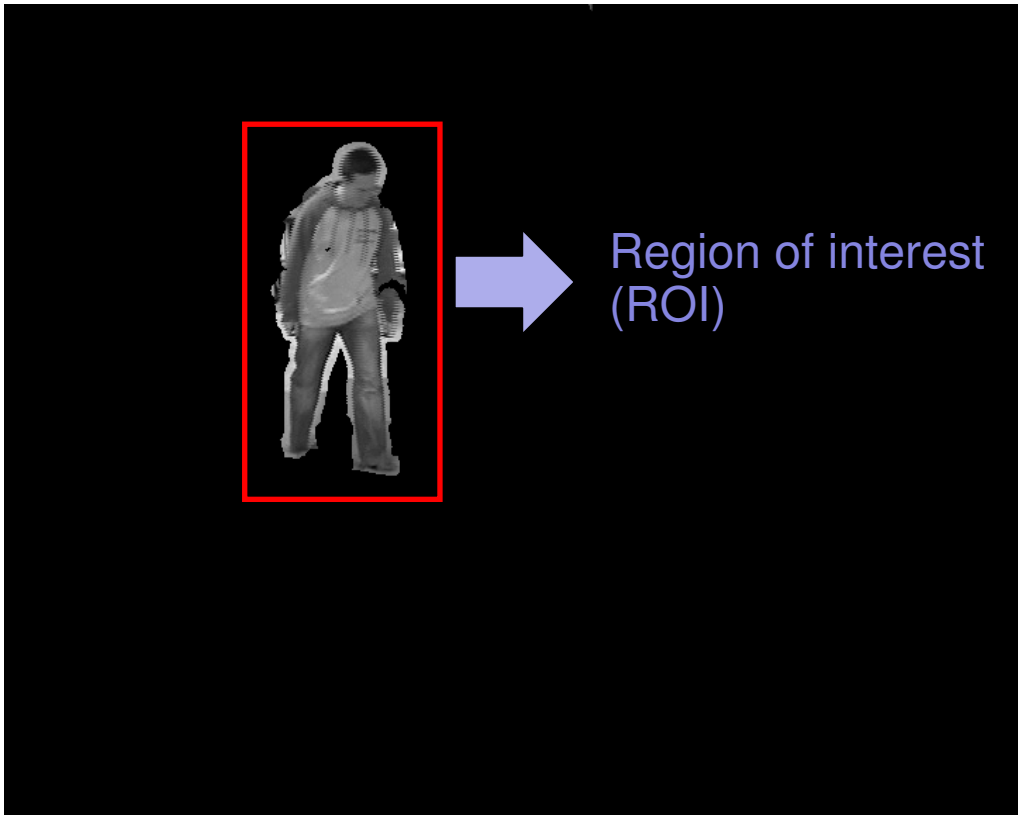


Foreground detection

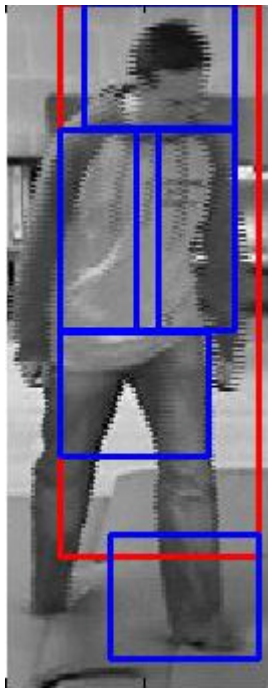


- Median of approximate median filtering

Shadow removal

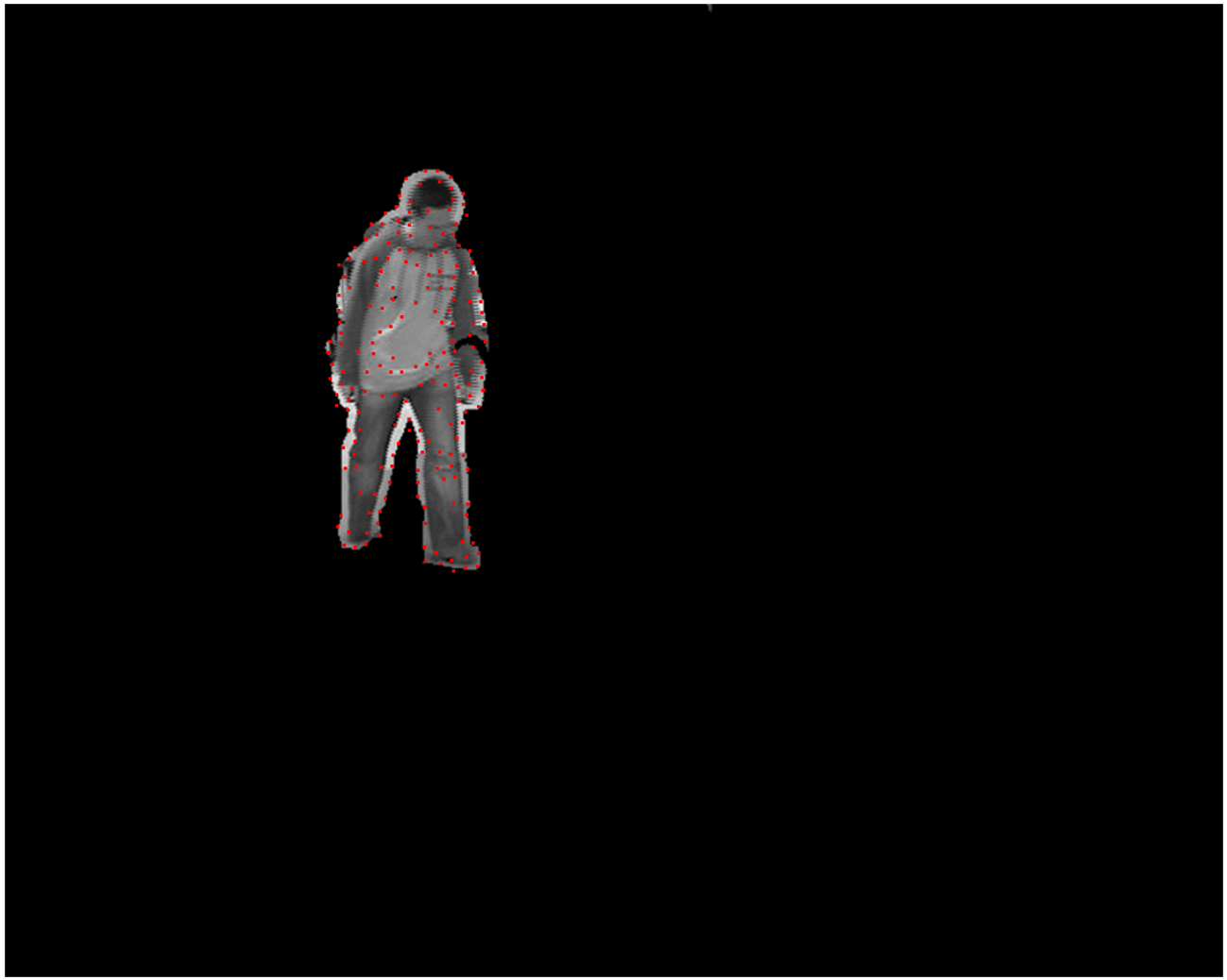


Person detection

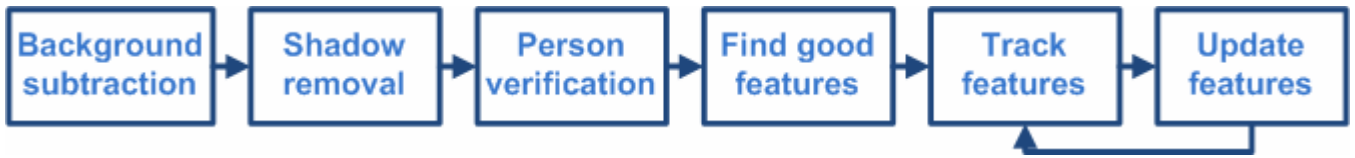


- ROI is used to restrict search space for person detection.
- Algorithm is based on Histograms of Gradient. (HoG)
- Algorithm developed by Ramanan *et al.,* as a multi-part version of the Dalal-Triggs detector

Feature tracking



Feature tracking



- Find good point features.
- Follow these across frames using KLT-tracker
- Replace lost and bad features.

Conclusion

- Robust image preprocessing is of ultimate importance of end result:
  - Good foreground segmentation
  - Good shadow removal
- Model-based person detector identifies people in the image
  - Removal of other movements (pets, curtains)
- Feature Tracking
  - integrates detection results across frames
  - Yields motion parameters for fall decision:
    - Fast downward motion of features
- Still in development

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Alternative method: Machine learning

Toon Goedemé

Machine learning approach

- Hard to describe a fall
  - Even by medical fall experts
  - Dr. Jan Lenaerts: “If the feet and pelvis both are lying on the ground”
- Hard to make a fall detector based on a fall model
  - ‘fast motion towards the ground’
- Alternative:
  - Train the system on what ‘normal behaviour’ is
  - Detect abnormal events
    - Hopefully including falls
    - Also including other dangerous situations: choking, epileptic attack, heart attack, ...

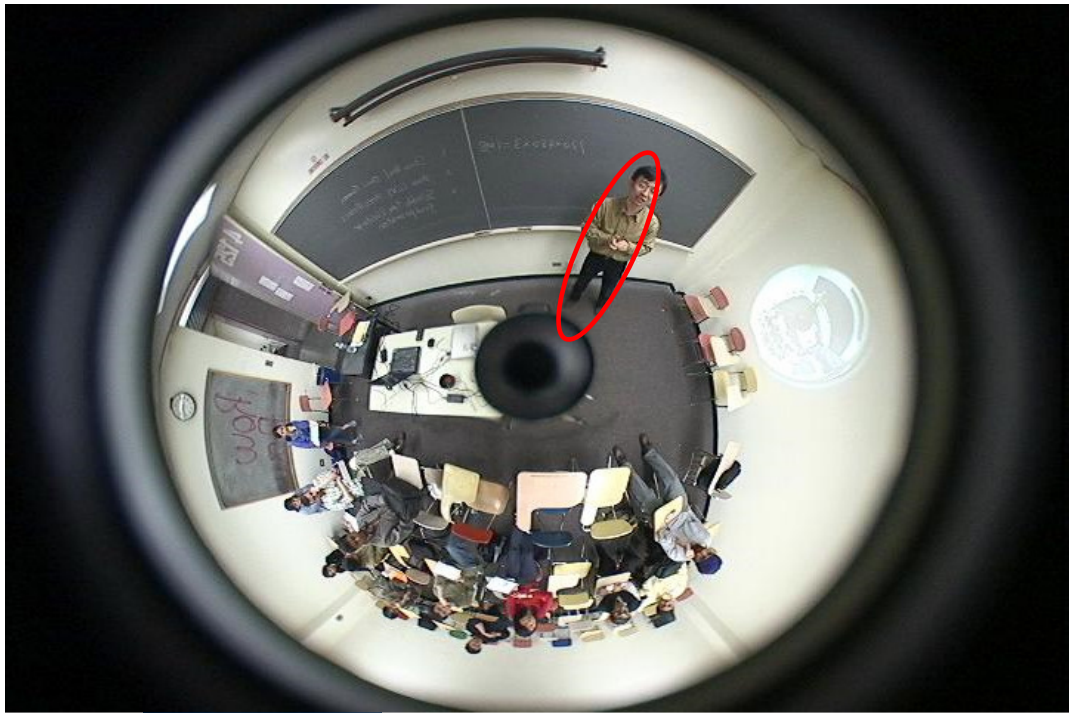
Machine learning approach

- Difficulties:
  - Lots of training data needed
  - Abnormal behaviour can be not dangerous
    - Something fell under the table, grandma picks it up
  - Parameter selection
  - Viewpoint position depedent criteria

- Advantages:
  - Detects more than falls
  - Can be made camera type independent (onmidir)
  - Can continue training while using with user imput

Machine learning approach

- Will be examined by a student this year
  - Using omnidirectional camera
  - Image preprocessing (foreground detection) as before
  - Ellipse fitting
  - Training system based on ellipse parameters w.r.t. position in image



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Discussion

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Mieke Deschodt

Questions?



Remarks?