Crowd Video Analysis

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Main informations required by security agents:

- Density of the people in an area. Why?
  - Danger when an area reaches an important occupation level
- Local - or global - abnormal movements in the crowd
  - Acceleration of the people speed (panic movement)
  - High speed of a high density crowd (general panic movement)
  - Spacing of a point (local danger)
  - Local people grouping (someone needing help, fight)
Examples of abnormal crowds movements
Motion analysis

- Generally divided into four steps:
  - **Detection**: extracts temporal changes
  - **Estimation**: computes velocity vectors of the movement
  - **Segmentation**: groups pixels which have similar displacement vectors
  - **Tracking**: builds the trajectories

- Some steps can be omitted
Motion estimation techniques existing:

- **Primitive Matching Techniques**
  - Block Matching

- **Differential Techniques**
  - Optical Flow:
    - Lucas & Kanade method
    - Horn & Schunk method

- **Frequential Techniques**
  - Gabor Filters
Motion estimation

➢ Block Matching:
  ➢ Principle:
    ➢ Divide images into small blocks
    ➢ Match them between two successives images according to a similitude criteria
  ➢ Two choices:
    ➢ Block size
      ➢ Small size: correct results for a low computational cost
    ➢ Similitude function
      ➢ Distance measure than a correlation measure
Motion estimation

➢ **Optical Flow:**
  ➢ **Principle:**
    ➢ Hypothesis: brightness of a particular moving point constant in time
    ➢ Equation: \( f(x+dx, y+dy, t+dt) - f(x, y, t) = 0 \)
      \[ \nabla f \cdot w = -\frac{\partial f}{\partial t} \]

➢ **Horn & Schunck Method:** B.K.P. Horn, B.G. Schunck - «Determining optical flow» - Artificial Intelligence, 1981
  ➢ Variation of the velocity vector is smooth from a point to his neighbour

➢ **Lucas & Kanade Method:** B.D. Lucas, T. Kanade - «An Iterative Image Registration Technique with an Application in Stereo Vision» - 7th IJCAI, 1981
  ➢ Minimize the cost function:
    \[ E = \sum_{x,y \in \text{Image}} \left[ f(x+dx, y+dy, t+dt) - f(x, y, t) \right]^2 \]
Motion estimation

➢ Gabor Filters

➢ Principle:
  ➢ Convolve the image with a set of Gabor filters
  ➢ Solve a set of equations to get the displacement vectors

➢ Properties:
  ➢ Very accurate
  ➢ But very time consuming

D.J. Fleet, A.D. Jepson - «Computation of component image velocity from local phase information» - IJCV
Motion estimation

➢ Displacement vectors filtering
  ➢ To smooth the motion field
  ➢ To delete vectors of interference movements (arms, legs, ...)
  ➢ Two kinds of filters for example:
    ➢ Spatial filtering
    ➢ Temporal filtering
Purpose:
- When congestion in a place exceeds a certain level: Potential danger may occur for a variety of reasons

Difficult problem:
- Only parts of the people body appears
- As crowd density increases:
  - The overlap among crowd members gets worse
Methods based on the extraction of significant features:

- **Statistical approach by Davies:**
  
  **Principle:**
  - Extraction of features by background removal or edge detection
  - Statistical comparison of the pixel number returned in the binary image with a data base of experiments

**Problem:**

- Need of a data base of experiments (manual count)

Methods based on the extraction of significant features:

- **Minkowski fractal dimension**

  **Principle:**
  - Extraction of edges
  - \( n \) dilatations are computed from the binary image. For each:
    - Computation of black pixels
    - Update of a graphic with the dilatation number on abscissa and pixel number on ordinate
  - Computation of the fractal dimension from the graphic
  - By the fractal dimension: determination of the classe of crowd density

  **Problem:**
  - Need of a data base of experiments to associate to each density class a fractal dimension range

Density estimation

Example with very low and very high density of crowds
Density estimation

➢ Method based on blob tracking
  ➢ Principle:
    ➢ Separation objects from the background
    ➢ Classification of each object:
      ➢ human or not? Analyse based on their size or their shape
  ➢ Problems:
    ➢ Precise object extraction is hardly possible
    ➢ Difficults to distinguish people which occlude each other properly