Lecture 29: Face Detection Revisited

Announcements

• Project 4 due next Friday by 11:59pm
Remember eigenfaces?

• They don’t work very well for detection

Issues: speed, features

• Case study: Viola Jones face detector
• Exploits two key strategies:
  – simple, super-efficient, but useful features
  – pruning (cascaded classifiers)

• Next few slides adapted Grauman & Liebe’s tutorial
  – http://www.vision.ee.ethz.ch/~bleibe/teaching/tutorial-aaai08/

• Also see Paul Viola’s talk (video)
**Feature extraction**

“Rectangular” filters

Feature output is difference between adjacent regions

Efficiently computable with integral image: any sum can be computed in constant time

Avoid scaling images → scale features directly for same cost

Viola & Jones, CVPR 2001

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**Large library of filters**

Considering all possible filter parameters: position, scale, and type:

180,000+ possible features associated with each 24 x 24 window

Use AdaBoost both to select the informative features and to form the classifier

Viola & Jones, CVPR 2001
**AdaBoost for feature+classifier selection**

- Want to select the single rectangle feature and threshold that best separates **positive** (faces) and **negative** (non-faces) training examples, in terms of **weighted** error.

**Resulting weak classifier:**

\[
    h_t(x) = \begin{cases} 
    +1 & \text{if } f_t(x) > \theta_t \\
    -1 & \text{otherwise} 
    \end{cases}
\]

For next round, reweight the examples according to errors, choose another filter/threshold combo.

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**AdaBoost: Intuition**

Consider a 2-d feature space with **positive** and **negative** examples.

Each weak classifier splits the training examples with at least 50% accuracy.

Examples misclassified by a previous weak learner are given more emphasis at future rounds.
AdaBoost: Intuition

Final classifier is combination of the weak classifiers
AdaBoost Algorithm

Start with uniform weights on training examples

\{x_1, \ldots, x_n\}

For T rounds

- Evaluate weighted error for each feature, pick best.

Re-weight the examples:

- Incorrectly classified -> more weight
- Correctly classified -> less weight

Final classifier is combination of the weak ones, weighted according to error they had.

Freund & Schapire 1995

Cascading classifiers for detection

For efficiency, apply less accurate but faster classifiers first to immediately discard windows that clearly appear to be negative; e.g.,

- Filter for promising regions with an initial inexpensive classifier
- Build a chain of classifiers, choosing cheap ones with low false negative rates early in the chain

Fleuret & Geman, IJCV 2001
Rowley et al., PAMI 1998
Viola & Jones, CVPR 2001

K. Grauman, B. Leibe
Viola-Jones Face Detector: Summary

- Train with 5K positives, 350M negatives
- Real-time detector using 38 layer cascade
- 6061 features in final layer
- [Implementation available in OpenCV: http://www.intel.com/technology/computing/opencv/]

Viola-Jones Face Detector: Results

First two features selected
Viola-Jones Face Detector: Results

K. Grauman, B. Leibe
Viola-Jones Face Detector: Results

K. Grauman, B. Leibe

Detecting profile faces?

Detecting profile faces requires training separate detector with profile examples.
Viola-Jones Face Detector: Results

Questions?