Introduction to Artificial Intelligence

Object Recognition Classifiers

Cascade and HOG/SVM Classifiers

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Object Detection/Recognition

Goal:
Find an object of a pre-defined class in a static image or video frame.
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Find an object of a pre-defined class in a static image or video frame.

Approach:
- Extract certain image features, such as edges, color regions, textures, contours, etc.
- Use some heuristics to find configurations and/or combinations of those features specific to the object of interest.
Statistical Model Training

- Training Set (Positive Samples/Negative Samples)
- Different features are extracted from the training samples and distinctive features that can be used to classify the object are selected.
Statistical Model Training

- **Training Set (Positive Samples/Negative Samples)**
- Different features are extracted from the training samples and distinctive features that can be used to classify the object are selected.
- Each time the trained classifier does not detect an object (misses the object) or mistakenly detects the absent object (gives a false alarm), model is adjusted.
Weak Classifier

- Computed feature value is used as input to a very simple decision tree classifier with 2 terminal nodes

\[
\begin{align*}
1 & \quad x_i \geq t_i \\
-1 & \quad x_i \leq t_i
\end{align*}
\]
Boosted Classifier

- Complex and robust classifier is built out of multiple weak classifiers using a procedure called boosting.
- The boosted classifier is built iteratively as a weighted sum of weak classifiers.
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- The boosted classifier is built iteratively as a weighted sum of weak classifiers.
- On each iteration, a new weak classifier $f_i$ is trained and added to the sum.
- The smaller the error $f_i$ gives on the training set, the larger is the coefficient/weight that is assigned to it.
Cascade of Boosted Classifiers

- Sequence of boosted classifiers with constantly increasing complexity.
- Chained into a cascade with the simpler classifiers going first.

![Diagram of a cascade of classifiers](image)
OpenCV: Cascade Classifier

- Uses simple features and a cascade of boosted tree classifiers as a statistical model.
OpenCV: Cascade Classifier

- Classifier is trained on image of fixed size (Viola uses 24x24)
- Detection is done by sliding a search window of that size through the image and checking whether an image region at a certain location looks like our object or not.
OpenCV: Cascade Classifier

Feature’s value is a weighted sum of two components:
- Pixel sum over the black rectangle
- Sum over the whole feature area
Cascade Classifier

- Instead of applying all the 6000 features on a window, group the features into different stages of classifiers and apply one-by-one.
- If a window fails the first stage, discard it. We don’t consider remaining features on it.
- If it passes, apply the second stage of features and continue the process. The window which passes all stages is a face region.
OpenCV: Cascade Classifier

OpenCV already contains many pre-trained classifiers for face, eyes, smile etc. Those XML files are stored in opencv/data/haarcascades/ folder

cv2.CascadeClassifier.detectMultiScale(image[, scaleFactor[, minNeighbors[, flags[, minSize[, maxSize]]]]]])
Histogram of Oriented Gradients (HoG)
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Linear classifiers

Find linear function to separate positive and negative examples

\[ x_i \text{ positive: } x_i \cdot w + b \geq 0 \]
\[ x_i \text{ negative: } x_i \cdot w + b < 0 \]

Which line is best?
Support Vector Machines (SVMs)

- Discriminative classifier based on optimal separating line (for 2D case)
- Maximize the margin between the positive and negative training examples
Support Vector Machines (SVMs)

- Want line that maximizes the margin.
OpenCV: HOG and SVM for Person Detection

1. Represent each example with a single, fixed HoG template

2. Learn a single [linear] SVM as a detector