Outline

- Introduction
- Adaboost
- Adaboost cascade
- Posibilistic Boosting-Tree
- Experimental results
INTRODUCTION

- Detects faces in an image
- Subwindows
  - 16*16
INTRODUCTION

- Features
  - Difference between rectangles
INTEGRAL IMAGE

- Allows the features used by our detector to be computed very quickly

\[
i_i(x, y) = \sum_{x' \leq x, y' \leq y} i(x, y)
\]

The value of the integral image at location 1 is the sum of the pixels in rectangle A. The value at location 2 is A+B, at location 3 is A+C, and at location 4 is A+B+C+D. The sum within D can be computed as 4+1-(2+3). [1]
INTEGRAL IMAGE

- Compute ii
  - $s(x, y) = s(x, y-1) + i(x, y)$
  - $ii(x, y) = ii(x-1, y) + s(x, y)$
    - $s(x, y)$ is the cumulative row sum, $s(x, -1) = 0$.
    - $ii(-1, y) = 0$
Adaboost

- given a feature set and a training set of positive and negative images
- select a small set of features (weak learner) and train the classifier (strong learner)
Adaboost

- **Weak learner**
  - Single feature

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

- **Weight**
  - Update based on error

\[
w_{t+1,i} = w_{t,i} \beta_t^{1 - e_i}
\]

\[
\beta_t = \frac{e_t}{1 - e_t}.
\]

- **Strong learner**
  - Combine weak learners
Adaboost --- example
Adaboost --- example
Adaboost --- example
Adaboost --- example
Adaboost --- example
ADABOOST CASCADE

- reject negative results
- reduce the threshold to minimize false negatives.

[1]
POSIBILISTIC BOOSTING-TREE
### EXPERIMENTAL RESULTS

**Adaboost cascade**

<table>
<thead>
<tr>
<th>stage</th>
<th>Right detection</th>
<th>False positive</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
<td>496</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>999</td>
<td>401</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>999</td>
<td>339</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>999</td>
<td>288</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>999</td>
<td>243</td>
<td>45</td>
</tr>
<tr>
<td>6</td>
<td>999</td>
<td>207</td>
<td>55</td>
</tr>
<tr>
<td>7</td>
<td>999</td>
<td>182</td>
<td>65</td>
</tr>
<tr>
<td>8</td>
<td>999</td>
<td>167</td>
<td>75</td>
</tr>
<tr>
<td>9</td>
<td>999</td>
<td>152</td>
<td>85</td>
</tr>
<tr>
<td>10</td>
<td>999</td>
<td>138</td>
<td>100</td>
</tr>
</tbody>
</table>

2000 training images
EXPERIMENTAL RESULTS

Adaboost cascade

<table>
<thead>
<tr>
<th>stage</th>
<th>Right detection</th>
<th>False positive</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>56</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>41</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>29</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>17</td>
<td>55</td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>14</td>
<td>65</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>13</td>
<td>75</td>
</tr>
<tr>
<td>9</td>
<td>100</td>
<td>12</td>
<td>85</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>11</td>
<td>100</td>
</tr>
</tbody>
</table>

200 training images
EXPERIMENTAL RESULTS
Positivistic boosting-tree

2000 training images
**EXPERIMENTAL RESULTS**

Positivistic boosting-tree

<table>
<thead>
<tr>
<th></th>
<th>1 1</th>
<th>1 0</th>
<th>0 1</th>
<th>0 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train</td>
<td>838</td>
<td>162</td>
<td>189</td>
<td>811</td>
</tr>
<tr>
<td>Test</td>
<td>100</td>
<td>0</td>
<td>67</td>
<td>33</td>
</tr>
</tbody>
</table>

2000 training images
Reference

- Rapid Object Detection using a Boosted Cascade of Simple Features, Paul Viola, Michael Jones
- Probabilistic Boosting-Tree: Learning Discriminative Models for Classification, Recognition, and Clustering, Zhuowen Tu, Integrated Data Systems Department Siemens Corporate Research, Princeton, NJ, 08540
THANG YOU