Robust Angle Invariant 1D Barcode Detection

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Goals:

- detection of 1D barcodes from real world images
- fast execution on a low computational power device
- robust to lighting variations, background clutter, rotation and distortions
Related Works

Existing 1D barcode detection methods:

• gradients analysis

• scan lines

• canny edge detector

Issues:

• slow
• rotation
Novel detection approaches:

- optical character recognition methods
  - numbers are not part of the barcode standard
- Hough transform for lines detection
  - successfully used for reading 1D barcodes
Detection of 1D barcode patterns in the Hough Transform space using a simple MLP network:

- **pros**
  - rotation invariant
  - fast

- **cons**
  - sensitive to noise
  - requires training
a regular grid $n \times m$ of cells $c_1, \ldots, c_{n \times m}$ is superimposed over the Hough accumulator matrix $A_H$

2. $c$ is given as input to the MLP

3. the MLP produces a new cell $c_t$

$$c_t(i, j) = \begin{cases} 1 & \text{if } c(i, j) \text{ denotes a barcode bar in } I. \\ 0 & \text{otherwise.} \end{cases}$$

4. the processed cells are combined together to generate $A_N$
5. given a row \( r \in A_N \), the sum of its elements denotes the likelihood \( l_r \) of a barcode appearing in \( I \) rotated by \( \theta_r \).

6. we build the histogram of likelihoods \( h_l \)

7. rows associated with max elements of \( h_l \) denote barcodes
Supervised Angle Detection - Details

MLP:

- 3 layers
- size of each layer: \( n \times m \)
- trained using \textit{rprop} (parameters from Igel \textit{et al.} 2005)
- 200 training patterns (150 bgs, 50 fgs)

\textbf{Training patterns} - \( \forall c_i \in A_H, (in_{c_i}, out_{c_i}) : \)

- \( in_{c_i} \) - vector representation of \( c_i \)
- \( out_{c_i} \) - elements of \( in_{c_i} \) denoting barcode bars are assigned 1, the others are assigned 0
## Supervised Angle Detection - Datasets

<table>
<thead>
<tr>
<th>Dataset</th>
<th>No. of Imgs</th>
<th>Device</th>
<th>Barcode Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWU Muenster Barcode DB*</td>
<td>1055</td>
<td>Nokia N95</td>
<td>±30°</td>
</tr>
<tr>
<td>ArTe-Lab 1D Medium Barcode**</td>
<td>215</td>
<td>Nokia 5800</td>
<td>//</td>
</tr>
<tr>
<td>Rotated Barcode DB**</td>
<td>368</td>
<td>Various</td>
<td>±180°</td>
</tr>
</tbody>
</table>

All the datasets are available online for download:

- * http://cvpr.uni-muenster.de/research/barcode/Database/
- ** http://artelab.dista.uninsubria.it/download/
Results:

• ArTe-Lab 1D Medium Barcode \( \simeq 100\% \ OA^\theta \)
• WWU Muenster Barcode DB & Rotated Barcode DB \( \simeq 95.5\% \ OA^\theta \)

Time:

• \( \sim 200 \) ms per image

Metric:

• \( OA^\theta = \frac{tp}{tp+fn+fp} \)
1. rotate $I$ by $\theta_r$ (detected during the previous phase)
2. get the segments parallel to the vertical, as in Matasyz et al., 1999
3. obtain a binary image $I_{S_b}$
4. define two histograms $h^r_{S_b}$ and $h^c_{S_b}$ describing the intensity profiles of the rows and columns of $I_{S_b}$ respectively
5 smooth the histograms to remove low value bins corresponding to isolated non-barcode segments

6 the detected bounding boxes correspond to the intersection area between the rows and the columns associated with the non-zero bins of $h_{S_b}^r$ and $h_{S_b}^c$
<table>
<thead>
<tr>
<th>Dataset</th>
<th>$OA^{bb}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWU Muenster Barcode DB</td>
<td>0.83</td>
</tr>
<tr>
<td>ArTe-Lab 1D Medium Barcode</td>
<td>0.86</td>
</tr>
<tr>
<td>Rotated Barcode DB</td>
<td>0.84</td>
</tr>
</tbody>
</table>

**Time:**
- $\sim 70$ ms per image

**Metric:**
- $OA^{bb} = \frac{tp}{tp + fn + fp}$
- $tp = \#$ of barcode bounding boxes correctly detected
- a bounding box $d_b$ is correctly detected iff $\frac{bb_b \cap d_b}{bb_b \cup d_b} \geq 0.5$
<table>
<thead>
<tr>
<th>Dataset</th>
<th>Reading Accuracy</th>
<th></th>
<th>$\Delta_{acc}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWU Muenster Barcode DB</td>
<td>0.73</td>
<td>0.81</td>
<td>+0.08</td>
</tr>
<tr>
<td>ArTe-Lab 1D Medium Barcode</td>
<td>0.82</td>
<td>0.85</td>
<td>+0.03</td>
</tr>
<tr>
<td>Rotated Barcode DB</td>
<td>0.61</td>
<td>0.82</td>
<td>+0.19</td>
</tr>
</tbody>
</table>
Thank You!

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