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

Existing 1D barcode detection methods:

- gradients analysis
  - O. Gallo and R. Manduchi, “Reading 1-D barcodes with mobile phones using deformable templates”, IEEE PAMI, 2011.
- scan lines
  - S. Wachenfeld, S. Terlunen and X. Jiang, “Robust 1-D barcode recognition on camera phones and mobile product information display”, Mobile Multimedia Processing, 2010.
  - R. Adelman, M. Langheinric, and C. Floerkemeier, “A toolkit for barcode recognition and resolving on camera phones”, MEIS, 2006.
- canny edge detector
  - E. Basaran, O. Ulucay and S. Erturk, “Reading barcodes using digital cameras”, IMS, 2006.

Issues:

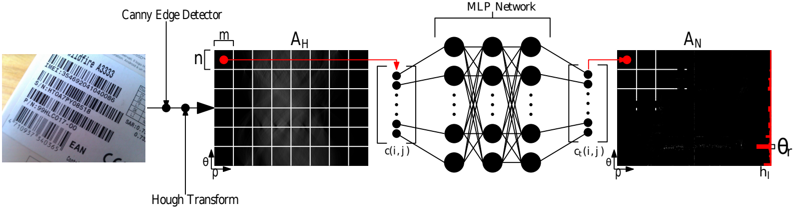
- slow
- rotation

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
    - R. Muniz, L. Junco and A. Otero, “A robust software barcode reader using the Hough Transform”, IISA, 1999.

Detection of 1D barcode patterns in the Hough Transform space using a simple MLP network:

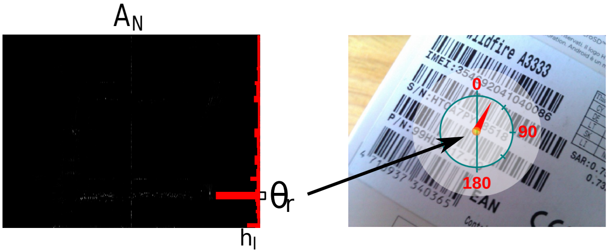
- **pros**
  - rotation invariant
  - fast
- **cons**
  - sensitive to noise
  - requires training



1. 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 θ_r
6. we build the histogram of likelihoods h_l
7. rows associated with max elements of h_l denote barcodes

MLP:

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

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

Dataset	No. of Imgs	Device	Barcode Rotation
WWU Muenster Barcode DB*	1055	Nokia N95	$\pm 30°$
ArTe-Lab 1D Medium Barcode**	215	Nokia 5800	//
Rotated Barcode DB**	368	Various	$\pm 180°$

All the datasets are available online for download:

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

Results:

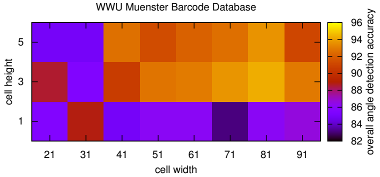
- ArTe-Lab 1D Medium Barcode $\simeq 100\%\ OA^{\theta}$
- WWU Muenster Barcode DB & Rotated Barcode DB $\simeq 95.5\%\ OA^{\theta}$

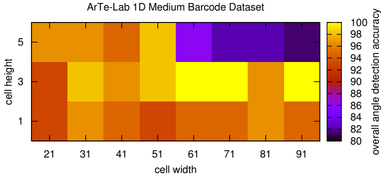
Time:

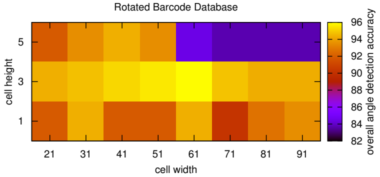
- $\sim$ 200 ms per image

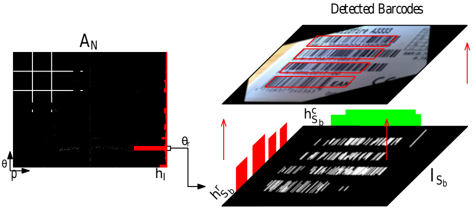
Metric:

- $OA^{\theta} = \frac{tp}{tp+fn+fp}$

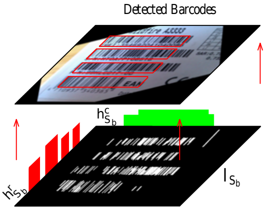








1. rotate I by θ_r (detected during the previous phase)
2. get the segments parallel to the vertical, as in Matasyz *et al.*, 1999
3. obtain a binary image I_{S_b}
4. define two histograms $h^r_{S_b}$ and $h^c_{S_b}$ describing the intensity profiles of the rows and columns of I_{S_b} respectively



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 $h^r_{S_b}$ and $h^c_{S_b}$

Bounding Box Detection - Evaluation

Dataset	OA^{bb}
WWU Muenster Barcode DB	0.83
ArTe-Lab 1D Medium Barcode	0.86
Rotated Barcode DB	0.84

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 $\frac{bb_b \cap d_b}{bb_b \cup d_b} \geq 0.5$

Dataset	Reading Accuracy		
	ZXing	Our ∪ ZXing	Δ_{acc}
WWU Muenster Barcode DB	0.73	0.81	+0.08
ArTe-Lab 1D Medium Barcode	0.82	0.85	+0.03
Rotated Barcode DB	0.61	0.82	+0.19

Q&A

Thank **You!**

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