Yaroslavl Demidov State University

Allocation of Text Characters of Automobile License Plates on the Digital Image

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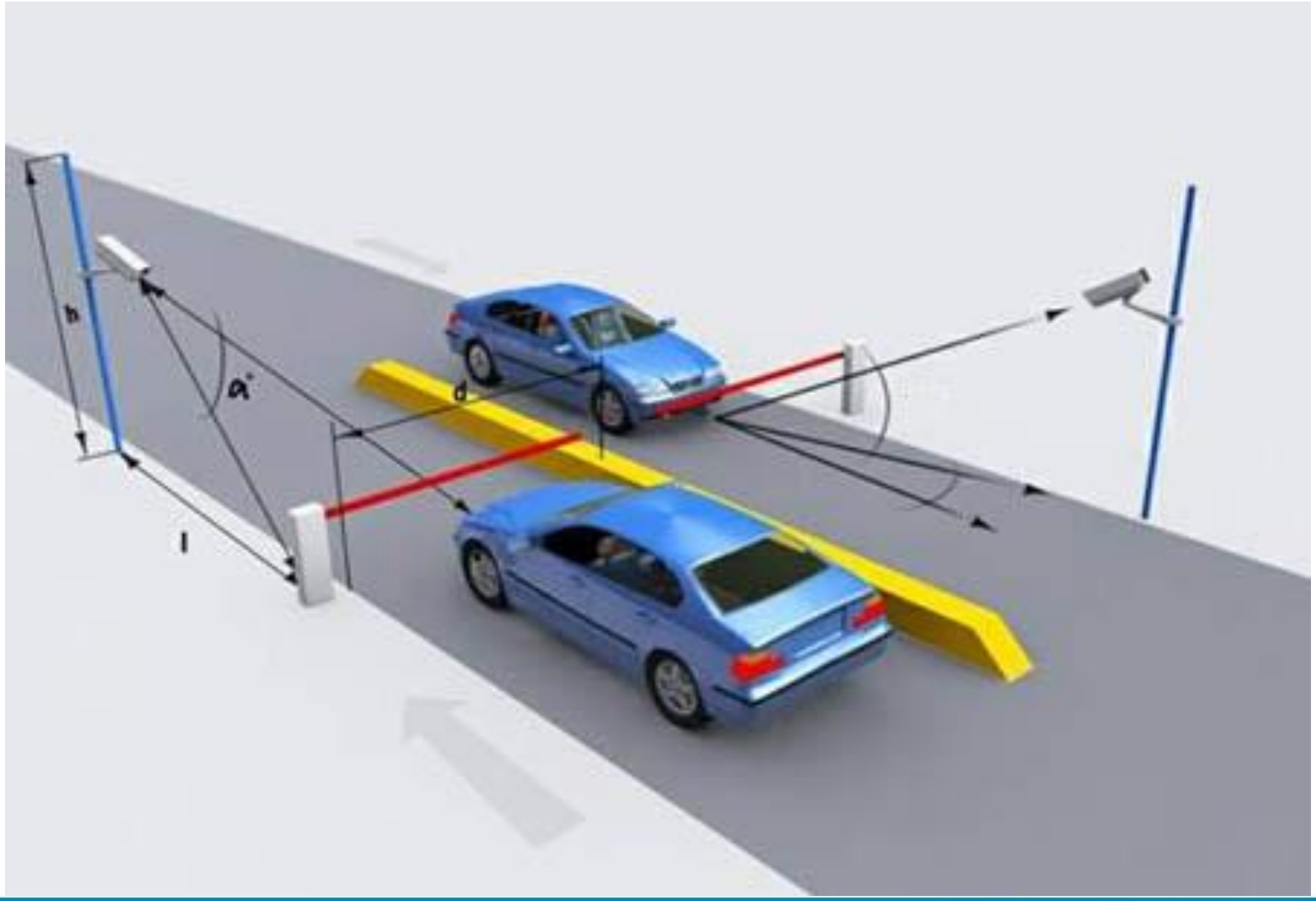
Agenda

1. Introduction
2. Proposed Algorithms
3. Research Results for Detecting Number Plate
4. Research Results for Segmentation Symbols
5. Conclusion

The problem



Introduction

The aim:

Development an affective automobile license plate detection and number segmentation system

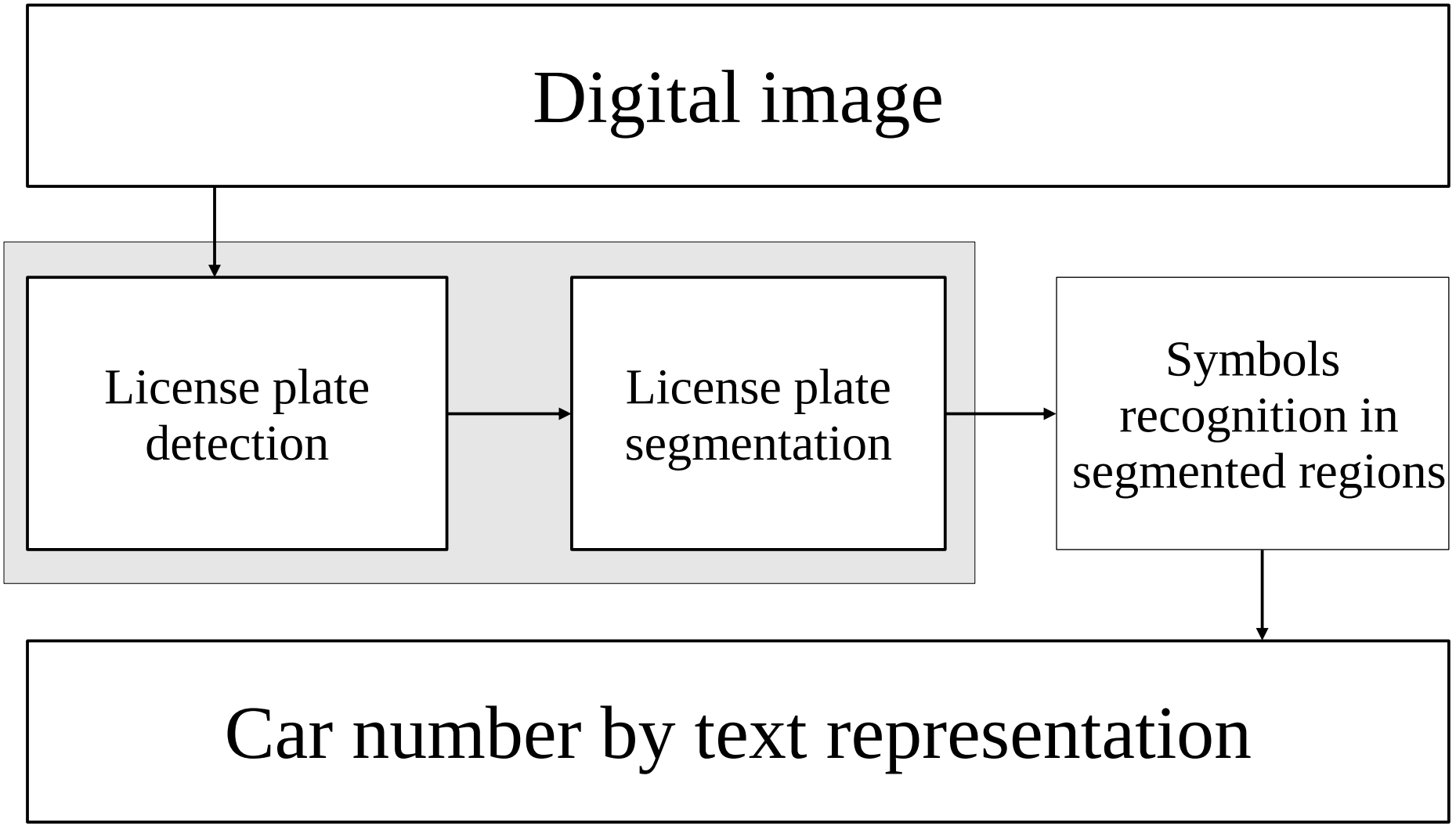
The tasks:

- Design the license plate detection on digital image algorithm
- Development the symbols of the plate segmentation approach
- Creation the original image database for testing all considered methods
- Test and analysis mentioned algorithms

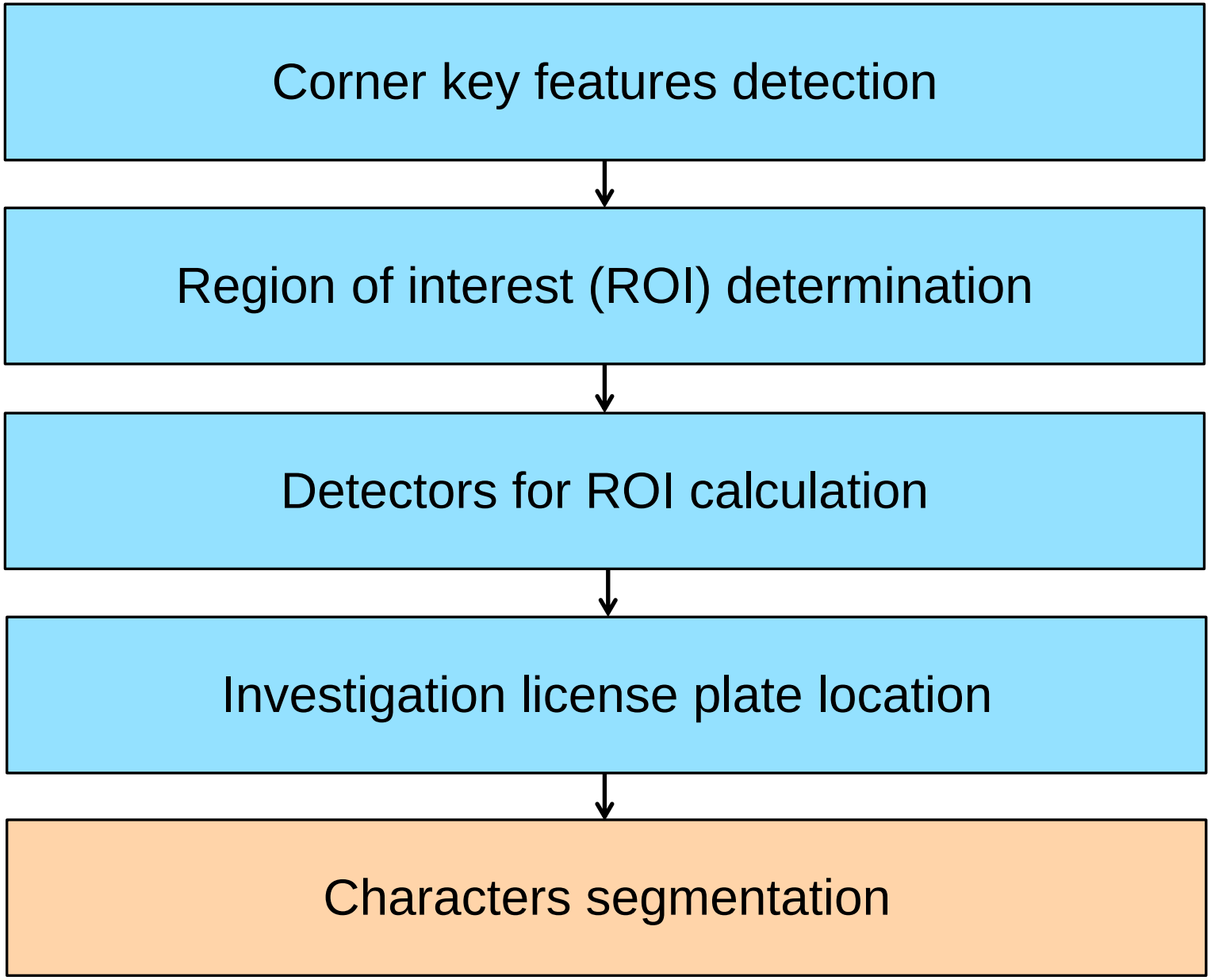
Conditions to the algorithms:

- descriptors in technical terms
- should not depend on priori information
- adopted to informational content on the plate

Automatic license plate recognition system



Proposed system



Harris Corner Detector

$$S(x,y) = \sum_u \sum_v w(u,v)(I(u,v) - I(u+x, v+y))^2$$

Weighted sum of squared differences between two regions

$$I(u+x,v+y) \approx I(u,v) + \frac{\partial I(u,v)}{\partial x} \cdot x + \frac{\partial I(u,v)}{\partial y} \cdot y \qquad S(x,y) \approx \sum_u \sum_v w(u,v) \cdot \left[\frac{\partial I(u,v)}{\partial x} \cdot x + \frac{\partial I(u,v)}{\partial y} \cdot y \right]^2$$

Taylor series expansion

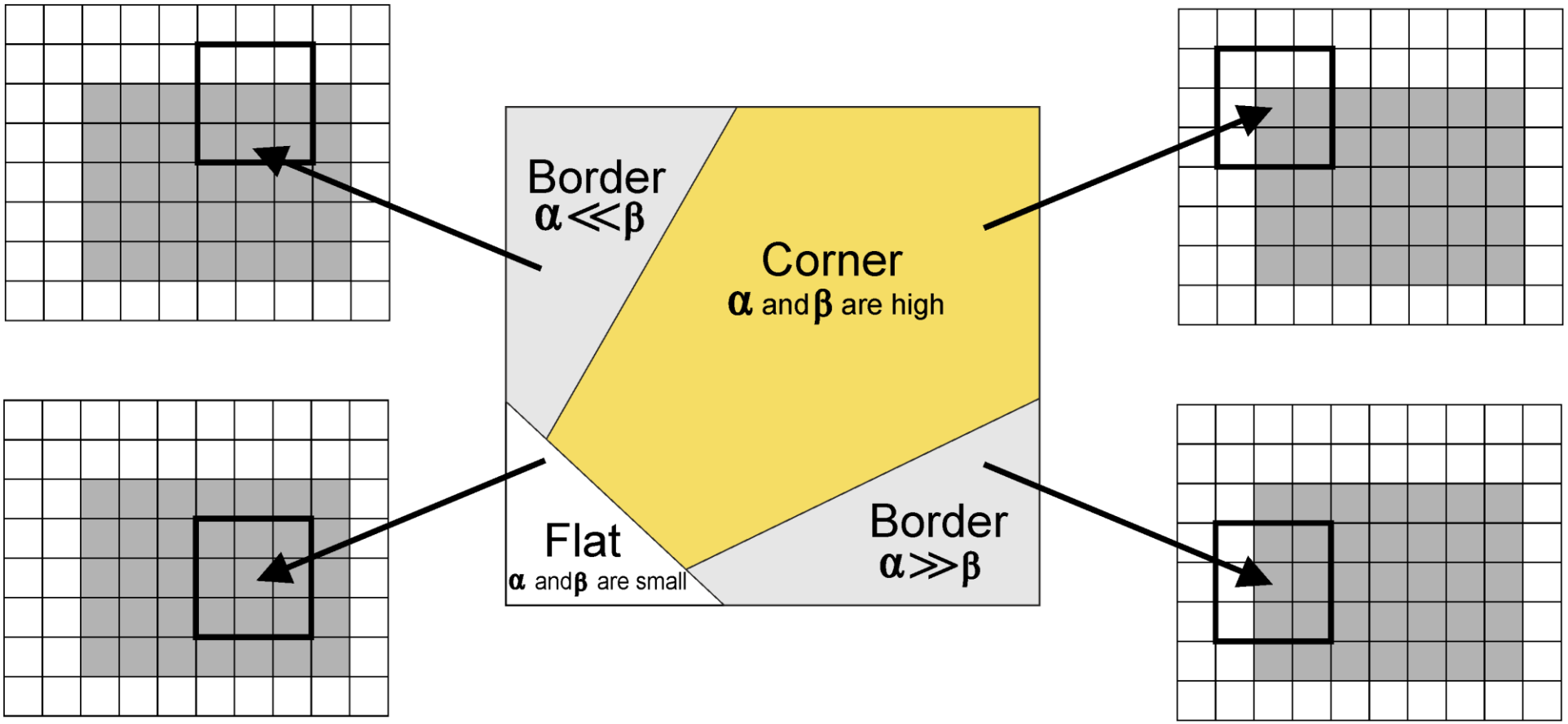
$$\mathbf{M} = \sum_u \sum_v w(u,v) \cdot \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} = \begin{bmatrix} \langle I_x^2 \rangle & \langle I_x I_y \rangle \\ \langle I_x I_y \rangle & \langle I_y^2 \rangle \end{bmatrix}$$

Matrix representation

$$\mathrm{R} = \det(\mathbf{M}) - \mathrm{k} \cdot \mathrm{trace}^2(\mathbf{M}) = (\alpha \cdot \beta) - \mathrm{k} \cdot (\alpha + \beta)^2$$

Corner response function

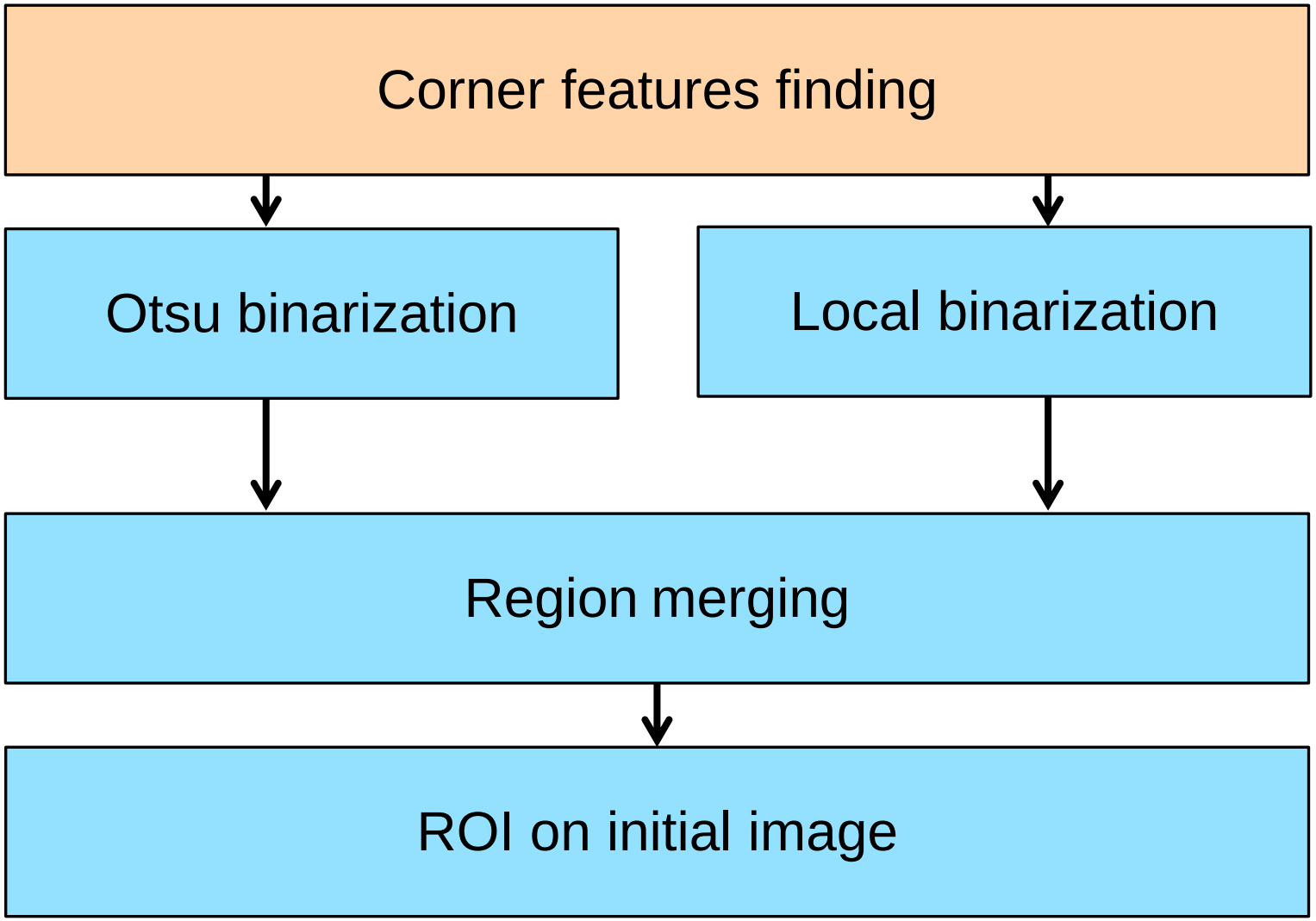
Key points



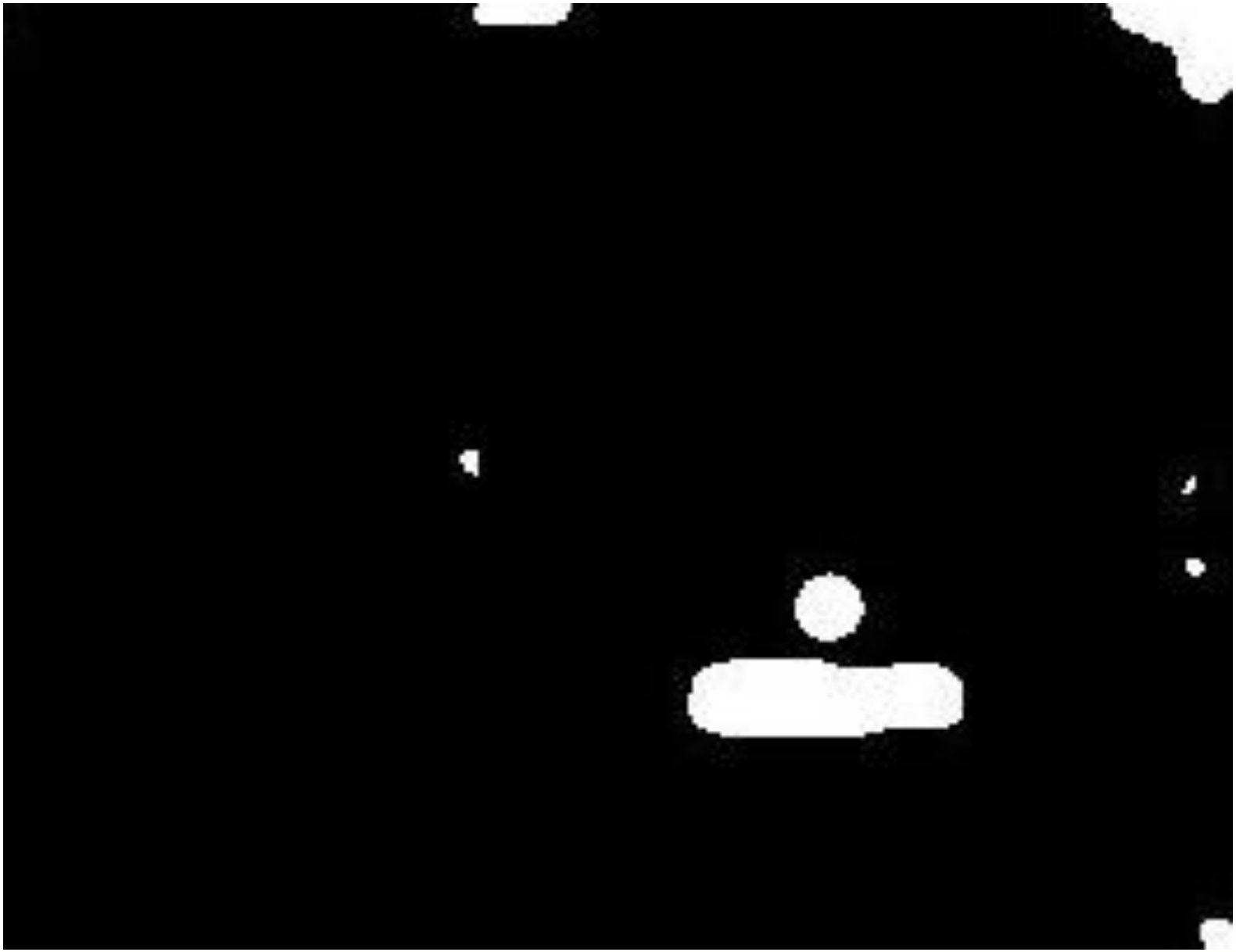
$\alpha \approx 0 \quad \beta \approx 0$	key features absence
$\alpha \approx 0$ и $\beta >> 0$	edge of the object
$\alpha >> 0$ и $\beta >> 0$	corner key feature

Response map of Harris corner detector

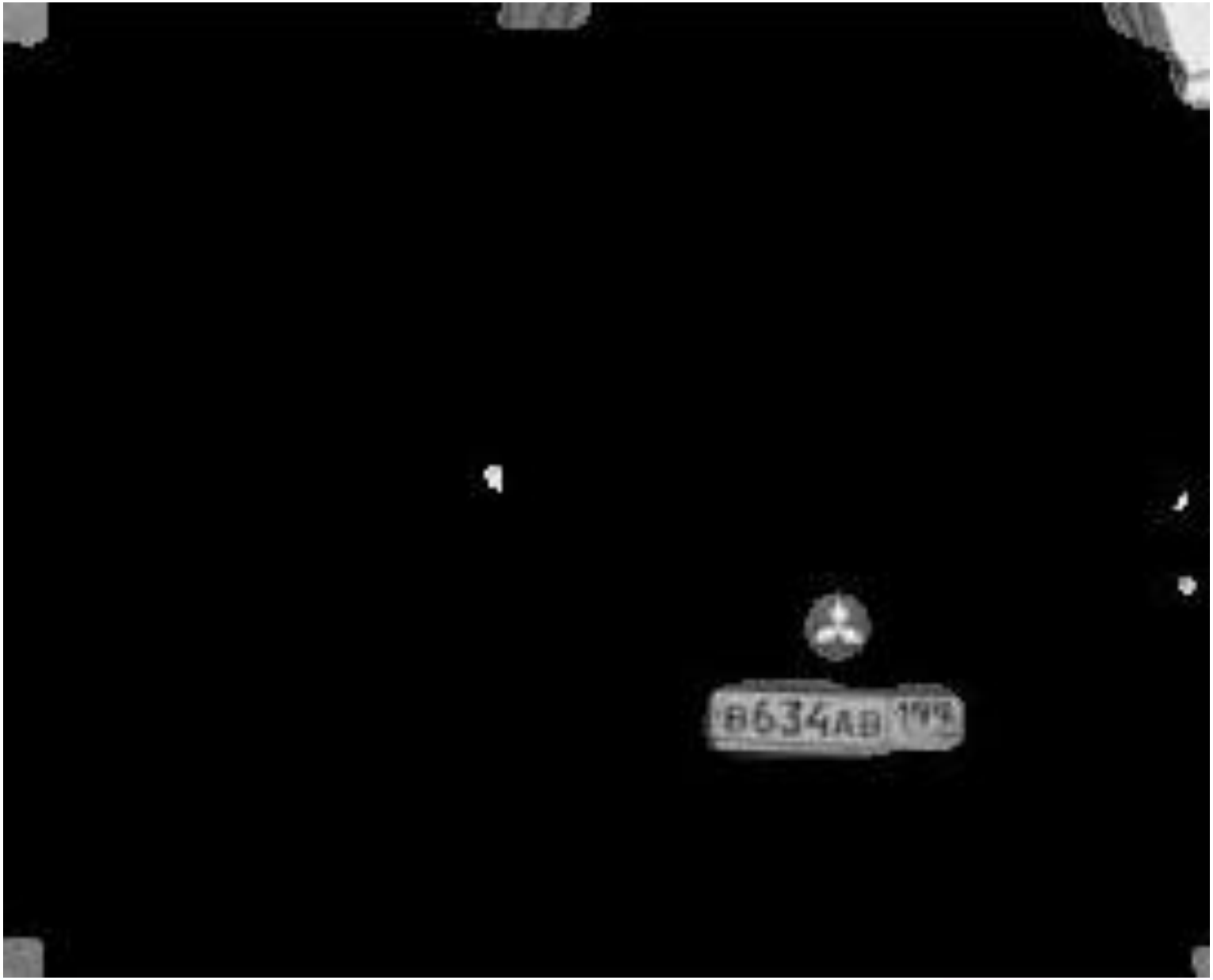
ROI construction



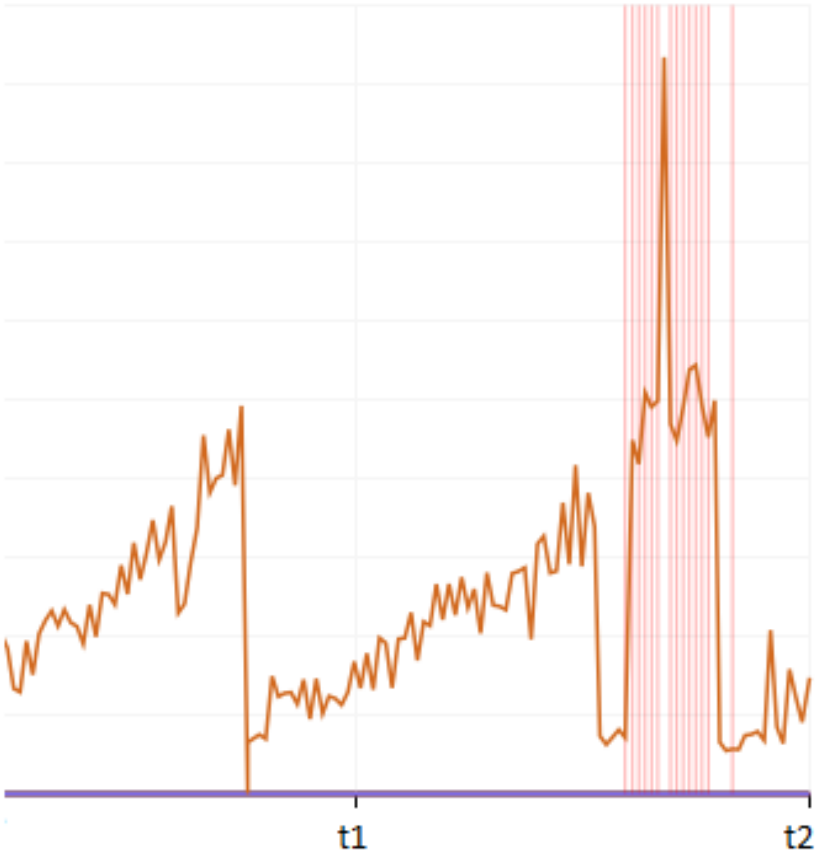
Regions binarization and merging

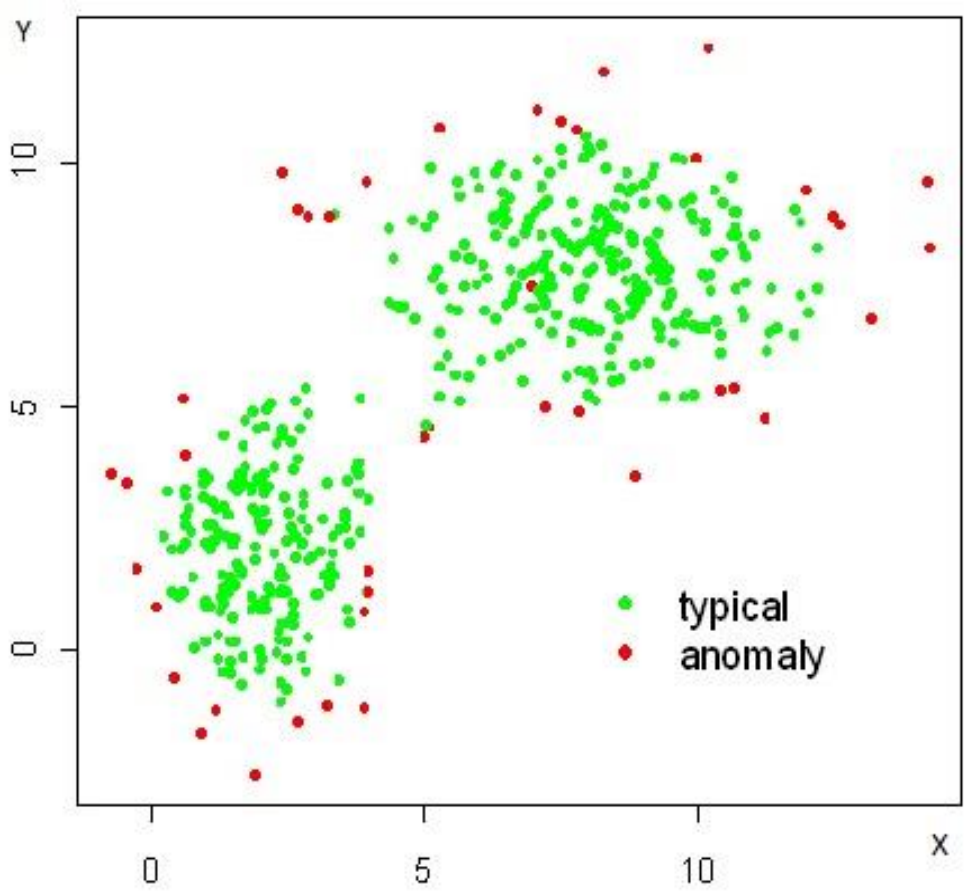


ROI on Initial Image



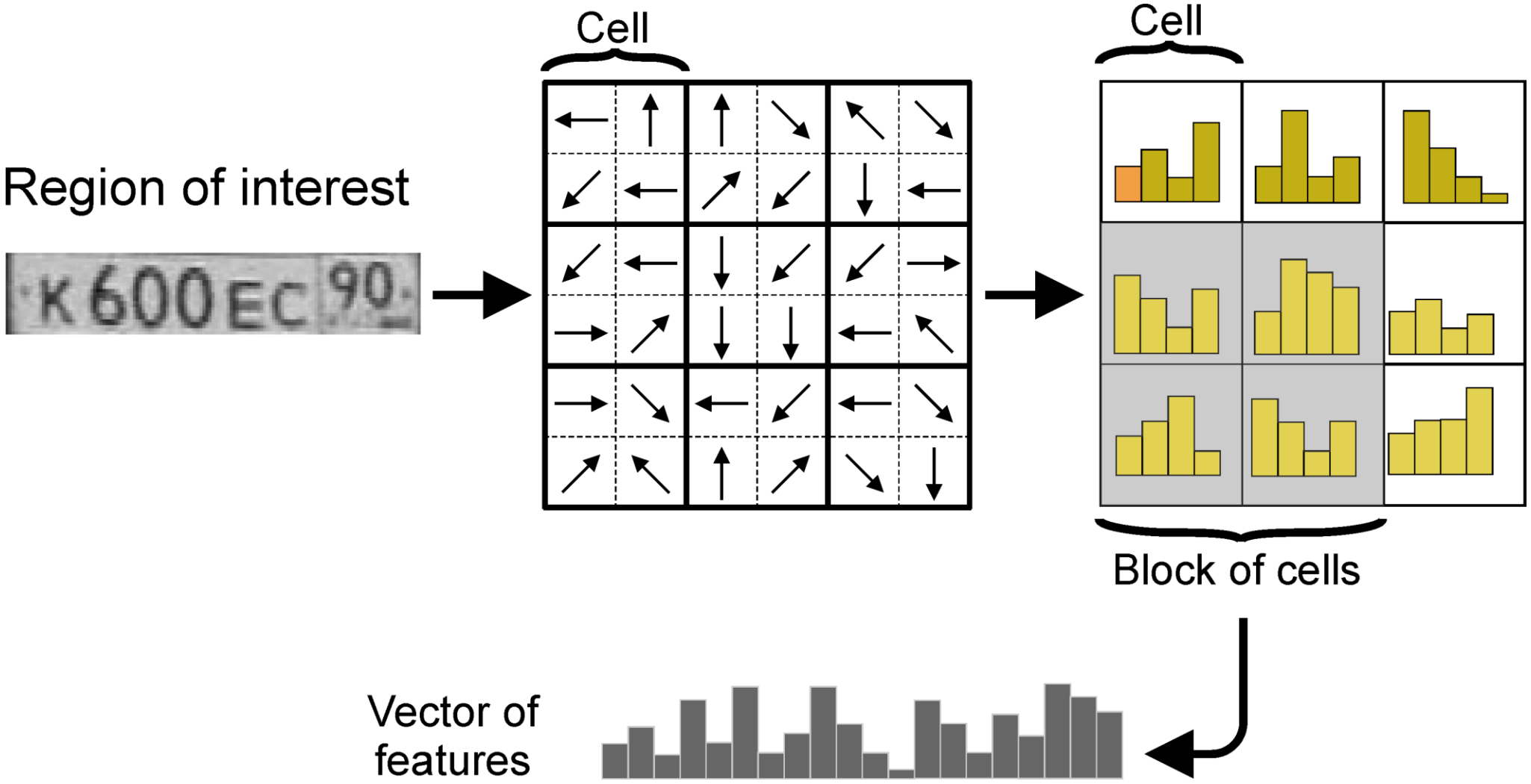
Anomaly Detection





Typical cases of anomaly

HOG descriptor investigtion

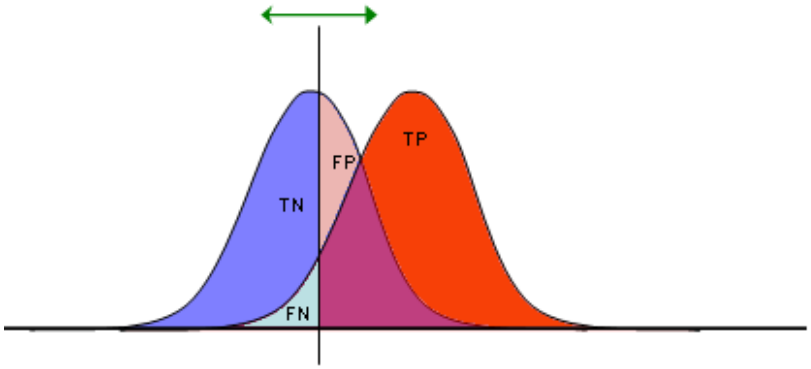


Testing database

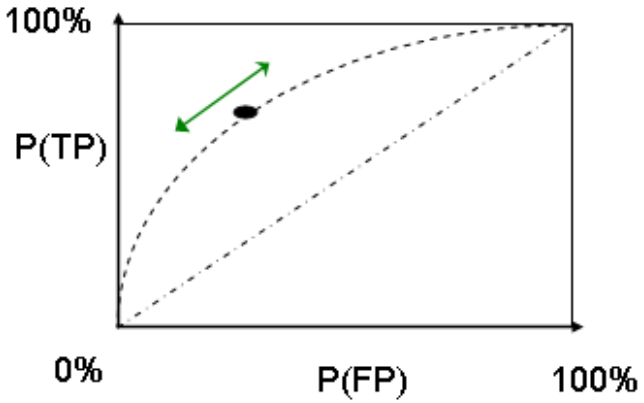
Street traffic

Checkpoint

ROC-curve

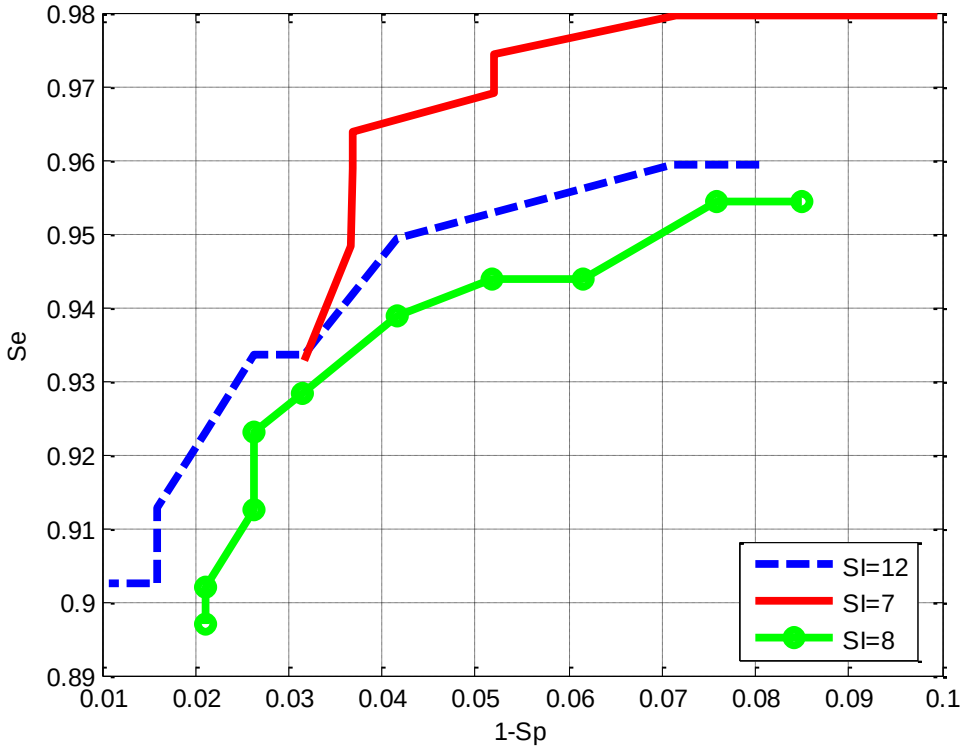


TP	FP
FN	TN
1	1

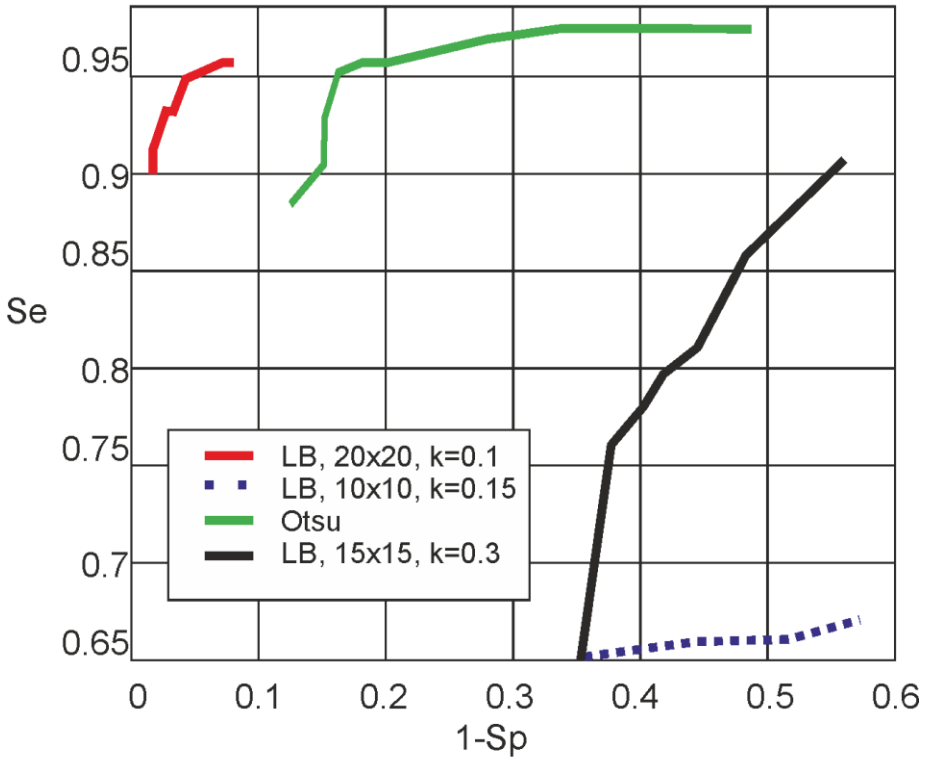


ROC-curve is a native representation of binary classification

Research results of number plate detector

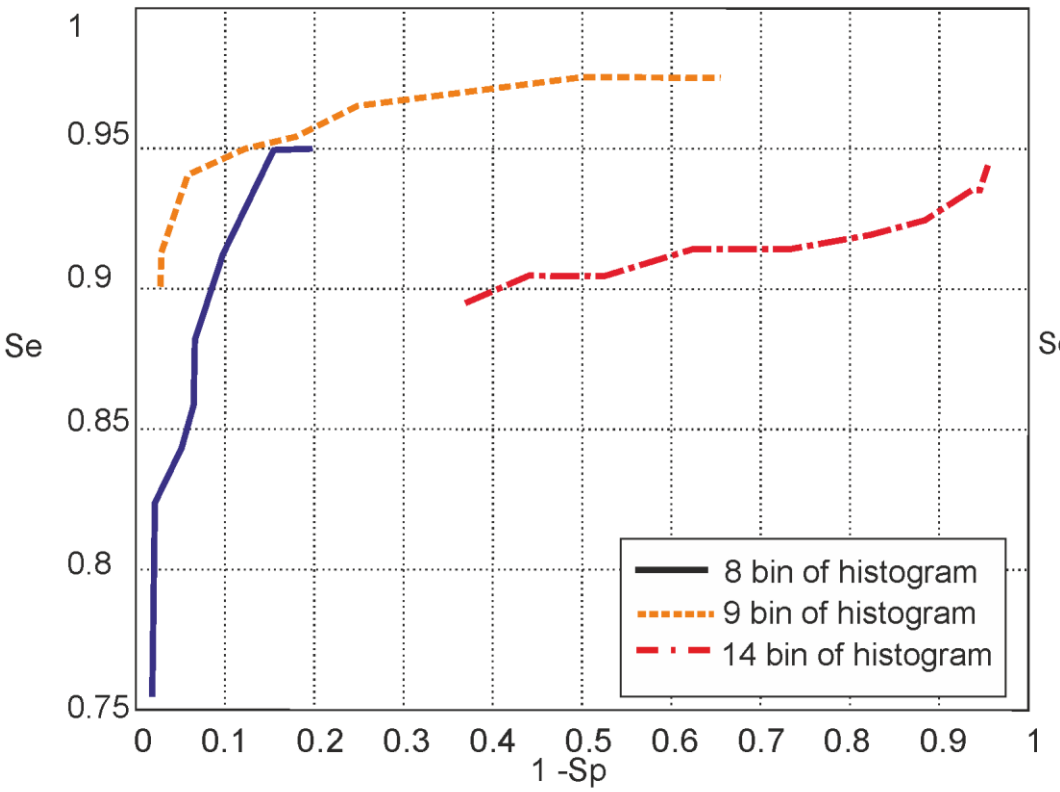


ROC-curve for window size of corner detector

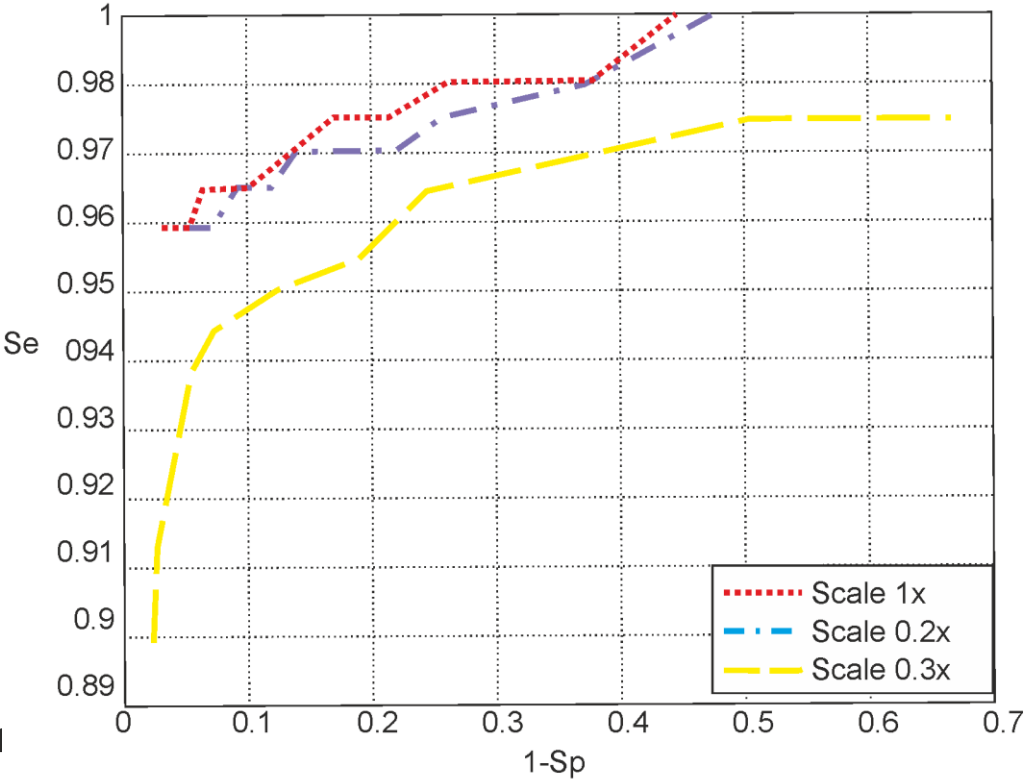


ROC-curve for binarization parameters

Research results of number plate detector

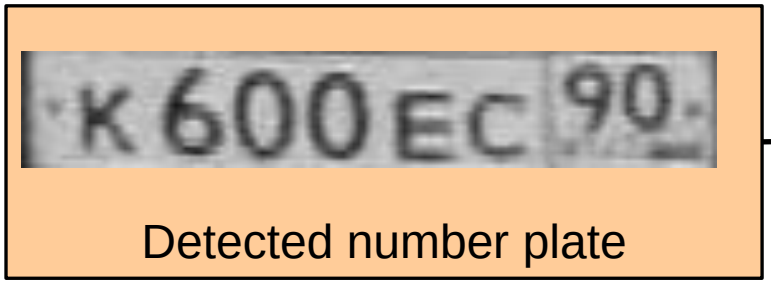


by number of bins in HOG histogram



by scale of training images

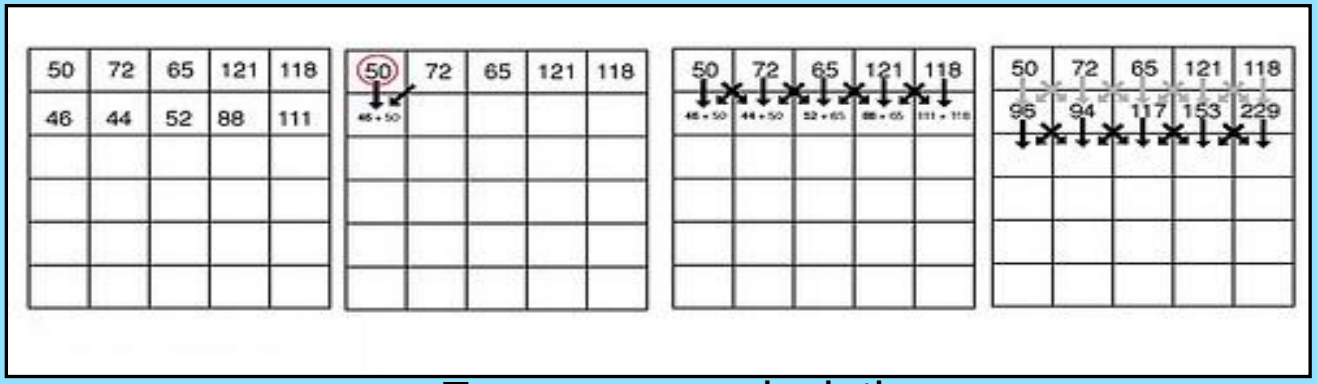
Symbols segmentation



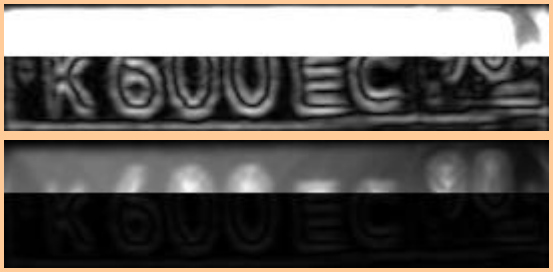
Detected number plate

$$e(I) = a \times \left|\frac{\partial I}{\partial x}\right| + b \times \left|\frac{\partial I}{\partial y}\right|$$

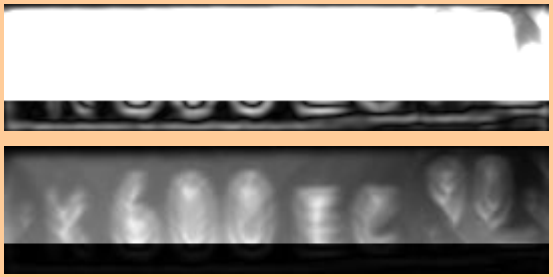
Gradient calculation



Energy map calculation

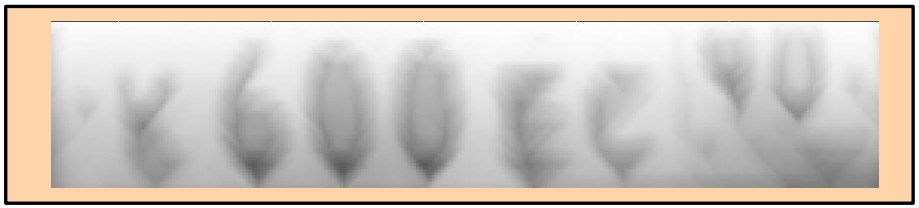


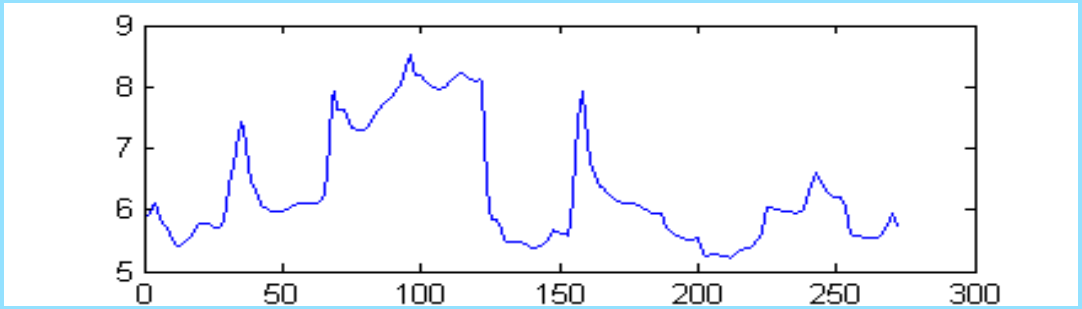
Step 18



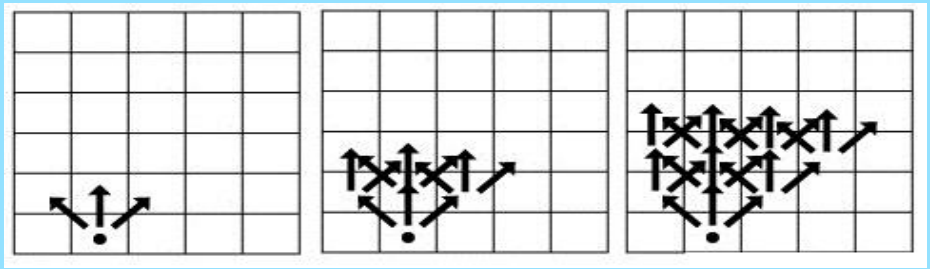
Step 43

Symbols segmentation

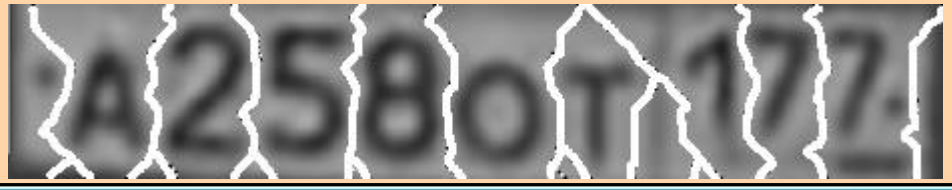




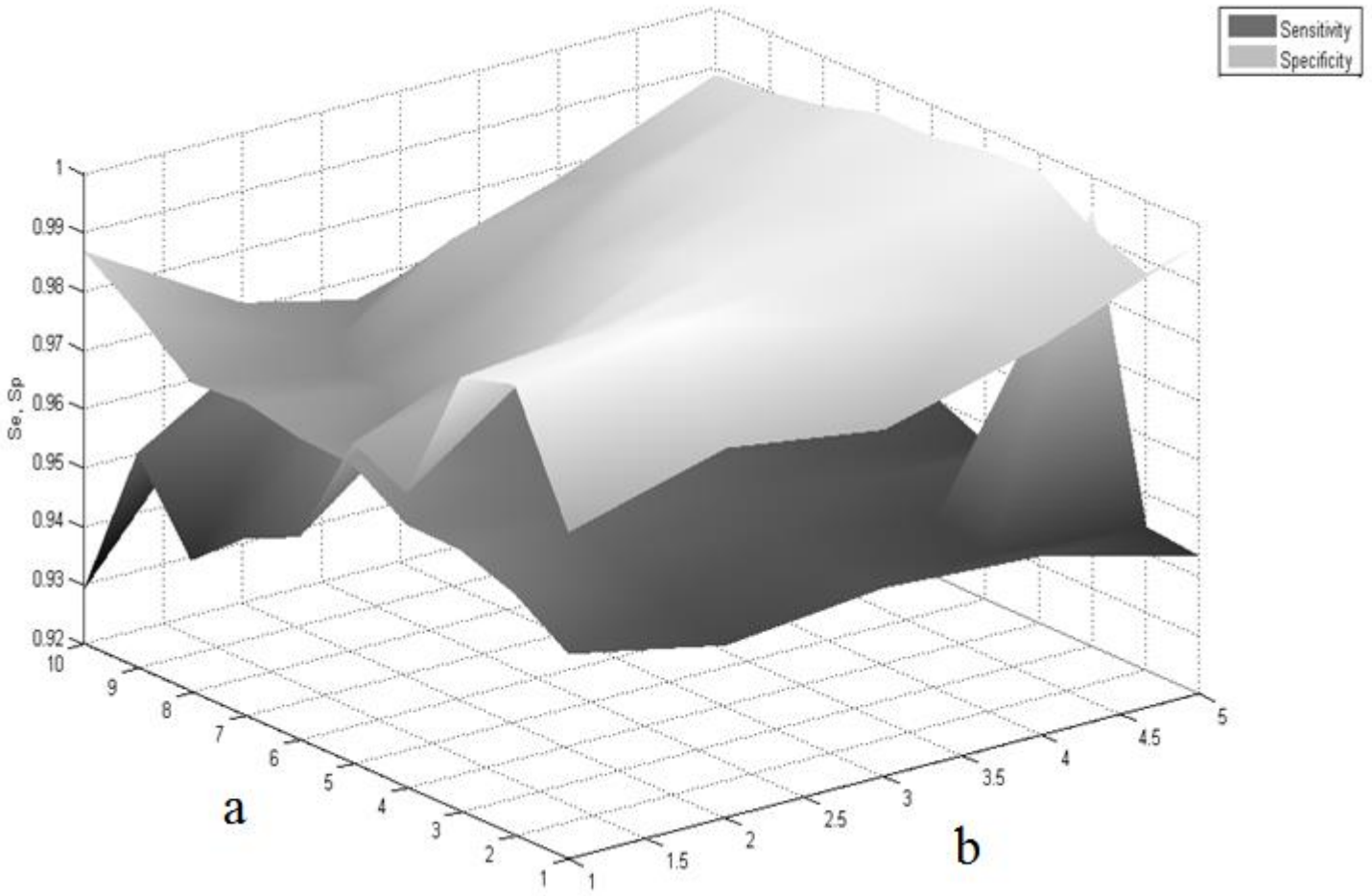
Accumulated energy at last line



Line construction rule



Research results of symbols segmentation



Dependence type I and type II errors on gradient parameters

Conclusions

- ✓ Automobile license plate system was developed
- ✓ Detection of license plate is carried out without making any a priori information into the system
- ✓ Detection accuracy is over 97%
- ✓ Other 3% occur due to low contrast and sharpness of the original image and can be changed by image preprocessing

Conclusions

- ✓ The symbols segmentation is independed on the informational content
- ✓ Optimization of the energy function increases the segmentation quality on over 98%

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