Recognition of Degraded Handwritten Characters Using Local Features

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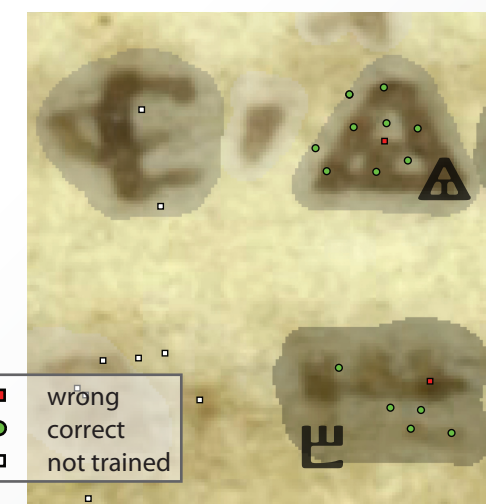
Motivation

- **Character recognition** of handwritten glagolitic codices
    - The oldest Slavonic alphabet
    - Written in the 11th century (Cod. Sin. slav 5N)
    - Discovered in 1975 at St. Catherine's Monastery

- Bad storage conditions
    - Result in faded-out ink
    - State of the art binarization fail

- No space between words
    - Word segmentation is hard
    - Excludes use of dictionaries

- Binarization free approach
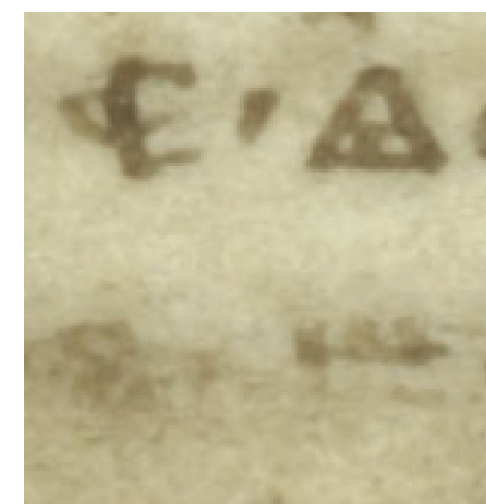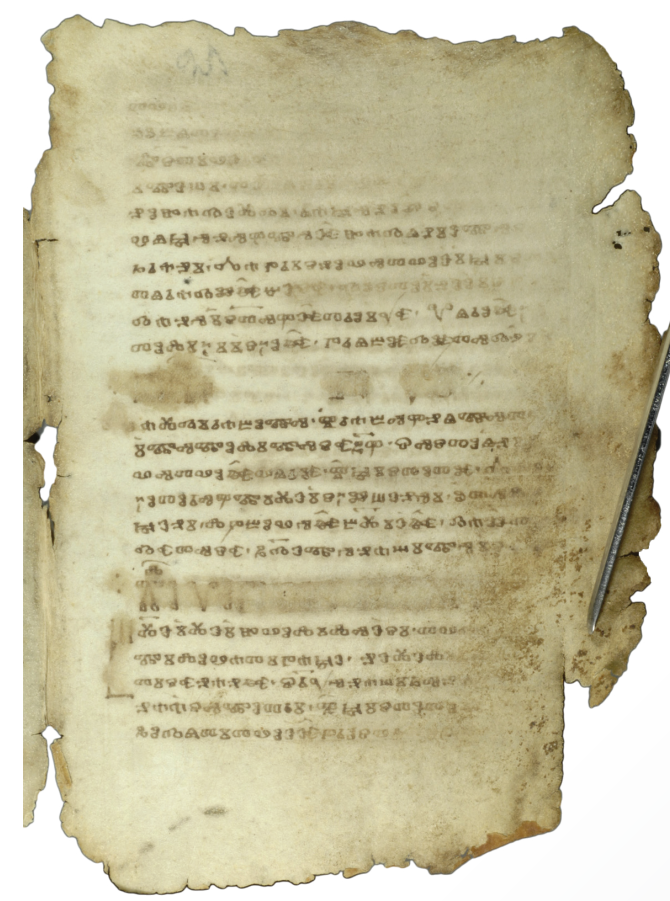
Faded out ink — Sauvola binarization [1] — Classification of local descriptors

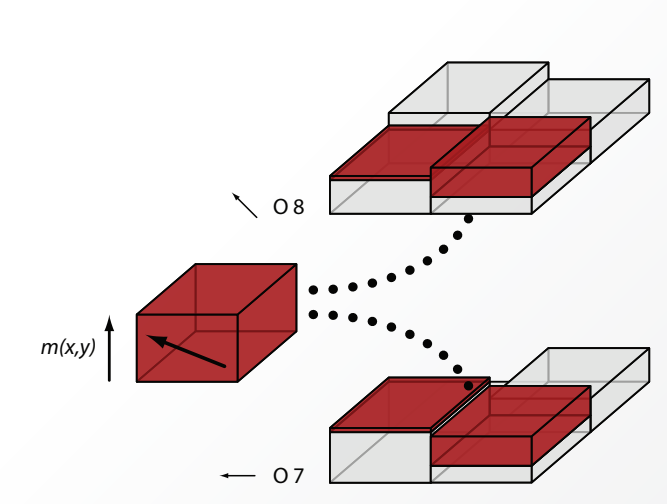(wrong / correct / not trained)

Methodology

- Character features represented by local descriptors
    - According to evaluations, SIFT is chosen

- Classification of descriptors by Multiple SVM's
    - RBF kernel (performance)
    - Propability histogram for each descriptor

- Character extraction by clustering DoG keypoints
    - k-Means Clustering
    - Initial cluster centers extracted in the scale-space
    - Split-Merge phase according to propability histogram

- Voting finally recognizes characters

(Initial Centers / Removed Centers / Interpolated / Clusters)
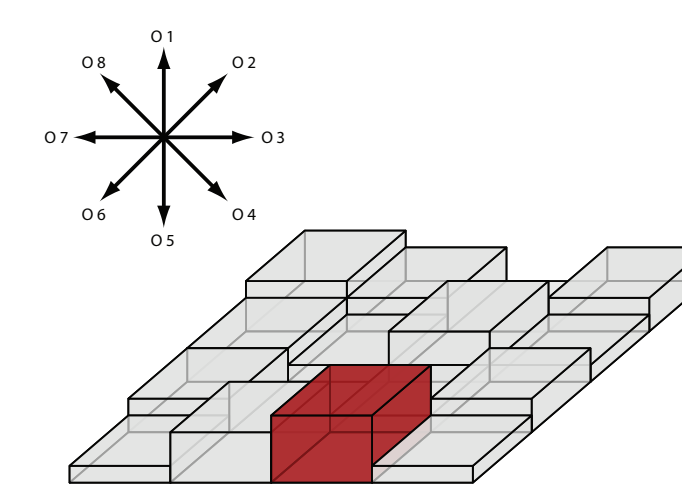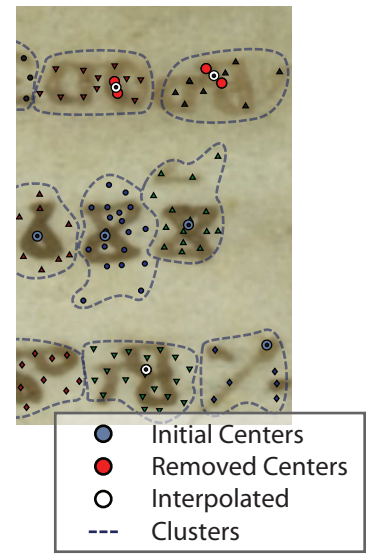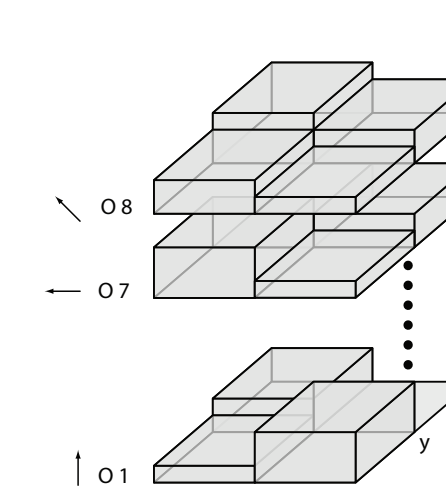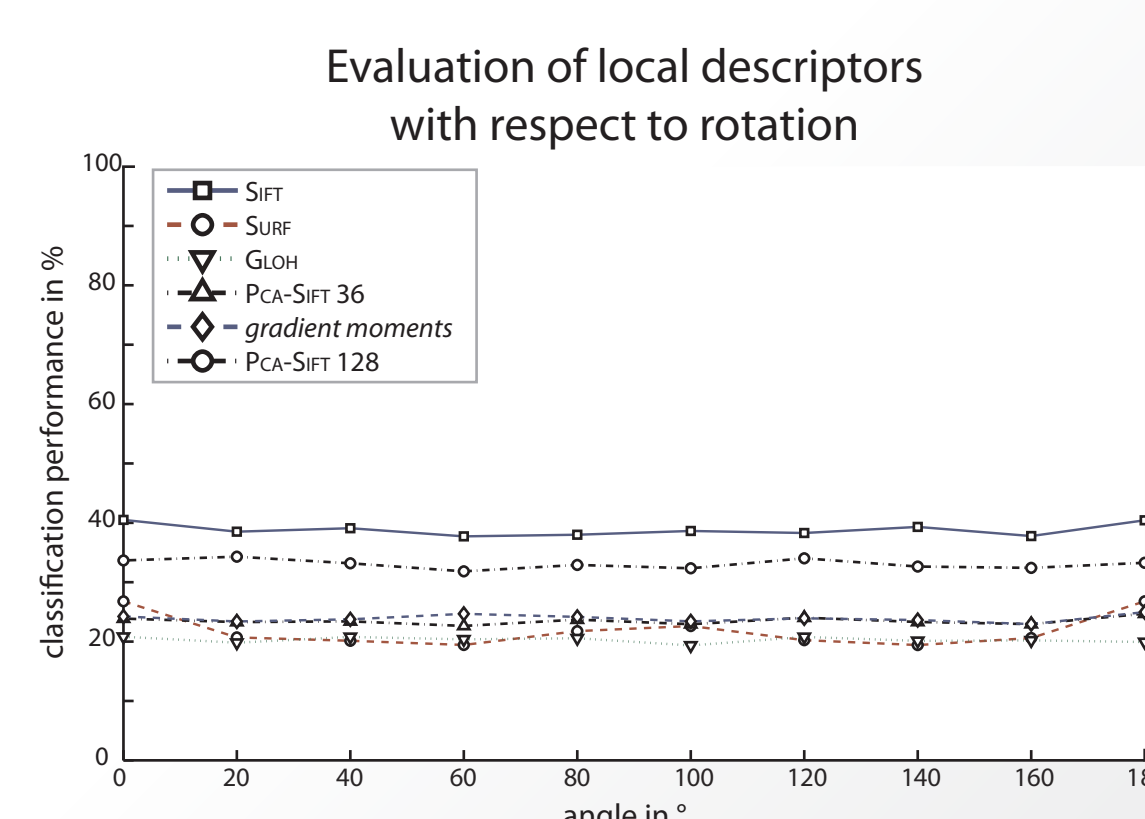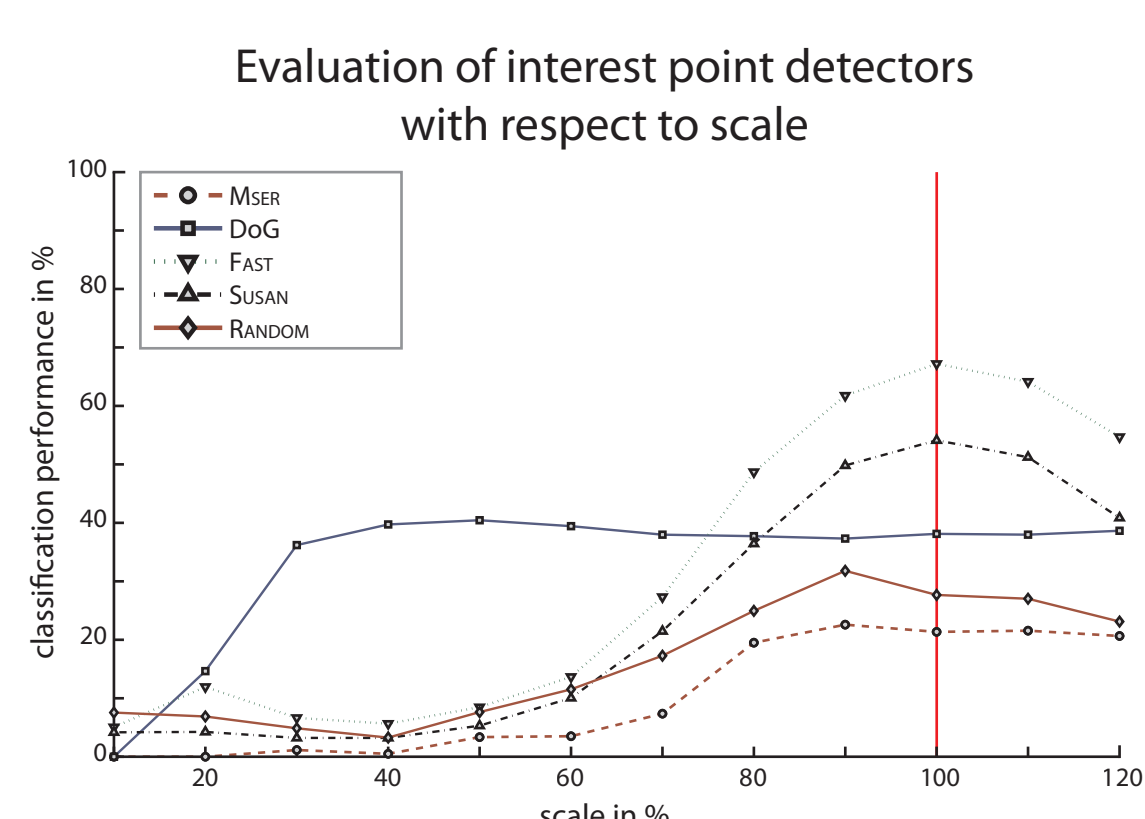
Local Image Patch — SIFT Descriptor — Interpolation of the gradient magnitude $m(x,y)$

Local Descriptor Comparison

- Comparison of interest points, local descriptors for their use in character recognition
    - Interest points: MSER, DoG, FAST, SUSAN
    - Local descriptors: SIFT, SURF, GLOH, PCA-SIFT, *gradient moments*
- SIFT performs best with respect to scale, rotation transformations

Descriptor	Detector	Author
SIFT	DoG	Lowe
SURF	Fast-Hessian	Bay, Tuytelaars, Van Gool
GLOH	Harris-Laplace	Mikolajczyk
PCA-SIFT	DoG	Ke, Sukthankar
gradient moments	Harris-Hessian-Laplace	Van Gool, Moons, Ungureanu

Evaluation of interest point detectors with respect to scale

(MSER, DoG, FAST, SUSAN, RANDOM)

classification performance in % — scale in %

Evaluation of local descriptors with respect to rotation

(SIFT, SURF, GLOH, PCA-SIFT 36, *gradient moments*, PCA-SIFT 128)

classification performance in % — angle in °

Results

- Evaluation of degraded characters (without clustering)
    - Test set with 198 degraded characters
    - 25 Classes (characters)
    - Mean class performance: 66.16%

classes — classes
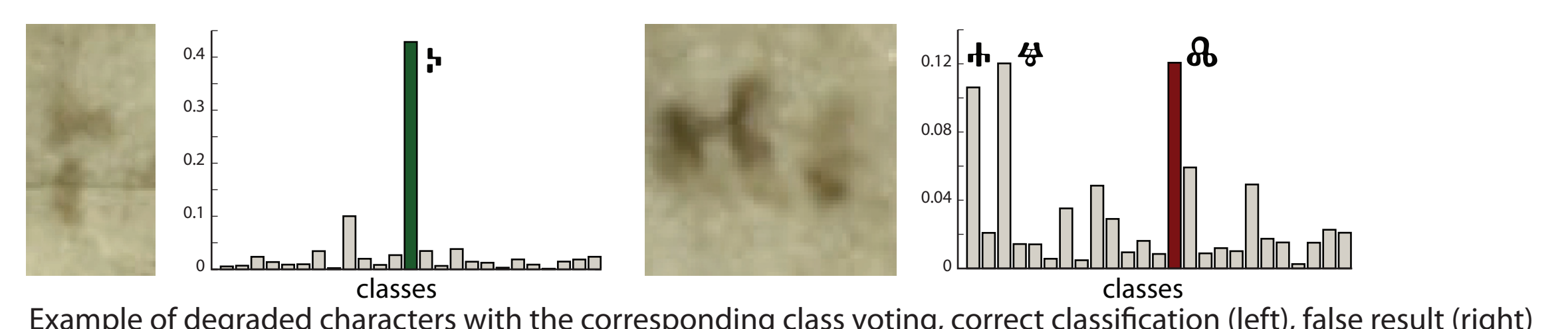
Example of degraded characters with the corresponding class voting, correct classification (left), false result (right)

- Evaluation using annotated test panels
    - Performance on well-preserved pages: 95.45%
    - Performance with faded out ink: 86.21%
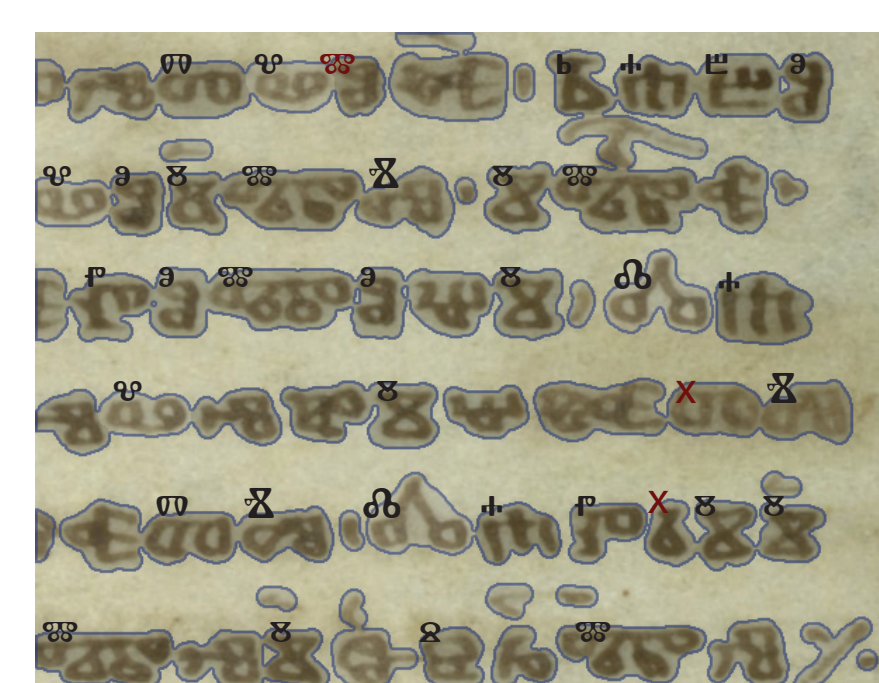
Example of a testpanel with the manually tagged groundtruth (blue border), and the classification results. Correct classes are colored black, false classes are red. Characters which were not detected are marked by X.

Conclusion

- The system handles degraded manuscript images
    - Without crucial binarization
    - Likelihood of classes is preserved for human observer
- Overlapping, partially visible characters are recognized
- Presented results are generated without dictionary verification
- Clustering ignores characters

Future Work

- Character extraction (clustering) will be improved
    - Verification after voting
    - Localization with generative models
- Extensive evaluation with additional test images
- Comparison with state of the art OCR systems