QR Code Localization Using Boosted Cascade of Weak Classifiers

Péter Bodnár and László G. Nyúl

QR code is a common type of visual code format that is used at various industrial setups and private projects as well. Its structure is well-defined and makes automatic reading available by computers and embedded systems. The recognition process consists of two steps, localization and decoding.

Belussi et al. [1] built an algorithm around the Viola-Jones framework [2], which proved that, even though the framework was originally designed for face detection, it is also suitable for QR code localization, even on low resolutions. The authors used a cascade of weak classifiers with Haar-like features, trained on the finder patterns (FIP) of the QR code. We extend their original idea, and propose improvements for both choosing the feature type of classifiers and their training target.

While Haar-like feature based classifiers are the state of the art in face detection, the training process is more difficult on FIPs. In order to increase the strong features of the object intended to detect, we propose training of a classifier for the whole code area. Even though QR codes have high variability on the data region, they contain data density patterns, a fourth, smaller FIP that can be perfectly covered with the center-type Haar-feature, furthermore, they contain the three discussed FIPs at more prominent location in the ROI.

Instead of Haar-like features, we also propose Local Binary Patterns (LBP) and Histograms of Oriented Gradients (HOG) for the feature evaluation. LBP and HOG based classifiers also can be trained both to FIPs and whole code areas, and since they are also considered as fast and accurate general purpose object detectors, evaluation of their performance on code localization is highly motivated. Furthermore, LBP can be more suitable than Haar classifiers, since it is not restricted to a pre-selected set of patterns, while HOG can also be efficient due to the strict visual structure and limited number of distinct gradient directions of the QR code.

We trained a total number of six classifiers, based on Haar-like features, LBP and HOG, both for FIPs and full code objects. For the FIPs, feature symmetry is also recommended to speed up the training process, while usage of the rotated features of Lienhart et al. [3] is not very useful, since these classifiers are not flexible enough to detect QR codes of any orientation. However, this issue can be solved by training two classifiers, for codes with orientation of $0°$ and $45°$, respectively. We used a 32×32 sample size, which is larger than the one of the reference method, since training to the whole code object requires finer sample resolution. We decided cascade topology for the classifier instead of tree, since it showed higher overall recall in [1], and left required recall and false positive rate at the default values for each stage, with a total number of 10 stages. We trained our classifiers on a synthetic database consisting of 10,000 images, divided into 4:1 proportion for training and testing. Images of the database are artificially generated QR codes, each containing a permutation of all lower– and uppercase letters and numerals. QR codes generated this way are rendered onto images not having QR codes, with perspective distortion.

For the classifiers trained to FIPs, post-processing is needed to reduce the amount of false detections. Belussi et al. proposes searching through the set of FIP candidates for triplets that can form QR code, using geometrical constraints. Since real-life images of QR codes also suffer perspective distortion, it is obligatory to give tolerance values for positive triplet response. Contrary to this construction, our proposed classifiers trained to the whole code area need no post-processing.

Cascade classifiers are general purpose tools for object detection, and the discussed approach can be adapted to other two-dimensional code types as well. According to our experiments, cascade classifiers seem to be a decent option for QR code localization, especially a classifier using LBP for features and trained for the whole code object.

References

[1] Luiz F. F. Belussi and Nina S. T. Hirata. Fast QR code detection in arbitrarily acquired images. In *Graphics, Patterns and Images (Sibgrapi), 2011 24th SIBGRAPI Conference on*, pages 281–288, 2011.

[2] Paul Viola and Michael Jones. Rapid object detection using a boosted cascade of simple features. In *Computer Vision and Pattern Recognition, 2001. CVPR 2001. Proceedings of the 2001 IEEE Computer Society Conference on*, volume 1, pages I–511–I–518 vol.1, 2001.

[3] Rainer Lienhart, Alexander Kuranov, and Vadim Pisarevsky. Empirical analysis of detection cascades of boosted classifiers for rapid object detection. In Bernd Michaelis and Gerald Krell, editors, *Pattern Recognition*, volume 2781 of *Lecture Notes in Computer Science*, pages 297–304. Springer Berlin Heidelberg, 2003.