Norwegian paper: Efficient Recognition of Speed Limit Signs

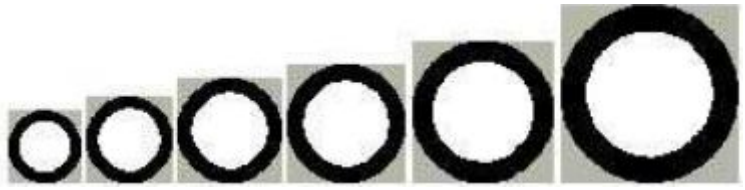
Link

https://folk.uio.no/jimtoer/ITSC04_Torresen.pdf

Description

First to sort out everything besides the red color and make it a contrast image:

Then they use templates to match the picture:



If you remove the smallest template you would only recognize speed signs that are closer and thereby bigger. This will give more pixels to recognize the speed sign in (and thus more accuracy and more computation time).
This part recognizes the speed signs position in the picture. Here they take the first digit and ignore the trailing zero.

Then they scale down to a 7x5 pixelgrid where a pixel is filled if it contains more black pixels than white pixels:

Fig. 6. Examples of extracted arrays from real images.

Then they use a “feed-forward neural network trained by the back-propagation algorithm” to recognize the number

Problems

Since they only know the first number and recognizes all signs with a red ring they had problems with signs like:

They do however anticipate that they can avoid this if they also recognize the zero in the sign.

Real-time detection and recognition of traffic signs

Link

https://www.researchgate.net/publication/224162933_Real-time_detection_and_recognition_of_traffic_signs

Description

Notice that they are not only recognizing speed signs.

They first detect if there's a traffic sign by the Viola-Jones detector which slides a detection window across the picture. At each frame it determines if there's a sign.
The training took 16 hours on a 4 CPU computer, and provided acceptable results with more than 20 fps.
It had a lot of false positives, but these will be sorted in later stages.

Then they resize the picture to 6x12 pixels and make it grayscale, and then a binary (1 or 0 as color value) picture.
This only works with evenly illuminated signs.

They use a multilayer perceptron network with back propagation that they implemented themselves without libraries. This is used to determine the number.

Then they do a vertical projection of the image and find the maxima in order to separate the digits. (the red lines)

Fig. 3. Input image (top) and the corresponding vertical projection (bottom)

Then they create the skeleton of the digit. (right)

They analyze these for line ends, junctions and loops.

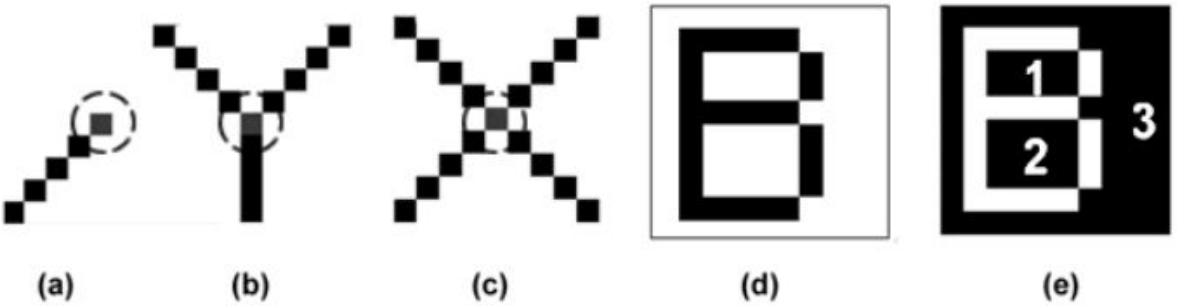


Fig. 6. Line ends (a), junctions (b),(c) and loops (d),(e)

0 is the only digit with no line ends, one loop and no junctions.
1 and 2 has the same amount of line ends, junctions and loops.

At last they include the position of the pixels in order to differentiate between the digits.

Problems
The result seems to be limited by the amount of training data.

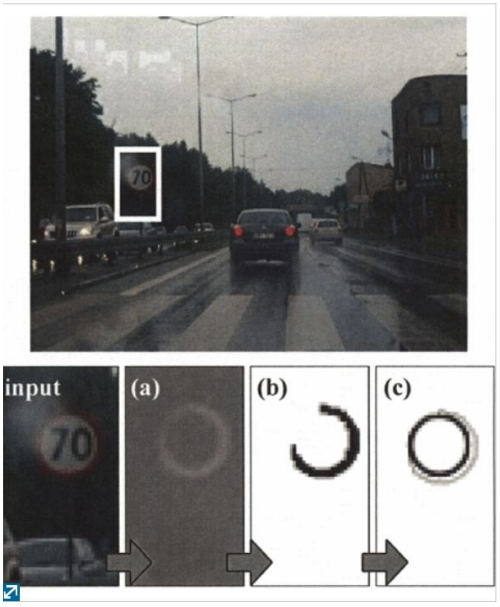
Integrated speed limit detection and recognition from real-time video

Link

https://ieeexplore.ieee.org/document/4621285

Description

In the first detection stage they work in the YCrCb color space. They first extract the Cr channel (a), then they use an adaptive threshold to isolate the red scene component (b). At last they use RANSAC based circle detection (c), which fits circles to the picture.



They would rather have false positives than miss some signs, as the false positives will be removed in later stages.

Then they remove the red boundary of the sign, so only the number remains. They convert this to grayscale and then to a binary representation.

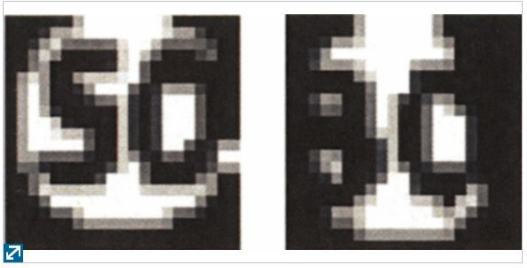
Figure 5:
Removing red boundary from numerical-limit sign candidates

They then scale it to 20x20 pixels and create a feed-forward multi-layer perceptron network. It has 400 neurons in the input layer (20x20 pixels), 30 neurons in the hidden layer and 12 neurons in the output, corresponding to the possibility for every sign and a value for no sign. They get 27 fps on a 1.6 GHz single-core Intel CPU and works in various weather conditions.

They miss 3 signs of 101 signs encountered and misinterpret 3 of 1158 pictures.

Problems

Signs like the one seen below are two of the signs that the system missed or misinterpreted. This is due to the sign being to far away to recognize. A solution would simply be not to try to recognize this sign.



Real-Time Traffic Sign Detection: An Evaluation Study

Link

https://ieeexplore.ieee.org/document/5595903