Deteccction and recognition of traffic signs

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B3/B4

CANDIDATE WINDOW GENERATION

1. Connected component labeling

Step 1. BWBOUNDARIES & REGIONPROPS functions

Extract the information regarding the Connected Component for each image

- ➔ Centroid
- ➔ Area
- ➔ BoundingBox
- ➔ PixelList
- ➔ Perimeter

Step 2. Metric Geometry

Study the geometry of each connected component in order to classify between:

- ➔ Circle
- ➔ Square
- ➔ Triangle
- ➔ Random geometry

Step 3. Filling Ratio

Use the previous geometric information and the information extracted from GT files.

- ➔ Delete small objects.
- ➔ Ignore huge objects.
- ➔ Study the medium objects taking into account the max/min size (height or width) and select the candidate objects.
- ➔ For each candidate object, study its filling ratio. Delete it if the filling ratio does not match with the filling ratios max and min extracted from the GT files.

2. Sliding window

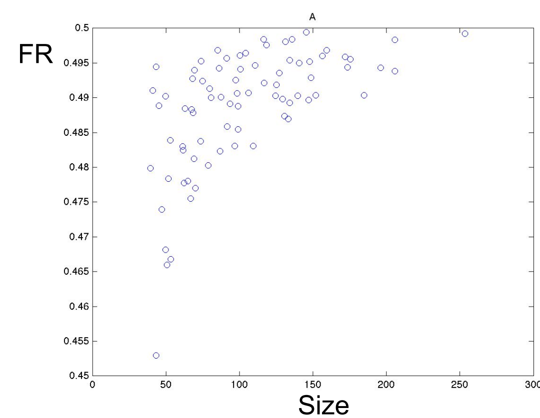
Window candidates

A window is defined by its size and its step. We use different windows:

		Size	Step	minFR	maxFR
small	1	40	2	0.5	0.7
medium	2	50	4	0.4	0.7
	3	90	8	0.4	0.75
	4	120	8	0.4	0.8
	5	150	8	0.4	0.85
	6	200	8	0.5	0.9
big	7	250	10	0.5	0.99
	8	300	10	0.6	0.99

Analyzing the size of signals of the ground truth, we observed that the majority of the signals have a size in the range 50-200 pixels.

The minimum and maximum FR thresholds are been set taking into account the principal type of signals that have the size of the window given.



$Area_{triangle} / Area_{square} = 0.5$

$Area_{circle} / Area_{square} = 0.72$

$Area_{square} / Area_{square} = 1$

2. Sliding window

Window candidates: procedure to follow

➔ *Check filling ratio* → If it is below 0.1, then, discard the window. Thus avoiding any black window.

➔ *Depth filling ratio study* → Determine if the candidate windows is between the minimum and maximum filling ratio.

Window candidates: Speed up improvements

➔ Filling ratio → Compute the integral image of the mask to speed up the algotrithm.

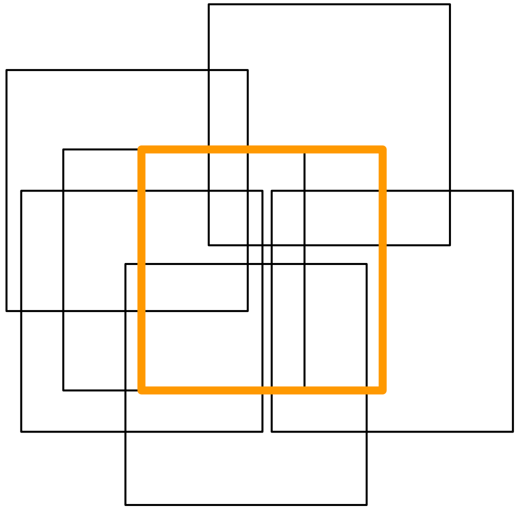
➔ Use different steps regarding the window size.

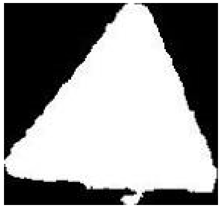
2. Sliding window

Merge windows

Detect which windows are overlopped taking into account only windows which have the same size.

For all overlapped windows, create a new window located on the resultant center position keeping the original window size.





Size: 50x50 px

Size: 90x90 px

TEMPLATE MATCHING

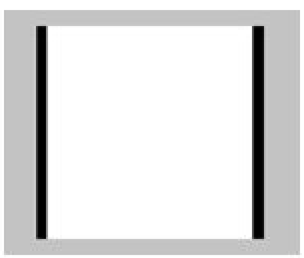
3. Models

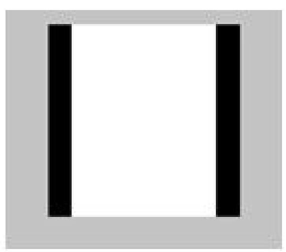
We create one 400x400 px grayscale model per signal shape.

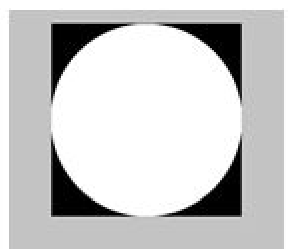
- Those are the maximum dimensions of train signals.

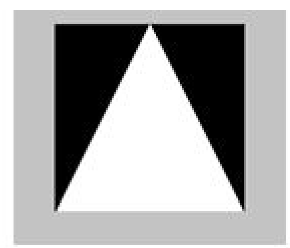
To draw the models we use the average aspect ratio of the ground truth (task1 B1)

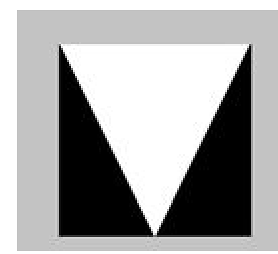
- Only square and rectangular signals are considerably distorted.


Square model
400x360px


Rectangle model
400x300px


Circle model
400x40px


Triangle model
400x400px


Giveway model
400x400px

4. METHOD 1 GRAYSCALE MEAN MODEL

Procedure to follow:

For each candidate window**:**

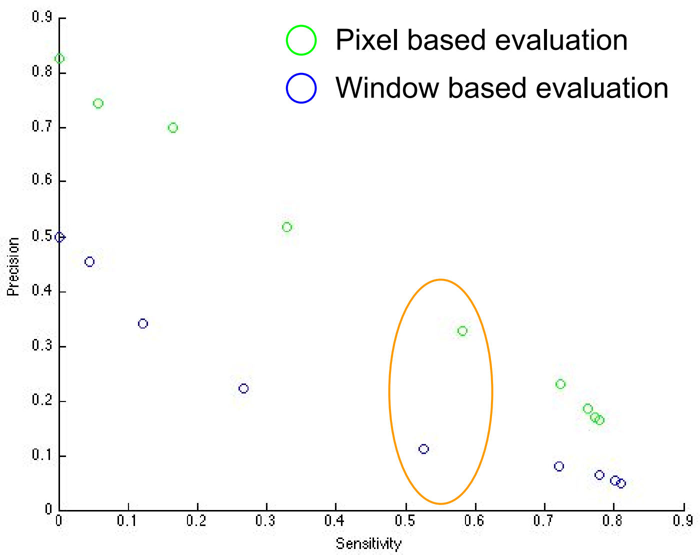
➔ Resize the models to the window size.
➔ Compute the similarity using cross-correlation coeficient ‘r’ [0-1].

$$r = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\left(\sum_m \sum_n (A_{mn} - \bar{A})^2\right)\left(\sum_m \sum_n (B_{mn} - \bar{B})^2\right)}}$$

$\bar{A}$ and $\bar{B}$ means of A and B, respectively.

➔ If the similarity is above the threshold, consider it as a candidate window.

➔ The best cross-correlation coeficient threshold, that achieved better precision/recall values, is 0,5.

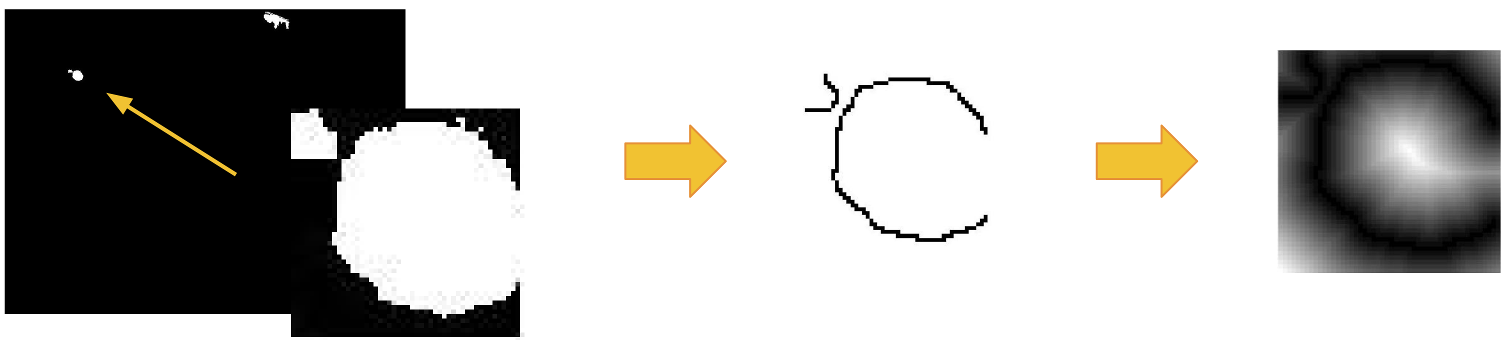


5. Method 2: Chamber distance model

Pre-Processing Window

Detection of the countours in the window is needed → Canny method is used with a threshold of 0.02 and a sigma of value 1.4.

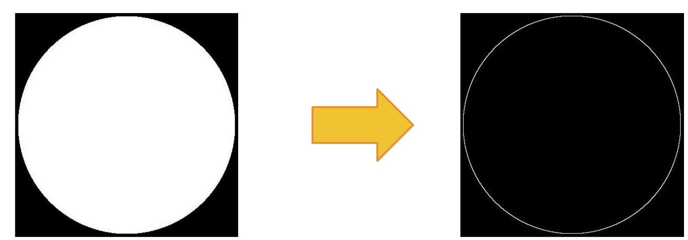
Using the window’s edge, the distance image is calculated.



Pre-Processing Template

Resize the template to the window size is mandatory to verify the similarity between them.

Compute the edge of the template.



5. Method 2: Chamber distance model

Chamfer Distance Model*

The distance between the window's distance image and the template is defined as:

$$D_{chamfer,G}(T,I) \equiv \frac{1}{|T|}\sum_{t\in T} d_I(t),$$

where |T| is the length of the template's contour.

Once distance transform image and match measure have been defined is necessary to determine a threshold which indicates if the window contains a traffic signal or, otherwise, is discarded.

$$D_G(T,I) < \theta.$$

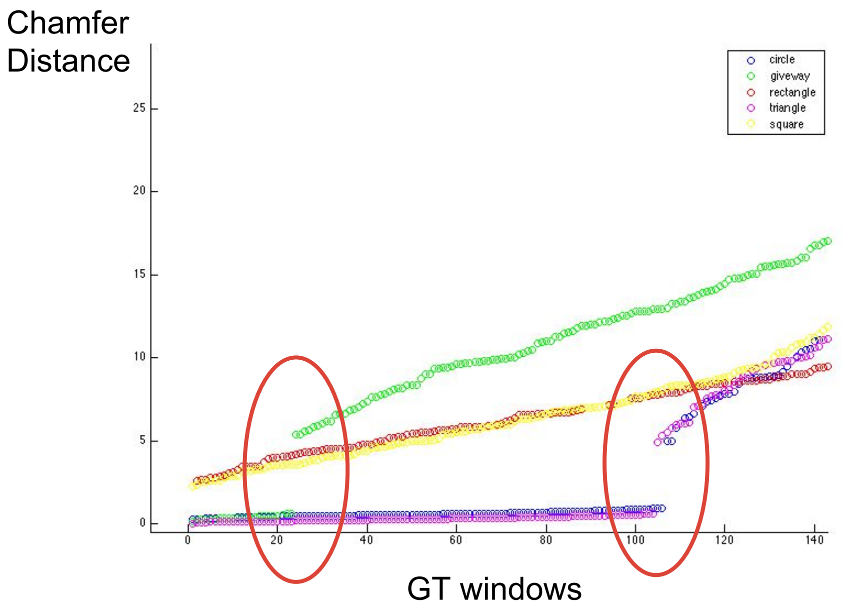
*Calculate distance and normalize methods extracted from the paper, "A Bayesian, Exemplar-Based Approach to Hierarchical Shape Matching" by Dariu M. Gavrila

5. METHOD 2: Similarity threshold

The threshold θ, determines the maximum distance which consider a match as a signal.

The best threshold has been obtained from the study of our models in the ground truth.

We computed the chamfer distance between our models and the windows defined in the ground truth. As we can see in the figure, all our models except the rectangle and square model present discontinuities around a distance between 2 and 5.



Thus, we selected the best threshold in the range [1, 20] that achieved better precision/recall.
That is θ = 9.

RESULTS

8. Results B3 test dataset

Pixel based evaluation

	Precision	Accuracy	Recall	F1-measure	TP	FP	FN
B1/B2	0.108	0.9767	0.8643	0.1078	795621	6571509	124879
CCL	0.2742	0.9935	0.6310	0.3823	580878	1537573	339622
SLW	0.1304	0.9814	0.8521	0.2262	784374	5229230	136126

Object based evaluation

	Precision	Accuracy	Recall	F1-measure	TP	FP	FN
CCL	0.1667	0.1293	0.3661	0.2291	67	335	116
SLW	0.0377	0.0376	0.8824	0.0724	330	8412	44

9. Results B4 test dataset

Pixel based evaluation

	Precision	Accuracy	Recall	F1-measure	TP	FP	FN
SLW	0.1304	0.9814	0.8521	0.2262	784374	5229230	136126
Method 1	0.2742	0.9935	0.6310	0.3823	580878	1537573	339622
Method 2	0.1287	0.9823	0.7864	0.2212	723898	4901393	196602

Object based evaluation

	Precision	Accuracy	Recall	F1-measure	TP	FP	FN
SLW	0.0377	0.0376	0.8824	0.0724	330	8412	44
Method 1	0.1165	0.1089	0.6260	0.1964	154	1168	92
Method 2	0.034	0.0338	0.848	0.0654	279	7919	50