ANPR

Automatic Number Plate Recognition

Sembra facile

Chi sono

Enrico Donelli

lavoro presso Incloudteam a Brescia, dove sviluppiamo sistemi a supporto della polizia locale

La lettura targhe

sempre più pervasiva

dal controllo accessi,

controllo permessi parcheggio,

controllo assicurazioni, revisioni

controllo di ...

come è nata questa ricerca?

necessità lavorativa

una mia incauta uscita "che ci vorrà mai? non sarà poi così complicato"

ovviamente, mi sbagliavo

occasione finalmente per capire e imparare qualcosa sull'Intelligenza artificiale

aspetti fotografici

- tempo scatto veloce per compensare movimento (a 80km/h in un 1/100 sec si fanno 22 cm)
- uso di infrarosso per lettura al buio, sfruttando il materiale riflettente sulla targa

| A | B |

Figure 1.1: (a) Illumination makes detection of reflexive image plates easier. (b) Long camera shutter and a movement of the vehicle can cause an undesired motion blur effect.

riconoscimento area targa

la targa non è altro che un'area rettangolare con occorrenze ripetute di spigoli orizzontali e verticali

usando matrici di convoluzione determiniamo l'area occupata dalla targa

si trovano solitamente più candidati, e tramite analisi euristiche si cerca il miglior candidato

- eseguito in 2 fasi:
  - identificazione banda orizzontale più ampia (band clipping)
  - plate clipping

vertical analysis - band clipping

usando matrici convoluzione si possono ricercare spigoli verticali e orizzontali


Figure 2.2: (a) Original image (b) Horizontal rank filter (c) Vertical rank filter (d) Sobel edge detection (e) Horizontal edge detection (f) Vertical edge detection

A	B	C
D	E	F

dopo una serie di operazioni di convoluzione, si può determinare l'area della targa usando delle statistiche sulle proiezioni verticali e orizzontali dell'immagine
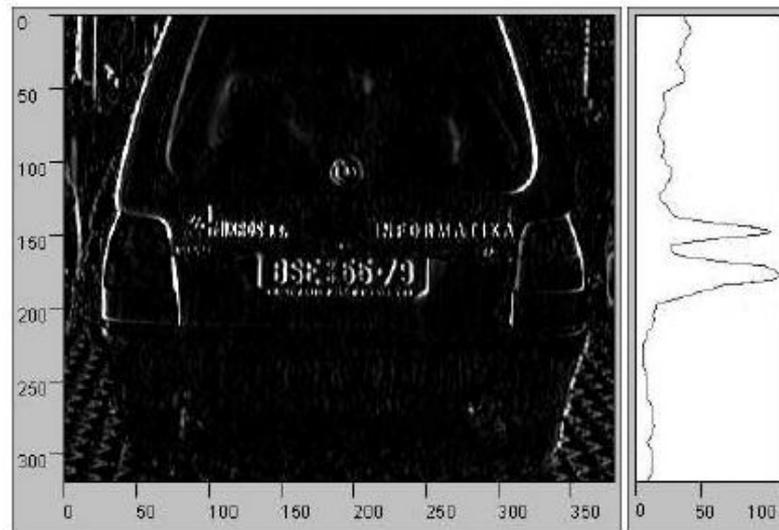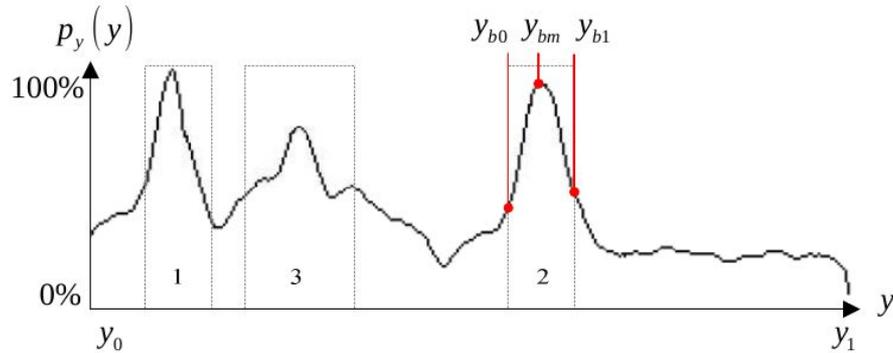

Figure 2.3: Vertical projection of image to a y axis
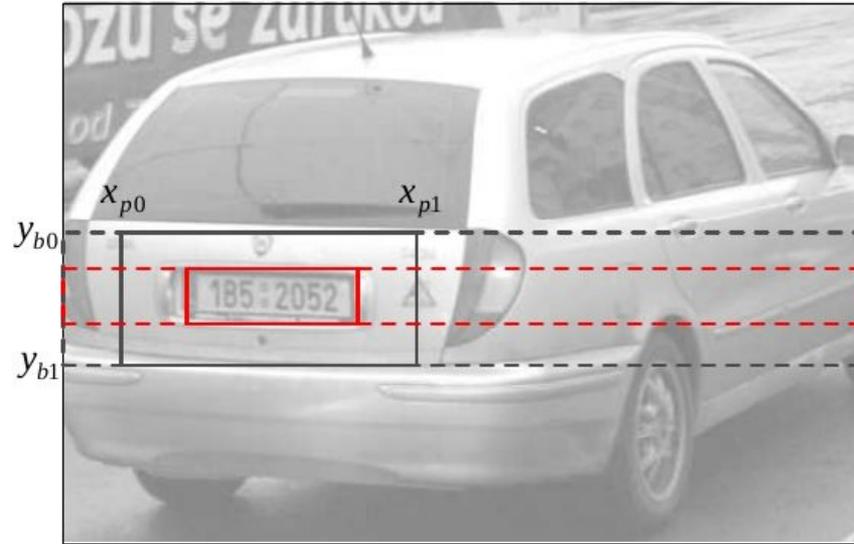
Figure 2.4: The double-phase plate clipping. Black color represents the first phase of plate clipping, and red color represents the second one. Bands are represented by dashed lines, and plates by solid lines.

vertical analysis - band clipping

Figure 2.5: The vertical projection of the snapshot 2.3 after convolution with a rank vector. The figure contains three detected candidates. Each highlighted area corresponds to one detected band.
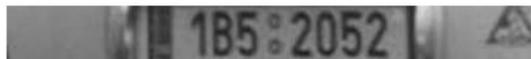

Figure 2.6: The band detected by the analysis of vertical projection

second phase - horizontal position

cerchiamo i bordi della targa supponendo abbia i bordi neri
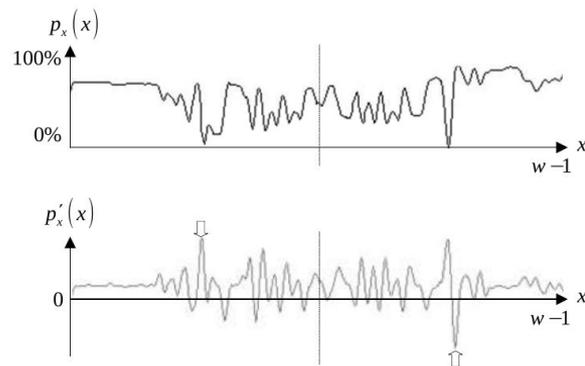
Figure 2.7: (a) The horizontal projection $p_x(x)$ of the plate in figure 2.8. (b) The derivative of $p_x(x)$. Arrows denote the "BW" and "WB" transitions, which are used to determine the boundaries of the plate.
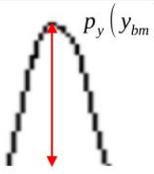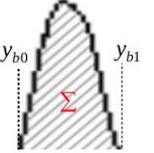
Figure 2.8: The wider area of the number plate after deskewing.

analisi euristica e selezione di targhe candidate

1. solitamente si trovano più bande candidate
2. sono ordinate in base a funzioni di costo
3. si considera il primo candidato
4. si segmenta e analizza con analisi più dettagliata (è la fase "time consuming")
5. se analisi al punto 4 fallisce, si scarta la targa e si torna al punto 3

analisi euristica

$$\alpha = 0.15 \cdot \alpha_1 + 0.25 \cdot \alpha_2 + 0.4 \cdot \alpha_3 + 0.4 \cdot \alpha_4$$

Heuristics	Illustration	Description
$\alpha_1 = \lvert y_{b0} - y_{b1} \rvert$		The height of band in pixels. Bands with a lower height will be preferred.
$\alpha_2 = \dfrac{1}{p_y\left(y_{bm}\right)}$		The "$p_y\left(y_{bm}\right)$" is a maximum value of peak of vertical projection of snapshot, which corresponds to the processed band. Bands with a higher amount of vertical edges will be preferred.
$\alpha_3 = \dfrac{1}{\sum\limits_{y=y_{b0}}^{y_{b1}} p_y\left(y\right)}$		This heuristics is similar to the previous one, but it considers not only the value of the greatest peak, but a value of area under the graph between points y_{b0} and y_{b1}. These points define a vertical position of the evaluated band.

13

$\alpha_4 = \left\lvert \dfrac{\lvert x_{p0} - x_{p1} \rvert}{\lvert y_{b0} - y_{b1} \rvert} - 5 \right\rvert$		The proportions of the one-row number plates are similar in the most countries. If we assume that width/height ratio of the plate is about five, we can compare the measured ratio with the estimated one to evaluate the cost of the number plate.

rotazione della targa

trovare angolazione della targa e applicare una trasformazione affine

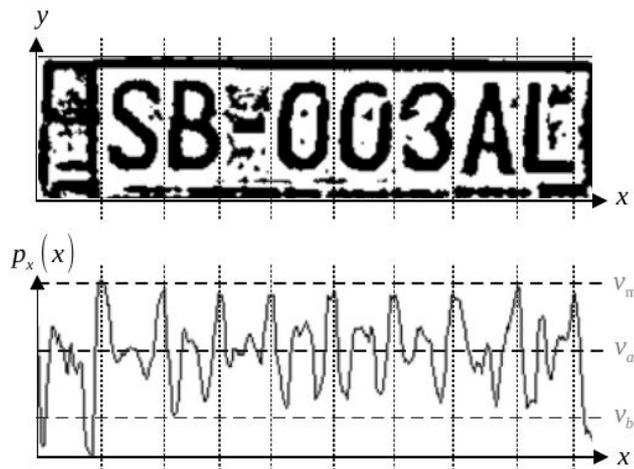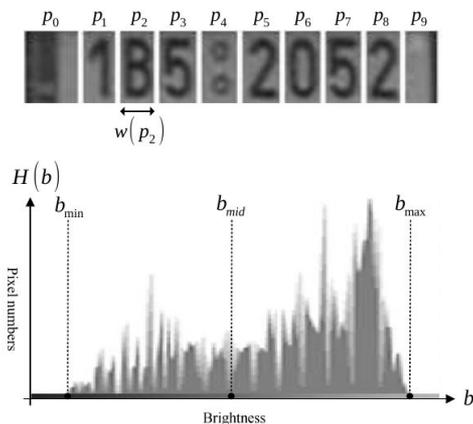Trasformazione di Hough è utilizzata per trovare angolo

Figure 2.13: (a) Original number plate. (b) Number plate after deskewing.

segmentazione della targa

uno dei passi più importanti

Figure 2.9: (a) The number plate must be segmented into individual characters for deeper heuristic analysis. (b) Brightness histogram of the number plate is used to determine the positivity of the number plate.
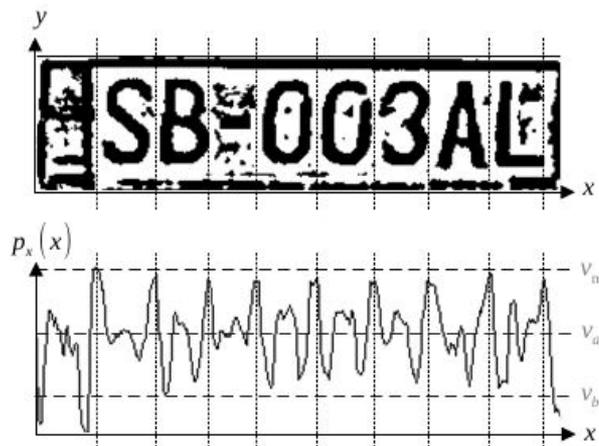
(a) Number plate after application of the adaptive thresholding (b) Horizontal plate with detected peaks. Detected peaks are denoted by dotted vertical lines.

si usa proiezione orizzontale

oppure si utilizzano le reti neurali

assumendo la targa sia su un'unica riga si tratta di trovare spazi orizzontali tra i caratteri

si elabora l'immagine per aumentarne il contrasto ed evidenziare i contorni (thresoholding filters)

Figure 3.1: (a) Number plate after application of the adaptive thresholding (b) Horizontal projection of plate with detected peaks. Detected peaks are denoted by dotted vertical lines.

estrazione caratteri dai segmenti

riconoscimento e rimozione dei pezzi estranei
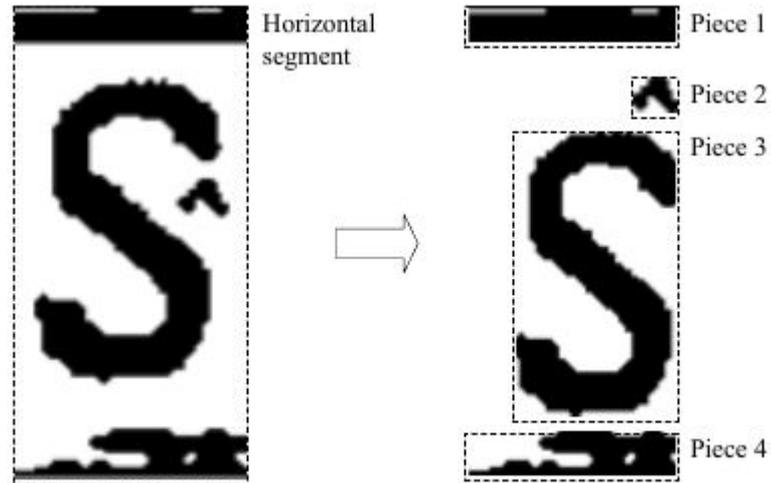
Figure 3.2: Horizontal segment of the number plate contains several groups (pieces) of neighboring pixels.

Figure 3.3: The input (a) and output (b) example of the segmentation phase of the ANPR recognition process.

riconoscimento del carattere dall'imm. bitmap

- The first step is a normalization of a brightness and contrast of processed image segments.
- The characters contained in the image segments must be then resized to uniform dimensions (second step).
- After that, the feature extraction algorithm extracts appropriate descriptors from the normalized characters (third step).

normalizzazione luminosità e contrasto

- histogram normalization,
- global thresholding
- and adaptive thresholding.

normalizzazione dimensione e ricampionamento

Before extracting feature descriptors from a bitmap representation of a character, it is necessary to normalize it into unified dimensions
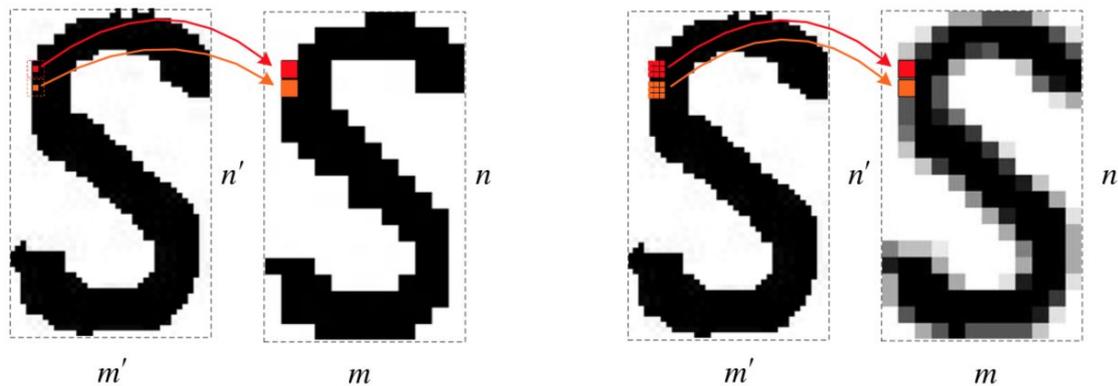
Figure 4.5: (a) Nearest-neighbor resampling significantly reduces information contained in the original image, but it preserves sharp edges. (b) Weighted average resampling gives a better visual result, but the edges of the result are not sharp.

feature extraction

le informazioni contenute nella bitmap non sono ancora sufficienti per essere elaborate e determinare il carattere

The external representation is chosen when the primary focus is on shape characteristics. The description of normalized characters is based on its external characteristics because we deal only with properties such as character shape. Then, the vector of descriptors includes characteristics such as number of lines, bays, lakes, the amount of horizontal, vertical and diagonal or diagonal edges, and etc. The feature extraction is a process of transformation of data from a bitmap representation into a form of descriptors, which are more suitable for computers

Skeletonization and structural analysis

The skeletonization is a reduction of the structural shape into a graph
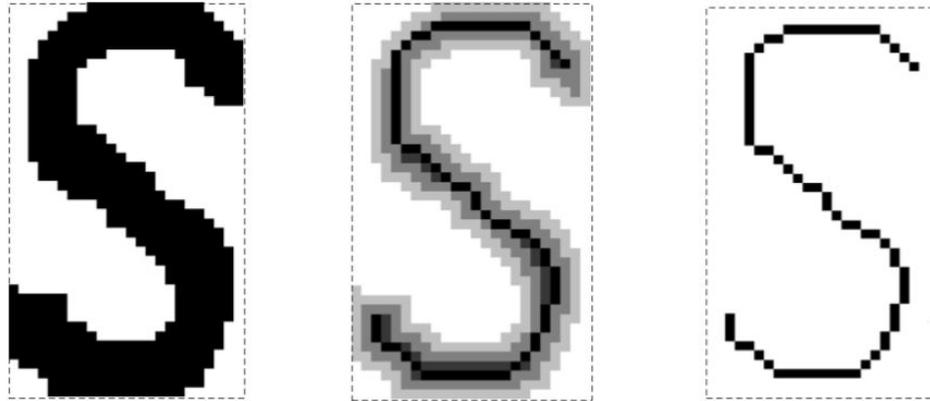
| A | B | C |

Figure 4.10: (a) The character bitmap before skeletonization. (b) The thinning algorithm iteratively deletes boundary pixels. Pixels deleted in the first iteration are marked by a light gray color. Pixels deleted in the second and third iteration are marked by dark gray. (c) The result of the thinning algorithm is a skeleton (or a medial axis).

riconoscimento tramite reti neurali

fino a qui molta intelligenza degli sviluppatori, ma poca della macchina.

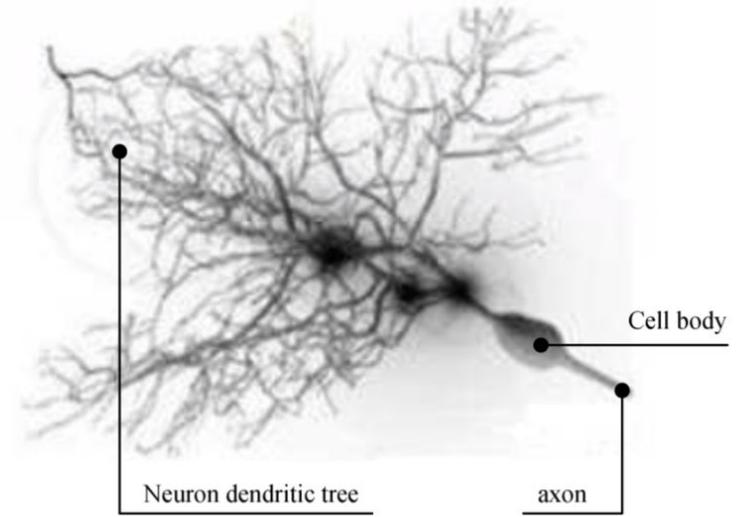usiamo reti neurali per riconoscere i caratteri

neurone

cervello composto da decine di milioni di neuroni. Ogni neurone è una cellula che usa trasformazioni biochimiche per trasmettere informazioni

n ingressi (dendriti)

1 uscita (assone)

2 tipi di connessioni: executive che amplifica segnale, inhibitive che lo sopprime


Figure 5.2: The biological neuron

percepton

il comportamento della connessione è rappresentato dal suo "peso"

la rete neurale consiste di fatto di meccanismi capaci di alterare i pesi delle connessioni

modelli matematici

- The McCulloch-Pitts binary threshold neuron was the first model proposed by McCulloch and Pitts in 1943. The neuron has only two possible output values (0 or 1) and only two types of the synaptic weights: the fully excitative and the fully inhibitive. The excitative weight (1) does not affect the input, but the inhibitive one negates it
- The major problem of such networks is that they are not able to solve linearly nonseparable problems

- This problem has been solved when the scientists Rumelhart, Hilton and Williams proposed the error back-propagation method of learning for multilayered percepton networks. The simple McCulloch-Pitts binary threshold neurons have been replaced by neurons with continuous saturation input/output function.

-
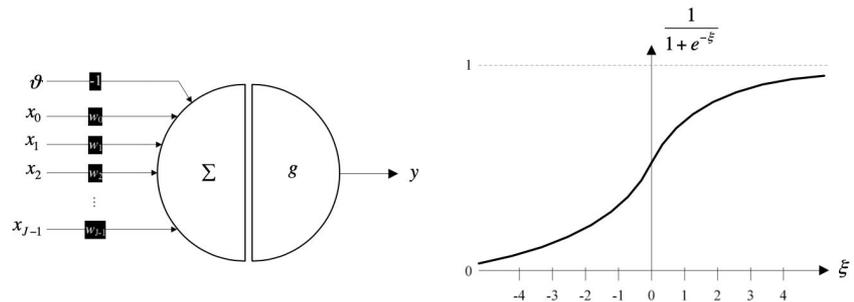
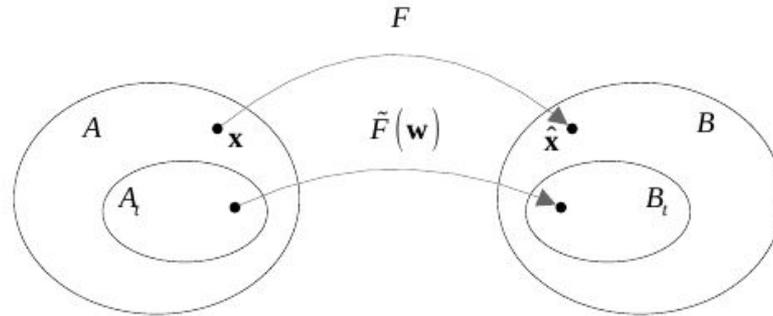A | B   **Figure 5.4:** (a) The summation Σ and gain (saturation) g function of the percepton with a threshold implemented as a dedicated input. (b) The sigmoid saturation function.

feed forward neural network
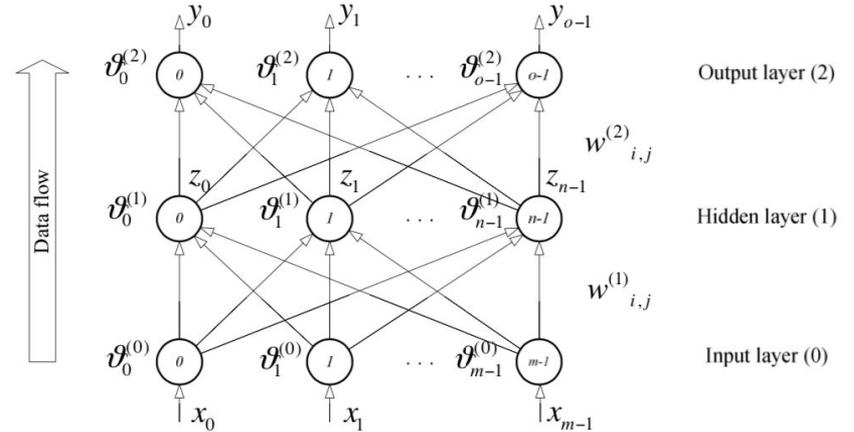
Figure 5.5: Architecture of the three layer feed-forward neural network.

feed forward neural network

Figure 5.1: The projection between sets A and B. The F is a hypothetic function that maps every possible combination of input pattern $\mathbf{x} \in A$ to a corresponding class $\hat{\mathbf{x}} \in B$. This projection is approximated by a function $\tilde{F}(\mathbf{w})$, which maps input patterns from training set A_t into the corresponding classes from the set B_t

prossime ricerche

usare IA per determinare zona della targa
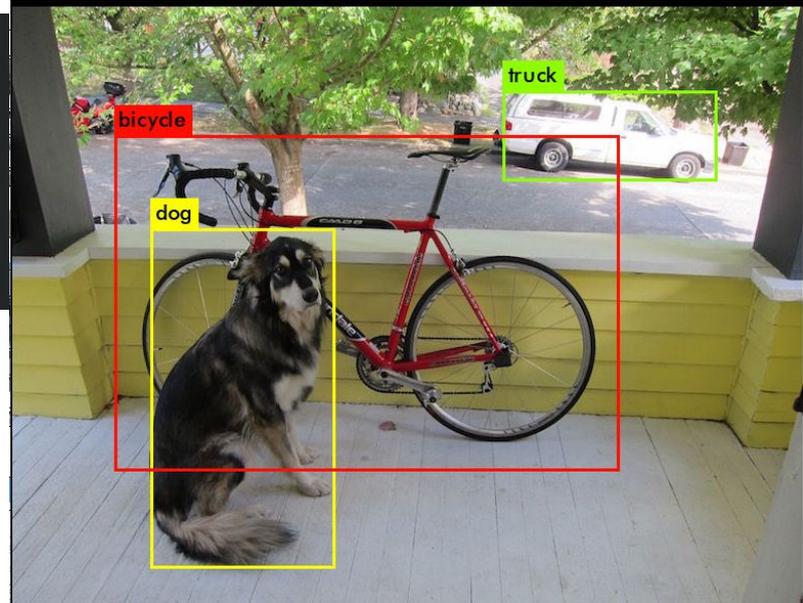
- opencv
- YOLO

usare tesseract 4 per lettura caratteri

usare tensorflow per lettura caratteri da bitmap

usare nnapi (neural network API) su android sui dispositivi più recenti

- https://developer.android.com/ndk/guides/neuralnetworks

YOLO - real time object detection


```
106 yolo
Loading weights from yolov3.weights...Done!
data/dog.jpg: Predicted in 17.038010 seconds.
dog: 100%
truck: 92%
bicycle: 99%
enrico@enrico:~/Projects/darknet$
```

./darknet detect cfg/yolov3.cfg yolov3.weights data/dog.jpg

https://towardsdatascience.com/automatic-license-plate-detection-recognition-using-deep-learning-624def07eaaf

opencv and python

per chi volesse giocare col codice

Openalpr:

- https://github.com/openalpr/openalpr

Javaanpr:

- http://javaanpr.sourceforge.net/
- realizzato da un ragazzo Ceco Slovacco, Ondrej Martinsky a corredo di una tesi di laurea, che è quindi un ottimo punto di partenza per capire la teoria sottostante la lettura delle targhe

YOLO

- https://pjreddie.com/darknet/yolo/

https://cvisiondemy.com/license-plate-detection-with-opencv-and-python/

https://towardsdatascience.com/automatic-license-plate-detection-recognition-using-deep-learning-624def07eaaf