A Deep Learning Network for Vision based Parking Space Detection System

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DEMO SCENARIO & CHALLENGES

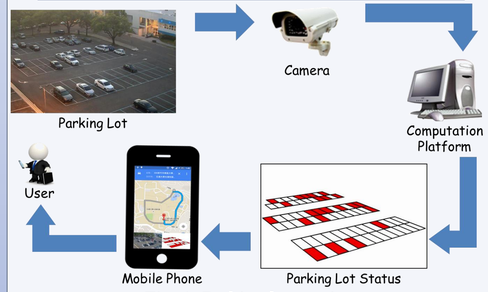

Fig. 1. Parking lot service

Challenges

- Inter-object occlusion and perspective distortions

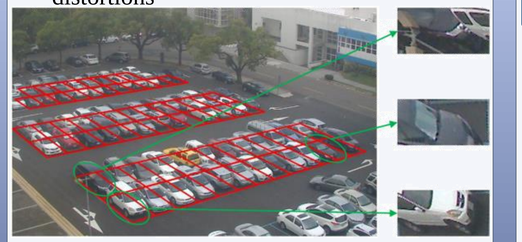

Fig. 2. Inter-object occlusion and perspective distortions

- Non-unified vehicle size and uncontrollable parking displacement

Fig. 3. Vehicle size and parking displacement problems

PROPOSED METHOD

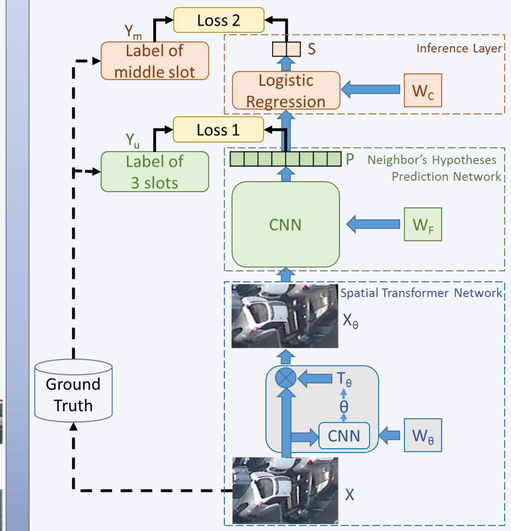

Fig. 4. The proposed framework

Spatial Transformer Network [1]

- Reducing the variations from perspective distortion, parking displacement, and vehicle size

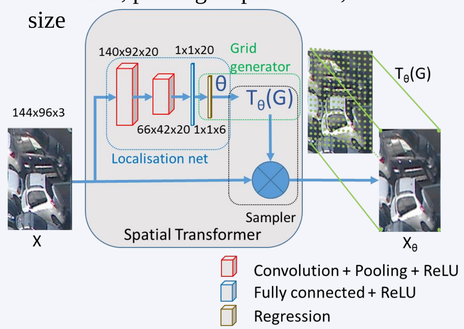

Fig. 5. Spatial Transformer Network

PROPOSED METHOD

Spatial Transformer Network (cont.)

$$\begin{pmatrix} x_i^s \\ y_i^s \end{pmatrix} = T_\theta(G_i) = \begin{bmatrix} \theta_{11} & \theta_{12} & \theta_{13} \\ \theta_{21} & \theta_{22} & \theta_{23} \end{bmatrix} \begin{pmatrix} x_i^t \\ y_i^t \\ 1 \end{pmatrix}$$

Where:

(x^s, y^s): the source coordinate in the input image

T_θ : 2D affine transformation (6 parameters)

(x^t, y^t): the target coordinate in the transformed image

Neighbor's Hypotheses Prediction Network (NHPH)

- Solving the inter-occlusion problem
- Designing a CNN-based deep learning network to predict the status of a 3-space unit
  - Being determined by many stages separated by a pooling layer
  - Down-sampling the input image to a small size before applying fully connected layers for classification
  - Increasing the number of kernels in the later layer

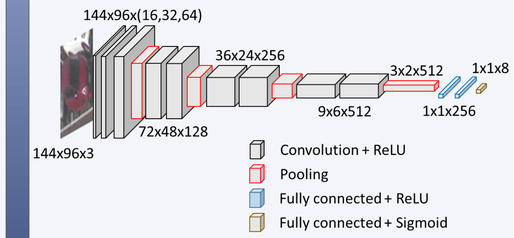

Fig. 6. Neighbor's Hypotheses Prediction Network

Inference layer

- Building a 2-class logistic regression model on the top of NHPN

EXPERIMENTAL RESULTS

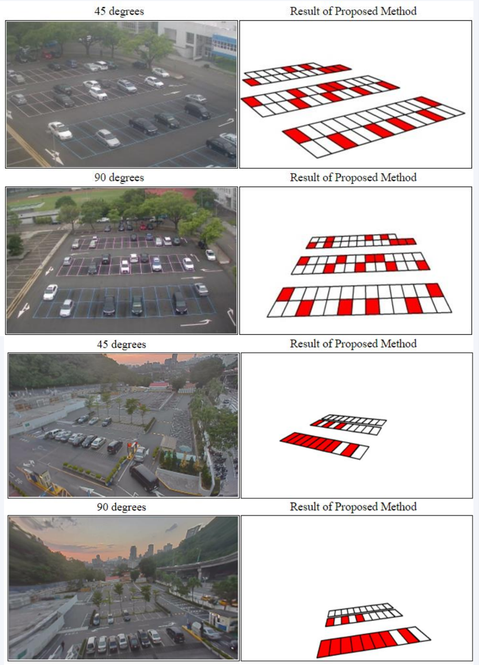

Fig. 7. A snapshot of the website demonstration. Visit the website [2] for details

Table 1. Performance Comparison

	ACC	FPR	FNR
Huang's work [3]	98.44%	0.0128	0.0173
CNN_1	96.78%	0.0666	0.0136
CNN_2	98.71%	0.0129	0.0129
$CNN\text{-}STN_1$	99.01%	0.0057	0.0124
$CNN\text{-}STN_2$	98.98%	0.0057	0.0129
Proposed method	99.25%	0.0029	0.0103

EXPERIMENTAL RESULTS

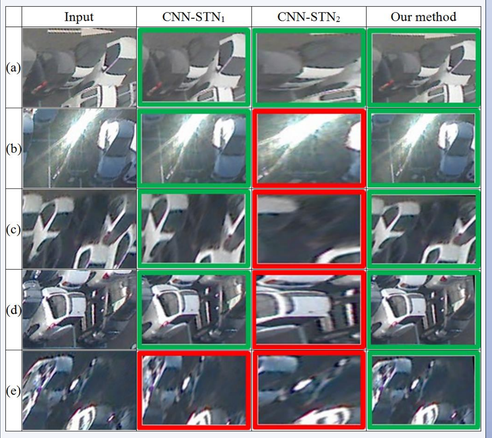

Fig. 8. Transformed Patches from different methods and the detection results. Red boxes indicate false detection and green boxes mean correct detection.

REFERENCES

[1] Max Jaderberg, Karen Simonyan, Andrew Zisserman, and Koray Kavukcuoglu, "Spatial transformer networks," *in Advances in Neural Information Processing Systems*, pages 2017–2025, 2015.

[2] C. C. Huang. (2015). *Huang's Projects*. [Online]. Available at http://acm.ee.ccu.edu.tw:2017.

[3] C.C. Huang, Hoang Tran Vu, "Vacant Parking Space Detection based on a Multi-layer Inference Framework," *IEEE Transactions on Circuit and Systems for Video Technology*, May 2016.

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