University of Barcelona

Facultat de Matemàtiques i Informàtica

Memory Project : Parking Occupancy Detection

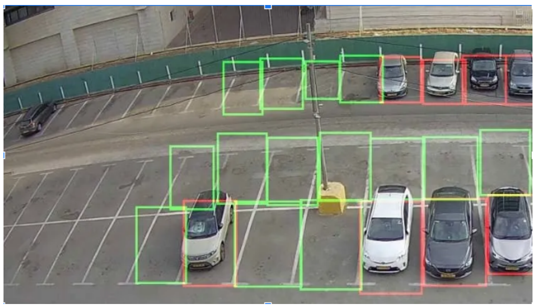
Vision Artificial

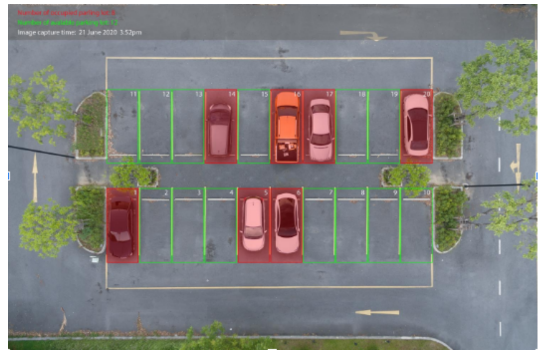
Zhipeng Lin
Zhihan Lin
Junjie Li
Manuel Liu Wang

December 2022

1 Introduction.

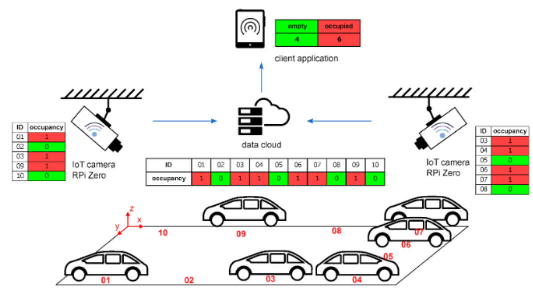
This algorithm seeks to determine the number of vacant and occupied parking spaces in a parking lot.





2 Context.

The primary setting for this application is in open spaces since there is more room for installing a camera in a high position, with this, we can better manage which spots are vacants or occupied.



3 Information on the implementation.

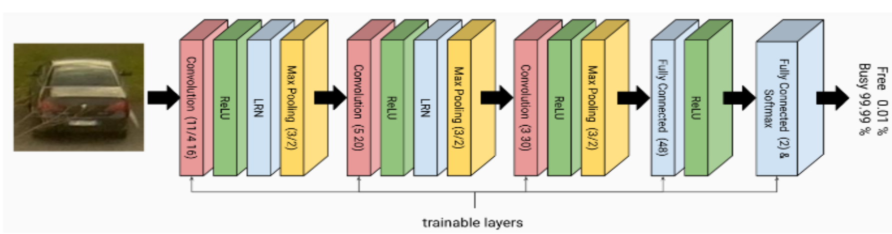


Figure 1: Information to the implementation

Convolutional neural networks, a subclass of deep neural networks, are the foundation of this application[1].

- The first layer is convolutional layout, and is used to extract the features of the image.

- The second layer is Rectified Linear Unit Layer, ReLu layer, using the function f(x) = max(0, x) as the activation function.

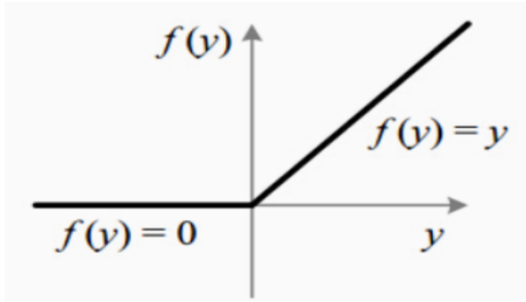


Figure 2: ReLu function

- The third layer is Subsampling layer, using MaxPoling, to reduce the space size of the data and reduce the sensitivity of the convolutional layer to the edges.

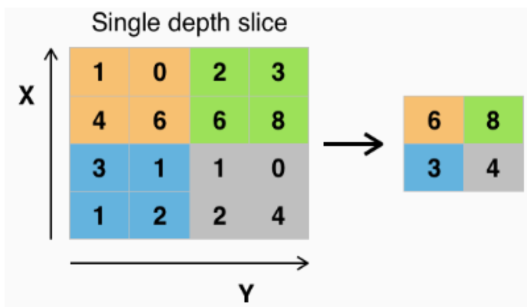


Figure 3: MaxPoling

- The last layer is the Backpropagation layer, to penalize the deviation between the predicted output of the CNN, and the data label, during supervised learning[2].

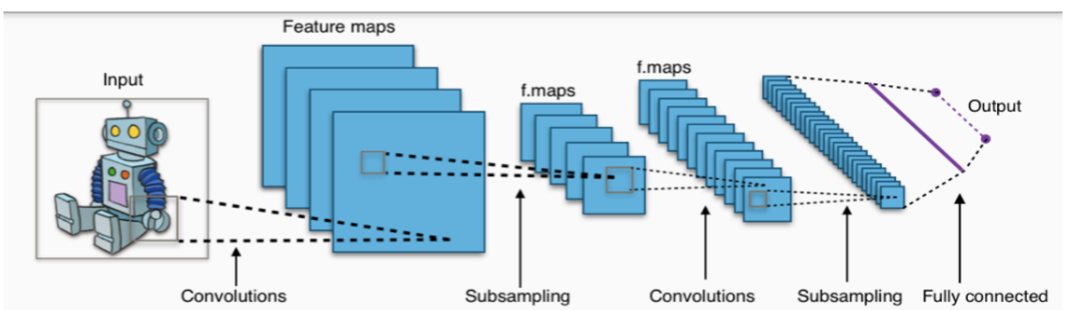


Figure 4: Backpropagation layer

3.1 Relationship with the material seen in class.

In the Convulational layout, we apply the filter bank seen in class to extract the feature of the images.

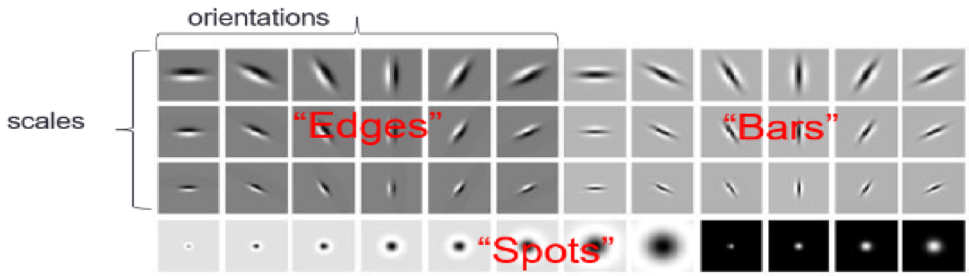


Figure 5: Convulational layout

4 Possible extensions of the application up to you.

Our application can be extended in many directions, not only limited to parking occupancy detection. based on the parking occupancy detection, we may begin working in the direction of security, we can add license plate recognition and face recognition to our application[3].

First of all, the application of license plate recognition function in the parking lot can be very wide. For example, in a private parking lot, the function can effectively prevent strangers from parking indiscriminately and seizing your spot to maximize the safety of your property.

Secondly, the license plate recognition function can be mutually assisted with the parking space occupation detection, monitoring whether the vehicle belongs to the parking lot, which can better help the parking lot management.

In the utilization of public parking lots, the license plate recognition function can better help us locate the parking space. Furthermore, it can also help us to park more efficiently, locate empty parking spaces quickly, or help us to find our car quickly.

The primary use of this concept is to prevent theft cases. To do this, we may create a whitelist that enables those people's faces to be recognized as the owners of the car. If a person tries to enter a car who isn't on the whitelist, an alert will sound, and the owner will be notified. This application is for safety measures.

Figure 6: License plate recognition

Figure 7: Face recognition

4.1 How would we implement them according to the material seen in the subject.

4.1.1 Vehicle plate recognition

- **Image features:** We can use the Template Matching (Sum of Squared Differences method, Correlation method , Zero-mean correlation method or Normalized X-Correlation method) and HOG.

- **Sift for images feature extraction:** We can use the Harris corner detection (Rotation invariant) or Censure detection (Rotation invariant and Scale invariant) to detect the interest points. But they are not invariant to illumination, so we can also use the Sift descriptor or Orb feature descriptor to identify the vehicle plate.

$$h[m,n]=\sum_{k,l}(g[k,l]-f[m+k,n+l])^2$$

Figure 8: SSD method

$$h[m,n]=\sum_{k,l} g[k,l]\; f[m+k,n+l]$$

Figure 9: correlation method

$$h[m,n]=\sum_{k,l}(g[k,l]-\bar{g})(f[m+k,n+l]-\bar{f})$$

mean of g

Figure 10: Zero-mean correlation

$$h[m,n]=\frac{\sum_{k,l}(g[k,l]-\bar{g})(f[m-k,n-l]-\bar{f}_{m,n})}{\left(\sum_{k,l}(g[k,l]-\bar{g})^2\sum_{k,l}(f[m-k,n-l]-\bar{f}_{m,n})^2\right)^{0.5}}$$

Figure 11: Normalized X-correlation

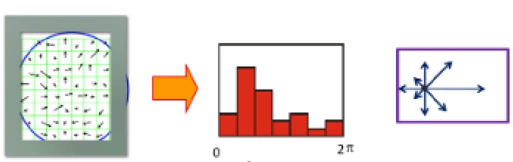


Figure 12: Sift descriptor

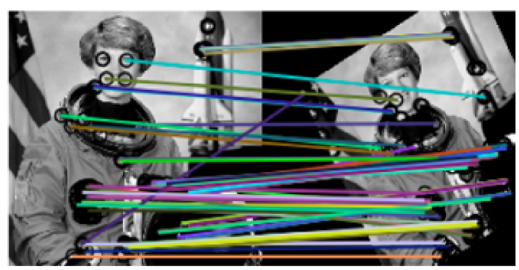


Figure 13: Orb feature descriptor

4.1.2 Vehicle's owner recognition

- **Face recognition:** We can identify the owner's face with Eigenfaces.

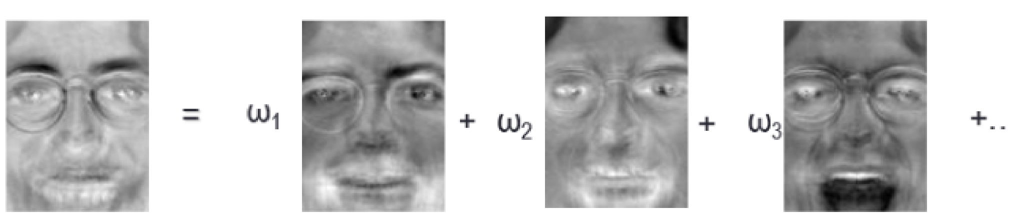


Figure 14: Eigenfaces

- **Algorithm to obtain the eigenfaces:** Construct the matrix ATA of size M x M where the columns are centered faces:

$$A = [X_1 - \bar{X}, X_2 - \bar{X}, \cdots, X_M - \bar{X}] \tag{1}$$

Compute the eigenvectors $V = [V_1, V_2, ...V_m]$ matrix of ATA.

Sort by magnitude of their corresponding eigenvalues and keep the most important eigenvectors (with higher eigenvalues).

The M eigenfaces are obtained by multiplying the matrix A with vi:

$$\mu_\iota = \sum_{k=1}^{M} \nu_{\iota\kappa} A_\kappa, \iota = 1, ...M \tag{2}$$

where A_k are the columns of the matrix A.

5 Conclusion

In conclusion, this algorithm is intriguing and has a wide range of applications. It incorporates many concepts we have studied in class, such as the convulsion and the use of a filter bank, and because there is only one model, it has a large number of layers to train and calculate the results of the detection.

References

[1] Giuseppe Amato et al. “Car parking occupancy detection using smart camera networks and deep learning”. In: *Computers and Communication (ISCC), 2016 IEEE Symposium on*. IEEE. 2016, pp. 1212–1217.

[2] Giuseppe Amato et al. “Deep learning for decentralized parking lot occupancy detection”. In: *Expert Systems with Applications* 72 (2017), pp. 327–334.

[3] “https://melabglobal.com/blogs/news/why-use-license-plate-recognition-parking-system”. In.