# Instructions for Authors of SBC Conferences Papers and Abstracts

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***Abstract.*** *Living in a big city, it's a common problem to find available parking spaces for your car. Having a real time parking space detection system based on images provided by CCTVs could considerably improve the parking experience at a relatively low cost.*

## 1. Introduction

Statistically the average time spent searching for a parking spot represents **7.8 minutes**. That is a waste of time and can also cause traffic congestion. There are several types of parking spaces monitoring systems, including counter-based and sensor-based, which try to solve the mentioned problem. Counter-based systems work by counting cars at the parking lot entrance, but their disadvantage is that they don't provide concrete informations about available spots, leaving the task of finding the place to the driver. A more precise solution could be sensor-based systems which provide availability information about each spot specifically. However, this solution implies higher costs (c.a **$40** per unit). An alternative approach would be using video provided by already installed surveillance cameras for real-time detection by implementing a computer vision system. This method relies on the detection of vehicles in delimited space areas and classification of a spot as available or occupied. The processed information will be delivered by a server in form of a web page and updated in real-time, which would make the solution accessible for everyone. That would definetely save time of the driver and considerably reduce traffic problems. Challenges that we should expect will be related to the scalability of the application. We should, for example, take into consideration that the application should work in different weather conditions. We also focus on the accessibility of the processed information in real-time, for which we will try to compare different AI algorithms and will choose the one with the best balance between accurate results and small processing time.

## 2. Related Work

One approach to video-based real-time parking space detection application was described in the academic paper of [Tschentscher and Neuhausen 2012]. To minimize weather and lighting conditions influences and to maximize the accuracy of the results, the approach evaluates several combinations of feature extractors and machine learning algorithms. They used a self-built dataset containing ca. 10,000 samples, from which they extracted features like Color Histograms [RGB, HSV, YUV] (to distinguish between asphalt color and the cars, to solve problems with brightness), Gradient Histograms, Difference-of-Gaussian Histograms and Haar-like (to extract edge information). Three classifiers were trained and compared to each other based on features mentioned above: k-Nearest Neighbor, Linear Discriminant Analysis, Support Vector Machine. The final

solution relies on HSV color histogram and Difference-of-Gaussian features and a SVM classifier, which reached an accuracy of 99.8 %.

An alternate approach for vacant parking space detection is described in [Acharya et al. 2018], which uses features extracted by a pre-trained CNN to train an SVM classifier for the detection of parking occupancy in a CCTV image sequence. The CNN extracts features from the publicly available PKLot dataset which consists of more than 12000 images collected from 3 parking sites on different weather conditions. Consequently, the extracted features from images of the PKLot dataset were used to train and test a binary SVM classifier. The evaluation of the classification accuracy is done by cross validation on the PKLot dataset and the transfer learning ability on the Barry Street dataset, which was created for the purpose of that research and includes a sequence of images captured by a camera overlooking a street with marked parking places.

The binary classification using the deep features achieved consistently reliable results with an average accuracyof 99.7% across different weather conditions for the PKLot dataset. As transfer learning was a more challenging task because the classifier was required to recognise unfamiliar images, the classification of Barry street images achieved the overall accuracy of 96.65%. It is worth mentioning that the processing time for each image segment of the parking spaces is 0.067 seconds on a simple desktop computer which means it takes approximately 2 seconds to process all the parking spaces in an image and hence the solution is suitable for real-time applications without any dedicated hardware.

### 2.1. Useful Tools

The following tools were used for implementing above mentioned approaches.

- Tensorflow
- Keras
- scikit-learn

## References

Acharya, D., Yan, W., and Khoshelham, K. (2018). Real-time image-based parking occupancy detectionusing deep learning.

Tschentscher, M. and Neuhausen, M. (2012). Video-based parking space detection.