Research Horizons Day
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InstaPark – Smart Parking Solution

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Overview

This project aims to perform a comprehensive study on the existing parking infrastructure and proposes intelligent parking solutions using novel **Big Data Analytics** with **Deep Learning** techniques. In particular, this research addresses the parking problems faced in most of the cities and growing colleges like the UAH.

Impact

According to parking studies conducted by Skipper Consulting in February 2017, UAH had a student body of 8,468, which included 6,507 undergraduate and 1,961 graduate students; of which 1,657 were residential campus students and 6,811 were commuter students. UAH has around 335 full-time faculty, 170 part-time faculty and 1,370 support staff. Since the parking studies last year, UAH has recorded its highest enrollment rate of 9,180 students which includes 7,090 undergraduate and 2,011 graduate students. Within the next few years, UAH is expected to exceed its target enrollment of 10,000 students, therefore signifying a great need for development of intelligent parking solutions to address the growing parking demands at the UAH.

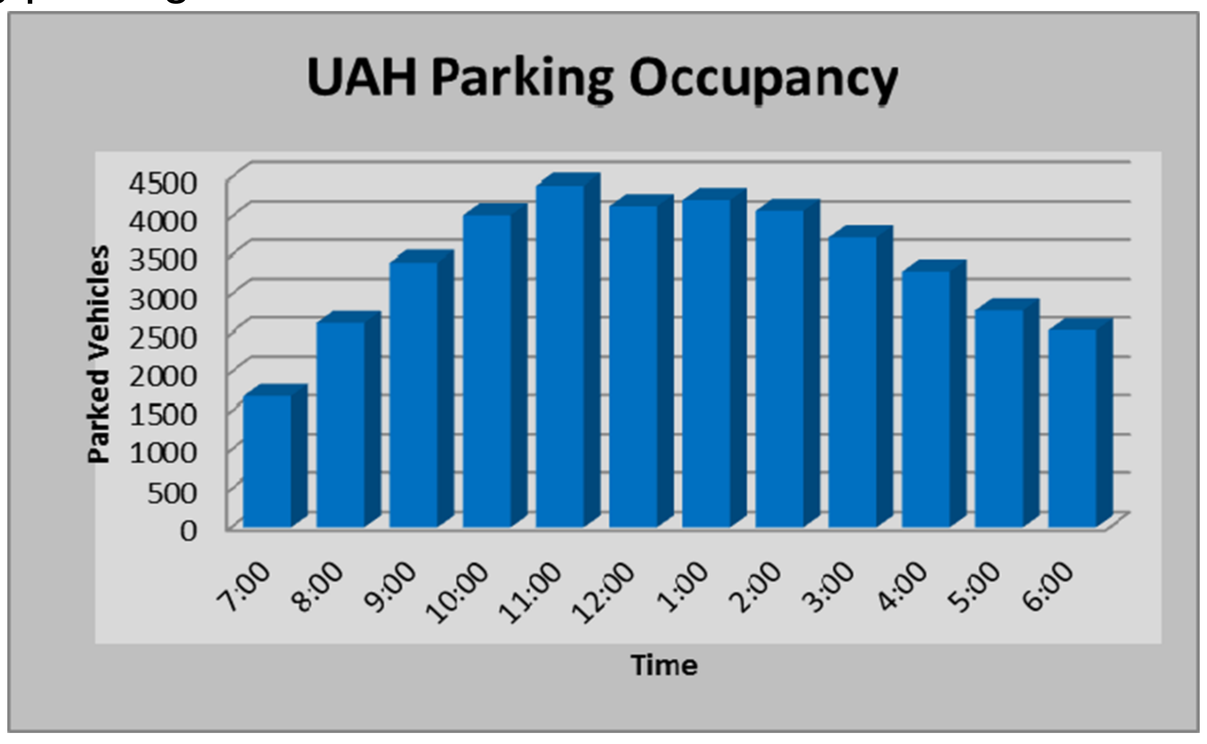

Figure 1: Bar graph of parking occupancy at UAH

Figure 1 illustrates the parking contention faced by students and/or faculty on a typical day at the UAH. Note that between peak hours of 11:00 A.M.-1:00 P.M, there is a high probability of not being able to locate a vacant parking slot. This on-going parking struggle is also indicative of expended resources such as student/faculty time, fuel, environmental pollution, and parking associated-stress. All of these factors could adversely affect an individual's productivity. Hence, it is essential to expedite the process of locating a parking spot. Currently, zone/salary-based parking have been used to regulate the on-campus parking issues. However, this work is the first of its kind which makes an attempt to analytically address the parking problem at the UAH using novel Big Data Analytics. This results of this work will prompt creation of a new mobile application that will assist UAH community to efficiently locate any available vacant parking spots.

Results and Future Work

CNN is used to perform deep learning as depicted in figure 5. It is validated with 5098 images, and is capable of identifying a single car image when presented.

Class Labels	Car	No car
Car	0.6265	0.0001
No car	0.1227	0.2504

Accuracy: 87.69%
Specificity(TNR): 67.11%
Sensitivity(TPR): 99.97%
False-Negative Rate: 00.03%
False-Positive Rate: 32.89%
***False Discovery Rate**:* 16.38%
***False Omission Rate**:* 00.08%

Figure 8: Confusion Matrix and performance statistics of the proposed model

Future work will be to combine the spatial features of the parking lot images shown in figure 6 with the CNN framework to enhance detection of vacant parking spaces. The traffic data will be fed to the CNN via a camera mounted on top of the building that captures the entire view of the parking lot. This data will be stored in a central database and can be accessed by the users via the InstaPark mobile application.

Method

Supervised classification was performed using convolutional neural network (CNN) to determine if a car is present/not in the parking spot. As shown in figure 5, the CNN has four main layers, one for each operation performed such as convolution, pooling, flattening, and full connection. The CNN was trained using cropped and pre-processed images of cars and empty parking spaces. The training data used in this study was chosen from a subset of 6100 images from the PKLot Dataset (see figure 2-4) generated by *"Universidade Federal do Parana"* in Brazil.

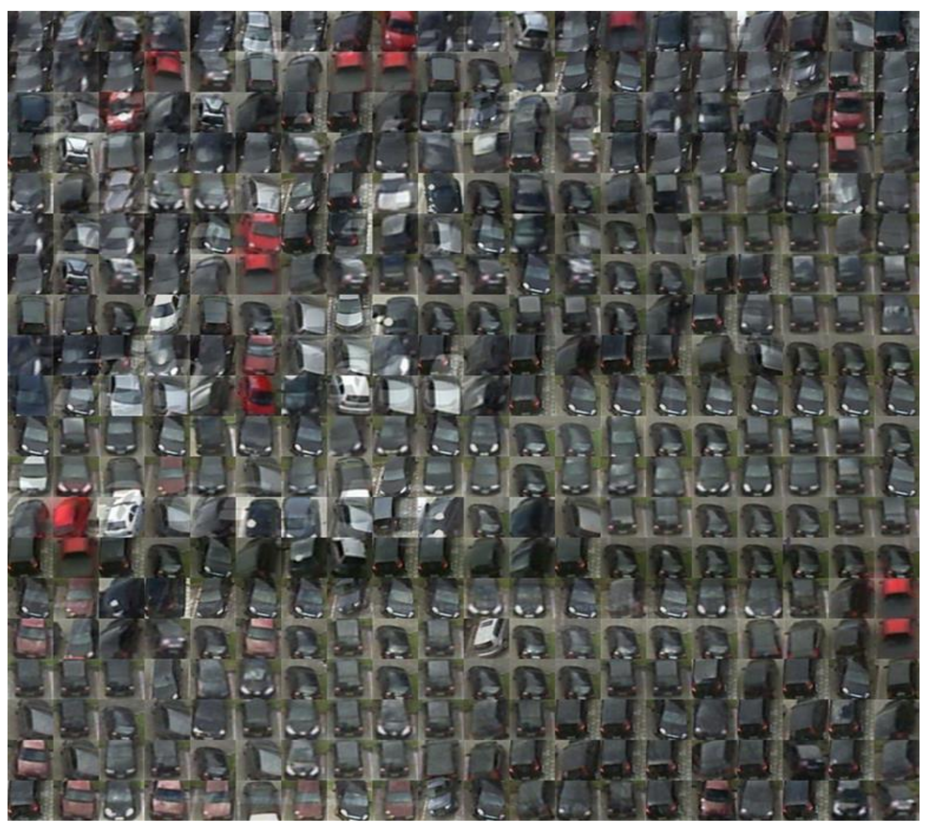

Figure 2: Mosaic of the car images from the PKLot dataset

Figure 3: Cropped images of spaces occupied by cars

Figure 4: Cropped images of empty parking spaces

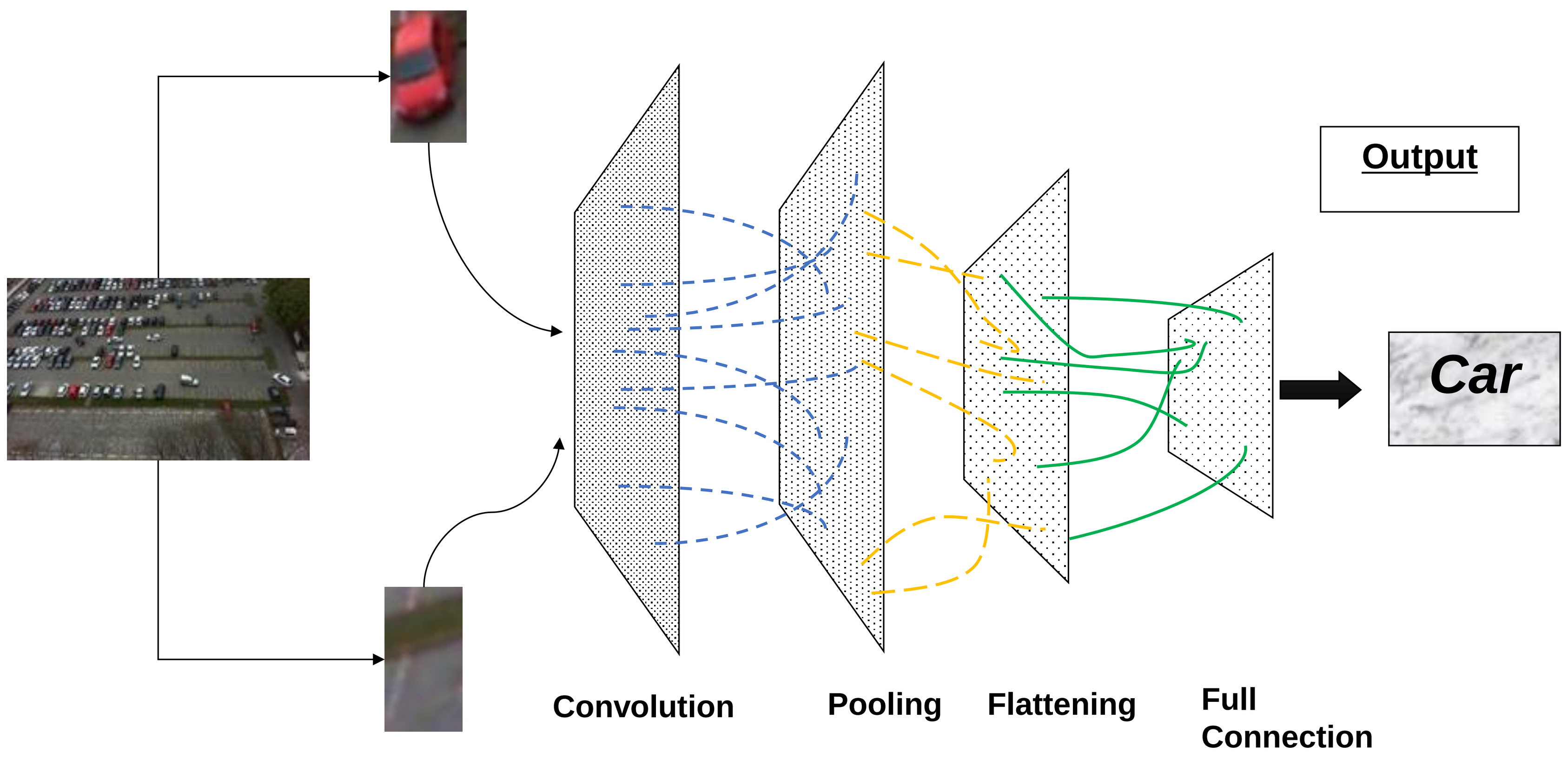

Figure 5: Architecture of the CNN demonstrating the data learning process

Figure 6 below shows the spatial features extracted such as edges from the entire parking lot images to aid in discrimination of an empty parking lot from a vacant spot.

(a) *Edge extraction performed on partially occupied parking lot*

(b) *Edge extraction performed on empty parking lot*

Figure 6: Spatial features of parking lot

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