# Joanna Riascos

Dr. Sylvain Jaume

Assignment Three

Capstone: Big Data & Bus Analytics

February 4th, 2017

# Expected Contribution and State of the Art

Many drivers around the world have always experienced issues while driving. Whether it is finding a parking spot or being stressed out about traffic in the mornings. Given the fact that there are more cars then there exists a greater amount of car emissions that affect our cities’ environments. According to a study by the Union of Concerned Scientists (UCSUSA), “transportation contributed more than half of the carbon monoxide and nitrogen oxides, and almost a quarter of the hydrocarbons emitted into our air.” The health risks of air pollution are shockingly dangerous. It could cause asthma, bronchitis, irritation of the eyes, and increased risk of heart attacks. Also, if a person is exposed to air pollution in the long run it could cause cancer and permanent lung damage.

Not only does air pollution affect us, it also affects the environment. In reference to the United States Environmental Protection Agency air pollution can cause the following environmental effects: acid rain, eutrophication, and haze. Acid rain “is precipitation containing harmful amounts of nitric and sulfuric acids.” Eutrophication “is a condition in a water body where high concentrations of nutrients stimulate blooms of algae.” Haze “is caused when sunlight encounters tiny pollutions particles in the air.” Similarly, trucks and heavy cars use a lot of petrol and diesel triggering the release of more carbon dioxide, which causes global warming. In addition, air pollution also affects the wildlife because just as human beings they might suffer from birth effects and respiratory diseases.

**Contribution**

If we stop and think about the serious problems that we are facing here then we would want to contribute to helping save the environment. What we believe can help reduce the air pollution produced by the vehicles’ emissions is by implementing smart parking all over the world. An investigation that we have purposed is to explore how smart parking can help solve environmental issues caused by traffic congestion. The purpose is to make cities more sustainable, healthy and happy to live in. By having a smart parking system there will be reduced traffic since there will be less cars looking for an available and open parking space. Also, there will be a reduction in air pollution because it will significantly decrease driving time therefore; it will lower the car emissions.

With the help of smart parking we will be able to contribute in helping save the environment. In addition, with the dataset that we have chosen for our data analysis project we could build models to extract real time parking data and predict future driver behaviors. As an example, a driver might have a daily routine of parking at the same time everyday. If we analyze and extract the data we could have a better understanding of when and at what time the same driver parks his or her vehicle. This will help immensely in having an accurate parking management system to predict when is most likely a parking spot going to be available or vacant. Therefore, as I mentioned in the previous paragraph, I believe we should investigate how smart parking can help solve traffic and environmental issues. We need to find a way to create and implement a smart parking management system in our cities with the help of big data analytics.

**State of the Art**

The smart parking management system has been implemented in various parts of the world, such as in the United Sates, United Kingdom, Europe, Japan and India. One of the cities that have introduced the concept of the smart parking assistance program is in Ellicott City, Md. They have developed a smart parking system that utilizes sensors to detect whenever a parking space is open and then it sends the data information to the drivers to let them know which parking spot is vacant. According to the Los Angeles County, the smart parking system “resulted in saving 31.3 million hours of travel time, 38 million gallons of fuel and 337,000 metric tons of carbon dioxide per year.”

There have been various related works throughout the years that discuss the importance of having and creating a smart parking management system. According to the article, “A Reservation-based Smart Parking System” by Hongwei Wang and Wenbo He. They have designed and implemented a prototype called “Reservation-based Smart Parking System (RSPS) which depicts and provides in real time parking data information to the drivers through an application and also, offers parking reservations as part of the system. The system contains a subsystem of sensory networks that deliver real time parking information in the upper layer. These sensory nodes detect and monitor the status of whether a parking space is occupied or vacant. They have also developed a parking demand model to simulate the real world traffic traces to acknowledge the parking demand.

What the authors have used for the simulator implementation is an object-oriented design that realizes the interactions between objects such as, drivers and parking. Many drivers don’t behave the same way but what they have in common is that they always look for a parking garage or lot that offers a better and more convenient price. In the simulation setup, the authors have used the map of Los Angeles Downtown as a target area. This part of Los Angeles has a lot of interstate highways so they depict the outgoing traffic in two different days of the week. “The peak time of incoming traffic is from 6am to 10am, and the rush hours of outgoing traffic is during 5pm to 8pm.” For this reason, we can see that the parking demand might be high after work since the majority of drivers go back home during those hours. Furthermore, the authors established a system hardware that is organized into three main components, the sensor network, and the mobile device. The sensors are integrated with two different wireless motes. The mote communicates the module of Bluetooth on a smartphone. As a result, “the sensor confirms the identity of users when vehicle is detected in reserved parking lot.” The mobile phone allows the Bluetooth module to communicate with the sensors to verify a user’s identity.

With the help of the smart parking system drivers can make parking reservations ahead of time. Also, the article states that the driving distance decreases at peak time, rather than increasing because drivers know ahead of time the “states” of their parking spaces. Similarly, the system also collects and stores data “about the performance metrics, including the status of parking space, reservation time, parking location, driver’s identity.” And also, the system allows drivers to check the parking, reservation information and where the parking spot is located.

Furthermore, according to the article “A Cloud-Based Smart-Parking System Based on Internet-of-Things Technology” by Thanh Nam Pham, Ming-Fong Tsai, Duc Binh Nyguyen, Chyi-Ren Dow, and Der-Jiunn Deng. The authors have developed a “novel algorithm that increases the efficiency of the current cloud based smart parking system and develops a network architecture based on the Internet-of-Things technology.” The algorithm that they have proposed will help greatly in reducing driver wait time and achieve successful parking. The system will help drivers find a free parking space at the most convenient price. The smart parking system consists of the having a vehicle park as an Internet-of-Things technology (loT) network. It will contain the data that includes the GPS location and distance between car garage areas.

All of this information then is transferred to a data center. The data center is a cloud storage server that “calculate the costs of a parking request, and these costs are frequently updated and are accessible any time by the vehicles in the network.” Moreover, the authors’ algorithm system consists of Radio-Frequency Identification (RFID) technology that monitors car parks. The Radio-Frequency Identification reader counts how much of free parking spaces there is in a parking lot or garage. “The use of RFID facilitates implementation of a large-scale system at low cost.” Whenever a driver or a user logs into the system, the driver should be able to choose any parking space he or she wants. Afterwards, the system will notify the driver with the parking spot saying that it is “pending” which doesn’t allow other drivers to reserve the parking space.

The system architecture consists of a cloud-based server, local unit, control unit, screen and RFID tag or ID card. The cloud-based server is a web entity that is in charge of the storage of the data and information that is provided by the local unit. The local unit is located in each car park and it storages the information and data of each vehicle space. The control unit is an Arduino module that connects to the RFID reader. “The card reader authenticates the user information and then displays this information on the screen.” If indeed, the information that the card reader reads is correct then it automatically open the parking garage’s door so that the vehicle can enter and park his or her car. Next, the screen depicts the “information on the capacity of the local car park, the total current percentage of free spaces, and the status RFID tag check.” Lastly, the RFID tag and the ID card are used to identify the user information and then calculate the amount of total free spaces that there might be available in a car garage or lot.

Likewise, in reference to the article “Towards Smart Traffic Management Systems: Vacant On-Street Parking Spot Detection Based on Video Analytics” by Xavier Sevillano, and Elena Marmol. They have created a sustainable solution to detect and find vacant parking spots. This work advocates fusing the information from small-scale sensor-based detectors with that obtained from exploiting the widely-deployed video surveillance camera networks.” The article discusses how video analytics is very much useful in regards to smart city solutions based on data and how they have developed a “vacant parking spot detection system based on the use of video analytics, rather than in the networks data fusion process itself.” The parking spot detection system is divided in a two-phase process. First, it consists of the training phase, in which the system detects the real time visualization of an occupied and vacant parking space. Secondly, there is a test phase in which the system analyzes and predicts the status of a parking spot.

The training phase is basically the “set up process of the system” whereas; the test phase “corresponds to the exploitation of the system.” Afterwards, they test their module the one that determines whether a parking spot is vacant or available by testing with classifiers. They employ the common algorithm, k-nearest neighbours (kNN).With the help of the kNN they will determine the status of a parking sport by looking at the sports in the training dataset that look visually very similar. The authors used the Euclidean distance “for measuring visual similarity.” Likewise, they have applied one of the most well known classifier systems called, Support Vector Machines (SVM) that differentiates vacant and occupied classes. This way a driver should be able to determine when a parking spot is vacant. As well, as part of the algorithm the authors are implementing the video data description. The authors recorded their own video in order to collect external factors. This way they were able to create their parking video analytics detector.

In conclusion, the less there exists traffic congestion the better for the environment. As I mentioned in the introductory paragraphs there are a lot of harmful effects that come from air pollution such as asthma and respiratory diseases caused by vehicle emissions. To solve these issues we need to implement smart parking in our cities. With smart parking we can create smart technology systems that will benefit animals, the environment, and us. By implementing smart parking we will be able to spend less money on gas, reduced traffic and stress, improve air quality, increased safety, optimized parking, less accidents, less time spent, decreased management costs, and enhanced driver experience.

**References**

#### "A Cloud-Based Smart-Parking System Based On Internet-Of-Things Technologies - IEEE Xplore Document". Ieeexplore.ieee.org. N. p., 2017. Web. 4 Feb. 2017.

Wang, Hongwei and Wenbo He, “A Reservation-based Smart Parking System”, 2017. The First International Workshop on Cyber-Physical Networking Systems. 4 Feb. 2017.

*"Towards Smart Traffic Management Systems: Vacant On-Street Parking Spot Detection Based On Video Analytics - IEEE Xplore Document".*Ieeexplore.ieee.org*. N. p., 2017. Web. 4 Feb. 2017.*

#### "Smart Parking Applications Using RFID Technology - IEEE Xplore Document". Ieeexplore.ieee.org. N. p., 2017. Web. 4 Feb. 2017.

#### "Smart Parking: An Application Of Optical Wireless Sensor Network - IEEE Xplore Document". Ieeexplore.ieee.org. N. p., 2017. Web. 4 Feb. 2017.

#### "Patent US6426708 - Smart Parking Advisor". Google Books. N. p.,

#### "A New “Smart Parking” System Based On Resource Allocation And Reservations - IEEE Xplore Document". Ieeexplore.ieee.org. N. p., 2017. Web. 4 Feb. 2017.

Shaheen, Susan. (2005). Smart Parking Management Field Test: A Bay Area Rapid Transit (BART) District Parking Demonstration. *Institute of Transportation Studies*. UC Davis: Institute of Transportation Studies (UCD)

#### Bagula, Antoine, Lorenzo Castelli, and Marco Zennaro. "On The Design Of Smart Parking Networks In The Smart Cities: An Optimal Sensor Placement Model." Sensors (14248220) 15.7 (2015): 15443-15467. Academic Search Complete. Web. 4 Feb. 2017.

Xu, Bo, et al. "Real-time street parking availability estimation." *Mobile Data Management (MDM), 2013 IEEE 14th International Conference on*. Vol. 1. IEEE, 2013.

Rodier, Caroline J., and Susan A. Shaheen. "Transit-based smart parking: An evaluation of the San Francisco bay area field test." *Transportation Research Part C: Emerging Technologies* 18.2 (2010): 225-233.

Yang, Jihoon, Jorge Portilla, and Teresa Riesgo. "Smart parking service based on wireless sensor networks." *IECON 2012-38th Annual Conference on IEEE Industrial Electronics Society*. IEEE, 2012.

Piovesan, Nicola et al. “Data Analytics for Smart Parking Applications.” Ed. Andrea Zanella and Toktam Mahmoodi. *Sensors (Basel, Switzerland)* 16.10 (2016): 1575. *PMC*. Web. 5 Feb. 2017.

#### “How Much Can a Smart Parking System Save You?” Glenn Surpris, Dahai Liu, DennisVincenzi. Ergonomics in Design. Vol 22, Issue 4, pp. 15 – 20. First published date: November-17-2014

Horng, Gwo-Jiun. “Using Cellular Automata for Parking Recommendations in Smart Environments.” Ed. Francesco Pappalardo. *PLoS ONE* 9.8 (2014): e105973. *PMC*. Web. 5 Feb. 2017.

*The Adaptive Recommendation Mechanism for Distributed Parking Service in Smart City*

*Wireless Personal Communications*, 2015, Vol.80(1), pp.395-413 [Peer Reviewed Journal]

Horng, Gwo-Jiun

Horng, Gwo-Jiun. “Using Cellular Automata for Parking Recommendations in Smart Environments.” Ed. Francesco Pappalardo. *PLoS ONE* 9.8 (2014): e105973. *PMC*. Web. 5 Feb. 2017.

*QuickSpot: a video analytics solution for on-street vacant parking spot detection*

Multimedia Tools and Applications, 2016, Vol.75(24), pp.17711-17743 [Peer Reviewed Journal]

Màrmol, Elena ; Sevillano, Xavier

*“Urban Infrastructure Deployment for Wireless On-Street Parking Sensor Networks.” Lin T, Rivano H, Le Mouël F. Procedia Engineering. 2015 vol: 115 pp: 29-36*

*Zhanlin, Ji, et al. "A Cloud-Based Car Parking Middleware For Iot-Based Smart Cities: Design And Implementation." Sensors (14248220) 14.12 (2014): 22372-22393. Academic Search Complete. Web. 4 Feb. 2017.*