

# **Bringing Smart Parking Technologies of Hangzhou to Charlottesville**

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science  
University of Virginia • Charlottesville, VA

In Fulfillment of the Requirements for the Degree  
Bachelor of Science, School of Engineering

Alvin Yuan  
Spring, 2020

On my honor as a University Student, I have neither given nor received  
unauthorized aid on this assignment as defined by the Honor Guidelines  
for Thesis-Related Assignments

Signature Alvin Yuan Date 4/26/20  
Alvin Yuan

Approved \_\_\_\_\_ Date \_\_\_\_\_  
Sharon Ku, Department of Engineering and Society

## **A Fable of Tomorrow**

In the earliest times of humanity, homo sapiens would hunt and gather through their own power, running to chase animals and walking to wherever they could find their next pray. As time advanced, humans were able to domesticate animals to rapidly evolve society, giving rise to new systems of agriculture and economy. They were no longer limited to small groups of families, but instead could develop urban communities assisted by horses for travel. Humans would continue to evolve and develop better modes of transportation like carts and wagons, eventually moving to industrial solutions through trains assisted by the steam engine. All these solutions were gradual advancements to what would be the most widely used and perhaps the most influential form of transportation ever invented: the automobile.

Two centuries ago, the first self-propelled vehicles were invented, bringing new innovations to transportation. Automobiles have affected all aspects of society and how humans live, giving the possibility of travelling long distances and expanding civilization further. People were no longer trapped within their small town and could adventure out to pursue their own dreams, and society was no longer limited to urban cities and could instead develop into suburbs to support a rapidly growing population. This brought geographical diversity, creating dynamic environments each with their own unique social, economic, and political developments. These environments foster communities and individuals, providing a way for people to develop themselves and their own sense of identity.

Automobiles were first mass produced in America in the early 20<sup>th</sup> century, contributing to the industrial revolution where the economy was quickly developing. It was a key factor in developing a consumerist society, spurring the growth of jobs in a variety of different fields like the petroleum and steel industry. It left an unforgettable impact on the daily lives of people,

influencing families and even changing household structures. Society became more mobile, and women were no longer restricted to their role in the house; with the development of suburbs, people needed a way to get around unlike within the small confines of a city, so women could also use automobiles to escape their domestic roles and compete with men for jobs outside of the house. Automobiles allowed people to gain independence and develop more as individuals; they represent growth, freedom and opportunity. They bring many powerful improvements to society and individuals, but they also bring their own challenges that civilization was unprepared for.

As one of the first commonly available methods of long-distance transportation, automobiles quickly became widespread, and society had to quickly accommodate for them. The old roads suitable for horses and carriages couldn't support the new metal titans that were much heavier and would travel much faster. Forests and fields were cleared to make way for highways and interstates, and spaces were cleared for parking locations. As road and parking infrastructure have developed over the years, some of the infrastructure has become outdated, unable to support the mass urbanization of modern society. In the most populated of areas, automobiles vastly outnumber the amount of available public parking, creating issues for residents of these communities. This increased demand highlights the imbalance with the development of the automotive industry and the expansion of urban infrastructure. As people drive out to work each day, parking is either unavailable, underutilized, or too expensive for people to want to pay for. Even when there is enough parking available in the city, it will often be mismanaged, uncoordinated, and inefficient. These issues contribute to people spending more and more time driving around the city streets just searching for parking, leading into a chain reaction of other negative impacts; traffic jams, carbon emissions, noise pollution, decreased city revenue, and even areas like the public perception of a city are affected by the inability to find parking.

For such a powerful and impactful invention, its legacy should not be tainted by such a seemingly simple issue. With the improvement of parking, citizens can be happier by spending less time looking for a space to park their car and more time connecting with family and community. Public parking should be modernized and standardized so that the system can support the growth and change that all started from the industrial revolution. As society develops, so does its capability of creating advanced technical solution to solve its issues. Parking can be improved through its management and infrastructure, but also with modern ways such as automation and intelligent information collection that encourage smarter parking through sustainable development. With these improvements, society can remove the shackles placed on automobiles from this issue and continue to use them for what they should represent: freedom, independence, and opportunity. People will be able to spend time fostering unique communities, and individuals can once again chase their own dreams.

## **Introduction & Research Questions**

With the development of society comes cities – largely populated locations, with extensive support for its people with systems such as housing, transportation, and communication. A city comes with many benefits: a city is thriving with culture, with countless local communities contributing to its history; it comes with convenience, where food, entertainment, work and other locations are just a short distance away; it also comes with opportunity, where citizens can become educated, develop a career, and even start a family and a community. With these benefits come logistical drawbacks, one such being parking.

Parking in densely populated cities is difficult, preventing people from going into the city. Residents cannot enter and engage with the community when they want to, and it is even

more difficult for those unfamiliar with where to park. This restriction means city access isn't readily available; parking is cumbersome, inefficient, and even potentially expensive in many places. Charlottesville is an example of a restricted city; parking is rarely easily available, and much of it is taken by locals who work within the city. Students, residents, or tourists who want to enter the city must first drive around the streets looking for a space that is most likely limited to a couple of hours, or by paying each time for parking. Many parking locations are underutilized, and the systems currently in place to find parking are either primitive or unbeknownst by a large portion of students and residents. For some, this is enough to prevent them from entering the city at all, which inhibits the growth of the local community.

A better solution must be created to alleviate the city's parking issues; one such solution is a smart parking app created to help people better find parking spaces. However, is the main issue for parking really space, or are there other more important factors that contribute to the problem? In this thesis, I will develop a comparative study to investigate the parking problem in Charlottesville and Hangzhou, a densely populated urban city with plans to bring smarter technologies to its parking systems to address the following questions: what are the current parking situations in China and Charlottesville, what technological innovations have China implemented to streamline the parking process, and can these solutions be implemented locally within Charlottesville?

## **Literature Review**

One of the main forces trying to combat the parking issue is China, a country with some of the most densely populated cities in the world. According to a census conducted by Beijing's transportation commission, Beijing requires 1.3 million more parking spaces, and China as a

whole requires 50 million more (Zhang, 2017). Another study by Tsinghua University found that compared to other developed countries which average 1.3 parking spaces per car, China only has 0.8 – a large deficit when cities are so densely packed. Their team found that 50 percent of all parking spaces were underutilized (Zhang, 2017). The same holds true in the United States as well; according a study on the usage of autonomous vehicles within cities, in L.A. alone, “tens of thousands of parking spots could be converted in nobler uses,” (Duarte & Ratti, 2018).

Parking spots can be better utilized with a smartphone app; if parking information was readily available, many parking locations wouldn’t be as underused, and excess space could be allocated for other uses. Smartphone apps can provide information and make parking more convenient for many. One of the values that an app would bring is accessibility; a study on the most used applications found that they incorporated accessibility features, showing that accessibility is a valuable consideration in development (Gebresalassi & Sanchez, 2018). Taking a look at existing solutions, the MyCville app is one that attempts to provide parking information, but not so clearly or easily. All of its information is simply a text-based list of parking garages and costs, making it hard to navigate and unclear (fig. 2). The only metric for available parking is a single number, which doesn’t help with finding the parking itself (fig. 3). This app averages 1.2 rating by four total reviews, and it has had around 100 installations on Android in the 1.5 years it has been up. This clearly shows there is not only a problem with its design, but also knowledge of its availability to Charlottesville Residents.



Figure 2. Information on Parking Garages



Figure 3. Real Time Parking Availability

China has implemented its own smart parking applications, but on a much broader scale. These apps are created by startups or companies with private investors who work with city officials and car park operators, though there have been proposals to have the government unify these solutions onto a single data-sharing platform. This process can be mirrored within the United States, where city governments can work with companies and parking garage owners to develop a local solution which can then be unified throughout the country.

One of the largest apps in China is called ETCP, and it covers 223 cities, 6,600 parking lots, and has 23 million users (Zhang, 2017). Some of its features include maps which clearly display available parking locations, parking spot reservations, and automatic payment (fig. 4).

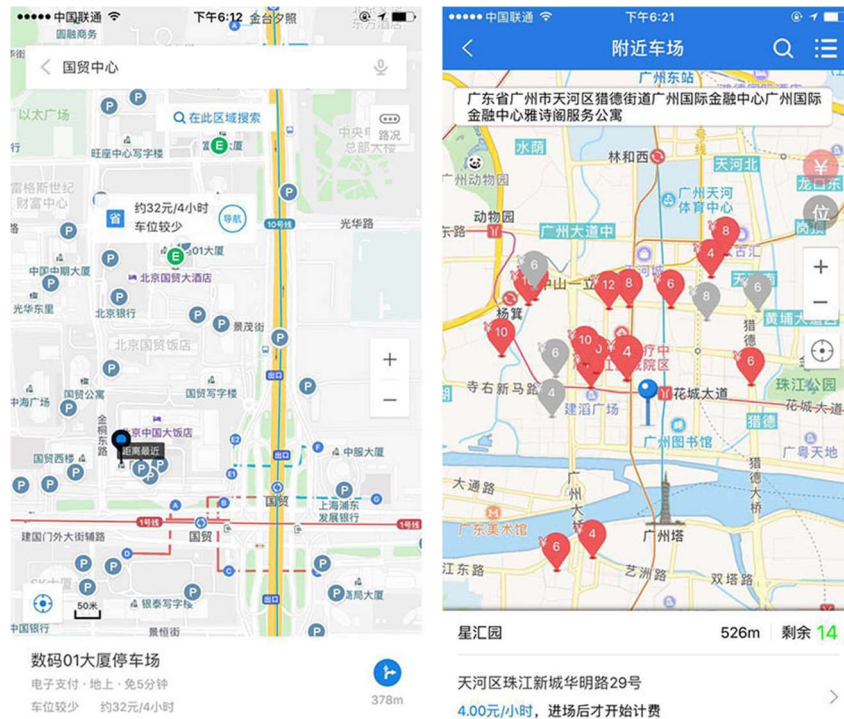


Figure 4. ETCP Smartphone Parking Application

The entire parking process is streamlined, and encompassed into one app; according to one user, “with the app, I can park as close as possible in just a short time” (Xuequan, 2018). One of the ways that it encourages people to use the app is by offering digital coupons and other incentives for mobile payments, making it quicker but also cheaper than traditional options. Integrating this modern solution with current infrastructure shows that it offers a better way of parking for many people, making it quicker and easier to enter the city. This application brings many features that can be implemented in a local app as well. If accurate sensors were installed in current parking locations, available parking would be easily locatable on a map, and proper development could lead to payment automation as well. This would bring more people into the city on a regular basis, and local shops could even be advertised within the app to provide benefit for both the local economy and for people looking to find places to go within Charlottesville.



## **STS Framework & Method**

The different perceptions and practices behind parking in Hangzhou and Charlottesville can be explained by the social construction of technology (SCOT) theory. Stakeholders involved in shaping the parking problems and policies will be identified to determine how both cities interpret their issues, as well as what they prioritize in their parking systems.

China is the largest country by population, and many of its cities have their own unique way of implementing different systems. Due to the diverse nature of its cities and provinces, this paper will focus on the parking infrastructure of Hangzhou, the capital of the Zhejiang province. It is a densely populated metropolitan city with large industries in manufacturing, agriculture, and textiles, so it serves as a good example for what parking issues arise in an urban environment. By focusing in on a single city, it narrows the perspective of this topic and allows there to be a focus on a few key questions: what are the parking issues in Hangzhou, how can smart parking solve the parking issues in Hangzhou, and how can these solutions be applied to solve parking in Charlottesville?

This thesis is written as part of a global classroom experience where students from UVA can connect with students from Chinese universities to share perspectives on what issues and solutions can be applied to each country. As a primary data collection method, a survey sent out to these Chinese students will bring more insight as to what they feel are the biggest issues related to parking are and will serve as first-hand experience for this topic. This survey includes questions such as their main and preferred methods of transportation, how much time and money they would be willing to spend to park, what they think are the most pressing issues to be fixed for parking, and how they rate their current city's parking system. Exchanging these perspectives will lead to a broader and more insightful path toward how these issues can be solved.

The secondary method of data collection for this project will be the analysis of documents related to Charlottesville and Hangzhou's parking systems. As a technologically advanced city, Hangzhou has already implemented some smart parking systems, so they have experience on how these initial implementations benefit their parking. These systems will be analyzed to see whether they will be effective or not when implemented in the small city of Charlottesville, and other smart parking systems will also be analyzed to see how Hangzhou's parking can be improved further. Charlottesville's local government has also spent considerable efforts toward improving its parking, so documents produced by the city related to their goals for parking improvements will be analyzed to see what solutions will best fit their vision and improve the city's parking infrastructure the most.

## **Data Analysis**

### Charlottesville: Parking as a Problem of Resource Distribution

To look at how to improve Charlottesville's parking infrastructure, it is first useful to see how the local Charlottesville government has planned to improve its parking to find the areas they believe are most beneficial to focus on. The city of Charlottesville published a parking action plan in 2016 in which they highlight some issues and target items that they are focusing on. They state that one of the problems with the city's parking is that they do not have a parking department or body to manage parking activities, and instead have distributed their tasks throughout the organization instead. This was effective in years past due to the smaller size of the city, but this approach is no longer sustainable with the city's growth. Charlottesville government has opted to start forming this central parking body and have come up with some key items to target as well. Their main areas of focus are optimizing existing resources,

enhancing access alternatives, and maintaining and growing supply. For resource optimization, their immediate focus is forming that central parking authority; they want to establish a parking action team consisting of city staff to support the parking system, as well as a panel to advise city issues comprised of local property owners and business representatives. With this formed, they can assess their future funding requirements for equipment such as parking meters to implement better parking systems in the future. In terms of enhancing access alternatives, Charlottesville aims to provide alternative mobility options such as public transportation or ride sharing to reduce the load needed for parking. They also hope to reduce parking costs for downtown employees, so they are not as burdened with parking issues. Their final area of maintaining and growing supply involves better managing their parking facilities and creating guidelines to control them so that public parking can be developed and financed properly. These three areas serve as a good starting point for the direction in which Charlottesville should proceed in parking improvements, as it is still a primitive city technologically speaking.

To form Charlottesville's parking action plan, the city conducted a comprehensive parking analysis in 2015 to find the aforementioned key actionable areas. They performed this analysis with the help of Nelson Nygaard, which is an internationally recognized transportation consultant. This analysis included updates to parking inventory, finding utilization rates of parking spots throughout the city, and significant stakeholder feedback to find the most important areas to improve upon. The most important statistics to take away from this analysis for this thesis are with parking supply, parking demand, and the opinions from stakeholder surveys. For downtown, there are 4,280 total parking spaces which are split into 1,001 public on-street spaces, 1,932 public off-street spaces, and 1,347 private off-street lot spaces. All on-street parking is unpaid while off-street parking is paid. Out of all the on-street parking spaces, only

396 are unrestricted – the rest are reserved for special uses like handicapped spaces or government staff or are restricted by time limits. Since many of the on-street spaces will be taken by downtown workers, the chances of finding unrestricted parking as a visitor are slim to none. An important metric for parking demand is parking utilization, which this analysis defines as a ratio of occupied parking spaces divided by the total inventory. It states that rates between 75 and 85 percent signify a nearing of practical capacity, rates over 85 can result in traffic and inconvenience for residents and for commercial perspectives, over 95 signifies difficulty finding parking, and over 100 percent signifies overcrowded and likely illegal parking.

The downtown cultural zone of Charlottesville is one area where the limitation on unrestricted parking shows – throughout the entire day, unrestricted parking is nearly at maximum capacity, and the same holds true with time restricted parking throughout many periods of the day (fig. 5). On weekends, the total parking utilization is even worse for on-street parking, at some points even exceeding 100 percent utilization indicating overcrowded or illegal parking. The off-street parking however is rarely full or even nearing that, showing that there is little incentive for people to take off-street parking. This situation is even worse in the highly crowded University Corner area where parking is almost all on-street, with overall occupancy of 85 percent or more at all times of day. Half of the total parking spaces are unrestricted, though the average duration of stay of greater than seven hours makes this number irrelevant; throughout all hours of the day, the parking utilization rate shows significant difficulty finding parking, and overcrowding in most areas (fig. 7, fig. 8). The stark contrast between the downtown area and the university corner shows that there are different issues between the various zones of Charlottesville – underutilized and inefficient usage of parking spaces in some areas, and an inadequate amount of spaces in others.

Utilization Rates: Downtown Cultural Zone							
Wednesday, April 22, 2015 (On-Street) – Wednesday, May 13, 2015 (Off-Street)							
	On-Street					Off-Street	
	2 Hour	1 Hour	Unrestricted	All Other Restrictions	Total, All Restrictions	Public Lots	Private Lots
Capacity	145	7	27	40	219	77-173*	117-213*
8 AM	35%	100%	96%	20%	42%		
9 AM	72%	100%	93%	55%	72%		
10 AM	89%	100%	100%	45%	83%	49%	52%
11 AM	79%	71%	93%	40%	74%		
12 PM	88%	71%	96%	58%	83%		
1 PM	86%	57%	100%	48%	80%	94%	42%
2 PM	76%	71%	93%	38%	71%		
3 PM	84%	100%	74%	65%	80%		
4 PM	83%	71%	89%	63%	80%	56%	28%
5 PM	88%	86%	93%	63%	84%		
6 PM	92%	86%	100%	80%	91%		
7 PM	91%	86%	100%	83%	90%	36%	33%

Figure 5. Weekday Parking Utilization for the Downtown Cultural Zone

Utilization Rates: Downtown Cultural Zone							
Saturday, May 2, 2015 (On-Street) – Saturday, May 16, 2015 (Off-Street)							
	On-Street					Off-Street	
	2 Hour	1 Hour	Unrestricted	All Other Restrictions	Total, All Restrictions	Public Lots	Private Lots
Capacity	134	7	26	47	214	173	117
11 AM	91%	57%	77%	47%	79%		
12 PM	89%	57%	77%	49%	78%		
1 PM	87%	71%	77%	57%	79%	31%	17%
2 PM	93%	71%	85%	66%	85%		
3 PM	96%	71%	81%	68%	87%		
4 PM	94%	71%	88%	66%	86%	23%	22%
5 PM	97%	57%	73%	79%	89%		
6 PM	101%	100%	65%	83%	93%		
7 PM	107%	100%	77%	79%	97%	45%	11%
8 PM	102%	86%	92%	70%	93%		
9 PM	99%	100%	96%	64%	91%		

Figure 6. Weekend Parking Utilization for the Downtown Cultural Zone

On-Street Utilization Rates: University Corner Study Area Thursday, April 23, 2015					
	2 Hour	Permit	Unrestricted	All Other Restrictions	Total, All Restrictions
Capacity	46	31	97	22	196
8 AM	85%	90%	100%	41%	88%
9 AM	87%	87%	98%	68%	90%
10 AM	80%	100%	98%	77%	92%
11 AM	87%	103%	98%	73%	93%
12 PM	91%	100%	98%	55%	92%
1 PM	96%	87%	96%	77%	92%
2 PM	89%	94%	97%	82%	93%
3 PM	89%	97%	97%	64%	91%
4 PM	83%	90%	97%	64%	89%
5 PM	80%	81%	93%	64%	85%
6 PM	89%	84%	94%	68%	88%
7 PM	91%	94%	95%	27%	86%

Figure 7. Weekday Parking Utilization for the University Corner

On-Street Utilization Rates: University Corner Study Area Saturday, April 25, 2015					
	2 Hour	Permit	Unrestricted	All Other Restrictions	Total, All Restrictions
Capacity	46	31	97	22	196
10 AM	67%	84%	98%	45%	83%
11 AM	80%	87%	97%	77%	89%
12 PM	78%	87%	97%	64%	87%
1 PM	74%	77%	97%	82%	87%
2 PM	78%	77%	99%	64%	87%
3 PM	74%	81%	99%	32%	83%
4 PM	76%	90%	97%	59%	87%
5 PM	87%	94%	101%	50%	91%
6 PM	93%	94%	99%	59%	92%
7 PM	93%	100%	99%	50%	92%
8 PM	100%	100%	97%	55%	93%
9 PM	96%	100%	99%	36%	91%

Figure 8. Weekend Parking Utilization for the University Corner

## Hangzhou: Parking as a Problem of Efficiency

The city of Hangzhou has already made efforts toward creating a smarter parking system. One such implementation is with automated payments – for the first time, cars can park and leave before paying fees by registering their vehicle with their mobile phones (Chinadaily, 2019). This system covers all districts and counties within Hangzhou, implemented in over 260,000 parking spots. With its implementation throughout the city, all data from the intelligent parking lots are shared with the government for better city management, and this allows road traffic to be controlled better. Parking lots can be constructed better according to demand, since all the data is recorded for analysis. Alibaba, which is based in Hangzhou, has also made effort toward improving the city's parking – it has created an invention called the “City Brain” which uses artificial intelligence to gather information from cameras and GPS data to coordinate road signals and prevent traffic gridlock (Erasmus & Toh, 2019). This has improved traffic conditions and commute times, also helping first responders get to emergencies faster. Before the system was implemented, Hangzhou ranked fifth among China's most congested cities, dropping to 57<sup>th</sup> with this change in place.

To assess the role of smart technology in future parking development, the Worcester Polytechnic Institute and the Smart Cities Research Center of Zhejiang Province collaborated to analyze which parking solutions would benefit Hangzhou the most. They categorize smart parking solutions into five different categories: parking guidance and information systems, transit-based information systems, smart payment systems, e-parking, and automated parking. They also assess the potential of mobile applications in smarter parking; it is estimated that 30% of urban traffic is caused by vehicles searching for parking, so creating an application that reduces this can be greatly beneficial. The parking process can be assisted and optimized through

a centralized system which navigates customers to an optimal parking spot and automates the payment process for speed and efficiency. Simulations conducted by other researchers indicate this kind of system can improve parking space utilization by 10-20%, which can help some areas of Charlottesville greatly. In discussing Hangzhou's unique parking situation, they have found that even with the smart technology being implemented, it cannot keep up with the city's growth, and that the city is too large to create a single, universal parking solution.

### Comparing Viewpoints between Cities

In a survey for the Charlottesville workforce, 84 percent reported that they drive to work and park downtown or at the University. For restaurant or retail employees, 92 percent indicate that there is no parking available at or near their place of work, and this is evidenced by the most common request for employers to improve parking within Charlottesville – more parking should be available, with the next most important factor being free or reduced cost parking. Customers hold a different perspective, with the majority rating the ability to stay as long as they want as the most important factor, having the cost as the next most important while availability ranked the lowest. There are a variety of varying opinions on the matter, but all these issues point toward needing a smarter parking solution for Charlottesville.

As a collaboration to promote global classrooms, a survey was created along with this thesis to gather first-hand accounts for what Chinese students think are the biggest parking problems. This survey does not create a representative sample for the Chinese population given that the surveyed party is specifically Chinese students in higher education, though this serves as an example for the general opinions of one of China's stakeholder groups. In the survey results, the majority of students do not own a vehicle, and most opt to ride public transit in its stead



(appendix). Driving however was the most preferred method of transportation, so it's clear that parking is an issue that can be important to them, especially as they graduate and move onto the workforce. Most students rated their current city's parking system as average, though more answered poor/extremely poor compared to good/extremely good. The majority will spend 5-15 minutes finding parking, and are willing to pay a small amount per hour for parking. One of the most important questions in the survey was ranking important parking factors for them, and the two most favored were convenience (being nearby) and ease of use (being readily available). This is further supported by the free response answers to what they believe the main issues and solutions for parking are: most students believe that the biggest issue is the lack of parking, and the best solution as creating more parking locations, whether it be through underground lots or through space efficient modern parking systems.

The opinions for Charlottesville's stakeholders and the students surveyed from China are similar in their prioritization for more parking space, though the ways in which the goal is achieved can be vastly different for both groups. The implementation of underground parking lots or space efficient parking systems is definitely one that can improve a city's parking capabilities tremendously, however it will also come at a great monetary cost, one that Charlottesville may not prioritize above other issues. As seen from Charlottesville's parking study, a large issue for its downtown parking is the overutilization of on-street parking while much of its off-street parking is still available. Given that the city is still relatively small, a better use of its resources may be improving its utilization rate for existing parking locations rather than building new ones – creating new locations in overpopulated areas such as the university corner can come afterward. In this regard, the solutions that may be the most effective for the densely populated Chinese cities could be inefficient for Charlottesville's current situation.

## **Discussion**

Though China and specifically Hangzhou are making great efforts toward improving their parking situation, their situation is far too different from Charlottesville to implement any of these smart parking solutions immediately. The rapid growth of Hangzhou has brought the need for advanced solutions which could not be properly utilized by Charlottesville. Some recommendations for better parking in Hangzhou from the Worcester Polytechnic Institute include technologies such as RFID or 5G, and these solutions would be highly cost inefficient and unnecessary for Charlottesville to pursue in its current state. As discussed in Charlottesville's parking action plan, its focus should be having proper management and authority for parking and utilizing current resources effectively. Once this has been improved upon, smart parking solutions can come afterward. As a start to transition into smart parking, solutions such as smarter parking lots through the utilization of sensors and cameras can greatly benefit the city's ability to gather parking data and manage it more effectively. This would allow the city government to better plan where parking lots should be built in the future, and traffic could be better controlled as a result. Once these sensors are in place, the city could then begin using mobile applications to control and provide parking assistance with systems such as intelligent guidance and automated payment. For now, the most important thing to focus on is better managing what Charlottesville currently has and to utilize parking garages and publicly owned parking lots better.

## **Conclusion**

Parking is a major issue in most cities and is one that can drastically reduce the quality of life for a city's residents. It can inhibit the ability for residents and visitors to get out into the city and engage with people in the community. Implementing better parking solutions with smart technology is one step that cities can take to improve upon this, and China has shown how impactful it can be. It can reduce traffic gridlock, improve parking utilization, and provide data for cities to manage and plan more effectively. Charlottesville its current state however is a relatively small and primitive city technologically, so it could use solutions such as better management and parking utilization first before taking these future steps. After taking the right path in growing its parking infrastructure, the city can then foster a greater number of people and support a dynamic environment where many people from all around the world can come to form their own communities in.

## Appendix

### Survey Questions

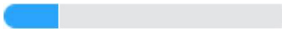
1. Do you own a vehicle?
  - a. Yes
  - b. No
2. What is your main method of transportation?
  - a. Driving
  - b. Carpool / Rideshare
  - c. Public Transit
  - d. Bicycle
  - e. Walking
  - f. Other
3. What is your preferred method of transportation?
  - a. Driving
  - b. Carpool / Rideshare
  - c. Public Transit
  - d. Bicycle
  - e. Walking
  - f. Other
4. How much time do you typically spend looking for parking?
  - a. 1-5 minutes
  - b. 5-15 minutes
  - c. 15-30 minutes
  - d. 30-60 minutes
5. What is the most you would pay for parking?
  - a. \$0 per hour
  - b. \$0.00 – \$1.00 per hour
  - c. \$1.00 – \$2.50 per hour
  - d. \$2.50 – \$5.00 per hour
  - e. \$5.00+ per hour
6. Rank the most three important parking factors for you
  - a. Duration (Park as long as you want)
  - b. Ease of Use (Parking is easy to find and use)
  - c. Convenience (Parking is nearby)
  - d. Cost (Parking is free or cheap)
  - e. Available (Parking is widely available)

7. How would you rate your city's current parking system?
  - a. Extremely Poor
  - b. Poor
  - c. Average
  - d. Good
  - e. Extremely Good
8. What is your preferred method of getting parking information?
  - a. Websites
  - b. Phone (App, Text)
  - c. Digital Signs
  - d. Other (Write a response)
9. What is the biggest issue with your city's parking system?
  - a. (Write a response)
10. How would you improve your city's parking system?
  - a. (Write a response)







## Survey Responses

Conducted through a Chinese teaching platform called Dingding

### 1. Do you own a vehicle?

选项	小计	比例
Yes	4	 19.05%
No	17	 80.95%
本题有效填写人次	21	

### 2. What is your main method of transportation?

选项	小计	比例
Driving	3	 14.29%
Carpool/Rideshare	2	 9.52%
Public Transit	9	 42.86%
Bicycle	3	 14.29%
Walking	4	 19.05%
Other	0	 0%
本题有效填写人次	21	

3. What is your preferred method of transportation?

选项	小计	比例
Driving	7	<div><div></div></div> 33.33%
Carpool/Rideshare	3	<div><div></div></div> 14.29%
Public Transit	6	<div><div></div></div> 28.57%
Bicycle	5	<div><div></div></div> 23.81%
Walking	0	<div><div></div></div> 0%
Other	0	<div><div></div></div> 0%
本题有效填写人次	21	

4. How much time do you typically spend looking for parking?

选项	小计	比例
1-5 Minutes	6	<div><div></div></div> 28.57%
5-15 Minutes	11	<div><div></div></div> 52.38%
15-30 Minutes	3	<div><div></div></div> 14.29%
30+ Minutes	1	<div><div></div></div> 4.76%
本题有效填写人次	21	

5. What is the most you would pay for parking?

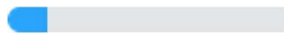
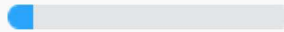

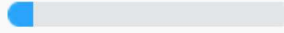
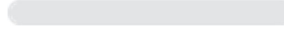
选项	小计	比例
\$0.00 per hour	5	<div><div></div></div> 23.81%
\$0.00-1.00 per hour	9	<div><div></div></div> 42.86%
\$1.00-2.50 per hour	6	<div><div></div></div> 28.57%
\$2.50-5.00 per hour	1	<div><div></div></div> 4.76%
\$5.00+ per hour	0	<div><div></div></div> 0%
本题有效填写人次	21	

6. What are the three most important parking factors to you?

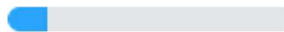
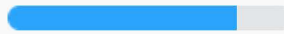
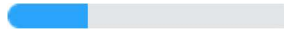
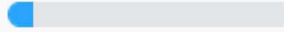
选项	小计	比例
Duration (park as long as you want)	7	<div><div></div></div> 33.33%
Ease of Use (parking is easy to find and use)	17	<div><div></div></div> 80.95%
Convenience (parking is nearby)	18	<div><div></div></div> 85.71%
Cost (parking is free or cheap)	12	<div><div></div></div> 57.14%
Availability (parking is widely available)	11	<div><div></div></div> 52.38%
本题有效填写人次	21	



7. How would you rate your city's current parking system?

选项	小计	比例
Extremely Poor	3	 14.29%
Poor	2	 9.52%
Average	14	 66.67%
Good	2	 9.52%
Extremely Good	0	 0%
本题有效填写人次	21	

8. What is your preferred method of getting parking information?

选项	小计	比例
Websites	3	 14.29%
Phone (app, text)	17	 80.95%
Digital Signs	6	 28.57%
Other	2	 9.52%
本题有效填写人次	21	

9. What is the biggest issue with your city's parking system? (Free response)

- Insufficient/inconvenient parking space (7 responses)
- Too many vehicles (4 responses)
- High/unreasonable fees (2 responses)
- Chaotic parking management (2 responses)
- Illegal parking (1 response)
- Primitive parking system (1 response)

10. How would you improve your city's parking system? (Free response)

- Increase parking space (8 responses)
  - Underground parking lots (3 responses)
  - Modern/vertical parking systems (3 responses)
  - Unspecified (2 responses)
- Improved pricing for parking (3 responses)
- Utilize idle parking spots more efficiently (1 response)
- Pass government legislation to enforce stricter parking (1 response)
- Encourage public transportation (1 response)
- Create a parking app (1 response)

## Bibliography

- Albuja, J., Altavilla, M., LeBeau, E., & Li, S. (2018, Dec). *Developing Future Smart Parking Solutions for Hangzhou's IoT Town*. Retrieved from <https://digitalcommons.wpi.edu/iqp-all/5304/>
- Chinadaily. (2019, Jul 12). *Intelligent parking benefits Hangzhou residents*. Retrieved from <https://www.chinadaily.com.cn/a/201907/12/WS5d283ba8a3105895c2e7d2b8.html>
- City of Charlottesville, VA. (2015). *Comprehensive Parking Analysis*. Retrieved from <https://www.charlottesville.org/home/showdocument?id=40131>
- City of Charlottesville, VA. (2016). *Parking Action Plan*. Retrieved from <https://www.charlottesville.org/home/showdocument?id=47693>
- Duarte, F. & Ratti, C. (2018). The Impact of Autonomous Vehicles on Cities: A Review, *Journal of Urban Technology*, DOI: 10.1080/10630732.2018.1493883
- Erasmus, L. & Toh, M. (2019, Jan 15). *Alibaba's 'City Brain' is slashing congestion in its hometown*. Retrieved from <https://www.cnn.com/2019/01/15/tech/alibaba-city-brain-hangzhou/index.html>
- Gebreselassie, M., & Sanchez, T. (2018, May 30). "Smart" tools for socially sustainable transport: a review of mobility apps. *Urban Science*.
- Liping, Z. (2017, Sep 11). *The entrepreneurs tackling urban China's parking problems*. Retrieved from <https://www.sixthtone.com/news/1000815/the-entrepreneurs-tackling-urban-chinas-parking-problems>
- Mu, X. (2018, Jan 26). *Smartphone apps help ease parking headache in Beijing*. Retrieved from [http://www.xinhuanet.com/english/2018-01/25/c\\_136924972.htm](http://www.xinhuanet.com/english/2018-01/25/c_136924972.htm)