License Plate Readers: Congestion Mitigation Through Dwell Time Analysis in Acadia National Park

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An Interactive Qualifying Project

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In Partial fulfillment of the requirements for the

Degree of Bachelor of Science

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Abstract

This research project explored the potential of utilizing license plate readers for congestion management. With increasing congestion issues at National Parks across the United States, it was imperative to explore effective strategies to alleviate this problem. Specifically, license plate readers were strategically installed at the entrances and exits throughout the main attractions at the park, enabling the collection of plate numbers to collect data. The project resulted in a successful showcasing of the cameras' accuracy and real-time data collection capabilities, enabling meaningful correlations to be established.

Acknowledgements

We would like to express our most sincere gratitude to all who have supported and contributed to this project.

Primarily, our team wants to thank all the WPI (Worcester Polytechnic Institute) professors and staff for giving us this wonderful once-in-a-lifetime opportunity and supporting us along our journey. In addition, we want to thank Friends of Acadia and the park service for their vital role in assisting and guiding us to achieve our goal. Subsequently, we want to thank CCTV Camera Pros for providing the technology that made this project possible.

Our team wants to give special thanks to our advisors, Frederick Bianchi, and Stephen McCauley, for navigating our team through difficult challenges and guiding us throughout the project. In addition, thanks to Professor Alejandro Manga for teaching and preparing our team so we could excel in this real-world project. Lucy Martin, for providing invaluable information and assisting in the research. Adam Gibson and Abe Miller-Rushing, our liaisons, for the opportunity and guidance. Lastly, James Haldas, an amazing engineer, deserves support for his critical role in our project's success.

We extend our deepest appreciation to everyone for their unwavering support and guidance. Your presence has played an instrumental role in the success of this project.

Contributions

Sam McCaffery: Sam was the lead writer and editor for much of the report. He contributed significant edits to every section of the writing and directly wrote in sections throughout the paper, such as the abstract, much of the background literature review, and pieces everywhere else. He was also the main contact with the advisors for receiving feedback on editing the paper and communicating that feedback with the group to work out implementation.

Nick Rogerson: Nick did significant research on the effectiveness and safety concerns of license plate readers for the background literature review. He helped make edits in multiple areas throughout the paper, including rewriting sections, and had a key role in setting up the cameras for data collection.

Ben Gilchrist: Ben was the primary liaison with the manufacturer, facilitating the successful operation of the License Plate Readers. He oversaw the successful deployment and testing of the cameras in every case study. His data analysis and conclusions form the basis for our research findings, in addition to his significant writing contributions. He also developed the graphs for the data using Python.

Zachary Pitts: Zach was also a key contributor for data analysis, setting up data sheets in Excel for dwell time calculations and finding summary statistics for the presentation. Zach wrote much of the executive summary and case study methods sections and performed significant reorganization edits to the presentation.

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Executive Summary

Background

Over the years, Acadia has faced a mounting challenge of increasing congestion, which has steadily intensified. It is a complication that has affected visitor enjoyment, park safety, climate pollution, and more. Previous WPI projects in Acadia worked to develop a reservation system that could use dwell time predictions to schedule a full park without overcrowding popular attractions. Recording additional dwell time data led to improved predictions and a better understanding of visitor movement in the park, particularly when addressing congestion.

License plate readers are electronic devices that can capture and record the license plate numbers of passing vehicles. In national parks, LPRs can be used to track vehicles' entry and exit times and their movements within the park. By analyzing this data, park managers can better understand visitor behavior, develop strategies to manage congestion, and improve the overall visitor experience.

With the ability for real-time data collection, privacy is a concern. There were multiple ethical considerations considered, such as location tracking, data sharing, abuse of power, and a lack of regulations and misuse. Our project was specifically reviewed by the International Review Board. However, if Acadia were to put this into full swing it would need to get approval in a more professional and serious manner, which is a process other parks have completed.

Methods

Our project served as a proof of concept for an automated method of collecting dwell time data. We used license plate readers (LPR) to track visitors' dwell times at congested attractions in the park. We conducted our study with two test cameras, batteries, and temporary stands composed of metal stands embedded in buckets filled with sand and rocks, which enabled us to conduct our testing seamlessly, without the need for permanent infrastructure.

Our pair of LPRs captured license plate numbers and entry and exit times, which we were able to match in Excel as well as in Python to record dwell time for each car. We compiled each day of data collection into graphs showing how dwell time changed throughout the day.

We ran case studies at five separate locations: The Cadillac Mountain summit parking lot, the entrance station at the bottom of Cadillac Summit Road, the parking lot at Sand Beach, locations between the Sand Beach entrance station and Otter Cliff turnoff along Park Loop Road, and distant locations between the Visitors Center and the entrance station of Cadillac Summit Road.

Findings

Our Equipment testing revealed an accuracy rate of ninety-six percent. The most common causes for incorrect license plate readings appeared to be bike racks or other objects obstructing the license plates, incorrect focusing of the cameras, unique license plate characters such as numbers or letters being displayed vertically within the license plate, and other issues. Some of these issues could be solved by better camera placement or improved camera software or hardware.

Our proof of concept for retrieving accurate dwell times succeeded at four of the five locations, only failing at Sand Beach because our placement allowed pedestrians to block the cameras. We were able to construct graphs of how dwell time changed throughout a given day, generate statistics on how many cars stayed longer or shorter than certain dwell times each day, calculate an estimate for the percentage of cars driving between two distant cameras without stopping, and figure out what order cars visited the locations of two distant cameras.

Conclusions

We would recommend the use of License Plate Readers and the associated technology to collect statistics and valuable data. Longer-lasting data collection could improve the reservation system by helping make more accurate dwell time predictions by correlating past dwell time with variables such as time of day, weather, visibility, day of the week, and more. A larger fleet of cameras could also help collect valuable real-time data on traffic speeds and parking lot occupancy to identify immediately when parts of the park are congested. The cameras' live feeds could also be used to manually check how some parts of the park look at any given time.

By implementing License Plate Readers, Acadia National Park could minimize congestion and more efficiently fill reservations to enhance the overall visitor experience. This approach could enable rangers and staff to concentrate on preserving the park's natural beauty and ensuring a remarkable experience for all visitors.

1 Introduction

National Parks across the US are experiencing a surge in popularity, but this increased visitor count is causing space constraints. As stated by the National Park Service, "traffic congestion and visitor use patterns are evolving at national parks." (NPS 2023) Without an effective strategy to combat congestion, parks will struggle to ensure visitors' satisfaction and encourage return visits.

Acadia National Park serves as a primary example of a park struggling with congestion. With its renowned attractions, people come from around the world to visit. Even with Acadia's reservation system, which limits access to the park, visitors often find themselves spending precious time in traffic rather than immersing themselves in the park's main attractions.

Fortunately, advancements in technology present a practical solution to alleviate congestion. An innovation such as the license plate reader can address many of the issues. Given the influx of vehicles entering and exiting the park and its attractions, accurately monitoring the number of visitors present can be next to impossible.

By deploying license plate readers, manual data collection efforts can be reduced. These devices offer superior accuracy and speed in data collection compared to conventional methods and efforts. Conclusively, our goal was to utilize license plate readers to mitigate congestion, estimate dwell time, and learn the visitor's movements. Thus, visitors will have a more seamless and enjoyable visit with reduced wait times.

2 Background Literature Review

2.1 Congestion

2.1.1 Congestion Across National Parks in the US

Congestion in national parks has become a significant issue across the United States. As park popularity increases, the inflow of visitors has resulted in overcrowding and challenges. With the sheer increase in population and popularity, parking areas have become constrained, leaving facilities with few options. Therefore, it is vital that efforts are made to mitigate such problems.

2.1.2 Congestion in Acadia

Acadia National Park faces significant congestion issues due to its immense popularity as a tourist destination. The stunning attractions of Sand Beach and Cadillac Mountain draw large crowds, exacerbating the problem. Despite implementing a reservation system at Cadillac Mountain to manage visitor numbers, demand remains high, leading to continued congestion during peak seasons. While the reservation system’s "limitations have helped keep congestion somewhat in check and have reduced illegal parking beyond the site’s one hundred fifty parking spots" (Times, 2021). More work is still needed to ensure the parks remain enjoyable and environmentally stable. The reservation system has been successful in regulating entry to certain areas, but the overwhelming interest has resulted in extended wait times. While reservation systems and other similar systems have seen some backlash, the Cadillac Mountain reservation system has been shown to be effective to "reduce overcrowding and protect the natural resources on the summit" (Times, 2021). Without systems like this, congestion would cause these sites to be unenjoyable, as citizens would need to battle the crowds to enjoy these resources.

FIGURE 1: SUMMIT OF CADILLAC MOUNT WHEN ITS BUSY

2.2 Previous WPI Research

Previous research from WPI has taken various approaches to monitoring vehicle congestion in Acadia for years. The most recent project in this chain was "A WPI Data Science Graduate Team, in the spring of 2022, created a machine learning model that would predict the length of stay of visitors on the summit based on the weather" (Burns, Guilfoyle, Martin-Nucatola, Reynolds, 2022). The effort began with more manual observation, such as manually counting cars at parking lots' entrances in lawn chairs, and from there the focus shifted to cameras and how they could track congestion.

One team set up a system that uploaded images of the parking lot to a website every minute, but even with this automation, it always took some manual work to look through the photos to gather numerical data. "We struggled with manually tracking the number of vehicles we did, so an increase in vehicles to track may be tough to handle. Thus, we suggest using a third party to complete the analysis if more vehicles will be tracked" (Barakian, Golias, Kirsh, and Zhang, 2020). We demonstrated in this paper that License Plate Reader technology could act as this third-party service.

Some teams even found comparable results to our analyses, such as in 2017, when "The team found that during the midday, cars were parked for approximately half an hour. However, for sunrise and sunset, cars arrived at varying times before sunrise and sunset and remained parked until half an hour after sunrise and sunset" (Cosmopulos, Gaulin, Jauris, Morisseau, and Quevillon, 2017). This directly correlates to our findings presented for case study number two.

Much research into congestion had shortcomings that our project hoped to address, such as the team in 2019 who, in the process of implementing a mobile tracking app, ran into the following problem: "[the app] was rejected by Google Play Protect, preventing its distribution. This was crucial because asking members of the public to disable this safety feature was not an option due to ethical concerns" (Plante, Hogan, 2019). Or the team in 2021: "Big data should be recognized as a useful tool for analysis, but it cannot be relied upon as the sole method to predict behavior" (Jozitis, Kern, Lewis, Lu, Shaw, 2021). Both teams contributed significantly to the congestion problem and provided valuable data to the park. However, without more extensive systems such as License Plate Readers, these solutions fall short of the grand task of alleviating congestion.

2.3 License Plate Readers

License plate readers are electronic devices that can capture and record the license plate numbers of passing vehicles. In national parks, LPRs can be used to track vehicles' entry and exit times and their movements within the park. By analyzing this data, park managers can better understand visitor behavior, develop strategies to manage congestion, and improve the overall visitor experience. However, concerns about visitor privacy and security threats have been raised.

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2.3.1 LPR Functions and Applications

Our objectives for LPRs were critical to ensuring the accuracy, effectiveness, and reliability of such technology. Achieving high accuracy is significant and ensures that it can support such accuracy throughout different weather conditions by harnessing the ability to collect data on various metrics such as dwell time, this advanced technology empowers us to access and display real-time data effortlessly, irrespective of our location, offering a wealth of information. Additionally, the real-time data records will allow for past data to be analyzed and compared. This would allow correlations to be made between time of day, day of the week, holidays, time, and even economic variables. The scalability of using technology is crucial, and the park could increase the LPR count to meet their needs.

2.3.2 Accuracy

Based on the License Plate Reader data, the cameras achieved a 96% success rate in capturing car license plates during a fifteen-hour video data collection period. Numerous factors contributed to the failure to pick up some license plates, including obstructions caused by pedestrians and objects like bike racks on cars. Additionally, challenges arose from the camera placement and the speed of the cars. However, the readers proved to have exceptional night vision capabilities and encountered minimal difficulties in reading license plates in low-light conditions.

2.3.3 Ethical Considerations

With the ability for real-time data collection, privacy is a concern. There were multiple ethical considerations, such as location tracking, data sharing, abuse of power, a lack of regulations, and misuse. Our project was specifically reviewed by the International Review Board. If Acadia were to put this into full swing, it would need to get approval more professionally and seriously. However, "such technology is legal in most states, and facing civil liabilities is However, "such technology is legal in most states, and facing civil liabilities is unlikely" (Keith, Gierlack, 2014). Nonetheless, other national parks have implemented license plate readers: Yellowstone, the Rocky Mountains, the Grand Canyon, and others. Although it was not easy to get approved, the parks mentioned above were successful and have found the technology to be of significant use.

3 Methodology

Our goal in combating congestion is to automate the collection of dwell time and other travel data. To achieve this, we aim to set up License Plate Readers (LPRs) at various key park attractions that have an issue with congestion. These LPRs will capture the entry and exit times of cars, allowing us to calculate the duration spent, or dwell time, in different areas of the park. Additionally, we will manually collect license plate numbers to ensure the accuracy of these systems.

Visitor congestion, or overcrowding, is a problem that national parks have been dealing with increasingly over time, even more severely for Acadia. In the last few years, the park has implemented a reservation system to control the congestion at highly visited spots, but the system needs more data on dwell time (how long visitors spend in reserved parts of the park) to predict how many reservations should be sent more accurately each day. Our purpose was to propose a way of automating the collection of dwell time data using LPRs, which can track how long each car spends in portions of the park. Automating this process would allow the park to collect dwell time data over a longer period, which would improve their ability to make judgments when combating congestion and scheduling reservations each day. Our individual goals for this project are shown in the following bulleted list:

- Establish the effectiveness of LPRs in capturing vehicle movement.
- Conduct locational case studies to demonstrate the utility of LPRs to address traffic management challenges in the park.
- Provide recommendations on broader applications of LPR traffic management.

3.1 Objective One: Test the Effectiveness of LPR’s for Collecting Vehicle Position and Movement

3.1.1 Equipment Setup

Our cameras were chosen to facilitate a temporary setup that could function as a minimum viable product. This system could then be used to evaluate the effectiveness of automated license plate detection systems as well as identify viable solutions to present to the park. The Viewtron IP LPR Camera was able to run off battery power and save all data locally to a microSD card. The use of these cameras, along with batteries and temporary stands composed of metal stands embedded in buckets filled with sand and rocks, enabled us to conduct our testing seamlessly without the need for permanent infrastructure.

FIGURE 2: LICENSE PLATE READERS SETUP AT THE SUMMIT OF CADILLAC MOUNTAIN

The final item needed to run our proof-of-concept testing was a simple network switch to connect to the cameras and pull all relevant data as described in the camera instructions. By implementing these systems, we were able to achieve round-the-clock recording of license plates as cars passed through our designated areas. Our approach involved alternating days of recording, followed by dedicated days for data collection and battery recharging, ensuring we could accurately pull data from various locations throughout the park.

3.1.2 Equipment testing

The accuracy of the cameras was assessed in each case study. The testing consisted of taking a video recording of everything the camera saw for one hour during normal operations. After this recording was done, it was then retrieved from the cameras and manually scrubbed to determine all license plates that passed into view of the footage. The scrubbed data could then be compared to the license plates that the camera automatically detected and logged to identify any discrepancies and determine the accuracy of the cameras.

3.2 Objective Two: Demonstrating the Utility of LPR

3.2.1 Case Study Methods

The LPRs capture pictures of license plates with a timestamp of when the pictures were taken, and they also read the letters and numbers off the image. The times and plate numbers are condensed into a table in csv format, which we can read and analyze through an Excel worksheet we set up, an example of which is shown below.

License Plate num	Entry time	Exit time	Dwell time
4SPS81	2:36	5:42	3:06
1WCP19	16:04	19:46	3:42
LG9371	16:01	19:19	3:18

The table above shows the entrance and exit time of the cars and by performing some simple math; we get dwell time.

Using formulas, we were able to match license plates on the entrance and exit cameras to record dwell time for each car, and we could use each car's entrance time to correlate larger trends of how factors like weather or what weekday it is affect dwell time in each location. A graph showing how dwell time changed throughout the day is shown below. This method was further improved by implementing Python programs to automatically calculate various statistics and add additional datapoints that could be analyzed and manipulated.

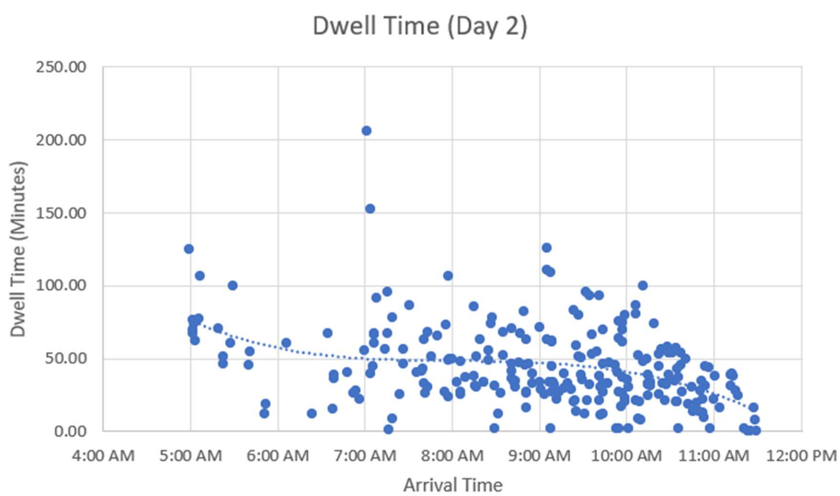

FIGURE 3: A GRAPH COMPARING ARRIVAL TIME VS DWELL TIME

3.3 Case Studies

3.3.1 Case Study #1: Cadillac Mountain Summit Lot

Focus: Dwell time in the summit parking lot

Camera Locations: The parking lot at Cadillac Mountain's summit. Mounted on the grass patch where the road splits at the entrance, one facing in and the other facing out.

FIGURE 4: CADILLAC MOUNTAIN LOCATION AS WELL AS THE CAMERA PLACEMENT IN THE RED CIRCLE

Reasoning: The summit lot is always filled with cars during busy seasons. Predicting visitor dwell time here would help advise the reservation system to unclog this highly sought-after spot.

3.3.2 Case Study #2: Cadillac Mountain Base

Focus: Full Cadillac Summit Road dwell time

Camera Locations: Directly after the reservation stand at the entrance to Cadillac Summit Road. Mounted at the turn to capture back plates of cars going both ways.

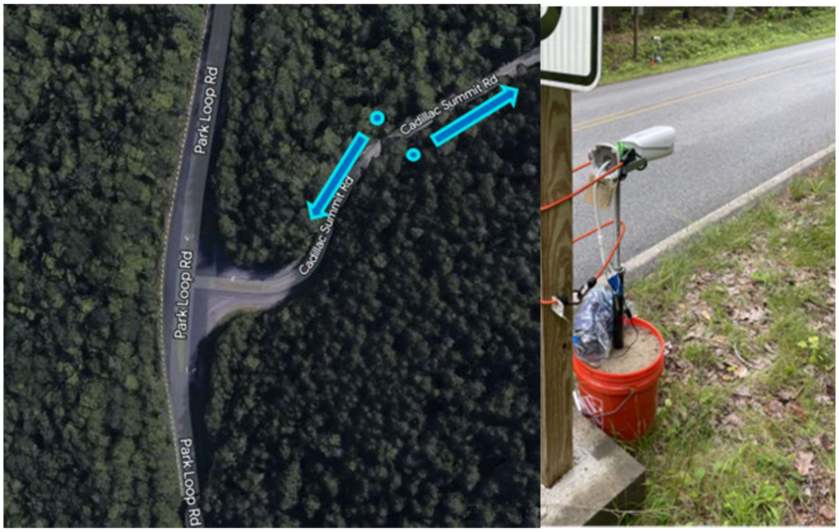

FIGURE 5: BOTTOM OF CADILLAC MOUNTAIN LOCATION AND CAMERA PLACEMENT

Reasoning: Cadillac Mountain reservations are signed in at this stand. Cameras here would capture dwell time for the entire summit road regardless of destination, which would help predict full reservation times and see the difference between how long people spend at the summit versus elsewhere on the road.

3.3.3 Case Study #3: Sand Beach Parking Lot

Focus: Dwell time in the front parking lot for Sand Beach

Camera Locations: Right after the Sand Beach entrance, on the road connecting the parking lot to Park Loop Road. Mounted on the sides of the road, capturing cars coming both ways.

FIGURE 6: SAND BEACH LOCATION AND CAMERA PLACEMENT

Reasoning: This lot serves as a parking spot for as many Sand Beach attractions as visitors are willing to walk to. As a result, the lot is often full, and dwell times may be quite variable since people park here for a variety of purposes.

3.3.4 Case Study #4: Ocean Drive Entrance & Exit

Focus: Full Ocean Drive dwell time

Camera Locations: One facing into the entrance of Ocean Drive (directly after the reservation stands), and the other facing forward further down the road, where Otter Cliff Road connects to Park Loop Road.

FIGURE 7: SAND BEACH TO OTTER CLIFF ROAD LOCATION AND CAMERA PLACEMENT

Reasoning: Ocean Drive has multiple hot spots and, as a result, is constantly packed with cars parked on the side of the road. Dwell time for this whole portion would help the park understand how long each visitor would be expected to occupy some portion of this road.

3.3.5 Case Study #5: Distant Locations

Focus: How capturing data using a fleet of cameras might work in concept and what data it can pick up. By putting significant distance between cameras, we can believe that we can understand the speed patterns, parking patterns and other data useful to the park.

Camera Locations: One camera captures license plates at the entrance of the visitor center as cars come in. One camera captures license plates after the entrance station of Cadillac.

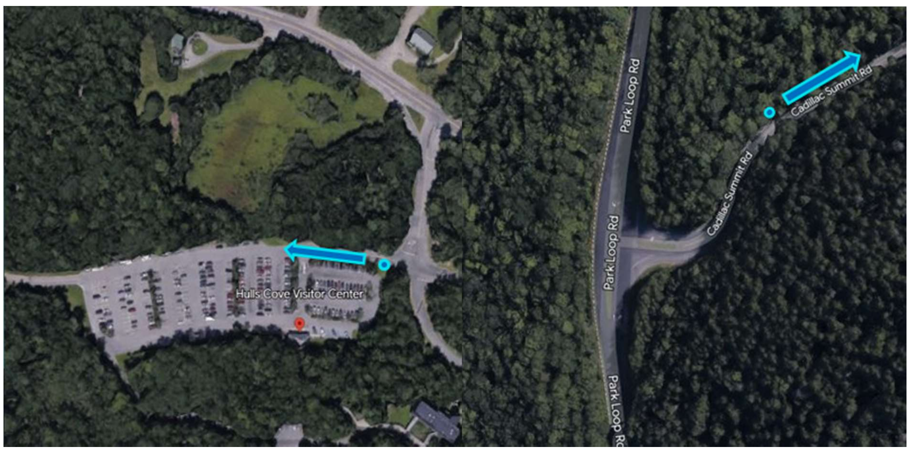

FIGURE 8: VISITOR CENTER AND THE BOTTOM OF CADILLAC MOUNTAIN LOCATIONS

Reasoning: We chose two congested areas of the park to observe: the Visitor Center and Cadillac Mountain. We believe that with this data, Acadia rangers could predict the incoming congestion at various locations in the park using big data from selected sites. Past data can also aid Acadia rangers in determining the most frequently visited location in Acadia.

4 Findings

4.1 Equipment Accuracy

Our Equipment testing revealed an accuracy rate of ninety-six percent. During the normal data recording done at the first three case studies, we also set up video recording for approximately three hours on each camera at each location. This footage was scrubbed to identify any missing cars or inaccurate license plate readings. Very few cars were missed by the license plate readers, with most of the four percent error rate coming from incorrect license plate readings. The most common causes for incorrect license plate readings appeared to be bike racks or other objects obstructing the license plates, incorrect focusing of the cameras, unique license plate characters such as numbers or letters being displayed vertically within the license plate, and other issues. Some of these issues could be solved by better camera placement or improved camera software or hardware; however, no license plate reader can be one hundred percent accurate. These problems are well documented by similar systems, such as the EZPass systems prevalent in many states.

4.2 Case Study #1

Our first case study location at Cadillac Mountain summit revealed a variety of data points that could provide useful information to the park. First dwell time at the east lot of the summit was calculated by placing two cameras on the small island just before the parking lot. With an average dwell time of fifty-four minutes, most cars spend less than an hour in the east parking lot. One problem that the friends of Acadia and park rangers brought to our attention was that many visitors who are unable to obtain sunset reservations purchase a daytime reservation and overstay their welcome until sunset comes. We directly identified this problem within our data most prevalent within six data points.

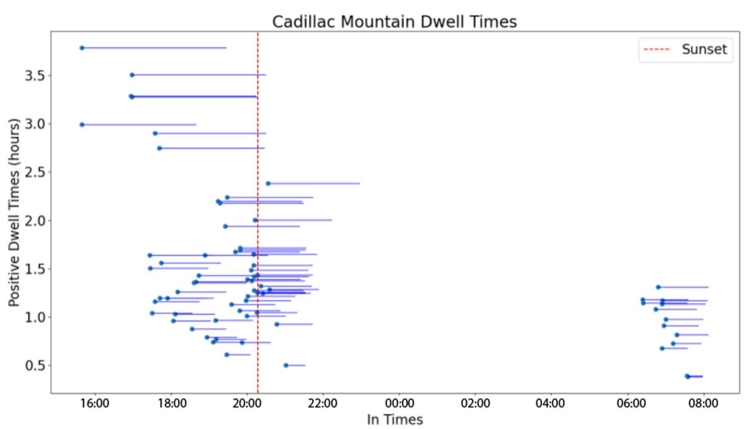

FIGURE 8: VISITOR DWELL TIME LENGTH AND SUNSET TIME

This graph shows the dwell times of various cars graphed against them in time. The aqua dots represent the times cars entered the east lot, graphed against their dwell times. The white lines represent the time that cars stayed on top of the mountain, extending from their entrance time to the right until their exit time. We can see in the top left of the graph that six cars arrived before six p.m. and stayed more than one hundred fifty minutes (about two and a half hours) to approach or exceed the time of sunset. This case study also revealed a unique data point that we had neither expected nor anticipated: our cameras were able to identify cars circling around the east lot, indicating a full lot. This, in combination with our occupancy graph collected from the bottom of the mountain, could provide valuable information on how well the reservation system was working.

4.3 Case Study #2

Our second case study, located at the bottom of Cadillac Mountain just past the entrance station, provided valuable data on how well the reservation system was working. We estimated the dwell time to be ninety-six minutes (about one and a half hours), which is notably longer than between the entrance station and the east lot. This led us to the conclusion that many cars are spending time in locations other than the east lot, such as Blue Hill Overlook. The other data point of significance was the occupancy of the mountain. This graph could be directly used to evaluate the strengths and weaknesses of the reservation system.

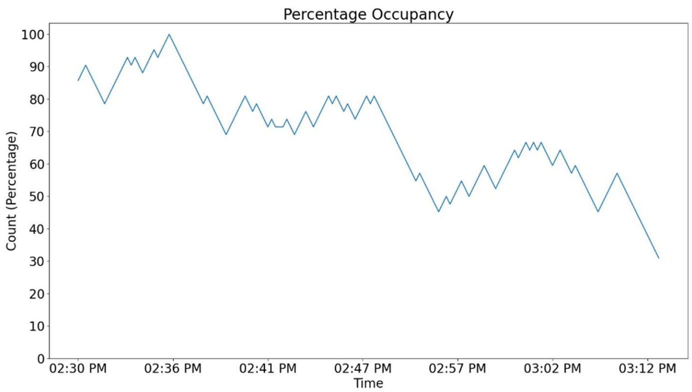

FIGURE 9: THE PERCENTAGE OCCUPANCY DEPENDING ON WHAT TIME OF DAY

This graph shows the percentage representation of how full the parking lots on Cadillac Mountain were. With more data and more accurate formulas this graph could directly be used to identify when more reservations are needed, such as the second half of this graph when occupancy dropped to around fifty percent or when the reservation system is working as intended such as the first half of the graph where occupancy stays around eighty percent. This real time data could have many applications such as displaying capacity on signage to better direct traffic.

4.4 Case Study #3

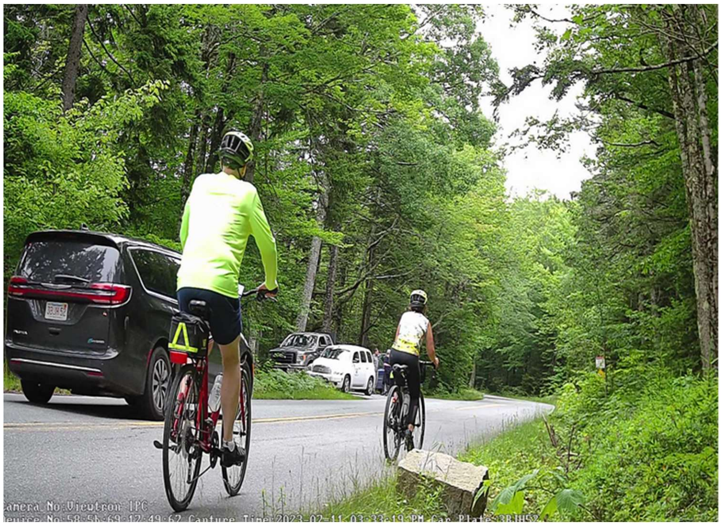

FIGURE 10: PEDESTRIANS OBSTRUCTING THE CAMERAS VIEW

Our third location was the sand beach entrance station, which was a lesson on camera placement and pedestrian movement. Our study only revealed eight cars captured on the entrance and exit cameras. This is a drastically small number compared to the hundreds or even thousands of data points captured at the other case study locations. When studying the footage taken from the Sand beach, the problem was identified as pedestrians walking in front of the cameras. Sand Beach Parking Lot is a rare case study location due to the considerable number of cars and people that travel along the same path. This leads to many people walking directly in front of the camera, rendering them useless. To accurately capture license plates in this location, camera locations would require adjustments to read license plates without the impediment of pedestrians.

4.5 Case Study #4

Our next study focused on a large stretch of park loop road and focused on finding a distinction between cars that park on this stretch of road either in a parking lot or at the right light parking where permitted and cars that proceed without stopping through both cameras. Our findings did identify this distinction and found significant information on dwell time and traffic speed that could assist the park.

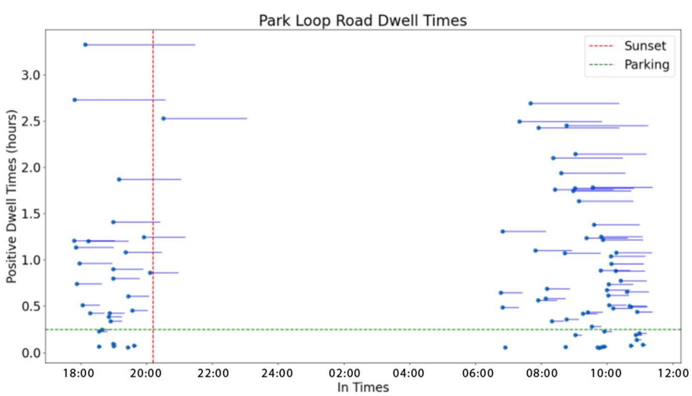

FIGURE 11: DWELL TIME VS SUNSET AND CARS THAT DID NOT STOP AT ANY POINT

This graph shows the cars we captured during an overnight study conducted. We see many cars dwelling around sunset like the Cadillac Mountain graphs. We also can clearly see a sizable percentage of cars that fall below the green line that represents a dwell time of fifteen minutes. Specifically, within our data we identified twenty-two percent of cars spent under fifteen minutes on park loop road. After some simple assumptions we make the claim that our data showed at least twenty-two percent of cars did not stop at any locations between the two cameras (sand beach entrance station and otter cliff road) during our study.

4.6 Case Study #5

Our fifth and final study focused on how a fleet of cameras could assist the parked in identifying traffic patterns around Acadia. This case studied was a success, successfully identifying fifteen cars that traveled between Cadillac Mountain and hull cove visitor center during our data collection. Ten cars were first seen at Cadillac Mountain before proceeding to the hull cove visitor center, while the remaining five was captured taking that journey in reverse. Dwell times varied significantly, with some cars doing the journey in under twenty minutes while others take more than four hours to complete their journey. With a wider fleet of cameras and more significant data points, the parked could learned this valuable information, which could inform decisions such as where to build roads, which roads require additional lanes, and where to placed valuable new attractions such as the moved of the hull cove visitor center.

Cadillac Mountain to Visitor Center	*Visitor Center to Cadillac Mountain*
8m	1h 51m
2h 5m	54m
17m	1h 37m
4h 53m	1h 47m
3h 21m	3h 24m
3h 23m	
11m	
16m	
1h 49m	
2h 21m	

FIGURE 13: TIME TAKEN FOR EACH CAR TO TRAVEL BETWEEN THE TWO DISTANT CAMERAS

5 Recommendations

5.1 The Use of Cameras Within Acadia

We would recommend the use of License Plate Readers and associated technology to collect statistics and valuable data. Our most important statistic, dwell time, could be automatically calculated and provided between any two cameras to monitor congestion, reroute traffic, estimate traffic speeds, or adjust reservations given. Occupancy graphs and datapoints could provide the park and visitors with real-time data pertaining to how full parking lots are, reducing the time spent searching for parking and increasing time spent enjoying Acadia National Park.

5.2 Further Work on Data Correlations

The reservation system could be improved with the guidance of additional data points. With a fleet of cameras, the park staff could get a real-time update on how full the Cadillac Mountain parking lots are. Given this information, the park could analyze the effectiveness of their reservation system. Once the reservation system collects enough data, it can measure its efficiency. For example, visitors may or may not spend significantly less time on the mountain during light rain. However, if enough data could be collected and this correlation could be made, then theoretically, reservations could be given out more often. Thus, allowing visitors to have a seamless experience on Cadillac Mountain.

6 Conclusion

A fleet of cameras could assist the park in a variety of ways, providing data that could be analyzed and used to improve congestion, monitor occupancy of various parking lots, improve the reservations system, add new locations, track vehicle movement, and provide other real-time data to park staff.

In addition to dwell time, occupancy, and various correlations, there are still many features of the camera that could assist rangers both with day-to-day operations and larger infrastructure planning. For day-to-day operations, the park staff could also use these cameras as traditional recording devices and have a live feed across the park to monitor congestion, road conditions, or anything else that requires attention. For large-scale infrastructure planning, a fleet of cameras could inform the park of traffic patterns and speeds. This could aid the park in deciding where to put new roads or buildings, as well as telling the architects and engineers directly how people travel around the park.

By implementing License Plate Readers, Acadia National Park could gather valuable data on vehicle movement, aiming to enhance the visitor experience, accommodate more visitors efficiently, and minimize congestion. This approach could enable rangers and staff to concentrate on preserving the park's natural beauty and ensuring a remarkable experience for all visitors.

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Appendix A: Timeline

Week	Tasks
1	Familiarize with park, work out where LPRs can be hooked up
2	Gather data at Cadillac Mountain, work out ways of analyzing/presenting data
3	Gather data at Sand Beach
4	Gather data at Park Loop Road
5	Extra week for weather flexibility
6	Analyze data / writing week
7	Develop conclusions / finish authoring the report

Note: Weeks 2-5 heavily dependent on weather conditions. The flexibility week existed to ensure we could move days around as the weather demands, to make sure we record under various conditions for each location.