Bar Harbor Project Center

Trail View: Acadia National Park

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Abstract

Acadia National Park is located off the coast of Maine and is made up of over 120 miles of hiking trails. Many people visit Acadia year round to hike these trails and enjoy the beautiful scenery. The main goal for Acadia during the next 100 years is to ensure that these hiking trails are preserved and are accessible to as many visitors as possible. The 2016 Trail View team continued a project that started in the year 2012, where the goal was to create 360-degree panoramic photographs of all the hiking trails and make a virtual tour of them. The 2015 Trail View team was able to photograph about 64.5 miles of trail in Acadia. This year the Trail View team completed the remaining trails that were open to the public. The 2016 Trail View team also created successful virtual reality proof of concept videos for two trails in Acadia as a recommendation for future teams to explore.

Executive Summary

The current goal of the National Park Service (NPS) is to preserve the national parks while making them publicly accessible to all. As a result, the NPS released *A Call to Action*. *A Call to Action* is a written commitment to uphold the overarching goals of the National Park Service while emphasizing the need for increased public accessibility as well as digitization.

The goal of the 2012 Trail View team was to bring Acadia into the digital age by focusing on the production of 360-degree photos of the trails. The 2012 Trail View team made little progress accomplishing this task due to the time-consuming nature of manual image stitching. The 2013, 2014, and 2015 Trail View teams turned their focus to more efficient spherical photography methods. Spherical photography allows the user to pan around an image that is wrapped in a sphere around the user. By linking these pictures together one can have a "virtual tour" of the trails of Acadia National Park, similar to Google Streetview. However, the lack of automatic image stitching technology in previous years led to a labor-intensive post production process.

The goal of the 2016 Trail View team was to finish the project by focusing on photographing the remaining trails and have Acadia National Park create the online tour. Over the past two years, new camera technology allowed the teams to make progress on the project at a faster pace. Through the use of new technology, the 2016 Trail View team was able to photograph 53.6 miles of trail in the park. This mileage, combined with the 64.5 miles from 2015 Trail View, completed the original Trail View mission of photographing the entirety of Acadia's trails. The Park aims to have the photographs online for the public by the winter of 2016.

One recommendation for the next year's Trail View team is to implement a new camera to enable clearer and improved virtual reality videos. A camera that would solve this problem is

the Giroptic 360cam because it allows for stabilized recording and 360-degree video at a high quality. The Giroptic 360cam also has the ability to accurately record sound in 360 degrees. It is a complete upgrade from the Ricoh Theta S, the primary camera for the 2016 team. Another recommendation is to successfully make use of the Oculus Rift headset. In order to do this the 2016 team must purchase a desktop computer that meets the minimum requirements for the Oculus Rift.

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Chapter 1: Introduction

Acadia National Park contains some of the most pristine coastline of the eastern United States. Acadia is operated by the National Park Service (NPS), which was established in 1916 by Congress and President Woodrow Wilson. The NPS strives to protect the parks across the United States while making them easily available for public use.

The NPS issued a planning document entitled *A Call to Action* just before the 100th anniversary of its establishment (A Call to Action, 2011). After a defining 100 years of operation, the goals of *A Call to Action* grew to meet 21st century needs. The plan calls for a renewal of attention to stewardship and the involvement of the public. The plan also details four points that can help the engagement and preservation of the park. Those four points are: (1) connect people to the parks; (2) advance the public education concerning the NPS; (3) preserve America's special places; and (4) enhance professional and organizational excellence. The investment in preservation, and extending the benefits of national parks to the public, will aid the conservation and appreciation for these parks.

Hiking trails are one of the most important forms of interaction and preservation that Acadia National Park can improve to fulfill the goals of *A Call to Action*. Trails allow the public to be surrounded by the beauty of the park, while also preventing unnecessary damage to the ecosystem. Therefore, the accessibility of hiking trails in Acadia is of utmost importance in sustaining and furthering the goals of *A Call to Action*. Unfortunately, not everyone has access to Acadia and its trails, or cannot physically hike the trails themselves. Whether the inaccessibility comes from living far away, or not having the physical ability to hike, the point remains: the public must have access to the trails of Acadia National Park. The WPI Trail View team strives to help solve the inaccessibility problem in Acadia.

The Trail View project began in 2012, when its main goal was to compile 360-degree pictures of the trails in Acadia for online display so that anyone, regardless of location or physical abilities, could view the park. However, due to a lack of proper technology at that time, the 2012 team was unable to completely photograph any trails. Since then, newer technology has become accessible for public use, which has made the task easier to accomplish. In 2015, the Trail View Team had access to a one-shot spherical-picture camera, which allowed the team to photograph 64.5 miles of trail. The 2016 Trail View team will continue using the technology from last year's team to photograph the remaining trails. This will enable those unable to access the park's trails to experience all that Acadia National Park has to offer on a computer. Additionally, the team plans to implement a proof of concept for full 360-degree spherical video of these trails. This allows for a truly immersive experience. This 360-degree video makes the viewer feel as though they were hiking the trail themselves, enabling them to see everything the hiker was seeing at the time the video was made. The goal for this proof of concept was to gather information from the public regarding this new technology. This information will lead this project in a new and exciting direction for years to come.

After every trail has been photographed using 360-degree photo technology, the photos will be sent to the Acadia National Park's web developers. The developers will then organize each photo into interactive views, which the public can then view online as interactive trail views.

Finishing the existing trails will be a major milestone for Acadia and the Trail View project's history. The public will have digital access to approximately 120 miles of trails, providing a solution to the inaccessibility as well as advancing the conservation of the park. The proof of concept for virtual reality offers a new and exciting way to engage people with the

natural surroundings of the trails. Completing the trails and incorporating virtual reality will reflect the goals NPS has cited in *A Call to Action* furthering the preservation and accessibility to the park.

Chapter 2: Background and Literature Review

2.1 The First National Park:

Yellowstone National Park was the first National Park in America, founded on October 1st, 1890 by Congress after vigorous advocacy by John Muir and others. Earlier, in 1889, Muir found that the Yellowstone area was being overrun by domestic sheep and its environment was suffering. Taking this into account, President Benjamin Harrison made Yellowstone a government protected area in order to preserve the beauty of natural America for generations to come. The importance of the national parks today has not been forgotten. These parks provide an irreplaceable natural area for "recreation, education, scholarship, and the preservation of endangered landscapes, natural communities, and species" (Library of Congress, 2016).

2.2 National Park Service:

The National Park Service (NPS) was founded in 1916, by an act of Congress and signed into law by President Woodrow Wilson. The mission of the NPS is to preserve "the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations" (National Park Service, 2006). One major step in the development of the National Park Service was an Executive Order in 1933. This order, issued by President Franklin Delano Roosevelt, transferred 56 national monuments and military sites from the Forest Service and the War Department to the National Park Service. In 2011, with its 100th anniversary in sight, the NPS released *A Call to Action*. In this document, the NPS states: "In our second century, the *National Park Service* must recommit to the exemplary stewardship and public enjoyment of these places" (A Call to Action, 2011). The plan details how the NPS will preserve and promote the national parks throughout 39 Action Points. Some of the points in *A Call to Action* are addressed by the 2016 Trail View project, such as Parks for the People (5),

Next Generation Steward (7), and Go Digital (17). Parks for the People increases the accessibility of national parks to those with the least access. Next Generation Steward strives to educate and excite a new generation of citizens to fuel the interest in national parks nationwide. Finally, Go Digital will offer interactive options and new ways to experience the nature of the parks (A Call to Action, 2011).

2.3 Origin of Acadia National Park:

The hiking and exploration of Mount Desert Island, found in Acadia National Park, began over 5,000 years ago, when Native Americans inhabited the area. "Explorer Samuel Champlain made the first European contribution to the area's recorded history when he landed on Mount Desert Island in 1604" (Acadia National Park, 2014). Sixteen years later, in 1620, the Pilgrims landed at Plymouth Rock and the region became known as New England. It was not until 1759, after over one hundred years of conflict between the French and the English that Acadia came to be under English control. By 1850, settlers were adapting to the area; they were fishing and farming along the coast, as well as clearing out large areas of trees for use as building materials. By 1880, 30 hotels were available for tourists, and the industry of tourism in the area was born.

Acadia National Park was officially founded in July of 1916 by President Woodrow Wilson and Secretary of the Interior Franklin Knight Lane, in an attempt to preserve Maine's natural beauty for locals, tourists, and future generations to experience. This government-protected area "comprises 49,000+ acres of rock-bound coast on Mount Desert Island" and is home to numerous species of wildlife and contains hundreds of miles of trails for travelers (Acadia National Park, 2014). It has different types of terrain, such as mountains, lakes, forests, and a glacial valley that cuts into the island. Considering the ecological variety of the area, it is

appropriate that the island be preserved so that anyone has the opportunity to enjoy it. Notably, Acadia National Park is the first national park to exist east of the Mississippi, far from the first park, Yellowstone. Acadia started out as a small village, but over time it grew to become a popular tourist attraction with hotels and gift shops in the Eastern half of the island for the less adventurous traveler. For the more adventurous, it is home to multiple mountains and over 120 miles of trail, as well as a network of carriage roads funded by John D. Rockefeller's donations.

2.4 Friends of Acadia:

Thousands of people from around the country still enjoy the breathtaking features of Acadia National Park that John D. Rockefeller and many others were generous enough to donate. The conditions of these features that tourists enjoy cannot be maintained without the help of human effort and interaction. The Friends of Acadia, established in 1986, is an independent and motivated organization that "preserves, protects, and promotes stewardship of the outstanding natural beauty, ecological vitality, and distinctive cultural resources of Acadia National Park" (Friends of Acadia, 2016). This organization is a modern effort to continue the work that was first started by those such as John D. Rockefeller.

The Friends of Acadia rely on the loyalty of its members and volunteers to fuel philanthropic events and obtain donations in order to keep the organization operational. Some of the actions of the Friends of Acadia include, "making crucial conservation grants, recruiting and leading volunteers, defending the area against emerging and ongoing threats, and being an advocate for Acadia before Congress and Maine Legislature" (Friends of Acadia, 2016). The trails are of utmost importance for the Friends of Acadia, "the trails and carriage roads have been a central focus of Friends of Acadia's work" (Friends of Acadia, 2016). The actions of the 2016 Trail View team will coincide with similar actions taken by the Friends of Acadia.

2.5 Acadia Trails Forever:

In partnership with the Friends of Acadia is the Acadia Trails Forever campaign. Established in the year 2000, this campaign aims to "rehabilitate Acadia's historic hiking trail system, reconstruct selected abandoned or unmaintained trails, build village connector trails to restore the once-abundant walking connections to the park, and endow the ongoing maintenance of the trails into the future" (Acadia Trails Forever, 2016). Corresponding with the human effort needed to preserve Acadia, the Acadia Trails Forever provides, "thousands of hours of physical labor each year to keep the trails in top condition" (Acadia Trails Forever, 2016). The Acadia Trails Forever campaign has "raised $9 million in private donations and $4 million from national park fees" (Acadia Trails Forever, 2016). The money raised by this organization can also fuel the advancement in technology. The new technology acquired with this money can help fund the preservation of the park for future generations and increase the accessibility of the park.

2.6 Cyber Tourism:

With recent progress in the funding of technology for national parks such as Acadia, developments in camera and lens technologies, and panoramic imaging have improved tremendously. Recently, it has become possible to take panoramic pictures of an area and capture every angle of a walk or route. Since Acadia National Park has been pushing to become more accessible, the next logical step would be to make the trails viewable by those who cannot see them in person due to travel difficulties or inability to hike the trail. This digital technology can also help future generations become more interested, excited and engaged in the preservation and admiration for Acadia. With regards to the inaccessibility of Acadia for many people, "[cyber] tourism will allow participants to travel to places via new technologies free of the usual restrictions of time, distance, cost and human frailty" (Cyber Tourism 2005). The technological

advances in cyber tourism have allowed for the equivalent of Google Street View for any trail that can be photographed, offering an exciting alternative to visit places that were previously inaccessible.

2.7 Auschwitz-Birkenau Museum:

The technological advances in cyber tourism have allowed other tourist destinations to adopt similar practices in order to become more accessible for the public. Although much different than Acadia National Park, one of the tourist destinations that has put cyber tourism into practice is the Auschwitz-Birkenau State Museum in Poland. This museum has addressed the problem of inaccessibility through this modern technology, "unlike physical visitors prohibited from roaming through the remnants of the crematoria, virtual visitors can get a close-up look of the facilities from the outside, the inside, and above" (Kaelber, 2007). This virtual tourism provides visitors with a meaningful experience. It creates a more accessible environment for the museum, "the remnants and surroundings of two large Birkenau crematoria can be explored, with hotspots depicting adjacent elements in the landscape" (Kaelber, 2007). Even when some aspects of the Auschwitz-Birkenau Museum are accessible, the experience can be more interactive through online technology, "online tourism can facilitate communication among the tourists and engage them in or provide them with a wider range of activities and experience than might be possible on site" (Kaelber, 2007). Cyber and online tourism in the Auschwitz-Birkenau Museum solved the same problem of inaccessibility that Acadia is facing in the 21st century.



Figure 1: Auschwitz-Birkenau Museum via online tourism

2.8 Computer Simulation Modeling:

Computer simulation modeling of the carriage road system at Acadia is another way researchers are furthering the preservation of the park. A study conducted in the mid-1990s by the School of Natural Resources collected data on the number of people coming into the park on random days, and used this data to develop a Computer Simulation Model showing the tourist activity level within the park (Wang, 1999). The modeling "explores the utility of computer simulation as a tool for describing visitor travel by building a dynamic model of visitor travel on the carriage roads of Acadia" (Wang, 1999). The purpose of the research was to investigate whether or not Acadia is reaching a carrying capacity level. The carrying capacity of an environment like Acadia National Park is ultimately a measure of how the "increasing numbers of visitors affects the quality of the outdoors recreation experience." There are two aspects of carrying capacity: evaluative and descriptive. The computer simulation modeling research done in Acadia addressed the descriptive component, of which "concerns the travel patterns of visitors within a park and the relationship between use level and indicators of quality" (Wang, 1999).

The environmental quality of Acadia and its carriage roads is a direct result of the preservation efforts taken on its behalf. “The carriage roads simulation model demonstrated that valid models can be built to simulate recreation travel patterns” (Wang, 1999). These conclusions suggest that computer simulation modeling can be used to determine if a National Park is reaching a carrying capacity. This further demonstrates that technology is one solution for the preservation challenges that Acadia faces in the 21st century. This successful research of implementing technology for the preservation of Acadia coexists alongside the ambitions of the 2016 Trail View Team.

Chapter 3: Methodology

3.1 Trail Access:

Virtual access to Acadia National Park is one of the ways that the WPI Trail View team has found in order to preserve Acadia and increase it's accessibility. The 120 miles of trails in Acadia allow people to explore the beauty of this national park without disrupting or harming the ecosystem. Making these trails digital not only furthers preservation, but also allows people who cannot physically walk the trails to experience them on a level not previously possible. Virtual trail access can be implemented as a 21st century solution for the issues of preservation and accessibility.

3.2 Trail Selection:

The 2015 Trail View team photographed 64.5 of the 120 miles in Acadia National Park. This team could only complete 64.5 miles of trails due to the seven-week time restriction each team is under for this project. They were also subject to equipment limitations, having only two cameras that could take the 360-degree panoramic pictures. The battery life on the cameras this team used did not last for a full day's work, further slowing the process. To increase efficiency, the 2015 team prioritized the trails they wanted to photograph. The team prioritized the trails through a series of informal interviews with both Acadia's staff as well as the hikers of Acadia. These informal interviews gave the Trail View team insight on the most sought out trails of the park. They photographed the most popular trails first before the seven-week time period ended.

The first goal of the 2016 Trail View team was to finish mapping the remaining trails, for a total of approximately 120 miles of trail mapped using 360-degree photos. Similarly to 2015, there had to be a system of choosing which trails to map out first. The first step was the process of eliminating the trails that the 2015 team mapped, in order to avoid overlap and to ensure no

trails were left unmapped. This process was immediately faced with difficulty. The combination of differing trail names between Acadia maps and the 2015 IQP paper, and GEO tags that did not match with any existing trails, made the elimination process very time consuming. In order to overcome these difficulties, the 2016 team had to conduct extensive cross-referencing in order to be sure the trails they were eliminating were indeed completed the previous year. This cross-referencing included using multiple maps as well as Internet sources, combined with the 2015 IQP trail chart, and the GPS mapping of the trails the 2015 team previously completed. This thorough investigation of the completed trails ensured no overlap and provided the 2016 team with the trails that still needed to be completed.

After the remaining trails of Acadia were identified, the final step in the trail selection process was to choose the order of which the trails should be mapped. Since the goal was to finish the remaining trails, a simple and systematic process was implemented in order to complete those trails. This process consisted of starting from the western side of Mount Desert Island and working our way towards the College of the Atlantic, located on the east coast. First, the 2016 team completed an easy trail in order to become familiar with the equipment and process of taking the 360-degree pictures. After the familiarization, the team went on to complete the remaining trails. This coast-to-coast approach allowed the Trail View team to spend less time speculating on where to hike and photograph next, and more time on completing the rest of the trails.

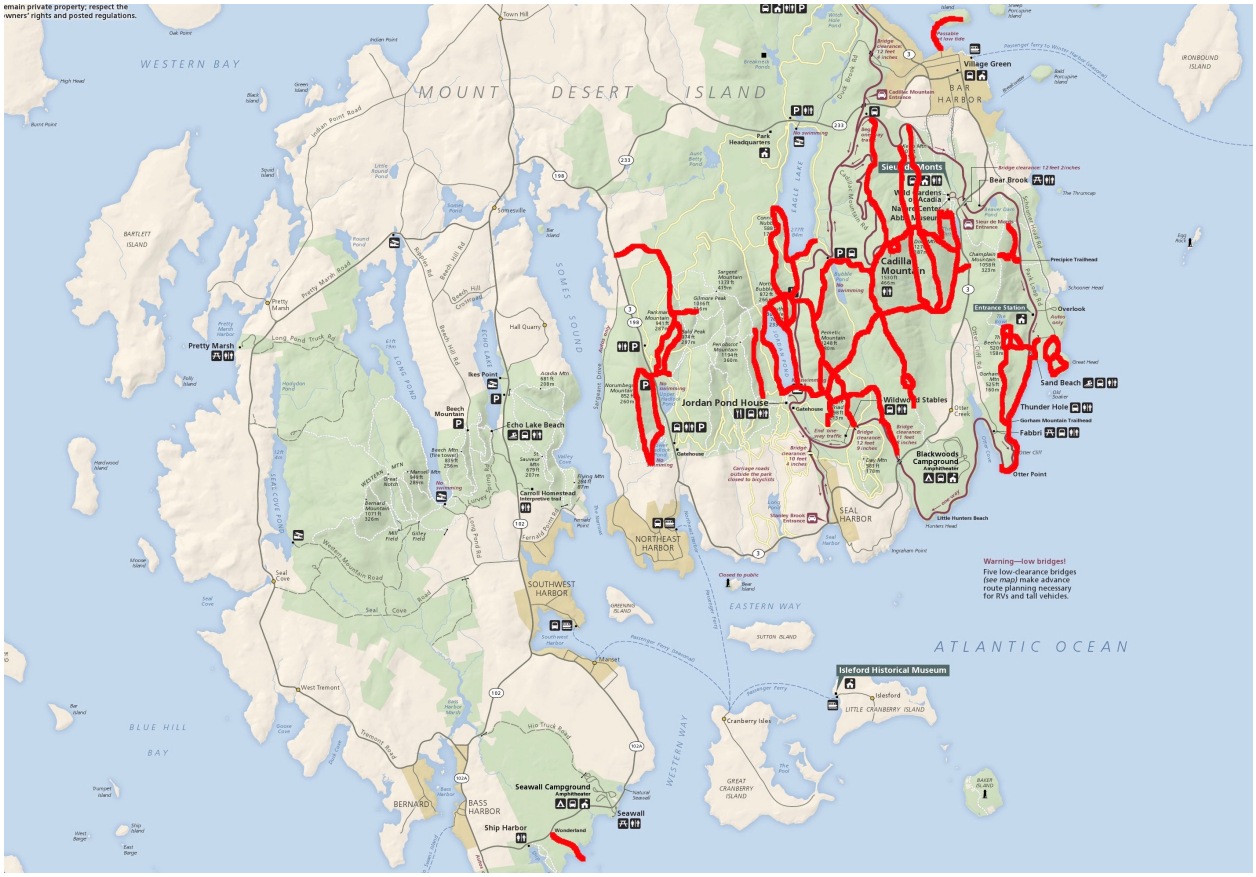


Figure 2: Trails photographed by 2015 Trail View team

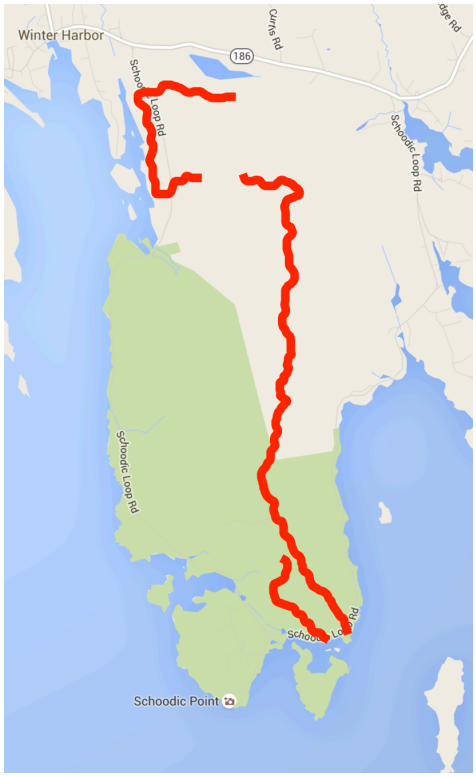


Figure 3: Trails photographed by the 2015 Trail View team cont.

3.3 Equipment Selection:

Once the trails were selected, the proper equipment was chosen in order to document them correctly. In order to decide what equipment was necessary for the project, the team took into consideration the important aspects of the project as well as suggestions from the previous project teams. The equipment chosen included 360-degree cameras, a wooden rod in order to mount the camera, as well as miscellaneous items for attachment of the camera, such as reusable zip ties and duct tape.

3.4 Camera Selection:

The camera selection process depended on the following three criteria: photo quality, ease of use, and virtual reality video recording capability. Each photo needed to not only be taken in 360 degrees, but also at a quality high enough to accurately depict the environment for the

viewer. In addition to 360-degree photos, the 2016 team's camera had to be able to record virtual reality video for the proof of concept. The camera required an interface that allowed the user to preview each photo taken as well as a way to extract the photos and videos from the camera with ease.

The camera that best met these requirements was the Ricoh Theta m15 (Figure 1) that was chosen by the 2015 Trail View team. The Ricoh Theta m15 is a camera with two fish eye lenses capable of capturing a 360-degree photo with a press of a button. Each photo taken by this camera is in 720p high definition detailed quality. This camera was ideal for conducting the 360-degree mapping of each trail. The only criterion that this camera did not meet was the virtual reality video recording. The m15 model did not support recording videos in a quality high enough to demonstrate the beauty of Acadia National Park in virtual reality. To solve this problem, the 2016 group chose to purchase the newest model of the Ricoh family, the Ricoh Theta S (Figure 2). The Ricoh Theta S is capable of taking 360-degree photos as well as virtual reality video in 1080p high definition. This camera was the perfect choice for demonstrating the 2016 team's proof of concept because its high definition virtual reality video recording will make the viewers feel as if they are hiking the trail every step of the way.



Figure 4: Ricoh Theta m15 and Ricoh Theta S

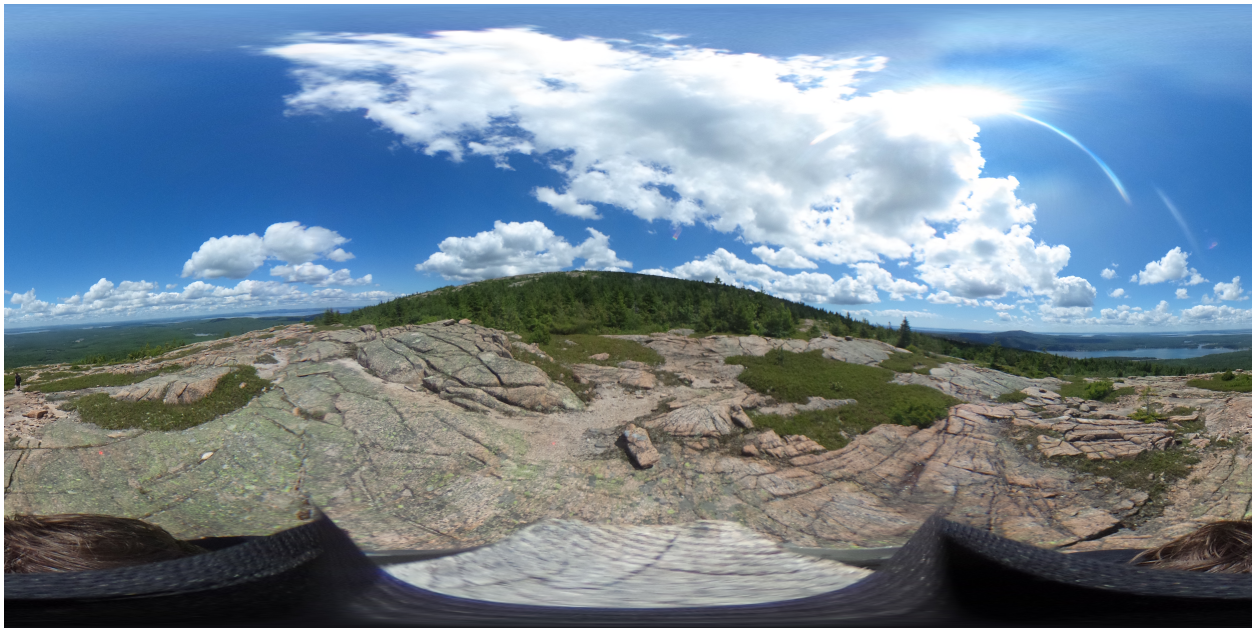


Figure 5: Example of 360-degree photo



Figure 6: Example of 360-degree photo

Both the Theta m15 and Theta S cameras can be controlled using a cell phone application called THETA. The THETA application allows the user to remotely control the cameras from a

distance. This allows for the person taking the photo/video to minimize their visibility in the photos/videos. This feature increases usability for the photographer while minimizing the number of people in each picture. The combination of the Ricoh Theta camera's ability to take a single 360-degree photos and the availability THETA application, eliminated the postproduction time that previous years experienced. To stabilize the camera at a fixed height before every picture, the 2016 Trail View team decided to use a fixed length wooden rod that was approximately 3 feet long. Having the camera attached to the end of the rod by means of the zip ties and duct tape, allowed the rod to easily be stabilized by the user for each picture.



Figure 7: Using the Ricoh Theta m15



Figure 8: Using the Ricoh Theta S

3.5 Taking the Picture:

The main process for documenting each trail was fairly simple and involved walking the trail and using the Ricoh Theta camera to take a picture approximately every 20 yards. Throughout this process, the camera needed to be still and at the same height and position for every picture in order to produce similar pictures. In order to ensure this sufficient production, the hiker needed to stop moving and steadily hold the wooden rod to their forehead to take the picture. The hiker would then move to the next position 20 yards away, and repeat the process.

3.6 Geotagging Equipment:

In a digital trail view that follows a set geographic path, all of the pictures need to have an accurate location geotag. The best way to do this was to use Global Positioning System (GPS). Because of this, the hiker needed to carry a GPS device, even one built within a smartphone would suffice. Since the Ricoh Theta camera was connected to a phone via the THETA application, it used the phone's GPS, making a handheld GPS unit unnecessary. Not needing a handheld GPS made the whole process much more efficient.

3.7 Geotagging Code:

The Ricoh Theta automatically names sequences of pictures 1, 2, 3 and so on, counting up. This means that the pictures are all in chronological order. However, this was not enough for our purpose and the pictures needed to have their geotags associated directly with their names. Thus, last year's team developed a code that takes a picture's associated geotag (if it exists) and adds it to the name. That is, a picture "R0101102" that was taken at 64 degrees North and 45 degrees West will be renamed "R0101102 64N-45W". The full code can be located in the appendix for further examination.

3.8 Virtual Reality:

After considering a technology recommendation from the 2015 Trail View team, the 2016 Trail View team also recorded two trails in a 360-degree virtual reality (VR) video as a proof of concept for future years' projects. In order to complete this task, the 2016 team had to find a 360-degree spherical camera that could handle taking long videos, and that also had a battery life able to last for at least one complete trail. The spherical camera also needed to be able to record video in a large-enough resolution to compensate for the compression algorithms in virtual reality software. The 2016 Trail View team looked at several cameras, but due to

virtual reality being a relatively new technology, many of the cameras observed were either unreliable, or were not available to the public. The one camera the 2016 team found was the newer version of the camera last year's team used, the Ricoh Theta S. With relative ease, one can use this camera to take 65 minutes of video in 25-minute intervals, run them through included software, and take part in a fully immersive experience from the comfort of one's home.

With the Ricoh Theta S camera, the 2016 team also had to choose a virtual reality headset for when the project was complete. There were only a few headsets available, with the least expensive and most accessible headset being the Google Cardboard. Like its name states, the Google Cardboard is simply a cardboard box, but designed to be able to convert images from a user's phone into immersive virtual reality. Another possible headset was the Samsung Gear VR. The team was able to use a Samsung Gear VR that belonged to one of the team members. However, the WPI Trail View teams of the future wont be able to use this headset, since it is owned by a team member. The quality of the video on this device was better than the Google Cardboard. Another option for a headset was the Oculus Rift. This headset had the best video quality and was the most expensive. The team was able to acquire the Oculus, but without the proper computer, the 2016 team was unfortunately unable to implement it this year.



Figure 9: Google Cardboard



Figure 10: Samsung Gear VR



Figure 11: Oculus Rift

With this new technology, it was essential for the 2016 Trail View team to know how the public reacted to these videos, and in what way it could impact their experience with Acadia. The 2016 team took continuous videos of walking various trails to see if the public also felt like they were walking the trail. The setup for taking these videos was nearly the same as the methods for taking photos with the Ricoh Theta m15. However, unlike the 360-degree still images, the virtual reality video did not require the hiker to stop moving. The hiker secured the wooden rod in the recording position and hiked the entire trail with it fixed in that position.

3.9 Tourist Interactions:

Once all the trails were photographed with the 360-degree cameras and some virtual reality videos were completed, the 2016 team conducted demonstrations at the Sieur De Monts Nature Center. These demonstrations took place from 11:00am to 2:00pm on July 13th and 21st. For these demonstrations, a table was set up outside the Nature Center with virtual reality

equipment (the smartphones, Google Cardboards, and Samsung Gear VR) for the visitors to experiment with. As visitors passed by the table, they were politely asked if they would like to try the virtual reality technology that displayed trails they might be familiar with. Once the visitors tested the equipment, the team proceeded to interact with them and ask them questions about their experiences. The questions pertained to whether or not the user enjoyed the experience, what could have been better, whether or not they would use the technology to preview trails, and what location they think would be the most useful for the implementation of the technology. The main goal was to gather information from the visitors about their opinions on the VR technology.



Figure 12: Using the Google Cardboard



Figure 13: A child using the Samsung Gear VR

3.10 Ethics:

Another important aspect the team took into consideration was the rules from WPI's Institutional Review Board. The Institutional Review Board's main goal is to ensure that the privacy and safety of each informant, interviewee, or survey participant is preserved. In order to preserve the visitor's privacy, if people were photographed, their faces were blurred out during post-production. Also, when conducting questions, no one was forced to answer any questions; everything was done voluntarily.

Chapter 4: Results

The 2016 WPI Trail View team successfully completed taking 360-degree photos for the remaining 50 miles of trail in Acadia National Park. The 2016 Trail View team also provided a successful proof of concept virtual reality experience for Beehive Trail and Emory Path.

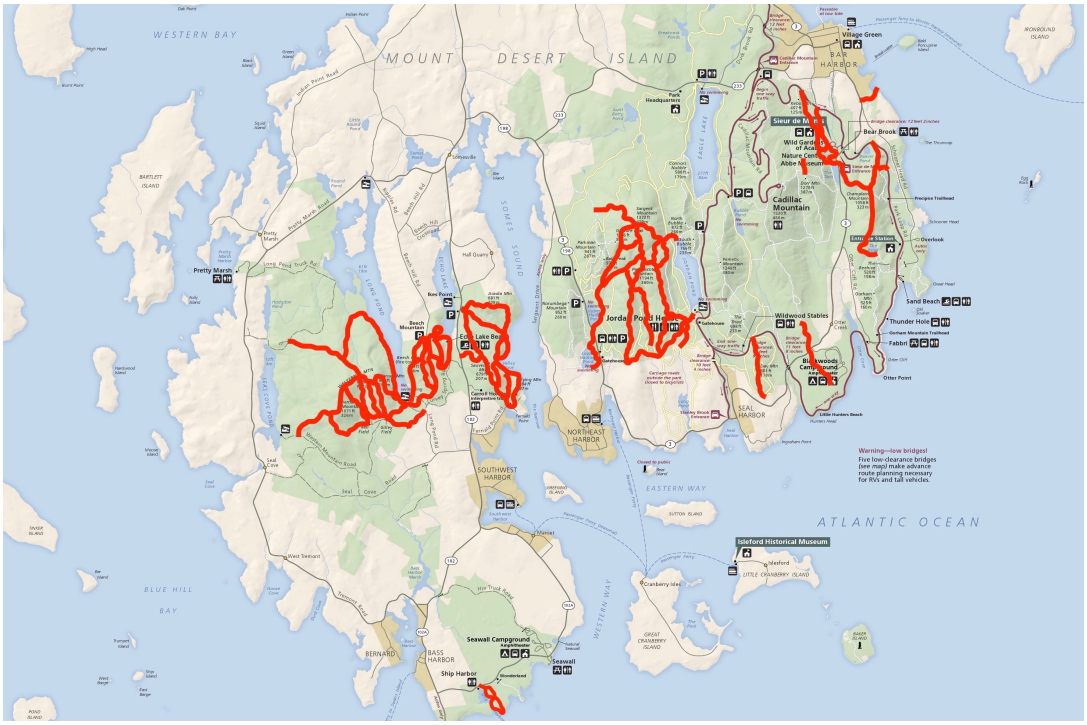


Figure 14: Trails completed by the 2016 Trail View team

4.1 Changes in Methods:

The original method of photographing the trails was to take 360-degree photos every 20 yards. Also, the team planned to hike together. However, after hiking the first trail, Ship Harbor Trail, the team realized that some changes needed to be made in order to increase efficiency.

The first problem encountered was the amount of time it took to make sure everyone was out of the photo. In order to solve this problem, the team decided to split up into two hiking groups. Each group would consist of two or three people, a wooden rod, one or two battery

packs, and either the two Theta m15 cameras or the single Theta S camera. By doing this, the team was able to cover twice the amount of distance in one day without having to worry about the battery life of the camera. In addition, splitting up into smaller groups decreased the total number of people present in each photo taken.

The second problem addressed was finding a balance for the amount of distance traveled between each photo. The original plan to take a picture every 20 yards quickly proved to be too rigid. To solve this problem, a new rule was implemented. The rule was: wherever a picture was taken, if the photographer could clearly see where the previous photo was taken, as well as where the following photo would be taken, then it was safe to take a picture. This rule proved that for curvy and strenuous trails, more pictures were required. Furthermore, for straight and easy trails, less pictures were required because the visibility was greater. On average, strenuous trails required consecutive pictures as close as 5 yards apart, whereas easy trails required pictures every 30 yards. If the photos were taken any farther than 30 yards apart, a user would not be able to zoom in far enough to see the previous or upcoming photo. Eliminating the strict rule of one picture every 20 yards made the flow of consecutive pictures less rigid and more natural.

4.2 Closed Trails:

Acadia National Park has been, for the past 32 years, a safe location for the existence of Peregrine Falcons. Acadia protects these falcons from the first sign of courtship to the time they leave the nest. This entire process happens between April and August. Due to this natural event, some trails where the falcons reside are closed off to the public, preventing the 2016 team from photographing those trails. The trails that were closed off were: Flying Mountain Trail, Champlain East Face Trail, Precipice Trail, and a section of Jordan Cliffs Trail. Since this event

happens every year, in order for the remaining trails to be photographed, the photos would need to be taken before April or after August.



Figure 15: Trails closed due to Peregrine Falcons

4.3 Acadia Park Trails Application:

Of the remaining 50 miles of trail, many contained small and complicated loops that are not easily identifiable on a large map. The 2015 Trail View team completed trails that were long, straight, and well known to the public. For the completion of the remaining trails, the 2016 team needed some assistance for navigating the complicated loops that were left for this year. In order to solve this problem, the team found the "Acadia Park Trails" cellphone application. This application contains all the trails of Acadia on a digital map, and uses a phone's GPS location to plot where the person is located on those trails at any given time. This means that no matter where that person is on the trail, they can pull up the application and locate their exact position. When faced with complicated loops and turns out on the trails, a member of the 2016 team could

pull up the application shortly after they've taken a turn, and ensure they are photographing the correct trail. This application allowed the 2016 Trail View team to hike faster and with more confidence, further improving the efficiency of the project. With a price of only $4.99 and conveniently located in the app store, this application proved to be a worthwhile investment for the 2016 Trail View team.

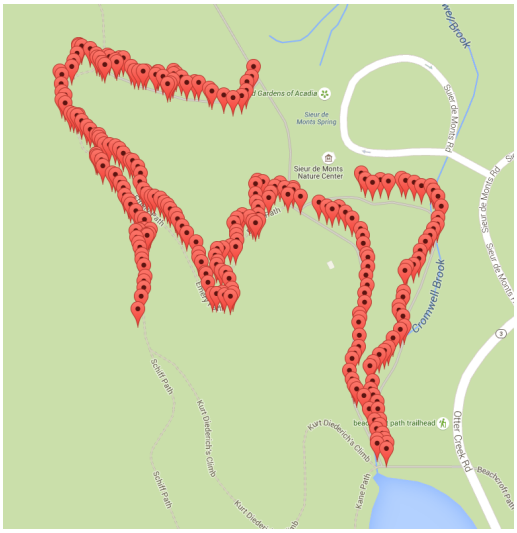


Figure 16: Complicated trail loops

4.4 PhotoGPS:

An obstacle that the 2016 Trail View team faced early on was narrowing down which trails in Acadia still needed to be photographed. Even though the prior team had supplied a list of trails that were completed last year, some trail names did not match up with the names of trails on the map, and the given names did not always describe exactly what parts of trails were done. The original solution for this problem was to convert the GPS coordinates on each picture's name into decimal notation and to mass-plot those points on Google Maps. This was a very time consuming and tedious process, so the team decided to pursue another method.

About a week into the project, Trail View 2016 discovered a free open-source online application called PhotoGPS by Ryan Seys (PhotoGPS, 2016). When a collection of photos is dragged and dropped into the application from a computer's file storage system, it reads the GPS location meta-data from each photo and places a 'pin' on a Google Map's map in the place where each photo was recorded as being taken. Using this application, the 2016 team was able to view a map of all of the trails that 2015's team had completed.



Figure 17: Example of trails via PhotoGPS application

4.5 Correcting Trails:

The online PhotoGPS application revealed some mistakes made by 2015's Trail View team. About 150 photos along the last .7 miles of Cadillac Mountain South Ridge Trail, ending at Route 3, had been incorrectly recorded as been taken in Salisbury Park in Worcester, MA. For a reason unknown to the 2016 Trail View team, each photo for this part of the trail had the same exact incorrect GPS coordinates set in their meta-data. Along with this set of 150 photos, about 15 other photos had GPS coordinates set to random locations across Mt. Desert Island. All of these photos were indeed visually correct. The problem with these photos was that the GPS tags were incorrect. With simple manual meta-data editing, the 15 scattered photos were easily moved back to their correct locations. In order to correct the photos along Cadillac Mountain South Ridge Trail, the 2016 team needed to redo the pictures for that section of the trail.

4.6 Processing the Pictures:

After each day of hiking, the pictures located on the Ricoh Theta cameras needed to be removed from the camera and put into detailed and organized folders. Organization of the photos was essential since they were turned over to a party that had no involvement with hiking the actual trails. The process started by transferring the pictures from the Ricoh Theta onto one of the group's main computers. The pictures were then partitioned into folders and labeled according to the trails they represented. Once the pictures were in labeled folders and on the main computer, the folders were dragged into the PhotoGPS website. Using this helpful website allowed the team to ensure there were no mistakes with the GPS location of the phone, which is essential for future web developers. After all the folders from that day's hiking were checked using the PhotoGPS website, they were then put on a USB disk, and then a master hard drive.

This systematic approach to processing the pictures after each day of hiking kept up with organization for future web developers, and ensured no set of pictures were lost in the process.

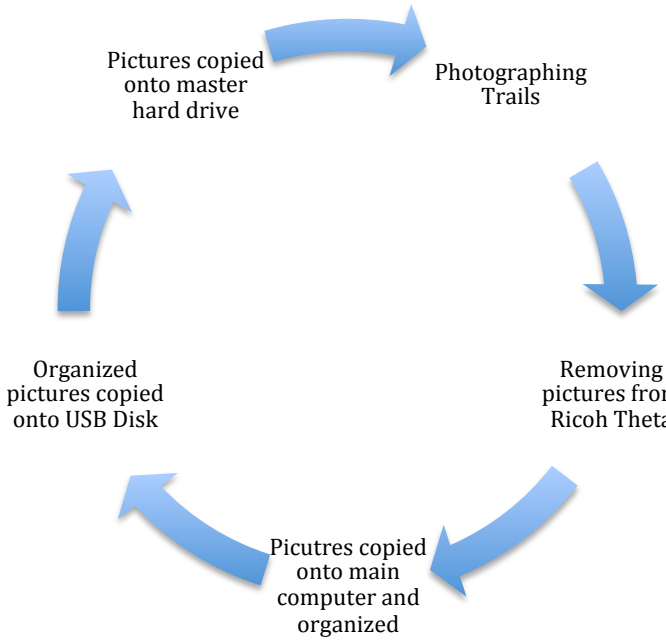


Figure 18: The processing of the pictures

4.7 Accomplished Mileage:

After the 2015 Trail View team completed 64.5 miles, the 2016 team was tasked with completing the remaining 50 miles of trail. The 2016 team was successful in taking 360-degree photos for the remaining 50 miles, including some of the trails from last year that needed to be corrected. The table below shows the trails accomplished by the 2016 team with an approximate distance.

Trail	Distance (miles)
Great Notch	3.1
Great Long Pond	2.9
West Ledge	1.6
Bernard South Face	1.0
Sluice Way	1.0

Razorback	1.4
Mansell Mountain	1.1
Perpendicular	1.1
Cold Brook	0.4
Ship Harbor	1.3
Beech Mountain Loop	1.1
Beech Mountain West Ridge	0.9
Beech Mountain South Ridge	0.8
Valley	1.5
Beech Cliff Loop	0.6
Beech Cliff Ladder	0.4
Canada Cliffs	0.8
Ledge South	0.6
St. Saveur Mountain	1.6
Valley Peak	1.5
Acadia Mountain	1.2
Sargent Mountain North Ridge	1.3
Sargent Mountain South Ridge	2.0
Grandgent	1.0
Maple Spring	1.4
Hadlock	0.8
Hadlock Brook	1.2
Amphitheater	0.8
Jordan Cliffs	0.8
Deer Brook	0.9
Penobscot East	0.5
Penobscot Mountain	1.6
Asticou	1.9
Jordan Stream	0.6
Day Mountain	1.3
Bar Harbor Shore Path	1.0
Strath Eden	1.1
Jesup	1.0
Memorial Trails	2.5
Beachcroft	1.2
Champlain Mountain South Ridge	1.6
Champlain Mountain North Ridge	1.2
Black and Orange Path	0.3
Dorr Mountain	0.2
Cadillac Mountain South Ridge	1.2
Hemlock Road	0.3
Total Trail Mileage	**53.6**

4.8 Data for Acadia:

The web developer for Acadia National Park is Kristi Rugg. As an essential contact for the 2016 Trail View team's work, the 2016 team met with her a couple weeks into the project. During the meeting, Ms. Rugg explained what her interpretations of Trail View's project entailed. She intends to create an interactive map of the park using the 360-degree photos with her development team. The 2016 team gathered, formatted, and organized all of the photos of the 120 available miles of trail for Ms. Rugg. The nearly 50 GB worth of photos were then turned over to her, by way of an external hard drive. Ms. Rugg estimates that the interactive trail view map should be ready for the park website by late 2016.

4.9 Virtual Reality Demonstrations:

The recent developments in virtual reality are new enough to the public that many people have not experienced it firsthand. A goal of the 2016 team was to determine whether or not the public would enjoy viewing a virtual reality video of a trail. To discern how the visitors reacted towards virtual reality, the 2016 team sought and received clearance from Dr. Abe Miller-Rushing to have virtual reality demonstrations at the Sieur De Monts Nature Center. During the demonstrations, the 2016 team asked the visitors informal questions about their experience with the virtual reality technology and recorded their answers. This informal process of gathering results from the demonstration kept the conversation friendly and active between the 2016 team and visitors, making the overall experience enjoyable for the visitors.

After recording the thoughts of multiple visitors, the 2016 team noticed almost unanimous feedback. Nearly all visitors agreed that virtual reality would be beneficial for the park and could help curious hikers determine whether or not they wanted to hike certain trails. Some users also believed this technology could help a hiker determine if they are physically

capable of hiking a certain trail. The 2016 team helped different visitors decide whether or not they could hike trails such as the Beehive Trail. The team used the virtual reality to aid those people to their decision. The virtual reality helped prove to some people they were capable of hiking the trail, while it also proved to other visitors they should not hike a demanding trail such as Beehive Trail. Most visitors also said virtual reality would be helpful for researching a trip online before committing to the actual trip. Furthermore, every group with children who tried the virtual reality thought it was fun and exciting.

Overall, everyone who tried the virtual reality encouraged the idea of it for Acadia National Park, and most people said they would use it for previewing trails. The only complaint given was that the quality of the video was mediocre, which is something that will be improved as the technology develops. Some of the visitors mentioned that prolonged use might cause vertigo. Fortunately, the 2016 team believes that these issues can be easily dealt with through an upgrade in technology, which is expanded upon in chapter 5.



Figure 19: Virtual reality demonstration



Figure 20: A women tries virtual reality technology for the first time



Figure 21: A group of kids enjoy the virtual reality technology



Figure 22: Multiple people trying virtual reality simultaneously

Chapter 5: Recommendations

Although the 2016 team was able to successfully demonstrate a proof of concept for virtual reality, it revealed issues that can hopefully be resolved with recommendations for future years. The 2016 team acquired the Oculus Rift for virtual reality, but without the proper computer to run it, the 2016 team was unable to implement it this year (Oculus, 2016). In the virtual reality videos taken, the 2016 team faced difficulties regarding the quality, stabilization, and sound in those videos. The team investigated extensively to find a solution that best meets all the issues presented.

5.1 Implementing the Oculus Rift:

The first recommendation for next year's Trail View team is to acquire the technology that is required for implementing the Oculus Rift. The challenge for this recommendation is that the Oculus will not run on computers with standard specifications and it will not run on a laptop. It requires a Desktop computer that can meet these specifications:

-Graphics Card: GeForce GTX 970 or AMD Radeon R9 290 or better

-CPU: Intel Core i5 4590 or greater

-RAM: 8GB or more

-Video port: HDMI 1.3

-USB port: 2 USB 3.0 ports

-Windows 7 SP1 or newer

Buying a desktop that meets these specifications can range anywhere from $1500 to $2000. Therefore, the 2016 team suggests future teams acquire the computer parts separately, and build the necessary desktop by hand. Building the required desktop by hand will lower the total cost of the computer tremendously.



Figure 23: The Oculus Rift

5.2 Giroptic 360cam:

The second major suggestion for future years is to upgrade the virtual reality video camera, which will improve the overall experience for the viewer. The 2016 team found a camera that will dramatically improve the virtual reality experience for future users. This camera is called the Giroptic 360cam (Figure 5). The Giroptic 360cam includes all the features of the Theta S and makes several improvements. The Giroptic 360cam records virtual reality in 2000 pixels with 360-degree sound in addition to capturing photos in 4000 pixels. To accompany its improved picture and video quality, this camera also contains a built in gyroscope and accelerometer for image stabilization. This single piece of new technology addresses the quality, stabilization, and audio issues that the 2016 team faced during the first year attempting virtual reality.



Figure 24: The Giroptic 360cam

Chapter 6: Conclusion

The 2016 WPI Trail View team successfully finished taking 360-degree photos of the remaining 50 miles of trail in Acadia National Park. The 2016 team was able to finish photographing these trails by using improved methods for taking the pictures, as well as implementing more camera technology that increased the team's efficiency. The WPI Trail View project has now photographed all available 120 miles of trail in Acadia National Park using 360-degree photo technology. All 18,348 photos have been turned over to Acadia's head web developer, Kristi Rugg. She will use her team of web developers to implement these photos into an interactive online tour of the trails. She hopes to accomplish this project around the end of 2016.

Additionally, the 2016 Trail View team was successful in establishing a proof of concept for virtual reality. This proof of concept would not have been possible without the Ricoh Theta S camera that was implemented this year. The 2016 team has video proof on YouTube of this cutting-edge technology working. To further the proof of concept, the 2016 team conducted virtual reality demonstrations at the Sieur De Monts Nature Center. The public responded with much enthusiasm for this new and exciting technology, and the demonstrations proved to be a huge success.

These successful demonstrations prove that virtual reality is indeed the future of this project. The team recommends an investment in much more advanced virtual reality technology for future years. This will enhance the virtual experience to a level that opens even more opportunities for Acadia using this cutting edge technology.

References

"About Us - Friends of Acadia." Friends of Acadia. Friends of Acadia, 2016. Web. 22 Mar. 2016.

"Acadia Trails Forever - Friends of Acadia." *Friends of Acadia*. Friends of Acadia, 2016. Web. 19 Apr. 2016.

Bar Harbor Info - Acadia National Park. (n.d.). Retrieved April 03, 2016, from http://www.barharborinfo.com/acadia_national_park/

"Brief History of the National Parks - Mapping the National Parks." The Library of Congress. N.p., n.d. Web. 22 Mar. 2016.

Dotson, O. D., Harnais, S. H., Hillman, A. H., Hugger, N. H., Kanellias, M. K., & Bianchi, F. W. F. advisor--H. (2015). Trail View Project. Worcester, MA: Worcester Polytechnic Institute. Retrieved from https://my.wpi.edu/bbcswebdav/pid-615791-dt-content-rid-3248317_1/courses/BH-PROJ-CENTER/Trail%20View%202015%20-%20Final%20Paper.pdf

Kaelber, L. (2007). A Memorial as Virtual Traumascape: Darkest Tourism in 3D and Cyber-Space to the Gas Chambers of Auschwitz. *Ertr, e Review of Tourism Research*, *5*(2), 24-33.

"National Park Service - Home." National Park Service - Home. N. 2006. Web. 22 Mar. 2016. United States. National Park Service. (n.d.). History (U.S. National Park Service). Retrieved April 03, 2016, from http://www.nps.gov/aboutus/history.htm

"Oculus." *Oculus*. N.p., 2016. Web. 23 July 2016.

"PhotoGPS." *PhotoGPS*. N.p., n.d. Web. 23 July 2016.

Ravelli APLT2. (n.d.). Retrieved April 19, 2016, from http://ravelliphoto.com/ravelli-aplt2.html

Ricoh Theta S. (n.d.). Retrieved April 14, 2016, from https://theta360.com/en/about/theta/s.html

Wang, B., & Manning, R. E. (1999). Computer simulation modeling for recreation management: A study on carriage road use in Acadia National Park, Maine, USA. *Environmental Management*, *23*(2), 193-203.

Appendix

Source Code

Please note this code is open source and can be forked at: https://github.com/DeadSocks/Photo-Geotagging

```
# -*- coding: utf-8 -*- from PIL import Image from PIL.ExifTags import TAGS, GPSTAGS
import os import time from shutil import copyfile
def get_exif_data(image):      exif_data = {}
    info = image._getexif()      if info:
        for tag, value in info.items():                decoded = TAGS.get(tag, tag)                if
decoded == "GPSInfo":
                gps_data = {}                    for t in value:
                    sub_decoded = GPSTAGS.get(t, t)                        gps_data[sub_decoded] =
value[t]
                exif_data[decoded] = gps_data                else:
return exif_data
exif_data[decoded] = value
```

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```
def _get_if_exist(data, key):      if key in data:
        return data[key]      return None
def _convert_to_degress(value):      d0 = value[0][0]
    d1 = value[0][1]      d = float(d0) / float(d1)
    m0 = value[1][0]      m1 = value[1][1]      m = float(m0) / float(m1)
    s0 = value[2][0]      s1 = value[2][1]      s = float(s0) / float(s1)
    return d + (m / 60.0) + (s / 3600.0)
def get_lat_lon(exif_data):      lat = None
    lon = None      if "GPSInfo" in exif_data:
        gps_info = exif_data["GPSInfo"]

gps_latitude = _get_if_exist(gps_info, "GPSLatitude")

gps_latitude_ref = _get_if_exist(gps_info, 'GPSLatitudeRef')

gps_longitude = _get_if_exist(gps_info, 'GPSLongitude')

gps_longitude_ref = _get_if_exist(gps_info, 'GPSLongitudeRef')

if gps_latitude and gps_latitude_ref and gps_longitude and gps_longitude_ref:

            lat = _convert_to_degress(gps_latitude)              if gps_latitude_ref != "N":

lat = 0 - lat
```

```
lon = _convert_to_degress(gps_longitude) if gps_longitude_ref != "E":

lon = 0 - lon
#else: # Depriciated, but keep becuase annoying to rewrite if

needed later.           #lat = [((99, 9), (99, 9), (9999, 999))]

#lon = [((99, 9), (99, 9), (9999, 999))] #gps_longitude = [((99, 9), (99, 9), (9999, 999))]
#gps_latitude = [((99, 9), (99, 9), (9999, 999))]

return lat, lon, gps_longitude, gps_latitude
def generateName(lat, lon):#This generates the string that is the
```



```
geotag from the exif data from the file.
return (str(lat[0][0]) + "." + str(lat[1][0]) + "." +

str(lat[2][0])[0:2]+ "." + str(lat[2][0])[2:4] + "N" + "-" + str(lon[0][0]) + "." + str(lon[1][0]) + "."
+ str(lon[2][0])[0:2] + "." + str(lon[2][0])[2:4] + "W.JPG")

def rename(name, indir, outdir):
    global num_taggless      num_taggless = 0      img = Image.open(indir + "/" + name)      imgIn
= open(indir + "/" +  name, 'r')      data = get_exif_data(img)
    lon = get_lat_lon(data)[2]      lat = get_lat_lon(data)[3]      #print lon      #print lat

if lon != None:
nameOfProcFile = generateName(lat, lon)
#nameOfProcFile = str(lat[0][0]) + "." + str(lat[1][0]) +

"." +
str(lon[0][0]) + "." + str(lon[1][0]) + "." + str(lon[2][0])[0:2] + "." + str(lon[2][0])[2:4] +
"W.JPG"

str(lat[2][0])[0:2]+ "." + str(lat[2][0])[2:4] + "N" + "-" +

    else:           num_taggless = num_taggless + 1           nameOfProcFile = "NoGPS.JPG"
    copyfile(indir + "/" + name, outdir + "/" + name[0:8] + " " +nameOfProcFile)
    imgIn.close()

indir = str(input("What's the name of the directory that your unprocessed pictures are in?"))
outdir = "Renamed " + indir
if not os.path.exists(outdir): os.makedirs(outdir)

files = os.listdir(indir) for elt in files:
    print str(elt)
```

```
rename(str(elt), indir, outdir) if num_taggless == 0:
print "All of these photos have GPS data." elif num_taggless == 1:
print "One of the photos doesn't have GPS data." else:
print num_taggless + "photos dont have GPS data."
```