

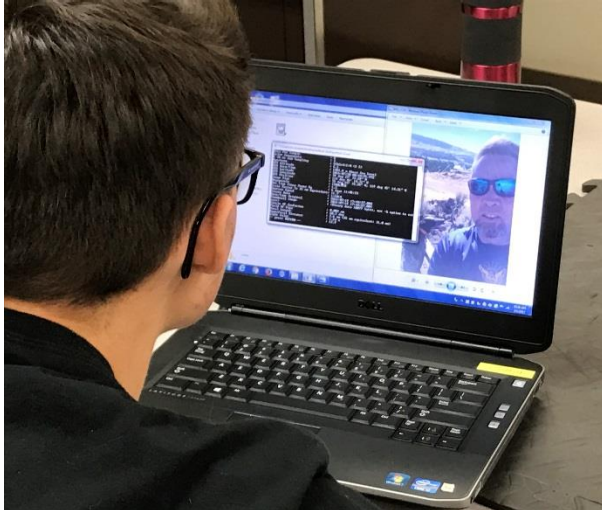
Metadata, positives and negatives.

Subject Area(s) Computer Science, Data Analysis and Probability

Associated Unit Cyber Citizenship

Lesson Title Metadata found in digital images

A digital picture can hide a thousand words.



Student from Carson High School, Carson City, NV analyzes exif metadata

Grade Level _10-11_ (9-12)

Lesson # _1_ of _1_

Lesson Dependency - None

Time Required _5_ Hours

Summary

Metadata is a set of data that describes other data. Metadata can be found in many different file types; however, most individuals overlook or do not realize they are storing metadata every time they take a picture with their smartphone. Often vital information is stored on the jpeg image file, such as the time the picture was taken, the date the picture was taken, and if the smartphone's location data is activated, then the location of where the pictures was taken, recorded in latitude and longitude coordinates. Through this lesson students will learn how to extract Metadata from digital images, analyze the Metadata and locate when and where the images were taken. Students also learn that if they can do this, then criminals can and are searching the web for images that have Metadata. Student also gain knowledge on how law enforcement officials can use Metadata to catch criminals. Most importantly, students learn from this lesson to be proactive in regulating the pictures they take with their smartphones and minimize their image submissions to the web.



Engineering Connection

There are many types of Engineers and regardless of their field of expertise i.e. Nuclear, Mechanical, Bio etc. all of them gather, process, analyze and disseminate information. Collecting Metadata is a fundamental skill of a Digital Forensics Engineer (DFE) who like other engineers uses the Engineering Design Process to find solutions to a myriad amount of cyber-security problems.

Engineering Category = 2. Engineering analysis or partial design

Keywords

- **Metadata** - A set of data that describes and gives information about other data.
- **GPS** - Global Positioning System

Educational Standards

Common Core Standards: ELA/Literacy - **SL.11-12.5**

NV State Standards:

Nevada, 2018, K-12 Computer Science Standards, 9-12.DA.S.2 (Grade 10-11): Evaluate the tradeoffs in how data elements are organized and where data is stored.

Nevada, 2018, K-12 Computer Science Standards, 9-12.DA.CVT.1 (Grade 10-11): Create interactive data visualizations or alternative representations using software tools to help others better understand real-world phenomena.

Nevada, 2018, K-12 Computer Science Standards, 9-12.DA.IM.1 (Grade 10-11): Create computational models that represent the relationships among different elements of data collected from a phenomenon, process, or model.

Connections to other Nevada Academic Content Standards (NVACS) at this grade level:

Science: (9-12.DA.S.2) – HS-ETS1-3, HS-LS2-7, HS-ETS1-2 & 1-3, HS-LS4-6, HS-ETS1-2 & 1-3, SEP8; (9-12.DA.CVT.1) – SEP2, HS-LS2-4, HS-LS2-1 & 2-2, HS-LS3-3, HS-LS4-3, HS-LS4-1, HS-LS4-6; (9-12.DA.IM.1) – SEP2, SEP4, SEP5, SEP8

Mathematics: (9-12.DA.S.1) – SMP 4-7; (9-12.DA.CVT.1) – SMP 4 & 5; (9-12.DA.IM.1) – SMP 4 & 5

ELA: (9-12.DA.S.2) – ELA RI.9-10.8; (9-12.DA.CVT.1) – ELA W.9-10.2a; (9-12.DA.IM.1) – ELA W.9-10.2a

National Standards:

NSS-C.9-12.5 Roles Of The Citizen.

ITEEA Standards

ITEEA, 2000, Standard 4: Technology and Society, I (grades 9-12): The cultural, social, economic, and political effects on technology.

ITEEA, 2000, Standard 6: Technology and Society, I (grades 9-12): The role of society in the development and use of technology.

NGSS Standards

NGSS, 2012, Engineering Design HS-ETS1-1 (grades 9-12): Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

CCSS Standards CCSS, 2010, Math, Practice MP2 Reason abstractly and quantitatively.
(Grades K – 12)

Pre-Requisite Knowledge - None

Learning Objectives

After this lesson, students should be able to:

- Define their role as a cyber-citizen in regards to the ethical practices of locating and using metadata attached to image files.
- Gather, process, analyze, and disseminate Metadata from image files
- Use web based tools to convert latitude and longitude coordinates to street addresses or map location.
- Properly use personal electronics, responsibly regulating their own digital image submissions to the web.

Introduction / Motivation

The instructor goes over the course topic of Citizenship and Responsibility and facilitates discussion between the students using guided questions to make the connection and relevance of good citizenship and responsibility within the confines of the cyber world. The instructor then goes over the topic of personal safety while in the cyber world, facilitating discussion between students. The instructor discusses with the students what metadata is and where it is found. Finally, the instructor facilitates discussion between the students about the positive and negative things that can result from providing a picture of themselves with meta-data to the internet.

The instructor will then demonstrate to the students a short quick way the bad guy could easily find out the meta-data from an image. The instructor uploads an image to Pic2Map an online EXIF viewer website located at <https://www.pic2map.com/>. The instructor then runs the extractor. The students will immediately see a lot of information displayed, in particular the address of where the picture was taken. The website also provides a satellite map of where the location is. The instructor further explains that even though this is a quick way to find out the information, it is not very safe as now the image has been uploaded to the internet and it is forever there. A better and safer way to find the metadata is to process the image the way forensics experts would do it.

The instructor explains that by downloading the Exiftool program, and using it to find the GPS location information from the data, and then recording that information and entering it into a GPS locator website to find the exact location and address, provides a layer of safety that only GPS coordinates are being entered into the internet, throughout the lesson. The instructor will then facilitate discussion between the students on how they think the good guys i.e. police officials could use this skill set, as well as how they think the bad guys would use this skill set.

Lesson Background & Concepts for Teachers

By examining digital photos that contain metadata, extracting that metadata, then using the meta-data to find the date, time and location that the photo was taken, the students develop a more sophisticated understanding of the concept of embedded metadata and how performing the processes of finding the metadata can be used in both positive and negative manners.(See Figure 1) Higher order thinking questions which the teacher should use to solicit *student* explanations and help them to justify their explanations:

- Knowing that Metadata describes data, explain what Metadata describes about a digital image taken with a smartphone? Time, date, GPS location.

- In the description of GPS it says exact position, explain what they mean by “exact position”? Provide an example: GPS-enabled smartphones are typically accurate to within a 4.9 m (16 ft.) radius under open sky (*VIEW SOURCE: <https://www.ion.org/publications/abstract.cfm?articleID=13079>*). However, their accuracy worsens near buildings, bridges, and trees.

Image Figure #1

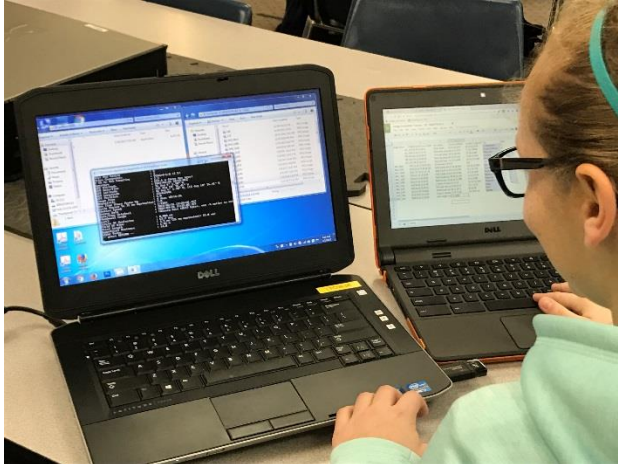


Figure 1. Analyzing Metadata

Vocabulary / Definitions

Word	Definition
Global Positioning System	GPS is a network of orbiting satellites that send precise details of their position in space back to earth. The signals are obtained by GPS receivers, such as navigation devices and are used to calculate the exact position, speed and time at the vehicle’s location.
Image file extension (i.e. .jpg, .png, .gif)	Students learn through observation that certain image types such as .png does not have sensitive metadata embedded and when uploading an image to the internet, they should convert the image to a file extension that does not embed meta-data.
Hacker	By working on the project students will understand the ease at which cyber-criminals such as “Hackers” can obtain sensitive information from digital pictures, posted on the Internet.

Computer Forensics	By working on the project students will understand that extracting metadata is also a tool used by private and public officials in a positive way to assist in solving criminal cases.
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Associated Activities

After demonstration, the instructor has the students use the computer software to practice obtaining metadata from images provided by the instructor. Then the students will take the meta-data and enter it into the GPS location website - www.gps-coordinates.org to determine the exact location of where the pictures were taken. After all students have been able to extract the metadata and find the location of where the image was taken from the known pictures provided by the instructor, they will then be directed to copy pictures from websites on the internet, and then perform metadata extraction on those pictures. After all students have performed metadata extraction on internet images, the instructor will facilitate discussion between students on what they found and if any of the information found was concerning in the realm of cyber security.

Lesson Closure

Metadata is embedded on all digital pictures taken with a smartphone. Even if the smartphone’s GPS is turned off, the date and time are still recorded. By having this knowledge, students can make responsible decisions about whether or not they should upload an image to the internet.

Assessment

Lesson Summary Assessment

Descriptive Title: Tracking metadata for the FBI

- The instructor will provide the cadets with a rubric-based project. The project is based upon a scenario where the FBI provides a forensics team (made up of 4 to 5 students) with a thumb drive. The thumb drive contains images of an older couple on their travels (the images are actual images that the instructor took of his own travels over the years, all images have been checked by the instructor to contain metadata, but not all pictures contain location data). The older couple is suspected by the FBI to be involved in a series of bank robberies across the nation. The FBI wants to find out if any correlation can be obtained from the metadata embedded in the pictures on the thumb drive with the locations of bank robberies that have happened across the nation.
- The student’s/team’s job is to use the Exiftool to read each picture’s metadata, and the GPS Coordinates Finder website (www.gps-coordinates.org) to locate the exact location for where the picture was taken. Each team member should conduct their fair share of the work. This means that if there are 30 pictures and there are five (5) team members, each member should work on six (6) of the images all by themselves.
- Each team will access their Google Classroom, follow the link to the appropriate table folder for their team. Once in the folder, the team will fill out the word document listing all members on the team. The team should title the document with their team number (i.e. period - A1 Table/Team 1). (0 to 50 pts possible)
- Using a spreadsheet kept in their table/team folder, **for each picture**, teams must record the image file name, the date the **original picture** was taken, the GPS Coordinates, the address of

where the coordinates are, and a description of the location of the picture. By using the google spreadsheet the instructor will also have access to the spreadsheet and can look at the modification history and confirm whether or not all students are doing their fair share of the work. (0 to 100 pts possible)

- Using a slide presentation in their table/team folder, the team will create slides for each year starting from the year 2010 to 2018 or whatever the years the images were taken. Students will ensure each slide will have a background of the outline of the United States (see Figure 2). The team will insert small circles where each picture was taken in chronological order. The team will also insert the date next to the circle using yyyyymmdd for the date format (ex. 20170227 = February 27, 2017). Finally the team will insert straight lines between each circle to indicate the travel path taken by the couple that year. By using the google slides the instructor will also have access to the slide presentation and can look at the modification history and confirm whether or not all students are doing their fair share of the work. (0 to 100 pts possible)

Image Figure #2



Figure 2
Image file: IngramPlotPres
ADA Description: Young man looking at computer screen and working on a slide presentation which has the image of the United States
Source/Rights: © Daniel Ingram, Carson High School, Carson Citv. NV

Figure 2. Plotting positional data, for slide presentation

- Once the team has completed their work, they will print all documents, staple them together with the google document on top, spreadsheet second, slides presentation last. (0 to 50 pts possible)

- Each team will be allowed fifteen (15) minutes to present their findings to the FBI (the instructor and their classmates). After the presentation of their findings, each team member will provide a quick outlook on what they found interesting about the project, providing both positive and negative points, and finally what their view about metadata is now as compared to before the start of the lesson. (0 to 100 pts possible)

References

GPS Coordinates Finder website (www.gps-coordinates.org)

VIEW SOURCE: <https://www.ion.org/publications/abstract.cfm?articleID=13079>

Online EXIF viewer website located at <https://www.pic2map.com/>

Attachments

Class Period: _____ **Team:** _____

Date: _____

Image Metadata Tracking Lesson Assignment Rubric

Scenario – The Federal Bureau of Investigation (FBI) has been provided with information that an older couple may be responsible for several bank robberies across the nation. Currently, there is no evidence that links the couple with the robberies; however, the FBI was able to obtain one of the couple’s thumb drives which holds many of their digital pictures. The FBI has tasked your team with finding the date, time and location of where each picture was taken and then put together a timeline of data that the FBI will then cross correlate with the known bank robbery dates, times, and locations.

Directions – Teams will use the Exiftool to read each picture’s metadata, and the GPS Coordinates Finder website (www.gps-coordinates.org) to locate the exact location for where the picture was taken. Each team member should conduct their fair share of the work. This means that if there are 30 pictures and there are five (5) team members, each member should work on six (6) of the images all by themselves.

1. Teams will access their Google Classroom, follow the link to the appropriate table folder for their team. Once in the folder, the team will fill out a google document listing all members on the team. The team should title the document with their team number (i.e. A1 Table/Team 1). **(0 to 50pts) Points Earned** _____

2. Using a google spreadsheet kept in their table/team folder, **for each picture**, teams must record the image file name, the date the **original picture** was taken, the GPS Coordinates, the address of where the coordinates are, and a description of the location of the picture. **(0 to 100pts) Points Earned** _____

3. Using a google slide presentation to be kept in their table/team folder, the team will create slides for each year starting from the year 2010 to 2017. Each slide will have a background of the outline of the United States. The team will insert small circles where each picture was taken in chronological order. The team will also insert the date next to the circle using yyymmdd for the date format (ex. 20170227 = February 27, 2017). Finally the team will insert straight lines between each circle to indicate the travel path taken by the couple that year. **(0 to 100pts) Points Earned** _____

4. Once the team has completed their work they will print all documents, staple them together with the google document on top, spreadsheet second, google slides presentation last. **(0 to 50pts) Points Earned** _____

5. Each team will be allowed fifteen (15) minutes to present their findings to the FBI (the instructor and the other classmates). After the presentation of their findings, each team member will provide a quick outlook on what they found interesting about the project, providing both positive and negative points, and finally what their view about metadata is now as compared to before the start of the lesson. (0 to 100 pts possible) **Points Earned** _____

Again, all team members must work on each of the documents with the exception of the Title Page (Google Document). The instructor will be checking the files in Google Classroom to ensure that each student has entered data. All students should ensure that they use their own Google Account to access the documents to get credit for their portion of the assignment.

Contributors

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Supporting Program

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Classroom Testing Information

March 2017, Carson High School, Carson City NV grade 10 – 70 students, grade 11 – 65 students.