Technological Feasibility

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Caribou Cams

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TABLE OF CONTENTS

1. INTRODUCTION

Large amounts of data take far too much time to analyze by hand. Many corporations face the problem of having too much data with not enough people to analyze it. The result of this is that people have to wait for the data to be analyzed, which can take a long time when just done by people and can result in human error.

Our sponsor, Kathleen Orndahl, is facing this problem of having an immense amount of data that needs to be more efficiently analyzed. With over 3 terabytes worth of data that need to be analyzed, and only human volunteers currently available to analyze it, Katie and her team estimated that the amount of time it would take would be a minimum of 1 year and 1 month before getting all results back. Ideally, she would like to have this information as soon as possible.

An Ecoinformatics Ph.D. student at Northern Arizona University, Katie has teamed up with a group of Ph.D. students at the University of Montana for a project that would analyze the grazing, migratory, and every-day-habits of Alaskan caribou. By attaching video camera collars to these caribou, she and her team have collected over 3 terabytes (90,000+ videos) worth of data, all of which need to be properly analyzed and categorized in order to collect information.

Our client's current process of analyzing the data is that she or her group look through the videos and choose a few to send to volunteers, who then enter information about each video into a google form so that the team can classify the videos accordingly. This information ranges in complexity, starting from things as basic as *quality of videos* to things as complex as *the specific species of plants being eaten by the caribou.* With humans being the ones analyzing these videos, a lot of problems arise, such as:

- *The sheer volume of videos will take a lot of time to analyze*
- *Volunteers have to repeatedly rewatch videos in order to find input for all categories*
- *Volunteers have to spend time inputting data that could have already been previously determined*
- *The transfer of information between the volunteers and the organizers is disjointed and inefficient*

In order to fix the above problems, our team will create an AI machine that will more efficiently analyze the videos, and create a website that allows a better user experience by providing an easier means to input data. These solutions will fix the above stated problems by:

- *The sheer volume of videos will take a lot of time to analyze* will be fixed by implementing an AI that will lower the amount of videos and information that needs to be analyzed

- *Volunteers having to repeatedly rewatch videos in order to find input for all categories* will be partially fixed by creating an AI that will already pre-categorize videos, which will reduce the amount that needs to be analyzed in a video
- *Volunteers having to spend time inputting data which could have already been previously determined* will be partially fixed by creating a website that already prefills all the data found for that video
- *The disjointed and inefficient transfer of information between the volunteers and the organizers* will be fixed by creating a website that will automatically upload the videos instead of the organizers having to look through and send the data

In this document, our team, which consists of team members Samantha Muellner (team lead), Shuyue Qiao, Keenan Swanson, and Dongyang Yu, will focus on the technical challenges that we will have to overcome in order to accomplish the above solutions.

2. TECHNOLOGICAL CHALLENGES

As stated in the previous section, the overall problem of our project is that the videos we have been given must be analyzed in an efficient, accurate, and secure way by not only our AI, but by the volunteers for this project as well. Our team has come up with five major problems that we will be facing, each of which is talked about in detail in the following five subsections.

2.1 VIDEO CLASSIFICATION

Our first major challenge is about how to classify caribou videos. Our AI system will be analyzing an immense amount of videos (over 90,000). We will be provided with base videos that have already been pre-categorized so that we can use something to train our model. Since a CNN (a Convolutional Neural Network) is the only current way to accurately analyze videos, our team will be creating one of these, so for this section we will be exploring the different options about how to create a CNN.

2.2 POWERFUL, SECURE SERVER

The second major problem is about which server we should choose to support our AI. We will be analyzing videos instead of images, meaning the AI that we will create will be much more complex and take a longer time than it would be for just images. This means that a home computer will not have enough processing power on its own to train our model.

2.3 WEB PAGE BACKEND DESIGN

Our third major problem is about the functionality of the web page we intend to design. Since one of our client's major problems is that the way volunteers input information is tedious, we want to be able to design a website that makes it easier and less time consuming for them. For this challenge, we will be exploring backend designs that will make the exchange and storage of data easier for both the client and the volunteer.

2.4 WEBSITE SECURITY

After we complete the design of our web page, the next problem our team will face is how to keep our website secure. Our client doesn't want people to have free access to these caribou videos as these videos are so rare. Thus, in order to create a secure website, we must make sure that both the videos and the information extracted from them are secure from outside threats.

2.5 LINKING WEBSITE AND AI

Lastly, our fifth major problem is that we will need a way to properly link the AI machine and the website together. This problem stems from the idea that we want to be able to upload the AI analyzed videos to our website for further classification by volunteers, but also have the AI able to extract videos from the website in order to better train itself.

3. TECHNOLOGICAL ANALYSIS

In this section, our group will be going into a more in depth analysis of the five challenges of this project discussed in the section before. These challenges are: classifying video instead of images, obtaining a powerful, secure server, applying a helpful backend design, creating a secure website, and linking the AI and website together. Below our team has separated each of these challenges into sections, underneath which we have presented different approaches we can take to solve each challenge, rankings for each of these options based on important metrics, and why we have chosen our final choice.

3.1 VIDEO CLASSIFICATION

The main requirement of our capstone is that we are able to analyze videos of caribou with AI and create a correct prediction about those videos. While our predictions do not need to be extremely detailed (such as what type of plant the caribou are eating), they do need to be accurate. Since it is currently the only way to analyze images with AI, our group has decided on using a Convolutional Neural Network (CNN).

A Neural Network is a set of algorithms that are loosely designed to simulate a human brain. A CNN is a neural network that has had a linear operation applied to it, making the neural network more suited for analyzing images than anything else. A CNN itself consists of two main layers, an input and an output layer, with any amounts of layers in between. These inner layers (determined by the programmer) are where the inputted images are analyzed using different algorithms and matrices that slowly transform the inputted data into a single, desired output.

The challenge that our team is facing with this type of video classification is with how we are going to design the CNN. In the following subsections are three options of designing a CNN that our group has experimented with. For this challenge, our group was most interested in the following three metrics of each option:

- Designability: How much freedom we will have in being able to design our own AI
- Ease-of-use: Whether we will need to create our own functions, how hard it will be to edit the parts of the AI, and how detailed or broad we will be allowed to program the AI and get the results we want
- Accuracy: How accurate of an output will this version of an AI produce

3.1.1 OPTION 1: CREATE OUR OWN CNN

As stated in the parent section before this, a Neural Network (NN) is considered a set of algorithms that are loosely designed to simulate a human brain. A Convolutional Neural Network (or CNN, as we will be referring to it throughout the rest of this paper) is when a neural network's algorithms are linear based, which make the NN specifically designed to analyze images. From an image, the algorithm assigns a level of importance to different aspects and objects of the image, and is able to differentiate them, thereby being able to compare these differentiations against other images.

For this option, our team designed a very basic CNN using Python, as well as performed research over various sites about basic CNNs. Despite that it was supposed to be simple, the CNN ended up being complex to write and required us to learn a lot of new mathematical concepts. Below, we have created a table (*Table 1.1: Create Our Own CNN Metrics Summary Table* (ratings out of 5)) consisting of our findings for the three main metrics we are looking for in this section.

Since we would be creating our own CNN from scratch, the *Designability* of this option would be a 5.0/5 as we could make any needed functions or attributes of the CNN as we see fit. As for the *Ease-of-Use*, our team is giving this option a mere 2.5/5 since we would have to devote a lot of our time to creating the CNN rather than training it. Our team estimates that we will probably have to dedicate half of our time to creating the CNN. This time includes the initial creation, as well as future work such as fixing past methods that aren't working correctly, thus we have taken off 2.5/5 points.

Accuracy we have given a 4.5/5 since, as stated before, we will be creating our own CNN and thus will be able to customize it accordingly to produce the correct results. However, there is a range of error for this option compared to our other options since our team will be in charge of designing all of the functions and how they react with each other, therefore giving us the possibility of creating false positives, so we have taken off 0.5 points to account for this.

Table 1.1: Create Our Own CNN Metrics Summary Table *(ratings out of 5)*

Option	**Designability**	**Ease-of-Use**	**Accuracy**
CREATE OUR OWN CNN	5.0	2.5	4.5

3.1.2 OPTION 2: CNN USING TENSORFLOW

Tensorflow is an open source platform used to create machine learning models of all levels. The framework offers different concept levels to choose from when developing your model, which allows you a very large range of how to go about creating your AI machine [3]. It is a base platform that allows the users to create an in depth CNN that can examine photos and predict outcomes based on the inputs that you give it [3].

With the help of online tutorials, our team created a basic CNN using Tensorflow in Python. In this CNN, we trained and tested images of cats and dogs in order to determine the accuracy, designability, and ease-of-use of this option. Below, is a table consisting of our findings for these three metrics that we are looking for in this section (*Table 1.2: CNN Using Tensorflow Metrics Summary Table* (ratings out of 5)).

Tensorflow allows for multiple levels of concepts that will allow us to choose the appropriate approach to analyze the data [3]. Since Tensorflow already provides us with a base-level framework for a CNN which is easy to manipulate to our needs, our team has given it a 4.0/5 for *Designability*. Since the functions for Tensorflow's framework are predesigned, our team has taken off 1.0/5 for designability since we will be required to use their specific functions in order to create a working CNN using Tensorflow [3]. However, Tensorflow still requires our team to create extra functions in order to complete even the simplest of CNNs. Since this will require our team to spend time getting even a basic CNN to work, we have taken 1.5 points off our rating for the *Ease-of-Use* metric for the time we will have to spend creating the CNN rather than properly training it. Thus, we have given the *Ease-of-Use* aspect a 3.5/5.

As for accuracy, our group found that with the use of 4000 images (2000 each for cats and dogs) the system was 95.7% accurate registering whether an image was for a 'dog' or 'cat'. Since our group will have access to more than 4000 images, we believe that we will be able to create a fairly accurate CNN with this option. Thus *Accuracy* was given a 5.0/5. The decision for this also takes into consideration that it would be relatively

simple for our team to change the desired output based on our training set and input data for the CNN.

Table 1.2: CNN Using Tensorflow Metrics Summary Table *(ratings out of 5)*

Option	**Designability**	**Ease-of-Use**	**Accuracy**
CNN USING TENSORFLOW	4.0	3.5	5.0

3.1.3 OPTION 3: CNN USING KERAS

Keras is a high-level neural networks library that helps to provide CNN programmers with fast and easy prototyping in a friendly, python environment [3]. The use of Keras eliminates time and effort spent on programming the base-level of a CNN by running on top of prebuilt frameworks such as Tensorflow, CNTK, and Theano [3]. This allows programmers to spend their time solely on designing their CNN to accomplish the output they desire rather than having to build one from scratch.

In order to test this option, our team conducted research and created our own CNN using Keras. We trained this CNN using a base-set of 2000 images of cats and dogs (each), then tested it against several different test images. Below is a table that lists our findings for how accurate, designable, and easy to use this option was (*Table 1.3: CNN Using Keras Metrics Summary Table* (ratings out of 5)).

Since Keras is an pre-existing library running on top of other frameworks such as Tensorflow, there isn't a lot of designability left for our team to implement. We are still able to change the input of the functions, and add a few functions it needed, but most of the work for creating the base of the CNN itself has already been taken care of by Keras [3]. If our team uses Keras to create our CNN, then we will have to follow their method as to how to do so, thus, our team has decided to give Keras a 3.0/5 for *Designability.*

Keras provides our team with all the building-blocks needed in order to create a well-working neural network, while also providing ease of extensibility that will allow our team to add in new blocks and easily debug our program [3]. Based on this, and how easily it was for our team to create the CNN using Keras, our team has given Keras a 5.0/5 for *Ease-of-Use*. As for accuracy, we trained our CNN using Keras with 4000 images (2000 of both dogs and cats) and tested it against several images of cats and dogs. The accuracy was around a 97%, and since our group will have more than 4000 images to train our CNN, we will be able to create a higher percentage of accuracy, so we have given *Accuracy* a 5.0/5.

Table 1.3: CNN Using Keras Metrics Summary Table *(ratings out of 5)*

Option	**Designability**	**Ease-of-Use**	**Accuracy**

CNN USING KERAS	3.0	5.0	5.0

3.1.4 SUMMARY

Below is a table that summarizes all of the options we have for the technological challenge of classifying videos.

Table 1.4: Video Classification Options Metrics Summary Table *(ratings out of 5)*

Option	**Designability**	**Ease-of-Use**	**Accuracy**
CREATE OUR OWN CNN	5.0	2.5	4.5
CNN USING TENSORFLOW	4.0	3.5	5.0
CNN USING KERAS	3.0	5.0	5.0

For video classification, *Accuracy* was our most important metric, but two of our options turned out to have a 5/5 for accuracy, so to determine between these two we used our second most important metric, *Ease-of-Use*, which led our team to decide on using the third option: creating a CNN using Keras. Despite this option having the lowest *Designability*, our group found this to be more good than bad. Since there are already options that provide us with a pre-designed base-level for CNNs, our team decided that we didn't need to spend time trying to create our own CNN from scratch. Since Keras is already running on the top of Tensorflow and other helpful platforms, we found it also unnecessary to choose option two alone as part of the coding was tedious in comparison to Keras yet accomplished the same goals.

Using the pre-existing Keras will be enough to accomplish our final outcome. This was proven by the demo CNN we programmed to recognize a cat versus a dog. The demo did exactly what we wanted without causing us too much hassle trying in getting it to do so. Programming and setting up the function calls weren't difficult but were personalized enough that we were able to change the specifications to what we wanted. This will be a great help when we are programming our own CNN as some of the things we will be trying to discern from the videos won't need much specifications, while others will need quite a lot.

3.1.5 PROVING FEASIBILITY

For our demo, we will be designing a CNN using Keras that will be used to analyze videos. We will use the predesigned functions to create our basic CNN. Since we have already tried this, we know that it will work well enough. We will then mostly be tweaking the different inputs and functions used so that we can get our desired output. Our end result will be a CNN that can properly train itself and produce an output for each video analyzed.

3.2 POWERFUL, SECURE SERVER

Our second challenge is that our group will need a powerful, secure server capable of analyzing hundreds to thousands of videos in an efficient and timely manner. After testing a basic training of a CNN and analysis of an image on our own personal computers, we found that it takes an average of 9-12 hours to train the AI system with 4000 photos. Since our group will be analyzing videos, which are more complex than images, a basic home computer will not be powerful enough to achieve the sort of analysis we want. Our group has come up with three options that we can use to overcome this challenge. For each of these options, we have three metrics that we are most concerned with meeting:

- Security: We want the clients data to be in a safe environment when the code is being analyzed
- Ease-of-access: We need to be able to access the servers somewhat easily to run large amounts of data. Also, we want the clients to be able to access these services if needed for configuration or management
- Cost: We want to be able to run large amounts of code for a cost within the client's budget (keeping in mind that we currently do not have a budget, thus a 5 would mean the server is free while a 1 means that we have to pay for it)

3.2.1 OPTION 1: MONSOON SERVER

Northern Arizona University possesses as server known as Monsoon, a high-performance computing cluster. A computing cluster is a group of either tightly or loosely connected computers that are seen more as a signal system than separate since they work together in order to process data. The Monsoon Server was acquired so as to further develop the campus-wide Computer and Informatics program [8]. The Monsoon server allows NAU students and affiliates a faster, more efficient way of running their programs.

Through our research of the NAU's Monsoon Server, our team was able to produce the table below (*Table 2.1: Monsoon Metrics Summary Table* (ratings out of 5)*)* that holds the rankings of this challenge's metrics. Based on our research, our team discovered that

there are several steps in order for anyone to get access to the server and the specific data being held and analyzed within it [8]. This means that the server is very secure, but since it is still a cluster server, it is possible for data to be exposed to others that use the cluster, especially if the server has some sort of academic use [14]. Thus, our group has given the ranking of *Security* a 4.5/5, with 0.5 points being removed since there is a chance parts of our data could be shared with others.

For *Ease-of-Access*, the Monsoon Website suggests that it will be relatively easy for us to submit our job but our job will be stored in a queue, meaning we will have to wait an unknown amount of time before receiving our output [8]. It is because of this that our team has taken of a 0.5/5 for *Ease-of-Access*, resulting in a final rating of 4.5/5. Likewise, the website informed our group that we will be allowed to use up to 10 terabytes of storage and it will be of no cost to us nor our client to use it, thus we have given it a ranking of 5.0/5 for *Cost* [8].

Table 2.1: Monsoon Metrics Summary Table *(ratings out of 5)*

Option	**Security**	**Ease-of-Access**	**Cost**
MONSOON	4.5	4.5	5.0

3.2.2 OPTION 2: AWS LAMBDA

Amazon Web Services Lambda, or AWS Lambda, is a service provided by Amazon that can run code without managing servers. It automatically runs the code when Lambda is triggered (by the person submitting the code), making big data processing a faster process [1].

After researching this service, our group has produced the table below (*Table 2.2: AWS Lambda Metrics Summary Table* (with ratings out of 5)), which holds the rankings for each of the aspects for this section. To analyze our code on AWS Lambda, our group would need to upload our code to the server, wait for it to be analyzed, and would then receive the output [1]. Since AWS Lambda is a cloud-based server, it is very difficult to gain access to another person's data. In addition, the data goes through some series of encryption that adds to the difficulty for others to access the data [20]. Therefore, our group has given AWS Lambda a 5.0/5 rating for *Security*.

For *Ease-of-Access*, our team has given this metric a rating of 4.5/5. Since the code will only need to be uploaded to the Lambda service, where it will then automatically execute without us having to do anything else, the *Ease-of-Access* for our group is fairly high. However, our team has docked 0.5/5 points since there is a slight chance that we might have to use other Amazon Web Services, which will cause our group to have to spend a small amount of time on these extra services [1].

Since AWS Lambda's free version only lasts for 37 days, which is too short of a timeline for our team, we would need to be charged for executing our code on their server [2]. This means that our team will be charged either $0.20 per 1 million requests (after our first 1 million requisitions) or $0.0000166667 per GB-Second (after our first 400,000 GB-seconds) per month [2]. Since our group believes that we will exceed 1 million requests, meaning we will use more than 400,000 GB-seconds, we have decided to dock the *Cost* metric 1.5 points. Since the charge is so low, we didn't feel as though we should dock a full 2.0 points but the price is still high enough that, while we are trying to correctly train our dataset, there is a chance we could still rack up a lot of charges, so we felt that docking only 1.0 points wasn't sufficient enough. It is because of this that our group decided on a ranking of 3.5/5 for *Cost*.

Table 2.2: AWS Lambda Metrics Summary Table *(ratings out of 5)*

Option	**Security**	**Ease-of-Access**	**Cost**
AWS LAMBDA	5.0	4.5	3.5

3.2.3 OPTION 3: AZURE

Azure is a set of cloud services that helps deploy code on large frameworks. It gives the opportunity to effortlessly scale your computations and storage up or down. It is owned by Microsoft and used by 95% of Fortune 500 companies (the top 500 largest companies in the United States) [15].

Through research, our team compiled data on this option and how it can be used. Below we present a table of our rankings for each of the three metrics we find important for this challenge (*Table 2.3: Azure Metrics Summary Table* (ratings out of 5)). With the research on security for the Azure servers, our team has concluded that Azure has very secure servers. They execute your code in the cloud which follows several encryption levels and spreads the data around, making it difficult to track [15]. Also, they are very trustworthy brand due to the types of clients they have and the amount of money they invest into security. Hence, we decided to give *Security* a rating of 5.0/5.

Azure does have a nice free option that lasts up to 12 months, but after that a subscription needs to be paid to use the services [6]. For example, they allow 1 million free requests on their server, but after that its $0.20 for each million requests [6]. Since this means that our clients would most likely have to pay in order to train their model in the future, and is on par with AWS Lambda, our team rated *Cost* a 3.5/5, docking points for the same reasons as we did for AWS Lambda.

Using Azure is not too difficult to do, but can be a nuisance. It requires a Microsoft account to be made, and linking the account to the apps being used to gain the premium access, even when on a free trial. Using their services seems a bit confusing, but luckily Microsoft provides helpful tutorials on how to use several of their computing products.

Thus, the rating we've provided for Azure is a 4.0/5, with 1.0 point being lost because our team will have to spend time and effort into learning the ins and outs of how the system works.

Table 2.3: Azure Metrics Summary Table *(ratings out of 5)*

Option	**Security**	**Ease-of-Access**	**Cost**
AZURE	5.0	4.0	3.5

3.2.4 SUMMARY

Below is a table that summarizes all of the options we have for the challenge of obtaining a powerful, secure server.

Table 2.4: Powerful Server Options Metrics Summary Table *(ratings out of 5)*

Option	**Security**	**Ease-of-Access**	**Cost**
MONSOON	4.5	4.5	5.0
AWS LAMBDA	5.0	4.5	3.5
AZURE	5.0	4.0	3.5

While our team believes that *Security* is an important metric for this section, we believe that *Cost* is more important since our team does not have a budget to work with, and the security for each option was high enough not to cause our group concern with any option. With this being the case, we have decided to use Monsoon as our server. We have not only decided to use the Monsoon server because of *Cost*, but also because of how high the ranking for *Ease-of-Access* was. Despite it having the lowest *Security* rating, our team does not feel as though this will be much of a problem, since the 0.5/5 missing from the security rating is simply because there is a possible chance that our information could be shared among other students and faculty. Since we don't believe that many, if any, NAU students or faculty will publish our information if they do somehow get a hold of part of it, this option still seems like the best to us.

Furthermore, after our group is finished with this project, if our client leaves NAU but still wishes to continue training the model, it will be easy for the code to be transitioned over to AWS Lambda since AWS Lambda accepts most programming languages and designs.

3.2.5 PROVING FEASIBILITY

For our demo, our group will create an account to use the Monsoon server and acquire the correct access permissions needed in order to run our program on it. We will then test our basic CNN on the server at least three times in order to see how well and fast it works.

3.3 WEB PAGE BACKEND DESIGN

The current way that volunteers are analyzing videos is tedious for them and our client/her team. The specific problem the volunteers are facing is that they have to input all the video information into a google form, even if some of that information has already been classified.

To eliminate this tediousness and make the process of analysis more efficient and convenient for them, our team has decided to use a software design pattern called Model–View–Controller (usually known as MVC). An MVC is used to separate how the information is presented and accepted by the user from how the information is represented internally [19]. This will help our team with keeping the videos and the information for them well sorted while also providing the users with a good website experience. Our group has come up with three options, each analyzed in the following subsections, that we can use to overcome this challenge. Below are the three metrics that we find most important in deciding which of these options are best:

- Designability: How much of freedom we will have in designing the framework
- Scalability: How well does this application/framework apply to either larger or smaller projects, how easy will the framework handle larger data sets if the amount of data in the future increases, and how well is the application/framework able to hold large to small amounts of data
- Performance: Refers to the speed in which web pages, videos, and data are downloaded and displayed on the user's web browser

3.3.1 OPTION 1: DJANGO FOR PYTHON

A high-level Python web framework, Django helps programmers with rapid development and producing a clean, pragmatic design [4]. Django makes it easier to build better web apps quickly and with less code. The development environment involves installing Python, Django, and a database system, which then allows the programmer to set up a few things before serving a template of the page to the user [16].

Our team conducted research on this framework and produced the table below (*Table 3.1: Django for Python Metrics Summary Table* (ratings out of 5)), which provides the rankings for the metrics important for this challenge.

Compared with other open source technologies, Django offers superior documentation and a wide range of functions [7]. This will allow our team to design our backend the

way that we need to without much hassle. There is no deduction on the designability, so we have given *Designability* a 5/5.

Since a lot of Django is extra functions that we can apply if we need them, but don't have to if we don't, and it provides us with its own built-in databases able to hold both large and small quantities, it has a large scalability [4]. Our team would be able to make our backend as complex or simple as we would like, as can be seen in many other websites that use Django such as *Disqus* and *Instagram*. Since it has such a large scalability, there is no deduction on the designability, we have given the rank of 5/5 for the *Scalability* metric.

With such a large scalability, the speed of Django can change depending on in-depth we design our system. Since our team will need to create a large database that can hold a decent amount of information, we researched the speed of Django and found it Django's own website to rate it as extremely fast [4]. For this reason, we have given *Performance* a 5.0/5 rating.

Table 3.1: Django for Python Metrics Summary Table *(ratings out of 5)*

Option	**Designability**	**Scalability**	**Performance**
DJANGO FOR PYTHON	5.0	5.0	5.0

3.3.2 OPTION 2: RUBY ON RAILS

Ruby on Rails is a web application framework that is extremely productive, allowing a user to develop an application around ten times faster than with typical Java framework [18]. Included in Ruby is everything needed to program a database-driven web application with the use of a Model-View-Controller pattern. Below is a table (*Table 3.2: Ruby on Rails Metrics Summary Table* (ratings out of 5)) that used research done by our group to develop the rating for the different metrics important to this challenge.

Ruby allows its users to write code in any style they choose, making it a multi-paradigm language [10]. With it also having an MVC architecture, the model allows its users to house their code while centralizing logic and rules used for data manipulation [10]. Since Ruby gives its users a lot of options as to how to design their code, as well as provides decent documentation on how to use it, there is no deduction on the designability, our team has given *Designability* a 5.0/5 ranking.

While Ruby on Rails is considered fairly scalable, it's not particularly good at working with small projects, causing more in overhead than it does in actually helpfulness with data [18]. Overhead can also be caused in larger projects, though this is rare. Ruby also provides its own built-in support for SQLite, which will make it easier for our group to use this database. Although our project is very large, only a small possibility will be

affected by system overhead. This situation is still possible, so we deducted 0.5 points, but since there is only a small possibility, it is not worth deducting 1 Points, so we set the scalability to 4.5/5.

As mentioned in the previous section, there was an experiment conducted in 2017 that showed Rub on Rails was faster than Python/Django. Though this was only by 0.7%, that can still be marginal when working with large amounts of data. Since Ruby can cause overhead, which can lead to possibly worse performance, but is better than Python/Django, it did not reach the point of deducting 1 point. Our team has given it a 4.5/5 for *Performance.*

Table 3.2: Ruby on Rails Metrics Summary Table *(ratings out of 5)*

Option	**Designability**	**Scalability**	**Performance**
RUBY ON RAILS	5.0	4.5	4.5

3.3.3 OPTION 3: EXPRESS.JS FOR NODE.JS

Defined as a flexible and minimal Node.js web application framework, Express.js provides a large number of helpful features to develop web (and mobile) applications [5]. It is a framework that helps to make the rapid development of Node based web applications easier for the user [5]. Based on our research of Express.js, we have created the table below (*Table 3.3: Express.js for Node.js Metrics Summary Table* (ratings out of 5)) that summarizes our teams rankings for each of the metrics we find important for this challenge.

The Express.js framework is relatively easy to use and helpful in developing applications that consist of different types of requests [5]. Middlewares have been set up for this framework that respond to HTTP request that will make it easier to manipulate, store, and use data from the website [11]. Based on this, and that Express.js is a way for users to use Node.js easier than just on its own, we have given *Designability* a 5.0/5.

Developers created compatible middleware packages for Express.js that can help solve almost any problems in web development. This means that Express.js has fairly good scalability, however it does not have any simple way to connect to relational databases without going through extra means such as using Object Related Mapping [11]. Since we wanted to store most of the data in a relational database, we didn't have any easy way to connect to the relational database, so we deducted one point and we gave Scalability a 4.0/5 ranking.

Node.js, the platform of Express.js, is asynchronous out of the box, and this makes for real advantages over traditional server-side environments. This asynchrony means applications are easier to develop (don't have to deal with concurrency issues) [16]. So,

Node.js/Express would therefore be better compared with Python. We have given performance a 5.0/5.

Table 3.3: Express.js for Node.js Metrics Summary Table (ratings out of 5)

Option	**Designability**	**Scalability**	**Performance**
EXPRESS.JS FOR NODE.JS	5.0	4.0	5.0

3.3.4 SUMMARY

Below is a table that summarizes all of the options we have for our web page design challenge.

Table 3.4: Web Page Design Options Metrics Summary Table *(ratings out of 5)*

Option	**Designability**	**Scalability**	**Performance**
DJANGO FOR PYTHON	*5.0*	*5.0*	*5.0*
RUBY ON RAILS	5.0	4.5	4.5
EXPRESS.JS FOR NODE.JS	5.0	4.0	5.0

Since our team considered *Performance* to be the most important metric for this section, we have decided to use Django for Python as our web page backend. Our team feels like this will be the best choice since *Designability* and *Scalability* both ranked a 5.0/5, meaning that we can design our backend to be the way that want it without sacrificing anything in return. Django also offers our group its own built-in database, which will be extremely helpful since we play to be storing data in large amounts and don't want to have to go through secondary programs in order to do so.

3.3.5 PROVING FEASIBILITY

For our demo, we will design a basic website using Django for python. We will create a simple connection between a database and our website, allowing information to be exchanged between the two. This information should be viewable to the users of the website where it is being displayed. Our ideal demo would be able to accept information inputted into the website and store it in the database.

3.4 WEB PAGE SECURITY

Since our client doesn't want unauthorized people to have free access to their classified videos, nor do they want them leaking onto the web since they are such rare pieces of information, our team is facing the challenge of making our website secure from outside threats. Our client does not wish to have top-of-the-line, CIA style security, but enough to keep people from freely taking the videos. For this, our team has devised three options as to how we could go about keeping this information relatively safe. Below we have listed the three metrics that we will be using to rank, and decide, our options for this challenge:

- Security: How secure will this type of protection keep the videos and their information
- Ease-of-use: This consists of what lengths we must go to in order to improve our code or add this option to our code
- Speed: The speed at which this level of security will be able to run and how it will affect how fast the website itself runs

3.4.1 OPTION 1: ACCESSIBLE BY LOGIN ONLY

The use of logins came about as soon as the 1960s when people with personal computers wanted to keep their information secure. Website logins came about soon after in order to protect websites that hold personal or sensitive information. Since our website will be holding sensitive information, we need a way to protect it, and one way to do that is to use a login that allows only certain people to access certain information.

In order to test this option, our team created a small website script that could grant login access to a few accounts to check if they can access those videos successfully. We then checked to see if those unauthorized to access the videos could still see them. Below is a table that lists all of our findings from this practice for the specific metrics of this challenge (*Table 4.1: Accessible by Login Only Metrics Summary Table* (ratings out of 5)).

While creating an account is a good level of security that will keep unwanted people from seeing info, a person who is minorly skilled with programming could easily obtain a username and password from a simple login on a website, leading to them being able to access and obtain the videos. Since, for this option, our team would only be making a simple login, perhaps with a simple encryption, we have given the *Security* metric a 2.0/5. We decided to take 3.0 points off because we think this security information wouldn't be hard to obtain as long as someone has a certain programming foundation about web programming.

Since we are only implementing a simple login and password this option, we have given *Ease-of-Use* a 5.0/5. Our team already understand how to implement a simple login and password system, and how to provide a simple encryption to usernames and passwords,

so integrating it into our code would not be hard. With a simple login and password, no extra APIs or modules need to be added to our code in order to make the login work. We would also only be encrypting the data with a simple key (such as multiplying the input by 4), which doesn't take much computation at all, so we have given the metric *Speed* a 5.0/5.

Table 4.1: Accessible by Login Only Metrics Summary Table *(ratings out of 5)*

Option	**Security**	**Ease-of-use**	**Speed**
ACCESSIBLE BY LOGIN ONLY	2.0	5.0	5.0

3.4.2 OPTION 2: SSL CERTIFICATE

Secure Socket Layer (SSL) Certificates establish a secure connection by providing special visual cues called EV indicators, which assure a user that their connection to the site is secure [13]. SSL Certificates are created with a key pair: a private and public key. These keys then work together to create an encrypted connection that keeps the information they open safe and secure as it is transferred and/or stored [13].

In order to test this option, our group researched and tested different sites that included SSL Certificates. Below we have produced a table that holds the ratings based on our research for each of the metrics we find important for this challenge (*Table 4.2: SSL Certificate Metrics Summary Table* (ratings out of 5)).

Since an SSL Certificate goes through so many lengths in order to provide protection, such as double encrypting information, leaving next to no room for our data to be compromised, we have given this option a 5/5 for *Security* [13]. We have also given a 5/5 for *Speed* since an SSL Certificate is seamless and barely takes any extra time to encrypt the data as it is transferred [18]. In fact, certain SSL's can even boost a website's speed by caching your site's content to proxy servers across the globe and then delivering it to users from the proxy server closest to them [12].

With an SSL Certificate, our team will need to go through the process of obtaining one and linking it correctly to our website, so for *Ease-of-Use* we have taken off 0.5/5 for the slight amount of extra work we will have to go through for this option. Other than these few extra steps that we have to do, the *Ease-of-Use* for an SSL Certificate is easy as it would already be integrated into our website and require us to do little else in order for it to work correctly, thus we have given 4.5/5 for this metric.

Table 4.2: SSL Certificate Metrics Summary Table *(ratings out of 5)*

Option	**Security**	**Ease-of-use**	**Speed**

SSL CERTIFICATE	5.0	4.5	5.0

3.4.3 OPTION 3: CODE OPTIMIZATION

Coding itself has been optimized and improved since the day it was first created. Better programs came out, and with them better was to program. In order to protect our code and videos from hacker attacks, code optimization could be a great option. Our team could install an effective program such as Bitdefender, Avast, AVG, and Panda that could keep us up to date on any bugs or flaws. This would help us optimize our code and secure our system from outside threats. Our team has researched each of these programs and produced the table below that holds the ranking outcomes of this challenges metrics (*Table 4.3: Code Optimization Metrics Summary Table* (ratings out of 5)).

Each of the before-mentioned programs will require us to download them and apply them to our website. This will then lead us to having to stay alert for any sort of threat or weakness it might detect, resulting in our team having to fix the problem ourselves. So, we have given this option a 1.0/5 for *Ease-of-Use*. We decided to take 4.0 points off because detecting and fixing flaws are difficult and time-consuming even while using helpful software by us who are undergraduate and don't have enough programming experience. For similar reasons, such as us or other, future programmers having to constantly be aware of what issues might have arisen, we have given *Security* a 2.5/5. We decided to take 2.5 points off because there will definitely be times when a problem will arise and not be fixed for some time. For this score we have also taken into account that, after our team is done with this project, there will likely be no real programmers working on this project. This means there will likely be no changes to the code we finish our project and any weakness we might have missed will never be fixed.

With code optimization meaning that we are simply improving the code of the website itself, this option will most-likely keep the code running at the same amount of time or better than before. However, there is a small chance that making our code safer from threats could end up slowing it down, therefore our team has taken off 0.5 for this rating, resulting in a rating of 4.5/5 for *Speed.*

Table 4.3: Code Optimization Metrics Summary Table *(ratings out of 5)*

Option	**Security**	**Ease-of-use**	**Speed**
CODE OPTIMIZATION	2.5	1.0	4.5

3.4.4 SUMMARY

Below is a table that summarizes all of the options we have for this technological challenge.

Table 4.4: Web Page Security Options Metrics Summary Table *(ratings out of 5)*

Option	**Security**	**Ease-of-use**	**Speed**
ACCESSIBLE BY LOGIN ONLY	2.0	5.0	5.0
SSL CERTIFICATE	5.0	4.5	5.0
CODE OPTIMIZATION	2.5	1.0	4.5

Since *Security* is our most important metric for this section, our group has chosen to use an SSL Certificate. Our team will be using a free certificate, since we don't have funds to pay for one, which should work just fine for what we are trying to accomplish. We feel as though this option is best because the *Speed* and *Ease-of-Use* metrics were also ranked fairly high, meaning that, while we are getting good security, we are also not sacrificing anything else in return.

3.4.5 PROVING FEASIBILITY

For our demo, we will apply our solution to use a free SSL certificate to keep our website secure. We will use some online website security testing tools or SSL server test to evaluate the security level of our website. The result will be based on security standards such as CMS, GDPR, PCI DSS, and HTTP Headers Security Analysis.

3.5 LINKING WEBSITE AND AI

The way our team designed our project is in two parts: an AI machine and a website. We designed these so that they interact with each other, with the AI receiving its training videos from the website as well as posting the videos it has analyzed on the website. In the future, we would like the AI to be able to take further analyzed videos from the website in order to be further trained on these videos (please see *Figure 1: Project Workflow* on page 26 for a visual of how this integration works).

Thus, we must create a way for these two parts to interact with each other. The following three subsections discuss the three options that our team has come up with in

order to solve this complication, each with a rating for three metrics we found most important to help use decide which option was best. The three metrics are as follows:

- Analysis Speed: This will be how fast the website and AI will be able to access the videos, as well as if this will affect the analysis speed of the AI
- Quantity of Analysis: This will consist of how many videos will be able to be analyzed at once
- Integration: How easy will it be for our team to integrate this option into our AI and/or Website

3.5.1 OPTION 1: DJANGO

Django is a high-level Python Web framework that helps to take care of most of the hassle of web development by allowing its user to code in Python [4]. While using Django, any python code that might be used alongside the website can simply be included in the code for the website, thus eliminating a separate step [4].

Our team has done research on Django in order to evaluate this framework. Below is a table (*Table 5.1: Django Metrics Summary Table* (ratings out of 5)) that consists of our ratings for the different metrics based on what we discovered in our research.

Django itself is a fast framework that takes almost no time at all to create and run a website since most low-level options have been abstracted out of it [7]. However, if using Django, our team would program our AI system directly into our website. This would slow down our website exponentially whenever our client wanted to analyze a video with the AI. The more videos we want to be analyzed, the slower the server would run. For this reason, we have given *Analysis Speed* a 2.0/5, taking off 3.0 points since we will be analyzing a lot of videos and thus dramatically slowing down both the speed of our AI and our website. For similar reasons, we have given *Quantity of Analysis* a rating of 1.0/5 since, if we don't want to impact the website's ability to function properly, the AI wouldn't be able to process many videos.

We have also taken into account the fact that, if we build our Python script directly into our website, it will be hard for us to run it on our server when we or our client want to retrain the AI. Our team would either need to submit the python code separate, or the entire website, which aren't certain Monsoon would even be able to run correctly [8]. This is only for training the model. For analyzing a single video, this can be done on the website itself which won't affect the integration of this system at all. Our team has taken off 2.5 points because of the complexities needed to actually be able to train the AI while using this option, resulting in a final score of 2.5/5 for *Integration*.

Table 5.1: Django Metrics Summary Table *(ratings out of 5)*

Option	**Analysis Speed**	**Quantity of Analysis**	**Integration**

DJANGO	2.0	1.0	2.5

3.5.2 OPTION 2: SCRAPING WITH PYTHON SCRIPTS

In 1991, the programming language Python was official invented and brought to the public. Since then, Python has grown to be a well-ranged platform that can produce anything from simple programs to complex programs. Python scripts are powerful programs that can be used to access data in a multitude of places. Accessing data from a website is an easy task for a well-programmed Python script. The script will merely be run and instructed by the AI system to scrape through the provided website for the necessary videos, load them into a data set, and let the AI analyze or train itself from them. For this option, we are assuming that we are embedding the videos directly into the website, which is why they would need to be scraped from it.

Our group designed a python script that scraped videos from a website and stored them in a file. The script efficiently pulled the data we need from the site but was slow despite us not scraping a lot of videos. In the table below (*Table 5.2: Scraping with Python Script Metrics Summary Table* (ratings out of 5)) our team has provided our ratings for each of the different metrics that are important for this challenge based on the research we conducted .

Based on the program we created, our team gave a web-scraping python script a ranking of 1.0/5 for *Analysis Speed* since it was already slow while scraping on a few videos, and we would need to be scraping anywhere between a few to thousands of videos. This means that our *Analysis Speed* of our entire system would be brought down by an enormous amount if we needed more than just a few videos. However, since there is no real limit to the amount of videos that we can scrap and analyze from a website *Quantity of Analysis* was given a 5.0/5.

If we were to incorporate a separate python script into our AI, we would have to program an entirely different script separate of the AI. This would result in our team taking away time and effort from analyzing the videos and testing the AI, and instead putting it towards just trying to get the videos. Despite this, a python script to scrape videos from a website is not that hard to program, so we have only taken off 1.0 point for *Integration* for the extra time and effort needed to be put into creating the script, resulting in a total score of 4.0/5.

Table 5.2: Scraping with Python Script Metrics Summary Table *(ratings out of 5)*

Option	**Analysis Speed**	**Quantity of Analysis**	**Integration**
SCRAPING WITH	1.0	5.0	4.0

PYTHON SCRIPT			

3.5.3 OPTION 3: USE OF FOLDERS

Folders are a time-old invention that were created around the time that computers were first invented. They serve as useful storage places for small to large amounts of data and can be accessed by a variety of means and resources. For this option, our team would simply have both the AI and the website separately access a shared folder that all the videos are kept in.

When originally writing the different types of CNNs, our group used folders to hold the contents of the training set and test set. This made it easy for us to analyze each set individually as there were no extra steps needed, such as the AI having to download the videos first before analyzing them. Likewise, while creating websites, our team used folders to hold basic components that the website was easily able to access. Below our team has created a table (*Table 5.3: Use of Folders Metrics Summary Table* (ratings out of 5)) that holds the ratings for this challenges three metrics, with each ranking based off of our experience with the previously mentioned use of folders.

Based on our testing, there are no extra steps needed to be performed in order to get the videos for the AI, and thus the entirety of time would be dedicated to analysis of the videos. Likewise, for the website, no extra time was spent trying to get information out of the folders that were included with the website. Thus, our team has given *Analysis Speed* a rating of 5.0/5. Our team found *Quantity of Analysis* to be a 5.0/5 as well since there is no limit on the amount of videos that can be held in a folder, thus there's no limit on how many videos the AI can analyze or use to train itself. For *Integration,* we have also given it a 5.0/5 since there were no extra steps or programs that needed to be created in order to integrate the folders into our AI or our website.

Table 5.3: Use of Folders Metrics Summary Table *(ratings out of 5)*

Option	**Analysis Speed**	**Quantity of Analysis**	**Integration**
USE OF FOLDERS	5.0	5.0	5.0

3.5.4 SUMMARY

Below is a table that summarizes all of the options we have for linking our AI and website.

Table 5.4: Linking Website and AI Options Metrics Summary *(ratings out of 5)*

Option	Analysis Speed	Quantity of Analysis	Integration
DJANGO	2.0	1.0	2.5
SCRAPING WITH PYTHON SCRIPT	1.0	5.0	4.0
USE OF FOLDERS	5.0	5.0	5.0

Our team decided that the most important metric for this challenge is *Quantity of Analysis* since a higher percentage of correctness for a CNN is determined by how many pictures/videos it's able to train itself with. Since our third option had the highest rating for *Quantity of Analysis*, we have decided to simply use folders as our way of linking our AI and website.

We felt that this was a better option than the other two, not just because it had a higher *Quantity of Analysis* rating, but also because the integration would be easy and the analysis speed was far superior. For *Integration*, using folders meant that our team would not have to spend extra time trying to write a python script or learn how to use Django. Instead, we will simply have to create a shared folder that both the website and AI can access. By doing this, we will also have to implement some way of keeping the data from being accessed by the AI and the website at the same time, as that can lead to a race condition. However, this can be easily implemented using Express.js for Node.js by doing something such as creating a simple lock that will keep volunteers from being able to access their account while the AI is working.

3.5.5 PROVING FEASIBILITY

For our demo, we will apply our solution to this challenge by using folders to hold the different categories of videos. There will be one main folder that holds subfolders referencing video quality, such as 'bad', 'fair', 'good', and 'poor'. In each of these subfolders will then be further subfolders for other categories, such as 'foraging' where videos of caribou foraging will be stored. Thus, 'good' quality videos of caribou 'foraging' will be stored underneath the path 'Main-Folder/Good/Foraging'.

The main folder containing all of these videos will be stored inside of the website itself, allowing the website to have immediate access to the videos. The AI will then be able to access this folder and all the videos within it by simply following the path to said folder.

3.6 TECHNOLOGICAL ANALYSIS SUMMARY

In the previous five subsections (Sections 3.1 - 3.5), we discussed the options and solutions to our challenges of: having to classify videos over images, obtaining a powerful, secure server, implementing a good backend design for our website, ensuring website security, and linking our website and AI. For the demo we will be presenting at the end of the semester, we will integrate all of these solutions into a basic, working example of what our final product will be.

In the next section we will be talking more about how each of these challenge solutions will be integrated into our demo, and describe what our demo will be.

4. TECHNOLOGICAL INTEGRATION

In the previous section, we discussed the options and solutions to our challenges of: having to classify videos over images, obtaining a powerful, secure server, implementing a helpful backend design for our website, ensuring website security, and linking our website and AI. In this section, we discuss in further depth as to how these solutions fit together as a whole project, and how we plan to use these solutions in our demo due at the end of the semester.

In order to properly categorize our videos, our team has decided to create a CNN (Convolutional Neural Network) using Keras. For this CNN, we will take a previous set of data (which has been analyzed by volunteers) and use it as a training set. This training set will “teach” the CNN what videos we want to classify underneath each category we provide it. Unfortunately, the analyzation of these videos using a CNN will take a tremendous amount of time on a home computer.

To fix this problem, our team has decided to use the powerful Monsoon server provided by NAU. We have decided to use this server since it will be easily accessible to us and is powerful enough to analyze our data in a reasonable amount of time. Once our videos have been analyzed, we will upload them to a well-designed website where the information that has already been determined by the AI will be stored in a dataset using Express for Node.js. The information already in this dataset will then be used to categorize these videos, which themselves will be stored in folders that can be accessed by both the AI and the websites backend.

For any videos that need further classification, volunteers will be able to sign into the website using a username and password, which will be secure since our group will be using an SSL Certificate, and analyze these videos further. The videos will display on a page with a small form next to them where they can input information that hasn’t already been determined about the videos. Their input will then be stored into the dataset so that, in the future, the AI can be better trained in more detailed categories. A

summary of this explanation and how the parts of our solution work together can be seen below in *Figure 1: Project Workflow*.

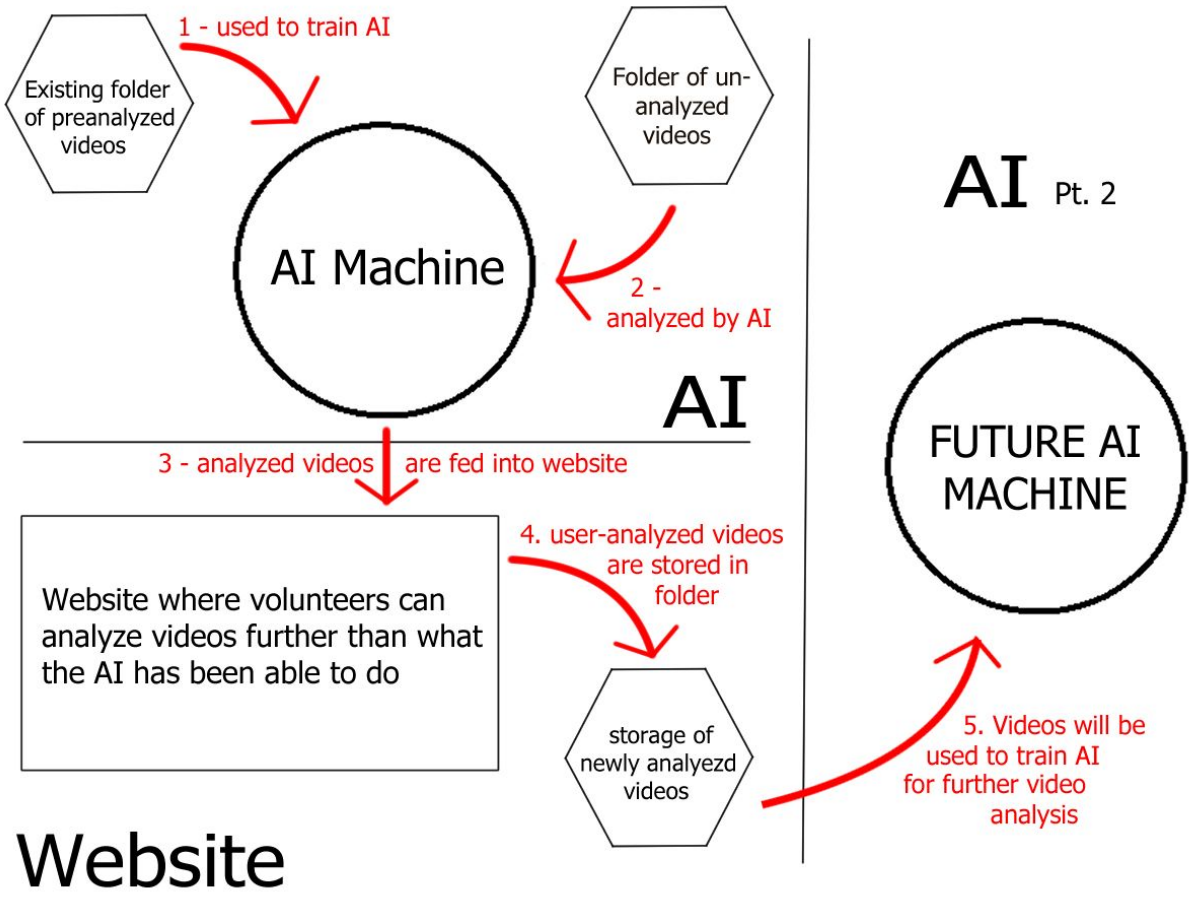

Figure 1: Project Workflow

For the demo our team will produce a basic version of what can be seen in the project workflow above. We will create a basic, working CNN that will analyze these videos and attempt to produce a correct output. We will also create a simple website that will be login accessable and show a form page that displays both a video, taken from its respective folder that is shared between the website and AI, and a form next to it where info can be stored. If time permits, we will be able to create our website in a way that will properly store the data entered into the form in a dataset that can be accessed again later.

5. CONCLUSION

Analyzing a lot of data is time consuming and prone to error when done by humans. Many companies and people suffer from having vasts amount of data that need to be analyzed and only have humans to do it, resulting in a long wait for possibly incorrect answers.

Our client Katie Orndahl is facing such a problem. She and her colleagues at the University of Montana have collected over 3 terabytes of videos of caribou that need to be analyzed. In 2017, Smart software collar cameras were attached to caribou that range across large amounts of Alaska and Western Canada. These cameras collected a vast amount of video of these caribous day-to-day lives, leaving our client Kathleen Orndahl and her associates with too much video for their team of volunteers to analyze alone which takes a lot of time and energy. The solution our team came up with for this problem is to create an AI system with deep learning that can analyze the basic components of these videos, thereby allowing volunteers to analyze the more detail attributes of the video on a website we will create.

The technical challenges our team will face revolve around our desire to speed up the analysis of images by AI as much as possible while ensuring safety and accuracy and creating a simple website and finally connect both. The table below lists our technical challenges, as well as the solutions we will take to solve them and our confidence interval in each solution.

Table 6: Summary of Technological Challenges and Solutions Table *(confidence rankings out of 5)*

Tech Challenge	**Confidence Interval**	**Proposed Solution**
VIDEO CLASSIFICATION	5	Create a CNN using Keras
POWERFUL, SECURE SERVER	4	Use of NAU Monsoon Server
WEB PAGE BACKEND DESIGN	4	Use Django for Python
WEBSITE SECURITY	4	Protecting logins with a SSL Certificate
LINKING WEBSITE AND AI	5	Create a shared folder accessible by both AI and Website

With these proposed solutions for our challenges, our team is confident that we will be able to build a reliable demo by the end of the semester, leading to a reliable product for our clients that will meet all of their needs without causing security threats or error.

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