Merging Videos of Mirage and Wind Speed to Train Artificial Intelligence

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Introduction

- The objective of this project was to obtain videos of objects affected by wind and their corresponding wind speed to train an artificial intelligence model that will analyze that information to determine wind speed in future videos.

- However, instead of using objects with a defined shape such as a flag or leaves, videos of mirage were collected and matched with their corresponding wind speed so that the wind speed can be known for every frame of the video.

Data Collection

What is mirage?

- Mirage is an optical phenomenon that is generated by the refraction of light as it passes through layers of air with different temperatures.

- Mirage occurs when the hot ground causes the layer of air above it to warm up. Since light *refracts* differently in hot air, the light passes through the colder air but bends in the warmer air, resulting in a "watery" image.[1]
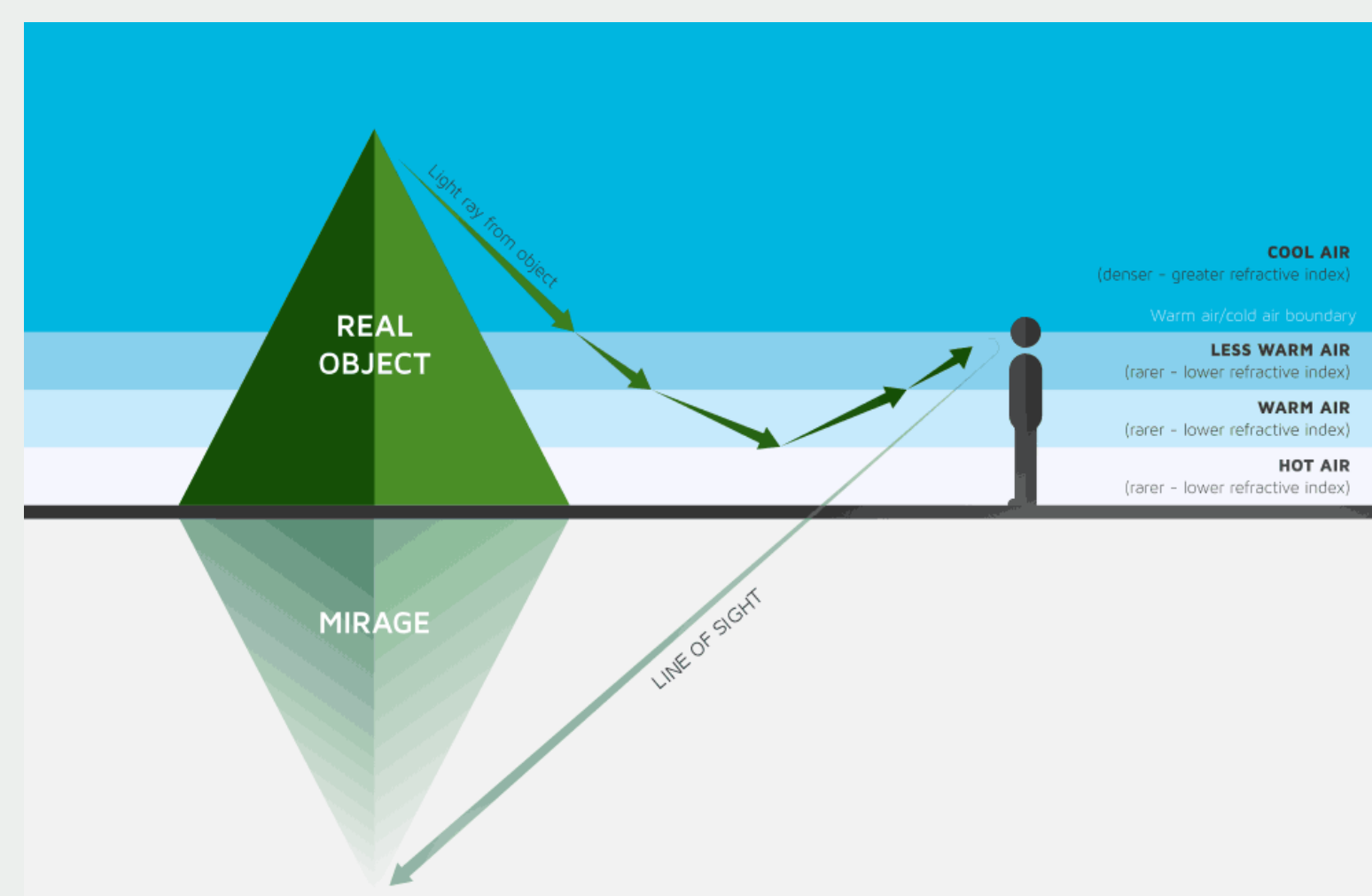

Figure 1. Visual representation of how light refraction causes mirage[2]

- Videos of mirage were taken by a camera set up on a tripod away from the site of mirage. The camera was zoomed in and focused so that the resulting video would have a clear and concentrated view of the mirage.

- A hand-held wind meter was used to capture wind speed at the site of the mirage.

Methodology

Jupyter Notebook:

- Jupyter Notebook is the coding platform that was used to run all of the code used in the project, including the ffmpeg and openCV programs. It can be used with a variety of coding languages, but Python was used for the purposes of this project.
- All the data from the wind speed recordings was converted into CSV (comma separated values) files by the wind meter's app so that the computer could open the CSV file and read every line of data within the file.
- While reading each line, it searched for two key phrases, "Wind Speed" and "Formatted Date_Time" that indicated the location of wind speed and date and time of recording in the file.
- Once those were found, those values were stored in a list.
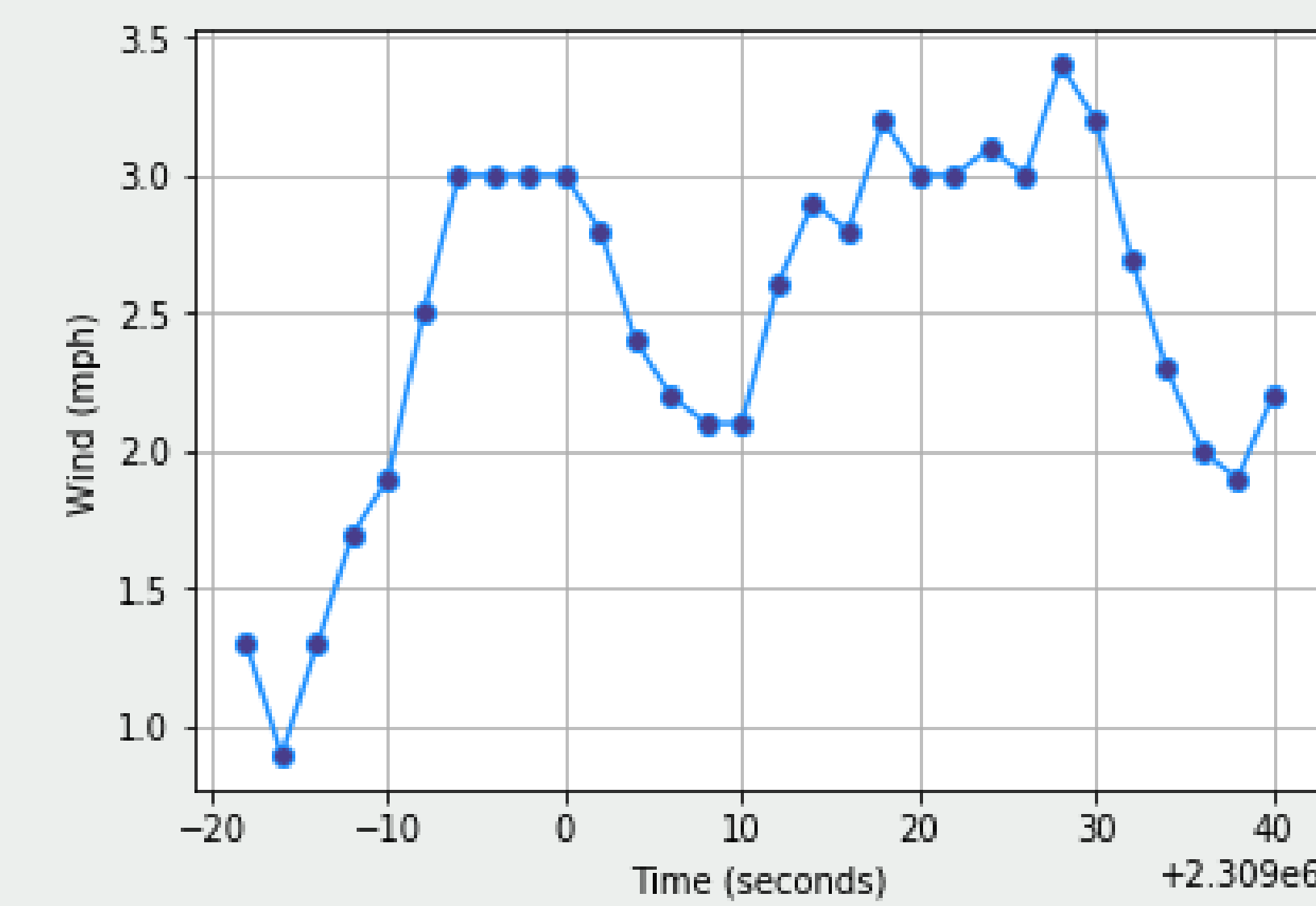
Graph 1. Wind Speed versus time[3]

FFMPEG:

- To ensure that the video recording would display the accurate wind speed, the time of recording for both the video and wind speed had to be aligned.
- Unlike the wind speed measurements, the recorded videos were MP4 files that could not be converted into CSV files. Instead, ffmpeg, a Python library, was used to extract the metadata from the file.
- Like the CSV files, the computer searched every line of the metadata for the phrases "creation_time" and "duration" then extracted the corresponding data value and stored it.

```
Input #0, mov,mp4,m4a,3gp,3g2,mj2, from 'A1.MP4':
  Metadata:
    major_brand     : avc1
    minor_version   : 0
    compatible_brands: avc1isom
    creation_time   : 2023-08-01T13:56:16.000000Z
  Duration: 00:01:18.45, start: 0.000000, bitrate: 2138 kb/s
    Stream #0:0(eng): Video: h264 (Main) (avc1 / 0x31637661), yuvj420p(pc, bt709), 768x432 [SAR 1:1 DAR 16:9], 1576 kb/s, 29.97 fps, 29.97 tbr, 30k tbn, 59.94 tbc (default)
    Metadata:
      creation_time   : 2023-08-01T13:56:16.000000Z
      handler_name    : Ambarella AVC
      encoder         : Ambarella AVC encoder
    Stream #0:1(eng): Audio: aac (LC) (mp4a / 0x6134706D), 48000 Hz, stereo, fltp, 128 kb/s (default)
```

Figure 2. Metadata obtained from MP4 files

OpenCV:

- OpenCV is a Python library that allows users to manipulate images and videos with its image processing and computer vision capabilities.
- Using openCV's commands, the wind speed values were displayed onto the video recording so that the wind speed would be known for every frame of the video.
- Since the time of recording and duration of both the video and wind speed was known, every second of the video was matched with the recorded wind speed to ensure that the video displayed the right wind speed for every frame.
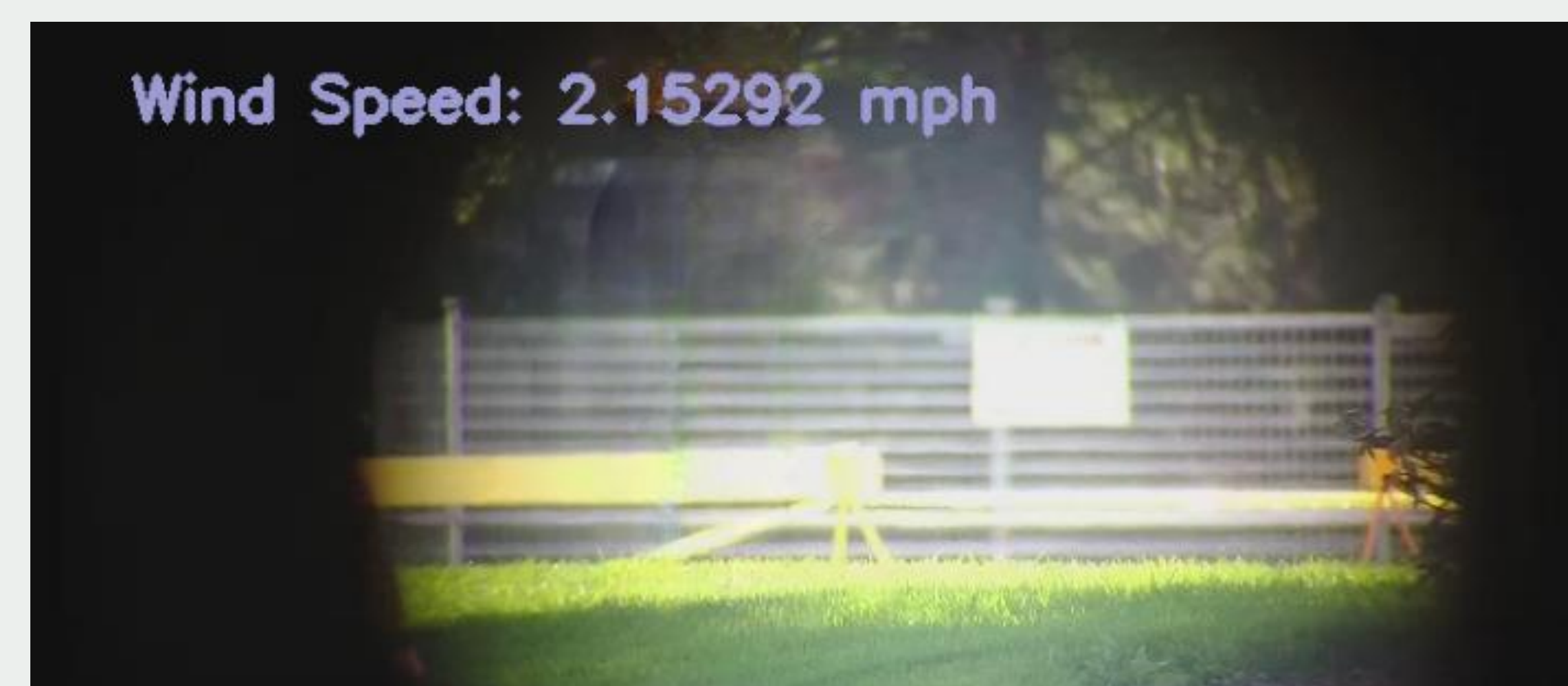

Figure 3. Final Product where wind speed is displayed on the video of mirage

Conclusion

Why does this matter?

- Although people can learn to estimate wind speed on their own, this takes time and experience that cannot be easily obtained.
- Using an artificial intelligence model means that it can take on that learning burden and provide a simple way of determining wind speed for inexperienced individuals.
- Additionally, there are situations where wind meters cannot be used so it would be more practical to use the AI model to determine the wind speed based on video surveillance or other recordings.

What happens next?

Now that the wind speed is known for every frame of the mirage video, that information can be given to the AI model that will analyze the videos and learn to determine wind speed based on how the mirage's shape is distorted as wind speed changes.

References

[1] Lynch, D. K., & Livingston, W. (2001a). *Colour and light in nature*. Cambridge University Press.
[2] Lorenzelli, L. (2015). *Superior and Inferior Mirage*. DensityDesign. Polytechnic University of Milan. Retrieved August 10, 2023, from http://www.densitydesign.org/courses/integrated-course-final-synthesis-studio-4.
[3] Created with Matplotlib

Acknowledgments

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