CIVIL SOURCE

ASCE UTAH SECTION NEWS LETTER

JANUARY 2024

President's Message

I hope that 2024 is off to a good start for everyone and that you had some time over the holidays to spend time recharging and with friends and family.

Two of our section members, Nathan Lunstad and Rob Sowby, had their ASCE Journal Paper featured on the ASCE Civil Engineering Source Site earlier in January. You can read their article "Smart Irrigation Controllers in Residential Applications and the Potential of Integrated Water Distribution Systems" (https://ascelibrary.org/doi/10.1061/JWRMD5.WRENG-5871)

This year student chapters within the Utah Section are hosting two student competitions:

- Intermountain Southwest ASCE Student Symposium (Utah State University, April 11-13, 2024, see flyer)
- ASCE Civil Engineering Student Championships (Brigham Young University, June 20-22, 2024).

We hope that you will take these opportunities to support our civil engineering students as a sponsor, judge, coordinator, or volunteer.

Southern Utah Branch Update

Matt Roberts (mwroberts@suu.edu)

During our December luncheon we award scholarships to Alexis Nackos, AJ Montalvo, and Austin Lund (pictured from left to right).

Wasatch Front Branch Update

Dimond Zollinger, PE

- January Luncheon
  - Legislative Update with Michael Smith (ACEC)
    - 12:00 pm Jan 28, 2024
    - Westech Campus

- February Activities
  - Combined luncheon with University of Utah Student Chapter

- February 23, 2024
  - E Week
    - Feb 18-24, 2024
    - Branch will be volunteering at 2 local elementary schools
      - There will be a presentation and Engineering activities with the students
    - Looking for volunteers.
    - Official invite will be sent out in the coming weeks

Future of Traffic Analysis – An Artificial Intelligence Approach

Lingkun Li, PE, PMP

Introduction

In traffic analysis, counting vehicles is one of the most labor-intensive but important tasks. It can be used in traffic impact studies, traffic flow monitoring, lane drop analysis, and traffic planning etc. By applying object detection techniques, it minimizes human errors and alleviates the tedious nature of this work. We started this project in March 2023.

The framework

This project is structured around accomplishing three primary objectives:

1. Train a deep learning model capable of detecting traffic in videos.
2. Develop a counting algorithm that aligns with the expectations of our traffic engineers.
3. Generate reports in a format conducive to easier analysis.

Deep learning model

Various object detection deep learning models are currently available, suitable for training custom models, including RetinaNet, Faster R-CNN (Regional-based Convolutional Neural Network), SSD (Single Shot Multibox Detector), Mask R-CNN, YOLO (You Only Look Once), DETR (Data Efficient Transformer), and more. Given our goal of processing live streaming videos, we have opted for YOLOv8, or You Only Look Once, as our model of choice. The decision is not only inspired by the acronym's alignment with a personal motto but also because the YOLO algorithm stands out as the fastest object detection model.

Convolutional Neural Networks (CNNs) have become ubiquitous in this field, evolving in two main directions: optimization and framework enhancement for image processing. Typically comprising convolution layers (CONV), pooling layers (POOL), and fully connected layers (FC), CNNs process images by evaluating numerous weights. For instance, in determining the presence of a cat in a 64x64 pixels image, the computer processes 12,288 (64x64x3) weights, with 3 denoting RGB color channels. CNNs, as variants of multilayer perceptrons, aim to mimic the behavior of a visual cortex. Figure 1 illustrates a typical CNN architecture (Convolutional Neural Network, n.d.).

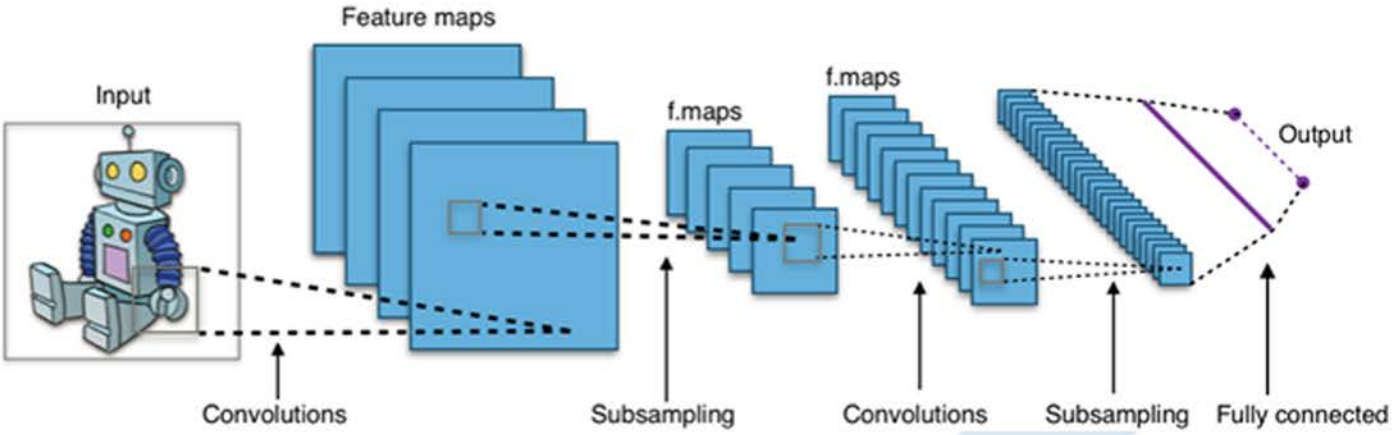

Figure 1. Convolutional Neural Network Architecture

The YOLO architecture is a specific object detection algorithm that utilized CNN as its underlying structure, but it revolutionizes object detection by adopting a distinct approach. Rather than scrutinizing individual pixels within an image, it takes a holistic view of the entire picture (Ng, n.d.). The algorithm divides each image into regions, forecasting bounding boxes and probabilities for each segment. Subsequently, it assigns weights to bounding boxes based on the predicted probabilities. This innovative methodology substantially reduces the processing time per image, enabling the model to efficiently handle live streaming video at rates of 24-30 frames per second.

Figure 2. YOLO Algorithm

Data

In machine learning and deep learning world, the biggest challenge is to have clean data to train the model. Whether it is an object detection or natural language processing model, clean and well-labeled data is the key to success.

To achieve this, our team annotated over 1000 pictures from YouTube live streaming traffic cameras for testing purposes. We used 8 different classifications: Pedestrian, Bicycle, Motorcycle, Car, Truck, Semi Truck, and Bus. To increase the data volume, we used some data augmentation methods including flip pictures horizontally, rotate pictures at a small angle, and adjust the brightness on the pictures. Then we randomly split the data into a training set, validation set, and testing set at 80:10:10 ratio (for a larger dataset, we would use 98:1:1). After successfully preparing the dataset, we started training the model. After 50 epochs and a couple hours waiting, our trained model reached nearly 99% precision and confidence. Figure 3 shows the model's performance.

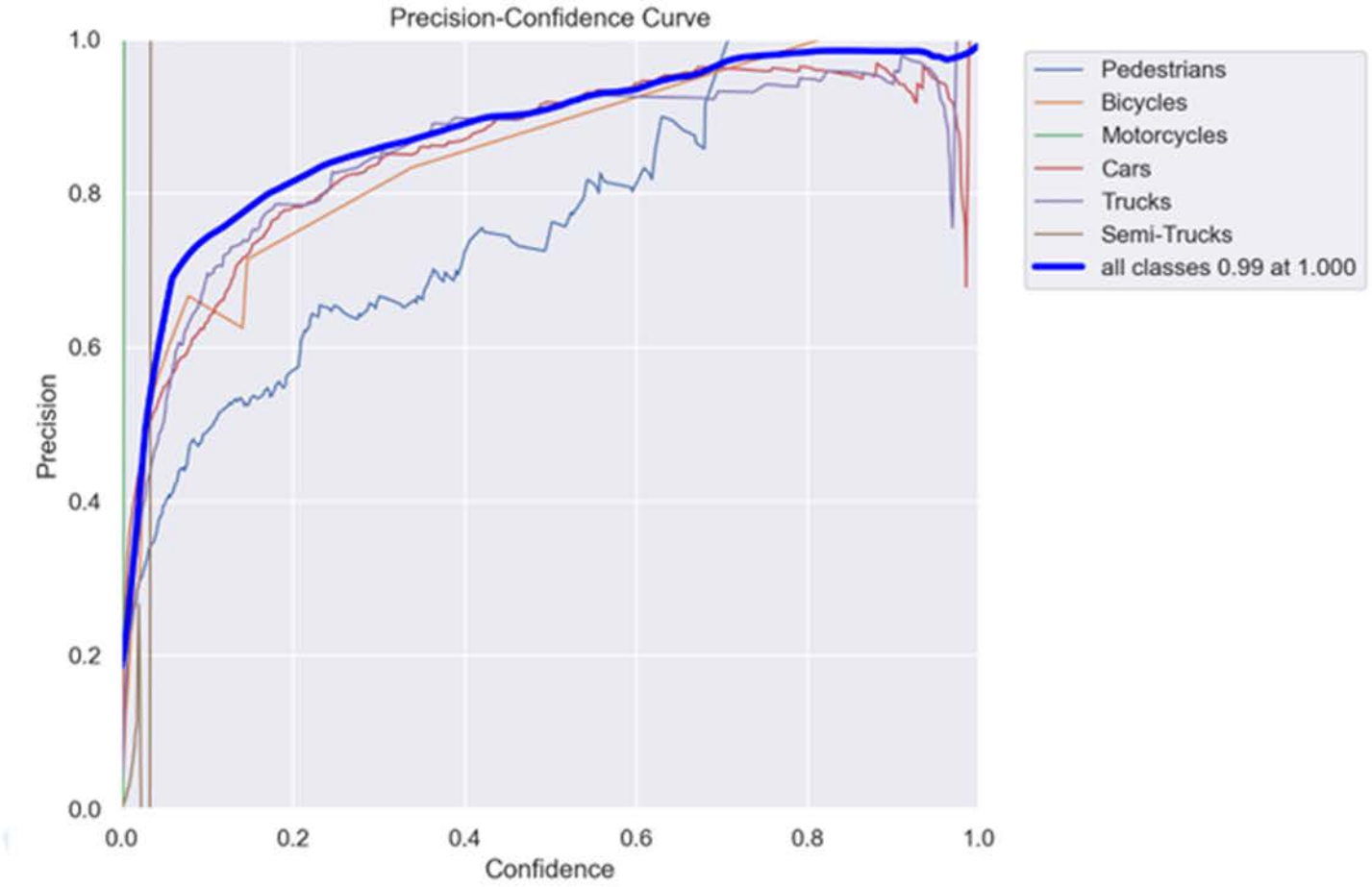

Figure 3. Model Precision-Confidence Curve

Applying the model to videos

After training the customed deep learning model, we deployed it into our traffic videos. We assign a unique ID to each object and determine if we need the classes classifications or just motor vehicles. One question I always got was: right now, the deep learning model can predict the object in each image, but in a traffic camera video, if there are multiple moving vehicles, how to locate and track the same object? The algorithm we are using is Euclidean distance. In deep learning, we usually use Euclidean distance or Cosine distance to find out the nearest neighbor. By mathematical definition, Euclidean distance is the distance between two points, Equation 1, while cosine distance is the angle distance between two vectors.

Equation 1

$$d(p,q) = \sqrt{\sum_{i=1}^{n}(q_i - p_i)^2}$$

Where: p, q = two points in Euclidean n-space
q_i, p_i = Euclidean vectors
n = n-space

We calculated the center of each object's bounding box for each frame, and ran it through Euclidean distance calculations, if the distance is smaller than our preset threshold, then we assume it is the same object in the consecutive frames.

Counting algorithm

Apparently in this application, training and deploying AI or deep learning model is not the most challenging part. How to count, especially the directional traffic is. The team brainstormed different ideas, line counter, polygon counter, and cosine counter etc. but eventually used polygon counter.

How does it work? Basically, we assigned two sets of polygons, tagging polygons to tag vehicles when they enter the polygon, and counting polygons to count vehicles, polygons are all color-coded, which is easier for users to identify where are those counted vehicles from.

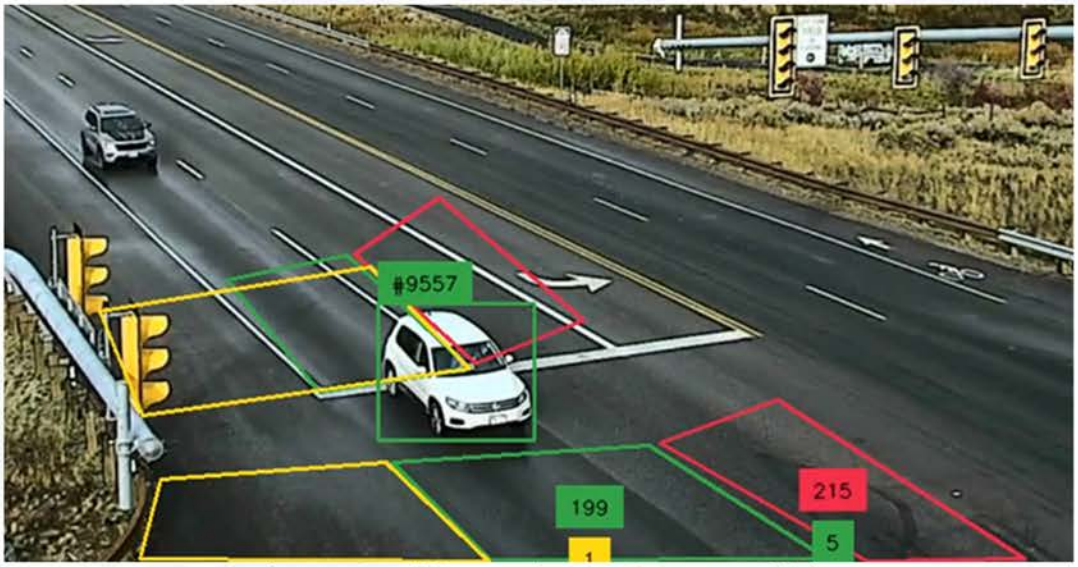

Figure 4. Video Polygon Count Exhibit

Report

In this specific application, our traffic engineers needed a csv file that records the tagging zone, counting zone, frame number, and time stamp from the video when a vehicle was counted. In this way they can check the green light phase and the miss-counts (green in red and yellow in green on Figure 4). And we were able to extract the frame number when a vehicle was counted, dividing by the video frame rate, we recorded the time stamp as well. And in this video example, our AI counts are 98.5% accurate after human check.

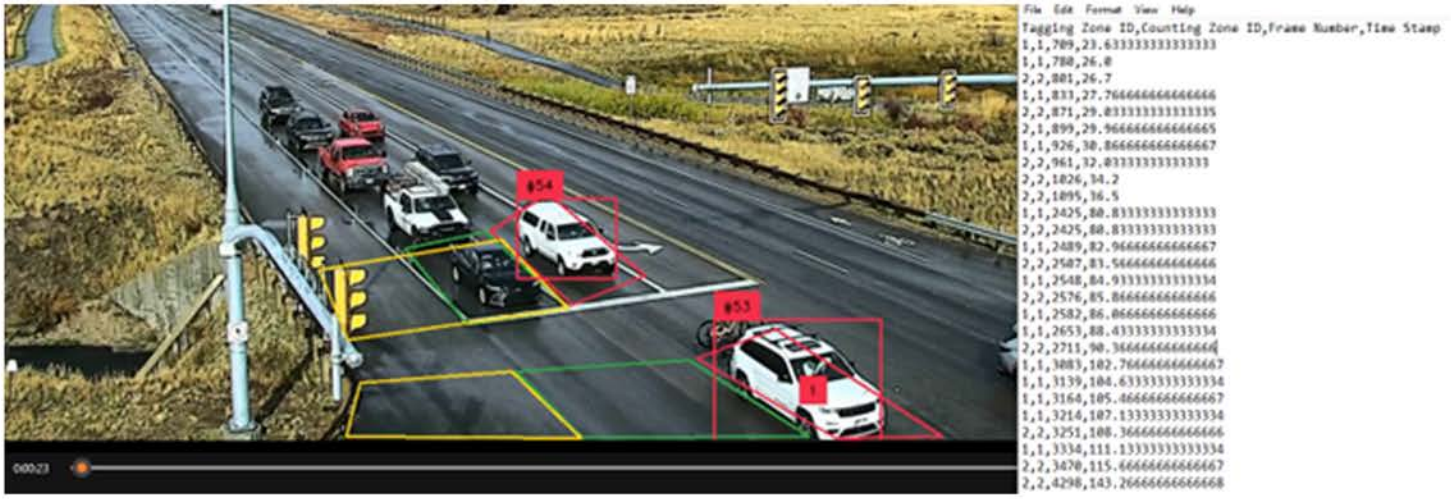

Figure 5. Video and CSV Time Stamp

Summary and Future Improvements

As of December 2023, this tool is still under development. We project the release of the final product in the first half of 2024.

Besides this AI Traffic Counting tool, we continually seek innovative approaches to minimize waste and enhance the efficiency of engineering processes. The integration of artificial intelligence into engineering promises to alleviate the burden of monotonous tasks for employees. Our team is actively gaining insights from this ongoing project and exploring potential applications

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REFERENCES

Convolutional Neural Network. (n.d.). Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Convolutional_neural_network

Ng, A. (n.d.). Deep Learning Specialization. Retrieved from Coursera: https://www.coursera.org/learn/neural-networks-deep-learning/home/welcome

YMF Update

Pedro Garcia Montesinos, EIT, Utah Section Young Member Forum President

We hope everyone had a relaxing holidays season and spent time with family and friends. Last month we had a training provided by Paige Nussbaum who is a Rotational Engineer with UDOT. She showed us her approach for a 12-K outreach activity to show future generations what is and the importance and impact of civil engineers in society by making "Roadway cookies". It was a great activity that we will be implementing it in our 12-K outreach, feel free to reach out if you would like to volunteer on future 12-k outreach activities organized by us!"

Moving forward, on January we will have our board meeting to plan for future activities, and coordinate efforts to put together our PE Review Course. Furthermore, I (Pedro) will be attending the 2024 Western Regional Younger Member Council in Seattle, Washington on February. It will be a great opportunity to be inspired, connect with leaders in the profession, and learn from the experts.