TCAM: Traffic Camera Air quality Monitoring

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Problem

Monitoring air quality traditionally relies upon the use of government-maintained stations or privately owned, WiFi-enabled air quality sensors.

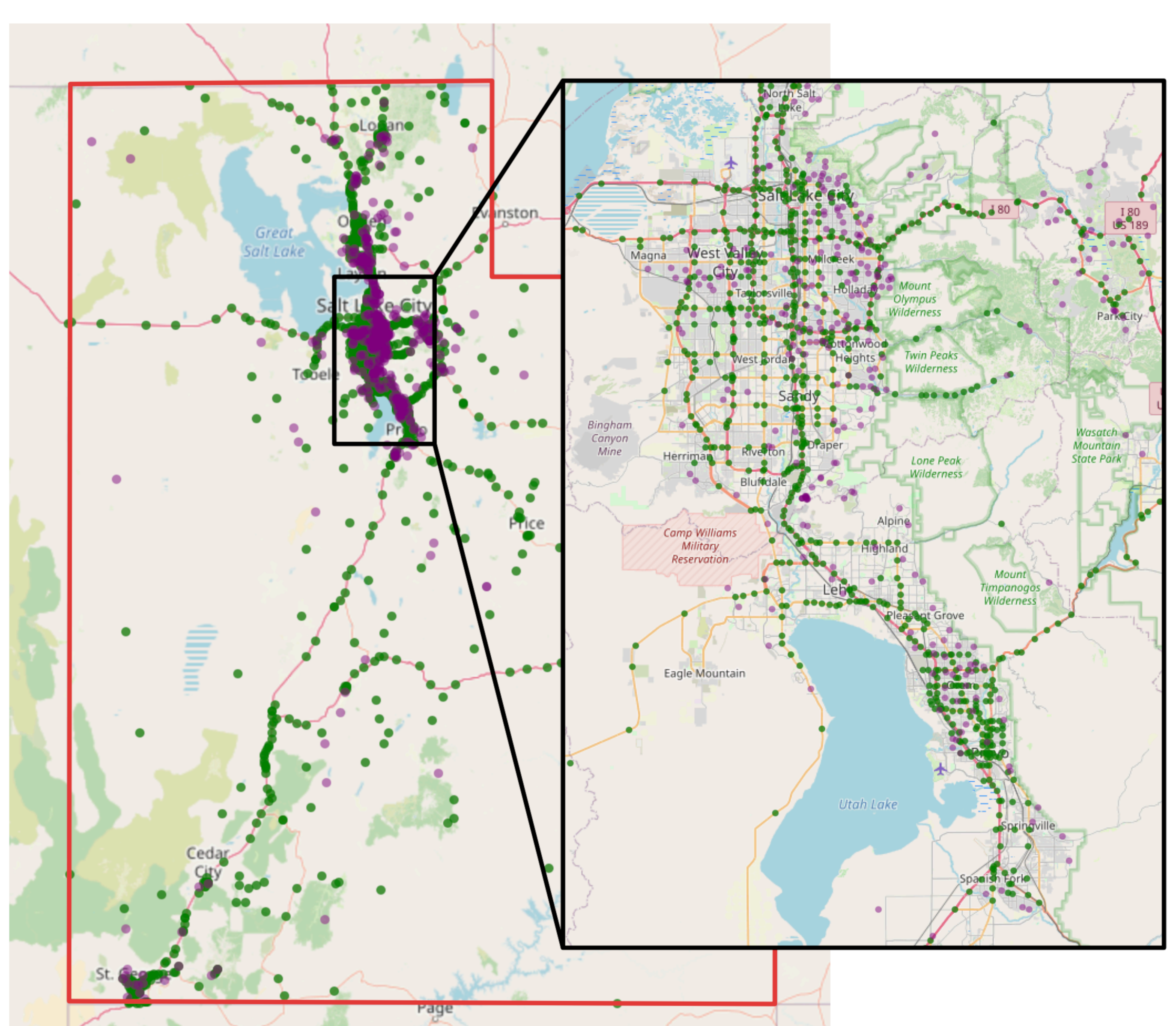
While these methods provide satisfactory coverage in their immediate radius of deployment, the granularity of their coverage is **dependent upon the number of deployed stations or sensors**.

Additionally, the **placement of these privately owned sensors mirrors economic disparities**, leaving lower-income areas with **less coverage** and subjecting them to **environmental discrimination**.

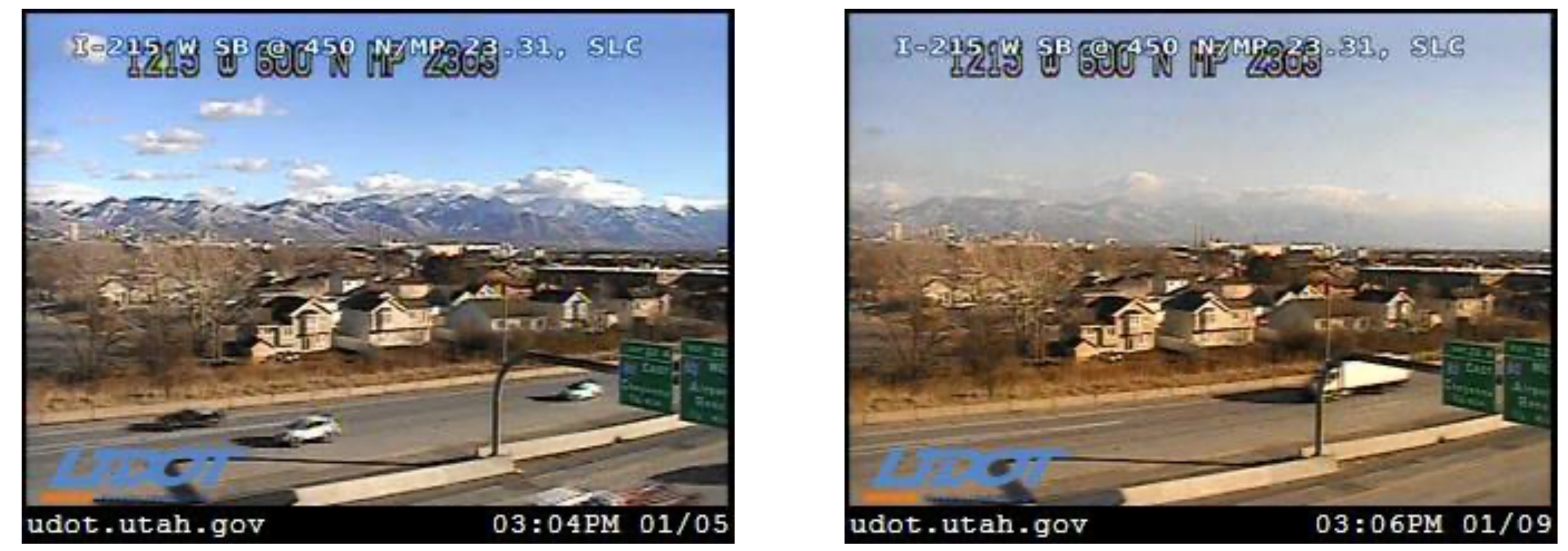
In response to this dilema, we introduce **TCAM**: a modular application that **correlates traffic camera images with particulate matter readings to determine real-time air quality**.

Our low-cost system requires **no extra hardware**, using publicly available UDOT traffic camera images to train a model that **assesses air quality from input images**.

With hundreds of deployed traffic cameras, **we gain far more data points** than DAQ stations and private sensors alone.



Number of publicly available cameras (green dots, 1395) compared to PurpleAir sensors (purple dots, 778).



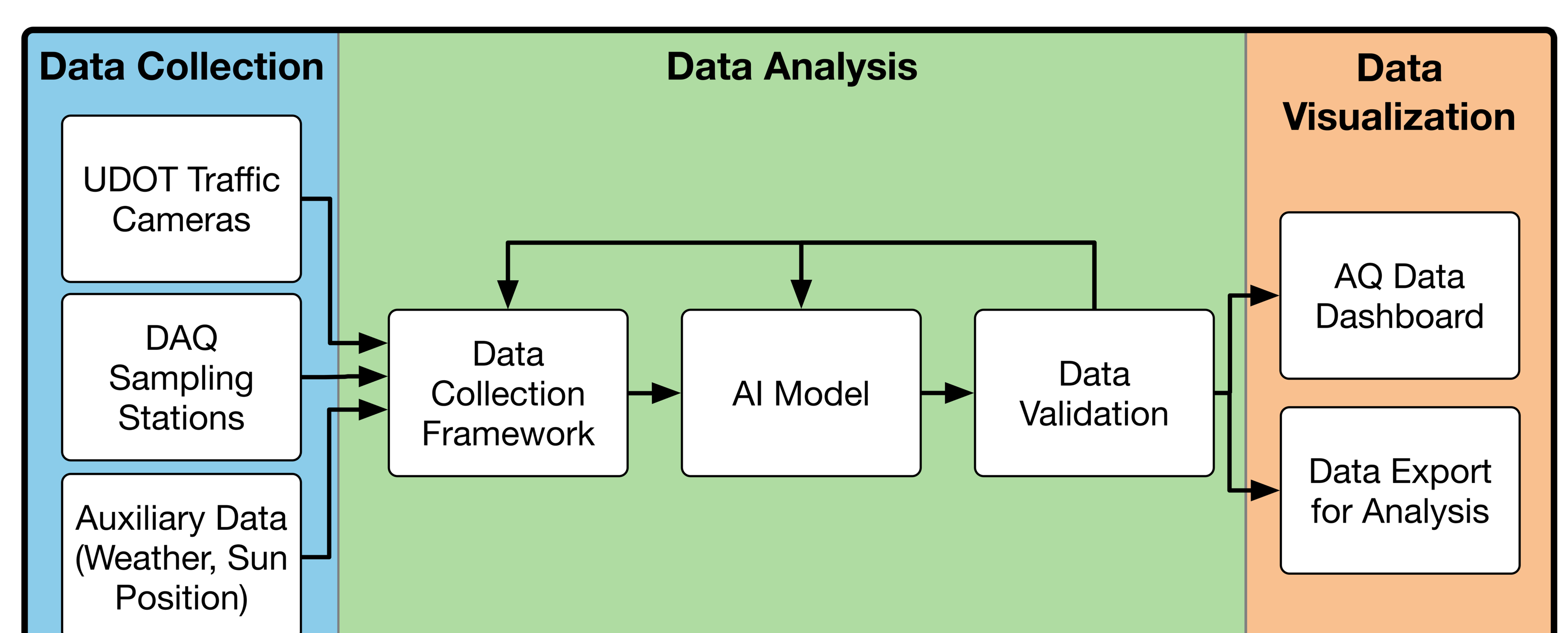
Good vs. bad air quality days (left vs. right) within the same week, still distinguishable despite low-resolution traffic camera images.

Methodology

To create a system that collects and prepares relevant environmental data, we break the process down into **two simples stages: data collection and data analysis.**

We collect data by deploying a series of Pythons scripts that scrape data from their appropriate sources. For the traffic camera air quality monitoring, we **collected over 218,000,000 images from 1395 traffic cameras** across Utah from 2021–2025.

We have also collected **corresponding hourly PM2.5 values from DAQ stations** as training data.



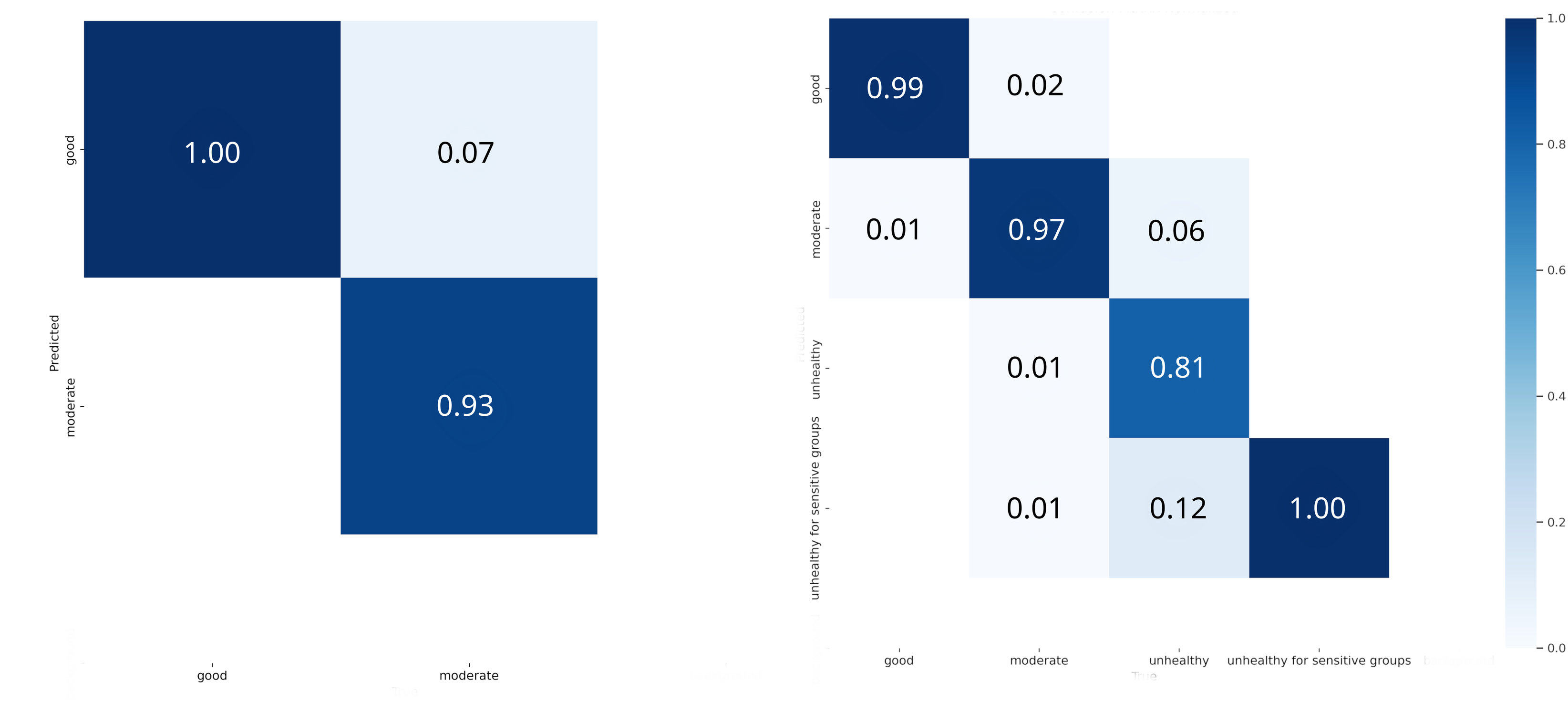
Overview of the framework design and workflow.

We divide this data into **3 distinct season-ranges (Summer-Fall, Spring-Summer, Fall-Winter)** to account for precipitation factors.

We then **train a YOLO-cls model to predict an AQ classification** category for a given image**.**

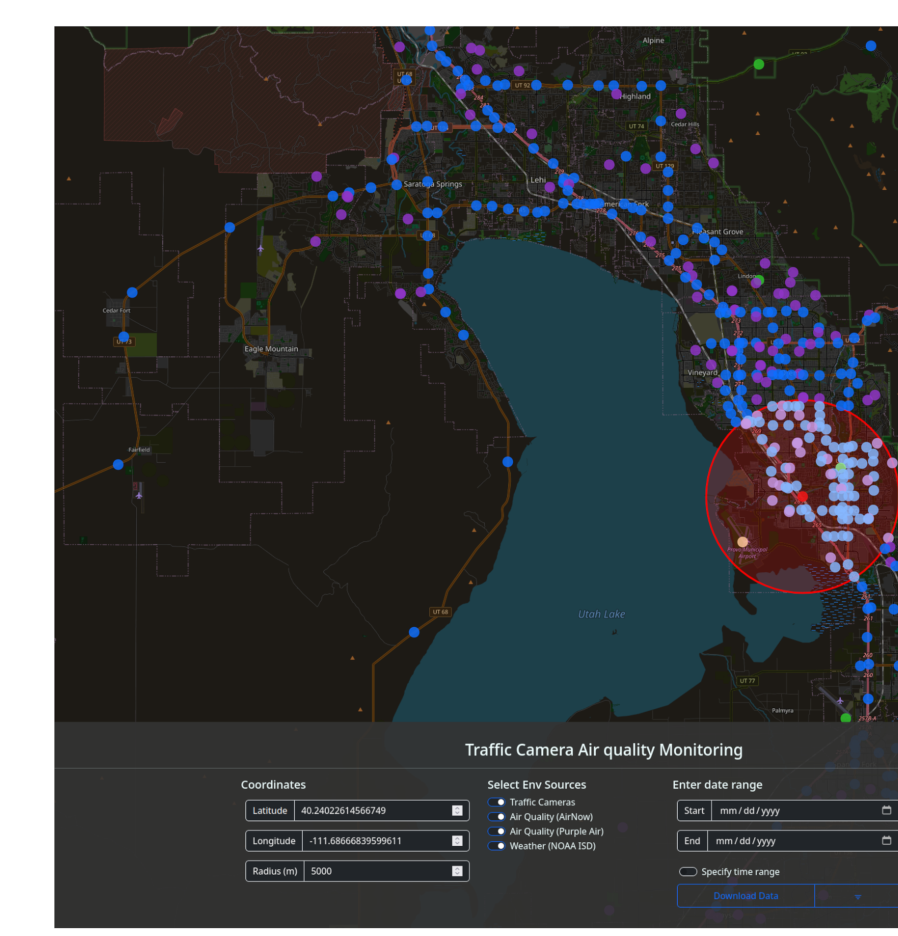
Results

While using the **YOLO-cls model**, we utilize the **AQI labels as the qualification thresholds**. We find that with preliminary test using one camera, we are able to **correctly predict the PM2.5 98.6% of the time**.



Strong correlation for Spring-Summer (left) and Summer-Fall (right). Fall-Winter (not shown) had one category.

We also created an **interactive web-based dashboard** to provide easy access to **temporally and spatially related data** for future models and projects.



Graphical dashboard showing locations of traffic cameras, PurpleAir sensors, weather stations, and DAQ sampling stations (purple dots).

Future Work

In its current state, TCAM is a **strong indication that traffic camera images are an additional viable medium** that assesses current air quality conditions.

Future goals include improving prediction accuracy through **multi-camera training** to develop **broader regional and seasonal models**. Additionally, we aim to expand the framework, enabling scientists to **share data on the public dashboard**, making more training data accessible which has the potential to foster addtional deeper insights.