2025 ITS·STI CANADA
CONFERENCE & EXPO | CONGRÈS-EXPO

Predictive Analytics for Transit Optimization

Leveraging Traffic Data and Cloud AI

Brett Tackaberry

Google Cloud

The Growing Mobility Challenge

Unlocking Policy, Playbooks & People

Speaker introduction

Brett Tackaberry

Principal Architect

Google Cloud
Canada Public Sector

Digital solutions for 20+ years in Ottawa.

Geospatial, Product, Digital Agencies

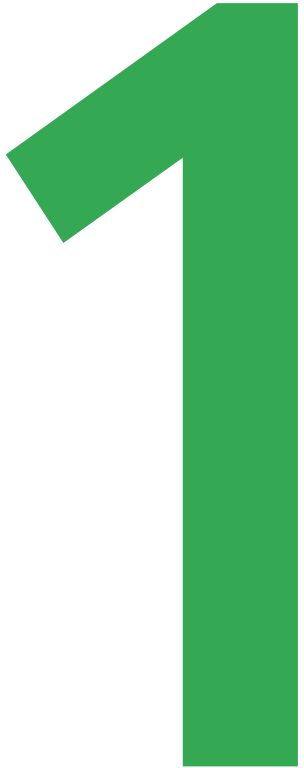
Might see me at Ottawa Civic Tech, AI, Climate tech, occasionally Invest Ottawa meetups

Ran Random Hacks of Kindness

01

Contents

Traffic Trends for traffic improvement and more

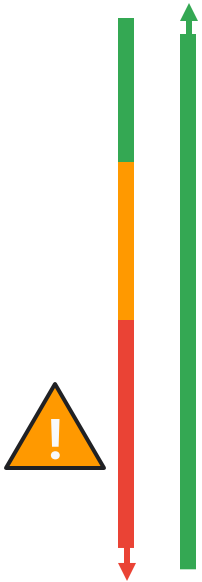


waze

Driver reports

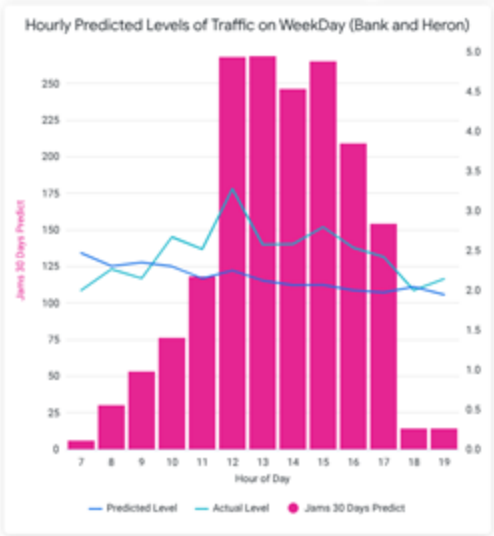
waze

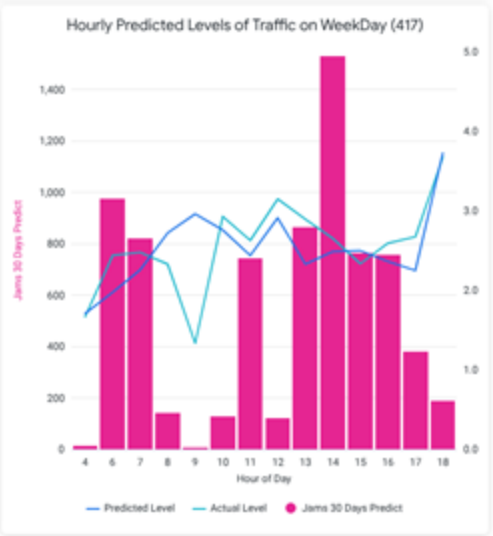
Traffic & Irregularity Detection

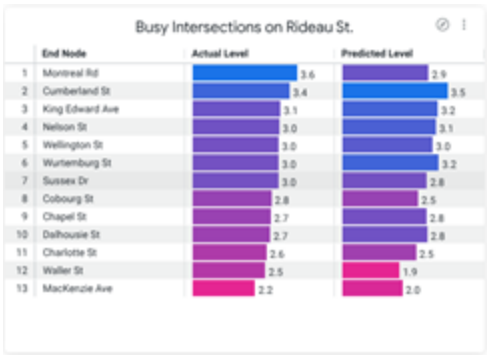


How Can Cities Take Advantage

- Waze Data for Cities Data Partnership
- Use for Forecasting irregularities
- Finding patterns
- Fuse with weather, events, bus locations, emergency vehicle locations
- Measure improvements







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Traffic Improvement for Environmental Impact

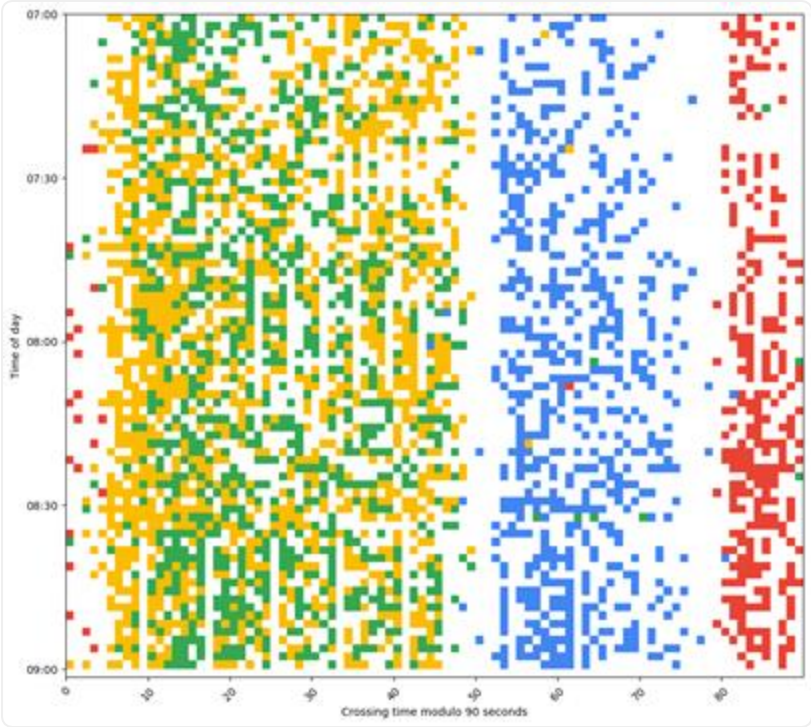
Green Light

Mitigating climate change by optimizing traffic lights and improving urban mobility

Step 1
Extract intersection properties

Analyze driving trends to extract signalized Intersection properties:

- Movements
- Phases
- Phase order
- Cycle time
- Green splits
- Actuation (road sensors)



3 phases in this cycle, each of the 4 colors represents a movement

Step 2
Calculate flow metrics

Calculate intersection traffic flow metrics:

- Car count
- Delay time
- Split failures
- Queue length
- Stop events

Step 3
Suggest an improved plan

Google calculates an improved plan that better fits traffic patterns

The city then receives these recommendations

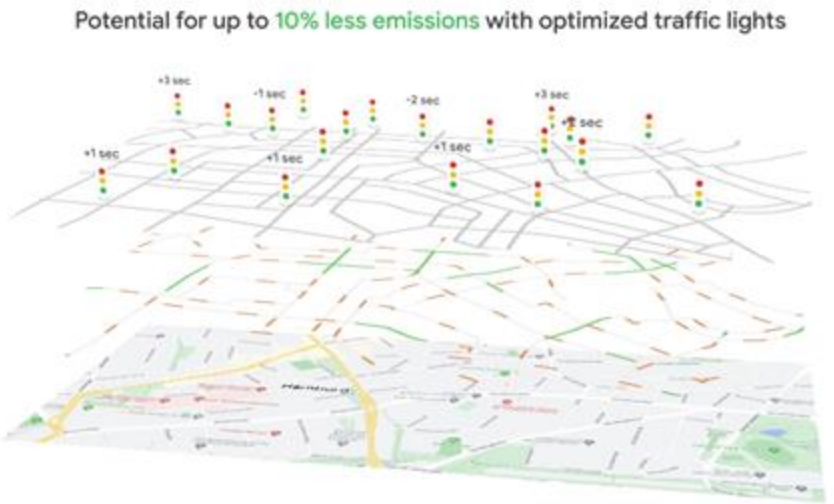
Once received, the city can then validate & implement the recommended modification

Step 4
Track the changes

Green Light tracks:

- Intersection properties (traffic lights plan)
- Traffic flow
- Intersection metrics (fit to traffic)

Detect program changes and the impact on delay and emissions



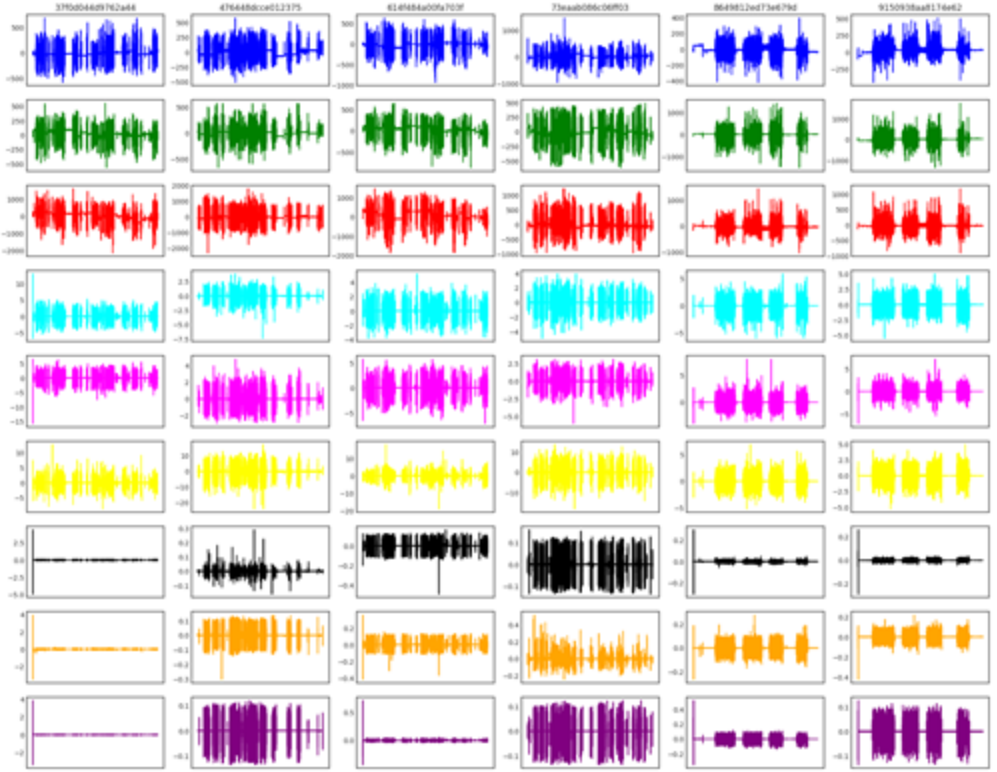
Predictive Maintenance with AI / ML

Predictive Maintenance to detect rail problems

- Smartphones retrofitted onto subway cars
- Capture subtle vibrations and sound patterns through built-in sensors
- Data sent in real time to cloud-based systems, for AI/ML to generate predictive insights.

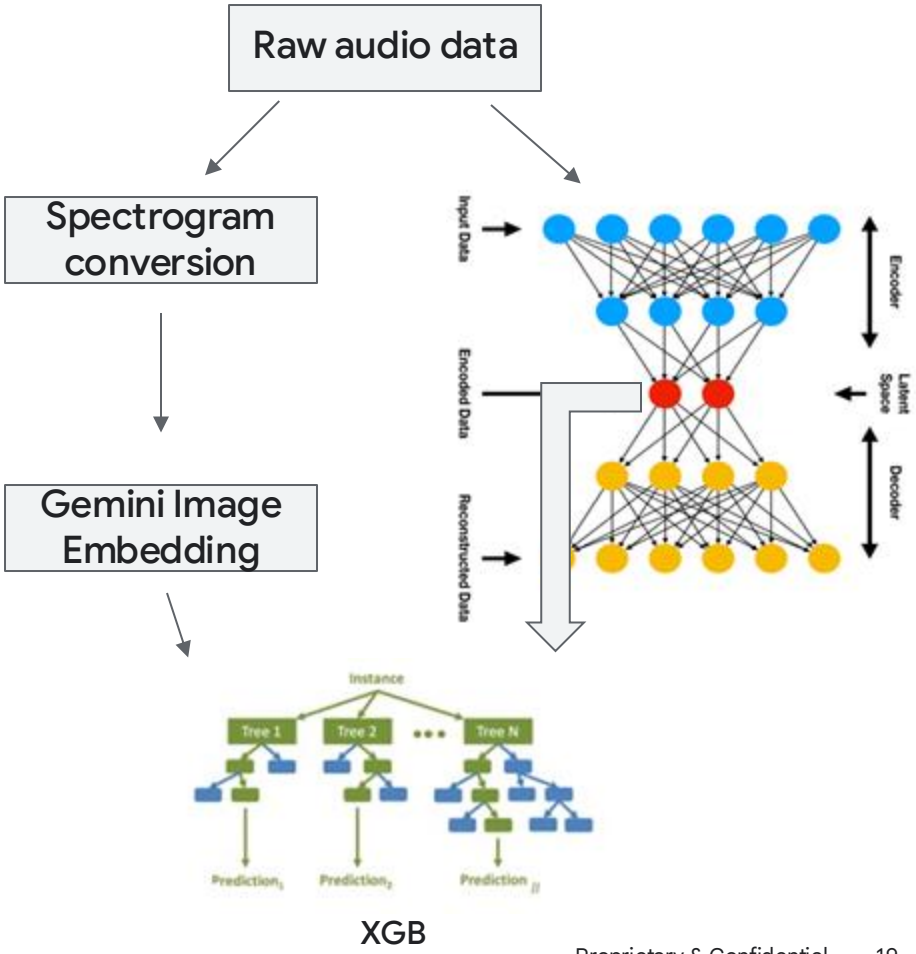
Sensor data

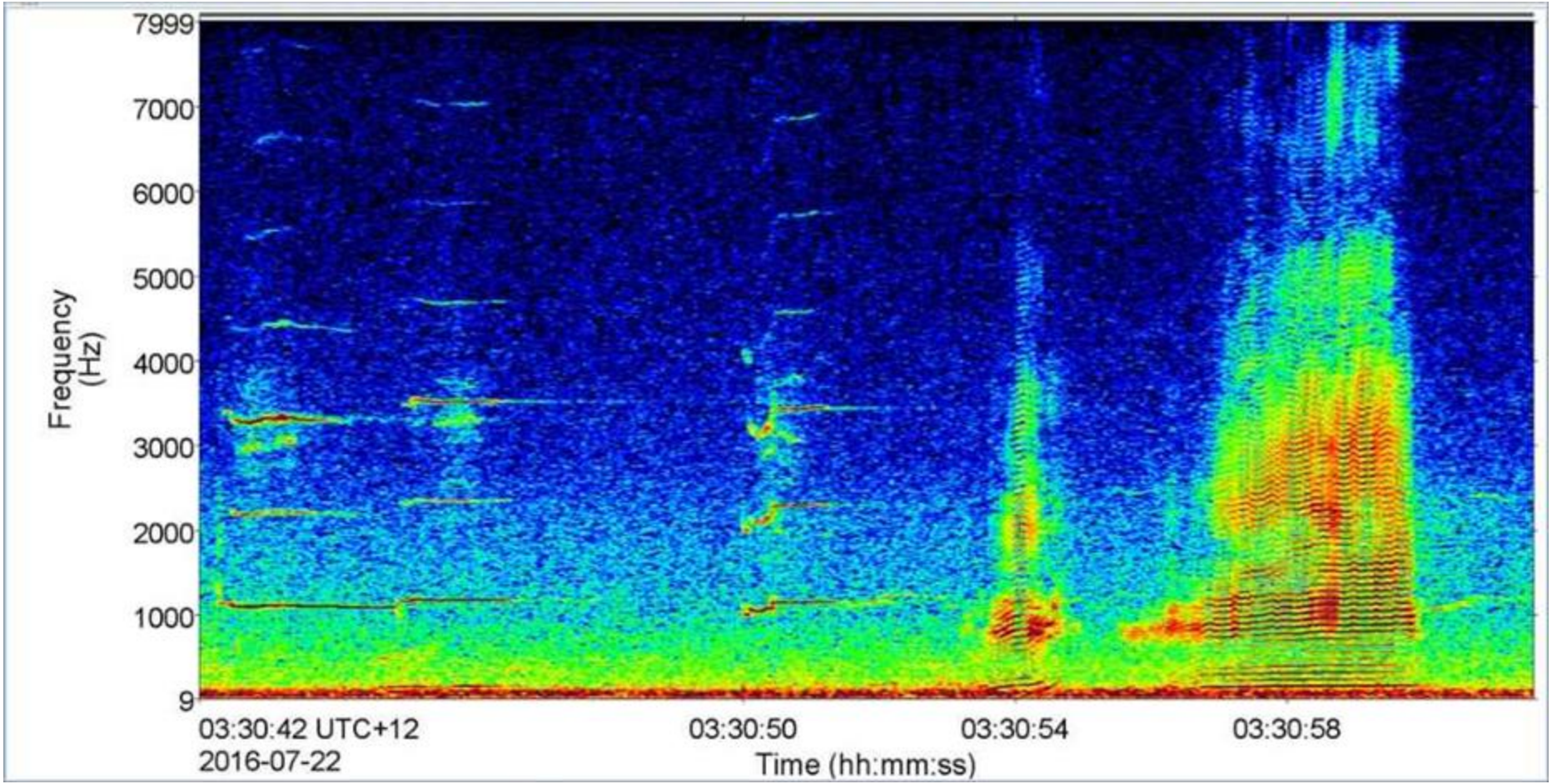
- **3 sensor data types; 3 axes; 6 phones**
  - Magnetization, Acceleration, Gyroscopic Precession
- **Need to know:**
  - Which track is the train on?
  - Where (1 ft precision) is the train?
  - At every point in time, is the train running over a defect?
- **Track sections:**
  - 190-200 used for training
  - 201-203 saved for test



Audio data

- **2 phones**
  - Limited periods of collection
  - Segmented periods of collection
- **10-100x less data**
  - Each waveform covers 1/20th of a second
  - 65k+ amplitude changes
- **Two modeling approaches**
  - Gemini
  - Custom Autoencoder
- **Track sections:**
  - 190-200 used for training
  - 201-203 saved for validation




7999
7000
6000
5000
4000
3000
2000
1000
9
Frequency (Hz)
03:30:42 UTC+12
2016-07-22
03:30:50
03:30:54
03:30:58
Time (hh:mm:ss)

Defect predictions

Very strong signal in the sensor and audio data

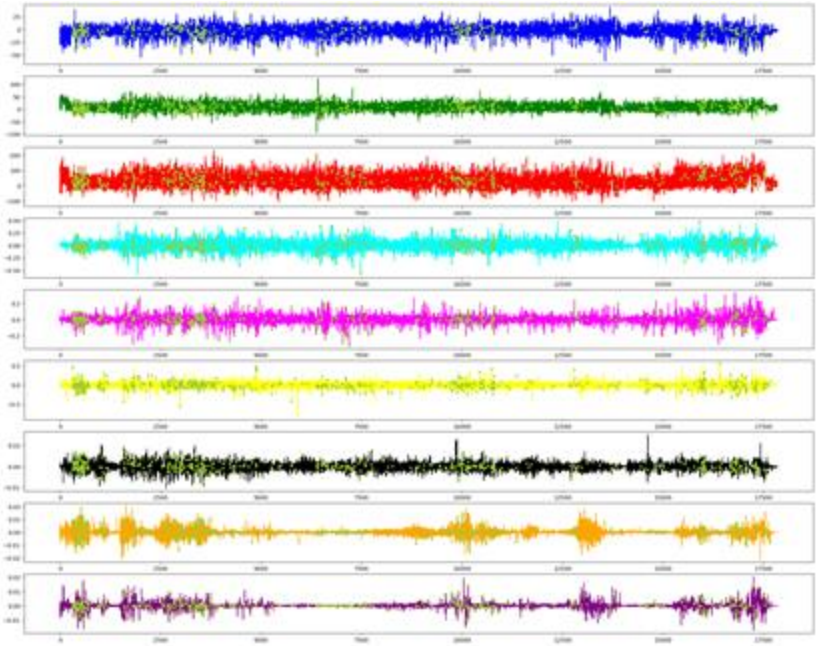
- Our model correctly predicts **>90% of the defects** in the HxGN when we tolerate a 1 in 2 false positive rate.

Validated using documented nonconformities

- For new (not used for model training) nonconformities between 10/7 - 11/18, our model identified them with high statistical significance (p-value < 0.001)

Unidentified defect detection

- Anomaly detection on weekly differences in sensor data can be used to identify undocumented nonconformities



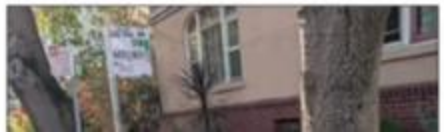
Improving Passenger Experience

```
batch1_df['image'] = batch1_df['url'].apply(preview_image)

Frame with embedded images
ri', 'image', 'metadata']].to_html(escape=False))
```

Run cell (⌘/Ctrl+Enter)
cell executed since last change

executed at 2:20 PM (0 minutes ago)
executed in 0.141s

9	gs://data-to-ai-02-multimodal/target/QA-02-dirty.jpg		[{'name': 'stop_id', 'value': 'QA'}, {'name': 'batch_number', 'value': 'batch-1'}]
10	gs://data-to-ai-02-multimodal/target/QB-01.jpg		[{'name': 'batch_number', 'value': 'batch-1'}, {'name': 'stop_id', 'value': 'QB'}]
			

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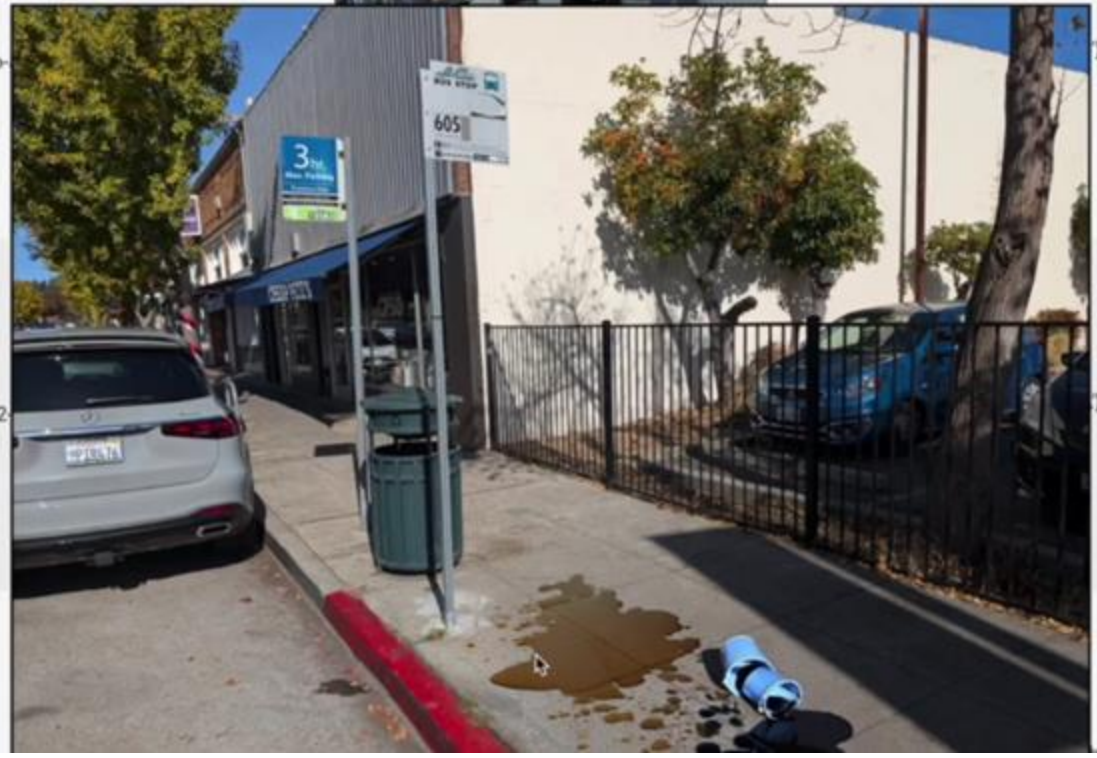
8	gs://data-to-		'}, {'name': 'batch_number', 'value': 'batch-1'}]
9	gs://data-to-ai-02-		'}, {'name': 'batch_number', 'value': 'batch-1'}]


6
800

```
INSERT INTO `multimodal.image_reports`
WITH llm_response AS (
  SELECT
    uri,
    updated,
    ml_generate_text_llm_result,
    metadata,
    multimodal.clean_generate_text_json_response(ml_generate_text_llm_result) as cleaned_result
  FROM
    ML.GENERATE_TEXT(
      MODEL `multimodal.gemini_flash_model`,
      TABLE `multimodal.objects`,
      STRUCT (
    '''
You are a transit supervisor responsible for monitoring bus stops in order to ensure they are safe and clean for everyone. The bus stops
Analyze these pictures of bus stop images and provide accurate details around safety and cleanliness in and around the bus stop. A bus s
Return your answer in valid JSON format (without JSON decorators) with these fields:
* "number_of_people" (Integer): Identify number of people in or around the bus stop.
* "cleanliness_level" (Integer): Rate the general cleanliness of this bus stop. Possible values: 1="dirty and warrants cleaning", 2="cle
* "safety_level" (Integer): Rate the general safety of this bus stop. Possible values: 1="unsafe and warrants attention", 2="safe and do
* "description" (String): Provide a detailed textual description of what is in the picture, focusing on cleanliness and safety. This des
All fields are required.
    ''' AS prompt,
    0.1 AS temperature,
    2048 AS max_output_tokens,
    TRUE AS flatten_json_output)
  )
WHERE content_type = "image/jpeg" AND updated > last_process_time
)
SELECT
  GENERATE_UUID() as report_id,
  uri,
  updated,
  (SELECT value FROM UNNEST(metadata) WHERE name = 'stop_id') AS bus_stop_id,
  CAST (JSON_VALUE(cleaned_result, '$.number_of_people') AS INT64) AS number_of_people,
  CAST (JSON_VALUE(cleaned_result, '$.cleanliness_level') AS INT64) AS cleanliness_level,
  CAST (JSON_VALUE(cleaned_result, '$.safety_level') AS INT64) AS safety_level,
  JSON_VALUE(cleaned_result, '$.description') AS description
FROM llm_response;
```

```
styled_incidents_df = incidents_df[
    ['bus_stop_id', 'resolved',
     'open_report_description', 'open_report_image',
     'resolve_report_description', 'resolve_report_image']].style.apply(highlight_unresolved, axis=1)

# Display the DataFrame with embedded images
HTML(styled_incidents_df.to_html(escape=False))
```

4	SA	False	The bus stop appears to be moderately dirty. There is some litter on the sidewalk and along the curb. The bus shelter has graffiti on the glass. The sidewalk has some cracks and appears to be in need of repair. There are no immediate safety concerns. The bus stop sign is in good condition. The street appears to be in a state of disrepair with cracks in the asphalt. The overall cleanliness of the bus stop is poor due to the litter and graffiti. The safety level is good as there are no immediate hazards.		None	None
5	MB	False	The bus stop appears to be in a state of mild disrepair. There is a bus stop sign, a bench, and some landscaping. The bench has a small amount of snow on it. There is a large patch of ice on the ground around the bus stop pole and a smaller patch near the bench. The presence of ice on the ground creates a potential safety hazard, making the area unsafe. The area is generally clean, with no visible litter or graffiti. There are some leaves on the ground near the curb. Two people are visible in the background.		None	None
6	RB	False	The bus stop appears to be in a state of disrepair and neglect. There is litter scattered on the ground, including paper and other debris. The bench shows signs of wear and tear, and there is a black object on the ground. The bus shelter itself has graffiti on the glass. The surrounding area also has graffiti. The overall cleanliness is poor, and the		None	None

+ Code + Text

L4 RAM Disk

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Analyze images

Detect and visualize incidents

h 2: Incident Tracking and lution

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Batch #4

: similarity search

rate vector embeddings

l vector index

e search helper function

ch for graffiti

ch for broken glass

ch for litter

id search

oning with search results

17	TD	False	bench appears to be in good condition. The bus stop sign is visible and appears to be in good condition. There are no apparent safety hazards. The		None	None
18	SC	True				
19	ND	True	vandalism. The surrounding area appears to be generally clean, but the damaged bench detracts from the overall cleanliness. There is a scooter parked at the bus stop. The sidewalk and street appear to be in decent condition. There		The bus stop appears to be in good condition. There is a bench and a sign. An electric scooter is parked near the sign. The sidewalk and street appear clean with no visible litter or hazards. The building behind the bus stop has a	

+ Code + Text

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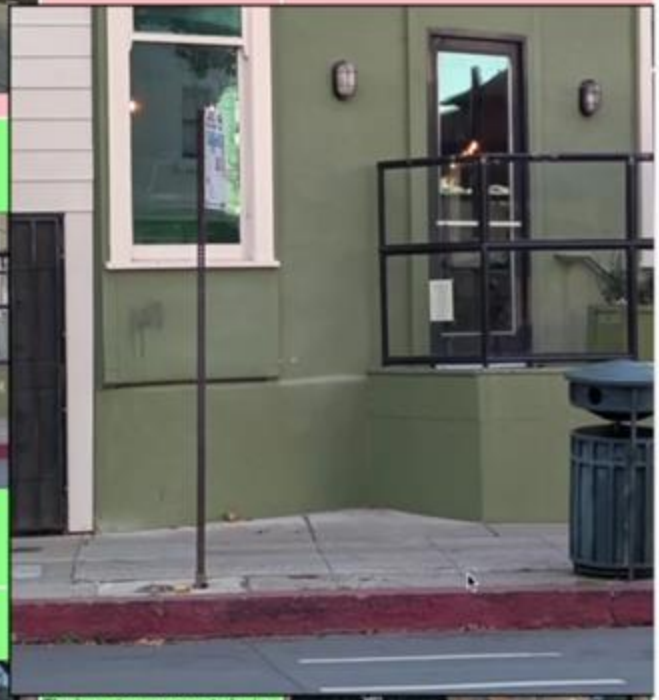
17	TD	False	bench appears to be in good condition. The bus stop sign is visible and appears to be in good condition. There are no apparent safety hazards. The cleanliness level is rated as 1 due to the presence of litter. The safety level is rated as 2 as there are no apparent safety hazards.		None	None
18	SC	True	The bus stop area shows a significant cleanliness and safety concern. There is a large amount of broken glass scattered on the sidewalk near the trash can. This poses a direct safety hazard due to the risk of cuts. The presence of broken glass also significantly lowers the cleanliness level. The trash can appears to be in good condition. There are no people visible in the image. The bus stop sign is present and appears to be in good condition. The building behind the bus stop has a glass enclosure, and there are lights on the building. The sidewalk is otherwise clean, but the broken glass is a major issue.			
19	ND	True	The bus stop appears to be in need of cleaning. The bench has significant damage, with large holes in the seat, indicating potential vandalism. The surrounding area appears to be generally clean, but the damaged bench detracts from the overall cleanliness. There is a scooter parked at the bus stop. The sidewalk and street appear to be in decent condition. There		The bus stop appears to be in good condition. There is a bench and a sign. An electric scooter is parked near the sign. The sidewalk and street appear clean with no visible litter or hazards. The building behind the bus stop has a	

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Gemini

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17	TD	False	bench appears to be in good condition. The bus stop sign is visible and appears to be in good condition. There are no apparent safety hazards. The cleanliness level is rated as 1 due to the presence of litter. The safety level is rated as 2 as there are no apparent safety hazards.		None	None
18	SC	True	The bus stop area shows a significant cleanliness and safety concern. There is a large amount of broken glass scattered on the sidewalk near the trash can. This poses a direct safety hazard due to the risk of cuts. The presence of broken glass also significantly lowers the cleanliness level. The trash can appears to be in good condition. There are no people visible in the image. The bus stop sign is present and appears to be in good condition. The building behind the bus stop has a glass enclosure, and there are lights on the building. The sidewalk is otherwise clean, but the broken glass is a major issue.		The bus stop appears to be in a generally clean and safe condition. There is a trash can present, which is in good condition. The sidewalk and surrounding area appear free of litter, with the exception of a small piece of trash near the curb. The bus stop sign is present and appears to be in good condition. There are no visible safety hazards such as broken glass or damaged infrastructure. The lighting appears adequate. There is no sign of vandalism.	
19	ND	True	The bus stop appears to be in need of cleaning. The bench has significant damage, with large holes in the seat, indicating potential vandalism. The surrounding area appears to be generally clean, but the damaged bench detracts from the overall cleanliness. There is a scooter parked at the bus stop. The sidewalk and street appear to be in decent condition. There		The bus stop appears to be in good condition. There is a bench and a sign. An electric scooter is parked near the sign. The sidewalk and street appear clean with no visible litter or hazards. The building behind the bus stop has a	

+ Code + Text

RAM
Disk

2025-02-03 15:36:34.608000+00:00

2025-02-03 15:34:48.9

2025-02-03 15:34:43.205000+00:00

```
df3['image'] = df3['url'].apply(preview_image)
HTML(df3[['bus_stop_id', 'updated', 'event_type', 'image']].to_html(escape=False))
```

	bus_stop_id	updated	event_type	image
0	33	2025-02-03 00:00:00+00:00	flood	
1	33	2025-02-03 00:00:00+00:00	thunderstorm wind	

Take Away

- AI/ML is easier than ever to take advantage of now with seamless integration into analytics tools
- Predictive analytics can be a part of continuous improvement, not just research projects
- Multimodal capabilities of LLM for image analysis is a very powerful tool

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Thank you

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tackaberry@google.com

Google Cloud