Machine Learning, Deep Learning, GenAl & Artificial Intelligence and how they can be applied to Probe Data

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# **Probe Vehicle Data**

#### What is it?

- Real-time or historic
- Traffic data collected from moving vehicles
- No roadside infrastructure
- Vehicles are the sensors
- 24x7 sample of network conditions
- Mixed vehicle types (passenger, freight, etc.)
- Mixed ping rates





# What is our Goal?

#### Making probe data more useful



INR

# High Level Concepts: Unraveling the Types of AI

Al is just computer software that mimics the way humans think to perform complex tasks





## **Machine Learning**

ML is a subset of AI that uses advanced algorithms to detect patterns in large data sets, allowing machines to learn & adapt

- Machine learning allows systems to identify patterns and improve themselves through experience and data.
- Has been used for decades in surface transportation
  - o Traffic Management
  - o Traffic signal optimization
  - Demand forecasting
  - Routing technology
  - Traffic prediction
  - o Predictive maintenance
  - Incident detection and response
  - o Ramp metering
  - Video analytics





## **Deep Learning**

A subset of ML which uses of neural networks to simulate the way human brains understand the world

- **Deep Learning** uses artificial neural networks in which multiple layers of processing are used to extract progressively higher-level features from data.
- Deep Learning is used many ways for example:
  - $\circ~$  Normalizing trips data as sources change over time
  - Predicting parking availability and occupancy
  - o Predicting speeds well into the future
  - Crash prediction models for risk assessment





# **Generative AI**

GenAl is a subset of DL models that generates content like text, images, or code-based on provided input

- Generative AI (GenAI) refers to systems designed to create new content, whether that's text, images, music, or even video. It uses foundational data models to generate information that is similar to the training data.
- Most people are familiar with GenAl trained on a large language model (LLM) to create outputs like <u>new</u> text, art, music, or other simulations.

#### Applications:

- Generating text (ChatGPT, GPT-3)
- Creating images from text prompts (DALL-E)
- o Composing music
- Simulating 3D environments







# **Artificial Intelligence**

What it is not!!!

- All three previous examples help frame what various types of new and existing Artificial Intelligence *is*, but just as important is what it is *not*.
- Al is not:
  - o Replacement for a human
  - $\circ~$  A black box that can magically answer any questions

0 ...



# Challenges

### What could go wrong?

- GenAI will give you an answer, no matter what
  - o Test, test, test
- Job displacement
  - Possible, but offers "upskilling" opportunities
- Scalability
  - Can the platform and tool address future needs and larger datasets?
- Over dependence
  - Some tasks continue to require human emotional intelligence, judgement, creativity



# **Challenges (continued)**

What else could go wrong?

#### Privacy/ Copyright concerns are real

- Read the fine print
- Files and conversations may be used to train future models
  - Your conversations with ChatGPT are not confidential
  - Any file you upload to ChatGPT is retained indefinitely within the service
- "There's also the risk of accidentally sharing confidential trade secrets or business information by inputting data into generative Al tools." – Harvard Business Review, April 7, 2023.



#### THE WALL STREET JOURNAL. CIO JOURNAL Sponsored content by Deloitte. - Learn More RISK MANAGEMENT | AI | REGULATORY Convright Office Report May

#### **Copyright Office Report May Pave Path for U.S. AI Regulation**

Guidance is expected to address issues such as digital replicas, copyrightability, AI model training, transparency, recordkeeping, labeling, and more

 $\overleftrightarrow$  Share A Resize

Listen (11 min)

The U.S. Copyright Office has <u>published a report</u> recommending "prompt federal action" to develop a new law governing copyright and AI as a result of the speed, precision, and proliferation of AI-created digital replicas. "Without a robust nationwide remedy [the] unauthorized publication and distribution [of AI-digital replicas] threaten substantial harm not only in the entertainment and political arenas, but also for private individuals," the report says.

"Digital replicas" refers to videos, images, or audio recordings that have been digitally created or manipulated to realistically but falsely depict an individual. It captures "deep fakes" as they are colloquially known and where those imitate a person.

The report is the first of three the Copyright Office says it plans to publish analyzing the impact of AI on copyright and making recommendations for

## Resources

There are tons of research and studies into the challenges and potential for AI in transportation

- FHWA ITS JPO
- Bureau of Transportation Statistics
- ITS America

Artificial Intelligence (AI) for Intelligent Transportation Systems (ITS)

Challenges and Potential Solutions, Insights, and Lessons Learned

www.its.dot.gov/index.htm Final Report – October 2022

FHWA-JPO-22-968

#### Identifying Real-World Transportation Applications Using Artificial Intelligence (AI)

Plan for Artificial Intelligence for Intelligent Transportation Systems

www.its.dot.gov/index.htm FINAL – August 2020 Publication Number: FHWA-JPO-20-813

## ITS 💐 AMERICA

AI POLICY PRINCIPLES

Artificial intelligence (AI) is poied to radically transform the capabilities of transportation planners and operators to utilize data to proactively enhance safety, efficiency, equity, resiliency, and sustainability. The Intelligent Transportation Society of America (ITS America) has developed AI Policy Principles to help guide the regulation, development, and deployment of AI technologies and applications in our transportation system so that these new tools are used safety, transportation effectively in ways that provide net benefits to people and their communities and to build trust in these technologies to scale their adoption nationwide.

**ITS JPO HIGH-PRIORITY** 

Data Access and Exchanges

Accelerating ITS Deployment

Emerging and Enabling Technologies

**RESEARCH AREAS** 

Cybersecurity for ITS

Complete Trip – ITS4US

Automation

June 2024



#### Potential Application of Al in Transportation

Al is revolutionizing every walk of life, allowing machines to learn from experience, adapt, and perform tasks that have historically required human cognition. The ITS Joint Program Office (JPO) established research in Al as a priority area to accelerate adoption of Al by state and local agencies for addressing transportation problems.

The Identifying Real-World Transportation Applications Using Artificial Intelligence (AI): Summary of Potential Application of AI in Transportation report (July 2020, FHWA-JPO-20-787) identified broad categories of AI-enabled applications that can be applied to address specific transportation problems and needs and summarized existing and potential applications enabled by AI under each category based on a literature review.





cambridge consultants Date degenerationer

The Impact of Al on Transportation and Mobility

ITS 🛃 AMERICA



## ITS 💐 AMERICA

#### AI DECODED

Artificial intelligence (AI) is poised to bring immense safety, efficiency, equity, resiliency, and sustainability benefits to the transportation sector. As we continue to see increased deployments of At tools, knowledge gaps have emerged. The Intelligent Transportation Society of America (ITS America) has developed Al Decoded to hele gezinia Al in a practical, nontechnical way for transportation practitioners and non-practitioners alke. Bringing greater awareness to Al use cases and demystifying its capabilities will help the industry continue to make strides in deployment. Education on new technologies, like AI, is key to deployment and realizing the transformational benefits of this technology.



# The INRIX Approach to Developing a Generative AI Solution

- Defined what we wanted to achieve
  - $\circ$  Use cases
  - Benefits (improve workflows, efficiency)
  - o Data Insights
- Needed a flexible platform that merged our data with a LLM
- Spent thousands of staff hours testing different platforms and models





# **INRIX Compass: Added Layer of Intelligence**

Our GenAI Tech Puts 20+ Years of Data & Expertise at Your Fingertips to Answer the What, Who, How, & Why

#### WHAT?

Quickly Pinpoints Issues: Al-driven analysis deciphers trillions of data points in seconds to quickly pinpoint traffic issues systemwide unlike current siloed solutions

#### WHY?

#### Deeper Insights to Determine Root Cause:

Al correlates information from diverse data-sets to provide insights about what might have caused issues like: congestion, accidents, signal failure, parking, events, etc



### HOW?

# Prescriptive Recommendations to Help Solve Issues:

Models are trained on decades of academic research & standards to provide solutions to issues like: traffic signal retiming plans, safety plans, street design improvements, etc.

## **"WHAT IF?"**

Predict Impact of Hypothetical Changes: Test performance of hypothetical situations, to analyze what impact they will have on your transportation network.



# **Massive Data Lake**

A vast digital blueprint captured from connected vehicles, devices, and infrastructure.



- 50 petabytes of rich transportation data
- Collected over past 20 years
- Proprietary and 3<sup>rd</sup> party sources
- Includes connected vehicle, truck, mobile device, incident, weather, cameras, smart infrastructure, events, and more



# **Current Compass Solution**

How Compass Works



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Agent Architecture



- Perceive, reason, and interact autonomously with data lakes and other tools
- Faster initial responses and more iterative user experience



- Users can load their own data into Compass, such as:
  - Crash data
  - Asset Inventory
  - Equity Indices
  - POIs





• Teach model with existing, industry-leading literature



# **Current Compass Solution (continued)**

How Compass Works



Prompt Engineering



- Carefully designing prompts
- Guide the LLM in analyzing data
- Set context for model analysis





Interpret and contextualize data within specific geographic locations and timeframes





- Humans test model
  responses
- Use feedback to refine and improve performance
- Ensure responses gain
  precision and usefulness



# **Use Case #1: Traffic Causality**

INRIX Mission Control --- A Real-Time Mobility Data Solution

# **INRIX Data Lake**



- Congestion alerts
- Incidents
- Traffic Speeds
- Holidays
- Weather
- Events
- Social Media



Click on "Congestion Alert"

- Congestion alerts
- Incidents
- Traffic Speeds
- Holidays
- Weather
- Events
- Social Media



Get details on location, what the issue is, and how much traffic flow is impacted.

- Congestion alerts
- Incidents
- Traffic Speeds
- Holidays
- Weather
- Events
- Social Media



Click "INRIX Compass" to get contextual, data driven answers using Generative AI.

- Congestion alerts
- Incidents
- Traffic Speeds
- Holidays
- Weather
- Events
- Social Media



User: Is the congestion here worse than normal?"

#### **INRIX Compass:**

Yes the congestion here is worse than normal. The current congestion on I-35 SB in Randolph hills shows delay of 3 minutes, with an average speed of 15 mph. Assessments indicate that congestion here tends to last for most of the day usually between 6:45 am -3:45 pm and the current time is 8:44pm is outside the regular congestion times. Additionally, the congestion has been ongoing since 8:32 pm, indicating it is abnormal for this time of day. Given the current clear weather conditions and lack of major events or holidays that could be contributing factors, this suggest the congestion is worse than typical conditions.



User: Are there any crashes near here?

#### **INRIX Compass:**

Yes, there is currently a crash on TX-1604 Loop Westbound from Kitty Hawk rd. that has the main roadway closed. This crash started at 5:53PM on Monday, May 13, 2024 and is ongoing. This high severity incident involving a crash and road closure is relatively close (2.1 miles) from the location being asked about so I would consider it a crash near the congestion on 1-35 Southbound in Randolph Hills?



# Use Case #2: Safety & Risk

Our existing Safety SaaS application with a GenAI proof-of-concept co-developed with Caltrans

# INRIX + Caltrans Data Lake

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#### Data Lake Datasets

- Congestion alerts
- Incidents
- Traffic Speeds
- Holidays
- Weather
- Events
- Social Media

#### Newer INRIX Data Lake Datasets

- Vulnerable Road User Index
- Speed Distribution Profile
- Volume Profile

#### Caltrans Datasets

- Crash Data
- Asset Inventory
- Equity
- POIs



## Use Case #2: Safety & Risk (Using Safety View™)

We "trained" Compass with FHWA provided safety countermeasures





## Use Case #2: Safety & Risk (Using Safety View<sup>™</sup>)

#### User:

What are the top 5 crash hotspots & what are the federal counter measures for the top 2 hot spots

#### **INRIX Compass:**

The top 5 crash hotspots based on the # of crashes are:

- 1. Segment 50974723 with 121 crashes
- 2. Segment 94211453 with 114 crashes
- 3. Segment 70831465 with 56 crashes
- 4. Segment 28485303 with 52 crashes
- 5. Segment 39531835 with 42 crashes





#### **INRIX Compass:**

For the top 2 crash hotspots, the federal countermeasures are:

- 1. Segment 50974723
- Countermeasures: Installing median barriers (concrete, cable, or beam guardrails) to prevent cross-median crashes and providing adequate clear zones and flattening side slopes to reduce the severity of run-off road crashes
- Data Sources:
  - A Guide for Reducing Collisions on Curves
  - Roadside Design Improvements at Curves
  - Traffic Safety Systems Guidance

#### 2. Segment 942114531

- Countermeasures: Implementing Variable Speed Limits (VSLs) to reduce crashes & installing median barriers (concrete, cable, or thrie-beam barriers) to prevent cross median crashes.
- Data Sources:
  - Traffic Safety Systems Guidance
  - Variable Speed Limits

#### 1. Segment ID: 509747233 0 Countermeasures: Installing median barriers (concrete, cable, or beam guardrail) to prevent cross-median crashes and providing adequate clear zones and flattening side slopes to reduce the severity of run-off-road crashes. Data Sources;

For the top 2 crash hotspots, the federal countermeasures are:

The top 5 crash hotspots based on the number of crashes are

1. Segment ID: 509747233\_0 with 121 crashes

2. Segment ID: 942114531\_0 with 114 crashes 3. Segment ID: 708314651\_0 with 56 crashes

4. Segment ID: 28485303\_0 with 52 crashes

5. Segment ID: 395318356\_0 with 42 crashes

::::

INRIX Compass

- A Guide for Reducing Collisions on Horizontal Curves
- Roadside Design Improvements at Curves Traffic Safety Systems Guidance
- 2. Segment ID: 942114531\_0
- Countermeasures: Implementing Variable Speed Limits (VSLs) to reduce crashes and installing median barriers (concrete, cable, or thrie-beam barriers) to prevent crossmedian crashes
- Data Sources;
- Traffic Safety Systems Guidance Variable Speed Limits

Ask a follow-up question...

## Use Case #2: Safety & Risk (Using Safety View<sup>™</sup>)

Safety View by I FUTURE ROADS INRIX Su, Mo, Tu, We, Th, Fr, Sa 12:00 AM - 12:00 AM INRIX Compass 🖌 Segment Map Caltrans District 04 0 Garage I Compass Al You: the top 2 crash hotspots?

2

Safety Benefits:

Flatten sideslope from 1V:3H to 1V:4H:

8% reduction for single-vehicle crashes.<sup>2</sup>

Flatten sideslope from 1V:4H to 1V:6H: 12% reduction for

single-vehicle crashes.<sup>2</sup>

Increase the distance to roadside features from 3.3 ft to 16.7 ft:

22% reduction for all crashes.<sup>3</sup>

Increase the distance to roadside features from

16.7 ft to 30 ft: 44%

reduction for all crashes.<sup>3</sup> For more information on this and other FHWA Proven Safety Countermeasures, please visit

https://safety.fhwa.dot.gov/ provencountermeasures/ and https://safety.fhwa.dot.gov/ roadway\_dept/counter measures/safe recovery/ clear zones/.

FHWA-SA-21-029

#### **Proven Safety** Countermeasures

OFFICE OF SAFETY

#### **Roadside Design** Improvements at Curves

· A clear zone is an unobstructed.

traversable roadside area that

allows a driver to stop safely or

regain control of a vehicle that has

left the roadway. Agencies should

such as trees and utility cabinets or

avoid adding new fixed objects

steepness of the sideslope to

of 1V:4H or flatter are considered recoverable (i.e., drivers can retain

control of a vehicle by slowing or

stopping). Slopes between 1V:3H

traversable, but non-recoverable (i.e. errant vehicle will continue to

the bottom of the slope).

and 1V:4H are generally considered

Horizontal curves account for 27 percent of all fatal crashes and 80 percent of all fatal crashes at curves are roadway departure crashes.<sup>1</sup> Roadside desian improvements at curves is a strategy encompassing several treatments that target the high-risk roadside environment along the outside of horizontal curves These treatments can reduce roadway departure fatalities and serious injuries by giving vehicles the opportunity to recover safely and by reducing crash

Roadside design improvements can be implemented alone or in combination. and are particularly recommended at horizontal curves-where data indicates a higher risk for roadway departure fatalities and serious injuries.

#### Roadside Design Improvements to **Provide for a Safe Recovery**

to regain control in the event of a In cases where a vehicle leaves roadway departure. the roadway, having strategic roadside desian elements, including an added or widened shoulder, **Reduce Crash Severity** flattened sideslopes, or a widened

clear zone can provide drivers with an opportunity to reagin control and re-enter the roadway in their lane or come to a safe stop before rolling over or encountering a fixed object. treatment. Three common types of roadside barriers are:

> · Cable barrier is a flexible barrier made from steel cables mounted on weak steel posts. Flexible barriers are more forgiving and have the most deflection.

rigid barrier where a W-beam or box-beam is mounted on steel or timber posts. These deflect less than cable barriers, so they can be located closer to objects where

#### Concrete barrier is a riaid barrier that has little to no deflection.



I Fatality Analysis Reporting System. 2 NCHRP Report 617: Accident Modification Factors for Traffic Engineering and ITS Improvements, (2008). 3 Elvik, R., and Vaa, T. Handbook of Road Safety Measures, (2004).



#### **Roadside Design Improvements to**

Since not all roadside hazards can be removed, relocated, or redesigned at curves, installing roadside barriers to shield unmovable objects or steep embankments may be an appropriate

Metal-beam guardrail is a semi-



Clear zone provided on the outside of the curve. Source: FHWA.

ZERO GOAL

#### 2. Segment 942114531

- Countermeasures: Implementing Variable Speed Limits (VSLs) to reduce crashes & installing median barriers (concrete, cable, or thrie-beam barriers) to prevent cross median crashes.
  - Data Sources:
    - Traffic Safety Systems Guidance
    - Variable Speed Limits

What are the top 5 crash hotspots and what are the federal countermeasures for

:::

Compass Al: Querying tool: CrashDataWithScratchpadTool

Compass Al: Querying tool: SortAndLimitWithScratchpadTool

#### Compass Al:

The top 5 crash hotspots based on the number of crashes are:

1. Segment ID: 509747233\_0 with 121 crashes 2. Segment ID: 942114531 0 with 114 crashes 3. Segment ID: 708314651\_0 with 56 crashes 4. Segment ID: 28485303\_0 with 52 crashes 5. Segment ID: 395318356\_0 with 42 crashes

For the top 2 crash hotspots, the federal countermeasures are:

#### 1. Segment ID: 509747233 0

- Countermeasures: Installing median barriers (concrete, cable, or beam guardrail) to prevent cross-median crashes and providing adequate clear zones and flattening side slopes to reduce the severity of run-off-road crashes.
- Data Sources:
- A Guide for Reducing Collisions on Horizontal Curves Roadside Design Improvements at Curves
- Traffic Safety Systems Guidance

#### 2. Segment ID: 942114531\_0

- Countermeasures: Implementing Variable Speed Limits (VSLs) to reduce crashes and installing median barriers (concrete, cable, or thrie-beam barriers) to prevent crossmedian crashes
- Data Sources;
- Traffic Safety Systems Guidance Variable Speed Limits

Ask a follow-up question...





## vehicle, and avoid obstacles. Slopes





the severity of run-off road crashes

For the top 2 crash hotspots, the federal

A Guide for Reducing Collisions on Curves

Roadside Design Improvements at Curves

Traffic Safety Systems Guidance

(concrete, cable, or beam guardrails) to prevent cross-median crashes and providing adequate

clear zones and flattening side slopes to reduce

Countermeasures: Installing median barriers

Data Sources:

Augustine D

**INRIX** Compass:

countermeasures are:

1. Segment 50974723

# **How to Get Started**

**Tips for Success** 

- Have to Have •
  - Structured, clean data • Well articulated problem statements
- Nice to Have •
  - Staff with GenAl technical understanding
  - $\circ$  A contract with INRIX  $\bigcirc$

# INRIX Compass How can I improve traffic flow on this corridor during rush-hour? Why is this street so dangerous INRIX Mission Con for drivers & pedestrians? 09 How can I make this intersection safer for pedestrians?

INRIX Compass

INRIX Compass A

# THANK YOU!

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Intelligence that Moves the World

