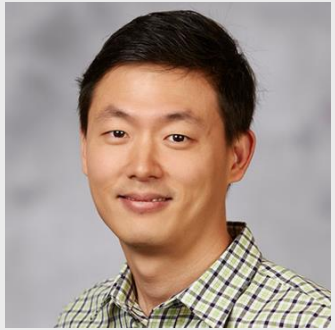
Manual work delegation to an AI-supported computer



Jee Woong (Jay) Park

Assistant Professor

Department of Civil and Environmental Engineering and Construction

Transportation Research Center

Myself

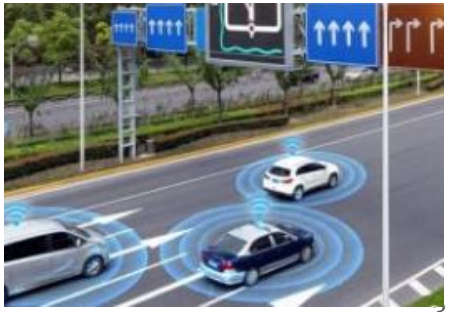
- B.S. from University of Hawaii at Manoa
- M.S. from Stanford University
- Ph.D. from Georgia Tech
- At UNLV since 2017

- My research interests lie in the use of information and emerging technologies to help various civil engineering problems where humans' capabilities lack.
- 10 years focused research on safety

Disruptive Technologies

- Intelligent Transportation Systems
- Autonomous and connected vehicles
- EVs
- Smart cities

Data Driven



We can/should do better beyond “road users”

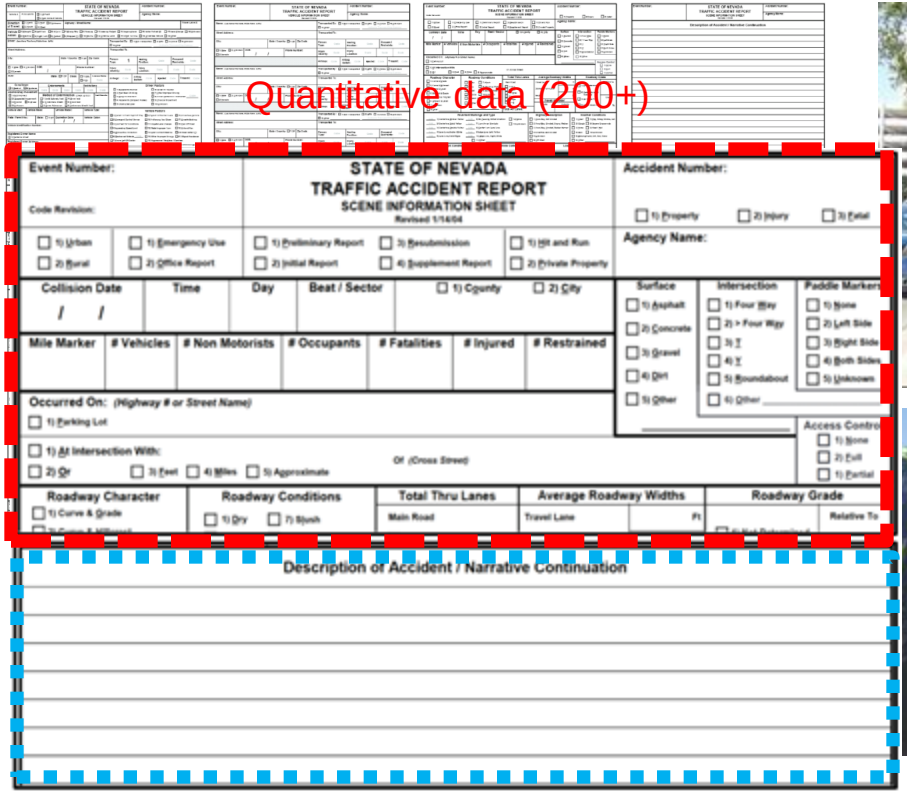
- Uber/Lyft
- Autonomous driving
- Connected systems

Road users

Traffic Infrastructure Management

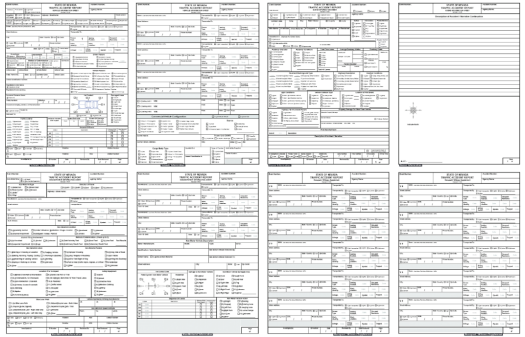
- Our limited capability
- Repetitive manual work

Crash Data Collection & Crash Data Analysis



Crash Data Collection & Crash Data Analysis

- Time consuming
  - Data collection (observing, entering, checking)
- Multiple activities
  - Traffic management, accident management, victim assistance



Our limited ability
Considerable manual process

Crash Data Collection & Crash Data Analysis

Further complications and challenges

- Unreliable data
  - Compromised data quality, missing/incomplete/wrong information
- Further analysis, and decision making
  - Understanding, countermeasures, political decisions
- Long exposure of officers to hazardous traffic
  - 8% of line-of-duty deaths are due to vehicles striking police officers while on foot.
- **All these matters are interconnected and interdependent**

Our limited ability
Considerable manual process

Crash Data Collection & Crash Data Analysis

My research

- Aims to introduce an automated approach to crash data collection
- By developing an AI-supported tool to delegate repetitive, manual work to AI-supported computers

Crash Data Collection & Crash Data Analysis

- Hypothetical scenarios (in fact, confirmed by DOTs)
  - NDOT better understand lane changes and their relations with crashes
  - MassDOT learned there are a considerable number of mismatching data between quantitative and qualitative data sets.
  - Distracted driving—texting, calling, smoking, eating, children?

P. Contributing Circumstances - Driver

1. No Improper Driving
2. Failed to Yield Right of Way
3. Disregarded Traffic Signs, Signals, Road Markings
4. Exceeded Authorized Speed Limit
5. Driving Too Fast for Conditions
6. Made an Improper Turn
7. Wrong Side or Wrong Way
8. Followed Too Closely
9. Failure to Keep in Proper Lane.
10. Operating Vehicle in Erratic, Reckless, Careless, Negligent or Aggressive Manner
11. Swerving or Avoiding Due to Wind, Slippery Surface, Vehicle, Object, Non-motorist in Roadway, etc
12. Under the Influence of Medication/Drugs/Alcohol
13. Visibility Obstructed
14. Inattention
15. Distracted
16. Fatigued, Asleep
17. Operating Defective Equipmer
18. Other Improper Action
19. Technology Related Distractic
20. Unknown

- Texting?
- Smoking?
- Eating?
- Children?
- Stereo?

Crash Data Collection & Crash Data Analysis

- Use narratives

1. V1, a pickup, was traveling in the right-hand lane of northbound SR-7 following V2, a van. V2 slowed suddenly. D1 did not notice V2 slowing in time and swerved to the right to avoid striking V2. V1 struck a tree off the right side of the road. V1 veered off the tree and proceeded to cross over the center median grass striking V3 traveling in the right-hand southbound lane injuring the driver of V1. After being struck by V1, V3 struck the curb on the right-hand side of the road, crossed over the sidewalk, and struck a pedestrian and then a light pole. V2 did not know the crash had occurred and kept on driving.
2. V1, a firetruck returning from an emergency, was traveling west on Garden Parkway approaching the Mayberry Street underpass when a malfunction in th hydraulic system of its hook and ladder apparatus caused the ladder swing to the right of the vehicle. When V1 went under the Mayberry St overpass the ladder and bucket struck the bottom of the bridge, break the top portion of the ladder. The ladder piece struck the right front quarter panel of V2, which was following directly behind V1. V2 lost control and struck the underpass bridge abutment on the eastbound side of the road.
3. D1 was stopped at the stop sign on the south end of the bypass road around the King's Mine Overpass construction. Upon entering US-41 with the intention of crossing over the northbound lanes and then turning to the south, D1 failed to see V2 northbound on US-41. V2 struck the front driver's side of V1 causing it to spin clockwise. D1 was either unconscious or disoriented. D1 apparently had her foot on the accelerator and went approximately 1,000 feet to the north in the median and then crossed over northbound US-41. After crossing the northbound lanes, V1 started up the ramp at the King's Mine Interchange which is currently closed for construction. V1 went head-on into the guardrail end terminal on the west side of the ramp.

Extract

- I was dispatched to the area for the report of a motor vehicle crash involving truc board.
- The second v , owned by a transportation to the passenger side of the motor v
- A female citiz en involved in an MVA with a school bus shortly before her arriva

Obvious cases with school bus, the reports marked "non-school bus"

Examples of errors impacting downstream analysis

- He again stated he did not remember bei speaking to me, I detected a strong odor of an alcoholic beverage coming from h est, I formed the opinion that he was o e influence of an intoxicating b

Obvious cases with school bus, the reports marked "non-alcohol"

- I smelled a st n. She called her brother and stated she was drunk and going to be in trouble because she was driving and involved in a crash. She was issued a criminal citation for liquor and negligent operation of a motor vehicle.

C alysis

1. V1, a pickup, was traveling in the right-hand lane of northbound SR-7 following V2, a van. V2 slowed suddenly. D1 did not notice V2 slowing in time and swerved to the right to avoid striking V2. V1 struck a tree off the right side of the road. V1 veered off the tree and proceeded to cross over the center median grass striking V3 traveling in the right-hand southbound lane injuring the driver of V1. After being struck by V1, V3 struck the curb on the right-hand side of the road, crossed over the sidewalk, and struck a pedestrian and then a light pole. V2 did not know the crash had occurred and kept on driving.
2. V1, a firetruck returning from an emergency, was traveling west on Garden Parkway approaching the Mayberry Street underpass when a malfunction in the

otor vehicle crash
oard.
wned by a
the passenger side

involved in an MVA

It takes time….
Retain what level of detail?
Extract information precisely and reliably?
Thousands to read

Our limited ability
Considerable manual process

How can we do better?

Crash Data Collection

- Manual data collection
- Time constraint
- Repetitive
- Errors, safety issues, unreliable historical data

Crash Data Analysis

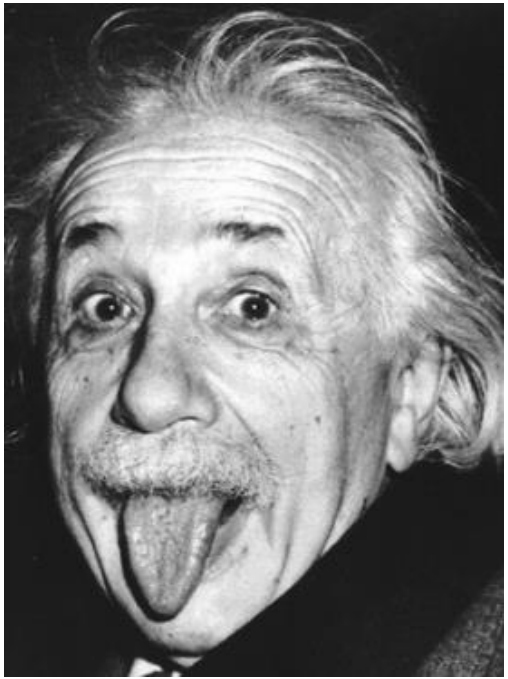
- Manual reading
- Time constraint
- Repetitive
- Subjectivity, unreliable

Delegate repetitive, manual work to AI-supported computers

Our limited ability
Considerable manual process

Human + Computer Interaction

Albert Einstein



7±2

Number of items an average human holds in working memory

George Miller, 1956

"Computers are incredibly fast, accurate, and stupid.
Human beings are incredibly slow, inaccurate, and brilliant.
Together they are powerful beyond imagination."

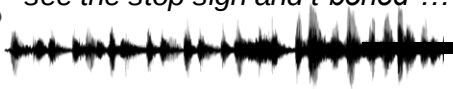
Work delegation to AI-supported computers

- Data collection – new platform dev.

Observing & collecting

Voice input

"The driver of vehicle 1 failed to see the stop sign and t-boned …"



SR-assisted Collection

AI-platform

Speech Recognition

Convert recording to text narrative

Natural Language Processing

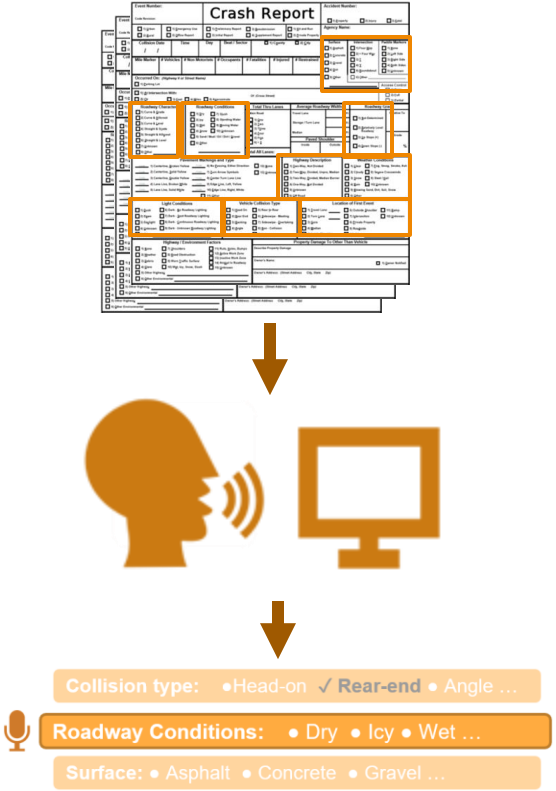
Identify crash factors in text

Completed Report

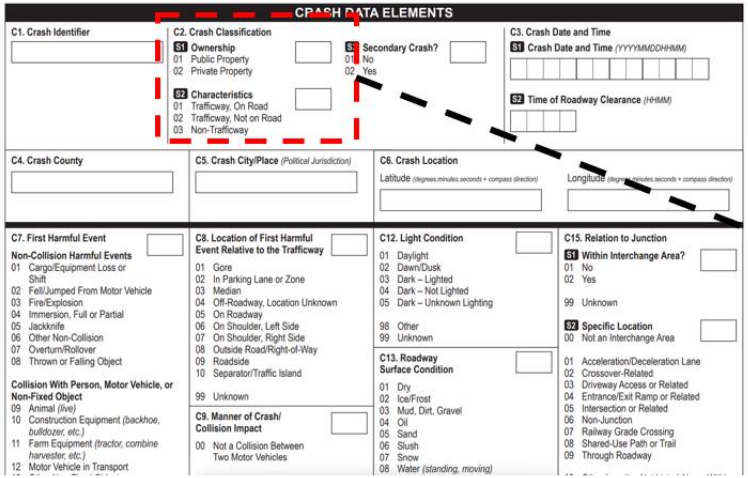
Areas of technical challenges and hurdles we will overcome to produce successful output

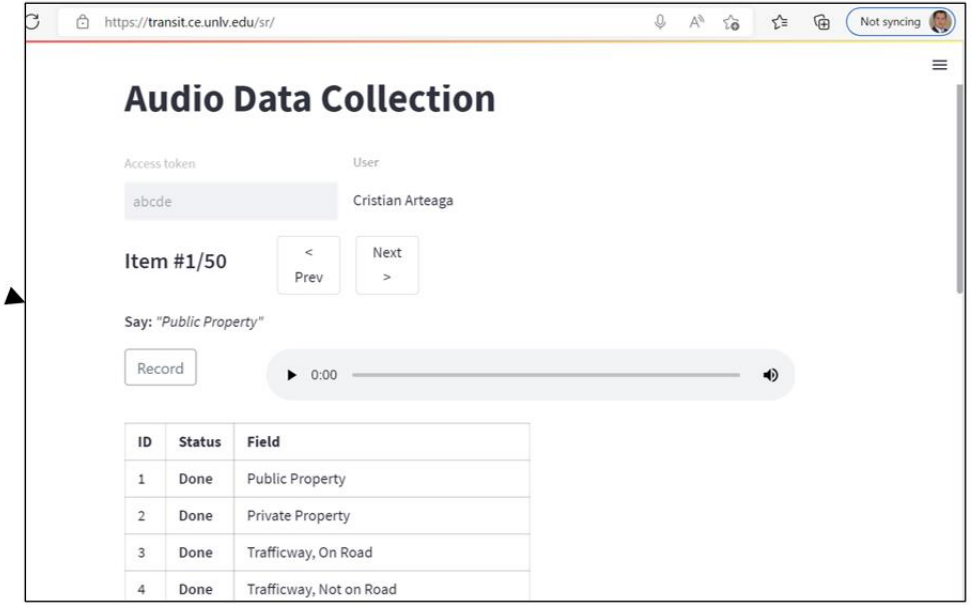
Multi-phase Systematic Development

- Phase 1: Prompted input
  - Determine the portions of the reports that can be efficiently collected via SR
  - Tailor SR models for reliable recognition of crash attributes
  - Create a processing platform to implement the tailored SR models
  - Validate the platform



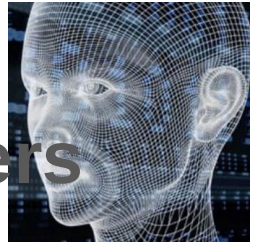
Data collection tool





<u>Part-time Undergraduate students</u>:
Monserat, Alberto, Elijah, Brianna, Kendal, Abraham, Marc, Christian

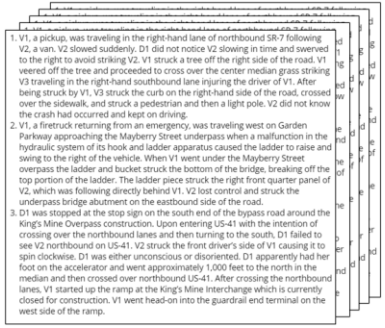
Work delegation to AI-supported computers



- Data Analysis – semantic search by AI

Query:
"The vehicle departed its traveling lane"

Narratives



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Semantic Similarity

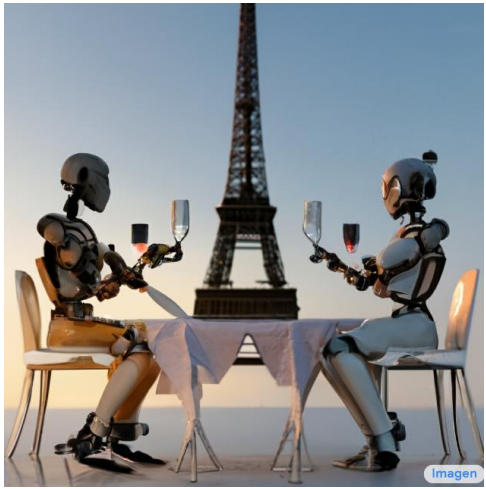
Areas of technical challenges and hurdles we will overcome to produce successful output

Find answers

1. V3 veered over the solid yellow line and struck the …
2. V2 was unable to maintain lanes …
3. V1 veered to the left, crossed over to the left shoulder, then
4. V2 crossed the center line and went onto the shoulder …
5. V2 veered into the median, overcorrected, and veered …
6. V1 traveling westbound went into the eastbound lane and collided …

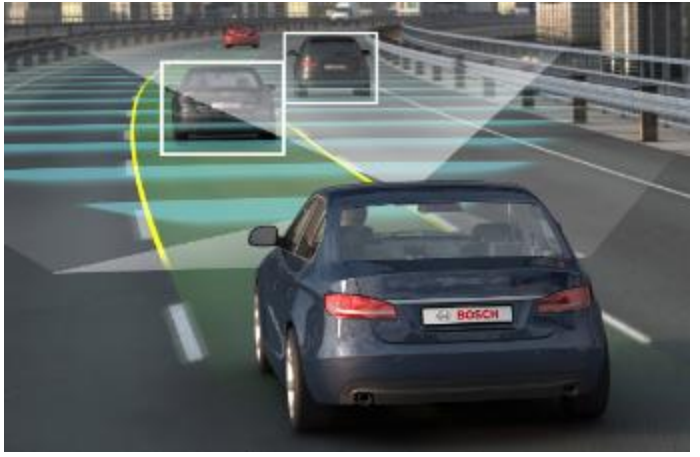
Multi-phase Systematic Development

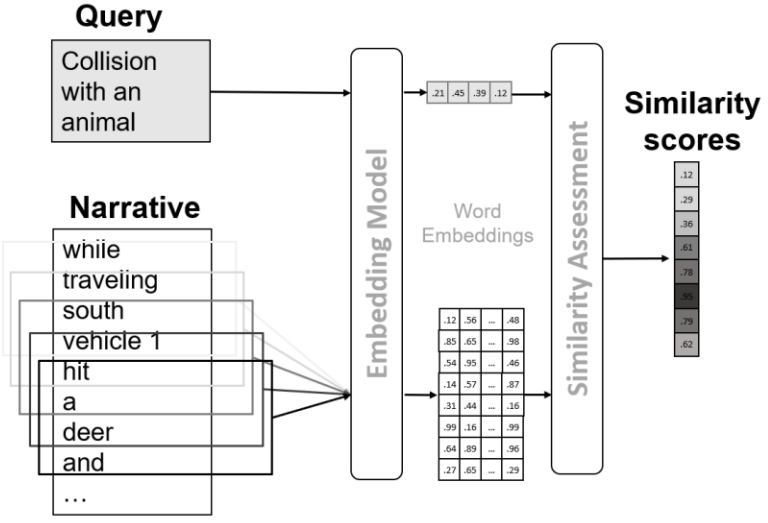
- Phase 1: AI-based semantic model / application
  - Identify state-of-the-art AI techniques for semantic search extensive text data
  - Implement the query-based approach for semantic search in crash narratives
  - Validate the proposed application in real-life settings



Technical challenges (1)

- What is we see and understand is different from what computers see and understand





Technical Challenges (2)

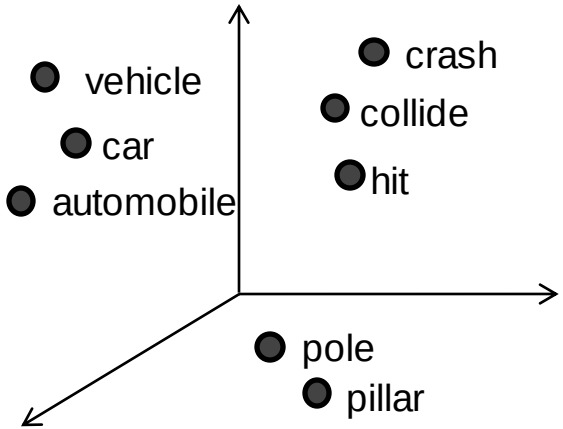
- Complexity in language expression

- V1 veered to the left, crossed over to the left shoulder, then hit a tree.
- V2 was operating at high speeds and was unable to maintain lanes …
- V2 crossed the center line and went onto the shoulder of the opposite lane.
- V2 veered into the median, overcorrected, and veered right into the shoulder.
- V1 traveling westbound went into the eastbound lane and collided head-on…
- V3 crossed the yellow line and hit the front of an upcoming car.

We need computers to be <u>smart and adaptive</u> to understand <u>*semantic information*</u> from human language beyond simple keywords match

Ongoing technical investigation

- Word Embeddings



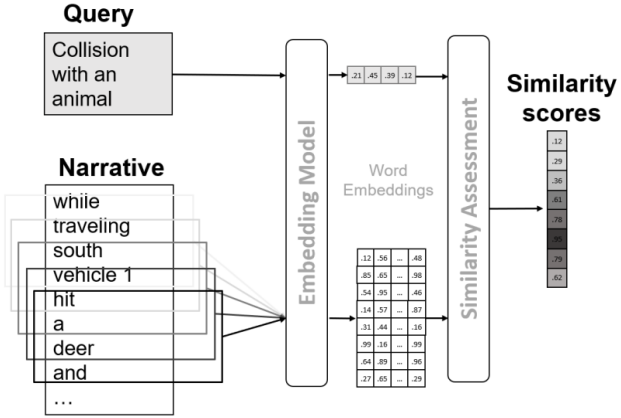
vehicle	0
hit	1
crash	2
pole	3
collide	4
car	5
pillar	6
…	…

embedding dimension

.12	.56	…	.48
.85	.65	…	.98
.54	.95	…	.46
.14	.57	…	.87
.31	.44	…	.16
.99	.16	…	.99
.64	.89	…	.96
.27	.65	…	.29

vocabulary size

…



Data attribute studies…
Portions of data for SR

Open-Source SR models

Open-Source Model	Company	Word Error Rate
Wav2Vec 2.0	Meta AI	2.1
Whisper	OpenAI	2.7
UniSpeech	microsoft/ UniSpeech UniSpeech - Large Scale Self-Supervised Learning for Speech	3.7

Expected benefit from successful outcome

- Considerable effective data collection & analysis methods
- Remove manual process
  - Reading hundreds/thousands narratives
  - Data collection
- Quick, effective, accurate, safe, and reliable
- More vigilant and robust practice given pressuring and hectic onsite activities
- Practice supported by technological advances and innovation
- Automated process supported by AI

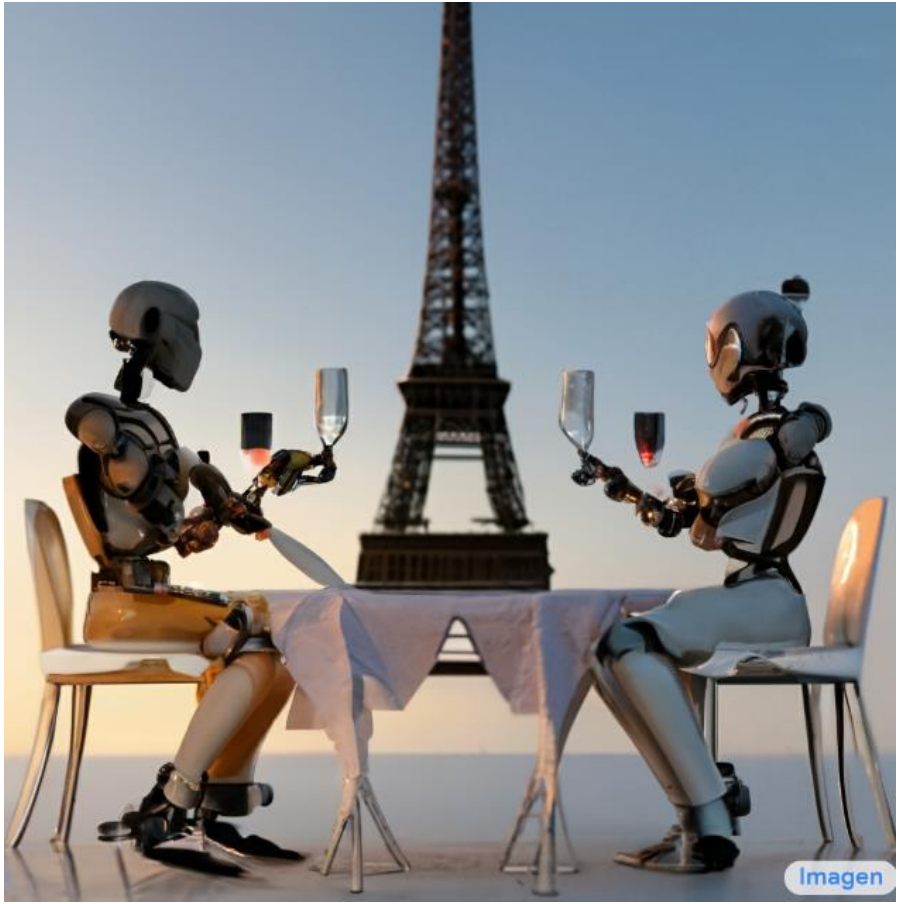
Q&A

- My research also include work-zone safety that implements emerging technologies. Feel free to contact me if there is anything we can discuss
  - Struck by accidents!!! (many real-life accidents) – repair cracks
- Special Thanks for OTS, NDOT, Kimley horn (Kevin, Peter, Amy, Lacey, Mike and others)

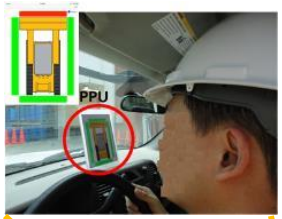
Can computers understand human language?

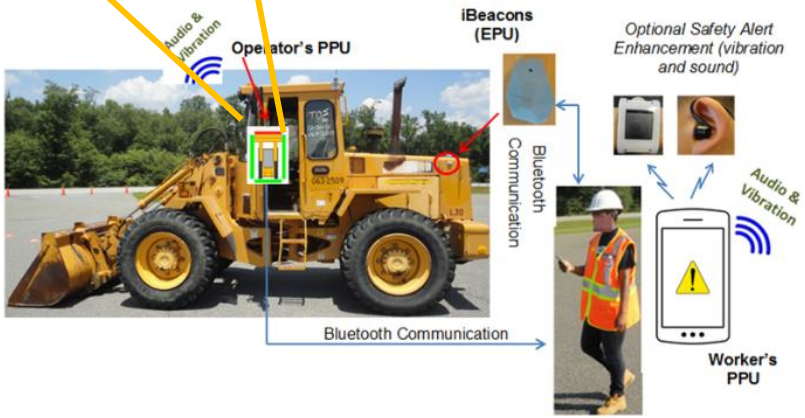
An AI model generated this image based on the description:

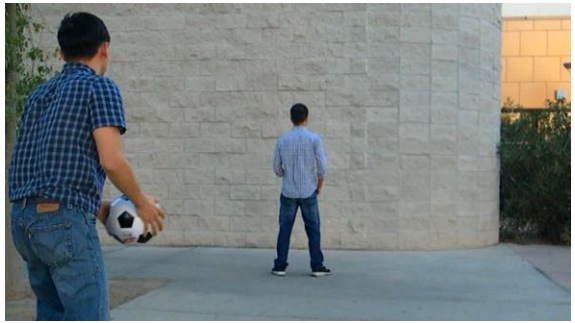
A robot couple fine dining with the Eiffel Tower in the background.



Collision Accident Prevention







SR-assisted collection of crash reports

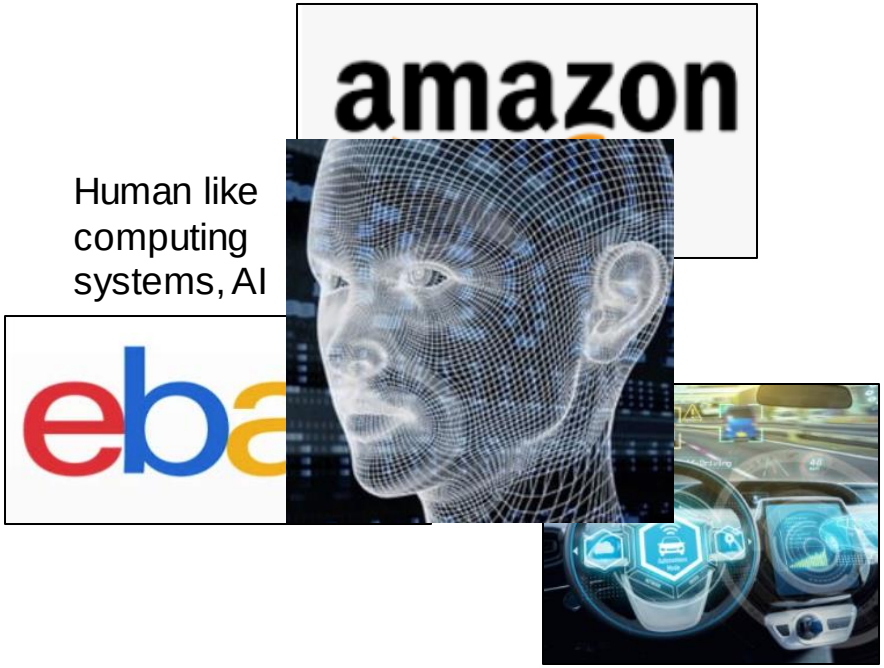
Semantic search for crash narratives

UNLV CEEC, Jay Park

Evolution of AI

- Better shopping experience
  - Find products
  - Better price, more selections
- Smarter --> Autopilot
  - Taking more parts of lives
  - Arguably, safer and more convenient
- Realized by
  - State-of-the-art techniques(e.g., AI)
  - Together with data
- Unlimited potential ahead in future

Human like computing systems, AI



Data…

MA crash narrative

1. V1, a pickup, was traveling in the right-hand lane of northbound SR-7 following
V2, a van. V2 slowed in time and swerved to the right to avoid not notice V2 slowing in time and swerved veered off the t struck a tree off the right side of the road. V1 V3 traveling in t o cross over the center median grass striking being struck by bound lane injuring the driver of V1. After over the sidewa rb on the right-hand side of the road, crossed the crash had o estrian and then a light pole. V2 did not know
2. V1, a firetruck r driving.
Parkway approa ergency, was traveling west on Garden hydraulic syster Street underpass when a malfunction in the swing to the rig lder apparatus caused the ladder to raise and overpass the la en V1 went under the Mayberry Street top portion of t ck the bottom of the bridge, breaking off the V2, which was f r piece struck the right front quarter panel of underpass brid ind V1. V2 lost control and struck the eastbound side of the road.
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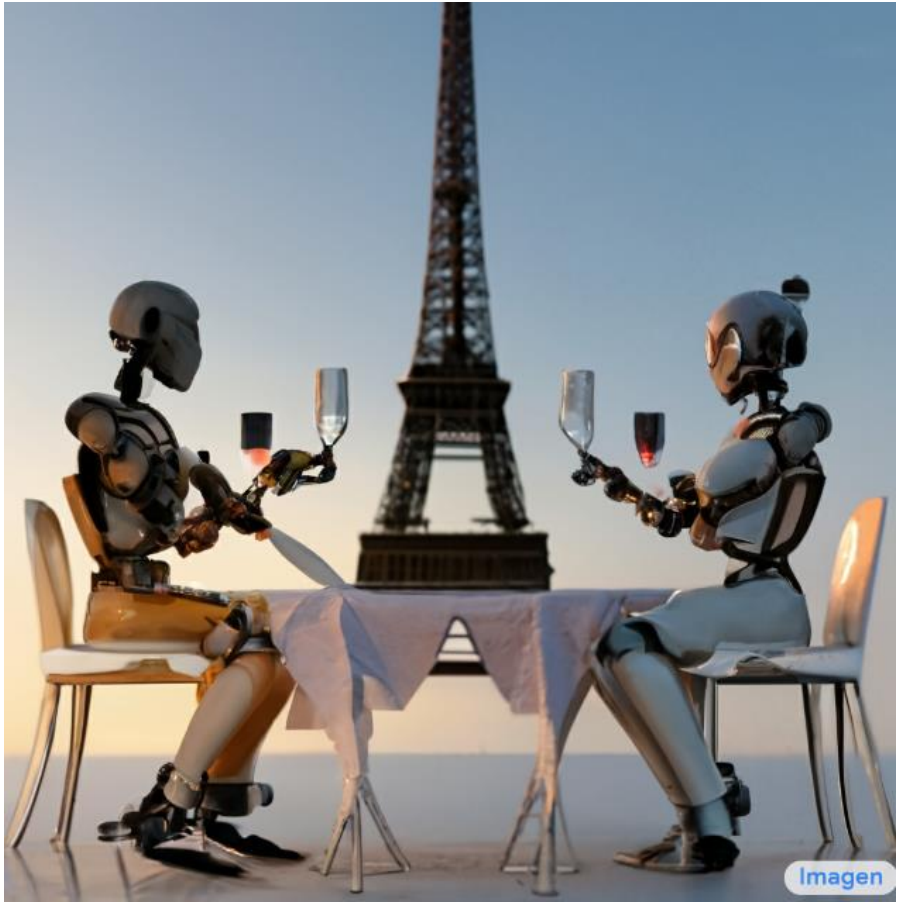
sions

Big picture…

Can computers understand human language?

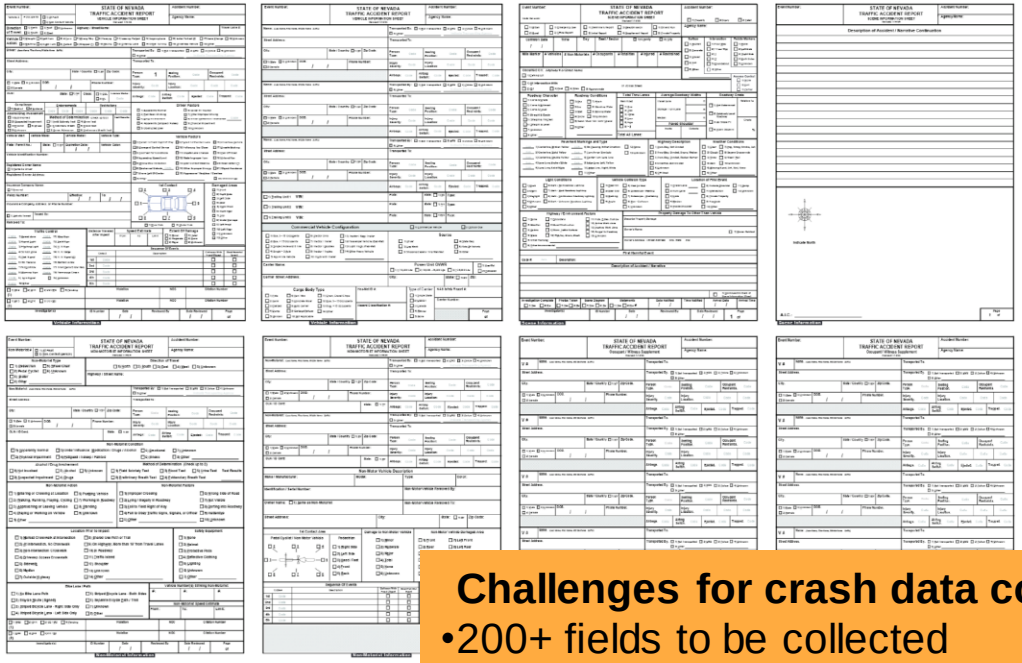
An AI model generated this image based on the description:

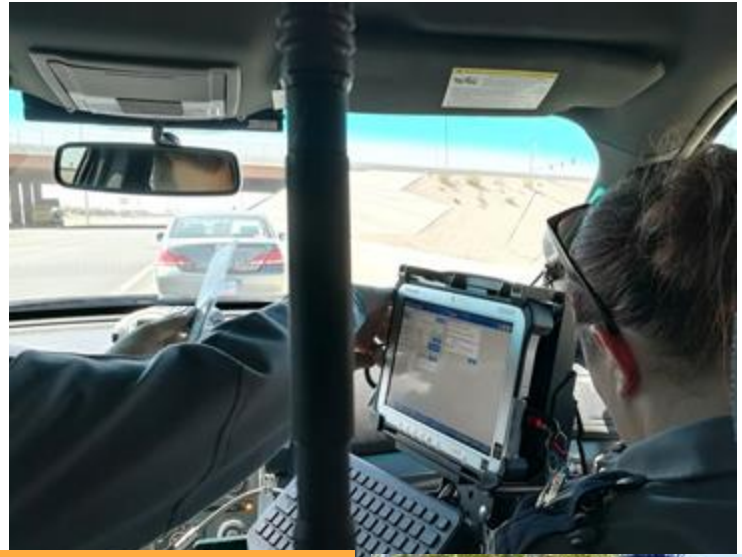
A robot couple fine dining with the Eiffel Tower in the background.



SR-assisted collection of crash reports

Current practice—Nevada Crash Report Form





Challenges for crash data collection:

- 200+ fields to be collected
- Manual typing on software
- Officers have multiple and time-sensitive activities at a crash scene

Problems with collected data

Query: **Driving under influence of alcohol**

Results:

He again stated he did not remember being in the crash. While he was speaking to me, I detected a strong odor of an alcoholic beverage coming from his mouth. Based on a sobriety test, I formed the opinion that he was operating a motor vehicle under the influence of an intoxicating beverage.

I smelled a strong odor of alcohol in her breath. She called her brother and stated she was drunk and going to be in trouble because she was driving and involved in a crash. She was issued a criminal citation for liquor and negligent operation of a motor vehicle.

Deficiencies in Florida Pedestrian Crash Data

Factor	% Error
DUI involvement/pedestrian	52%
Pedestrian at fault	44%
DUI involvement/driver	23%
Posted speed limit	22%
Speeding related	12%

Spainhour and Wootton (2007)

Problems

Further complications and challenges

- Unreliable data
  - Compromised data quality, Mismatching information
- Exposure of officers to hazardous traffic
- Further analysis, and decision making
  - Understanding, countermeasures, political decisions,

The semi-automated data collection

- New platform of data collection
  - Quicker, reliable, accurate, safer

Speak a report as you observe

Voice input

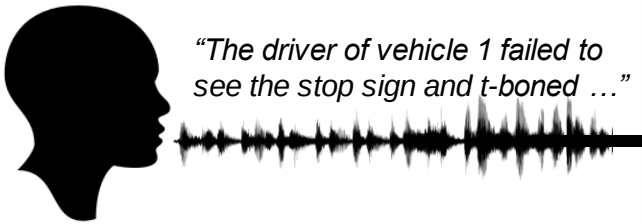
"The driver of vehicle 1 failed to see the stop sign and t-boned …"

Completed Report

Our proposed solution

- Technical challenges we will overcome

Voice input



SR-assisted Collection

AI-platform

Speech Recognition

Convert recording to text narrative

Natural Language Processing

Identify crash factors in text

Completed Report

Areas of technical challenges and hurdles we will overcome to produce successful output

Multi-year approach…

Our proposed solution

Phase 1

Prompted inputs

Collision type: ●Head-on ✓ **Rear-end** ● Angle …

Roadway Conditions: ● Dry ● Icy ● Wet …

Surface: ● Asphalt ● Concrete ● Gravel …

Phase 2

Narrated inputs

Rear-end (1) fatal (2) crash located at Flamingo Road (3), 500 feet (5) from Maryland Parkway (4) in an urban area (6). The road is a three-lane (8) arterial road (7), paved (9), straight (10), and level (11), with broken-white lane markings (12), left-side paddle markings (13), and paved shoulders (14). The crash occurred at daylight (15), with rainy weather (16), low visibility (17), and wet road (18).

Phase 3

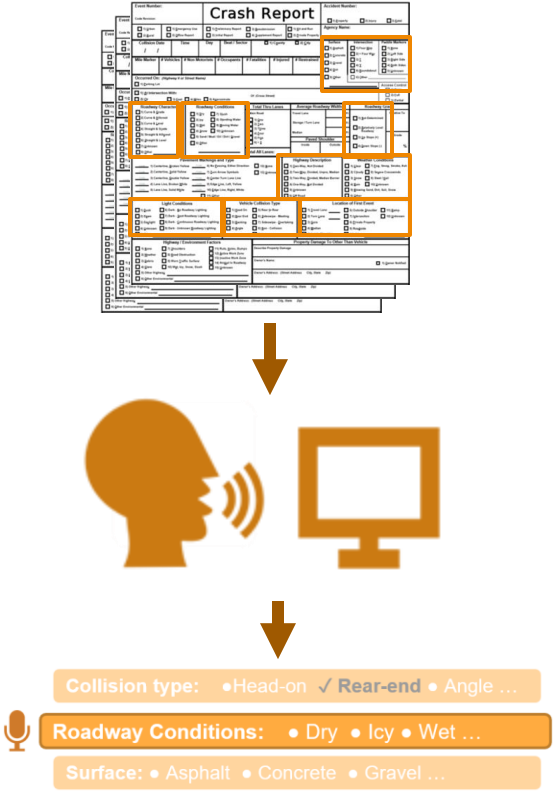
Expand for extra data items

Citations

Witness Statements

Project Objectives (Phase 1)

- Determine the portions of the reports that can be efficiently collected via SR
- Tailor SR models for reliable recognition of crash attributes
- Create a processing platform to implement the tailored SR models
- Validate the platform



Semantic search for crash narratives

The problem

1. V1, a pickup, was traveling in the right-hand lane of northbound SR-7 following V2, a van. V2 slowed suddenly. D1 did not notice V2 slowing in time and swerved to the right to avoid striking V2. V1 struck a tree off the right side of the road. V1 veered off the tree and proceeded to cross over the center median grass striking V3 traveling in the right-hand southbound lane injuring the driver of V1. After being struck by V1, V3 struck the curb on the right-hand side of the road, crossed over the sidewalk, and struck a pedestrian and then a light pole. V2 did not know the crash had occurred and kept on driving.
2. V1, a firetruck returning from an emergency, was traveling west on Garden Parkway approaching the Mayberry Street underpass when a malfunction in the hydraulic system of its hook and ladder apparatus caused the ladder to raise and swing to the right of the vehicle. When V1 went under the Mayberry Street overpass the ladder and bucket struck the bottom of the bridge, breaking off the top portion of the ladder. The ladder piece struck the right front quarter panel of V2, which was following directly behind V1. V2 lost control and struck the underpass bridge abutment on the eastbound side of the road.
3. D1 was stopped at the stop sign on the south end of the bypass road around the King's Mine Overpass construction. Upon entering US-41 with the intention of crossing over the northbound lanes and then turning to the south, D1 failed to see V2 northbound on US-41. V2 struck the front driver's side of V1 causing it to spin clockwise. D1 was either unconscious or disoriented. D1 apparently had her foot on the accelerator and went approximately 1,000 feet to the north in the median and then crossed over northbound US-41. After crossing the northbound lanes, V1 started up the ramp at the King's Mine Interchange which is currently closed for construction. V1 went head-on into the guardrail end terminal on the west side of the ramp.

Crash narratives contain **<u>useful information</u>**, but extracting this information is challenging.

- Large amounts of data
- Language variability
- Reading is time-consuming and prone to subjectivity

The problem

Example: **How to identify lane-departure crashes?**

- V1 veered to the left, crossed over to the left shoulder, then hit a tree.
- V2 was operating at high speeds and was unable to maintain lanes …
- V2 crossed the center line and went onto the shoulder of the opposite lane.
- V2 veered into the median, overcorrected, and veered right into the shoulder.
- V1 traveling westbound went into the eastbound lane and collided head-on…
- V3 crossed the yellow line and hit the front of an upcoming car.

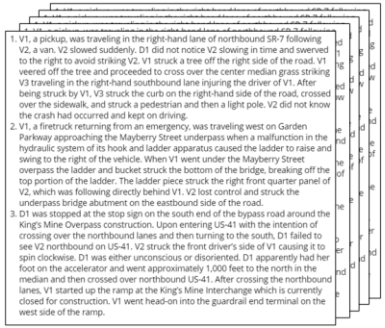
Keyword search is challenging (which keywords to use and combine?)

Our proposed solution

Search based on semantic similarity

Query:
"The vehicle departed its traveling lane"

Narratives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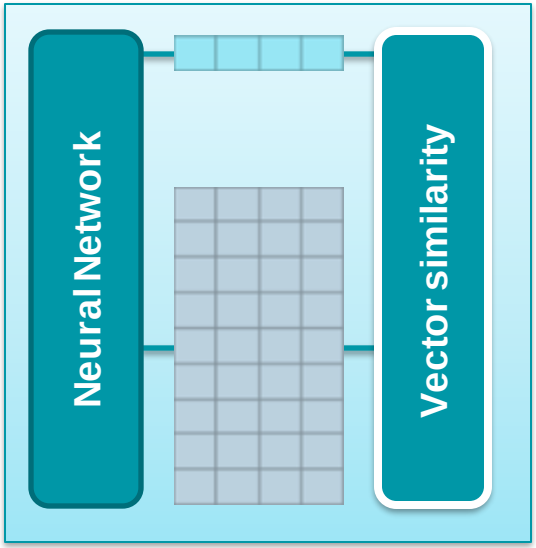
Semantic Similarity



Ranking

1. V3 veered over the solid yellow line and struck the …
2. V2 was unable to maintain lanes …
3. V1 veered to the left, crossed over to the left shoulder, then
4. V2 crossed the center line and went onto the shoulder ...
5. V2 veered into the median, overcorrected, and veered ...
6. V1 traveling westbound went into the eastbound lane and collided …

Our proposed solution

Phase 1

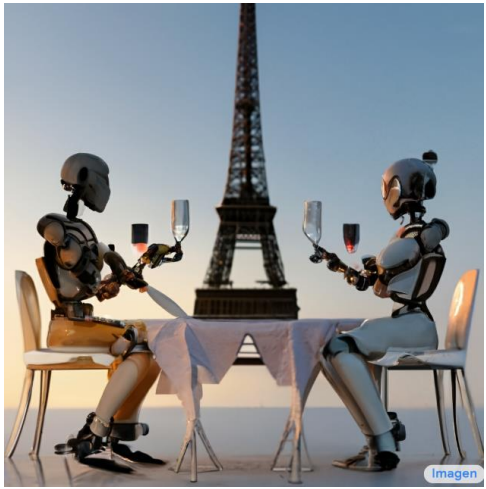
Develop an AI-based prototype application for semantic search in crash narratives

Phase 2

Foster an extensive adoption of the proposed approach by State agencies and relevant authorities

Project Objectives (Phase 1)

- Identify state-of-the-art AI techniques for semantic search extensive text data
- Implement the query-based approach for semantic search in crash narratives
- Validate the proposed application in real-life settings



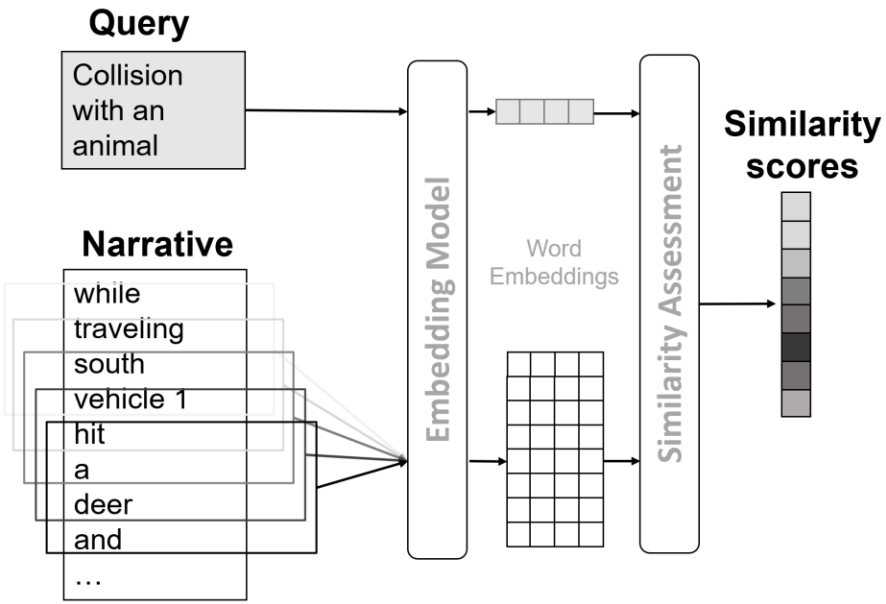
Fix potential errors using semantic search

The records below were originally miscoded as not involving school buses, but the contents on the narratives, explored using semantic search, say otherwise. These records are from a real dataset.

School bus involved

- I was dispatched to the area for the report of a motor vehicle crash involving a truck and school bus with children on board.
- The second vehicle, a 2016 yellow school bus, owned by a transportation company. The bus had damage to the passenger side of the motor vehicle
- A female citizen was reporting that she had been involved in an MVA with a school bus shortly before her arrival.

Illustration of the semantic search approach



Q&A