AI for Transportation: From concepts to implementation

Recitation 3: Multimodal Machine Learning for Transit Data

Open Learning

Prof. Jinhua Zhao | Professor of Cities and Transportation

JTL | MIT TransitLab

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R1: Introduction

R2: Discrete Choice Modeling

R3: Multimodal Machine Learning

R4: Generative AI

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Acknowledgements:
Awad Abdelhalim
Michael Leong

R3: Multimodal Machine Learning

- S1: Introduction: Natural Language Processing
- S2: Using MetroBERTA on Transit Tweets
- S3: Introduction: Computer Vision
- S4: Using Image Segmentation on Transit Videos

Natural Language Processing

Natural Language Processing (NLP) focuses on the **interaction between computers and human language**. It involves the ability of a computer to understand, interpret, and generate human language in a way that is meaningful and useful. NLP enables computers to process, analyze, and derive insights from vast amounts of textual data.

Common NLP tasks include **Text Classification, Named Entity Recognition, Information Extraction, Sentiment Analysis, Machine Translation, Question Answering**, and **Text Summarization**.

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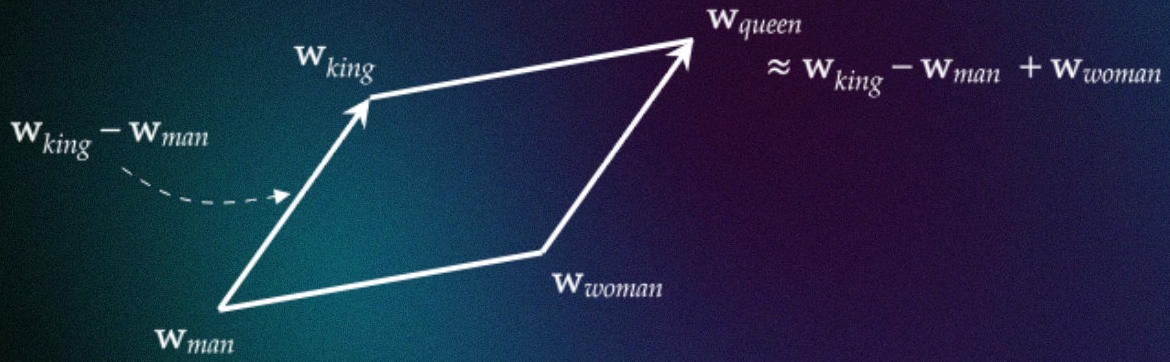
NLP - Emerging capabilities



Allen, Carl. "'Analogies Explained' … Explored." *Carl Allen: Homepage*, 1 July 2019, carl-allen.github.io/nlp/2019/07/01/explaining-analogies-explained.html. Accessed 27 Aug. 2025.

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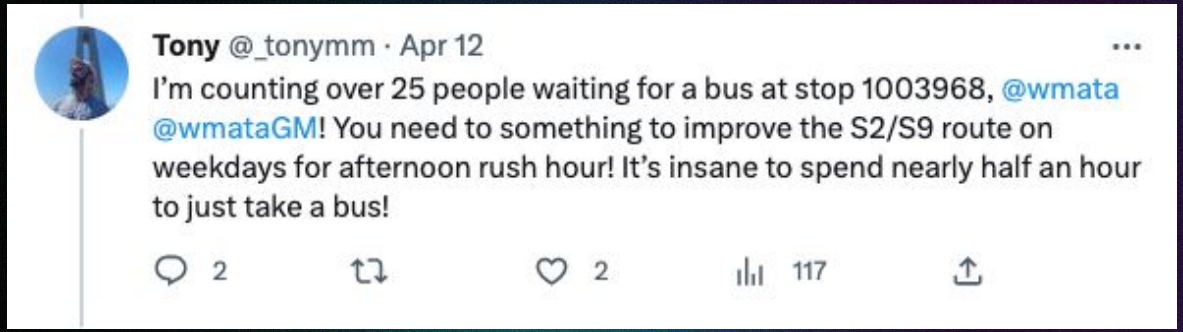
Data is often unstructured



Tony @_tonymm · Apr 12

I'm counting over 25 people waiting for a bus at stop 1003968, @wmata @wmataGM! You need to something to improve the S2/S9 route on weekdays for afternoon rush hour! It's insane to spend nearly half an hour to just take a bus!

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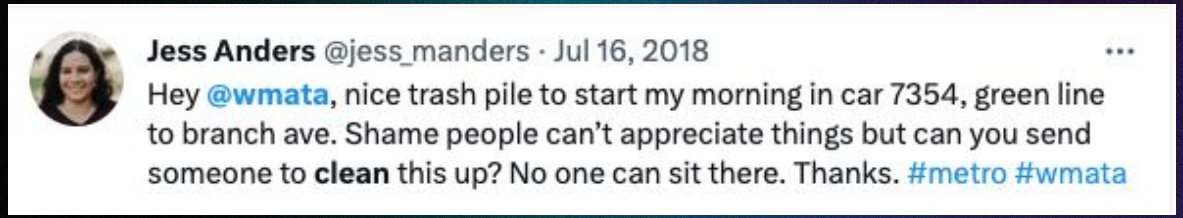
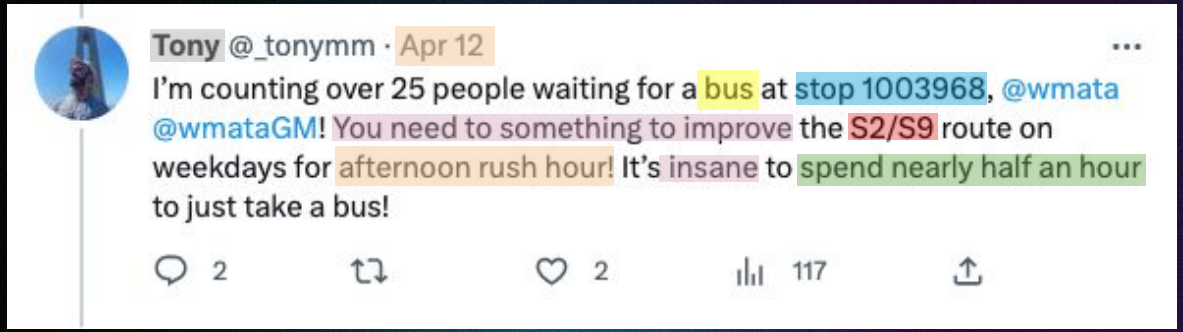


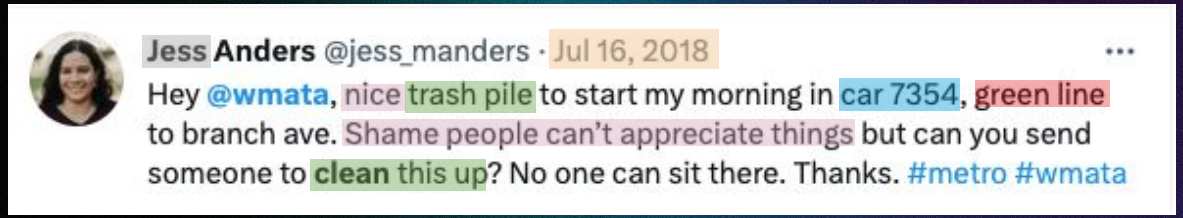
Jess Anders @jess_manders · Jul 16, 2018

Hey **@wmata**, nice trash pile to start my morning in car 7354, green line to branch ave. Shame people can't appreciate things but can you send someone to **clean** this up? No one can sit there. Thanks. #metro #wmata

But can provide invaluable insights



Mode: Bus
Route: S2, S9
Location: Stop 1003968
Time: 4/12/2023 6:48pm
Topic: Schedules / Delays
Sarcasm: Not Present
Sentiment: Negative
Inferred Gender: Male



Mode: Train
Route: Green Line
Vehicle: Car 7354
Time: 7/16/2018 8:03am
Topic: Cleanliness
Sarcasm: Present
Sentiment: Negative
Inferred Gender: Female

Classification models

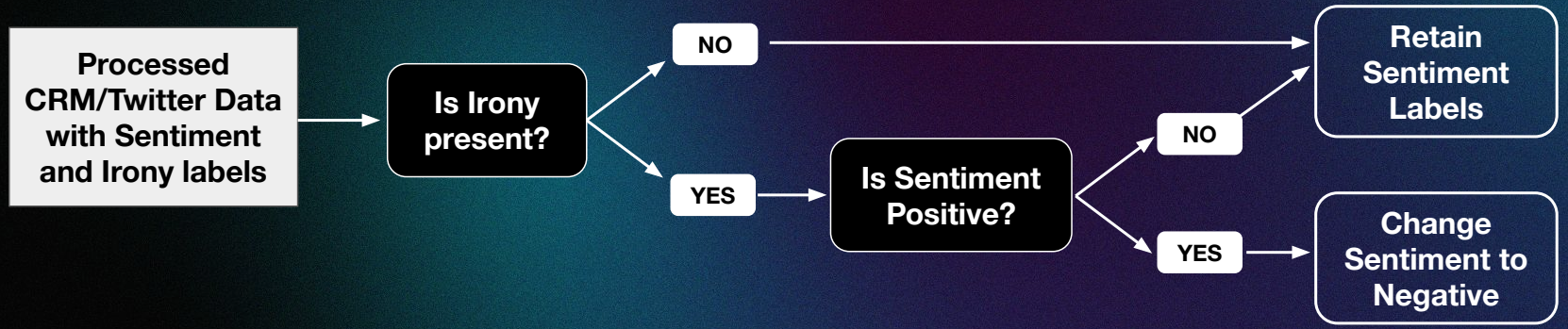
Sentiment Analysis

- BERT Open-Source Sentiment Analysis Model
- BERT Open-Source Irony Detection Model (for sarcasm)

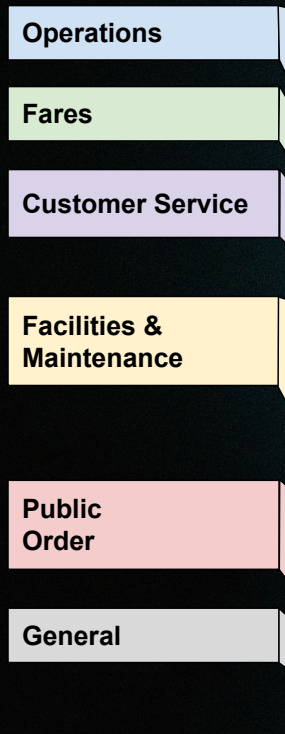
Topic Detection

- MetRoBERTa: In-House Model to detect 16 Transit-Specific topics

Sentiment analysis



MetRoBERTa: Open-text feedback analysis



Topic	Top Keywords
Announcements	Announcement(s), audio, automated, hear, PA, speaker, difficult to understand, extremely loud
Driving	Traffic, lane(s), horn, hit, intersection, stop, turn, ran light, speed limit, turn lane
Stopping	Did not stop, failed stop, kept going, open door, people waiting, right past
Schedules / Delays	Arrived, late, driver, schedule, stop, service, time, waiting, delay, no show, early
Information Provision	Display, going, information, route, service, sign, stop id, stop moved, stop sign, train leaving, said
Doors	Close, closing, conductor, driver, open, board train, exit train, doors closed
Crowding	Crowding, data, morning, rush, feedback, car train, real time
SmarTrip Card / Fares	Account, add value, balance, charged, fare, machine, parking, refund, SmarTrip Card, missing, incorrect
Customer Service	Asked, customer, employee, service, station manager, bus driver, thank, rude, unprofessional, assistance
Heating / Cooling	AC, blowing, cold, hot, temperature, cooling, heat, temperature
Elevator / Escalator	Elevator, escalator, exit, stairs, walk, maintenance, accessibility
Cleanliness	Area, clean, dirty, filthy, smell, urine, trash, health hazard, human feces, cleaning, maintenance, safety
Trip Planner / Navigation	Address, destination, information, location, map, plan trip, website, inaccurate
Restrooms	Asked, door, open, allow use
Lighting	Dark, entrance, fix, garage, lighting, morning, night, parking, stop, street
Vehicle / Infrastructure Maintenance	Construction, loud noise, making, high pitched, tracks(s), work, sounds, maintenance
Crime / Harassment / Security	Asked, incident, man, officer, police, safety, feel safe, station manager, crime, harassment, safety, security
Fare Evasion	Exit, gate, evasion, umping, money, pay, police, turnstile, faregate, ride free, faregate
Public Health / Infectious Diseases	Covid, enforce, mask, health, wear
Smoking	Cigarette, marijuana, weed, police, smoking, non smoking, smoking signs
General	General Information (suggestion, or not strongly in any other category)

MetRoBERTa: Open-text feedback analysis with 94% accuracy

“just want to shout out the station manager at Dupont Circle for helping me out when I had some extenuating circumstances. very personable. an asset to the wmata force for sure. I wish I had gotten his name. Thank You!	MetRoBERTa Predicted Topic: **Customer Service**
“hey @wmatagm, does @wmata intentionally slow down trains so customers miss connecting buses or is it a byproduct of their complete indifference to customers? train sat outside huntington for several mins just long enough so I could see 161 bus pulling away”	MetRoBERTa Predicted Topic: **Schedules/Delays**
“hey @wmata, bus 7108 is out here on wisconsin in tenleytown just cutting everyone off and going through red lights	MetRoBERTa Predicted Topic: **Driving**
“one small request @wmata… 8 car trains during rush hour, on the red line to be exact”	MetRoBERTa Predicted Topic: **Crowding**

What we will be doing

- Analyze 5000 tweets on
  - Sentiment
  - Irony
  - Topic

- Analyze the progression of tweets and their content over time

See it in action

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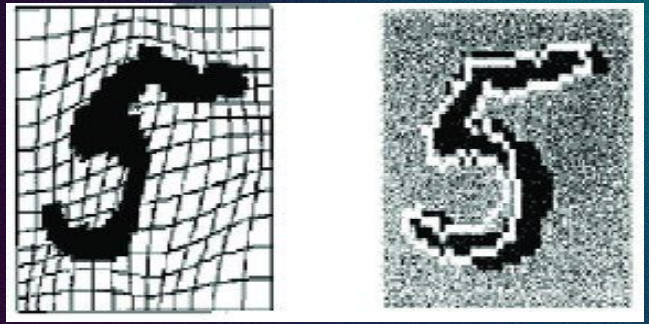
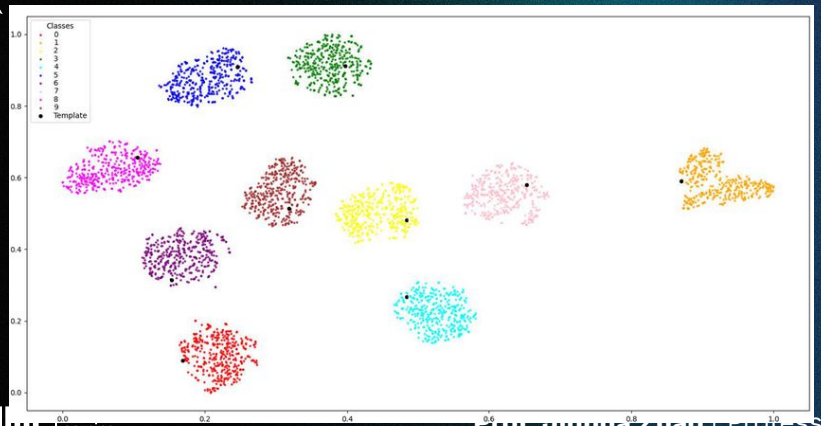
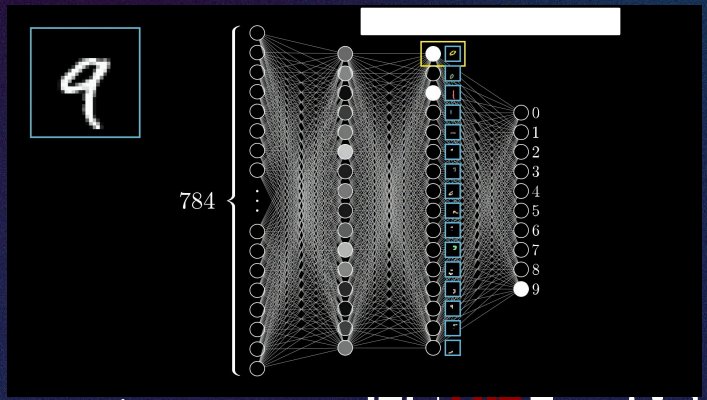
Traditional approaches before Convolutional Neural Networks (CNNs)

1. Template Matching
2. Feature-Based Models
3. Bag of Visual Words (BoVW)
4. Support Vector Machines (SVMs)
5. K-Nearest Neighbors (KNN)
6. Neural Networks (before CNNs)
7. Principal Component Analysis (PCA) and Eigenfaces
8. Decision Trees and Random Forests

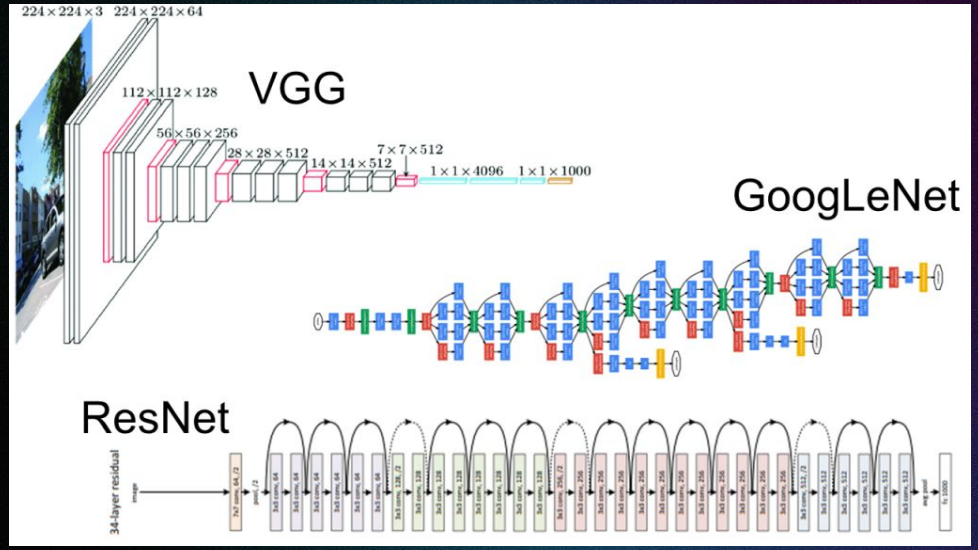




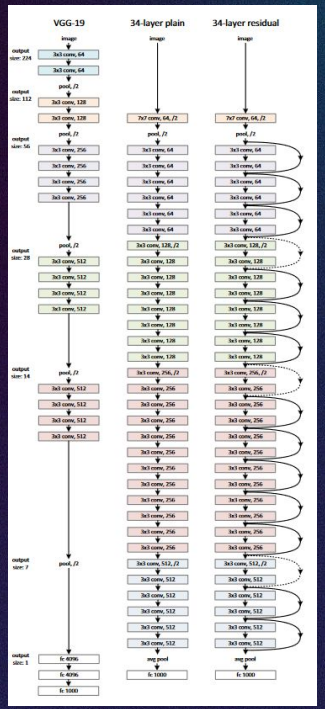


The evolution of Deep NNs for vision

Simonyan, Karen. "Very deep convolutional networks for large-scale image recognition." *arXiv preprint arXiv:1409.1556* (2014).



He, Kaiming, et al. "Deep residual learning for image recognition." *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2016.



Common tasks for vision models

Segmentation

Detection

Applicability in transit

MTA expands use of automated bus lane enforcement technology

MTA plans to install 300 ABLE camera system by the end of 2022 and an additional 600 by the end of 2023.

Mischa Wanek-Libman

Oct. 5, 2022

Applicability in autonomy

Yurtkulu, Salih Can, Yusuf Hüseyin Şahin, and Gozde Unal. "Semantic segmentation with extended DeepLabv3 architecture." *2019 27th signal processing and communications applications conference (SIU)*. IEEE, 2019.

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Identifying crowding in Vienna

What we will be doing

- Analyze 10 minutes of video and identify the pixels belonging to “people”

- Analyze
  - the progression of crowd density over time
  - the relation between crowding and train arrivals

See it in action