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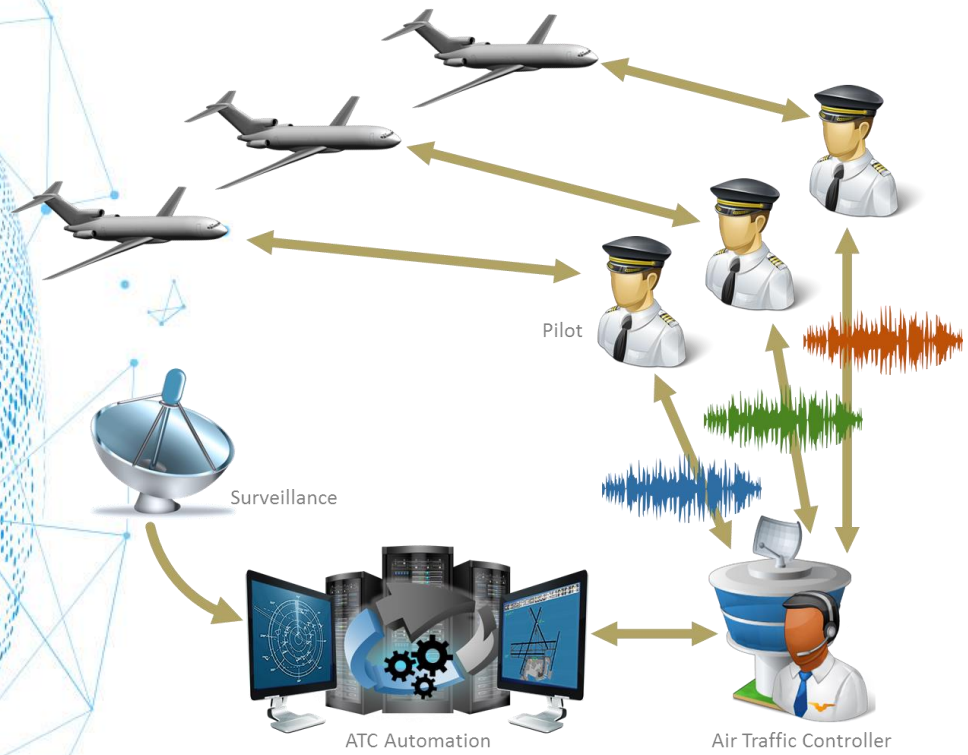
Automatic Speech Recognition and Understanding of ATC Voice Communications

Presentation by: Hunter Kopald
MITRE
hkopald@mitre.org

Outline

- Why ATC voice communications?
- How to get information through speech analysis?
- Examples
- What's next?

Why: ATC Voice Communications are Central to NAS Operations



Air-ground communication

- Pilot or Controller initiates radio contact
- Several scenarios:
  - Controller issues clearance, information to pilot, Pilot reads back instructions
  - Controller provides traffic information
  - Pilot reports weather
  - Pilot makes request, Controller grants or denies request

Ground-ground communication

- Controllers coordinate with each other

Note: Data Communications used instead of voice for some en route and pre-departure clearance operations

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Why: Value of Information within ATC Voice Communications

For Analysis

to understand and improve operations in the future

In Real-Time

to improve operations immediately

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Why: Value of Information within ATC Voice Communications

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Better and easier understanding of specific events

Identify operational information not otherwise available

Assess effects of procedure changes on operations

For Analysis

to understand and improve operations in the future

Why: Value of Information within ATC Voice Communications

- Detect unsafe instructions
- Detect aircraft not following controller instructions
- Detect pilot reports of weather information
- Detect readback/hearback errors

In Real-Time

to improve operations immediately

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How: Natural Language Processing – Automatic Speech Recognition and Semantic Extraction

Automatic speech recognition

November three one golf runway one zero right cleared to land

Semantic extraction

N4231G, CTL | 10R

Application

May also need:

- Audio segmentation
- Speaker role identification
- Non-speech context information

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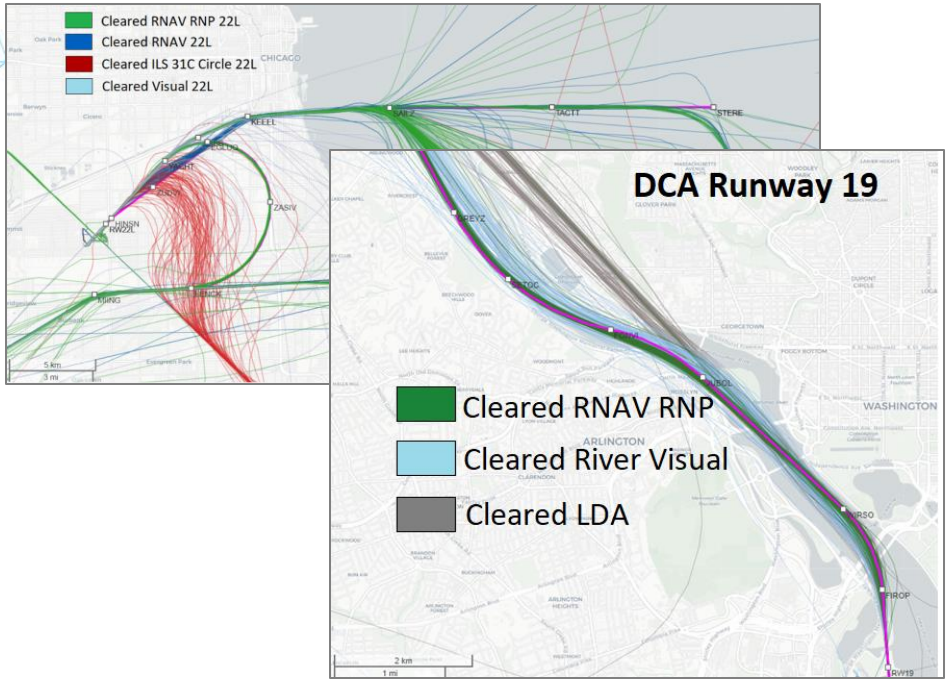
Identifying Operational Information Not Otherwise Available

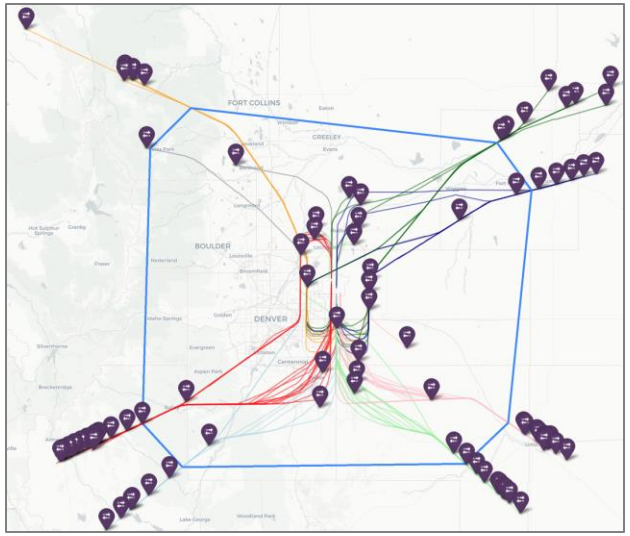
Approach clearances

Which approach procedure was used?



Runway assignments

Where were flights when their runway is assigned by Denver TRACON?



Example: PIREP Detection

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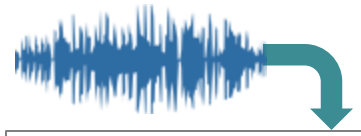


Delta eleven forty seven flight level three eight zero smooth ride

vs

Southwest one oh four do you have any smooth ride reports ahead

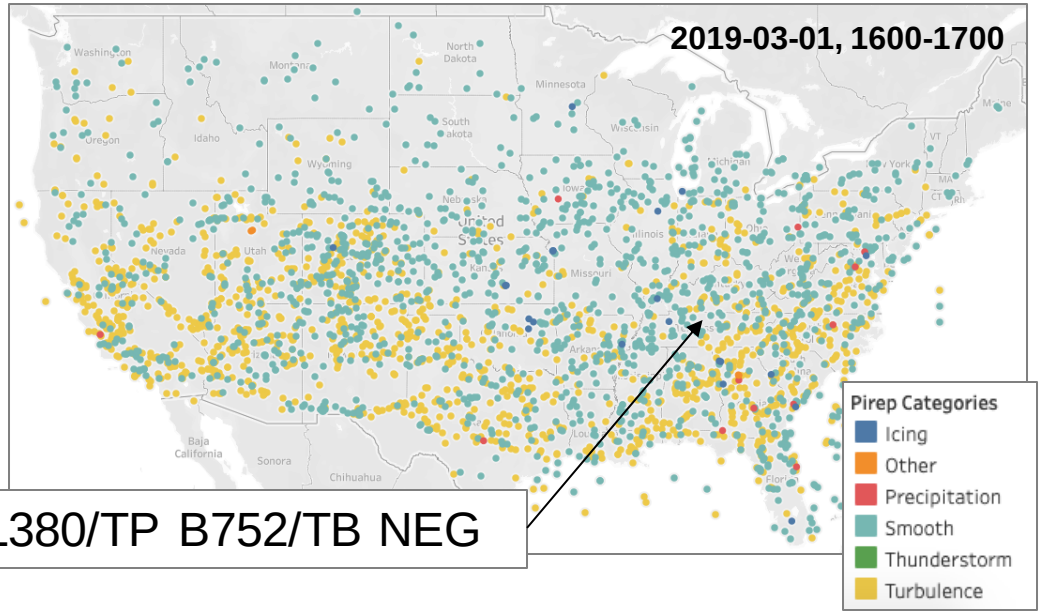
DAL1147, smooth ride

Find: location, altitude, aircraft type

UA/OV 3446N 08999W/TM 1119/FL380/TP B752/TB NEG

Goal: capture pilot reports of weather information (PIREPs) not otherwise captured.

Example output: Historical data for researching forecast model improvements



Long-term: near-real time?

Research to Detect Unsafe Situations

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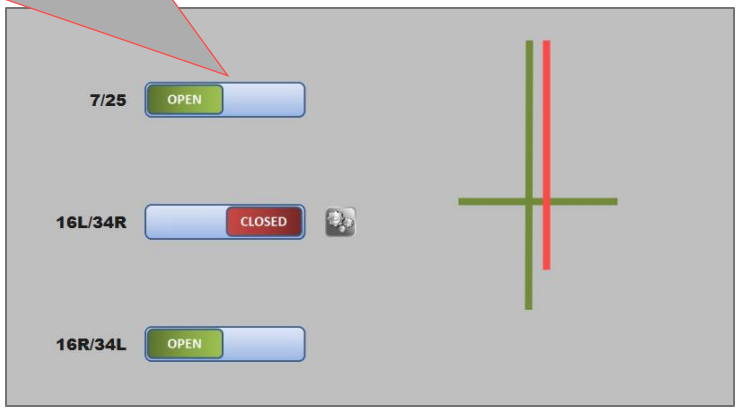
Closed Runway Operation Prevention Device (2012-2017)

Controller: "…runway thee four right cleared to land"
System alert: "Runway three four right is closed"



Notes

Early R&D required significant site-specific customization

Relatively easy application: only need to detect clearance; no callsign

Since 2017, we've added more data to our corpus for machine learning, enabling more sophisticated models (deep neural networks)

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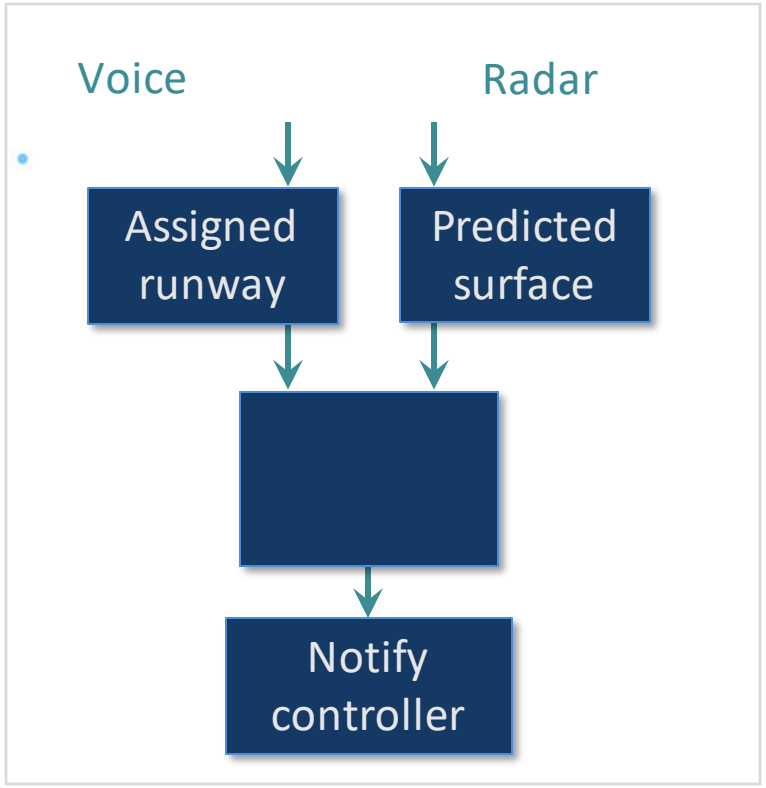
Research to Detect Aircraft not Following Controller Instructions

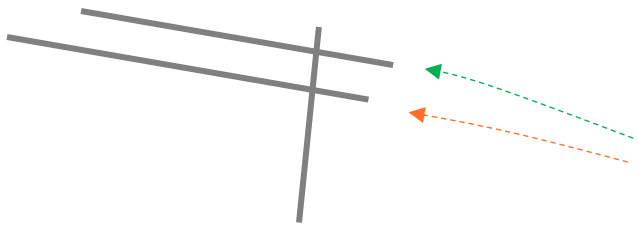
Real-Time Wrong Surface Operation Detection



Notes

More difficult application: requires correct callsign detection

Easier, quicker site-specific customization because baseline models are more robust



…runway 28R cleared to land…

FAA-MITRE Progress Over Last 10 Years

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In Real-Time

to improve operations immediately

For Analysis

to understand and improve operations in the future

We are here

Early R&D on real-time applications → Easy to adapt research platform real-time testing

Accumulated speech corpus → Speech recognition accuracy and ATC language understanding

Remote audio access to 130 FAA facilities → Opportunity and ability to analyze voice data NAS-wide

*Over **2 million hours of audio** and **2 billion transmissions** transcribed each year*

The Next 10 Years?

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We are here

Easy to adapt research platform real-time testing

Speech recognition accuracy and ATC language understanding

Opportunity and ability to analyze voice data NAS-wide

Real-time use in the NAS on ATC speech

Possible → Implementation

In Real-Time
to improve operations immediately

e.g., for safety event detection/prediction, NAS-wide PIREP capture, readback error detection

Speech recognition and understanding on other types of NAS speech

e.g., traffic management telcons, flight deck speech

The difference between real-time and post-op analysis becomes very small

Continual accuracy improvements enable more and easier applications of voice information