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:
  o Controller issues clearance, information to pilot, Pilot reads back instructions
  o Controller provides traffic information
  o Pilot reports weather
  o 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
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
Why: Value of Information within ATC Voice Communications

For Analysis to understand and improve operations in the future

- Better and easier understanding of specific events
- Identify operational information not otherwise available
- Assess effects of procedure changes on operations
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
How: Natural Language Processing – Automatic Speech Recognition and Semantic Extraction

November three one golf runway one zero right cleared to land

Automatic speech recognition

Semantic extraction

Application

May also need:
- Audio segmentation
- Speaker role identification
- Non-speech context information
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

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

Example output: Historical data for researching forecast model improvements

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

2019-03-01, 1600-1700

Long-term: near-real time?
Research to Detect Unsafe Situations

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)
Research to Detect Aircraft not Following Controller Instructions

Real-Time Wrong Surface Operation Detection

- Voice:
  - Assigned runway
  - Predicted surface

- Radar:
  - Assigned runway
  - Predicted surface

Notify controller

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

Early R&D on real-time applications

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

We are here
The Next 10 Years?

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 Implementaton

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
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