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Automatic Speech Semantic Recognition and verification in Air Traffic Control

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Automatic Speech Semantic Recognition and Verification in Air Traffic Control



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Presented to: 32nd Digital Avionics Systems Conference

By: Daniel R Johnson, Dr. Val Nenov

Date: October 9, 2013

Introduction

- **FAA Human Factors Branch**
 - Optimize human-system performance
 - Measure human performance
 - human-in-the-loop simulation
 - field data
- **Brainventions Corporation, Inc**
 - Based in Los Angeles, California since 1992
 - Software and electronics research, development and commercialization
 - Research in clinical information systems, clinical trials, imaging (PET, MR), and ANN, AI, NLP, ASR



Introduction

- **Cooperative Research and Development Agreement (12-CRDA-0287)**
 - Investigate the current state of the art in ASSR
 - Measure its accuracy
 - Explore the potential applications in Air Traffic Control



Overview

- **Common uses of ASR in ATC**
 - Simulator training and pseudo pilots
 - Offline transcription for research and forensics
 - Voice entry of waypoints in FlightDeck by VoiceFlight
 - Controller workload estimations
- **ASR approaches in ATC**
 - Using and training Commercial Off The Shelf engines
 - Building dedicated recognizers from scratch and domain specific acoustic and language models



Brainventions System

- **ValsVox**
 - Web-based Software as a Service (SaaS) application for real-time speech recognition and semantic parsing of ATC voice communications
- **Cloud-based client/server architecture**
 - Microsoft Speech Server
 - ValsVox Application (.Net)
- **Grammars**
 - ICAO Standard Phraseology, FAA 7110.65
 - Conversational plus FAA sample sets



DEMO



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Data Collection

- **Facility**

- Research and Development Human Factors Laboratory (RDHFL)
- Designed to conduct real-time, human-in-the-loop simulations and Human Factors research

- **Simulated ATC Environment**

- The Distributed Environment for Simulation, Rapid Engineering and Experimentation (DESIREE)

- **Aircraft dynamics and pseudo-pilot stations**

- The Target Generation Facility (TGF)



Data Collection

- **Audio source**

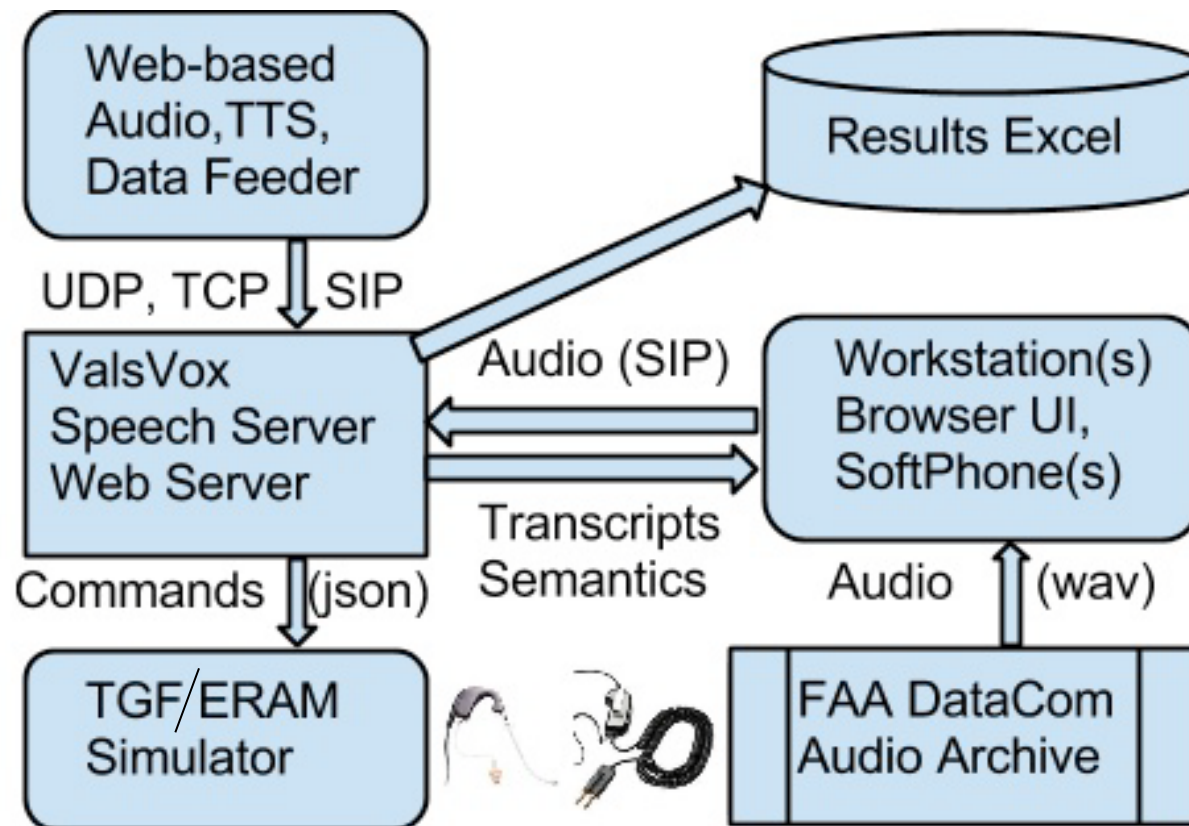
- Previously recorded study with available transcripts
- DataComm HITL (2009)
- Genera Center fictional airspace
- 10 runs selected
 - each approximate 50 mins (500 total mins)

- **Ptt Player**

- Used to replay scenario with speaker position identification



System Architecture



Metrics

False Positive Rate (FPR)	Ratio of false positives to the total number of real events
Event Detection Rate (EDR)	Ratio of correctly detected events to the sum of total real events and false positives
Event Detection Rate without call sign (EDRnc)	EDR with the exception that the call sign need not be correct
Event Correct Rate (ECR)	Ratio of correctly detected events with all details correct and the sum of total real events and false positives
Event Correct Rate without call sign (ECRnc)	EDR with the exception that the call sign need not be correct



Results

Semantic Metrics

	FPR	EDR	EDRnc	ECR	ECRnc
Avg (%)	5.99	40.62	83.34	35.61	74.47
StdDev	2.20	11.74	3.79	11.35	5.64

	Altitude	Heading	Speed	Fix	Freq
Proportion	25	3	6	33	33
Avg EDRnc (%)	85.31	78.33	62.06	72.20	96.44
StdDev	13.07	31.48	17.40	12.40	3.08

Word Error Rate

	Corr	Sub	Del	Ins	Err
Avg	68.8	16.2	15.1	2.9	34.2
StdDev	4.2	2.8	2.2	.8	4.2



Discussion

- **Recognition of call signs**
 - First concept controller utterances
 - Phonetic distortion, PTT truncation
 - Weighted towards training
- **Loose numbers disambiguation**
 - Cross-utterance pattern matching
- **ASSR in Simulation**
 - Simulation Pilot VUI



Conclusion

- **ValsVox vs other ATC ASR Systems**
 - Small training set (hours of audio, hundreds transcriptions)
 - Generic acoustic model
- **Future Work**
 - Develop ATC specific acoustic model
 - Perform grammar enhancements
 - Decrease non-recognitions
 - Investigate statistical variation in semantic metrics



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