

Augmented LLMs for Aviation with Extended Reality/Virtual Reality Integration

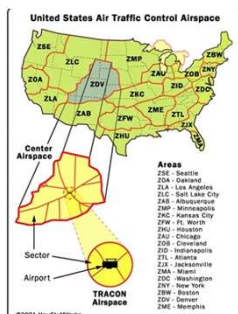
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Abstract

With the increase in air traffic and shortage of ATCs, advanced training is necessary to ensure safety in the skies. This project investigates the integration of LLMs with extended and XR/VR to enhance training, situational awareness and human-machine collaborations in ATC and ATM. The goal is to create XR/VR-enabled environments powered by AI, capable of tailoring support to individual operators while enhancing safety, adaptability, and task efficiency in complex airspace settings. We also propose a way to detect when ATC will need breaks or assistance from their speech patterns, in which to understand when controllers will need a break due to increased workload.

Introduction

The growing complexity of the aviation ecosystem driven by increases in air traffic and travel demands new approaches to training, safety and operational efficiency. Simultaneously, advancements in Large Language Models (LLMs) and immersive technologies such as Extended Reality (XR) and Virtual Reality (VR) are creating new opportunities to support the evolving needs of Air Traffic Management (ATM) and Air Traffic Control (ATC). By investigating past XR/VR work with ATC we can understand what has worked in the past and best practices to help future ATC. This allows us to focus on new ways to help ATC and ensure resources are utilized effectively. By utilizing past work with LLMs to detect emotion in speakers voice we can attempt to understand how stressed an ATC is. Furthermore, using LLMs trained on ATC language and information allows easier XR/VR setup and integration.



Sources

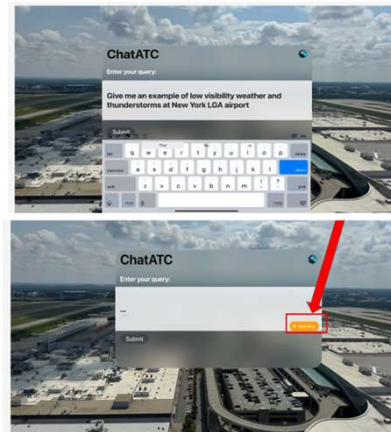


Methodology

XR Interface Design

Interface for Apple Vision Pro to support ATCs with real information and AI tools:

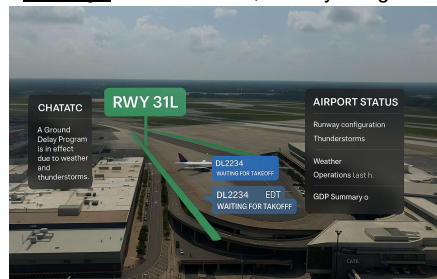
- Wireframes created in Figma simulate the headset experience
- Voice and text input lets controllers query ChatATC
- Interface is gesture and gaze controlled to reduce manual input and distraction
- Designed to keep critical information visible without obstructing the environment



Use Case – Air Traffic Training XR

We developed a prototype that uses XR and AI to simulate ATC scenarios for training:

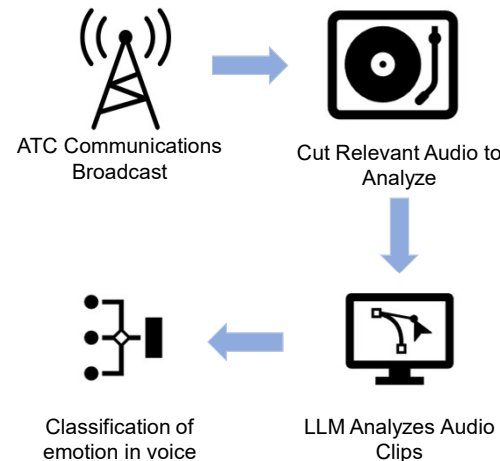
- Environment:** Vision Pro shows real airport imagery enhanced with AR overlays
- Functionality:** User asks questions and ChatATC responds in real time
- Overlays:** Aircraft status, runway assignment



Stress Detection using LLMs

Detecting Stress in from voice patterns:

- Stress and fatigue can lower operational capacity [1]
- Speech patterns can be used as a tool to detect stress level [2]
- LLMs have shown capability to detect these signals in speech [3]
- Using a trained model of Open-AI's Whisper, emotions can be detected [4]
- This model was trained on a databases of people speaking with different emotions [5,6,7,8]
- This model had accuracy and precision of 92%



Working with ATC

- ATC can have stressful work with many aircraft in their airspace
- All ATC communications are accessible through LiveATC.net
- We downloaded these audio files to analyze them
 - We look for specific high-stress scenarios to test the model
- From these tests, we hope to understand the limitations of this method
- Tested with many ATC clips and model was successful
- Model showed ability to classify with static

Integration

- Voice- Activated ChatATC Window:** Ask ChatATC for weather, regulations via floating voice/text panel in XR
- Real Time Voice & Stress Detection:** LLMs analyze speech patterns to detect stress and show subtle alerts in XR
- Smart, Context-Aware Suggestions:** LLMs monitor traffic and suggest reroutes, alerts or reminders directly on the XR display



Future Work

- Fine tune the model to detect fatigue as well as stress
- More training on ATC data
 - Noise from static in transmissions
 - Ways to reduce the static
- Automate audio cutting process
- Controlled study with other ways to detect stress in speakers to compare to LLM prediction
- Understand common errors in the model to mitigate them
- Detect fatigue and stress via Apple Vision Pro eye/gaze tracking
- Add real time voice commands using LLMs in XR interfaces
- Compare Apple Vision biometric data with LLM stress detection
- Test the XR/VR mockups with real ATCs

Special Thanks

LiveATC.net
Mary Saah, SURE Coordinator