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Flight Safety - Alcohol Detection Assisted by AI Facial Recognition Technology

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ABSTRACT

The Federal Aviation Administration's (FAA) "Bottle to Throttle" rule prohibits pilots from consuming alcohol within 8 hours of a flight and mandates a blood alcohol content (BAC) below 0.04%. However, pilots may still experience impairments beyond this timeframe. Current alcohol testing methods, including random screenings and confirmation tests, are limited in scope and timeliness, leaving potential gaps in aviation safety. This study aims to develop an AI facial recognition technique using Human-Centered Computing (HCC) to evaluate pilots' readiness to fly by identifying subtle alcohol-related impairments, regardless of BAC levels. This innovative approach has significant implications: AI facial recognition enables rapid, non-invasive alcohol screening for all pilots, enhancing safety compared to traditional random tests. It can serve as a preliminary screening method before BAC confirmation, ensuring comprehensive monitoring. Furthermore, the AI adapts to individual variations, addressing the limitations of the uniform 0.04% BAC threshold. By leveraging AI and facial recognition, this technology offers a more effective solution for ensuring pilot readiness and aviation safety.

Keywords: Flight safety, Public safety, Artificial intelligence, Safety policy, Human centered computing

INTRODUCTION

Human factors, including illness, medication, alcohol consumption, fatigue, stress, and emotional state, play critical roles in transportation safety (Alavi *et al.*, 2017; Shandhana Rashmi and Marisamynathan, 2023). Even minor illnesses can severely impair pilot performance by reducing judgment, alertness, memory, and coordination. While medications may control symptoms, they can introduce side effects that degrade cognitive and motor abilities (Hafez *et al.*, 2023).

In aviation, the Federal Aviation Administration (FAA) enforces the "Bottle to Throttle" rule, prohibiting pilots from consuming alcohol within eight hours of a flight and setting a blood alcohol limit of 0.04% to ensure flight safety. However, a pilot may still experience impairment even after the eight-hour period has passed. Previous research has demonstrated that pilots can experience performance impairments in a flight simulator even 10 hours after consuming alcohol (Bates, 2001).

According to the Department of Transportation (DOT) and FAA, aviation employees performing safety-sensitive functions are subject to random alcohol testing to ensure compliance with safety regulations (As per the FAA's Drug Abatement Division, random drug/alcohol testing program in 14 Code of Federal Regulations part 120, §§ 120.109(b) and 120.217(c) apply to all air carriers and operators certificated under part 119 and authorized to conduct operations under part 121 or part 135). Typically, determining a pilot's prohibited alcohol concentration involves a two-step process: a screening test followed by a confirmation test if the initial result exceeds the allowable limit. The confirmation test is conducted 15 minutes later to verify the findings. Implementing a rapid and accurate testing method before each flight would significantly reduce the likelihood of a pilot operating under the influence of alcohol or other substances. Artificial Intelligence (AI) driven facial recognition model has been used in other industries to assess human subjects' health status (Chan *et al.*, 2024) and cognitive workload (Iarlori *et al.*, 2024). However, this technology has yet to be widely implemented in aviation or other transportation sectors to address alcohol-related issues, highlighting a significant opportunity for innovation in ensuring safety.

METHODOLOGY

This study aims to develop an AI model utilizing facial recognition to determine whether pilots are under the influence of alcohol, enhancing aviation safety through rapid and non-invasive assessment.

AI Facial Recognition System

The rationale for this research is rooted in the critical link between alcohol consumption and aviation safety, underscoring the need for precise and individualized assessment tools.

First, extensive research has established a strong negative correlation between blood alcohol levels and both cognitive and flight performance, demonstrating alcohol's detrimental effects.

Second, while alcohol-induced facial changes may be too subtle for human detection, AI-powered facial recognition using Human-Centered Computing (HCC) can accurately identify these indicators (Chan et al., 2024). Figure 1 is a flowchart in which subtle changes of facial images can be observed at certain time points before and after alcohol consumption.

Third, the current standardized limit of 0.04% blood alcohol concentration within 8 hours may not necessarily determine a pilot's fitness to fly due to individual physiological differences. Thus, this study aims to develop an AI-driven, rapid, and accurate screening method to enhance aviation safety by providing a more personalized assessment of alcohol influence. The proposed research follows a three-step approach to develop and refine an AI facial recognition system for assessing alcohol-induced impairments, with each task building upon the previous one to enhance the algorithm's accuracy and real-world applicability.

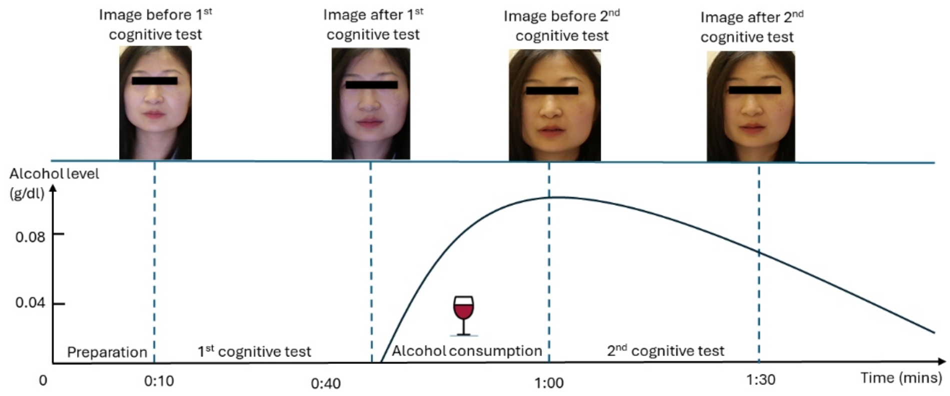

Figure 1: Facial images took at different time point during the experiment.

Study Design

Task 1 (Model Building – Secondary Data): This phase involves training an AI classification model using publicly available datasets of facial images from individuals at different levels of alcohol consumption (sober, mildly intoxicated, and heavily intoxicated). Image preprocessing techniques, such as facial landmark detection and attention-based segmentation, will be used to isolate key regions (e.g., eyes, nose, mouth, and skin tone) that are sensitive to alcohol-induced changes. A deep convolutional neural network (CNN) will be trained to classify images and establish relationships between facial features and alcohol influence.

Task 2 (Experiment – Repeated Measures Design: Cognitive Testing): This task aims to evaluate the initial AI facial recognition algorithm on a group of healthy participants (n = 20) before and after alcohol consumption. Participants will complete a series of cognitive tests assessing deductive reasoning, working memory, concentration, associative learning, and spatial planning. Their baseline and post-alcohol cognitive performance scores will be recorded, alongside facial images captured via the computer's camera. Alcohol concentration data, collected through a breathalyzer at multiple time points, will be integrated to refine the AI model, enhancing its accuracy in detecting alcohol-related impairments.

Task 3 (Experiment – Repeated Measures Design: Flight Simulation): In this phase, the AI facial recognition algorithm will be further fine-tuned using pilots' flight simulation data. Licensed pilots (n = 20) will perform flight simulator tasks before and after alcohol consumption. Their facial images will be recorded using an onboard camera, and alcohol concentration levels will be measured with a breathalyzer throughout the experiment. Performance metrics extracted from the flight simulator will be used to customize the AI model for aviation applications, ensuring it accurately assesses pilots' readiness to fly.

Ethic Approval

This research project has been granted ethical clearance by the Embry-Riddle Aeronautical University Institutional Review Board (IRB) under approval #25-096.

More Details About Experiments

In most healthy individuals, blood circulates throughout the body within 90 seconds, allowing alcohol to begin affecting cognitive functions almost immediately. However, the full effects of alcohol consumption are typically felt within 15 to 45 minutes, depending on the speed of absorption. For both Task 2 and Task 3 experiments, each participant will spend approximately 30 minutes consuming alcohol, resulting in a blood alcohol concentration (BAC) around 0.018% when they begin their performance tasks (cognitive testing in Task 2 and flight simulation in Task 3). Since participants' alcohol absorption rates can vary (for example, some may consume refreshments alongside alcohol), BAC will be measured at multiple time points during the experiments using a breathalyzer as a reference. Task 2 will focus on testing and fine-tuning the AI algorithm in a controlled laboratory setting, where healthy participants will complete cognitive tasks before and after alcohol consumption, allowing the AI's detection capabilities to be aligned with observable changes in cognitive performance. Task 3 will refine the algorithm further by utilizing performance data from flight simulators, ensuring its applicability to aviation safety, particularly for pilots.

CONCLUSION

This research develops a robust AI system using HCC facial recognition to assess pilots' alcohol influence, offering a significant improvement over traditional spot-checking methods. By enabling alcohol testing through simple facial scans, the system enhances flight safety and can serve as an initial screening test before breathalyzer confirmation. More importantly, the technology provides a more accurate way to determine if a pilot is still under the influence, addressing the limitations of the standard 0.04% blood alcohol concentration threshold, which may not apply to all individuals. This system has the potential for broad applications, not only in aviation but also in road safety, offering a new approach to detecting alcohol impairment in drivers and contributing to safer transportation environments overall. Moreover, similar to alcohol, medicine, and drug use, impairment compounds risk by impairing judgment and coordination while increasing susceptibility to disorientation and hypoxia (Dom, Hulstijn and Sabbe, 2006; Finn *et al.*, 2009). Therefore, this technology could also be expanded to detect the influence of other substances, including prescription medications, narcotics, and recreational drugs, providing a comprehensive solution to ensure transportation safety.

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