Facial Expression Affective State Recognition for Air Traffic Control Automation Concept Exploration

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1. Introduction
Current methods for evaluating workload and usability of air traffic control automation concepts are often heavily reliant on subjective data. Typically subjects (often off-duty air traffic controllers) assess new tools or technologies in controlled experimental sessions, and then report on their memories of the session experience in some structured format, such as interviews, surveys, or scalar responses to standardized questions. These subjective reports may be affected by post-session memory distortions, and concurrent validation of is often difficult.

The National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA) are exploring Augmented Reality Tower Tool (ARTT) concepts for next-generation air transportation systems. The concept exploration includes assessments of head-trackers, sensor fusion, and see-through head-mounted display systems that are evaluated by off-duty controllers in an operational air traffic control tower environment. The off-duty controller subjects may ‘shadow-control’ with augmented reality tool prototypes, while the on-duty controllers concurrently perform the operational tasks.

The current state of the art in evaluating such systems is acknowledged as insufficient; they do not span the entire range of air traffic control workload, from low to high (underload to overload). Current performance measures are not adequate to provide indices of performance potential-and hence safety. The FAA has requested more objective evaluation methods from NASA to provide planners with more a scientific basis for evaluating new automation and display concepts.

2. Background
Physiological measurements may be used to gather objective data on subjective states, though these methods usually require an intrusive sensor. The invasive aspects of physiological sensors may introduce artifacts into the data (e.g. a subject may be more discomfited by skin electrodes than by an uncomfortable head-mounted display). The ARTT studies involve evaluations of several unfamiliar and unusual devices that controller subjects must wear (e.g. head-trackers, see-through displays), so introduction of additional unfamiliar sensors is contraindicated.

The MIT Media Lab Affective Computing Group’s Self-Cam is a realtime (30 fps) system that uses a video input to track facial feature-points, motions, shape, and color deformations to identify affective communication and infer cognitive states (e.g. agreeing, disagreeing, interested, confused, concentrating, thinking). This breakthrough technology stimulated NASA to collaborate with MIT Media Lab.

3. Initial Investigations
Facial expression affective state recognition may be used to evaluate next-generation air traffic control concepts, such as the prototype Augmented Reality Tower Tool ‘see-through’ display.

Recent pilot studies at NASA Ames Research Center flight simulation facilities and the Moffett Field Air Traffic Control Tower investigated the feasibility of using automatic affective state recognition systems to objectively quantify workload and usability data. This system may be used to assess the effects of automation on complex tasks by recording automatically ‘recognized’ facial expression data. In addition to the Self-Cam baseline affective states, consideration is also being given to: confusion, comprehension, doubt, confidence, affirmation, negation, tension, relief, expectation, satisfaction, and surprise.

4. References