Measuring Satellite Operators' Attention using eye-tracking technology

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Synopsis

Although several studies have highlighted the importance of attention in human performance, few, if any, have attempted to objectively measure the attention of satellite operators. One technique that can be used to assess satellite operators' attention is eye tracking. Eye tracking is widely accepted as one of the most direct and continuous measures of attention, given that where a person looks is highly correlated with where their attention is focused.
With the primary objective of investigating hazard identification capabilities and visual attention in the presence of an unexpected alarm, specifically an anticipated eclipse occurring earlier than scheduled during satellite control, this study pioneers the application of eye-tracking technology in the field of satellite operations safety. This study will be conducted to examine participants' eye movement patterns and attention distribution when exposed to a hazardous situation in a satellite control room environment. To achieve this objective, a real-life satellite operation scenario at the Brazilian Space Operations Center, encompassing multiple areas of interest, is presented to ten participants. Their eye movements are recorded using an eye-tracking system. Subsequently, absolute duration heat maps are generated, and fixation-, gaze-, and saccade-related metrics are calculated for each area of interest. As part of space operations, human performance requires operators to develop a comprehensive understanding of how control room technologies affect their actions and decision-making. Recent technological advances enable the continuous measurement of eye movements through eye-tracking systems, which are strongly associated with key human performance constructs such as attention and situation awareness. This study aims to describe eye-tracking metrics and discuss their application in satellite control room simulator studies.

Background

Satellite operators may fail to identify hidden hazards or even a danger sign in an operational context that involves both expected and unexpected required maneuvers. Space operations increasingly rely on complex human–machine interfaces (HMIs), in which effective attention management is critical to operational safety. While eye-tracking techniques are well established in domains such as aviation, driving, and industrial process control, their application in satellite operations remains limited. Measuring where operators direct their gaze during both expected and unexpected situations provides an objective proxy for assessing attention allocation and situation awareness.

Methods

The GEO Satellite Controllers (CONSAT) will carry out a test divided into two parts, which are part of the execution of two nominal operational procedures:

1st – Synchronization of the SGDC clocks;
2nd – Monitoring of a lunar eclipse.

Both parts of the test last approximately 20 minutes, with a 10-minute interval between them. Neurophysiological measurements will begin at the start of the execution of each procedure.

The 1st procedure will take place in a nominal manner, with no unexpected alarms beyond those clearly listed in the operational guidelines.

The 2nd procedure will involve a failure scenario, in which the eclipse occurs earlier than scheduled, triggering multiple alarms. In this situation, contingency actions are required from the CONSAT, under the supervision of the GEO Satellite Engineer (EngSat GEO).

Objective (Specific aims)

- Characterize gaze patterns (fixation, saccade, dwell, transitions) across AOIs during planned and unplanned scenarios.
- Compare performance (time-to-first-action, total response time, error/compliance) between planned vs. unplanned events.
- Model attention–performance links using mixed-effects analyses to predict response latency/compliance from gaze metrics.
- Deliver heat maps and AOI-level metrics to guide interface prioritization and alarm design.

General Assumption

- Unplanned alerts elicit measurable attentional shifts distinguishable from planned tasks.
- Eye-tracker precision (≥60–120 Hz) and calibration are sufficient for AOI-level analysis.

Participants

- N = 10 (pilot): space ops professionals or graduate students with aerospace/HMI background.
- Inclusion: normal/corrected vision; basic computer proficiency.
- Exclusion: uncorrected vision issues; eye-tracker calibration failure; >30% gaze loss.
- Ethics: informed consent; anonymized data; right to withdraw.

Apparatus & Software

- Eye-tracker: remote screen-based (≥60–120 Hz; binocular if available).
- Display: 24–27″ monitor, 1920×1080 or higher; standard room lighting.

Results

On going project

Discussion

On going project

Disclosures (if any)

[Provide any disclosures (e.g., conflicts of interest) here.]

References

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