Alert Modality and Escalation Effects on Situational Awareness During Human-Robot Interaction

Abraham Camargo, Christopher Morales, Sachiko Matsumoto
College of Engineering, California Polytechnic State University, San Luis Obispo
acamar06@calpoly.edu, cmoral79@calpoly.edu, sematsum@calpoly.edu

CAL POLY
Noyce School *of* Applied Computing
COLLEGE OF ENGINEERING

Introduction

Motivation

Robots are increasingly sharing spaces with humans. It is crucial to consider how robots alert humans when encountering a situation they cannot handle autonomously. Potential consequences include errors, reduced work output, & increasing danger due to stress. This is especially challenging when humans have their attention dedicated to a primary task.

Research Question

When people are monitoring a primary task and a robot interrupts with an alert, how does a robot's initial alert modality and second alert modality affect people's

1. Workload perceptions
2. Primary task performance
3. Situational awareness

Background

Situational awareness (SA) refers to a person's perception of their environment, comprehension of its meaning, and anticipation of future states [1]. In human-robot collaboration, SA breaks down when humans need to dedicate their attention to multiple tasks simultaneously. Alert modality affects whether humans notice and correctly respond to robot signals [4, 5]. This study examines how initial alert modality and escalation modality affect SA, workload, and task performance when a mobile robot requires human intervention.



Fig. 1: Stretch SE3 robot used in this study.

Methodology

Research Design:

Interpretation of communication modalities are highly dependent on the context of the situation. Therefore, we conducted surveys to determine which LED & sound system were most appropriate for our scenario.

Scenario:

Participant acts as an inventory logger in a shared room with the Stretch robot. The robot autonomously navigates the room fetching objects. When it encounters an unknown item it sends an alert. The participant responds via a Handle It or Wait button. If no response within a set window the robot escalates its alert modality.

Results

Based on initial findings from the pilot study, we plan to use the drive animation preset for communicating alert levels in the full study. For sound, we plan to use low-frequency tones (400 Hz) at longer durations (0.5-1.0s), as participants found higher-frequency short bursts jarring.



Fig. 2: SLAM Mapping of Working Environment

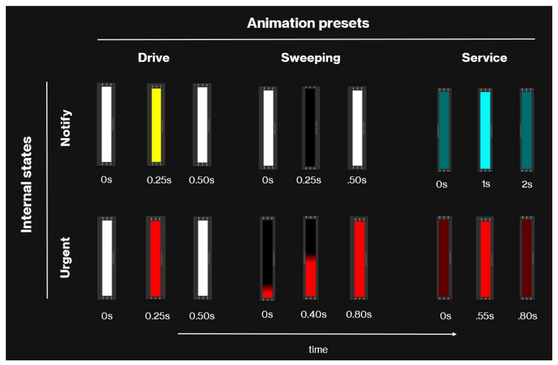


Fig. 3: Animation presets vs. Internal States. Adapted from Sharan et. al & Bacula et. al.

Main task priority	Interruption task priority	Interruption system
medium	low	Negotiated/delayed
variable	Higher than main task	Immediate (infrequent)

Fig. 4: Task Priorities Determines Interruption Method. Figure created by authors using data from Kolbeinsson et. al.

Future Work

Near Future

Pilot Study: Pilot sessions will calibrate escalation timing, verify logging task difficulty, and confirm alert salience from the participant workstation before the full study begins.

Full Study: A within-subjects experiment with 16-24 participants will test four conditions — Light→Light, Light→Sound, Sound→Sound, Sound→Light, measuring workload (NASA-TLX),

primary task performance, situational awareness (SART), and response time.

Extend Modalities

Multi-modal combination: explore designed combinations of light and sound delivered simultaneously at different urgency levels

Extend System

HTR: System is current one directional (RTH). A more collaborative system would include person assigning task to the robot, communicate availability, and offer guidance. This can be done via voice commands or hand gestures.

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