NAVI: Neuro-Adaptive Vehicle Interface

Johann Chen, Madeleine Korver, Nathan Phillips | Mentors: Jundi Liu Ph.D., Thomas Lenz

Problem Statement

Can **situational awareness** and **workload** of a remote operator be improved by:

- **Specializing** operators' tasks and locations
- Altering the duration and variability of the **time between tasks**

Background

Robotaxis - Autonomous vehicles without a driver present. These vehicles often encounter **edge cases** where they fail

Remote Operators - Humans who provide high-level assistance to robotaxis if they encounter edge cases

Problems With Remote Operators

Situation Awareness

- Remote operators are in a remote environment
- Limited time analyzing the robotaxi
- Lack of visual input

Workload

- Too high or too low taskload
  - Passive/Active fatigue
- Complex scenarios
- Time pressure

Remote Operator Queue

Queuing

- Each edge case must be distributed to a **fleet of operators**
- As robotaxi numbers increase, **continuous monitoring** of multiple vehicles will be **infeasible**
- **Queuing systems** will allow fleet and operators to scale arbitrarily
  - Servers: remote assistants
  - Jobs: robotaxi assistance requests

Algorithm

- How should jobs and servers be **matched**?
  - **Evenly distribute load** by assigning jobs to longest inactive server
  - **Appropriately load** operators through proper staffing levels
  - **Exploit local knowledge** by assigning jobs to operators who know that area
  - **Develop expertise** by allowing operators to specialize in types of task
- Queues well studied, and humans well studied, but **no studies about how queues affect humans**

Potential Improvements & Hypotheses

- Speed up the gain of **situation awareness** and **task performance**
- Manage **workload** to avoid passive or active fatigue
- Improve **safety** through better decisions

Methods

Testing

- Test was given through our experimental GUI made using **Carla** and **Pygame**
- Test was prepared with tasks consisting of **different durations** between tasks, **variability**, **task types**, and **location**
- **Situational awareness** and **workload** was determined by metrics, such as **surveys, physiological data**, and **simulator statistics**

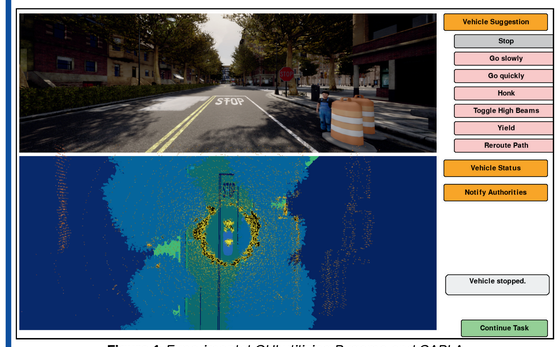

Figure 1: *Experimental GUI utilizing Pygame and CARLA*

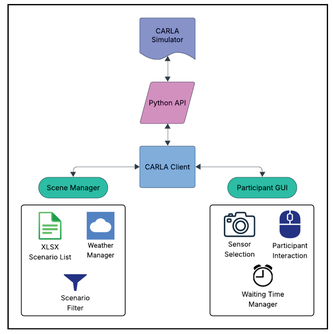

Figure 2: *CARLA Remote Assistance Flowchart*

Independent Variables

Specialization

- **Location** - Operator assigned specific location *(e.g. city block, neighborhood, busy construction area)*
- **Task type** - Operator receives similar tasks *(e.g. weather issues, sensor errors, unknown obstacle)*

Time Between Tasks

- **Duration** - Amount of time that operator waits between tasks *(e.g. an operator waits 15 seconds between tasks)*
- **Variability** - Variance of time between tasks *(e.g. an operator waits 8 seconds after finishing task 1, but waits 2 seconds after finishing task 2)*

Dependent Variables

Situation Awareness

Workload

- **Hardware** - EmotiBit [Heart rate and GSR], Eye tracking glasses
- **Simulator Statistics** - Number of crashes and incorrect decisions, reaction time
- **Surveys** - NASA TLX [Workload and Performance], ASQ [User satisfaction]

Pilot Testing

Goal

- **Assess** the current Remote Operator Simulator (GUI & tasks)
- Analyze **preliminary data**

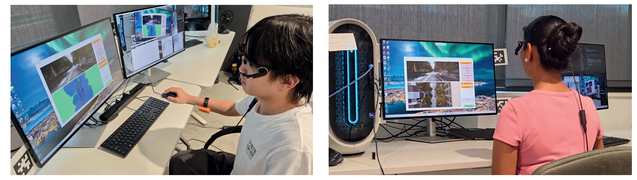

Figure 3: *Pilot testing with participants*

Takeaways

- Insight into human subjects testing
  - Importance of **qualitative feedback**
  - Ideas for improvement: **tasks, interface**
  - Importance of **note-taking**
- Subjects reported a strong learning effect: **training period** needed
- **More testing needed** for clear results

Pilot Data

- **Two** subjects
- More testing planned for **Fall 2025**

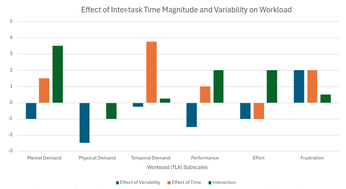

Figure 4: *Pilot testing participant workload*

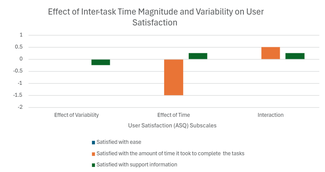

Figure 5: *Pilot testing participant satisfaction*

Discussion

- The **way tasks are presented** affects user perception of **performance, workload**
  - **Queueing** strategies can affect **performance**
- **Variability** decreased **mental demand, performance,** and **physical demand**
- Longer **waiting time** increased **mental demand** and **perception of performance**
- Users were **dissatisfied** when waiting time was **longer**.

Future Work

- **More testing**
- Validation of **generalizability and relevance** of tasks to industry
- Analysis of eye tracking and biometric data for **objective workload metrics**
- Road map for **industry takeaways**

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