A LITTLE *PEEK* INTO MY MASTER THESIS:

AI-Driven Context-Adaptive User Interfaces for in-car Infotainment Systems

Design, Prototypical Implementation and Evaluation

In simple terms: the goal was to see how well modern LLMs can generate GUI for Infotainment screens under different situations in real-time

Let’s imagine a scenario 🤔💭

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It’s Night you’re Driving at Low fuel in Poor weather and getting Nervous

Wouldn’t it be nice if your car would be able to:

1) Process these constantly changing **contextual variables**
2) Figures out how **this specific combination** of variables **affects you** in **this specific moment**
3) And based on that, it intelligently **adjusts the infotainment screen**

For Example?

Under the above scenario, an intelligent system might....

- dim non-essential elements
- boost contrast of important components
- emphasise nearby open gas stations within range
- reduce animations to address your nervousness

Sounds helpful, doesn’t it? :D

Motivation

With tech advancements, the data available to cars is on rise

Continuous & dynamic variables

speed, traffic, weather conditions, time of day, driving behavior, presence of pedestrians or nearby vehicles, planned maneuvers, etc.

Stable / slowly changing variables

media content preferences, interaction styles, calendar, frequently visited locations, long-term usage patterns, vehicle-specific info

If cars would be able to process these combined variables in real-time:

it can design GUI in real-time to provide meaningful & personalised UX

.....and doing this with AI not just makes it feasable, it can potentially simplify design and development processes!

Research Gaps

Current Research in infotainment adaptivity

1. **Carried out with:**

   Mock-ups or Rule-based systems, Traditional machine/deep learning techniques

   } *Lacking in research using Modern LLMs*

2. **These Addresses:**

   What to Show.
   When to Show.

   } *What about Detailed adaptation?*

3. **We found:**

   Transformer-driven adaptivity algorithms with technical measurements *[3]*

   } *How does it affect UX?*

Goal: Fill these gaps by create something that:

Leverages modern LLMs
+
Scalable & Functional
+
Real-time

Controls
detailed
GUI adaptations

Measure its effect
on UX and Safety

Addressing the Goal

Creation of two systems for A/B Testings

System A

Fully functional and **scalable LLM-Based** system which can create **GUI in real-time**

System B:

Classic pre-designed version of the system serving as a conventional baseline

What did we measure?

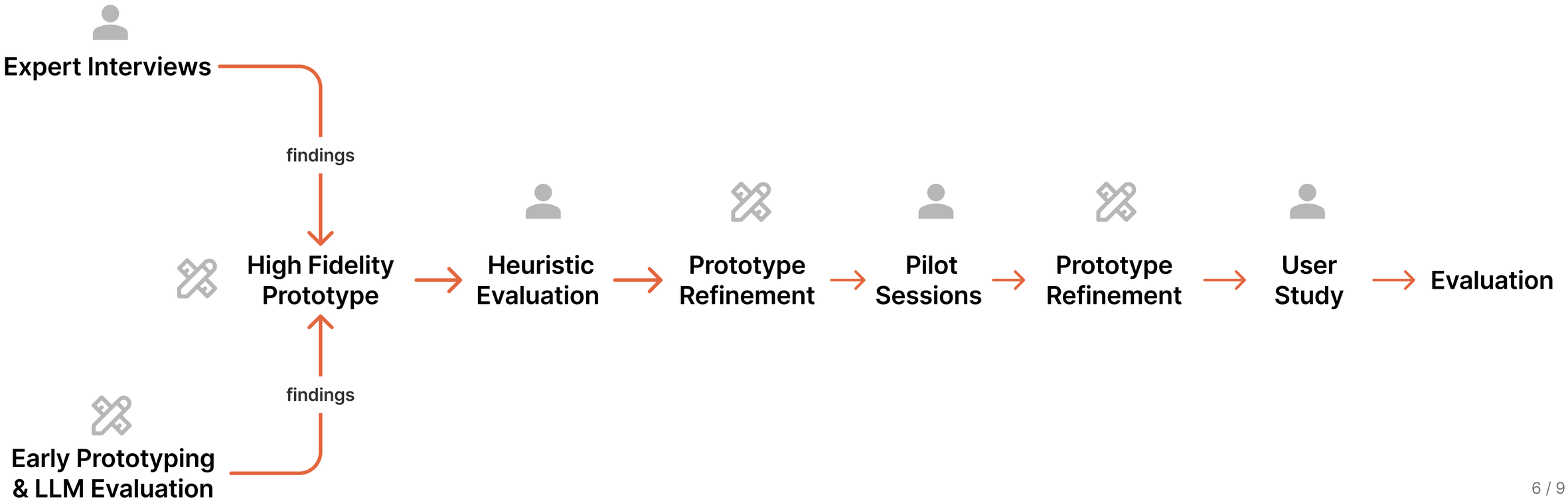
How each of these systems differ in terms of *percieved*..
clarity, value, cognitive load, distraction, situational awareness and adaptivity.

Measuring Instruments?

UEQ-S and UEQ+ scales, NASA-TLX, Situational Awareness Global Assessment Technique, Custom Likert Scales, Open Ended Feedback

Approach we used:

Human centered Research-Through-Design



Expert Interviews

- 7 Professionals
- Across 5 Departments
- Semi-Structured
- Thematic Clustering involving 2 researchers

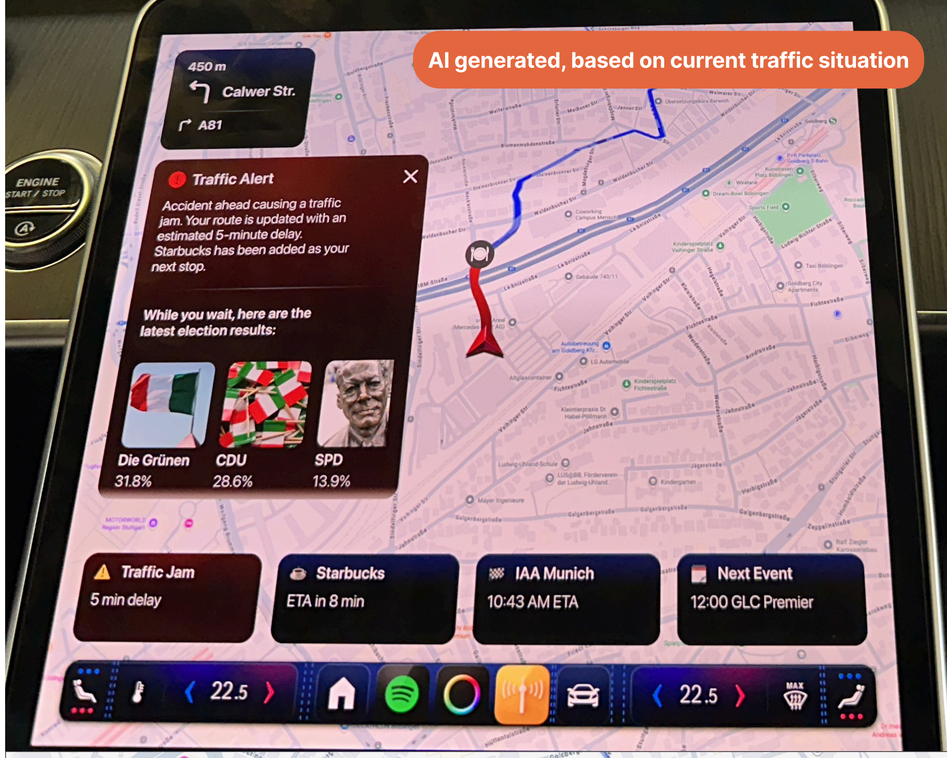
LLM Evaluation

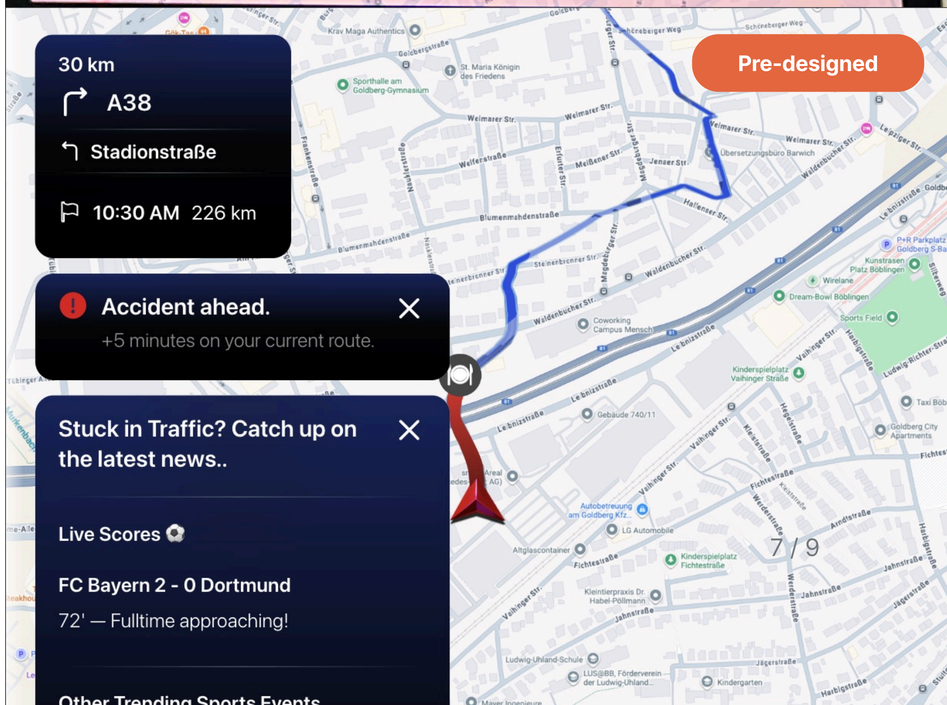
for latency and GUI creation and adaption ability

- Evalutation of different Models from Gemini, GPT, Claude
- Created early functional Prototype where LLM had access to limited elements to generate GUI

High Fidelity Prototype

- Functional system based on Python, React, and Gemini services
- GUI component library extended to over 30 elements for component generation and full screen assembly
- Push to Talk Integration for natural, conversational interaction using ElevenLabs
- Provided LLM system an ability to choose between different parts of the screen based on different criteria





Usability Heuristic Evaluation

- Exercise involving different design experts
- Based on guidelines and materials from NNGroup
- Identification & classification of usability issues using usability workbook and severity ratings
- Prototype refinement based on findings

User Study

- Involving 30 Participants, based on priori and sensitivity analysis
- Within-group study design & 4 experimental group using counterbalancing technique reducing order effects
- Prototype integration into real production vehicle in a stationary environment
- Scenario based study sessions involving different sub events

Data Evaluation

- Statistical Analysis for p-values and effect sizes
- Exploratory Analysis on demographical data
- Inductive Thematic Analysis for open-ended feedback


User Study Setup


Prototype Integration

🙂 THAT'S ALL FOR A *PEEK*!

If this made you curious about the *findings*,
and the detailed *research related insights*,
I would be happy to discuss it with you!

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