Transforming the Driver Experience with Augmented Reality in Cars

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Outline

1. What is the opportunity for Augmented Reality with Cars?
2. What are the design issues (cognitive and perceptual)?
3. How to create and evaluate content for Automotive AR?
Human-Machine Interfaces (HMI)

Mission Statement:

Explore enriching the driver’s experience
As a kid in Canada...
We are working on a 3-D HUD for Augmented Reality of the driver’s field of view.

Why? Information is shown... in context, higher bandwidth, and personalized.

HI-CAR: Honda Interactive Contextual Augmented Reality
Challenges

Technology

People
Human Factors were cited most frequently as accident causes... 93%

- Treat et al., 1979
Solutions

Autonomous Cars

Google

Enhanced Driver

Mercedes
“We need augmentation, not automation”

Need to build trust in our human-machine interfaces.

Understand how decisions were made.
The Ultimate Mobility Device

Portable, connected

Location-based services and maps

Multiple modalities of interaction for user

Car:
multiple, large interaction surfaces
+ More sensor options
+ Larger field of view
+ Direct see-thru view
+ Transports user

Sensors for environment
Augmented Reality for Cars

*From Wikipedia:*

Augmented reality (AR) is a live, direct or indirect, view of a physical, real-world environment whose elements are *augmented* by computer-generated sensory input such as sound, video, graphics or GPS data.

**HI-CAR:**

Honda Interactive Contextual Augmented Reality
Where’s the Opportunity?

Blue pill

Red pill
Perspectives for Driving Aids

Primary Task driving aids
- Braking bar, Tönnis et al. 2007
- Time-to-collision, Fu et al. 2013
- See-through System, Ferreira et al. 2013

Navigational aids

Design issues
- Stereoscopic Perceptual issues
  Drasic and Milgram 1996
- Mobile Perceptual issues
  Spijker et al. 2010
- Technical implementation issues
  Tönnis and Plecher 2011
- Visualization issues in Driving
  Fröhlich et al. 2010

What about the user?
- Medenica et al. 2011
- Reduce distraction/errors,
  Kim and Dey, 2009
Driver Distraction

According to NHTSA and others

manual

visual

cognitive
Situation Awareness

Self

Others

Environment

Where is my exit?

Is this car trying to merge?

There's a motorcyclist up ahead

Is there a car behind me?

Is there more traffic ahead?

Is there a car in my blind spot?

Can I pass this truck?

Is this car going faster than me?

What are the road conditions?

Am I too close to the truck?

Am I driving straight?

What is in front of the truck?

Is there more traffic ahead?

Is there a car in my blind spot?

Where is my exit?

Is there a car trying to merge?

Should I slow down to let this car in?
Situation Awareness

Endsly 1995: Three Levels of Situation Awareness

1. Perception of elements in the environment
2. Comprehension of their meaning
3. Projection of future system states

Essence of defensive driving

Augmented reality can help visualize these spatio-temporal, context-sensitive relationships.
Cognitive Issues

Perception
- Situation Awareness
- Visual Stimuli

Driver Distraction

Behavior
- Defensive Driving
- Reflexes

Inattentional Blindness

Good AR
Bad AR
Dying is a bad user experience
Three user-centered perspectives to consider in design:

- Human Perception
- Distraction
- Behavior
What do we need to know about the display?
Cognitive Dissonance Problem

27 Broadway
$206/night

32 Broadway
Danio's Café

***
Create a consistent world view

27 Broadway
$206/night

32 Broadway

Danio’s Café

***
Dual focus problem

http://webphysics.davidson.edu/physlet_resources/dav_optics/examples/eye_demo.html
Testing depth perception with different cues.

Experiment 1: Depth Estimation
Only size change condition
Parallax problem

Experiment 3: Frontal plane vs. 3-D Ground plane
Inattentional blindness

[Mack 2003]
People tend to adjust their risky behavior depending on the perceived level of safety—being less cautious when they feel more safe.
How to create content?
Where to locate the display?
Design-Prototype Cycle

- **Low fidelity prototypes**
- **High fidelity prototypes**
- **Research and development**
- **User evaluation**

The cycle involves:
- **Design**
- Low fidelity prototypes
- High fidelity prototypes
- Research and development
- User evaluation
User-centered Design

User research  Brainstorming observations  Idea generation
Identify Themes

Intersections
Highway
Situated Interaction
Parking

Identify Constraints

Stay within HUD field of view
Showcase 3-D capabilities
Patentability/Uniqueness

Visual elements are projected onto windshield
3D elements appear to exist in the real world
Life Cycle of a Driving Application
Brainstorm Concepts

Team members explain to each other, comment

Vote

>= 2 votes

Refine and detail sketch

Comment, rate, select for prototyping
Prototyping

- 120 deg driving view
- Adjustable size powered chair
- Customizable driving simulator
- In-lab HUD Prototype
Projected path visual style: which is the “best”?
Early Usability Testing: Left Turn Aid Example

Which visuals did you prefer?

- Wireframe
- Chevron: obstructed road less, provided motion
- Solid path

Number of people preferring visual

Chevron path design

Solid path design
Formal Evaluation: Left Turn Aid Pilot Study

Main Experiment
• Two driving courses, with and without projected path
• Ten left turns in each course
• Two different speeds of oncoming vehicles (35 mph and 55 mph)
• Driving parameters & eye gaze data are recorded

Qualitative survey after the experiment

4 pilot subjects (age 26-32, 1 female, 3 males, avg 12.25 years of driving)
Insights from Evaluation

Average Gap Acceptance in seconds (time between oncoming vehicles)

- No Aid
- With Aid

- Aggressive
- Conservative

However, with deeper analysis...

Automotive UI 2013
Conclusions

Augmented reality for cars has potential to aid and engage drivers.

Must design carefully for driver.
Design, prototype, test and iterate.

Design to collaborate with drivers – not distract them.
Thanks

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