

# DA Final: Presentation Concepts for Conformal Navigation Systems

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# Overview

## Introduction

- **Motivation**
- **Problem Statement**
- **Human Depth Perception**

## Main Content

- **Related Work**
- **Design Concepts**
- **System Setup**
- **Experiment**

## Conclusion & Future Work

# Motivation

## In-vehicle Systems (2003 [Broy])

- 80 embedded Systems
- Total Software Size of about 60 MB

## Navigation System



## Problems:

- Glance-away problem
- Cognitive effort for interpretation and transformation of route information

## Motivation

### Navigation System with conformal Route Guidance Indication

- Head-Up Display (HUD): Reduced Glance-Time
- Augmented Reality (AR): Same frame of Reference



## Problem Statement: Location fixed Indication

### Depth Perception

- Understanding of the aid's Position

### Perceptibility in Distance

- Enable the Driver to anticipate

### Intuitive

- Must be designed natural and intuitive

=> Display

=> Design

# Humans Depth Perception

## Oculomotor Cues

- Accommodation
- Convergence

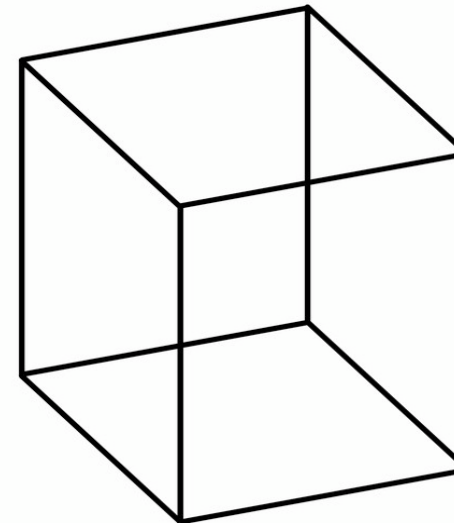
## Binocular Cues

- Retinal Disparity

## Motion Parallax

## Monocular Cues

- Relative Size
- Occlusion
- Linear Perspective
- Lights and Shadow
- ...



=> Display Constraints

=> Design Constraints

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## Related Work

### Video-based Augmented Reality Navigation

- Siemens AG, Johannes Kepler Universität Linz & Ars Electronica Future Lab

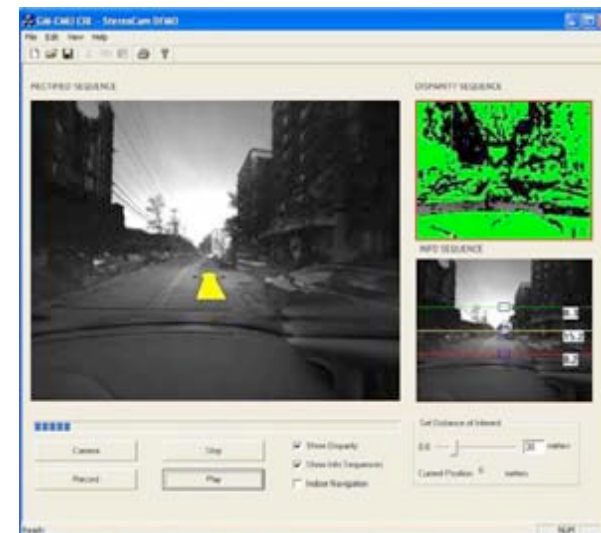
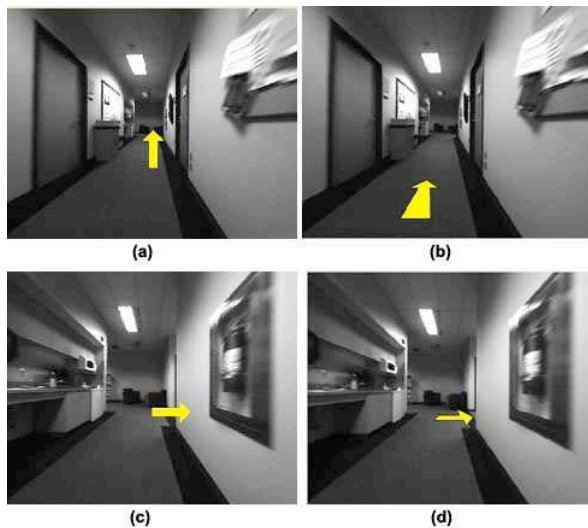




# Related Work

## Video-based Augmented Reality Navigation

- Carnegie Mellon University & General Motors

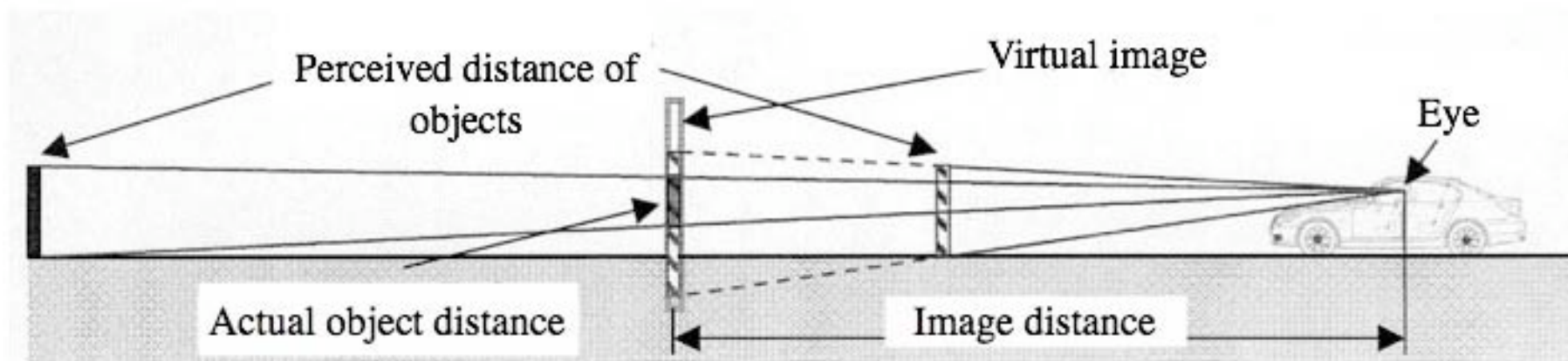


- Pro: Independent to Daylight Conditions
- Contra: Glance-away Problem and Nightlight Problem

## Related Work

### Perceptual Issues in Augmented Reality for HUD-Technology

- Bergmeier at TU München: Conformal visualization for driver assistance information in 10 -100 meter
  - Minimizing the effectiveness of oculomotor and binocular cues
  - Providing sense of depth with monocular
- => Placing image plane in a distance of 50 meters



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# Design Concepts

## Main Key Issues

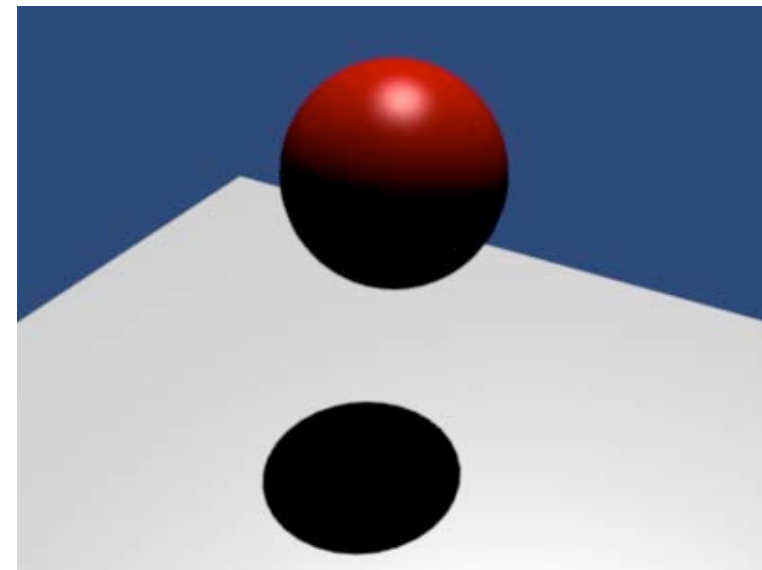
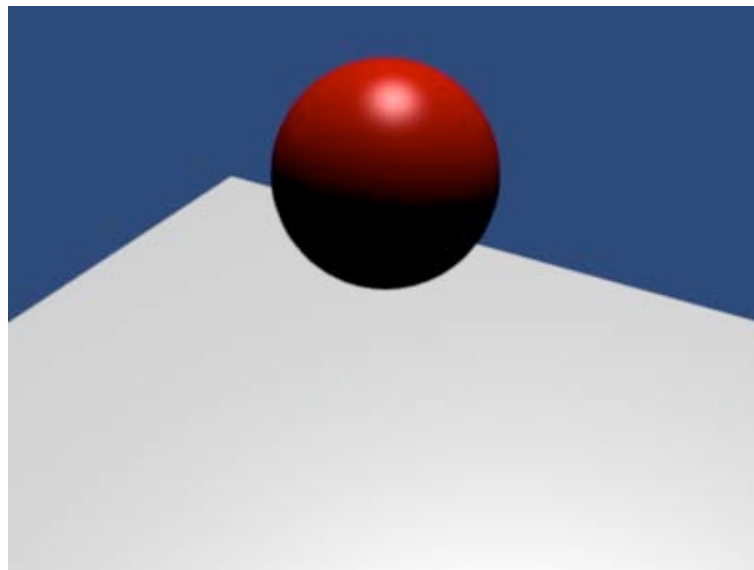
- Perception of Depth
- Perceptibility in Distance
- Intuitive

## Outline of Design Concepts

- General Consideration
- Location fixed Schemes
- Car fixed Schemes
- Hybrid Schemes

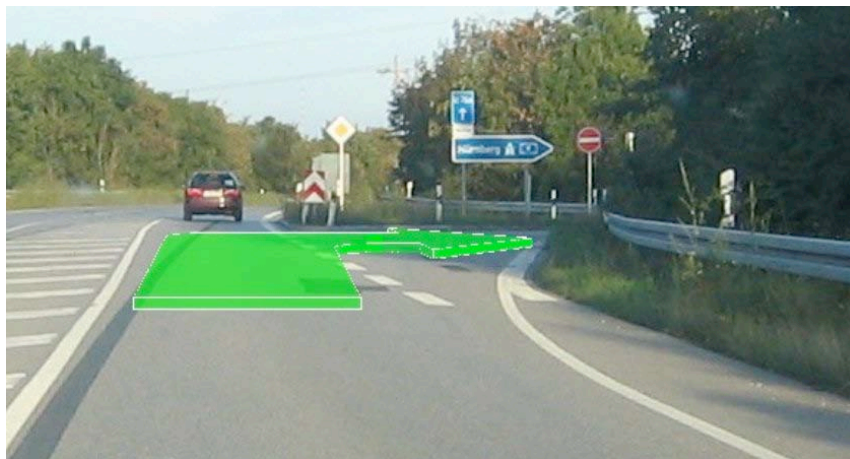
# Design Concepts: Perception of Depth

## Light and Shadow



# Design Concepts: Perception of Depth

## Occlusion



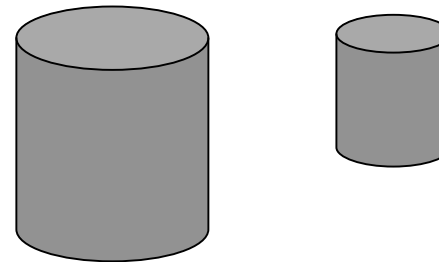
# Design Concepts: Perception of Depth

## Relative Size

- Relative Size

## Linear Perspective

- Linear Perspective



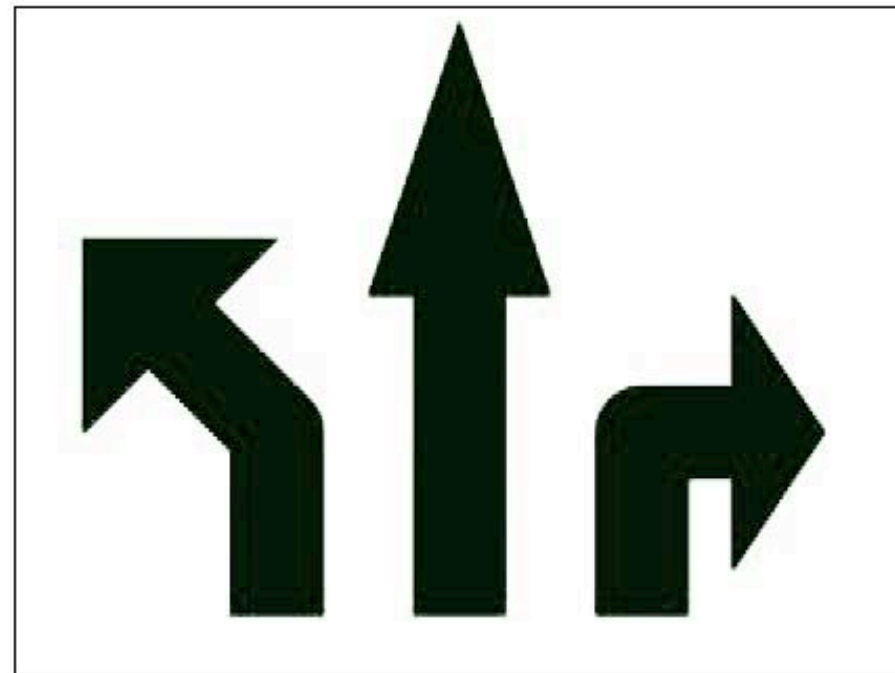
# Design Concepts: General Considerations

## Contrast





## Design Concepts: Location fixed schemes



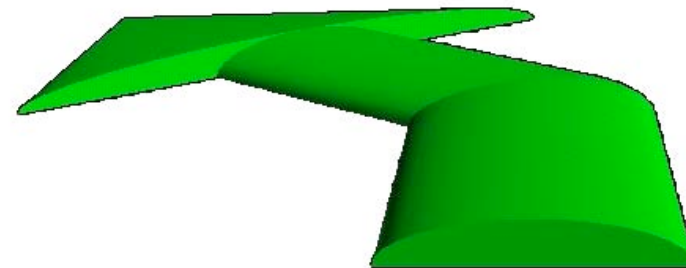
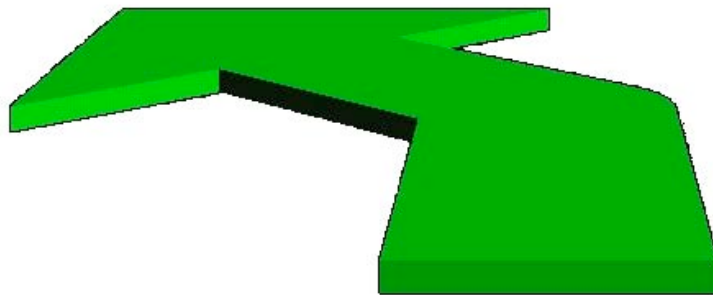
# Design Concepts: Location fixed schemes

## Conformal Arrows



## Design Concepts: Location fixed schemes

### Three-dimensional Conformal Arrows

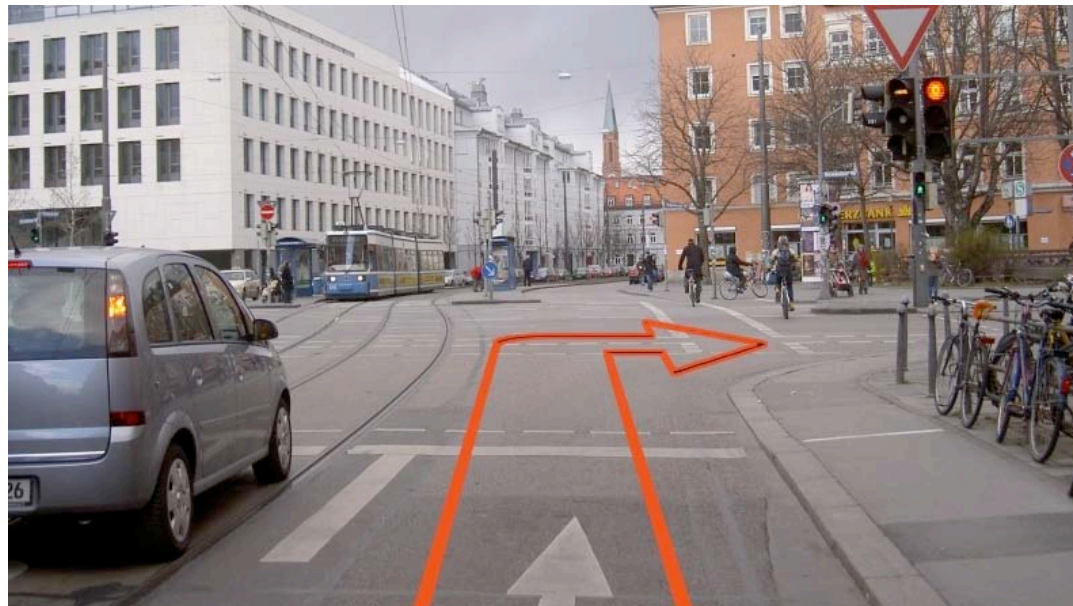


## Design Concepts: Car fixed schemes

### 3D Pointing Device

- Compass-Like Indication

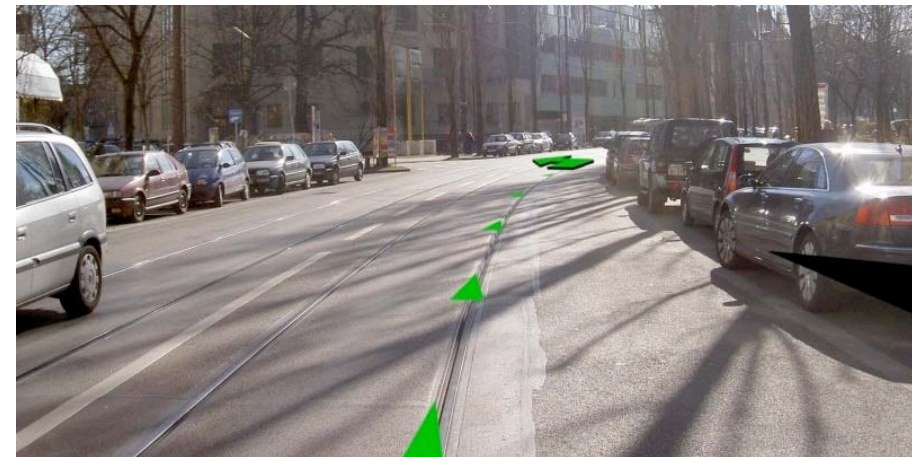
### Leading Arrow



## Design Concepts: Hybrid Schemes

### Points on the Path

- Hansel and Gretel metaphor: Points, Arrows, Bars on the Path



### Pathway Indication

- The full Path is highlighted => Occlusion Problem

### Alternation between Symbolic and AR-Indication

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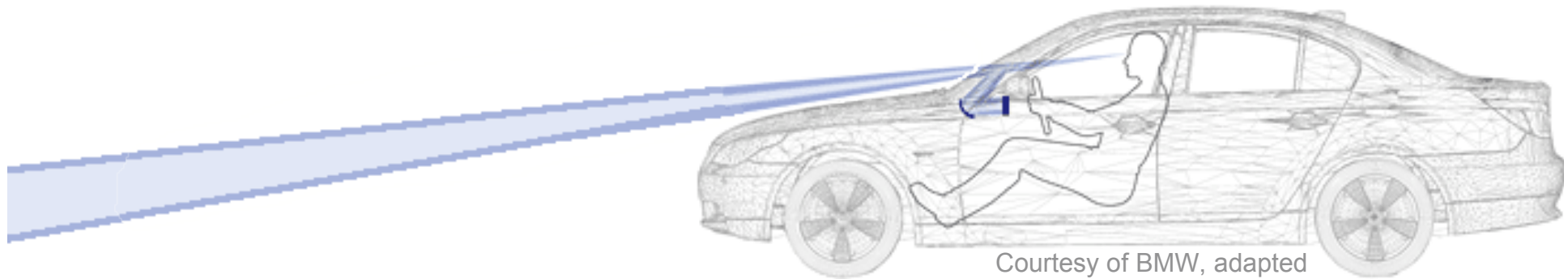
- Related Work
- Design Concepts
- **System Setup**
- Experiment

## Conclusion & Future Work

## System Setup

### Optical Setup

- Image Plane in Distance where oculomotor and binocular cues are minimized

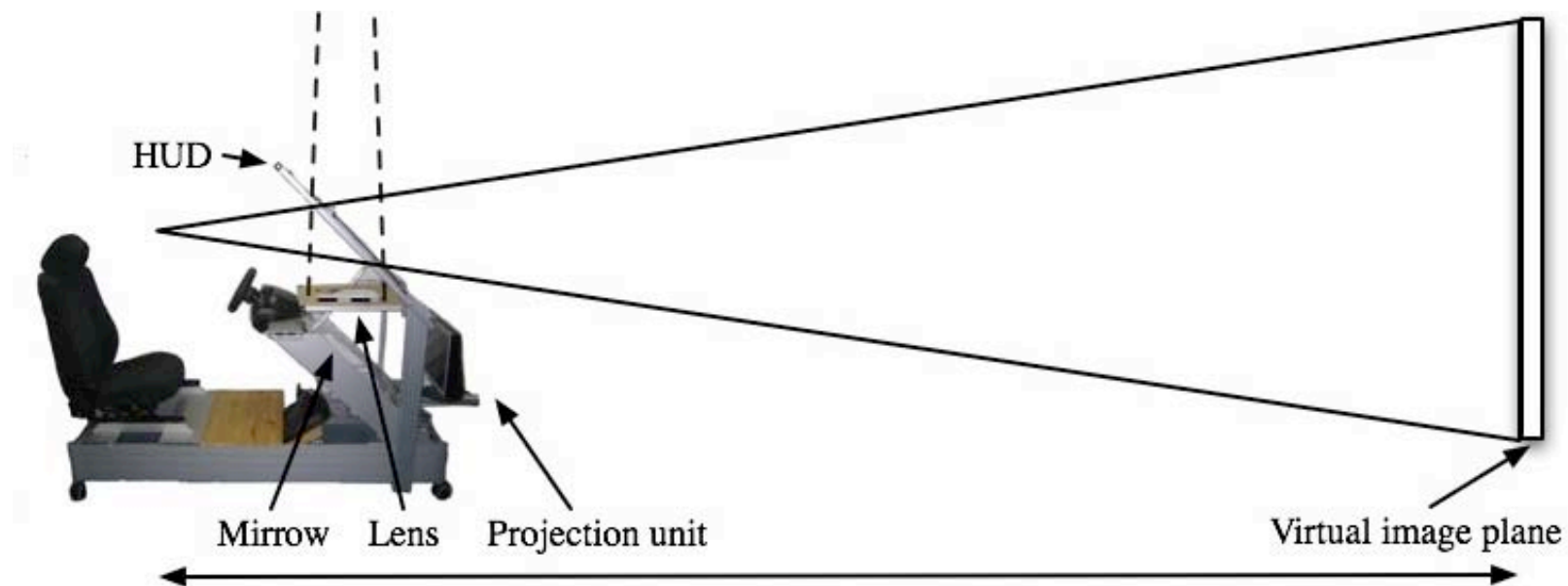


Courtesy of BMW, adapted

# System Setup

## Optical Setup

- Image Plane in Distance of about 11 meters

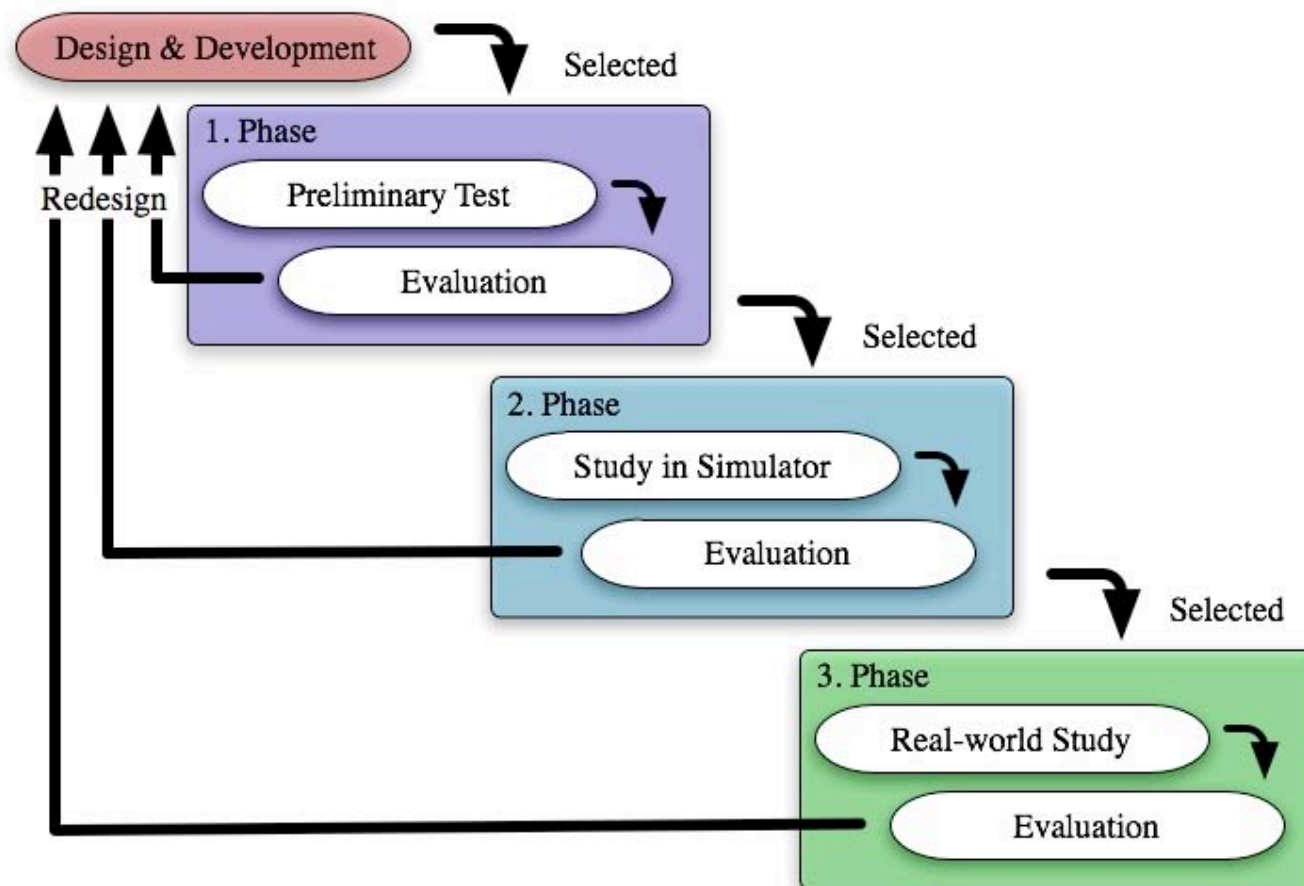


### Problem:

- Image Plane in Distance is enlarged => Large relative size of pixels



# System Implementation



## System Implementation

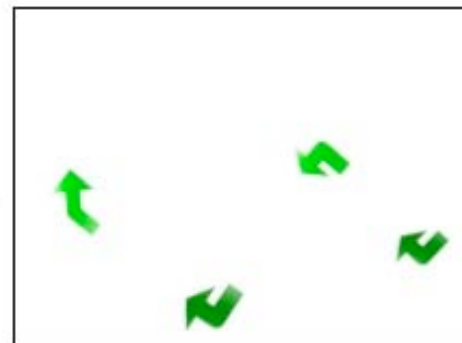
### Feature:

- Placing Route Guidance Information in Virtual World
- Virtual World corresponds to Real World



Real Street Scenery

+



Virtual Navigation Aids

=

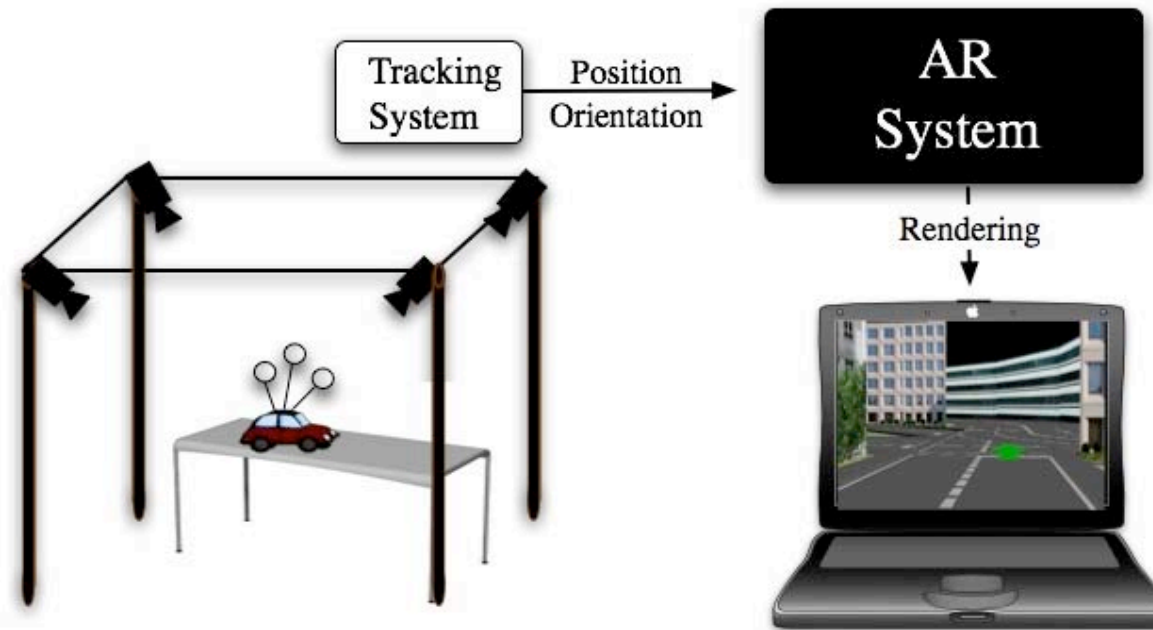


Real & Virtual Aligned

# System Implementation

## First Evaluation Phase

- Pilot-Study for Design Verification



# System Implementation

## First Evaluation Phase

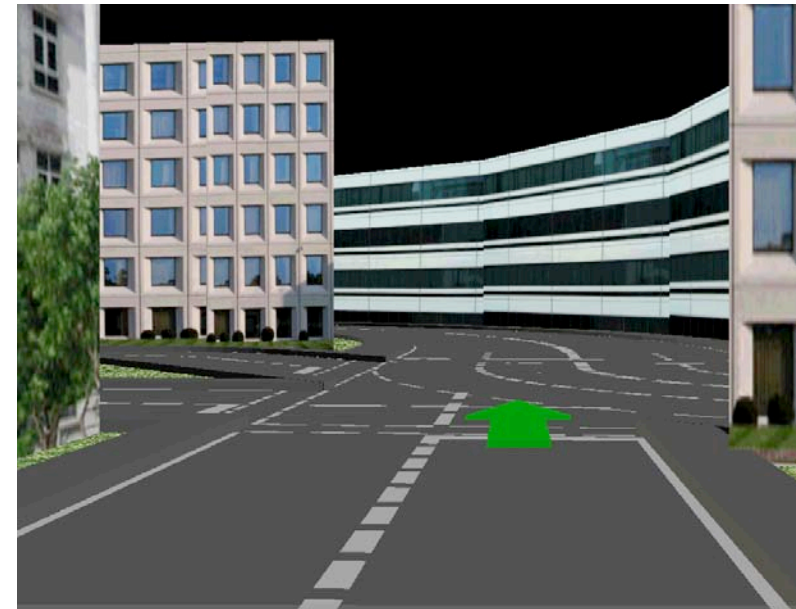
- Virtual World



# System Implementation

## First Evaluation Phase

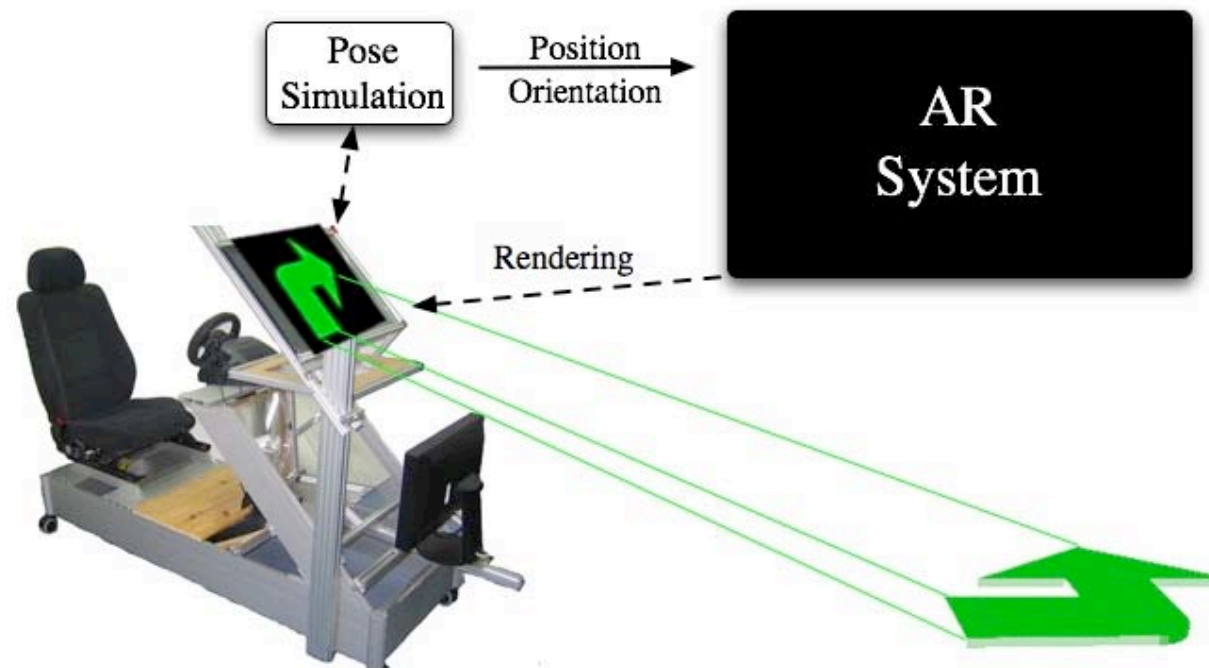
- Virtual World with Navigation Arrows aligned for Preevaluation



# System Implementation

## Second Evaluation Phase

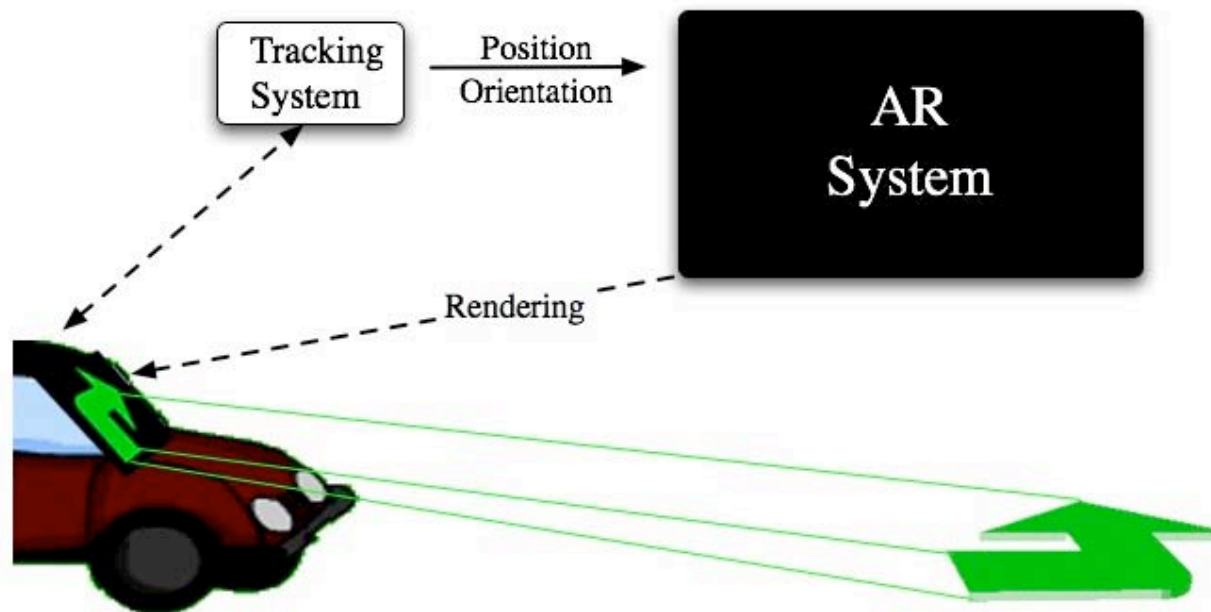
- Study with the Prototypical automotive HUD Simulator



# System Implementation

## Third Evaluation Phase

- Real-World Studies: Integration of Global Positioning System (GPS) & Gyrocompass



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# Usability Study

## Identification of Distance Limitations for Conformal Indication

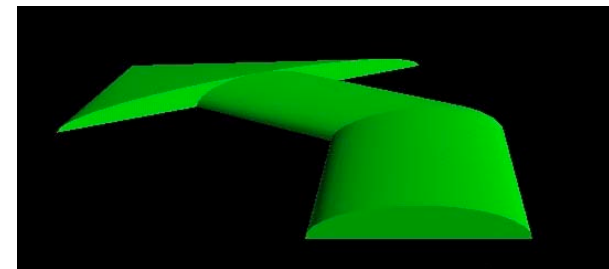
- Perceptibility Difference between the Types
- Perceptibility Difference between Types when driving 50 km/h
- Perceptibility Difference between Types when driving 100 km/h
- Perceptibility Difference between 50 km/h and 100 km/h for Type A
- Perceptibility Difference between 50 km/h and 100 km/h for Type B
- Perceptibility Difference between 50 km/h and 100 km/h for Type C
- Subjective Difference between the Types



Variant A



Variant B



Variant C

# Usability Study

## Participants:

- 16 Subjects (14 Male & 2 Female)
- Within-Subject Design (3 Trials with 30 Arrows each)
- Questionnaires: Demographic, NASA TLX & Final Questionnaire



# Usability Study

20 and 60 meter

Variant A



Variant B



Variant C

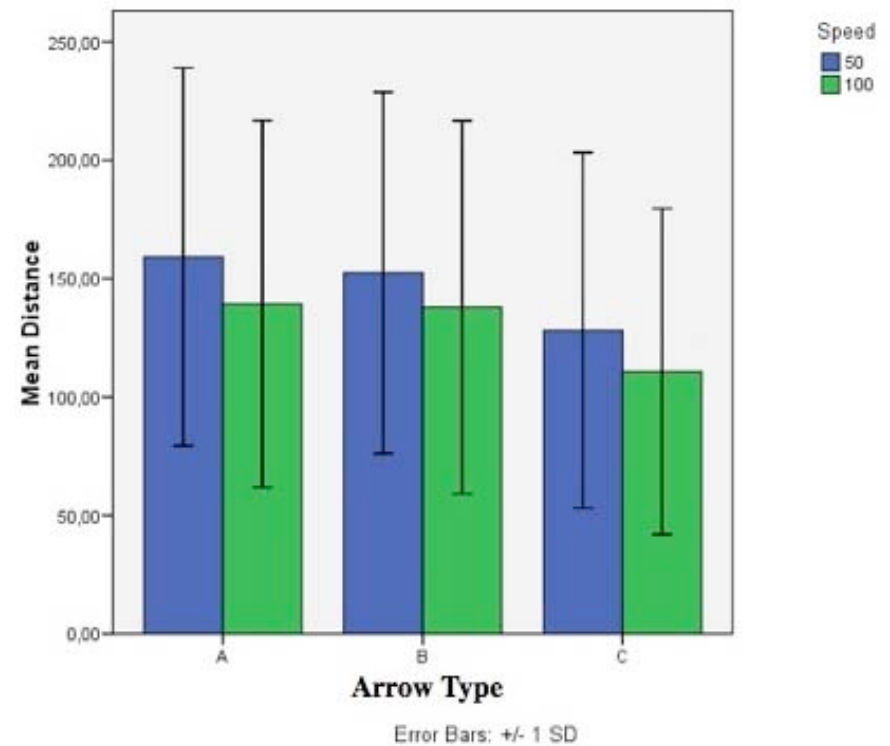


# Usability Study

## Results:

- Perceptibility Difference between the Types: **Significant**

alpha	50 km/h	100 km/h	Total
ANOVA	,000	,000	,000
Type A/B	,637	,979	,698
Type A/C	,000	,000	,000
Type B/C	,003	,000	,000



# Usability Study

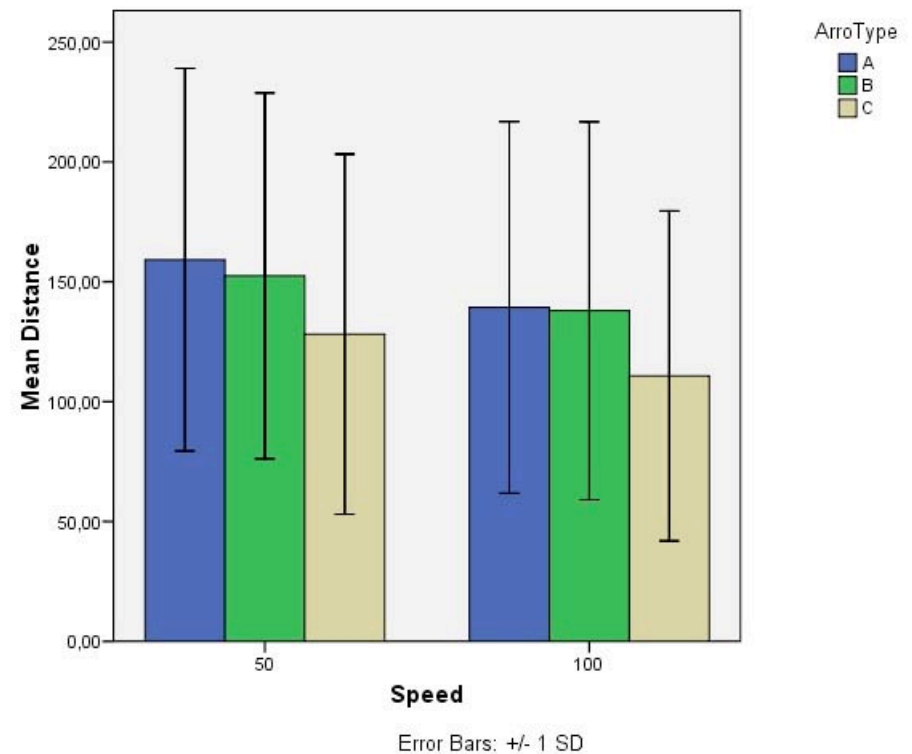
## Results:

- Perceptibility Difference between the Speed

alpha	Type A	Type B	Type C
50/100 km/h	,007	,041	,009

## There is a Difference:

- Type A is best perceptible
- Type C is worst perceptible



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# Conclusion

## Design

- Most challenging to counterbalance  
Perception of Depth & Perceptibility in Distance

## Implementation

- Test environment for preliminary Studies
- Basis for Real-World Studies

## Experiment

- Indication Distance Threshold: Mean Value of Type about 149 meter
- Threshold can be influenced by the Design

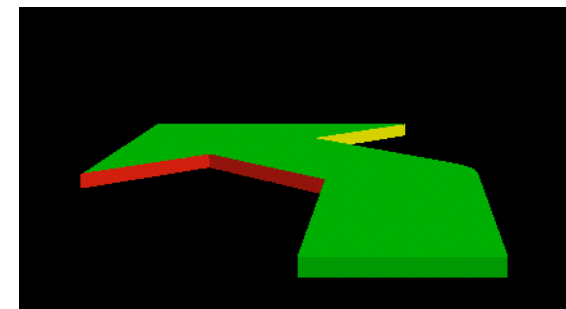
## Future Work

### Perception of Depth

- Are monocular Cues enough for correct Distance Estimations?

### Perceptibility

- Do colored edges enhance Distance threshold?
- Effect of coloring in general
- Determination of Level-Of-Detail
- Transfer between large Distance Indication and AR-Indication



### Real-World Studies

- Impact of conformal Indication on perceptual and cognitive capabilities within a complex, continually changing scene.
- Effect of the omnipresent Nature of such Visualization





**?!Thank You!?**

**Manuel**

**Thank you for your attention!**  
**Now it's your turn for questions?**  
**Any Questions?**