Cartography M.Sc.

Design Guidelines for Mobile Augmented Reality Reconstruction

Peilun Yuan

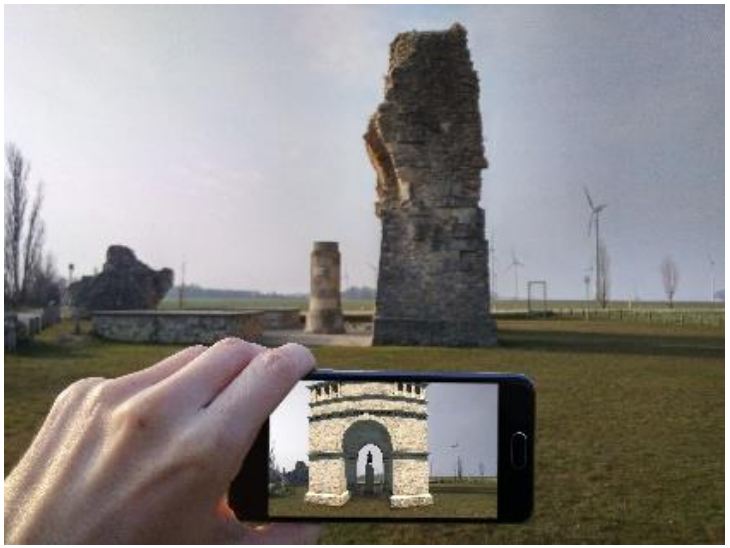
Supervisor
Dr. Mathias Jahnke
Prof. Dr. Georg Gartner

Content

1. Introduction
2. Research Objectives & Questions
3. Methodology
4. Features of AR Reconstruction
5. Design Guidelines
6. Evaluation
7. Conclusion & Outlook

Introduction
Background

- Augmented reality (AR)
- Lack of the researches for AR design
- Special needs for AR reconstruction



AR ronstruction example
(Hoshang et al., 2018)

Introduction
Motivation

- Develop design guidelines for AR reconstruction
- Help the developers for the development

Research Objectives & Questions

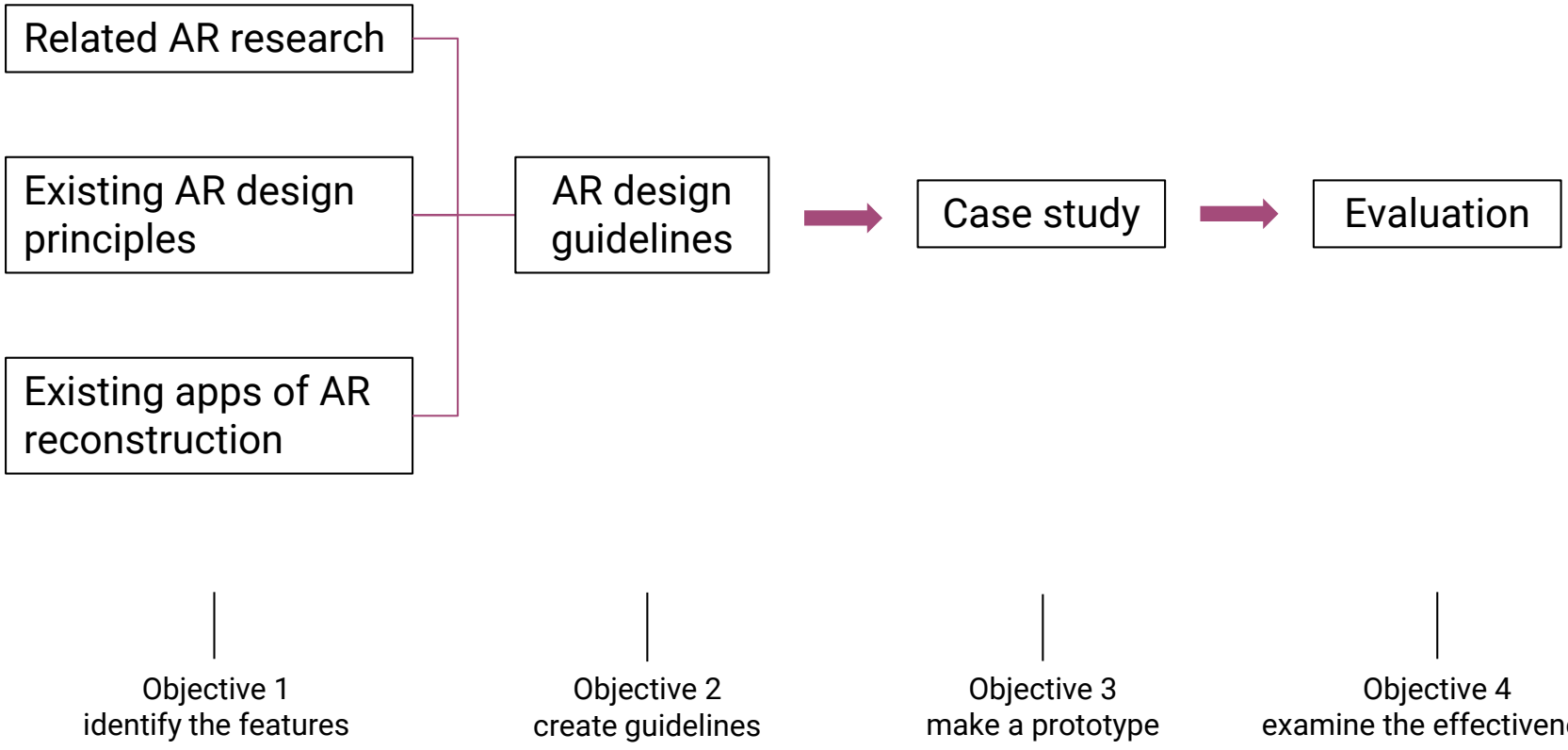
1. Identify the features of AR reconstruction.
   - What is special to applications for AR reconstruction?
   - How to identify the features of AR reconstruction?
2. Integrate the mobile AR design principles from various aspects and form a new set of AR design guidelines.
   - How to develop the guidelines?
   - What should be included?

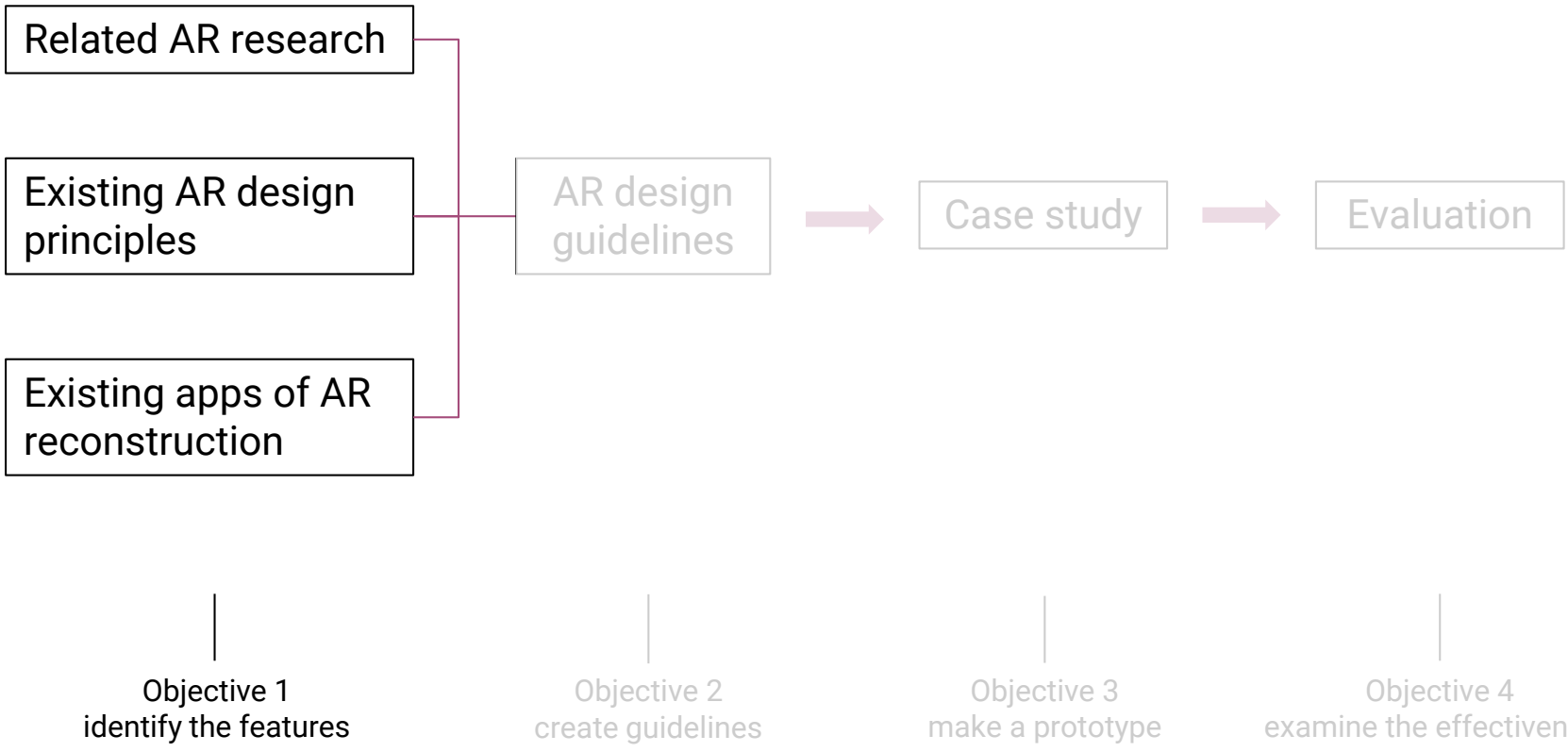
Research Objectives & Questions

3. Develop a prototype based on the proposed guidelines.
   - How to develop the prototype?
   - How to integrate with the proposed guidelines?

4. Evaluate the effectiveness of the guidelines with the prototype.
   - How to design the evaluation experiment?
   - How helpful are the proposed design guidelines?

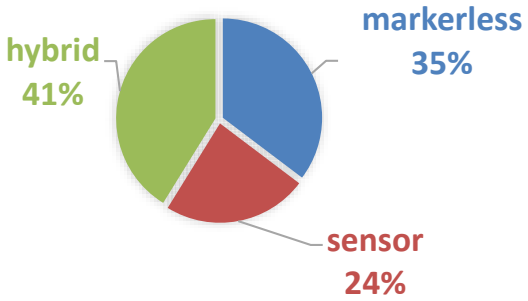
Methodology




Related AR research
Existing AR design principles
Existing apps of AR reconstruction
AR design guidelines
Case study
Evaluation
Objective 1
identify the features
Objective 2
create guidelines
Objective 3
make a prototype
Objective 4
examine the effectiveness

Features of AR Reconstruction
From the related research

- Location-specific
  - outdoor or indoor
- Rely on AR tracking
  - Camera-based: ~~marker~~ / markerless
  - hybrid tracking with inertial sensors
- Tangible interaction
  - on-screen gestures

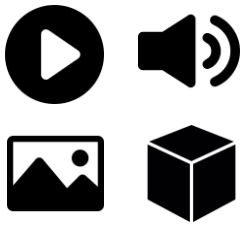


Outdoor MAR method
for cultural heritage
(Bekele et al., 2018)

Features of AR Reconstruction

From the related research

- Multimedia materials
  - Use diverse media to enrich the experience



- Reconstruction and exhibition purpose
  - helpful to visitors and the professionals
  - ideal for preservation

Features of AR Reconstruction

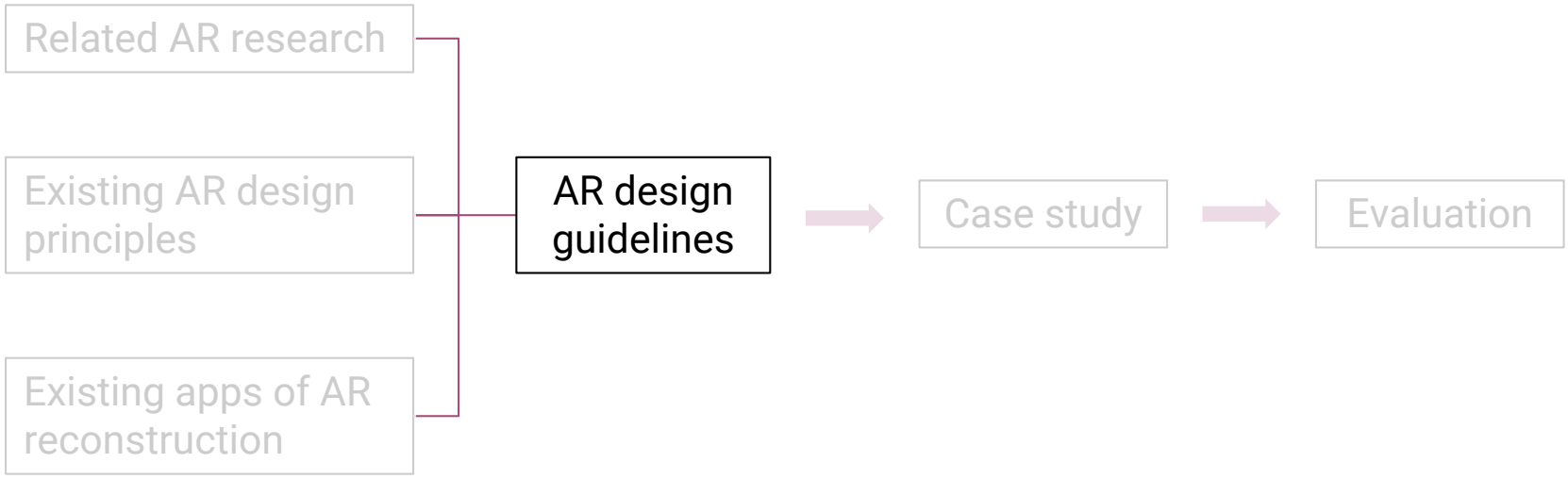
Existing AR design principles

- Compare 49 design principles from various aspects
- Some common principles:
  - cognitive load
  - physical efforts
  - user supports
  - feedbacks
  - intuitive interaction

Features of AR Reconstruction

Existing apps of AR reconstruction

- Overlay 2D media or 3D models 
- Adjust transparency 
- Map 
- Timeline 


Related AR research
Existing AR design principles
Existing apps of AR reconstruction
AR design guidelines
Case study
Evaluation
Objective 1
identify the features
Objective 2
create guidelines
Objective 3
make a prototype
Objective 4
examine the effectiveness

Design Guidelines

1. Suitable tracking method
2. Quality 3D models
3. AR interaction versus non-interaction
4. Storytelling
5. Provide user guide and feedback
6. Prevent cognition overload

Design Guidelines

The relation of the guidelines and where they derived from

Summa-rizations / Guidelines	Suitable tracking method	Quality 3D models	AR interaction versus non-interaction	Storytelling	Provide user guide & feedback	Prevent cognition overload
Technical requirements	×	×				
Features of AR reconstruction		×	×	×		
Research for AR reconstruction			×	×		
Developed AR application			×	×	×	
General AR design principles	×		×		×	×

Design Guidelines

1. Suitable tracking method

Use suitable tracking to achieve high accuracy, responsiveness, and low latency

- The needs of the project
- Various AR software development kit (SDK)

Some common AR SDK

SDK	Tracking methods			Platforms	License
	Camera	Sensor	SLAM		
Apple ARKit	2D, 3D object tracking	GPS, IMU	No	iOS	Free
Google ARCore	2D tracking	GPS, IMU	Yes	iOS, Android	Free
ARToolKit+	2D tracking	-	No	iOS, Android	General public license
Wikitude	2D, 3D object tracking	GPS, IMU	Yes	iOS, Android	Free and commercial
Vuforia	2D, 3D object tracking	GPS, IMU	Yes	iOS, Android	Free and commercial

Design Guidelines
2. Quality 3D models

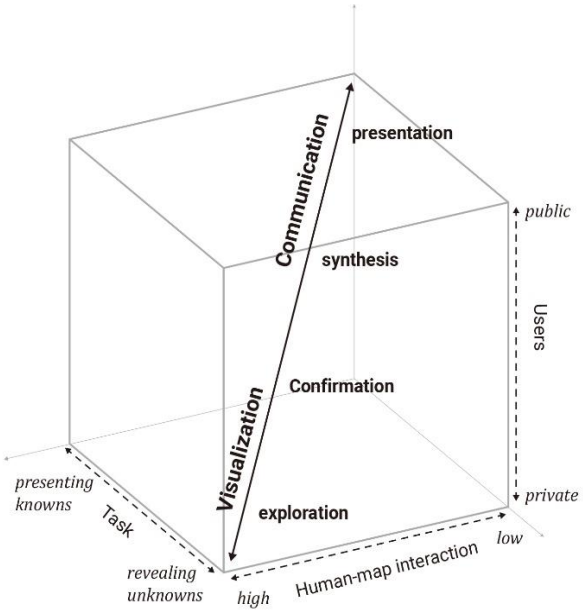
Make the balance between user experience and hardware performance

- Scale and geometry
- Clear communication

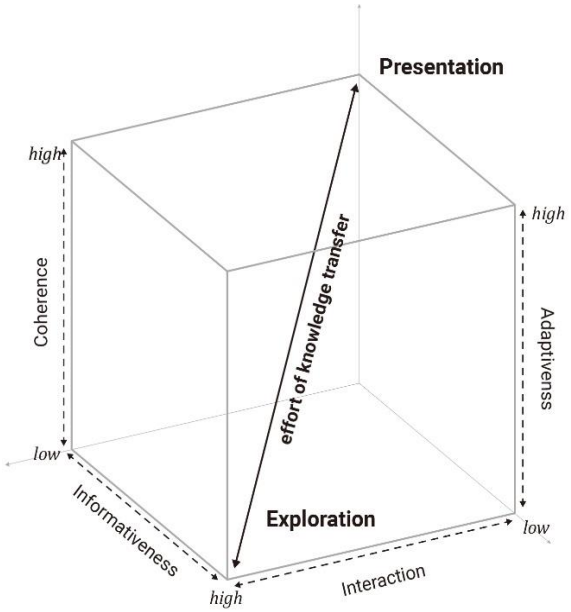
Design Guidelines

3. AR interaction versus non-interaction

- Interaction → explore
  - Interaction methods: transparency, highlight
- Non-interaction →present



Cartography cube
(MacEachren, 1994)



AR visualization cube
(Keil et al., 2018)

Design Guidelines

4. Storytelling

Design and present appealing stories to interest the public

- Link to the history and the surroundings
- The use of maps

Design Guidelines

5. Provide user guide and feedback

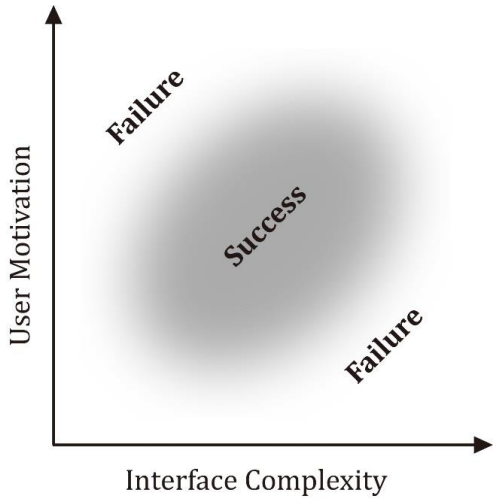
Reduce user frustration, confusion and misuse.

- Interface issue
- Guide the users

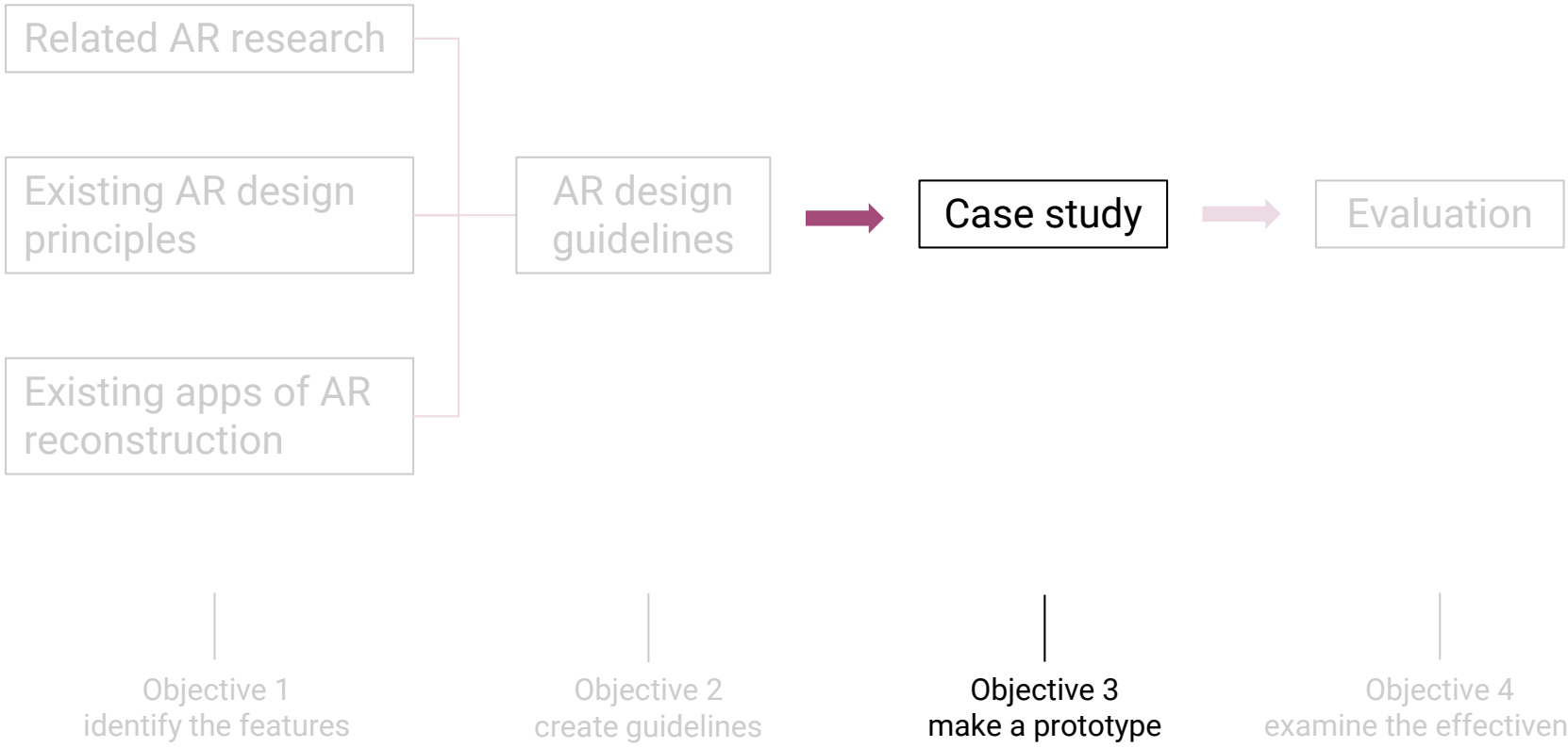
Design Guidelines

6. Prevent cognition overload

- Due to the complexity of AR visualization
- Appropriate interface complexity

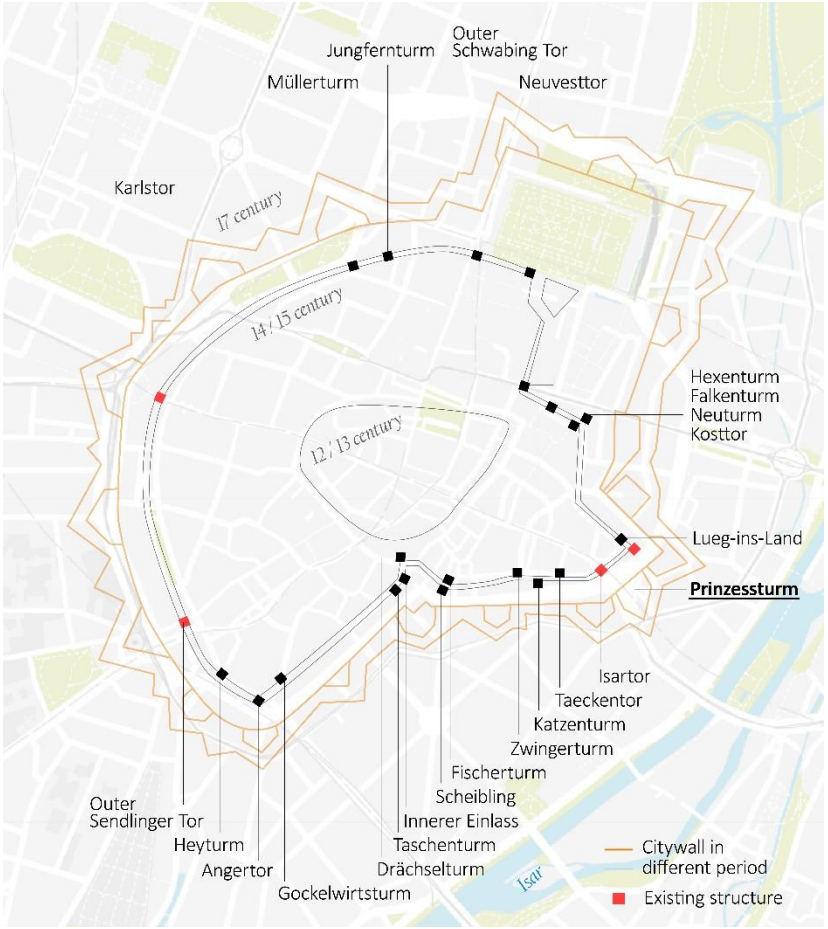


Interface complexity versus user motivation
(Roth, 2013)


Related AR research
Existing AR design principles
Existing apps of AR reconstruction
AR design guidelines
Case study
Evaluation
Objective 1
identify the features
Objective 2
create guidelines
Objective 3
make a prototype
Objective 4
examine the effectiveness

Case Study
Prinzessturm

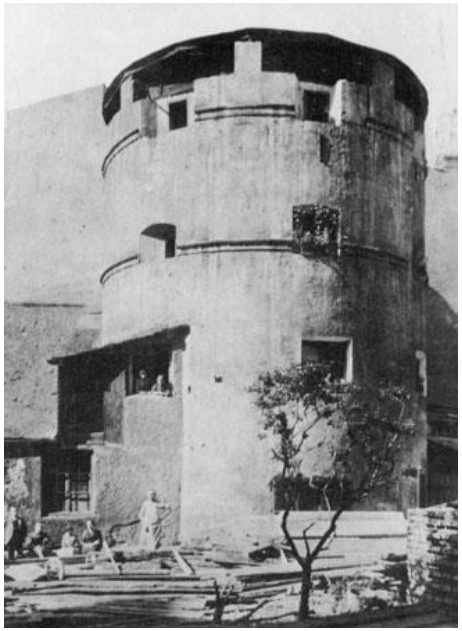
- Locate in Munich
- First mentioned in 1473
- Torn down in 1892
- Discovered in 1978



The location of Prinzessturm and other city structure

Case Study
Prinzessturm

- Locate in Munich
- First mentioned in 1473
- Torn down in 1892
- Discovered in 1978



Prinzessturm in 1890

The ruin of Prinzessturm

Case Study
Prinzessturm

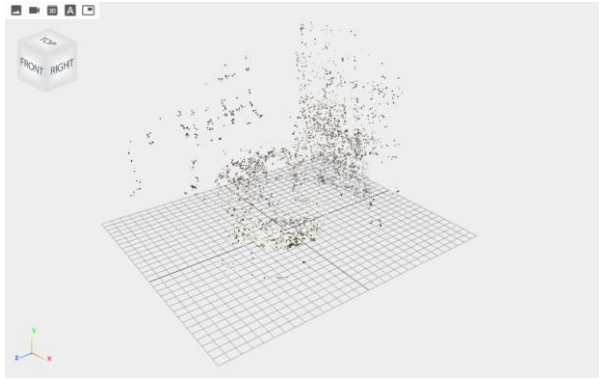
The view from Thomas-Wimmer-Ring

The view from the backyard

Case Study
Prototype

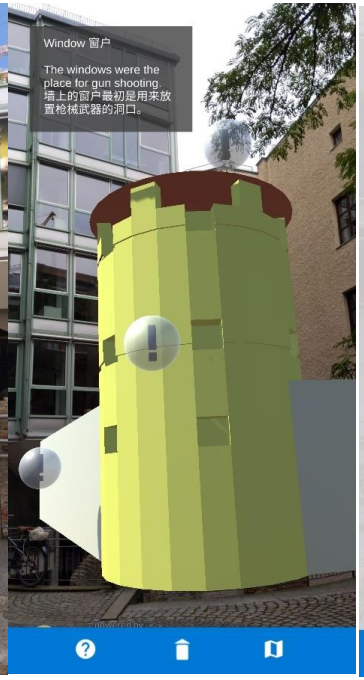
- 3D modeling
- Markerless-based tracking
  - Wikitude SDK
- App development

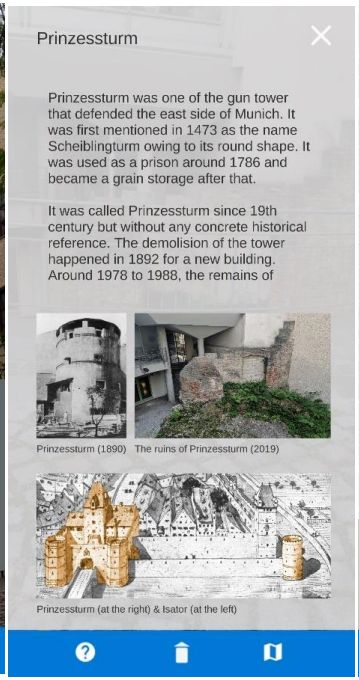
3D model of Prinzessturm

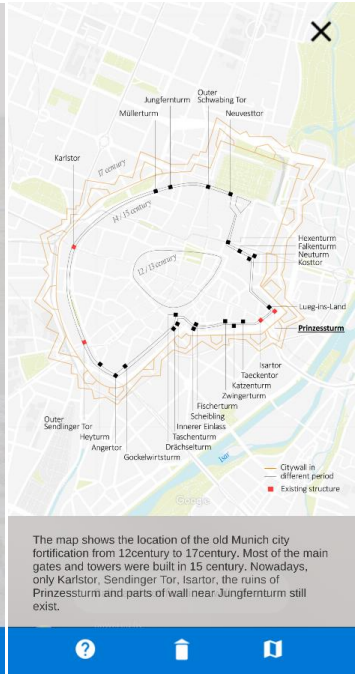


The point cloud data of the ruin

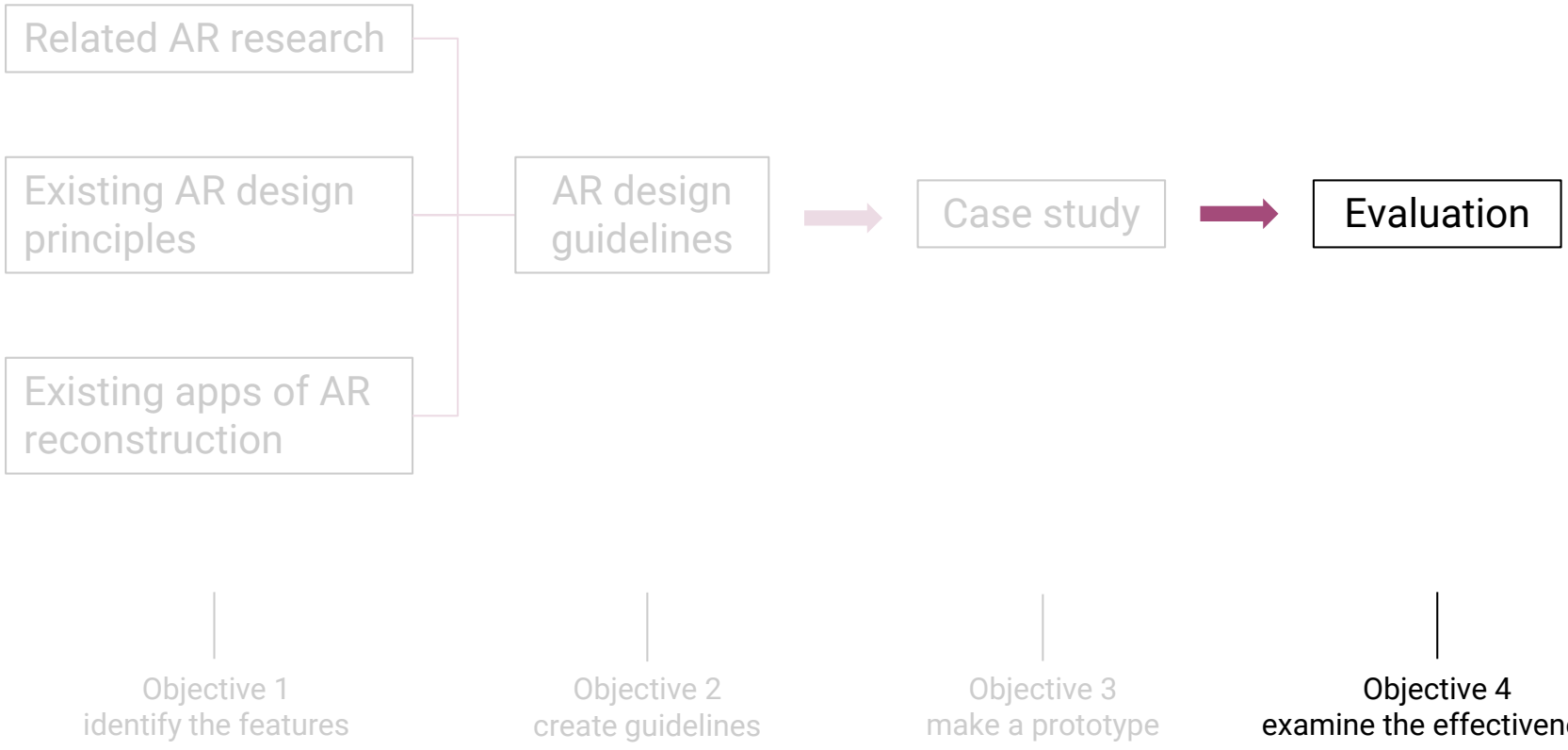
Case Study
Prototype







intro & help | instruction | AR view | story | map


Related AR research
Existing AR design principles
Existing apps of AR reconstruction
AR design guidelines
Case study
Evaluation
Objective 1
identify the features
Objective 2
create guidelines
Objective 3
make a prototype
Objective 4
examine the effectiveness

Evaluation
Setup

- Explore the effectiveness of the guidelines
- Materials & Participants
  - Google Pixel 3 XL
  - 26 user tests with questionnaires (group1 & group2)
  - 2 interviews with tour guides

Evaluation
Users

- Over 80% had AR exp.
- No one knew Prinzessturm
- Group 1
  - 14 users
  - With AR interaction (click information box)
- Group 2
  - 12 users
  - Without AR interaction

The statistics of the users

Type		Group1	Group2	Total
Age	Below 20	2	1	3
	21-30	3	3	6
	31-40	5	3	8
	41-50	3	2	5
	51-60	0	2	2
	Over 61	1	1	2
Gender	Male	9	7	16
	Female	5	5	10
Identity	Tourists	9	10	19
	Citizens	2	1	3
	Foreign workers or students	3	1	4

Evaluation
User tests

- Six multiple choice questions
  - Compare the percentages of the correct answers
- Open questions
  - What do you like about the app?
  - What problems happened when using the app?
  - What can be improved?

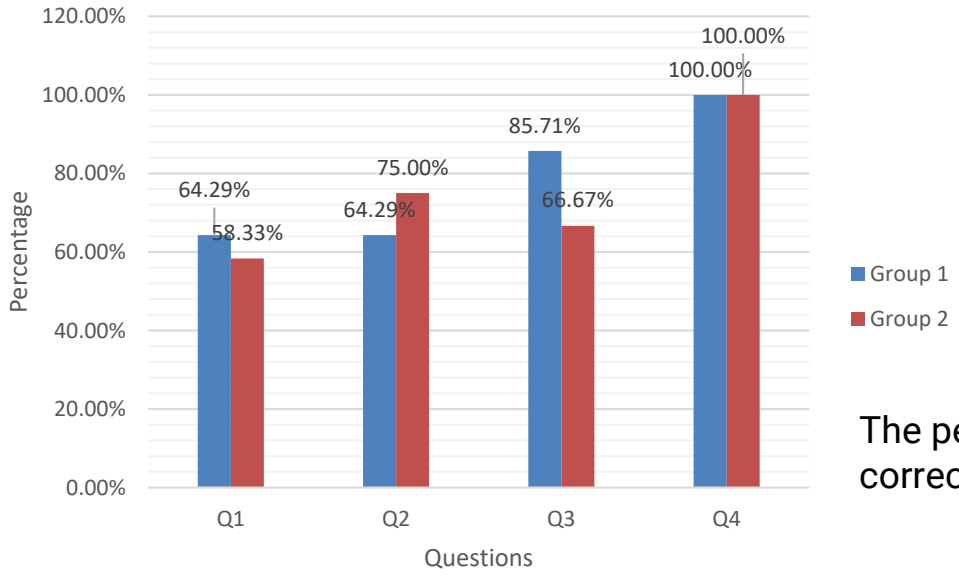
Evaluation
Interview

- Open questions
  - What is your opinion toward AR reconstruction?
  - As a tour guide, what is essential to AR reconstruction?
  - What do you like about the app?
  - What can be improved?

Evaluation
Result

1. When was Prinzessturm built?
   - 16 century, ~~18 century~~, ~~19 century~~
2. When was Prinzessturm torn down?
   - ~~18 century~~, ~~19 century~~, 20 century

general questions



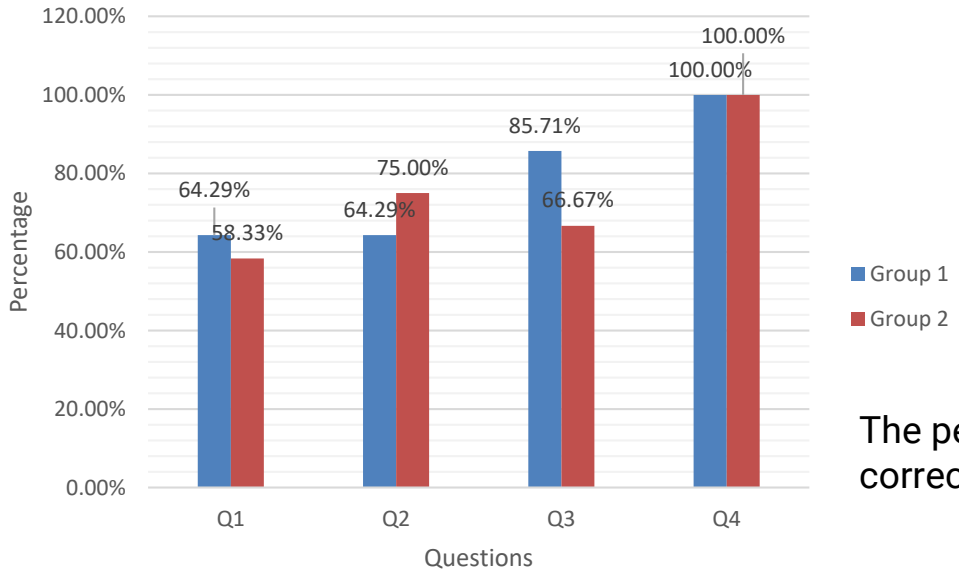
The percentages of the correct answers for Q1 to Q4

Evaluation
Result

3. What is the nearest existed gate to Prinzessturm?
   - Isartor, ~~Sendlinger Tor, Karlstor~~

4. What is the function of the window?
   - ~~to see the view~~, to place weapon, ~~for ventilation~~

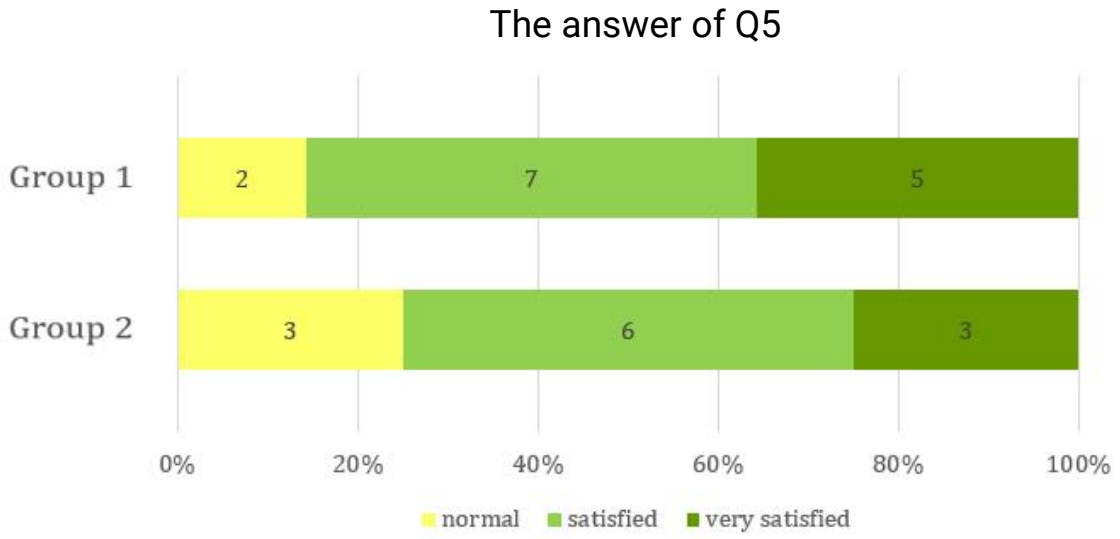
involve AR interaction



The percentages of the correct answers for Q1 to Q4

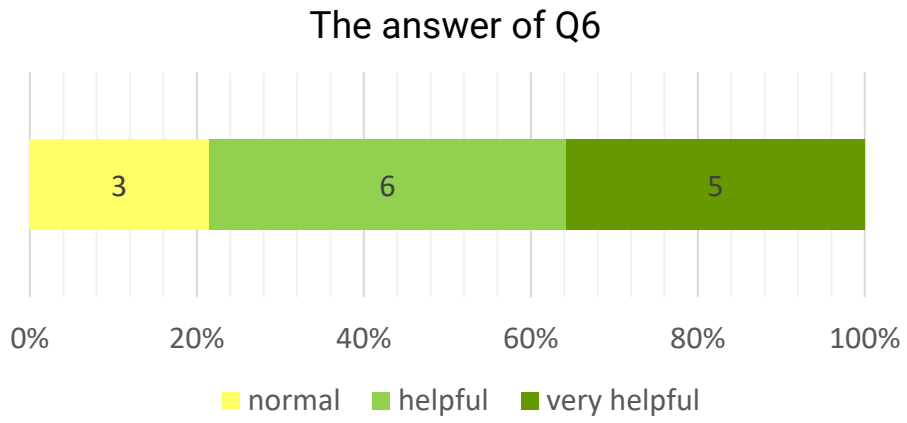
Evaluation
Result

5. How do you feel about this AR experience for reconstructing the tower? (Group 1)



Evaluation
Result

6. How helpful is the highlight function for understanding the tower? (Group 1)



Evaluation
Result

- What do you like about the app?
  - Interesting, attractive, impressive…
- What problems happened when using the app?
  - Text, distance
- What can be improved? What else function would you like to have?
  - Voice guide, gamification, connect with other tourism resources
- Opinion from the tour guides

Evaluation
Discussion

- Help enhance understanding to the heritage
- Felt satisfied and helpful
- AR interaction led to group difference
- Limitation
  - Question design
  - Need more samples

Conclusion

- A start point of researches of design guidelines for AR reconstruction
- Six design guidelines
- Enhancing understanding
- Facilitate further research

Outlook

- Further examine the guidelines
- Integration with gaming


ITC
UNIVERSITY OF TWENTE.
TECHNISCHE
UNIVERSITÄT
DRESDEN
Technical
University
of Munich
TU
WIEN
TECHNISCHE
UNIVERSITÄT
WIEN
Vienna University of Technology