High Accuracy GPS Antennas in Educational Location-Based AR

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Benefits of AR for Field Trips

- Introduces students to the real built environment
- Promotes exploratory and inquiry based learning
- Allows non-guided field trips

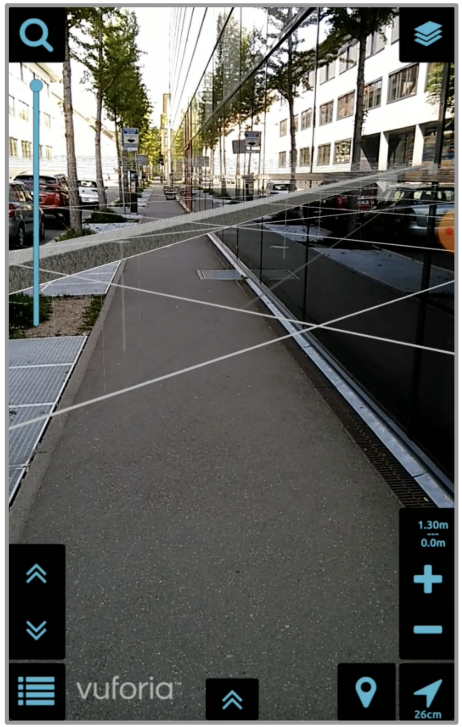
[Be08], [BDK15], [YYJ11], [KG19]

GPS-Based AR

Source: augview.net, flaticon.com

GPS-Based AR Limitations without antenna

- Low accuracy
- Slow position retrieval
- Unstable visualization



Research Question

To what extent the use of GPS antennas improves the usability and leads to better learning outcomes?

Study

Technical Setup

Experimental Group

GIS App: AugView

GPS Antenna: ***Leica FLX 100***

Mobile Device: Leica Zeno Tab 2

Expected precision:

0.02m to 4m

Control Group

GIS App: AugView

GPS Antenna: ***None***

Mobile Device: Leica Zeno Tab 2

Expected precision:

1.8m to 35m

Technical Setup

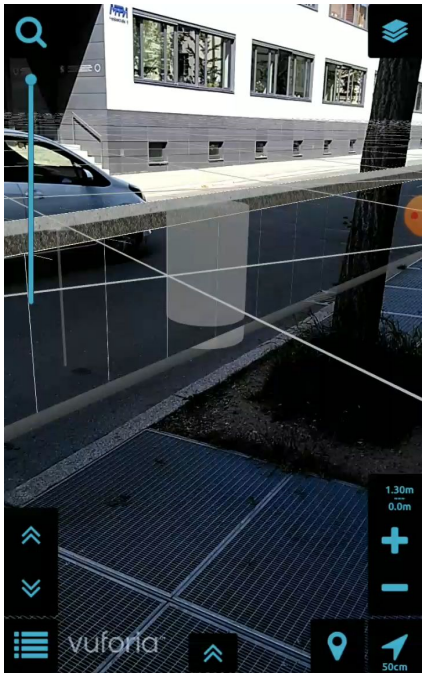
Experimental Group

Control Group

Study Design

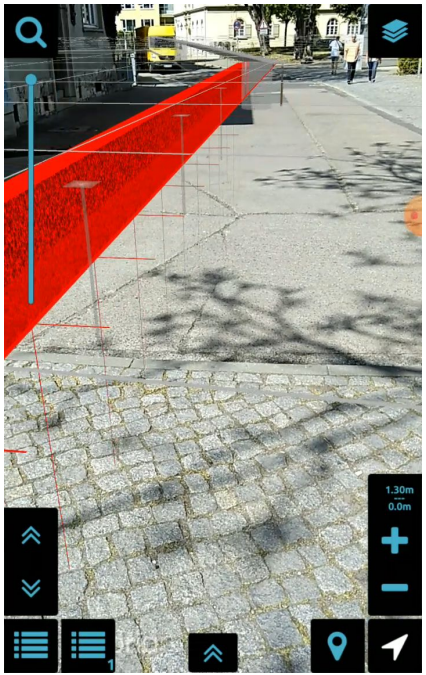
Step	Description	Duration [min]
1	Briefing	5
2	Pre-Test	5
3	**Practical Task: Visualization**	**5**
4	**Practical Task: Modelling predefined pipes and manholes including visualization check**	**15**
5	Questionnaire and Post-Test	10
6	Semi-structured Interview	15

Examples of the task



Step 3
Practical Task:
Visualization

Step 4
Practical Task:
Modelling predefined pipes and manholes including visualization check



Participants

- 16 participants
- 8 male and 8 female
- 8 with prior knowledge and 8 without

- Study majors: Civil Engineering (3 participants), Environmental Engineering (4), and Urbanism (2), Digital Engineering (4), Human Computer Interaction (1), Digital Marketing (1) and Media Management (1)

Results

Usability assessment via PSSUQ

The smaller the better!

Subscale values of PSSUQ (7-point scale ("Strongly agree" for 1, "Strongly disagree" for 7) (Lewis, 1995))

Usefulness of AR-Visualisation

#	Statement	All	Experimental	Control
1	“AR is useful”	5	4	1
2	“AR is useful but needs improvement”	5	2	3
3	“AR is not useful”	6	2	4

Results acquired via thematic analysis of semi-structured interviews

One statement per participant

Overall Evaluation of Positioning Accuracy

#	Statement	All	Experimental	Control
1	“Accuracy is poor”	10	2	8
2	“Accuracy is good”	4	4	0
3	“Accuracy is sufficient”	2	2	0

Results acquired via thematic analysis of semi-structured interviews

One statement per participant

Other statements about Positioning Accuracy

#	Statement	All	Experimental	Control
1	“Accuracy is gained fast”	7	6	1
2	“Had to manually adjust visualization a lot”	4	1	3
3	“Accuracy is gained slowly”	3	0	3
4	“System is unreliable”	3	0	3

Results acquired via thematic analysis of semi-structured interviews

Knowledge Gain: Perceived Learning from Interviews

#	Statement	All	Experimental	Control
1	“Positive learning experience”	11	7	4
2	“Knowledge gain is low because of prior knowledge”	5	3	2
3	“Low knowledge gain”	5	1	4

Results acquired via thematic analysis of semi-structured interviews

Knowledge Gain: Pre- and Post-Tests Assessment

Condition	N	Pre-Test Mean	Post-Test Mean	Difference Mean	Difference SD
All	16	6.5	7.7	1.1	1.13
No GPS Antenna	8	6.2	7.2	1.0	1.82
GPS Antenna	8	6.9	8.1	1.3	1.25
No Prior Knowledge	8	6.2	7.0	0.8	1.73
Prior Knowledge	8	6.9	8.3	1.4	1.55

Pre- and Post-Tests consisted of 12 same multi-choice questions

Discussion

Main findings

RQ: To what extent the use of GPS antennas improves the usability and leads to better learning outcomes?

Antenna led to a better learning experience and user experience

Positioning accuracy → Knowledge gain; Usability of the app; Usefulness of the app and AR

Considerations

Antenna:

- Accuracy gain was not as strong as we hoped
- Other sensors (like compass) can mess AR-visualisation
- Accuracy depends on the street layout
- Movement influences the accuracy too

Learning:

- Participants in the area seem to be more interested

Conclusions

1. Accuracy seems directly influence usability and learning outcomes
2. GPS-based AR is not yet good enough for the use, but very promising
3. Environment and movement has a strong influence on the accuracy of the GPS-Based AR Apps

Future work

Another technical setup:

- vGIS
- Current tablet / current Android version
- Results seem to be better, but not yet perfect

Thanks!

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Appendix

Appendix A: Pre-Post Test question examples

Which piped infrastructure is usually indicated by signs posted?

- [ ] Gas lines
- [ ] Sewers
- [ ] Drinking water pipes

What material are manhole covers usually made of?

- ( ) Metal sheet
- ( ) Cast iron
- ( ) Concrete
- ( ) Hard plastic

Appendix B: PSSUQ (Post-Study System Usability Questionnaire)

Category	#	Question	Mean	
			With Antenna	Without Antenna
SYSUSE	1	Overall, I am satisfied with how easy it is to use this system.	2,25	3,75
	2	It was simple to use this system.	2,125	4,125
	3	I could effectively complete the tasks and scenarios using this system.	3	3,875
	4	I was able to complete the tasks and scenarios quickly using this system.	2,75	4,125
	5	I was able to efficiently complete the tasks and scenarios using this system.	2,5	4,25
	6	I felt comfortable using this system.	2,125	4,625
	7	It was easy to learn to use this system.	2	3
	8	I believe I could become productive quickly using this system.	2,375	4
OVERALL	19	Overall, I am satisfied with this system.	2,625	4,375