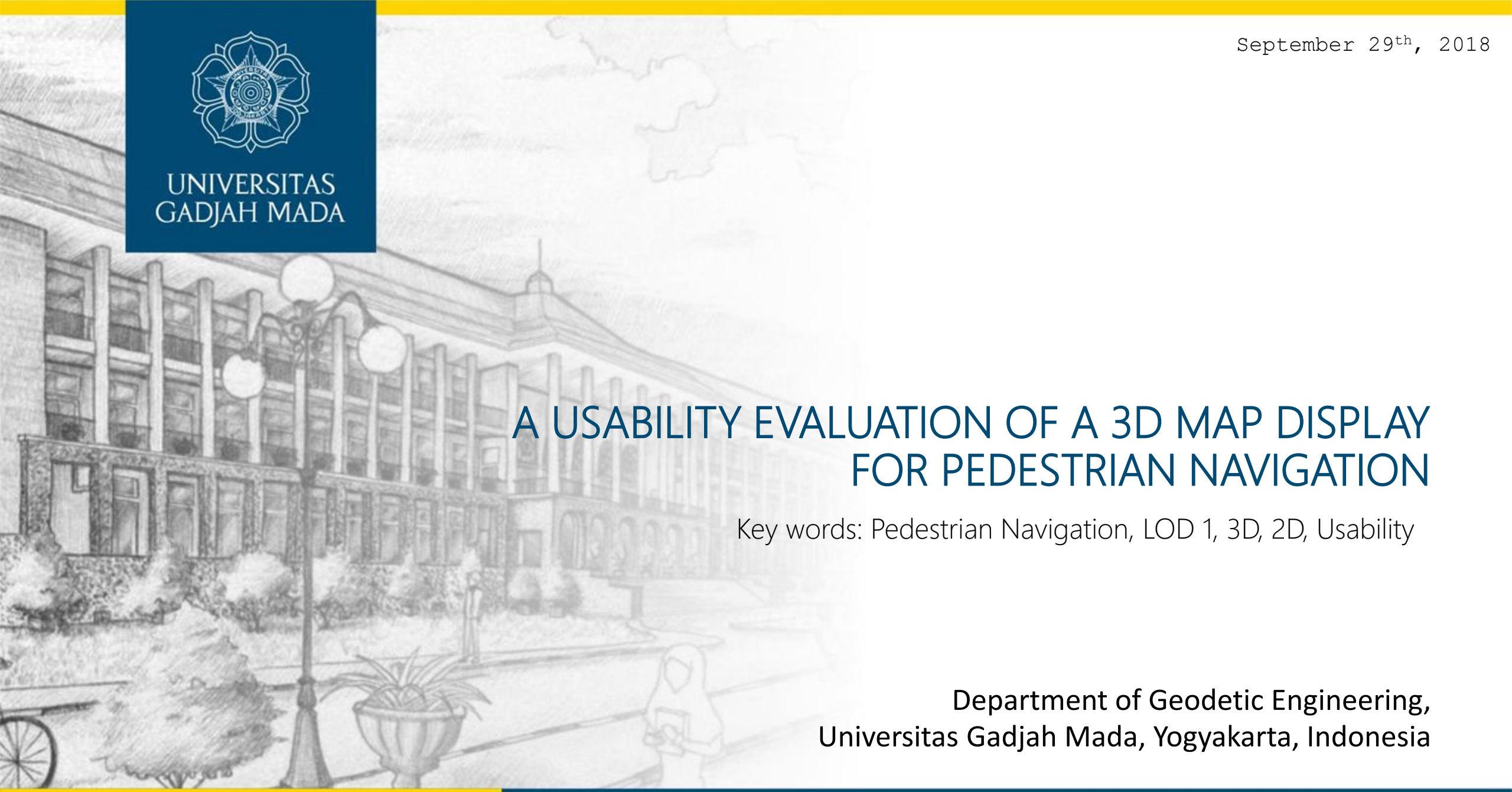

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September 29th, 2018

A USABILITY EVALUATION OF A 3D MAP DISPLAY FOR PEDESTRIAN NAVIGATION

Key words: Pedestrian Navigation, LOD 1, 3D, 2D, Usability

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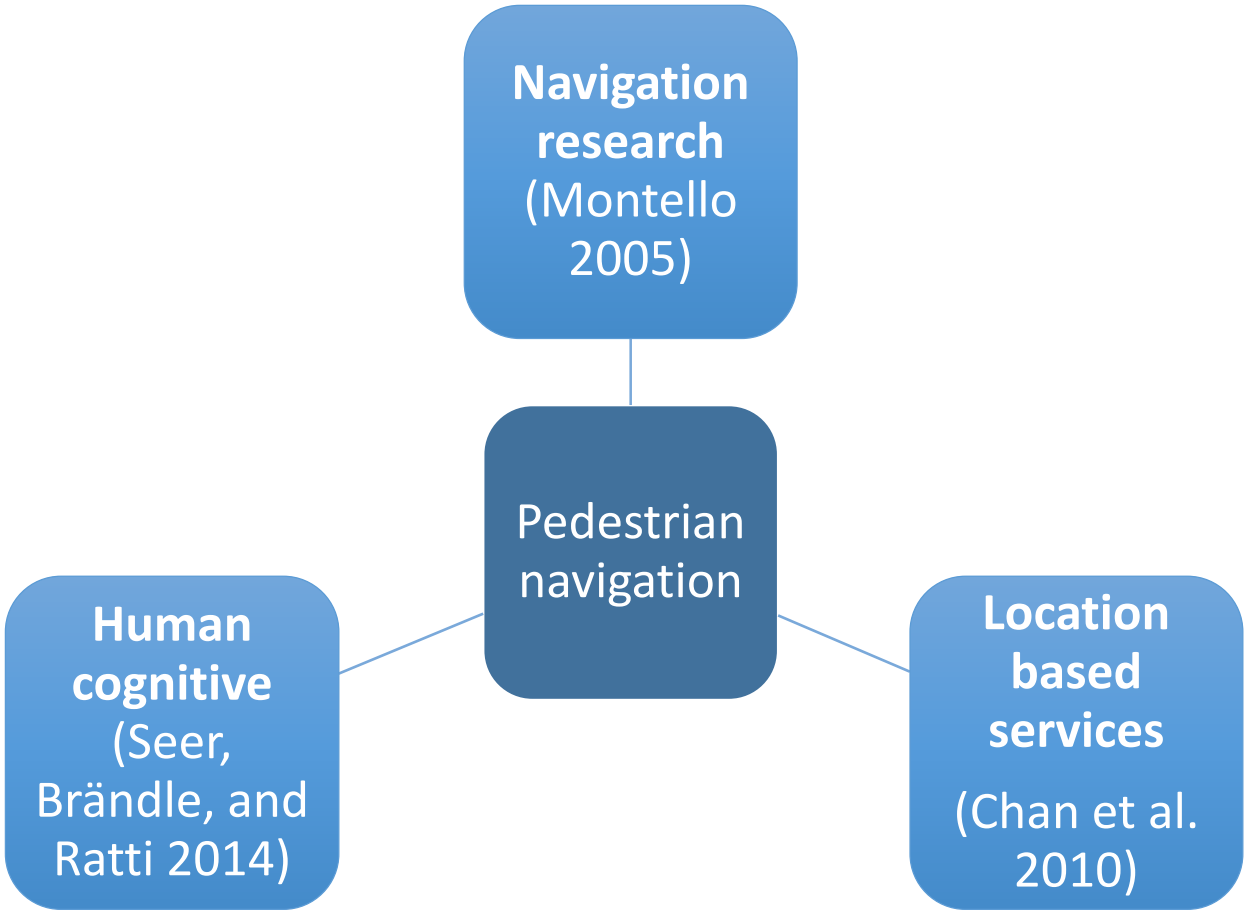
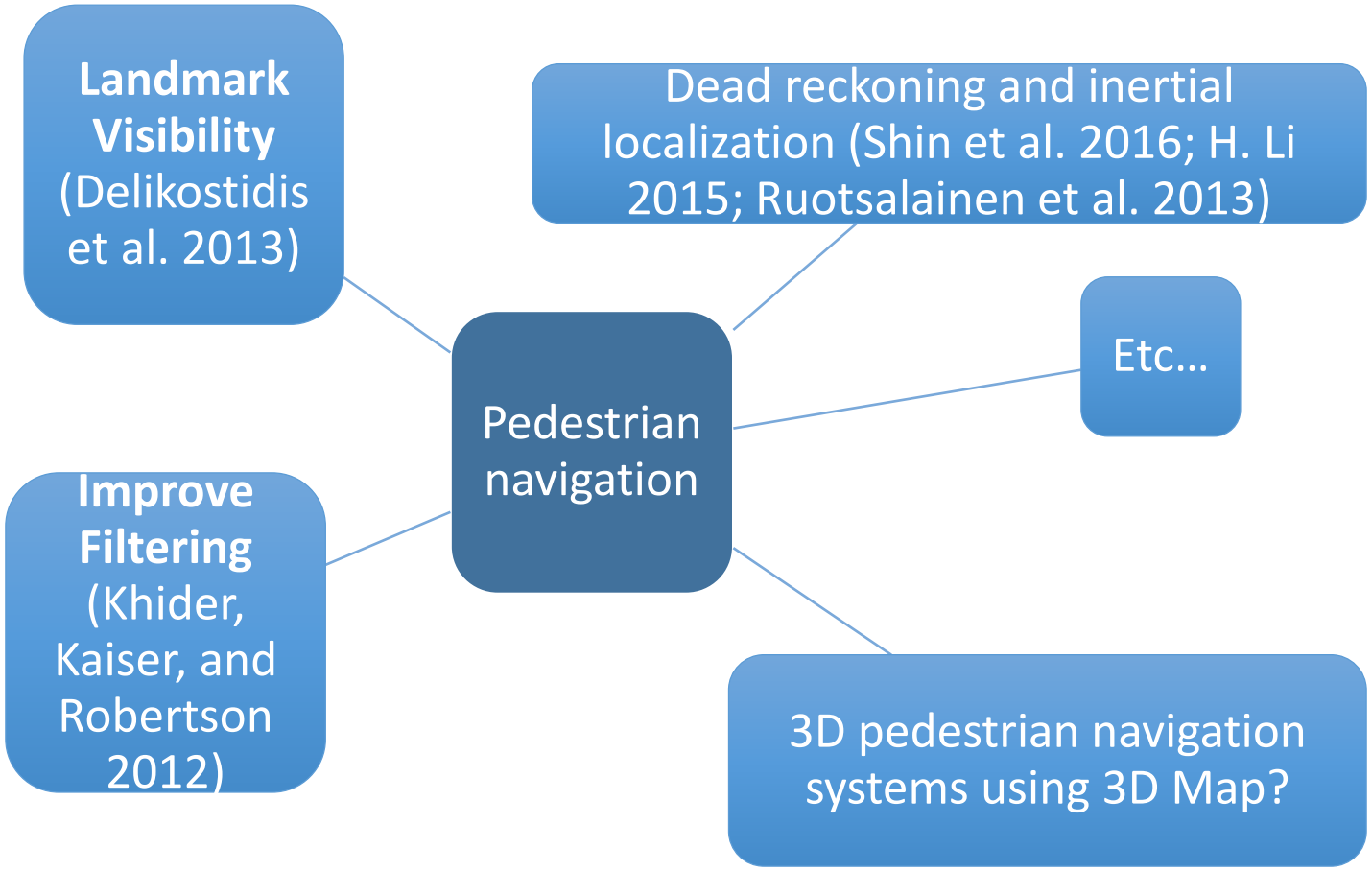
Introduction



In more particular, pedestrian navigation is the interaction field of study related to geospatial information, transportation intelligence, and built environment.

(Ma and Yarlagadda 2014).

Introduction



3D pedestrian Navigation may offer more realistic perspectives about urban environments, but it may provide too much complexity for the users.

In case of urban environments of a tourist site with many similar building appearances, can this be used?

In regard to map display technology

2D pedestrian navigation system	3D pedestrian navigation system
• The problem is about their adaptability for helping pedestrian travellers, especially when they are looking for specific target in the middle of similar urban canyon.	• 3D pedestrian navigation systems may offer more realistic perspectives about urban environments, but it may provide too much complexity for the users.

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Research Rationale

Effective and efficient navigation can be measured based upon users' movement and accuracy toward the target.

This paper focuses in testing a 3D visualization of urban environment to support pedestrian navigation.

Digital map of 3D models of buildings and their corresponding POI (Point of Interest) are prepared as an android application.

Preivous work: three kinds of navigation processes (Liao et al. 2017), self-localization, spatial knowledge acquisition and navigation (Liao et al. 2017)

Study Area

The study area is located in central tourist area of Yogyakarta City, which known as Malioboro pedestrian street.

Methods: Designing the 3D pedestrian navigation app

The app is intended to support navigation and routing in urban environments. Inputs that were required by the apps include:

(1) 3D building models originally created from OpenStreetMap's building features
(2) Location information is derived from the GPS sensor in the android unit,
(3) route services accessed from MapBox API
(4) a simple basic map accessed from MapBox API.

The app has ability to self-localization, show buildings and the search target on the map displayed through the apps.

Methods: User Interaction and User Activity

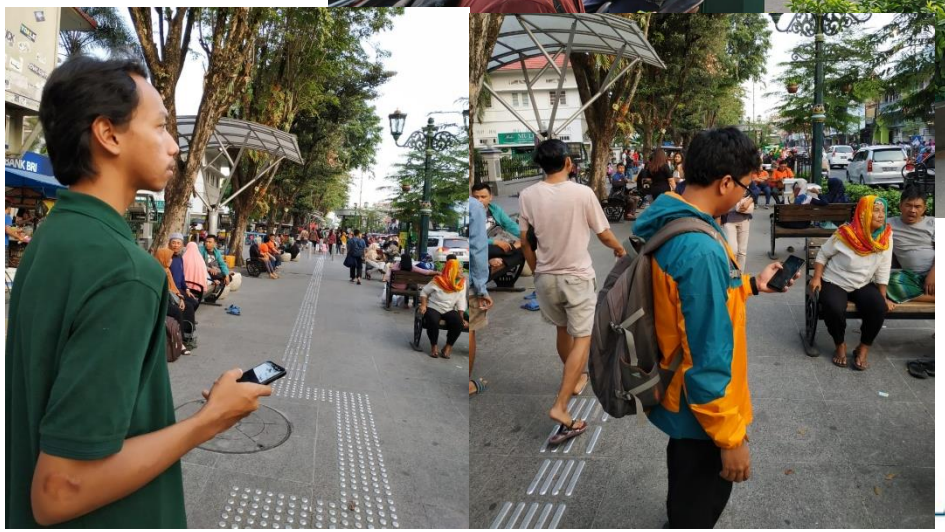
Search Task	Sub Task	Statements	Evaluation criteria
Navigation Processes	Self-Orientation	2.Q5	Effective
		2.Q3	Efficient
		2.Q1	Easy to Learn
		2.Q2	Error Tolerant
		2.Q5	Engaging
	Spatial knowledge development	2.Q6; 2.Q7	Effective
		2.Q8	Efficient
		2.Q11	Easy to Learn
		2.Q12	Error Tolerant
		2.Q13	Engaging
	Navigation Decision	2.Q10	Effective
		2.Q4	Efficient
		2.Q9	Easy to Learn
		2.Q12	Error Tolerant
		2.Q13	Engaging
Users' interaction	Searching	1.Q7	Effective
		1.Q2	Efficient
		1.Q1;1.Q6	Easy to Learn
		1.Q3	Error Tolerant
		1.Q4;1.Q5	Engaging
Utility & crowd-sensing	-	-	Effective
		-	Efficient
		3.Q2	Easy to Learn
		3.Q4;3.Q5	Error Tolerant
		3.Q1;3.Q3	Engaging

This research will focus to differentiate the usability measures of LOD 1 3D map against 2D map of the city buildings for pedestrian navigation purposes.

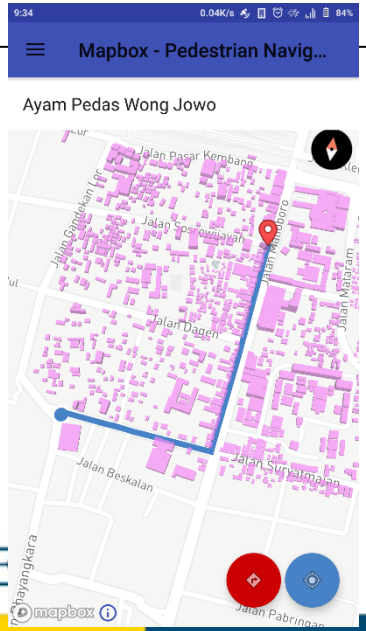
The user interaction and user activity will be evaluated based upon users' experiences and feedback.

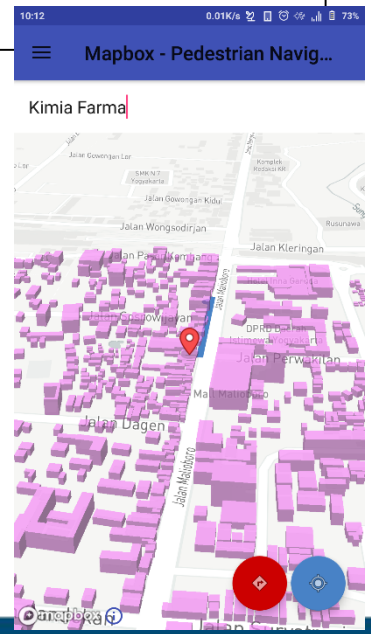
A questionnaire survey to test participants and elaboration of comments and test participant's sensor recordings were collected to answer 5Es attributes

Methods: Usability Evaluation Test

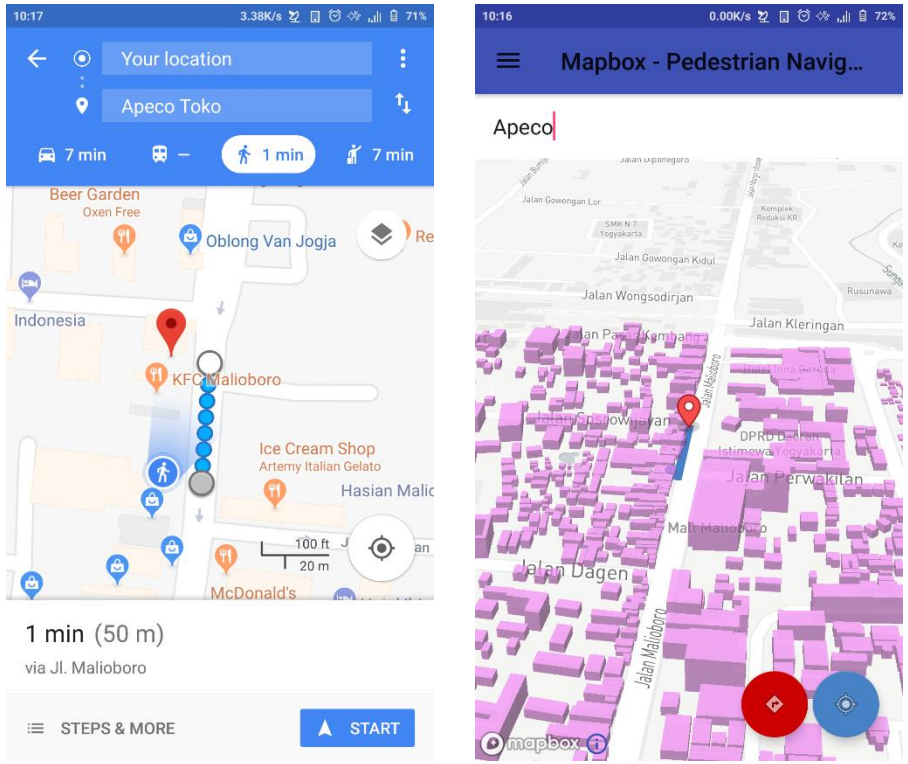


Usability evaluation of pedestrian navigation and pedestrian crowdsensing were tested on the field. The evaluation was done to gather information about the **interaction and activities** of each user when using this app. **16 Test Participants** are involved in the field test. The participants consist of 10 males and 6 females.





Methods: 3. Usability Evaluation Test



Routing information with 2D map display (left) and with 3D map display in the pedestrian navigation app (right)

The applied usability evaluation was a combination of questionnaire survey and observation that include recordings of users' movement, direction and orientation. **The research data acquired from the usability testing comprised of five information:**

- ❑ users' movements as tracks represented in *kml format.
- ❑ users' screen captures of their navigation activities from 3D map display dan 2D Google map display.
- ❑ users' acceleration, direction and orientation derived from their mobile sensors.
- ❑ users' responses to the test questionnaire.
- ❑ users' feedback.

Results and Discussions:
Participants' feedback

TPs' responses to questionnaire were collected using the **Likert scale**. As specified earlier, the questionnaire contains three main issues, namely **users' interactions** (Section 1), **responses to navigation processes** (Section 2), and **crowd sensing** (Section 3).

Statements of Section 1	1Q1	1Q2	1Q3	1Q4	1Q5	1Q6	1Q7
Average Responses	3.9	3.7	3.7	3.4	3.6	3.5	3.1

The summary for TP responses to Section 1 (*Statements related to test participants experiences on their interactions with the app (1Q))*

This is very clear that the representations of individual building in test areas are found to be not optimal (1Q7). 6 TPs found difficulties in differentiating individual buildings on 2.5 D map. **This is very reasonable as the 2.5 D display is limited to LOD 1 where individual buildings are differentiated only with the size and height of the 3D boxes.**

Results and Discussions:
Participants' feedback

Statements of Section 2	2Q1	2Q2	2Q3	2Q4	2Q5	2Q6	2Q7	2Q8	2Q9	2Q10	2Q11	2Q12	2Q13
Average Responses	3.8	3.6	3.7	3.1	3.4	3.4	4.4	3.5	3.9	2.8	3.3	3.3	3.9

The summary for TP responses to Section 2 (*Statements related to test participants experiences on their responses to navigation processes(2Q))*

In case of 2.Q10 it can be seen that the participants prefer looking at the map display then choosing to their own path than following directions given by the app. In total 7 TPs responded that they did not follow the directions shown in the map display (2.Q10). Three of them also argued that the visual lines to 3D target is not clear (2.Q11). **This can be understood as these participants have been familiar to the location**. Thus, further field-test for TPs in more unfamiliar location could be suggested.

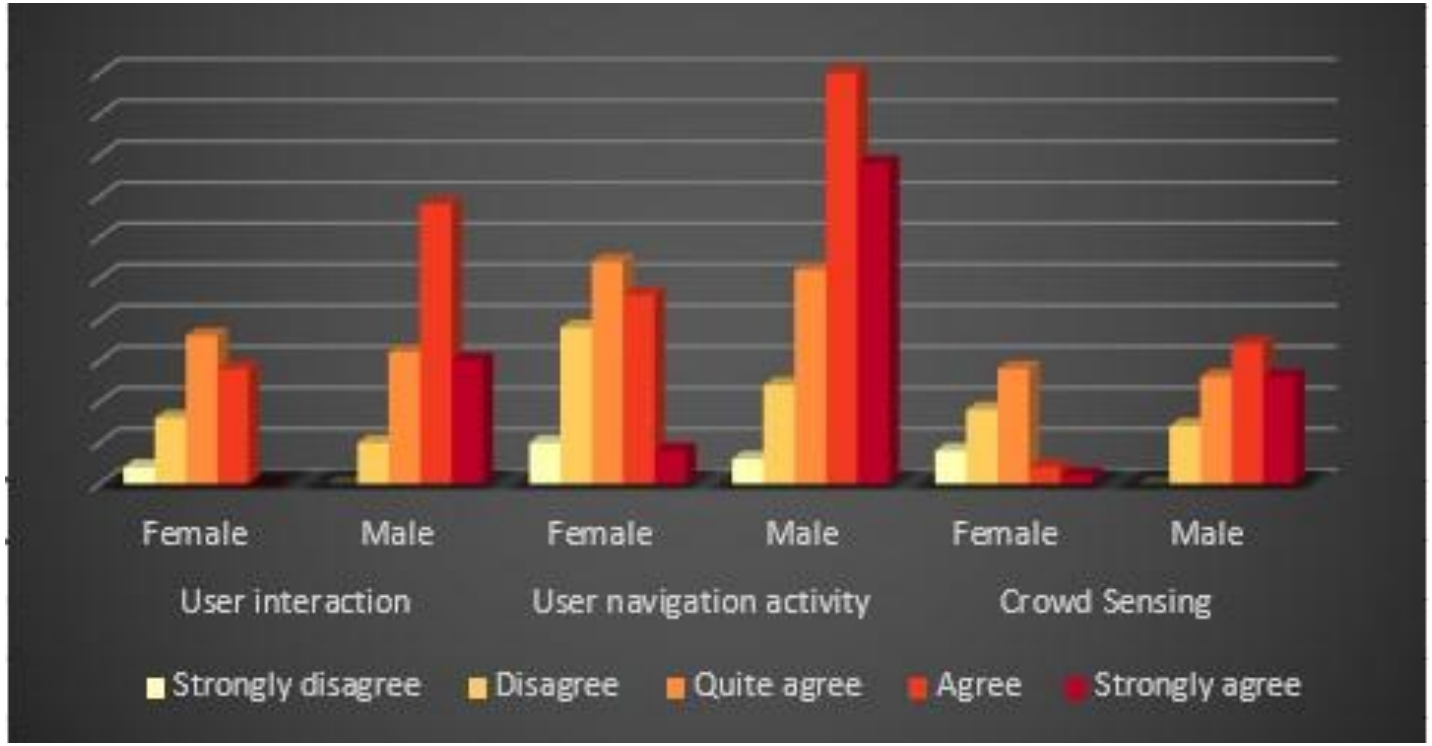
Results and Discussions:
Participants' feedback

Statements of Section 3	3Q1	3Q2	3Q3	3Q4	3Q5
Average Responses	3.1	3.1	3.4	3.3	3.5

The summary for TP responses to Section 3 (*Statements related to the app utility and potential use of the app for crowdsensing (3Q)*)

The statement 1 (on sound disturbances or violations) was made in negative sentence to challenge the TP critical observations. The response is positive in terms that some TPS, although minor, still found there were some sound disturbances. **The lack of sound and smell disturbances complained can be the case since the area is considered as the city's prime tourist area that is well preserved.** In addition to that, the test was done during the opening hours of shops and places of attractions.

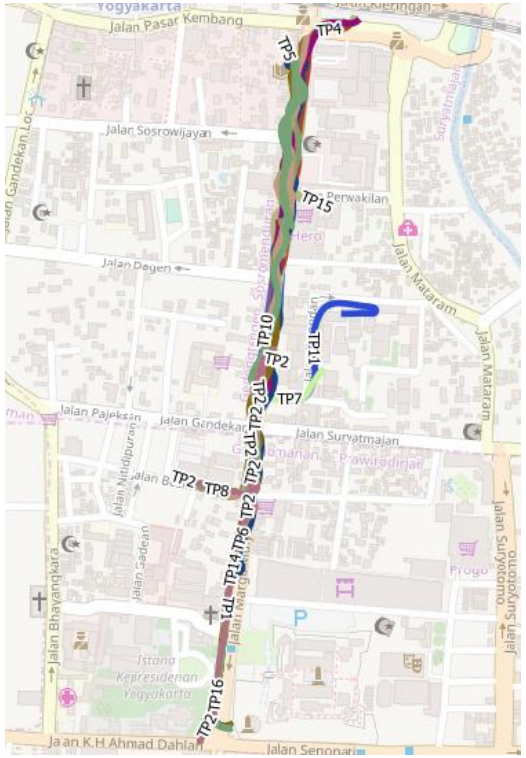
Results and Discussions:
Participants' feedback

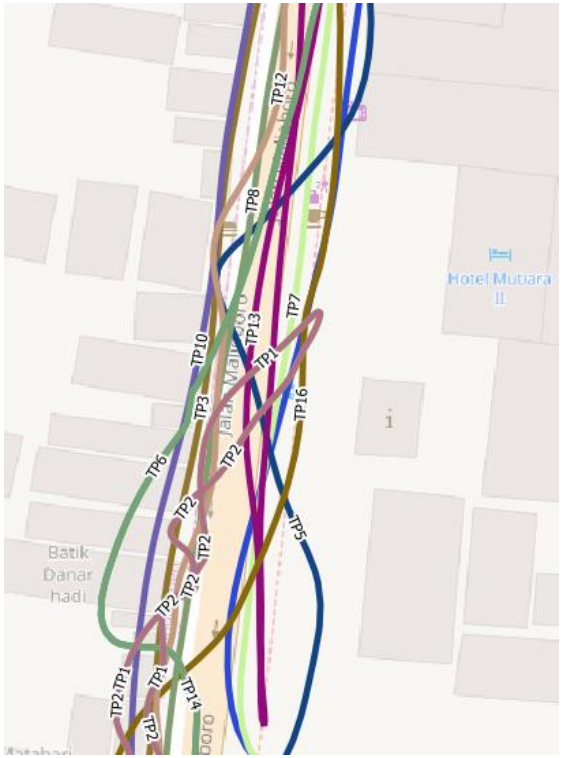


The summary of users evaluation to the app usability on users interactions, navigation processes, and crowdsensing & app utility.

Results and Discussions:

The Visualization of Users' Movements

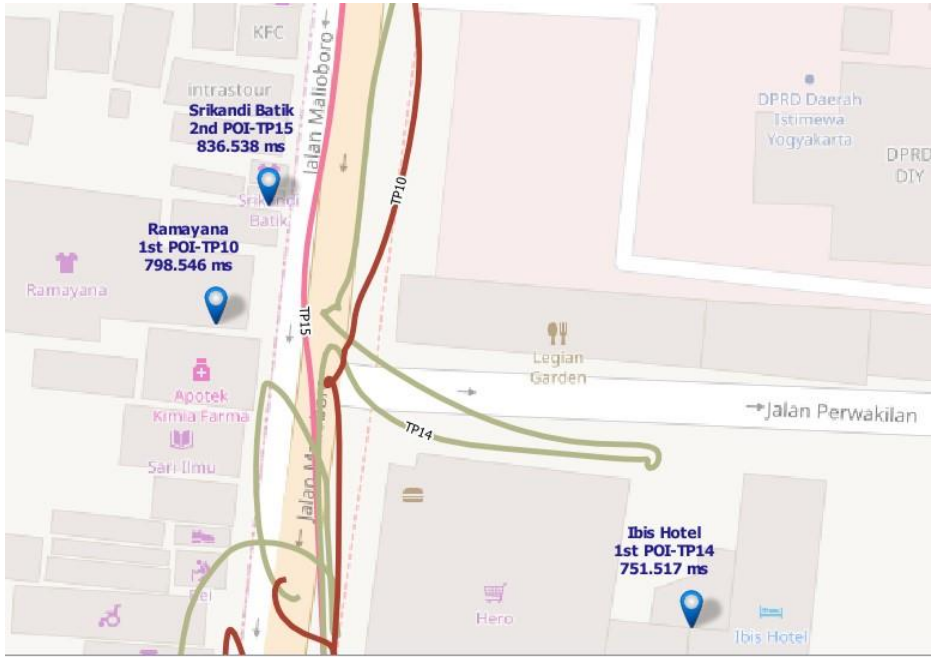


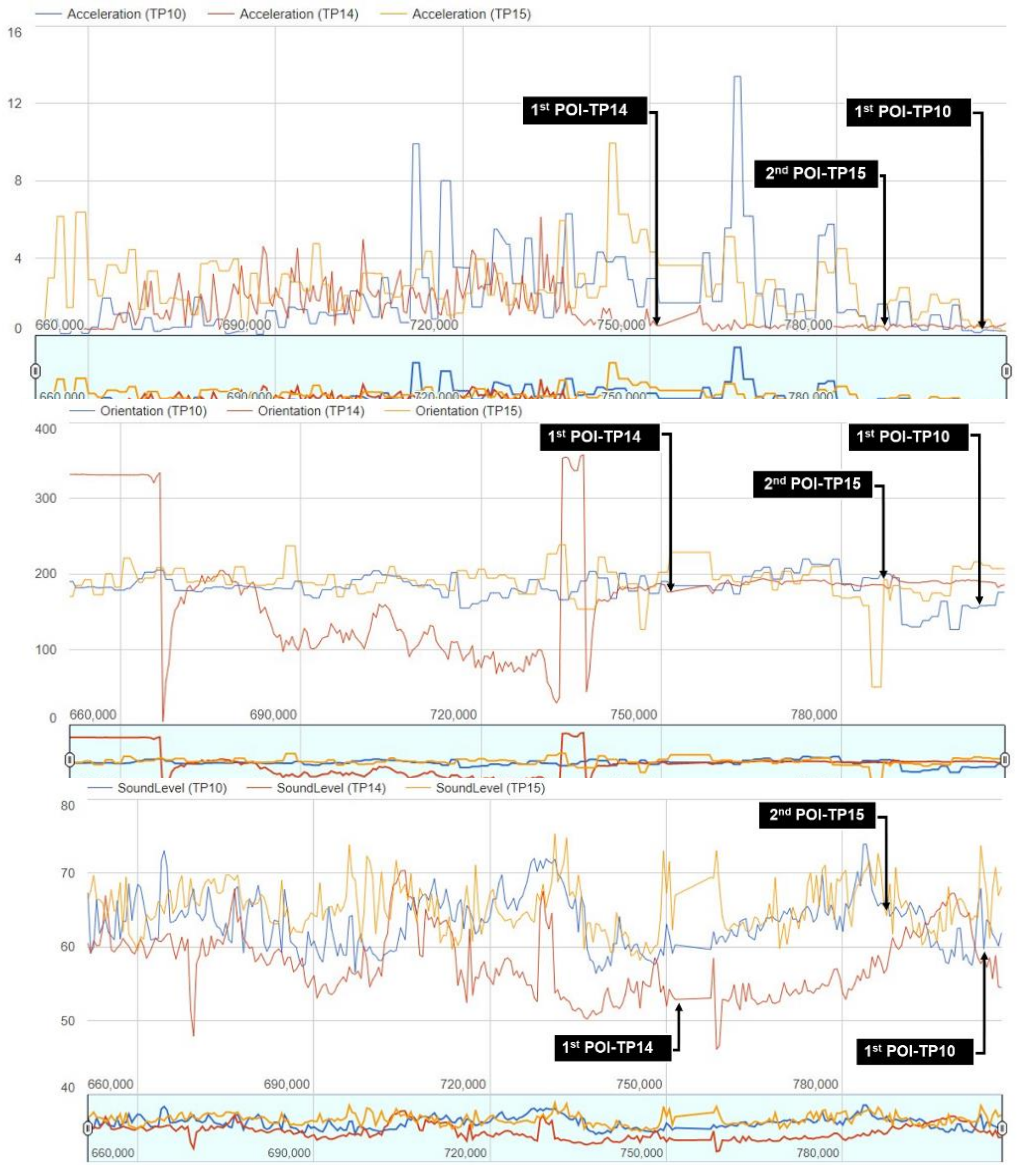


The goal to save users' track using **MyTracks** and to collect TP movements using **AndroSensor** app was aimed at checking the pattern of TP navigation paths and the correctness of the visited target. The readings from accelerometer, gyroscope, orientation, and sound sensors for each TP were processed and plotted into the **graphs format**. The sensor data processing of all TP was done using **Fusion Table**. The length of navigation activity ranges **from 15 minutes to 59 minutes** in order to find **3 targeted POIs.**

Results and Discussions:

The Visualization of Users' Movements





Here, those selected 3 TPs (TP 10, TP 14, and TP 15) have closed targeted POIs along the same pedestrian lane. The pattern can also be checked from the sensor data. The black textbox over the sample plots indicates the position when the TPs found their navigation targets.

Results and Discussions:
Usability Attributes

The responses to questionnaire's questions or statements on user interaction, user navigation activity and app's utility and crowd sensing were used assess the values of usability attributes offered by the app. **A summary of the responses of participants to the comparison displays based on the 5E variable.**

2D Maps / 3D Maps	Effective	Efficient	Easy to Learn	Error Tolerant	Engaging
Searching: Self-Orientation	Less / More	Less / More	Less / More	Less / More	Less / More
Related statement(s)	2.Q5	2.Q3	2.Q1	2.Q2	2.Q5
Searching: Spatial Knowledge Dev.	Less / More	Less / More	Less / More	More / Less	Less / More
Related statement(s)	2.Q6; 2.Q7	2.Q8	2.Q11	2.Q4; 2.Q12	2.Q13
Searching: Navigation Decision	More / Less	More / Less	Less / More	More / Less	Less / More
Related statement(s)	2.Q10	2.Q10	2.Q9	2.Q12	2.Q13
Users' interaction	Less / More	Less / More	Less / More	Less / More	Less / More
Related statement(s)	1.Q7	1.Q2	1.Q1; 1.Q6	1.Q3	1.Q4; 1.Q5
Crowd Sensing: Searching	Less / More	Less / More	Less / More	Less / More	Less / More
Related statement(s)	-	-	3.Q2	3.Q4; 3.Q5	3.Q1; 3.Q3

Conclusions

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- The usability attributes of uses of 3D map display in form of LOD 1 of buildings for pedestrian navigation in urban area are all positive.
- It can be confirmed that effectiveness and efficiency of 3D map display to support self-orientation, spatial knowledge development, and navigation decision are well delivered by the app. Here the app needs to use better pedestrian navigation wayfinding APIs.
- Although the results show users preferences for 3D over 2D map to help self-orientation, to recognize the surrounding, and to make navigation decisions are quite obvious, some unclear answers are still gained in terms of navigation clarity.
- The results also suggest that the development of LOD 1 for pedestrian navigation is acceptable but in case that the navigation require faster building comparison, the LOD 1 is not sufficient.
- Crowdsensing application using the navigation app is possible especially for its ability to provide an app, seen to be easy to learn, error tolerant, and engaging.

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THANK YOU

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