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Towards Improving User Interaction with Navigation Apps: an Information Quality Perspective

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Abstract

Traffic congestion is a major problem for large cities, and with the ubiquitous use of smartphones with GPS capabilities, drivers have increasingly come to rely on navigation applications for avoiding traffic congestion and routing to unfamiliar destinations. However, in certain situations the suggested route may not be what the user expects and could result in perceived delays over known routes, increased stress and frustration for the driver, or even back tracking. This has created a situation where drivers perceive that the information provided by navigation applications are not completely reliable and do not follow the suggested routes, thereby reducing the overall effectiveness of congestion avoidance. Additionally, drivers also make additional interaction with the navigation applications to verify the believability of the suggestions routes, creating more distraction and reducing on-road safety. As such, this preliminary work assesses mobility information quality provided by leading navigation applications (Google Maps and Waze) against four dimensions of the PSP/IQ information quality framework to identify areas for improving information quality in three common driving scenarios. The results indicate that both apps have similar levels of completeness, concise representation, and consistent representation. And while the relevancy of the information quality is also similar in both apps, Waze's representation of the some information elements allowed for quicker comparison and decision making. The findings from this work can be used to enhance user interaction and information presentation in navigation applications in order to improve user perceptions of information quality.

Keywords: smart mobility information, mobility information quality, congestion avoidance

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1. Introduction

Traffic congestion is a serious problem for large cities with many negative effects on the economy, the people, and the environment. It is envisioned that smart mobility

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solutions will reduce traffic congestion through deploying a network of traffic sensors throughout the transportation infrastructure and within vehicles to monitor, analyze, predict and shape traffic flow [1, 2]. However, such solutions will require significant financial investment and a long time to implement on an effective scale. Meanwhile, other solutions must be utilized to help reduce traffic congestion and related negative effects. An effective technique that drivers often employ to avoid congestion is to check traffic conditions before making a trip and choosing routes to avoid congested road segments. And with the ubiquitous use of GPS enabled smartphones today, drivers can check real-time traffic conditions and make routing decisions before and during their trips. Navigation applications like Waze and Google Maps uses smartphones to collect anonymous location data from drivers and passengers and analyze this data to predict traffic conditions and calculate travel time [3, 4]. As the location of the phone changes, the speed of traffic, estimated travel time, the fastest route through the traffic, and re-routing as congestion condition changes can be calculated. This has enabled drivers to access real-time traffic information as well as travel time estimates and route suggestions while driving. Google Maps and Waze are among the most popular applications for navigation and traffic congestion information in many countries because they do not have to rely on information from the transportation infrastructure and can provide traffic information even in areas without traffic cameras or sensors. These two applications are chosen for assessment because they are among the most popular navigation apps being used and they both provide real-time traffic information and suggest routes to avoid congestion.

Providing traffic information such as estimated travel time and traffic conditions have been reported to influence drivers' route selection [5] and improve overall traffic conditions [6]. Unfortunately, many drivers have had negative experiences where navigation applications have recommended what they perceived to be non-optimal routes and provided inaccurate estimated time of arrival (ETA) [7, 8]. This creates a situation where drivers feel that they could not fully trust the recommended route and may not follow the suggested route, thus reducing the expected congestion reduction benefits. Not only that, drivers would also perform additional interactions with the applications to verify whether the suggested routes were believable while driving which increases the risk of an accident. Earlier research on traveler information systems have noted that improving trip-time prediction accuracy would likely increase drivers' trust in the system and compliance in following the recommended route [9]. Information quality has also been found to influence user adoption and trust in a variety of information systems [10–12] but it has been largely unexplored in traveler information system research. As such, this preliminary work assesses two of the most popular smartphone navigation applications (Google Maps and Waze) against the PSP/IQ [13] to explore various information quality factors that are applicable to how navigation applications and how they might impact user interaction. The scope of the assessment in this work has been limited to information quality dimensions that can be directly represented in the apps, and does not include dimensions that are dependent on sources outside of the application as further explained in the next section. The findings are expected to be useful for improving information presentation and user experience.

The next section provides a brief overview of related literature, followed by the methods to assess information quality, results, finally a discussion and conclusion section.

2. Related works

There are mainly two areas related to this research. They are traveler information systems and information quality dimensions.

2.1. Traveler Information Systems

Many research work in the area of advanced traveler information system (ATIS) in late 1990s and early 2000s explored how drivers made route choices when provided with various traffic information [5, 6, 9]. For example, it was reported that when provided with real-time travel information such as estimated congestion level, travel speed, or travel time through road segments, drivers were likely to switch to an a less congested route during their journey; males have a higher tendency to switch routes than females and that older drivers had a lower tendency to switch routes [9]. It has also been reported that quantitative information had higher effect on route switching than qualitative information [5] and that travel time had higher influence than travel costs. Thus, providing traffic information to drivers had been found to influence drivers route selection and route switching and helped to reduce overall traffic congestion. A key factor for not following the recommended fastest route was perceived inaccuracies in predicting travel time and traffic conditions. Factors that were not related to the system such as trip distance and trip purpose, i.e. going to work or to school, have also been reported as being related to non-compliance [14].

2.2. Factors of Information Quality

Although not specific to mobility information, the Product and Service Performance Information Quality (PSP/IQ) model which focused on information consumers was developed in [10] and subsequently enhanced in [13]. The model included many dimensions as shown in Table 1 and Table 2. The model takes the view that information is a product to be delivered to customers has been used extensively in the area of IS/IT information quality assessment, so it is selected for use in this work. However, some dimensions were excluded from assessment as they were considered to be impractical or inappropriate for assessing navigation apps as discussed below.

Table 1: Mapping IQ dimensions to the PSP/IQ model, from [13].

	Conforms to specifications	Meets or exceeds consumer expectations
Product quality	Sound information	Useful information
	- Free-of-error	- Appropriate amount
	- Concise representation	- Relevancy
	- Completeness	- Understandability
	- Consistent representation	- Interpretability
		- Objectivity
Service quality	Dependable information	Usable information
	- Timeliness	- Believability
	- Security	- Accessibility
		- Ease of manipulation
		- Reputation
		- Value-added

Because the goal of this preliminary work is to assess information quality that are directly presented within the smartphone navigation apps themselves before doing a user survey, some quality dimensions were considered inappropriate or impractical to assess. Kahn, et al. [13] mapped the IQ dimensions into four groups: Sound Information, Dependable Information, Useful Information, and Usable Information as shown in Table 1.

- The Sound Information quadrant of the table is described as 'usually free of task and decision'. Of the four dimensions in this group, Concise representation, Completeness, and Consistent representation were chosen for assessment, while free-of-error was not. The key travel information of interest to the users (i.e.

Table 2: PSP/IQ dimensions being used in this work, from [13].

Dimensions	Definitions	Assessed
Accessibility	The extent to which info is available, or quickly and easily retrievable	No
Appropriate amount of info	The extent to which the volume of info is appropriate for task	No
Believability	The extent to which info is regarded as true and credible	No
Completeness	The extent to which info is not missing and is sufficient for task	Yes
Concise representation	The extent to which info is compactly presented	Yes
Consistent representation	The extent to which info is presented in the same format	Yes
Ease of manipulation	The extent to which info is easy to manipulate and apply to different tasks	No
Free-of-error	The extent to which info is correct and reliable	No
Interpretability	The extent to which info is in appropriate languages, symbols, units, and definitions are clear	No
Objectivity	The extent to which info is unbiased, unprejudiced, and impartial	No
Relevancy	The extent to which info is applicable and helpful for task	Yes
Reputation	The extent to which info is highly regarded in terms of source	No
Security	The extent to which info is restricted appropriately	No
Timeliness	The extent to which info is sufficiently up-to-date for task	No
Understandability	The extent to which info is easily comprehended	No
Value-added	The extent to which info is beneficial and provides advantages from its use	No

ETAs, travel time) were unlikely to be error-free due to the high variability of traffic congestion, so an assessment of this dimension would have to be done using a perception survey. This is beyond the scope of this preliminary work.

- The Dependable Information dimensions are described as 'current, secure, and provided in a timely manner to support the task at hand'. Timeliness is dependent on the mobile networks of the users so it is not assessed. Security specifications are unknown to the users, so this dimension would also have to assessed based on user perception and is thus excluded.

- The Useful Information dimensions are 'task dependent' and should be 'sufficient to support decision making'. The quality of the dimensions in this group are obviously subjective in nature and requires a user survey for proper assessment so Appropriate amount, Understandability, Interpretability, and Objectivity were not assessed. However, since this work plans to assess the dimensions based on specific usage scenarios, it was thought that Relevancy could compared by how the apps present information to the user so this dimension was retained.
- The Usable Information dimensions are all user perception based, so they are excluded.

This leaves four dimensions that were deemed to be assessable directly from the navigation apps: Completeness, Concise representation, Consistent representation, and Relevancy.

3. Methods

The foundation of this work is based on review of related research in the areas outlined above. Direct observation of the smartphone navigation applications is made to identify the IQ dimensions from the PSP/IQ model that are appropriate in this context. Analysis of IQ is done based on specific usage scenarios to form a comparative assessment. The Google Maps and Waze applications are selected based on their popularity for navigation and traffic congestion avoidance in Thailand. These apps are also available worldwide and their core functionality of traffic information is not dependent on the transportation infrastructure. Android Auto, a driving-specific version of Google Maps, was considered for assessment, but it is not available in the Thai Play Store. As noted, user perception is not included in this stage of the research, so assessment of the apps is made by the researchers by way of comparing the implementation of information quality dimensions between the two applications. The assessments are made on three common usage scenarios: 1) fastest route for immediate departure, 2) compare toll and toll-free routes for immediate departure, and 3) planning a route for future departure. The information presented by the applications in these scenarios are compared in the context of initial route suggestions for driving in Bangkok during high traffic conditions where there are options for drivers to avoid traffic, such as taking elevated tollways, surface roads, or going through alleyways to avoid congested spots. This context provides the opportunity to compare all information elements in the scenario described above. The scope of the analysis is on the start of the trip where drivers enter trip destination and choose a route since it has been reported that these actions make up more than 50% of total interaction with navigation systems and [15]. No analysis is made for interaction after route selection.

4. Results and discussion

Scenario 1: Fastest route, with immediate departure

This is probably one of the most common scenario where drivers would check traffic as they are starting to drive to a destination. In such a use case, it is not uncommon for drivers to interact with the navigation system while driving [16]. Fig. 1 shows the screenshots for this case. In both applications, the user taps a button to perform a search for a new destination or choose from a list of recent and pre-set locations like home or work. Destination entry can be done through speaking (tap microphone icon) or typing, and the fastest route is pre-selected (relevancy). A number of common information elements are shown by both applications i.e. fastest travel time (43 min for Google Maps vs 33 min for Waze), distance (19 km vs 16 km) color-coded congestion levels on the route, and an icon (coins vs tollbooth) to indicate a toll. Waze shows only the fastest route using a major road (Sirat Expressway) as the route name, and includes an ETA (17:38), while Google Maps displays a map with a few of the best routes along with their trip times. Note that the actual traffic conditions here are irrelevant and are referred to so that the reader may identify the various information elements in the figures.

Table 3: Comparison of IQ dimensions for Fastest Route with immediate departure.

IQ Dimensions	Google Maps	Waze
Completeness	trip time, congestion levels, distance, toll indication, major road name; shows ETA on navigation screen	ETA, trip time, congestion levels, distance, toll indication, major road name; shows map on Routes screen
Concise representation	map, text, icon, color coded congestion on route	Map, text, icon, color coded congestion on a line
Consistent representation	Consistent within this screen	Consistent within this screen
Relevancy	Pre-select fastest route	Offer only fastest route first

On the completeness dimension, Waze prominently offers ETA on this initial screen, but Google Maps does not. However, Google Maps provides a more concise representation of the entire route on this initial screen, and shows the ETA when navigation starts. This map view also allows drivers to visualize on which section of the route to a b

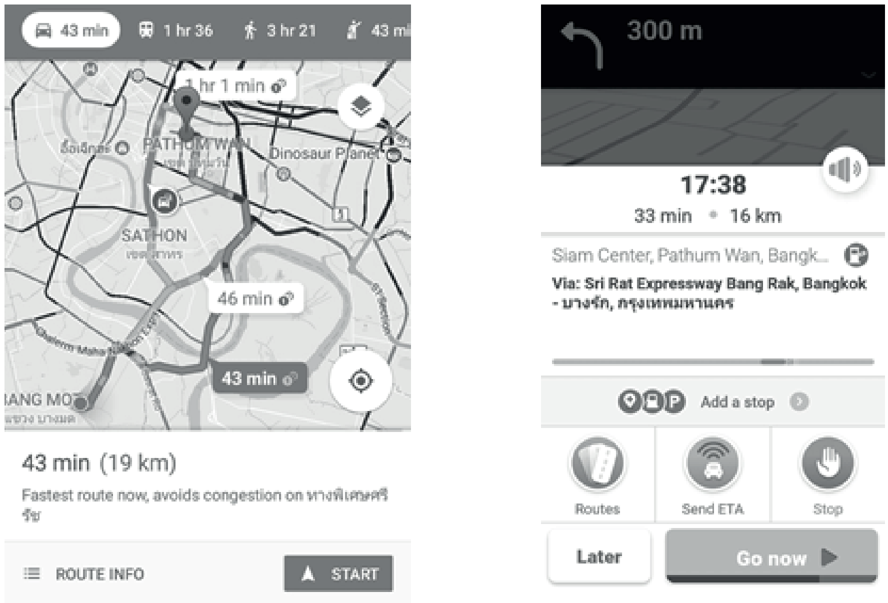

Figure 1: The initial route suggestions of (a) Google Maps; (b) Waze.

expect congestion. Waze's representation of congestion is color coded onto a horizontal line below the ETA. This could be considered less complete than Maps since drivers cannot know where to expect congestion, although this does not really matter in this scenario where the driver is expected to choose the route with the shortest trip time (relevancy), regardless of traffic. Waze will also show a map view of the route if the user taps the Routes button. A summary of IQ comparison is shown in Table 3. Overall, the level of IQ in each dimension is about the same, the key difference lies more in how the information is presented to the user.

Scenario 2: Compare toll and toll-free routes for immediate departure

This is the use case where saving money on toll charges or taking a less congested route may be perceived as more cost effective or less stressful than simply using the fastest route. The screenshots for route comparison is shown in Fig 2. For Maps, routes are calculated either with tolls or without tolls which is selected through a separate route options dialog. In this example, the best toll-free route is 44 min, which is only one minute longer than the fastest route with toll. However, the user has to remember what the best route with toll (Fig 1a) was in order to compare to the toll-free routes in Fig 2a (relevancy).

Figure 2: (a) Google Maps avoid toll; (b) Waze alternate routes.

In Waze, tapping the Routes button at the bottom of the fastest route screen (Fig 1b) will display both toll and toll-free routes together (better relevancy). Waze shows the routes in a list view and a map view (Fig 2b). Here, the toll-free route takes 45 minutes, and is shown next to the fastest route with toll. In the map view, the fastest route is pre-selected with the toll-free route being the thinner line (in a different color) going to the left; a toll indication is shown for the selected route. The list view shows traffic conditions along the route, but the map view does not; this could be considered inconsistent representation. In comparing IQ between the two apps, completeness is similar, but Waze is easier to compare toll vs toll-free routes (relevancy) where Google Maps requires going to a dialog to recalculate toll-free routes. However, this is more of a user experience issue rather than an IQ issue since both apps do provide the relevant information. In this usage scenario, Waze's list view is the easiest to use for comparing trip time and toll costs (concise representation). Table 4 shows a summary of the IQ comparisons.

Table 4: Comparison of IQ dimensions for Compare toll and toll-free routes for immediate departure.

IQ Dimensions	Google Maps	Waze
Completeness	trip time, distance, toll, congestion along the routes	ETA, trip time, distance, toll, congestion along a line
Concise representation	Two separate map views: toll and toll-free	List view and map view; shows both toll and toll-free routes in each view
Consistent representation	Consistent	no congestion info in map
Relevancy	User must remember info from each query to compare toll vs toll-free routes, because they are shown on separate screens	Can directly compare toll vs toll-free routes in List view; In Map View, needs to tap each route to see toll indicator

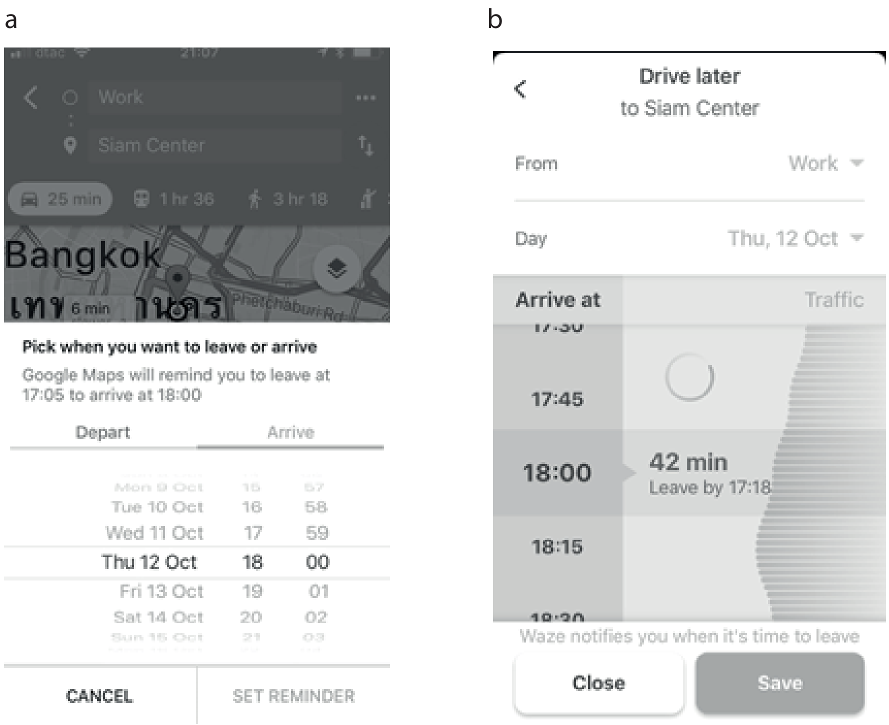

Figure 3: Planning a later drive (a) Google Maps; (b) Waze.

Scenario 3: Planning a route for future departure time

In this use case, a user may not be certain how long a trip usually takes and thus wants to know when to leave in order to arrive at a certain time, or perhaps when to leave to avoid heavy traffic. The user interface for setting a later time is shown in Fig 3.

Both applications use a scrolling interface to select the desired departure/arrival time. In Maps, setting up a future departure time is done by selecting the option button to set a reminder for a time to leave. The user has the option to choose when to depart or when to arrive as shown in Fig 3a. In Waze, the user taps the Later button at the bottom left of the fastest route screen and is presented with a traffic 'graph' (Fig 3b) (concise representation). Both apps will set a reminder to start the trip at the selected time and recalculate the fastest route when the trip starts. Waze shows traffic information and trip time (completeness) where Google Maps does not. Although both apps use a similar scrolling user interface, the traffic graph in Waze is very helpful for selecting lighter traffic and hence shorter trip time (relevancy), whereas it is not immediately clear whether changing the 'departure' or 'arrive' time in Maps will reduce the trip time or not. A summary of IQ comparisons for this usage scenario is shown in Table 5.

TABLE 5: Comparison of IQ dimensions for Planning a route for future departure time.

IQ Dimensions	Google Maps	Waze
Completeness	Shows departure time and arrival time	Shows arrival time, trip time, departure time, traffic level
Concise representation	Text	Text, graph
Consistent representation	Consistent within this case	Consistent within this case
Relevancy	Does not show trip time, more difficult to choose 'faster' trip	Easy to choose time with less traffic

5. Conclusion

This work has shown that, through a simple procedure, certain IQ dimensions in navigation apps could be identified and compared, and areas of IQ improvement can be easily identified. Analyzing IQ for specific use cases can also provide useful insights into specific areas of deficiency that may not be as apparent if an overall IQ assessment of the whole application had been done.

In this work, leading smartphone navigation applications, were analyzed in three usage scenarios with the goal of using them for traffic avoidance. The apps were analyzed against IQ dimensions and were considered to have similar levels of quality in all dimensions. For completeness, both apps provided the same information items in slightly different representations. And although Waze's user interface provided easier access to relevant information in the specific scenarios discussed, overall relevancy of the provided information was at a similar level. It would appear that the defining features between the two apps are not the information that is being provided, but rather how information is accessed. Future work could be done to explore whether the different user interactions would have an effect on the IQ of the dimensions not assessed in this work.

Although, the simple methods utilized in this work was able to highlight some areas where navigation applications could be improved, there are a number of limitations. The nature of smartphone navigation applications has limited our assessment to only a few IQ dimensions. And with the very few information items and number of screens of each app, consistent representation was not much of an issue. Further research should be conducted to collect user perception on these and other IQ dimensions and compare them against the reported findings. In addition, a comparison of user perception of overall IQ for an application against IQ for specific use cases may provide further insights.

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