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An AHP-based evaluation of car navigation apps in Korea¹

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Abstract

This study aimed to suggest the standards of evaluating car navigation app by examining and categorizing app's attributes. This study suggested four main criteria for app evaluation model; Functionality, Usability, Networking ability and Additional features and three sub-criteria belonging each main criterion. Also, the study conducted comparing each attribute and evaluating navigation apps competing in Korean market based on suggested criteria. As a result of this study, users put high weights on functionality, and the additional feature was least considered from users when they select car navigation app. Also, usability and networking ability show similar level of importance.

Keywords: Car navigation app, AHP (Analytic Hierarchy Process), Korean car navigation market

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1. Introduction

Car navigation is the device that helps the driver to find the unfamiliar route and reach the final destination. It is usual for drivers to use this car navigation while driving no matter which type of device they have (Jalayer et al., 2016).

Car navigation provides several functions such as mapping, searching route, turn by turn driving direction (Jalayer et al., 2016). As information technology has been progressed, car navigation system can be evolved dramatically as well (Sohn et al., 2014). By using seamless internet data, car navigation can even analyze cost (e.g., highway fee, and gas fee), arrival time, real-time traffic and so on. Thus, the driver can select optimal routes among recommendations to get to the final destination based on their preference.

Rapid growth and diffusion of smartphone and mobile technology have influenced on car navigation as well. Because now drivers can use their smartphone as car navigation, they do not need to pay an extra charge for car option or purchase the additional device for navigation. App type car navigation taking advantage of internet network offers various location-based services such as real-time information, searching service and so on. In this regard, app type car navigation might be more practical and economical than any other types (Park et al., 2013).

In Korea, there is intense competition for taking car navigation market share among diverse providers including telecommunication company and internet service company (Joo, 2017; Kim, 2018; Park 2018). Each service provider has improved its navigation app's function focusing on their strength and characteristic. The user selects specific car navigation app among many different alternatives. Car navigation app is consist of several function and technological aspects. Also, the user has their preference and priority which is considered when they select apps. Regarding app service providers, it is important to understand user's preference and priority of each attribute.

From the result of this study, the standard of evaluating car navigation app can be established. This approach applied the model to assess and compare the several key attributes of three car navigation apps which are currently most dominant in the Korean market. To achieve these research purpose, at first, theoretical criteria framework is suggested. Secondly, the relative priority of each standard is determined by that criteria model. Thirdly, the criteria model is applied to assess and compare three mobile car navigation apps in Korea. The result of this research is expected to be useful for practitioners in terms of understanding which attribute they need to intensify and user more consider. Consequently, the result of this study might contribute improvement of car navigation app's functionality and user convenience.

2. Literature Review

2.1. Car navigation

To understand the car navigation system, GPS (Global Positioning System) the core technology of car navigation need to be discussed first. GPS is satellite-based navigation system comprised of several satellites, and it can provide information about time and location at all times if the device is on the sight of GPS's satellite. These systems are used by not only automobile also various industries such as mining, aviation, agriculture, and military. In-car navigation systems, the GPS antenna and GPS receiver serve to receive signals from these satellites, thereby facilitating vehicle tracking and positioning.

First car navigation which is PDA (Personal digital assistant) type was introduced to Korea in 1997 (Park & Yang, 2009). It was not easy to be popularized in that period due to its expensive cost. From 2004, however, car navigation began to be spread widely in Korean market as well. So now Korean car navigation market is considered as a field which is grown rapidly in a short time (Park & Yang, 2009).

In the past, the map of car navigation showing the route and direction was simple 2D display. However, now advanced information technology has been applied to car navigation system, so car navigation is available to implement 3D map combined with air-photo which is more delicate and practical. Moreover, AR (Augmented Reality) technology providing more presence and the intuitive information is utilized in-car navigation so the user can experience whole new dimension of driving experience with a high degree of immersion (Sohn et al., 2014).

2.2. Car navigation (app) market

The report conducted by Berg Insight (2017) explains that generally car navigation market is divided into two categories. Automobile company provides in-dash navigation if customers want to equip navigation into their car. This system can be standard or optional on a new automobile. Drivers who want to use car navigation after purchasing their vehicle can choose from many aftermarket solutions (Berg Insight, 2017). Alternatives include in-dash navigation system, Personal Navigation Devices (PNDs) and navigation apps for mobile phones (Berg Insight, 2017). At the end of 2011, there were 340 million navigation systems in use worldwide, including an estimated 60 million factory installed and aftermarket in-dash navigation systems, about 150 million PNDs and an estimated 130 million navigation-enabled mobile phones (Berg Insight, 2017).

In Korea, currently, car navigation market is led by significant telecommunication provider (e.g., SKT) and internet service providers (e.g., Kakao and Naver) based on their mobile apps (Yeo, 2017). This competition of car navigation app seems to have a purpose of raising and holding their market share by retaining telecommunication or internet services users outwardly. On the other hand, it is more like the investment for enhancing autonomous car and connected car technology (Joo, 2017).

Autonomous car technology requires the vast amount of geographic and traffic information (Anderson et al., 2016), so developers want more people to use their car navigation app and interact with navigation as much as they can. Since the more people use their navigation app, the more information such as driving pattern, location and geography can be collected from that app (Joo, 2017). If so, collected information will be utilized for raising not only the performance of navigation but an autonomous car and connected car technology. In this point of view, the importance of car navigation will be strengthened, and it is quite confident that car navigation app is likely to be the hub system of smart car technology.

As a result of intense competition between navigation app providers, there are many different types of navigation apps with different characteristics. Likewise, users might have their preference for apps. Someone might prefer to use navigation app with the simple interface or someone might only need apps with stable networking. Car navigation's specific attributes and functions can be divided and categorized in several ways. Therefore, there are many studies about these attributes such as design, route guide, networking technology and so on. Prior research about car navigation's functions, interface, design and geographic or network technology have been done separately so far. The primary purposes of these researches are making a solution to advance each of attribute.

Nonetheless, not enough studies are trying to find which attribute of car navigation app is most decisive and considered when driver select a particular app among many different options. That is, we need to know the priority of car navigation app's attribute regarding user's preference and which app is most appreciated and why. Because knowing which attribute is most considered when a user selects car navigation app might be useful for a service provider.

Thus, this study aims to suggest the standards of evaluating car navigation app by examining and categorizing app's attributes. Also, the study will conduct comparing each attribute and evaluate navigation apps competing in the Korean market.

Hence, research question of this study is proposed:

RQ 1: What characteristic should be considered when a user selects the car navigation app?

RQ 2: Which characteristic is relatively more significant than others?

RQ 3: Which car navigation app is then the most highly evaluated?

3. Theoretical background

3.1. Evaluation of Apps and Websites

This study reviewed the literature related to an evaluation of mobile apps and websites and their attributes. To evaluate the performance of the mobile app, functionality, ease of use, information, quality, graphics, layout, visual appeal, interactivity, fit to target group and stimulates repeat use can be used (Stoyan et al., 2015). Similarly, Park et al. (2012) proposed assessment model consisting of accessibility, efficiency, informativeness, user control and visibility to compare the usability of mobile apps. Also, Albert et al. (2016) examined potentiality of injury crashes while using a smartphone when driving a car and try to know which app should be favored and which functions compose such meaningful app, with an Analytic Hierarchy Process.

To assess the quality of three different websites, Moustakis et al (2004) utilized AHP method and set five main criteria; appearance and multimedia, content, structure and design, navigation, and uniqueness. Mich et al. (2003) developed 2QCV3Q model to help developers evaluate web site quality from both owner and user viewpoint. This research suggested identity, content,

services, location, management, usability and feasibility as main criteria and 15 sub attributes including accessibility, currentness, accuracy, functionalities (Mich et al., 2003). Bauer & Scharl (2000) set the operational criteria; content, interaction, and navigation for classifying and evaluating websites. Olsina et al. (1999) examined more detail to specify the quality characteristics and attributes for web sites by including reliability and efficiency as the evaluation criteria.

From this review, there were common characteristics and attributes between mobile apps and websites in terms of user experiences such as functionality, usability and contents quality.

3.2. Car Navigation App Evaluation Criteria and Alternatives

This study examines the concepts which is consistently related to car navigation apps and tries to categorize all of these. Finally, study selects four main concepts; Functionality, Usability, networking ability and additional features. Theoretical background of these four main concepts is below.

3.2.1. Functionality

Functionality is basic attribute of car navigation app. The ability of finding accurate route and guiding drivers to the final destination efficiently is important attributes and it is likely to depend on app's functionality. Car navigation app and it features can be assessed with three sub-criteria accuracy, efficiency and predictability.

3.2.1.1. Accuracy

There are many studies to enhance accuracy of navigation and its algorithm (Chang et al., 2013; Keler & Krisp, 2015). How the car navigation app performs well in terms of route guidance is highly related to its accuracy of app. If navigation app guides a wrong way or

destination, credibility of user to navigation app and its provider will be weak (Lee, 2016). In this sense, accuracy of car navigation can be the important attribute for evaluation.

3.2.1.2. Efficiency

In addition, car navigation app connected with internet utilizes real-time traffic information to show drivers the fastest and efficient route. Even though final destination is same, the route and lead time to get there are depend on which type of car navigation driver use (Lee, 2016). Tmashita et al (2004) suggest using route guidance mechanism to increase driver's utility by reducing traffic congestion. Depends on this ability of mechanism of each car navigation app, the efficiency of driving might be different from users.

3.2.1.3. Predictability

Also, car navigation apps can calculate how much time will take to arrive at final destination based on real-time traffic information and their own collected data from their active user (Park, 2016). That is why predicted lead time is all different between diverse car navigation apps, even though final destination is all same from same starting point. Calculating lead time is not easy to perfectly match with actual lead time. In this way, predictability is likely to depend on app's functionality. How accurate the ability of calculating lead time is the sub-criteria of assessing car navigation app's functionality.

3.2.2. Usability

Usability is about how comfortable and easy for user to use mobile apps (Chang & Ji, 2011; Park et al., 2012; Stoyan et al., 2015). This standard is commonly found in many different types of apps such as music, game, messenger and so on. Park et al (2014) pointed out that usability principle and interface design need to be considered in evaluation and development of car

navigation app. In this sense, usability is also important factor when user evaluate mobile navigation app. Nigel (2009) suggests four core standards for usability including user interface design, assurance, software quality and human-centered design process. Similarly, usability of car navigation app can be assessed in three specific aspects; ease of use, accessibility and visibility.

3.2.2.1. Ease of use

Likewise, most of apps should do, car navigation app should be easy to use as well. Car navigation app, especially, which is usually used while driving should be more carefully designed to adjust and handle each function of apps such as changing destination or routes, searching local information or real-time traffic information and so on (Park et al., 2014). If it is too complex to operate certain function, it would be the pressure to user while driving. Searching destination and route should be clear and compact.

3.2.2.2. Accessibility

Additionally, accessibility should be considered when user evaluate certain type of app (Park et al., 2012). If the process of installing app or update is too complex and time consuming, overall usability of app will be lower. Car navigation app, peculiarly, needs to be frequently updated about real-time traffic information, map, route and so on. In this way, accessibility of car navigation app is quite important attribute affecting usability of car navigation app.

3.2.2.3. Visibility

Car navigation app which is usually operated by smartphone having 3.5 ~ 5 inches display in average has more limitation of infographic and POI (Point of Information) than In-car navigation (Park et al., 2013). Nevertheless, car navigation should overcome this limitation and

help driver to reduce cognitive burden interpreting the abstracted information displayed on screen (Sohn et al., 2014). There is user's preference for scale of maps in in-car route guidance and navigation system and it can result in huge impacts on driver's traffic safety (Ramos et al., 2016). In this sense, overall layout, font, color, and a map is highly related to classify and deliver information to the driver (Park et al., 2013). So good legibility of map might support driver's driving experience and quick decision making during driving in limited time and effort.

3.2.3. Networking ability

Commonly, car navigation estimates the car position from dead reckoning and the GPS (Kim & Kim, 2001). Car navigation app is run by processing network data and update information from the motion of the car along the actual track. It means that performance of the app is related to the ability to process massive data from the network (Salz, 2014). If networking ability is high enough, there will be less system error with stable networking and driver can obtain right information at the right time. In this regard, networking ability is determined by three sub-attributes; precision, reaction rate and networking stability.

3.2.3.1. Precision

Car navigation app indicates the position of the car to the screen by processing real-time data immediately. According to this, drivers can recognize where they are an estimate which way they have to take for a destination. If navigation app has a problem with GPS noise and data processing, estimated position of a car which is displayed on the screen will be unclear (Kim & Kim, 2001). It might be the more risky issue for a driver who does not have enough driving experience or local information. In this sense, the ability to estimate position precisely is quite essential.

3.2.3.2. Reaction rate

Hammad et al. (2015) pointed out if the app had trouble with the network or responded slowly, a user might evaluate that app negatively. Car navigation app provides turn-by-turn voice-guidance helping drivers navigate their routes (Jalayer et al., 2016). When a driver enters the wrong way unintendedly, car navigation app should re-explore the new way promptly. Besides, when drivers have to change the lane or enter the crossroad, navigation should notice this information to a driver as soon as possible before they pass the way. These sorts of circumstances depend on how fast the car navigation app reacts. In this way, the reaction rate is the crucial aspect of networking ability.

3.2.3.3. Networking stability

From the research by hummad et al. (2015) the most frequent and impactful complaint type of app were functional error and network problem. In the point of car navigation app, if navigation app does not work well and has an unstable network, this could be the huge problem. If the network connection is not stable and route guidance lagged, this issue is also highly related to driver's safety while driving as well.

3.3.4. Additional features

In addition to functions related to route guidance, car navigation apps provide diverse additional functions such as voice recognition, black box, entertainment function and so on. Whether information and service provided by the app are useful, diverse and unique or not can be the standard for evaluating car navigation app's additional features. In this sense, car navigation app's additional function can be assessed in three aspects; diversity, usefulness, and uniqueness.

3.3.4.1. Diversity

Each car navigation app providers upgrade their app by utilizing exist own technology and vast data. How diverse their app's functions can be the one of standard to show the competency of additional features. It seems each company tries to satisfy user's needs as much as possible from their diverse additional functions.

3.3.4.2. Usefulness

Moustakis et al (2004) pointed out that usefulness is one of important aspect to assess quality of websites. Even though usefulness is quite subjective goal, app provider should keep checking and developing functions to match with wide user's needs. This also apply to car navigation app's additional functions. Even though navigation has several additional features, it would be hard to appeal users without usefulness of features.

3.3.4.3. Uniqueness

Moustakis et al (2004) proposed the model for assessing websites and define uniqueness as user's recognition that the site shows something that makes it different in a world full of sites and this is judged regarding to content, aesthetics and design characteristics. Kim & Kim (2012) examined the factors of buying smartphone app and argued innovativeness is one of the crucial aspect. These attributes are highly related to uniqueness of car navigation app's additional features. If specific function is highly differentiated with other apps, this could be the competitive aspect of additional features.

3.3.5 Alternatives

SKT's T map turned into free of charge service in 2016 and, currently, it has more than 10 million monthly active users (Lee, 2018). Kakao's Kakao Navi acquired preeminent startup company Locnall Inc. developing car navigation app called 'Kimgisa' and, now Kakao Navi has more than 5 million monthly active users (Seo, 2017). Naver, the biggest internet service

provider in Korea, upgrade its map app by adding car navigation function in 2015. Furthermore, SKT applied its AI (artificial intelligence) platform NUGU to T map (Kim, 2017) and other car navigation providers are trying to catch this trend up by applying voice recognition function for the user to get safe and convenient experience while driving. In this study, these three car navigation apps which are most dominant in terms of the number of active user are selected to evaluate their attributes. The purpose of this study is to understand the user's subjective priority when they evaluate car navigation app. In this sense, selecting these three apps having the dominant number of users is more comfortable to get users opinion and preference of each app.

4. Methodology

4.1 Analytic Hierarchy Process (AHP) model

The Analytic Hierarchy Process (AHP) is the useful method for complex decision making, and it helps decision makers to set priorities of standards and make their optimal decision based on these priorities (Saaty, 1985). This method approaches the decision making in both subjective and objective aspects by reducing complicated decision-making process to a series of pair-wise comparisons and synthesizing the results. Furthermore, this method can handle the decision maker's inconsistency issues occurred when comparing several items so it can reduce the bias of decision-making process (Saaty, 1990).

AHP method is commonly used for evaluating and selecting of alternatives, problem solving and planning. From this method, in addition, studies about analyzing factors appealing user to new service or media (Lee et al., 2013) and analyzing user preference of new service (Nam et al., 2014) has been done widely.

Nikou & Mezie. (2013) used AHP method to evaluate mobile services and identify most substantial factors appealing user to adopt. Nam et al. (2014) examined user preference of Location Based Service (LBS) in a mobile system applying AHP method. This research pointed

out that navigation and tracking service was most favored service among diverse LBS services including information, entertainment, safe & emergency and advertising & commerce (Nam et al., 2014). These studies suggest that AHP can be a proper means for structuralizing and quantifying decision factors in mobile services and apps.

Thus, AHP has been broadly accepted as a useful method for the quantitative decision-making process. Given that the purpose of this study is to propose an assessment model and to apply it to evaluate car navigation app alternatives, it is quite confident that this study is suitable with AHP approach.

4.2. Data Collection

The survey questionnaire consisted of two parts. In the first part, the 332 active user were asked to compare the car navigation selection factors of each level in pairs (e.g., Functionality vs. Usability, Networking ability vs. Additional features and so on.).

Table 1. Respondents' background

Demographics	Gender	Age
	male	173
	female	159
		20s
		30s
		40s
		50s
Driving experience	Less than 1 year	32
	1~3 years	62
	3~5 years	45
	5~10 years	67
	10~15years	61
	15~20years	31
	more than 20 years	34

The second part of the questionnaire asked the users to evaluate three car navigation app alternatives based on the car navigation app evaluation factors suggested from the first part. Short introductions to the three representative alternatives were given before the evaluation questions. The nine points comparison scale was used since it is the most commonly used scale (Kim & Kim, 2016; Saaty, 1985).

4.3. Data Analysis

For data analysis, MATLAB, a technical computing language software, was used. The code used for computation was borrowed from Kim & Nam (2014). Hand-in-hand with the calculation of MATLAB code, some manual handling of the data with Microsoft Excel was done for the analysis, and it followed the five steps below: Convert individual case's answers to pairwise data matrix. CI (consistency index) index of each data matrix was calculated. Composite CR (consistency ratio) scores were calculated via multiplying the weights of each criterion with individual CI index, summing them up, and dividing them into random consistency index (RI). Cases were screened based on the CR score of 0.2. Cases with CR score below 0.2 were eliminated from further analysis. Group AHP weights were calculated using the weight of each criterion and alternative.

Through the process mentioned above, the total of 292 respondents' answers out of 332 was found valid regarding composite consistency ratio. When put into a more rigorous threshold, 0.1, only 167 answers were found valid. Although 0.1 is considered as a given standard for CR score, there are also opinion where those with 0.2 or less could also be valid in the context of social science since its ambiguity of constructs could compromise the consistency of the respondents to certain extent (Kim & Kim, 2016; Yang et al., 2007).

5. Result

5.1 Criteria weight

At first, local weight score for the first and second layer of the Analytic Hierarchy Process (AHP) model were calculated. Therefore, global weight scores were computed by multiplying the first layer weights and the second layer weight scores. All local and global weight scores for the evaluation criteria and the rankings are given in the <Table 2>.

Table 2. AHP criteria weights and ranks

criteria (1 st layer)	weight (Wc)	Sub-criteria (2 nd layer)	local score (WL)	Global weight (Wc * WL)	Rank
Functionality	0.449	Accuracy	0.402	0.18	1
		Efficiency	0.348	0.156	2
		Predictability	0.25	0.112	4
Usability	0.26	Ease of use	0.463	0.12	3
		Accessibility	0.216	0.056	9
		Visibility	0.321	0.083	6
Networking ability	0.205	Precision	0.411	0.084	5
		Reaction rate	0.306	0.063	7
		Networking stability	0.283	0.058	8
Additional features	0.086	Diversity	0.225	0.019	11
		Usefulness	0.605	0.052	10
		Uniqueness	0.17	0.015	12

The result indicated that functionality (.449) was the most important evaluation factor for car navigation app. Usability and networking ability followed Functionality. The relative importance of usability (.26) and networking ability (.205) did not show a substantial difference, while that of additional function (.086) was quite lower than the three criteria.

Concerning the sub-criteria under the umbrella of Functionality criterion, the local score of accuracy (.402) was the highest. Efficiency (.348) followed next, and predictability (.25) came the last. Regarding usability, ease of use (.463) was proved to be the most crucial sub-criterion. Visibility (.321) and accessibility (.216) followed next in sequence. Among networking ability, the weight of precision was higher than reaction rate (.306) and networking stability (.283). Concerning sub-criteria under additional features, the local score of usefulness was significantly higher than diversity (.225) and uniqueness (.17).

As a result, the Global weight (WC*WL) showed that the most critical criterion in the evaluation of car navigation app model is Accuracy (.18). Efficiency (.156) and Ease of use (.12) were ranked second and third. Diversity (.019) and Uniqueness (.015) were considered the least important.

5. 2 Alternative priority

The priority among the alternatives is computed by using the global criteria weights(WC) of each factor obtained from above and the three alternatives' local weight score(WL) for twelve sub-criteria. The sum of the product index becomes the final weight of an alternative [$\sum (WC * WL)$]. Before calculating the criteria weight, the local scores for each alternative's excellence regarding the twelve sub-criteria are presented in <Table 3>.

When we look into the local weight scores for each alternative of car navigation app in Korea, T map was found to have advantages in Efficiency (.482), Accuracy (.442) and Predictability (.436). T map has advantages regarding overall aspects.

Table 3. AHP alternatives' local scores and ranks

Criteria	T map		Kakao Navi		Naver map, navigation		
	local score (WL)	rank	local score (WL)	rank	local score (WL)	rank	
Accuracy	0.442	2	0.305	12	0.2534	6	
Functionality	Efficiency	0.482	1	0.308	11	0.21	12
	Predictability	0.436	3	0.329	8	0.235	11
Usability	Ease of use	0.413	6	0.343	5	0.244	10
	Accessibility	0.358	11	0.364	1	0.278	4
	Visibility	0.401	8	0.346	4	0.2531	7
Networking ability	Precision	0.434	4	0.315	10	0.25	9
	Reaction rate	0.426	5	0.323	9	0.251	8
	Networking stability	0.405	7	0.33	7	0.265	5
Additional features	Diversity	0.35	12	0.361	2	0.29	1
	Usefulness	0.383	9	0.335	6	0.282	2
	Uniqueness	0.365	10	0.356	3	0.279	3

There were no significant differences among the factors affecting the selection of Kakao Navi. Some of the most critical factors affecting selection of Kakao Navi were accessibility (.364), diversity (.361) and uniqueness (.356). On the other hand, efficiency (.308) and accuracy (.305) were scored quite least than other factors.

Similarly, with Kakao Navi, Naver map, navigation has a lack of predictability (.235) and efficiency (.21). However, Naver map, navigation has been perceived to have strength in diversity (.29) and usefulness (.282) than other factors.

Among four main criteria, specifically, functionality and networking were highly evaluated in T map than in second movers Kakao Navi and Naver map, navigation.

Regarding Kakao Navi the internet service provider, diversity (.361) was most essential sub-criteria affecting user to select Kakao Navi and also uniqueness (.356) was on the second place. Naver map, navigation which is rated lower than other alternatives had advantages in additional function criteria while other criteria have been evaluated low.

5. 3 Alternatives' priority ranks due to criteria weights

Through all three alternatives including 'T map,' 'Kakao Navi' and 'Naver map, navigation,' accuracy, efficiency, and predictability were most highly evaluated local scores in this order.

Besides, it was common in all three alternatives that all of the sub-criteria within additional features including diversity, usefulness, and uniqueness had the lowest contribution to the selection of car navigation app.

T map got a high local score in some criteria which had relatively high weights than other criteria, so that leads T map could be the most highly evaluated app in overall (.425).

On the other hand, Naver map, navigation got the high local score in some criteria which had relatively low weights than other criteria. Moreover, Naver map, navigation achieved the low local score in some criteria having relatively high weights. This results lead Naver map, navigation to be the lowest evaluated navigation app.

Table 4. Alternatives' priority ranks due to criteria weights

Criteria	criteria weight (Wc)	T map		Kakao Navi		Naver map, navigation	
		Global weight (Wc*WL)	rank	Global weight (Wc*WL)	rank	Global weight (Wc*WL)	rank
Accuracy	0.18	0.08	1	0.055	1	0.046	1
Efficiency	0.156	0.075	2	0.048	2	0.033	2
Predictability	0.112	0.049	4	0.037	4	0.026	4
Ease of use	0.12	0.05	3	0.041	3	0.029	3
Accessibility	0.056	0.02	9	0.02	7	0.016	7
Visibility	0.083	0.033	6	0.029	5	0.021	5
Precision	0.084	0.036	5	0.026	6	0.021	6
Reaction rate	0.063	0.027	7	0.02	8	0.016	8
Networking stability	0.058	0.023	8	0.019	9	0.015	9
Diversity	0.019	0.007	11	0.007	11	0.006	11
Usefulness	0.052	0.02	10	0.017	10	0.015	10
Uniqueness	0.015	0.005	12	0.005	12	0.004	12
Total weight [$\sum(WC * WL)$]		.425		.324		.248	
Alternative Ranking		1		2		3	

In similar with ‘Naver map, navigation,’ Kakao Navi got the high local score in some criteria which had least weights than other criteria. Nonetheless, Kakao Navi obtains the high local score in usability which had comparatively high weight so Kakao Navi could be more highly evaluated (.324) than Naver map, navigation as the second place among alternatives.

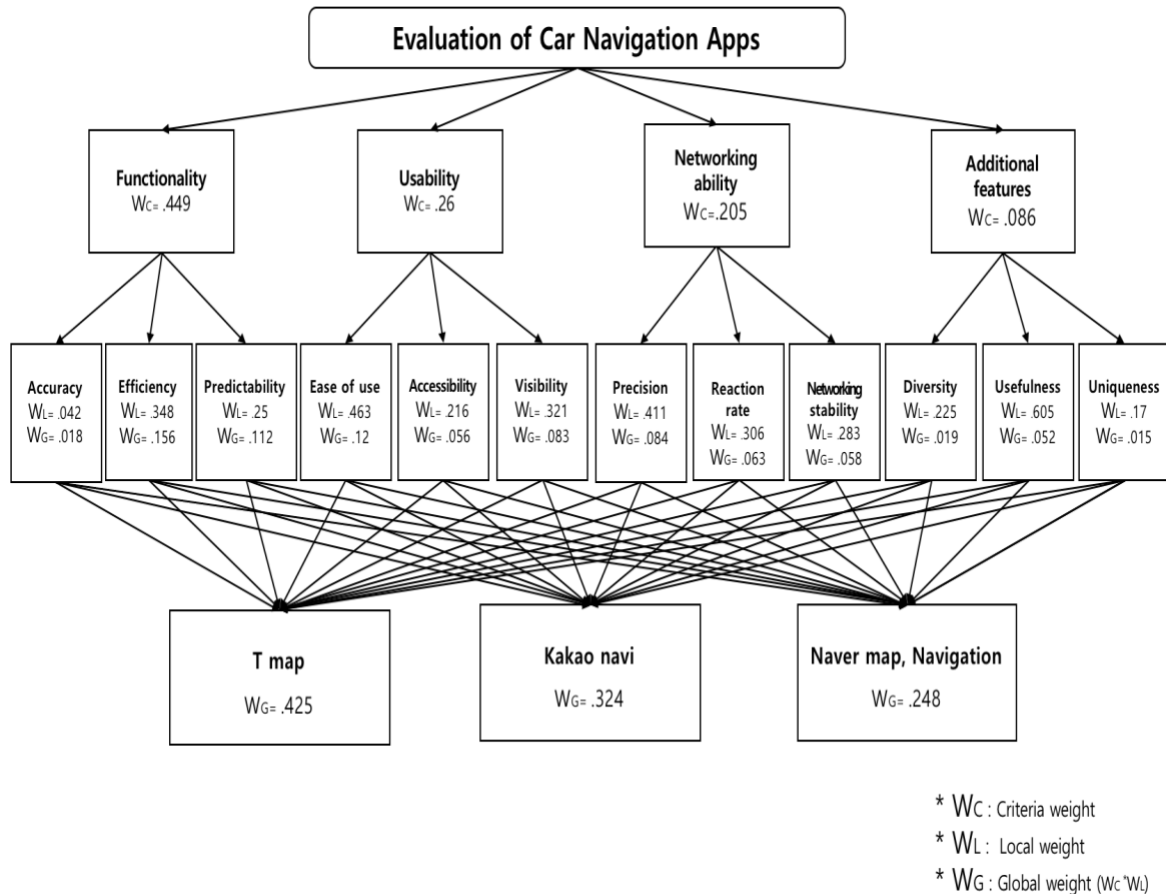


Figure 1. AHP decision model with weight scores

6. Discussion and Conclusion

Frist finding of this study is that users put high weights on functionality and it means that functionality is most essential aspect when users select car navigation app. Mainly, whether car navigation app can help a user to find a final destination with high accuracy and suggest user the fastest route considering real-time traffic information were primarily considered.

Secondly, one of the main criteria; Additional features was least considered from users when they select car navigation app among four main criteria. Even though navigation app providers have promoted their latest function and technology including searching route with AI voice recognition, providing local information and so on, the fact that these additional functions do not have a significant effect on user's navigation app selection was proved from this study.

T map has provided their navigation service during the longest period than other alternatives. In this sense, T map could collect vast database and information from the majority of users. This aspect is likely to help T map to have priority of functionality which is highly related to the amount of information and database. Be worthy of apps serviced by the telecommunication company, T map's networking ability was highly evaluated by users as well. Similarly, acquiring 'Kimgisa' which was prominent local navigation app works as the critical strategy not only for absorbing existing users and also for utilizing its already collected interface, data and information, and it might lead Kakao Navi could get a quite good reputation from this study. In this sense, the third finding of this study is that well-collected data and experience during the relatively extended period are likely to relate to the performance of car navigation app.

Fourth, there was a common priority of criteria on additional features among both of internet service provider's navigation app. From utilizing diverse information collected in their portal platform, other apps, and services, it seems they tried to positioning their navigation as multi-functioning app providing not just only the route, also diverse type of information and functions to users. Regarding Kakao Navi, this result might stem from providing the app 'Kakao T' combining parking lot, taxi-hailing, chauffeur services and car navigation. In the same way, Naver map, navigation was made by adding navigation function to existing app 'Naver map' to combine whole traffic service such as subway, map, bus, navigation and so on into one integrated app.

This study has practical implication to provide the standard of app evaluation, especially for car navigation app which was not much studied so far. This approach can be applied to evaluate other ubiquitous or location-based services as well. From this standard, it can be helpful to understand which factor might be mainly considered when a user selects car navigation app. It could be the solution for navigation service provider to know which factor they should concentrate their competence or which factor they should improve.

ICT companies in many different countries including Korea, currently, keep their invest to develop technology and retain data related to the autonomous and connected car. This study expects that we can look into how each representative Korean ICT company such as telecommunication company and internet service companies tries to obtain traffic information, location data and driving pattern and how their capacity and outcome from this process can affect the core technology of autonomous and connected car.

By going one step further, this study can give a chance to predict which type of ICT company could lead the early market of the autonomous and connected car. In the promising autonomous car and connected car market, which company has comparative advantage and which factor of company or product (Autonomous car or connected car) is prominent can be studied in the future based on this study.

This study still has limitation. During collecting the data, there was no control of smart phone model. It might have effect on the result of evaluating each alternative's networking ability. Network of app is also highly related to GPS ability of smartphone and different type of smartphones have different GPS performance. In this sense, this uncontrolled factor might have effect on result of this study.

References

- Albert, G., Musicant, O., Oppenheim, L., & Lotan, T. (2016) Which smartphone's apps may contribute to road safety? An AHP model to evaluate experts' opinions. *Transport Policy*, 50, 54-62.
- Anderson, J. M., Kalra, N., Stanley, K. D., Sorensen, P., Samaras, C., & Oluwatola, A. (2016). Autonomous vehicle technology: a guide for policymakers. RAND Corporation, 2016, www.rand.org/pubs/research_reports/RR443-2.html
- Bauer, C., & Scharl, A. (2000). Quantitive evaluation of web site content and structure. *Internet Research*, 10(1), 31-44.
- Berg Insight (2017). Mobile navigation services and devices. Retrieved 2017 from www.berginsight.com/reportpdf/productsheet/bi-mns5-ps.pdf
- Chang, I. C., Tai, H. T., Yeh, F. H., Hsieh, D. L., & Chang, S. H. (2013). A VANET-Based A Route Planning Algorithm for Travelling Time- and Energy-Efficient GPS Navigation App. *International Journal of Distributed Sensor Networks*, 2013, 14~27.
- Hammad, K., Emad, S., Melyappan N., & Ahmed, E. H. (2015). What Do Mobile App Users Complain About?. *IEEE Software*, 32(3), 70-77.
- Jalayer, M., Zhou, H., & Zhang, B. (2016). Evaluation of navigation performances of GPS devices near interchange area pertaining to wrong-way driving. *Journal of traffic and transportation engineering*, 3(6), 593-601.
- Joo, Y. (2017). Tongshinsa navigation ‘kyoungjang’ algoboni jauljoohang sijang deta hwakbo jeonjaang. [avigation competition among telecommunication company, the main reason of that competition is about collecting data for autonomous car technology], *Kyunghyangbiz* Retrieved 20 July 2017 from www.biz.khan.co.kr/khan_art_view.html?artid=201707201443001&code=920501#csidx00a982f7a2f45ee9d2c4f9d34b153f1
- Jukka, M. K., & Andreas, K. (2015). Car navigation – computing routes that avoid complicated crossings. *International Journal of Geographical Information. Science*, 29(11), 1988-2000.
- Kim, M. (2017). AI pumen tmap, SKT cunnected jadongcha chosueok maryeon [Tmap’s AI system is the. foundation of SKT connected car technology], *Asiatoday*, Retrieved 7 September 2017 from www.asiatoday.co.kr/view.php?key=20170907010003516

- Kim, S., & Nam, C. (2014). Strategic research for news content distribution and digital. news ecosystem reform in N-Screen environment. *Korea Press Foundation*.
- Kim, S., & Kim, J. H. (2001). Adaptive fuzzy-network-based c-measure map-matching algorithm for car navigation system. *Transactions on industrial electronics*, 48(2), 432-441.
- Kim, S., & Kim, S. (2016). A multi-criteria approach toward discovering killer IoT. application in Korea. *Technological Forecasting and Social Change*, 102, 143–155.
- Kim, Y., & Kim, D. (2012). Factors of Buying Defined on Smart Phone App Using AHP. *Journal of Integrated Design Research*, 11(1), 23-33.
- Keler, A., & Krisp, J. M. (2017) Detecting vehicle traffic patterns in urban environments using taxi trajectory intersection points. *Geo-spatial Information Science*, 20(4), 333-344.
- Lee, J. (2016). Navigation anenmankeumddogddoghaejinda [Navigation can be smarter if they can have more information], *Kyunghyangnews*, Retrieved 10 August 2016 from www.biz.khan.co.kr/khan_art_view.html?artid=201608101905001&code=900370
- Lee, S. (2018). SKT ‘Tmap’irago ssego ‘mobile navigation trendra iknenda [SKT’s Tmap is the trend], *Energykyoungje*, Retrieved 1 May 2018 from www.ekn.kr/news/article.html?no=359445
- Moustakis, V. S., Litos, C., Dalivigas, A., & Tsironis, L. (2004, November). Website quality assessment criteria. In proceedings of the 9th international conference on information quality (pp. 59-73).
- Nam, S., Jin, C., & Kim, D. (2014). Preference analysis for Location Based Services on smartphone environment using AHP. *Journal of the Korea Institute of Information and Communication Engineering*, 18(6), 1337-1342.
- Nigel, Bevan. (2009). International standards for usability should be more widely used. 4(3), 106-113.
- Olsina, L., Godoy, D., Lafuente, G.J., & Rossi, G. (1999). Specifying quality characteristics and attributes for Websites. Paper presented at the First ICSE Workshop on Web Engineering (WebE-99), Los Angeles, USA.
- Park, C., & Yang, H. D. (2009). User-Centered Innovation on Internet: Case of Automobile Navigation. *Information Systems Review*, 11(1), 145-160.
- Park, H. (2016). Navigation silsigan bbarren gil chatgi, applmada dargo jungwhakdo ddulujinen iunen [The reason why real time route searching function of navigation has

- low accuracy and the result is all different], *Greenpostkorea* Retrieved 4 February 2016 from www.greenpostkorea.co.kr/news/articleView.html?idxno=56197
- Park, I. K., Lee, E. J., Yun, J. Y., & Lee, K. H. (2013). A color applicability comparison of user interface design in navigation application for smart phone. *Journal of design trend*, 39(0), 281-290.
- Park, I. K., & Lee, K. (2014). Usability evaluation of user interface operation elements while using a navigation app for a smart phone in driving condition. *Journal of Basic design & art*, 15(2), 11-19.
- Park, J., Han, S., Park, J., Park, W., Kim., & Hong, S. (2012, May). In proceeding of Ergonomics Society of Korea (pp. 154-157).
- Ramos, A. M., Decanini, M. S., Pugliesi, E. A., Tachibana, V. M., Oliveira, R. F., & Soares, J. M. (2016). Preference for map scale of in-car route guidance and navigation system. *Boletim de Ciências Geodésicas*, 22(3), 472-491.
- Saaty, T. L. (1985). Decision making for leaders. *IEEE Transactions on Systems, Man, and Cybernetics*, 15(3), 450-452.
- Saaty, T. L. (1990). How to make a decision: the analytic hierarchy process. *European Journal of Operational Research*, 48, 9–26.
- Salz, P. J. (2014). Monitoring mobile app performance. *Journal of direct, data and digital marketing practice*, 15(3), 219-221.
- Sohn, M., Lee, S., & Lee, J. (2014). Research on Cognitive Effects and Responsiveness of Smartphone-based. *Korean Journal of Computational Design and Engineering*, 19, 272~280.
- Stoyanov, S., Hides, L., Kavanagh, D., Zelenko, O., Tjondronegoro, D., & Mani, M. Mobile App Rating Scale: A New Tool for Assessing the Quality of Health Mobile Apps. *JMIR Mhealth Uhealth*, 3(1), 1-9.
- Seo, Y (2017). Kakaonavi Wolgan iyongja 500 man dolpa Incheongonghang choida. bangmoon [Kakao navi's monthly active user is more than 5 million, most trending venue was Incheon airport], *Financialnews*, Retrieved 29 December 2017 from www.fnnews.com/news/201712291141323394
- Toru, I., Hiromichi, F., Osamu, J., & Atsuyuki, O. (2008). Wayfinding with a GPS-based mobile navigation system: A comparison with maps and direct experience. *Journal of Environmental Psychology*, 28, 74–82.

- Yang, D.-H., Kim, S., Nam, C., & Min, J.-W. (2007). Developing a decision model for business process outsourcing. *Computers & Operations Research*, 34(12), 3769–3778.
- Yeo, J. (2017). Naver vs. SK vs. Kakao: Who's the Winner?, *Techkorea*, Retrieved 30. March 2017 from www.techforkorea.com/2017/03/30/naver-vs-sk-vs-kakao-whos-the-winner