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A Classification of Car-related Mobile Apps: For App Development from a Convergence Perspective

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차량용 모바일 앱의 분류: 융복합 관점의 앱 개발을 위해

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Abstract This study selected car-related mobile apps for app developers suffering from low revenue and classified car apps assisting users in driving or managing a car. A total of 697 car apps were classified into eight categories. Most apps are in four categories: car news & information (28%), locating service (23%), car rental service (15%), safe/efficient driving service (12%). The remaining categories are buying & selling, driver's communication, maintenance management, and expenses monitoring. Many apps are simple and too similar in their main functions. Only a few apps are designed to be more comprehensive and have functions in two or more categories. For the practicality of the categorization scheme, this study checked the inter-rater reliability in two tests and got 0.886 and 0.828. The result from this study suggests functions that are not implemented yet or need to be combined. Future research will focus on identifying promising car apps or designing multi-functional car apps.

Key Words : Mobile Apps, Car Apps, App Classification, Connected Car Services, Smart Cars

요 약 다수의 앱 개발업체가 사업에 어려움을 겪고 있는 상황에서 수익을 높일 수 있는 분야로 본 연구에서는 자동차용 앱을 선정하고, 자동차를 운전하거나 관리하는 용도로 쓰이는 모바일 앱을 분석하여 분류하였다. 총 697개의 자동차용 앱(애플의 앱 스토어에서 273개와 구글 플레이 스토어에서 424개)을 분류한 결과 8개 집단으로 나뉘었는데, 대부분 차량 뉴스 및 정보(28%), 위치 서비스(23%), 대여 서비스(15%), 안전/효율 운전(12%) 집단에 속하였다. 나머지는 매매, 운전자 소통, 유지보수 관리, 경비 관리용 이었다. 하지만, 다수의 앱들이 주 기능면에서 너무 비슷한 경우가 많았고, 단지 소수의 앱만이 둘 이상의 집단에 속할 만큼 다양한 기능을 제공하고 있었다. 분류 체계의 실용성을 높이기 위하여 분류자간 신뢰성 검사를 두 번에 걸쳐 실시한 결과 Cohen's Kappa 값이 0.886과 0.828로 수용할 만한 수준이었다. 본 연구의 결과는 자동차용 앱 개발업체가 기존 앱이 제공하지 않는 기능을 발굴내거나 다기능을 복합한 앱을 개발하는데 유용할 것이며, 향후 유망 앱을 찾기 위한 방안을 연구할 필요가 있다.

주제어 : 모바일 앱, 차량용 앱, 앱 분류, 커넥티드 카, 스마트 차량

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1. Introduction

Although millions of mobile apps have been developed and listed in app stores, many developers try to find areas for app development due to low revenue [1, 2]. Meanwhile, the automotive industry is at the turning point in that ICT (Information and Communication Technology) starts to play a significant role not only in the functionality but also in the persuasiveness of a car. Automakers have made serious efforts to improve the safety and comfort of car users by utilizing ICT. Traditionally a car was considered as a standalone machine for only transportation. Nowadays the car can be connected to the whole world and provide space for infotainment, communication, office work, or almost anything.

Automakers attempt to provide the best car experience which would attract potential car buyers. They have developed telematics or in-car systems for connected car services for the past two decades. Some representative services include vehicle tracking, navigation, remote locking/unlocking, emergency warning, eCall, etc. for individuals and organizations. These services have increased the value of a car, expanded the size of the global car market, and boosted the revenue of automakers. Although the automotive industry has become more competitive and improved the connected car technology quite significantly, its overall structure has been largely unchanged for decades.

However, the automotive industry is at the brink of revolutionary changes and expects rapid transformation of the overall structure in the near future [3, 4]. Most executives of automakers have realized the disruptive power of connected services and autonomous driving [5]. From the 2015 global survey involving more than three thousand car customers, the positive response to the question about 'the willingness to switch automakers for connected car services' has increased to 37% from 20% in the previous year. In addition, the willingness to pay for connected car services has increased to 32% from 21% [5].

These are good news, but there is bad news. Automakers are not the only players in the automotive market any more. Recently companies such as Google, Apple, and Microsoft in the ICT industry provided platforms for connected car services. Google even built new prototype cars which are fully autonomous and under road tests at present. Apple is also developing a self-driving car.

Even though automakers have accumulated experiences in developing ICT systems and acquired some capabilities for implementing connected car services, they cannot identify all the requirements that various customers demand and cannot deliver all services that satisfy every customer. They need to set up a strategy for building an ecosystem and for capturing values created by the ecosystem. Unfortunately, it is not clear for the best outcome which services automakers should provide and which services partners or the 3rd party should provide. App developers as the 3rd party are also looking for potential sources for revenue. There is a need to investigate existing apps for cars and to devise a categorization that can give guidance to automakers and app developers.

This study attempts to identify and classify currently available services. Services by automakers are implemented in applications running on built-in devices (hereafter in-car systems), while most services by the 3rd party are implemented in apps running on mobile devices such as smart phones and tablets (hereafter car apps).

The next section summarizes the background information such as connectivity types and apps available from app stores. Then, the next section presents the categories of mobile apps for cars and the following section shows the inter-rater reliability of the categorization. The final section concludes this paper with directions for future research.

2. Background

2.1 Connectivity types

A connected car is equipped with connectivity to technical systems, inside and outside the car, that provide services to car users by utilizing ICT. Connected car services have evolved from telematics which is a compound word made up of telecommunications and informatics. For connected car services, there are three types of connectivity: embedded, tethered, and integrated [6].

In the embedded type, both the communication (UICC or SIM) and the app are built directly into the car. Some services that require high availability and high reliability are good can dedicate for the embedded type. For example, for tracking a stolen car or for emergency call service, the embedded type is better than the other types for fast execution.

In the tethered type, the app resides in the car, while the communication involves an external device. There are two sub-types: tethering with a built-in modem and tethering with an external modem [7]. The tethered type with a built-in modem utilizes the customer's UICC only for connectivity and is useful for information services for charge, since this type allows the user to control the cost for services. The tethered type with an external modem uses customer's smartphone, USB key, or On-Board Diagnostic dongle for connectivity and modem. In this subtype, there are multiple ways to enable tethering: USB cables, Bluetooth profiles or WiFi. This external modem subtype has an advantage of more up-to-date modem since customers upgrade smartphones more often than cars, but the compatibility of profiles/protocols between the customer's smartphone and the car's head-unit is a disadvantage. The tethered type may not be appropriate for safety related service, since there is no guarantee that the driver will use tethering consistently [8].

In the integrated type, both the communication and the app strictly remain on the smartphone. The human machine interface (HMI) generally remains in the car, but sometimes remains on the smartphone. The integrated type has advantage in using customer's mobile network for higher bandwidth and numerous smartphone apps available such as on-demand music, Internet radio, social networking, access to traffic information, and external navigation. But it is unreliable for safety related services, due to the need for the driver to activate their smartphone.

〈Table 1〉 Connectivity Types [8]

	Embedded	Tethered	Integrated
Modem	car	car external	phone
UICC	car	external	phone
App	car	car	phone
User Interface	car HMI	car HMI	car HMI / phone

〈Table 2〉 Connectivity Types for Various Services

Services \ Automaker	A	B	C
SOS	1	1	3
Auto crash response	1	1	3
Emergency services	1	1	3
Crisis assist	1	1	3
Roadside assist	1	1	3
Stolen vehicle assist	1	1	3
Stolen vehicle slowdown	1	1	×
Remote ignition block	×	1	×
Lane departure warning	×	×	×
Locate your vehicle	4	4	×
Hands free calling	1,3,4	1,4	1,3,4
Check data plan usage	3,4	3,4	3,4
Remote diagnostics	3,4	3,4	3,4
Remote door look/unlock	4	4	4
Remote horn and lights	4	4	×
Remote ignition	4	4	×
Temperature control	4	×	×
ETC(Electronic Toll Collection)	×	×	×
Maintenance notice	1,3,4	1,4	1,3,4
Reservation service	1,3,4	1,4	×

1: Embedded
2: Tethered with built-in modem
3: Tethered with external modem
4: Integrated

A summary of the connectivity types is shown in <Table 1>. An automaker may choose a combination of these connectivity types since they are not mutually exclusive. Even one car may employ multiple connectivity types for different services in order to

optimize the car experience. <Table 2> summarizes which connectivity types are employed by three global automakers for different services [9].

2.2 App Categories

A mobile app is a small, self-contained computer program running on a mobile device such as a smartphone or tablet [10]. The number of apps available for download in app stores was almost 4 million as of July 2015 [11, 12]. Almost 1.9 million apps are available from the Google Play Store as of December 2015 [13] and 1.5 million apps were available from the Apple App Store as of June 2015 [14].

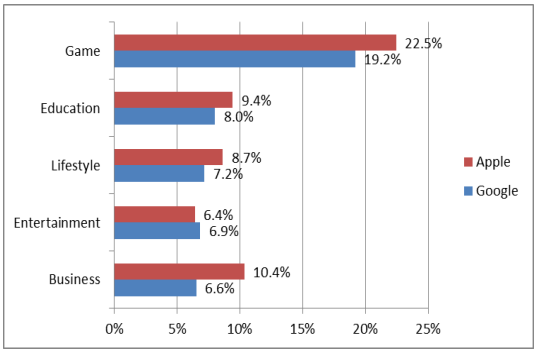
Google Play classifies apps into 25 categories and Apple Store has 24 categories. The games category in both app stores has 18 subcategories (See <Table 3>).

〈Table 3〉 App Categories of Two App Stores

Apple	Google
Books	Books & Reference
Reference	
Business	Business
Catalogs	-
-	Comics
-	Communications
Education	Education
Entertainment	Entertainment
Finance	Finance
Food & Drink	-
Games(18 subcategories)	Games(18 subcategories)
Health & Fitness	Health & Fitness
-	Libraries & Demo
Lifestyle	Lifestyle
-	Media & Video
Medical	Medical
Music	Music & Audio
News	News & Magazines
Magazines & Newspapers (28 subcategories)	
-	Personalization
Photo & Video	Photography
Productivity	Productivity
Shopping	Shopping
Social Networking	Social
Sports	Sports
Utilities	Tools
Navigation	Transportation
Travel	Travel & Local
Weather	Weather
24 categories	25 categories

Two taxonomies look very similar. Only two categories in Apple's taxonomy and five in Google's taxonomy do not have corresponding category. There are two categories whose labels are different. Another difference is that Apple Store has 28 subcategories in the Magazines & Newspapers category.

As of June 2015, the number of worldwide cumulative downloads from Apple Store reaches 100 billion including 25 billion downloads in the past 12 months. Google Play has 50 billion worldwide downloads in the same 12 months [15]. In both app stores, the most popular app categories are game, education, lifestyle, entertainment, and business, as shown in [Fig. 1] [13, 16]. A lot of app designers and researchers focus on the health app usage [17, 18] or user intention design [19], as well as app interface design [20].



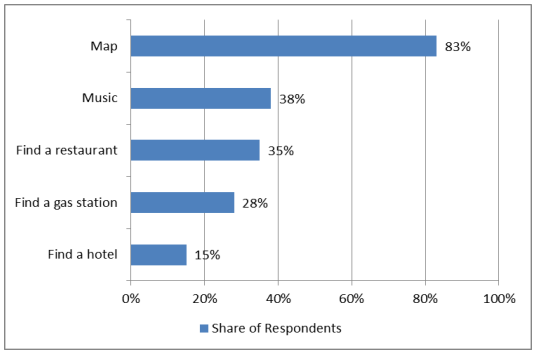
[Fig. 1] Most Popular App Categories[13, 16]

Navigation/Transportation and Travel & Local/Travel are two candidate categories for which this study needs to search. The Travel & Local/Travel category has quite many apps, but Navigation/Transportation category has much smaller number of available apps [21], as shown in <Table 4>.

〈Table 4〉 Number of Apps in Two Categories

	Google	Apple
Travel & Local/Travel	82,186 (4.3%)	50,400 (4.2%)
Navigation/Transportation	29,072 (1.5%)	14,400 (1.2%)

A survey result shows the percentage of car drivers who downloaded different kinds of apps such as map app, music app, and apps for finding a restaurant, gas station, or hotel, as shown in [Fig. 2]. However, this classification can hardly be useful to automakers or app developers.



[Fig. 2] Download by US Car Drivers [22]

3. Data Collection and Categorization

From a long term perspective on connected car services or car app market, there is a need for a systematic categorization of car apps currently available. Although there are a few taxonomies as mentioned in the previous section, there is still no systematic or comprehensive categorization useful for both automakers and app developers. This appears to be an emergent issue.

The categorization work spanned one and half years from October 2013 till March 2015 in two rounds. The first round started in October 2013 and ended in May 2014. The purpose of this first round was to explore the car-related mobile apps in the market, grasp comprehensive understanding about its functionality, and devise a categorization framework of car apps. The second round lasted for another ten months from June 2014 till March 2015. The purpose of the second round was to check the reliability of the categorization framework. The second round will be discussed in the next section.

From the two representative app distribution platforms, the authors collected 1,036 apps: 490 from Apple iTunes App Store and 546 from Google Play Store, by browsing apps in Travel, Navigation, or Transportation categories and by searching the stores with keywords such as car, navigation, automobile, driving, vehicle maintenance, locating, car expenses, car rental, and so on. We read the description of each app and downloaded it for trials.

The search results included apps for car racing games, paper folding games, and even cartoons. These apps were filtered out. Apps in Entertainment or Music category are also excluded from this study, since those apps are made for use outside the car even though they can be run inside the car. Finally 424 apps from Google Play Store and 273 car apps from Apple iTunes App Store remained. Among 424 apps from Google Play, 395 were free and 29 were paid. Among 273 apps from Apple Store, 218 were free and 55 were paid (See <Table 5>).

〈Table 5〉 Number of Apps for Classification

	Google	Apple
Free apps	395	218
Paid apps	29	55
Total	424	273

The remaining apps were evaluated in two ways: one way is to run the app directly on a smartphone; the other way is to use simulators such as BlueStacks (a popular Android simulator used for running apps on PC) or Xcode (an iOS simulator used for running apps on Mac). Each of 697 car apps was executed for examining its features, functionality, and utility. Then, all 697 car apps were classified into eight categories.

Eight categories are safe driving, locating service, maintenance management, renting service, expense monitoring, communication, buying & selling, and news & information. The features and functions of apps in each category are summarized in <Table 6>.

〈Table 6〉 Features and Functions in Each Category

Category	Features & Functions
Safe Driving	-Auto accident report. -Event data recorder function (EDR). -Monitors car speed, speed warning system, acceleration, braking G graph, car odometer. -Sends an address from the Maps app directly to the Internet-connected navigation system. -Accident call and SOS service.
Locating Service	-Uses GPS, Bluetooth, and smartphone map to find and save locations. -Uses Photo to show parking sign or street. -Use note to remember. "MEMO". -Use "off-line compass memory" or "Augmented Reality Technology" to find car. -Parking meter alarm and notification service -Find nearby gas stations, ATM, parking lots. reputable mechanics, car wash locations,
Maintenance Management	-Keeps track of car maintenance records, remind of oil changes, inspections, & part replacement. -Uses iCloud or dropbox to sync your vehicles and notifications across all your devices. -Keeps track of repair service, part number, part price and information. -Helps with no-start or other car problem. -Introduces car maintenance knowledge.
Renting Service	-Makes/cancels a booking and check its status -Manage previous booking and favorite address. -Tracks the rental vehicle on a map. -Uses GPS to find a location as a pickup point. -Checking in/out.
Expense Monitoring	-Keeps track MPG. -Calculates money spent on a car. -Calculates average costs of the car. -Reminds about tax or insurance deadline. -Monitors spending on fuel, maintenance, fees, car washes, part exchanges, repairs, etc,
Communication	-Driver community -Communicate with others about supplies, how to start, where to go for parts and help. -Guides users how to paint car in steps and show to friends. -Guide user how to design a car audio system -DIY assembly guide for restoring a classic car
Buying & Selling	-Showing car price, etc. -Apps used as a platform for purchasing and selling new or used cars. -Search best dealer nearby. -Dealer information -Save customer details. -Car loan and tax calculator
News & Information	-General car information, model, color, brand logo, car images, videos etc. -VIN number, plate number, license number -Car specs, horsepower, powertrain -Car news, reviews.

The top five categories of safe driving, locating service, maintenance management, renting service, and expense monitoring are directly related with car driving or management. The remaining three categories of communication, buying & selling, and news & information are not.

In spite of extraneous efforts, not all apps could be nicely classified into a specific category. If an app had functions that belong to two or more categories, it was classified on the basis of their main features or functions. The result shows that most of app developers focus on building car apps in four categories: car news & information (28%), locating service (23%), car renting service (15%) (12%), safe driving. The apps that are directly involved in car driving or car management account for 63%. <Table 7> shows the number of car apps in each category.

〈Table 7〉 Number of Apps in Each Category

Category \ Platform	Apple	Google	%
Safe Driving	27	54	12%
Locating Service	53	107	23%
Maintenance Management	21	23	6%
Renting Service	47	60	15%
Expense Monitoring	24	25	7%
Communication	6	8	2%
Buying & Selling	12	35	7%
News & Information	83	112	28%
Total	273	424	100%

Many car apps in the categories of locating service and renting service are too homogeneous in that their main functions and user interfaces are very similar. Only a few apps are designed to be comprehensive and contain functions from two or more categories.

4. Inter-Rater Reliability Test

The practicability of the categorization framework presented in <Table 5> needs to be checked by the inter-rater reliability test. Inter-rater reliability refers to the degree of agreement among raters. Generally, Cohen's Kappa is a statistical measure for assessing

the degree of agreement. Cohen's Kappa refers to a measurement of concordance or agreement between two raters or measurement methods.

〈Table 8〉 Sample Ratings in Test 1

Rater / App Name	Rater 1	Rater 2	Agree
Car Recorder	Safe Driving	Safe Driving	Yes
Find My Car	Locating Service	Locating Service	Yes
About My Car	Maintenance Management	Expense Monitoring	No
AJ Rent Car	Renting Service	Renting Service	Yes
CarXpense	Expense Monitoring	Expense Monitoring	Yes
ALL CAR	Communication	News & Information	No
Car for you	Buying & Selling	Buying & Selling	Yes
Cars	News & Information	News & Information	Yes
Total	8	8	6/8

〈Table 9〉 Cohen's Kappa in Test 1

	Value	Asymp Std. Error	Approx. T	Approx. Sig
Measure of Agreement Kappa	.886	.054	14.853	.000
Number of Valid Cases	40			

Forty car apps were selected from eight categories (five car apps from each category) for two tests. In the first test, two consumers were asked to classify forty apps and in the second test two professionals working in the automotive industry were asked to classify them.

<Table 8> shows a rating sample by Rater 1 and Rater 2 for eight car apps, one from each category. The statistical analysis of Test 1 shows that the Cohen's Kappa is 0.886 with the standard error of 0.054 and p-value of 0.000 (See <Table 9>). We can reject at the 5% significance level the null hypothesis that two rater's agreement occurred by chance. In general, Cohen's Kappa value greater than 0.70 is acceptable.

In Test 2, the same forty car apps were given to Rater 3 and Rater 4. <Table 10> shows a ratings sample by Rater 3 and Rater 4 for the same eight car apps.

The statistical analysis of Test 2 shows that the Cohen's Kappa is 0.828 with the standard error of 0.064 and p-value of 0.000 (See <Table 11>). Again, we can reject at the 5% significance level the null hypothesis that two rater's agreement occurred by chance.

〈Table 10〉 Sample Ratings in Test 2

Rater / App Name	Rater 3	Rater 4	Agree
Car Recorder	Safe Driving	Safe Driving	Yes
Find My Car	Locating Service	Locating Service	Yes
About My Car	Expense Monitoring	Maintenance Management	No
AJ Rent Car	Renting Service	Renting Service	Yes
CarXpense	Expense Monitoring	Expense Monitoring	Yes
ALL CAR	Communication	Buying & Selling	No
Car for you	Buying & Selling	Buying & Selling	Yes
Cars	News & Information	News & Information	Yes

〈Table 11〉 Cohen's Kappa in Test 2

	Value	Asymp Std. Error	Approx. T	Approx. Sig
Measure of Agreement Kappa	.828	.064	13.875	.000
Number of Valid Cases	40			

Through the two inter-rater reliability tests, the categorization suggested by this study seems practicable. However, some apps such as 'About My Car' and 'ALL CAR' were put into different categories by the four raters. 'About My Car' was classified into 'expense monitoring' or 'maintenance management.' In case of 'ALL CAR', four raters put it into three different categories of 'communication', 'buying & selling', and 'news & information.' This could be due to either the taxonomy or the app. This needs further investigation.

5. Conclusion

Because of the well-developed mobile app market, app designers always want to increase their profits [23] and decrease the risk caused by forgery attack or designing blindness [24]. Especially, the automotive industry is expecting seismic changes in the near future. Many experts speculate that the automotive industry would become a software-driven mobility industry or 'transportation as a service' industry [8]. Automakers and ICT companies including mobile network operators, app developers, new entrants like Tesla and global giants such as Google and Apple have great interests in the industry and are making enormous efforts to seize their own share of the market.

This study made a serious attempt to categorize car-related mobile apps which can be a major revenue source for app developers. It identified 697 apps from Google Play Store and Apple App Store, devised a categorization with eight categories, and classified 697 apps into the eight categories. Then, the taxonomy went through two inter-rater reliability tests. Although this taxonomy may need further refinements and modifications, the current taxonomy seems useful from the practical perspective. Automakers and app developers can utilize this taxonomy in order to find areas for developing car apps.

There are two suggestions for improvement. First, driver's communication functions should be emphasized in car app designing process. Actually, an excellent management and service system developed with car manufacturers, drivers, and app developers can form a close connection and it may bring traditional car manufacturers more competitiveness and may evolve into a car app trading platform. Second, current car app's functions can be integrated. For example, integration for basic car information, new car buying and selling, renting, second-hand car buying and selling, driver's communication and seller's communication may give drivers much more convenience.

From an academic perspective, this study made a way to do research for investigating car apps. Future research will focus on identifying promising car apps or designing multi-functional car apps with HCI technology and persuasive technology.

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