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How to identify the trends of services: GTM-TT service map

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ABSTRACT

Recently, due to the explosive increase of services, firms have faced with challenges to analyze patterns and trends in services in an intuitive but objective ways. The notion of service map can be adapted to this end. Maps, in general, have been receiving a great deal of attention because of their potential as visualization tools that can allow people to visualize massive amounts of information. Specifically, the generative topographic mapping through time (GTM-TT) algorithm is suitable for dynamic analysis since GTM-TT provides a time-based clustering and change path. In response, this study proposes an approach for developing and using GTM-TT service maps consisting of a service clustering map and a service sequence map for analyzing service trends. The proposed approach, broadly, is comprised of four steps: (1) the construction of a database, (2) data preprocessing, (3) development of a GTM-TT service map, and (4) interpretation. The proposed approach is expected to aid in the identification of dynamic service trends.

1. Introduction

Recently, the business focus has been increasingly shifting from manufacturing-oriented to service-oriented systems (Toivonen & Tuominen, 2009; Yang, 2007). This change has already taken place in many industries, and the trend is expected to continue as future economic growth is foreseen to come predominantly through services-based businesses (Gebauer & Friedli, 2005; Oliva & Kallenberg, 2003; Pilat, 2000; Toivonen & Tuominen, 2009). This phenomenon is especially true of mobile services where a lot of services are simultaneously generated and many are short-lived. The rise of the smartphone has led customers to use many more services compared with traditional phone use, and the competition in this service industry has grown much tougher (Benbunan-Fich & Benbunan, 2007; Lin, 2011). With the rapid technological advancements, a lot of new services will be generated and consumed, and this phenomenon is expected to continue.

In the wake of this quantitative and qualitative expansion of services, the need to analyze trends of services has been also increased. Due to the explosive increase of services, service companies face difficulties analyzing the patterns and trends in services. However, analysis of dynamic patterns can provide service companies with significant implications regarding the identification of service trends and clues for the development of viable new services. Therefore, the identification of service trends cannot be neglected.

The use of a visualization tool, more specifically, a map, fits this purpose. The use of maps has been receiving great attention as a way to visualize massive amounts of information (Chen, 2003; Keller & Tergan, 2005; Ware, 2004). The use of maps can result in unexpected discoveries, deepened understanding, and new ways of thinking, eureka-like experiences, and other intellectual breakthroughs (Chen, 2010). The use of maps has a strong advantage in that it can allow for the organization of massive service data into a clear and simple visual form that can provide insights into trends and patterns of service evolution, which implies that the role of the map fits for analyzing the trends of services.

However, despite the significance of the map, research into the development of dynamic service maps has been immaterial. While some research has been suggested regarding service maps (Kim & Park, 2010; Kwak, Lee, & Park, 2010; Song, Kang, Yoon, & Park, 2010), most of this research concerns using maps as a form of static analysis. Kwak et al. (2010) suggested using a service map as a method for transforming non-spatial data to graphical representations for exploring new service opportunities by unifying the service features and customer needs through principal component analysis (PCA). With a similar context, a user-centric service map was also proposed (Kim & Park, 2010) to identify new service opportunities by matching the context between a potential-needs dictionary and existing services. However, these studies still rely on investigating current status of service, providing a static map. In terms of dynamic map, Song et al. (2010) suggested a dynamic

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service map that considers service evolution based on product utilization. However, the mapping method in this paper still remains qualitative and subjective. Therefore, based on the existing research, we propose that it is important to address the question of how to develop a dynamic service map to identify the service trends in an automatic and objective way.

This study proposes an approach for developing and using generative topographic mapping through time (GTM-TT) service maps consisting of a service cluster map and a service sequence map for identifying the service trends automatically with an objective perspective. Of course, though it is very hard to identify and understand whole service trends, service clusters on the service cluster map and the sequence of service change in a period on the service sequence map can contribute to identify service trends. GTM-TT is a mapping and visualization technique for multivariate time series data that allows for a dynamic analysis of service data. This technique can be applied to the analysis of service trends for the following reasons. First, GTM-TT can contribute in terms of providing time-based clustering, which can provide evidence of time-based service trends. Second, GTM-TT can contribute to the identification of the dynamic change path of services. That is, GTM-TT provides the change path that can describe the time-based pattern after time-based clustering. This information can provide clues for analyzing the service evolution from analyzing the interrelated patterns within service information. Therefore, GTM-TT is used to develop a service map for analyzing and monitoring the trend of service. In this paper, the Apple AppStore, one of the important and innovative data sources for mobile application services, has been used as the data source for service information.

The rest of the paper is organized as follows. The next section provides the background for this study. The third section focuses on the overall research framework and detailed processes for the development of a GTM-TT service map that is used to analyze the service trends. The advantage of the proposed approach is explained in the fourth section. A case study using AppStore data is provided in the fifth section, finally followed by the discussion and conclusion.

2. Background

2.1. Trend analysis

Trend analysis has been employed to analyze the current trend of business, technology, or customers. The purpose of trend analysis can be summarized as follows: to identify the overall pattern of change in an indicator over time, to compare one time period to another time period, to compare one geographic area to another, to compare one population to another, and finally, to make future projections (Rosenberg, 1997). Generally, mathematical or statistical techniques are used to gather time series data to identify future trends. The basic assumption of trend analysis lies in the fact that past conditions and trends will continue in the future more or less unchanged (Wu, Hsu, Lee, & Su, 2011).

The strength of trend analysis lies in its data-based approach, which offers substantial and data-based forecasts of quantifiable parameters. However, this strength might be also a shortcoming since a significant amount of good data is required to provide a reasonable result for trend analysis. Moreover, trend analysis works only for quantifiable parameters, and is vulnerable to cataclysms and discontinuities (Wu et al., 2011).

Techniques for trend analysis vary in sophistication, from simple to complex techniques (Wu et al., 2011). The basic methodology for trend analysis is the bibliometric analysis on the basis of literature metadata and information. Bibliometric analysis has been widely used in many fields, such as pharmacology and pharmacy journals, global stem cell research, research on mental health in the workplace, and nanotechnology innovation systems (Wu et al., 2011).

Extending from the bibliometric analysis, more advanced techniques have been suggested, such as visualization methods. Visualization methods are preferred data mining methods because they often offer superior results compared to other conventional techniques (Kim, Suh, & Park, 2008; Westphal & Blaxton, 1998). Visualization methods haves great power in terms of information representation since they provide means for quick and easy knowledge retrieval. For example, high level managers who make technology investment decisions find visualization methods more useful than conventional methods, such as text or tables (Ganapathy, Ranganathan, & Sankaranarayanan, 2004; Kim et al., 2008).

Among the many visualization techniques, the most widely used method is the map. Maps offer a visual representation of an area, highlighting the relationships between related elements, such as objects, regions, and themes. In most cases, maps are represented in either a two-dimensional space or three-dimensional space. Maps can be applied to provide a quick and easy way to capture important information. Even though the concept of a *map* starts from a geographical context; it is widely used in the management disciplines in terms of identifying management trends.

To develop a map, text-mining is frequently used to discover previously unknown information by automatically extracting information from various unstructured data (Delen & Crossland, 2008; Wu et al., 2011; Yang & Lee, 2004). In particular, mapping is used to identify the technology trajectories in the scientific areas, where text-mining has been vigorously employed (Liang & Tan, 2007), and technology-intelligence tools also have assisted experts to make strategic technology plans., Moreover, many tools for technology intelligence have been suggested to identify technology trends and provide technological insights through content analysis of technical documents (Tsai, 2012; Yoon, 2008; Yoon & Kim, 2011).

2.2. Generative topographic mapping through time (GTM-TT)

2.2.1. Basic concept of the GTM-TT

Manifold learning models attempt to describe multivariate data in terms of low-dimensional representations, often with the goal of allowing the intuitive visualization of high-dimensional data (Olier & Vellido, 2008). Generative topographic mapping (GTM) has been introduced by Bishop, Svensén, and Williams (1996) as one of the statistical machine learning models that provides a principled alternative to the self-organizing map (SOM) algorithm of Kohonen (1982). Unlike the SOM, the GTM model defines a genuine probability density and thereby overcomes many of the limitations of the SOM (Bishop, Hinton, & Strachan, 1997). Its probabilistic setting has enabled various subjects, such as missing data imputation (Carreira-Perpiñan, 2000; Vellido, 2006), discrete data modeling (Bishop, Svensén, & Williams, 1998; Girolami, 2002), and robust outlier detection and handling (Bullen, Cornford, & Nabney, 2003; Vellido, 2006).

The GTM-TT is one such extension of GTM for the exploratory analysis of multivariate time series (Bishop et al., 1997) by performing simultaneous time series clustering and visualization. Multivariate time series are not independent identically distributed (i.i.d.) data (i.e., multivariate data corresponding to nearby times will be highly correlated). Therefore, the standard definition of the GTM can only provide a rough approximation to its proper modeling. To deal with this limitation, Hidden Markov Model (HMM) is used in the GTM-TT. As a result, GTM-TT can be understood as a topology-constrained HMM. Parameter estimation can be accomplished in GTM-TT by maximum likelihood using EM algorithm, in a similar fashion to HMMs: details can be seen in a paper by Olier and Vellido (2008).

The GTM-TT is appropriate for analyzing service trends because the service data are also in the form of a multivariate time series, where the data are correlated because later service is affected by prior service. Further, the two-dimensional map provided by GTM-TT is very useful for analyzing and understanding complex service trends.

2.2.2. The algorithm of the GTM-TT

The GTM-TT is an extended model of standard GTM (Bishop et al., 1997). The structure of the GTM-TT is shown in Fig. 1, in which the hidden states of the model at each time step are labeled by the index i corresponding to the latent points $\{u_i\}$.

The underlying principle of the GTM-TT is as follows. The probability of an observation sequence $X = \{x_1, x_2, \cdots, x_n, \cdots, x_N\}$, given a fixed state sequence $Q = \{q_1, q_2, \cdots, q_n, \cdots, q_N\}$ is defined as:

$$p(X|Q) = \prod_{n=1}^{N} p\{x_n|q_n = u_i\} \tag{1}$$

where q_n is the state u_i at time n. The likelihood of the GTM-TT is defined as the sum of probabilities of the observation sequence given of all possible state sequences:

$$p(X,\lambda) = \sum_{allQ} \pi_{q_1} \prod_{n=1}^{N=1} P_{q_n q_{n+1}} \prod_{n=1}^{N} p_{q_n}(x_n) \tag{2}$$

$$P_{q_n q_{n+1}} = P[q_{n+1} = u_j | q_n = u_i] \tag{3}$$

$$p_{q_n}(x_n) = p(x_n|q_n = u_i) \tag{4}$$

$$\lambda = \{\{\pi_i\}, \{P_{ij}\}, W, \beta\} \tag{5}$$

π_{q_1}: the initial state probability of Q, $P_{q_n q_{n+1}}$: the probability of transition from one hidden state to another, $p_{q_n}(x_n)$: the probability of an observation sequence, and λ: the set of model parameters.

As in HMM, the likelihood defined above can be efficiently calculated using the forward–backward procedure. The probability of being in the state u_i at time n, given the observation sequence and the model, also known as responsibility R_{in} is calculated as:

$$R_{in} = P(q_n = u_i|X,\lambda) = \frac{A_{in}B_{in}}{p(X|\lambda)}. \tag{6}$$

The forward variable A_{in} is the joint probability of the past subsequence $X_1, X_2, \cdots, X_n$ and the state $q_n = u_i$ as follows:

$$A_{in} = P(\{x_1, x_2, \cdots, x_n\}, q_n = u_i|\lambda) \tag{7}$$

The backward variable B_{in}, which is the probability of the future subsequence $X_{n+1}, X_{n+2}, \cdots, X_N$ given hidden state $q_n = u_i$ is represented as follows:

$$B_{in} = P(\{x_{n+1}, x_{n+2}, \cdots, x_N\}|q_n = u_i, \lambda) \tag{8}$$

In addition to parameters (w, β), which can be obtained in the M-step of the EM algorithm as for the standard GTM, GTM-TT modeling entails the estimation of the initial state probabilities $\{\pi_i\}$ and the state transition probabilities $\{p_{ij}\}$. In order to describe the procedure for the re-estimation of this parameters, we first define $\xi_n(i,j)$: the joint probability of hidden state u_i at time n and hidden state u_i at time $n + 1$, given the data X and the model. In this way, the re-estimation formulae are defined as follows:

$$\hat{\pi}_i = R_{in} \tag{9}$$

$$\hat{P} = \frac{\sum_{n=1}^{N-1} \xi_n(i,j)}{\sum_{n=1}^{N-1} R_{in}} \tag{10}$$

The GTM is embodied with visualization capabilities that are akin to those of the SOM. The clusters of multivariate time series points can be summarily visualized in the low-dimensional latent space (in 1 or 2 dimensions) of GTM-TT by means of the posterior-mode projection (Bishop et al., 1998), defined as:

$$q_n^* = \arg\max_{1 \leqslant i \leqslant M} R_{in} \tag{11}$$

The optimum path over the space of states is defined by the state sequence $Q^* = \{q_1^*, q_2^*, \cdots, q_N^*\}$. Beyond the posterior mode, the distribution of the responsibility over the latent space of states can also be directly visualized in full.

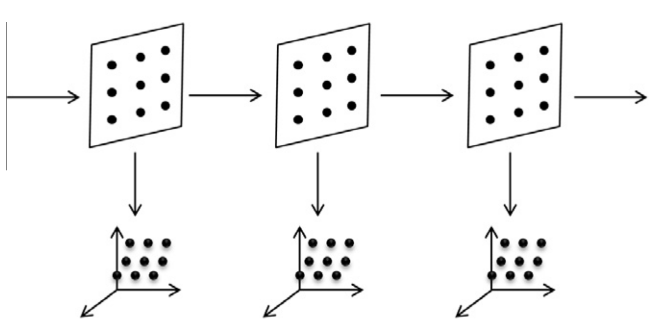


Fig. 1. The structure of the GTM-TT model.

3. Research framework for GTM-TT Service map

3.1. Overall process

The overall process of the proposed approach mainly includes the following steps: (1) construction of the database, (2) data preprocessing, (3) development of the GTM-TT service map, and (4) interpretation, as shown in Fig. 2. In the first step, the service documents are collected from the service area of interest to construct the database (DB). Since the service documents collected in this step are unstructured data in that they are expressed in text format, it is necessary to transform the unstructured data into structured data for analysis. Therefore, in the second step, preprocessing is conducted by experts through the text-mining technique in which, using text-mining tools, keywords are extracted from the documents, and, subsequently, multivariate time series data from the service documents are generated. For visualization of text data, each document must be transformed into a multivariate time series data that is made up of quantitative values such as weighted keyword frequency or binary value by the occurrence of keywords and time information of each document. In the third step, the GTM-TT algorithm is employed to develop the GTM-TT service map using MATLAB. In the fourth step, the service trends are derived through the interpretation of the GTM-TT service map. These steps are introduced sequentially hereafter.

3.2. Detailed procedures

3.2.1. Step 1: construction of the database

As an initial step, the construction of the database is conducted as follows. First, the search and the selection procedures for the target service area to be analyzed are executed. These procedures are important because they are not only very closely related to the purpose of research, but also affect the overall analysis process. Next, the available data source is determined. Although data related to services can be collected from various data sources, such as reports from service firms, academic papers, books, newspapers, and survey data, the Web has been considered an emerging data source recently because it is a source of plentiful and diverse data and computer-based techniques can be applied for collecting and analyzing the data (Pérez, Berlanga, Aramburu, & Pedersen, 2008). Hence, this study uses Web data related to target services.

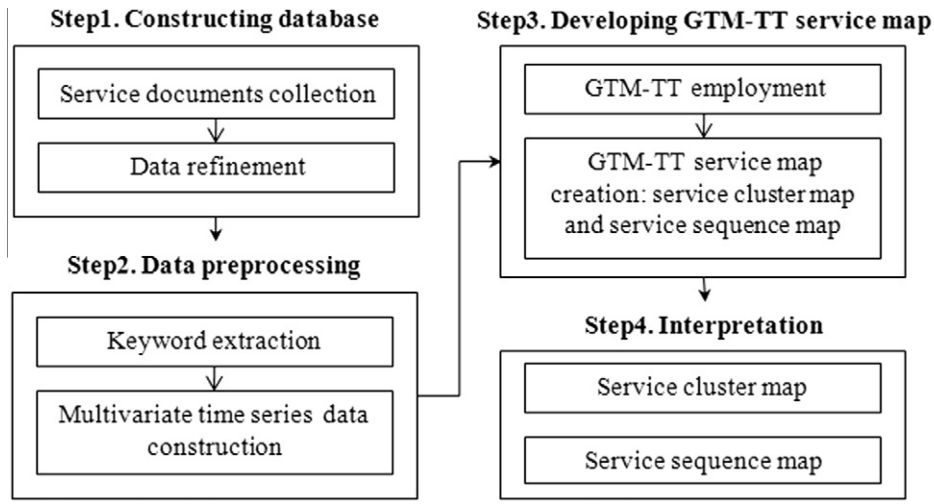


Fig. 2. Overall process.

Finally, service documents in a specific service area are collected. In practice, it is difficult to collect a lot of data manually. Therefore, in this research, a computer-based system using JAVA is used to automatically collect data from the Web. Then, experts who have domain knowledge or experience refine the collected data by eliminating unrelated data.

3.2.2. Step 2: data preprocessing

Since service documents are expressed in natural language format, it is necessary to transform them into structured forms appropriate for analysis. Most text-mining algorithms use keywords as features for expressing the document (Sebastiani, 2002). Therefore, in this study, the process of keyword extraction is applied to identify keywords, and the extracted keywords are used to represent services. The detailed steps of the data preprocessing are follows.

In this step, the first task is to extract keywords from collected service documents. Text-mining serves as a tool for analyzing the relationship among service documents. Respective service documents, specifically, are featured by keywords that represent service characteristics. The extraction of keywords relies first, on text-mining technique, and second, on domain experts. After a keyword list is derived from the text-mining analysis, it is necessary to screen the keywords on the list in order to eliminate the ones that are meaningless or irrelevant to the strategic purpose of the analysis. For the purpose, experts' domain knowledge is used, based on which a final keyword set for the following analysis is determined. Consequently, repetitive trials between experts and a computer-based approach are required to define the form and elements of the keyword vector in a service context. Then, for each service document, the occurrence of each keyword is assigned to a corresponding vector field and, as a result, each service document is distinguished by a keyword vector. Once keyword vectors are constructed, they are sorted by first launching date of each service in chronological order to make multivariate time series data that are used as input data for analysis, as shown in Fig. 3.

3.2.3. Step 3: development of a GTM-TT service map

After data preprocessing, the GTM-TT algorithm is employed to create a GTM-TT service map for identifying service trends with multivariate time series data, that is, chronological keyword vectors. In this paper, a proposed GTM-TT service map is defined as a two-dimensional map using GTM-TT for identifying service trends according to the change of time and consists of two maps; a service cluster map and a service sequence map. Where, a *service cluster map* represents the kind of services that are being developed and launched during that time, and service clusters are expressed by square nodes on the two-dimensional map. And a *service sequence map* exhibits the flow of service changes by using several arcs automatically provided by GTM-TT. The main components of a GTM-TT service map are as follows:

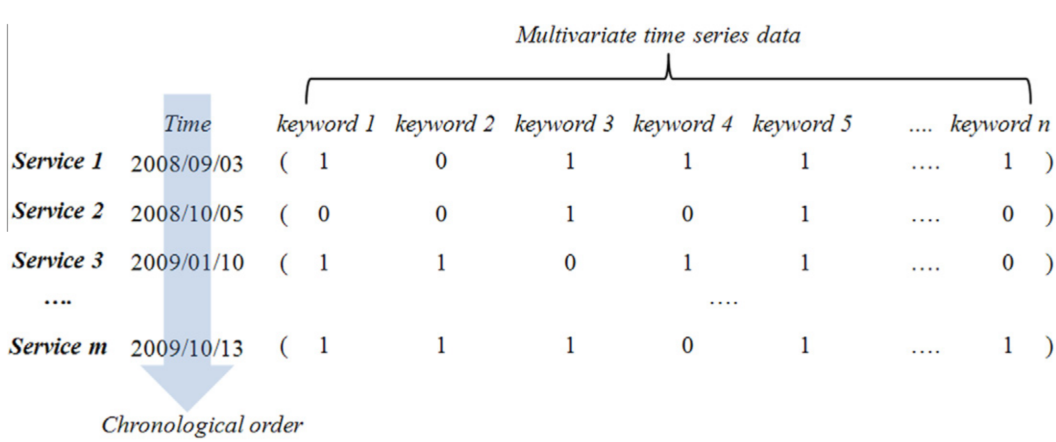


Fig. 3. An example of multivariate time series data.

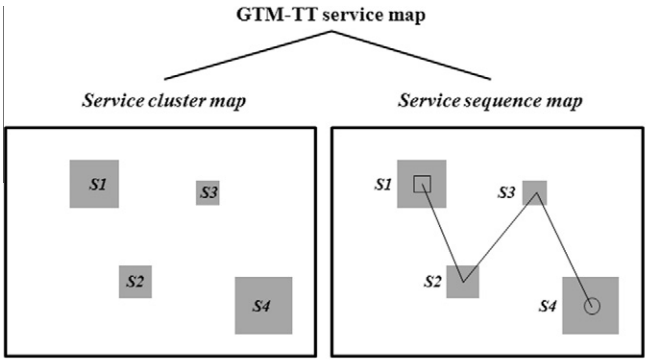


Fig. 4. Structure of a GTM-TT service map.

- Node: cluster of similar services in similar time
  - Node size: scaled according to the ratio of clustered services
- Arc: linkage between service clusters according to the change of time, which can represent service dynamics between service clusters
  - Line: service change path
  - Square: start point of service change
  - Circle: end point of service change

Once nodes, which represent service clusters, are identified on the two-dimensional map, arcs starting from square to circle among nodes, which represent the dynamic change path of services, are also provided by GTM-TT. An example of a GTM-TT service map is depicted in Fig. 3. From this example, service clusters of a specific service field are explained by four nodes including S1, S2, S3, and S4 on the service cluster map, and these service clusters are changed from S1 to S4 in order, according to the line starting from square to circle on the service sequence map. As shown in Fig. 4, the service trend is identified intuitively through the proposed GTM-TT service map.

As a result of employing GTM-TT, services are clustered, and they are displayed with a trajectory on a rectangular planar surface. In this research, MATLAB software is used to employ GTM-TT. In a GTM-TT service map, clusters are represented by squares that are scaled according to the ratio of data points and linked by contextual information for each data point. Unlike other clustering models including standard GTM, different series are represented in the latent space by different distributions and trajectories when GTM-TT is employed since GTM-TT considers contextual information for each data point. This indicates that the model is actually identifying the difference between series. Therefore, GTM-TT algorithm is used to identify the service trends.

3.2.4. Step 4: interpretation

According to the result of investigating all services in the clusters, a GTM-TT service map (Fig. 4) obtained by GTM-TT algorithm is interpreted from a trend analysis view. In terms of the service cluster, the titles, categories, descriptions, etc. of services in the service cluster are investigated to identify the characteristics of the obtained clusters and label them. In terms of the dynamic change path of the derived service clusters according to the change of time, the arc on the service map is utilized.

4. Advantage of the proposed approach

The main advantages of the proposed approach are as follows. The first stems from the use of computer-based techniques in order to deal with the vast amount of service data, which is becoming increasingly difficult to explore and analyze. The proposed method uses the developed JAVA programming to collect data and construct the database, and additionally, when extracting keywords, the text-mining technique is used. This method can save the time and efforts of researchers. Next, since the GTM-TT automatically provides not only service clusters on a two-dimensional map, but also sequence between service clusters for identifying service trends, researchers can understand service trends, intuitively. In sum, the automation and visualization of the proposed approach is the main advantage.

5. Case study: camera technology-based mobile application service

A case study of camera technology-based mobile application service is presented to illustrate the suggested approach. We considered this case example appropriate for the following reasons. First, since the mobile application service is considered as a kind of service, they can be used as service data. Particularly, mobile application services are a specific subset of electronic services, which are defined as services that are offered via mobile and wireless networks (Bouwman, De Vos, & Haaker, 2008; Hofacker, Goldsmith, Bridges, & Swilley, 2007).

Second, camera technology-based mobile application service is considered as one of the most critical mobile application services because mobile application services based on the mobile camera technology have been occupied a large portion of total mobile application services, and camera technology-based mobile application services have been used for various purposes, such as taking a picture, scanning barcodes, video recording, and video calling. Third, the various advanced application services using mobile camera technology are continuously introduced, and the amount of customer needs are increasing, and therefore, trend analysis of this case is useful. Finally, the number of service documents in this case is a convenient size for illustrating the proposed approach.

5.1. Construction of database

The AppStore served as the data source for collection of mobile application service documents. A total of 432 service documents about camera technology-based mobile application service were collected over the period of 2010 first with the aid of a JAVA program, which we developed for this case, and then, with the help of the domain experts. Among all collected service documents, top 100 service documents with high average rate were used to consider the quality of services. The constructed database included a variety of information, such as the name of the mobile application service, last changed date, category, developer, version, size, launching date, and description, as shown in Table 1. In this study, the categories title of mobile application service, average rating, first launching date, and description of mobile application service were employed to develop the GTM-TT service map.

5.2. Data preprocessing

The output of keyword extraction for camera technology-based mobile application service documents is the keyword list. For this, A TextAnalysis 2.32 software was first used as a text-mining tool. After executing text-mining, the keywords are listed in the order of frequency, and keywords with high frequency are considered in the analysis based on the assumption that more important keywords appear more frequently. Finally, as a result of the keyword screening, through which the domain experts eliminate meaningless or redundant keywords, 26 keywords remained, and these will be the basis of the following analysis.

With the extracted 26 keywords including portrait, video, augmented reality, resize and so on, 100 keyword vectors for individual

Table 1
Constructed database.

Title	Last changed date	Category	Developer	Version	Average rating (reviews)	Size (mb)	Launching date	Description
PhotoCalc	10/7/2	Photography	Adair systems, LCC	1.2.3	3.00(421)	0.6	08/8/27	Photocal is a utility...
Camera Art	10/8/14	Photography	Sudobility	3.1.5	2.50(39)	1.1	08/12/2	This app is inspired...
Spy remote	11/1/6	Utilities	Flying pig	1.2.1	3.00(39)	0.1	09/3/8	Spy remote allows you...
ABABasic	11/5/3	Education	kV Adaptive LLC	1.2	2.00(8)	0.1	09/11/18	Designed by a BCBA and biomedical engineer...

service documents were constructed. Note that the fields in *keyword vector* are filled with the occurrence, which is expressed with 0 or 1. For example, the occurrence of 1 for "portrait" field in the service document 1 means that "portrait" occurs in the document of service 1. Finally, all keyword vectors are arranged in the order of launching date to consider contextual information in the analysis. In other words, multivariate time series data to be used as input data for developing a GTM-TT service map are constructed.

5.3. Development of a GTM-TT service map

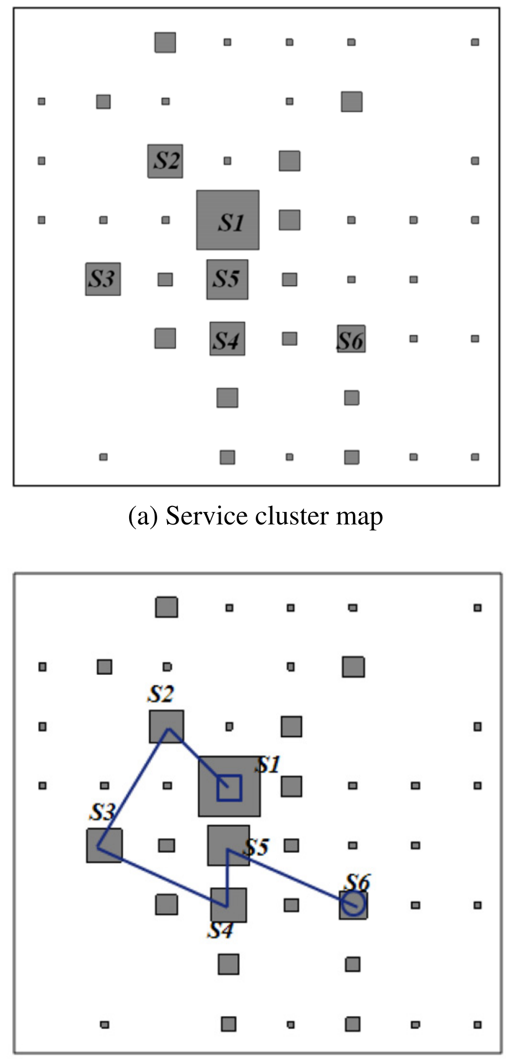
As pointed out before, the GTM-TT service map was developed by executing the GTM-TT with the constructed multivariate time series data. The GTM-TT service map consists of two maps including a service cluster map and a service sequence map, as shown in Fig. 5. In practice, a GTM-TT service map is constructed differently according to the parameters used for employing GTM-TT. In other words, the shape of the GTM-TT service map is affects the number and features of service clusters. And the shape of the GTM-TT service map is changes by different parameters, such as the number of grids, the basis function, the number of iterations, and so on.

5.4. Interpretation for the service cluster map

In the Fig. 5(a), the top 6 total of service clusters, including S1, S2, S3, S4, S5, and S6, are selected as service clusters of camera technology-based mobile application services in 2010. For each cluster, specifically, the titles, categories, descriptions, and keywords that have been indexed in the text mining process are reinvestigated to label the obtained service clusters. As a result, S1 is labeled as "Entertainment service" since this service cluster mainly consists of mobile application services for editing photos for fun and has keywords including fun, resize, draw, and text. S2 is named as "Location information-based service" because many of mobile application services in this service cluster are representing location information on the photos or maps and location, text, fun, and so on are included as keywords. S3 is a "Video related service" which has mobile application services for taking, editing, managing, or analyzing a video and includes keywords such as video, movie, text, etc. S4 is named as "Social communication service" which mostly comprises mobile application services to be used for distributing photos and videos among friends and acquaintances and description and keywords of mobile application services in S4 are highly related to the social communication. In a similar way, S5 and S6 are labeled as "Professional purpose service" and "Healthcare service", respectively. The result is summarized as shown in Table 2 with three examples of mobile application services. In sum, each individual service cluster has its unique characteristics, and each one is distinguished from the others.

5.5. Interpretation for the service sequence map

In the Fig. 5(b), the dynamic change path of service clusters, in which S1, S2, S3, S4, S5, and S6 are connected in order, is identified. At the beginning of 2010, mobile application services related to *entertainment* for editing photos for fun were launched primarily. Then mobile application services based on *location information* using mounted GPS on the smartphone were released in order to satisfy the needs of smartphone users want to know the location information. After that, the service trend was changed to *video-related* mobile application services because of the needs of customers for video. And then, mobile application services for *social communication* sharing original or edited photos and videos with other people such as friends and family were provided. The next is mobile application services for *professional purpose* to edit photos for specific purposes professionally. And mobile application services providing *healthcare service* were launched.



(a) Service cluster map

(b) Service sequence map

Fig. 5. GTM-TT service map for camera technology-based mobile application service in 2010.

Table 2
Service clusters of camera technology-based mobile application services in 2010.

Group	Characteristic	Description	Mobile application services
S1	Entertainment	Editing photos for fun	Picture3D, Light Painting Camera, iPhone Self-Timer
S2	Location information-based	Expressing location information on the photos or maps	Snap + Map, Photo Locations, Duplicam Camera Module
S3	Video related	Including camcorder feature, managing private video, and editing videos	Swing Pro, Video Call for iPhone, SketchPad Pro
S4	Social communication	Sharing photos and videos with other people	PhotoSpread, Photo Share Pro, iMotion Flashlight Pro For iPhone 4
S5	Professional purpose	Editing photos professionally	StudioVisit, True NightVision, Empire ISIS AR
S6	Healthcare service	Managing body line and personal health	Instant Heart Rate, Heart Fitness, Bodybuilding.com

6. Discussion

6.1. Dynamic analysis

Since this map provides the dynamic trends of services, setting an appropriate period determines the quality of analysis. The determination of period solely depends on the analyst's decision, according to the purpose of analysis. For example, if a firm wants to investigate the general pattern of three-year service trends, the scope of analysis is determined as three periods. If a firm wants to analyze the period-wise trends, the scope of analysis can be a single year with three different maps.

To compare the results, we conducted additional analysis. On one hand, we constructed three dynamic maps for 2009, 2010, and 2011. A total of 300 service documents (100 for each period) with high average rate score were collected and pre-processed. And then, the GTM-TT service map for each year is constructed using GTM-TT. To compare the result, we also analyzed the service trend for entire 3 years, using 300 service documents for 3-year period (from 2009 to 2011) as well. For both analyses, 8×8 squared grids were used to train both models.

As a result, Fig. 6 shows the GTM-TT service map for 2009, 2010, and 2011, respectively.

The service trends for 2009, 2010, and 2011 are described respectively as shown in Tables 2–4. For all three periods, a service cluster for entertainment is shown as the first cluster that shapes the overall trends for each period. Some differentiated patterns are also found according to the period.

6.1.1. Service trends for 2009

For example, in 2009, two main themes of service are found: entertainment and social communication services. These services dominate the service trends, appearing and disappearing according to the timeline. Services such as Sports Brush, iJuly4th, and How2-Draw Faces are the representative services in this period. All are the services to provide entertainment for uses, by providing a paint brush or providing unique digital pictures. The second cluster, communication cluster shows the communication-based services such as Reflections, Visual Fusion Contribute, and Emoji Brush Lite. Most of these provide additional communication with their friends after taking pictures. The third cluster, entertainment service shows the highest group among the service trend. As well, services with professional purposes such as PhotoCanvas, Foto Flair, and Loupe are found in the next trend. Most of these are related to the photo-editing services, importing services, or creative artworks. Then, services for social communication and entertainment are followed. These service trends are summarized in Table 3.

6.1.2. Service trends for 2010

The service trends have been slightly changed in 2010, showing more specific patterns such as location-based service, video-related services, or professional services. Starting from the entertainment services which take a big seat in the entire mobile services, the service trend has been changed to the location based services, video-related services, social communication services, professional services, and healthcare services, as shown in Table 2. For more information, please refer to the previous section to describe the service trends for 2010.

6.1.3. Service trends for 2011

In 2011, the fourth cluster, entertainment also plays a critical role for shaping the service trend. The trend has been changed from entertainment, utility-based service, video-related service, and back to the entertainment services. Compared to the previous periods, services related to the technology such as utility or video-related services show the dynamic trends in 2011. However, similar to other periods, entertainment services still occupy a big seat in service trends.

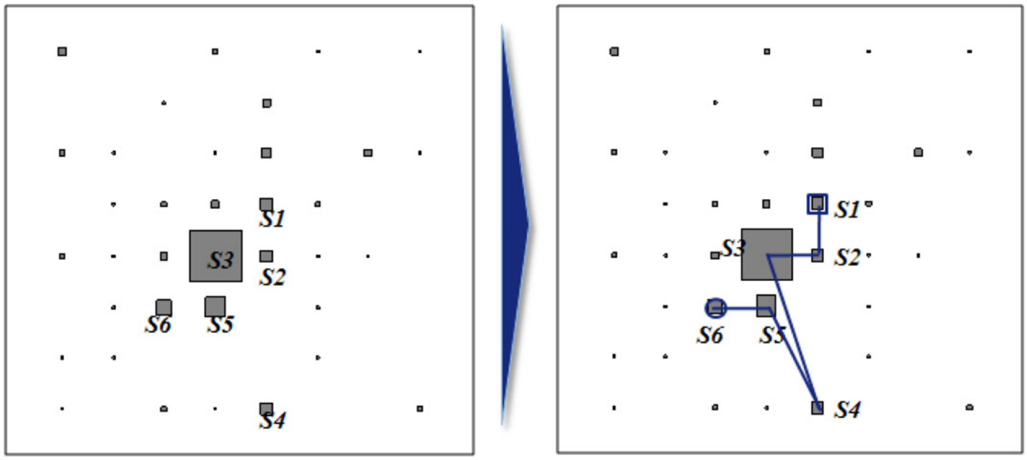
As shown in Table 4, In 2011, utility services such as iCarBlackBox Lite, SnapTimer Lite, NO Camera+, and Private Camera 2 provide the utilitarian value for customers using camera function. For example, iCarBlackBox provides evidences in a case of car-accident, by automatically recording a car-accident. The next trend is related to the video-related services such as SynthCam, iSentry, and Portable Monitor. Extended from taking pictures, these services provide the video-recording services or motion-sensing function to the customers. Similar to other period, entertainment service and social communication service are also frequently found in 2011 as well.

6.2. Period determination of GTM-TT service map

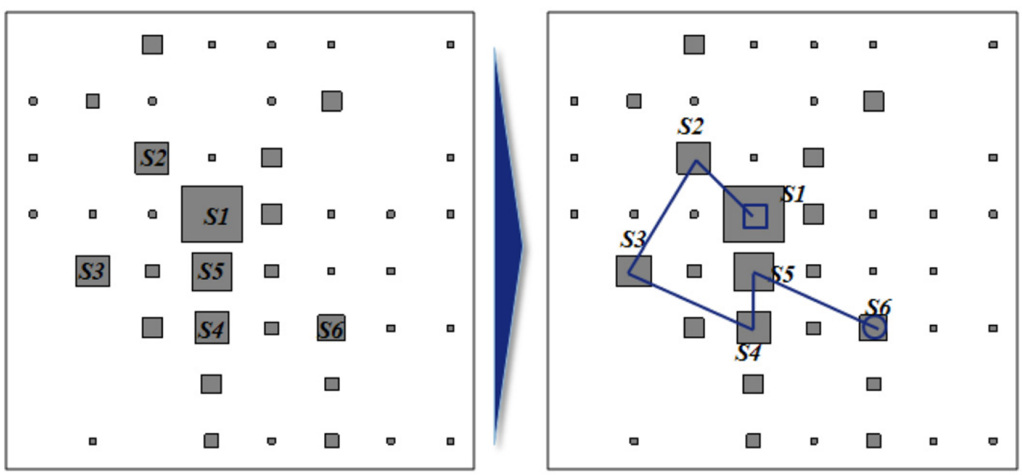
Since the aim of this paper is to construct the GTM-TT service map to identify the trends of service, dynamically, period determination is a significant issue to be considered. For example, the GTM-TT service map can be constructed for various time periods.

For example, three snapshot of Fig. 6 which shows the yearly trends can be differently constructed. For investigating three-year dynamics, we can gather the service data for 3 years and construct a single service map, illustrating the entire service trend for 3 years in a single map, as shown in Fig. 7. The result of three-year analysis is shown in Table 5.

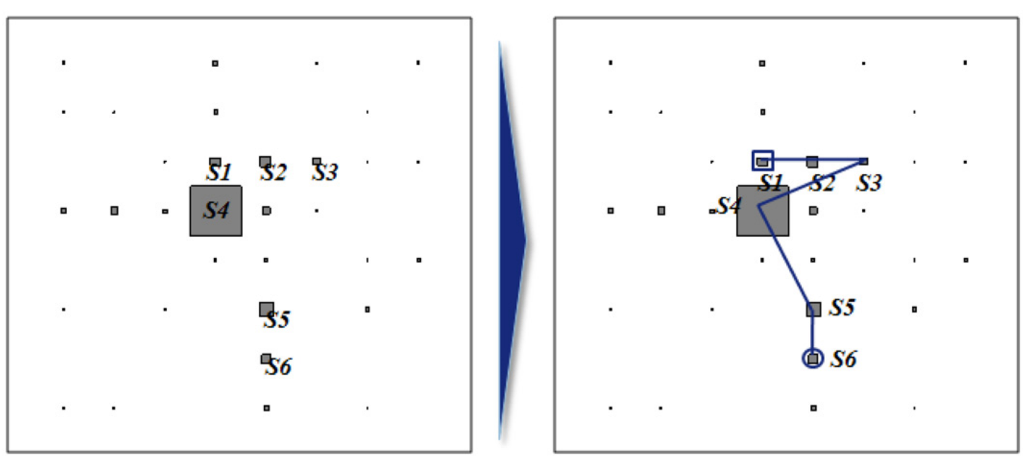
Comparing the result of Fig. 6 and 7, we can derive the important implication for determining the period for constructing the GTM-TT service map. Compared to the service map of three-year period, that of one-year period shows the close link between clusters. In other words, the distance between clusters seems to be closer in one-year period. This means that each cluster in three-year period is more unrelated and distinct than that in one-year period. This result is natural, since only 5 clusters are found in entire three-year period in Fig. 7 whereas 6 clusters are found in each year in Fig. 6. Of course, service trends in three-year period might be more generic whereas that in one-year period seems to be more



(a) Service cluster map (left), service sequence map (right) for 2009



(b) Service cluster map (left), service sequence map (right) for 2010



(c) Service cluster map (left), service sequence map (right) for 2011

Fig. 6. GTM-TT service map for each year (2009, 2010, and 2011).

specific. Summarizing the result, Table 6 summarizes the result of comparison different periods.

The determination of period can be decided according to the analyst's decision. If one wants to see the general patterns of longer period, a single map can provide a clear and neat view. However, if a firm wants to see more specific results, analysts should set the analysis period short, in order to provide more detailed view.

However, even when we determine the analysis period as longer, specific patterns can be also derived by controlling the number of grids. For example, currently 8 × 8 grids are used to provide the

Table 3
Service trends of camera technology-based mobile application services in 2009.

Group	Characteristic	Description	Mobile application services
S1	Entertainment	Creating different version of pictures or customizing photos	Sports Brush, iJuly4th, How2Draw Faces
S2	Social communication	Sharing experiences or emotions	Reflections, Visual Fusion Contribute, Emoji Brush Lite
S3	Entertainment	Adding a new function to the photos	Bobble Buddy, Zapp, HoloSnaps, SmackShot Lite, Wiggle3D
S4	Professional purpose	Providing feature-rich and easy-to-use photo editing/enhancing tool	PhotoCanvas, Foto Flair, Loupe
S5	Social communication	Providing easy update or easy access to the social network	Pichirp Pro, QUICKPING – Update 40 Social Networks At Once, Update Tycoon – Facebook + Twitter Tool
S6	Entertainment	Adding functions for fun	VooDude, Photo Geo, Tic Tac Face

Table 4
Service trends of camera technology-based mobile application services in 2011.

Group	Characteristic	Description	Mobile application services
S1	Entertainment	Providing additional functions for specialized experiences	Corel Paint it! Now, Happy Chinese New Year 2012 Dragon Photo Fun, Pacific Park on the Santa Monica Pier
S2	Utility	Providing special functions such as automated recording, protection, and privacy	iCarBlackBox Lite, SnapTimer Lite, NO Camera+, Private Camera 2 – protect your photos and videos
S3	Video related	Adding functions for video-related applications	SynthCam, iSentry, Portable Monitor (Camera to PC withOUT Client)–Third Eye Lite
S4	Entertainment	Providing fun by customizing the pictures such as color change, browsing, and retouching	Makeup Simulator, La Koketa – Your digital wardrobe and modern go-to stylist, ColorRetouch
S5	Social communication	Sharing photos or information with friends or family	iRate Bikez Pro, iRate Tats Pro, Paul
S6	Entertainment	Customizing pictures or their own backgrounds	Dog Booth, Glow Wallpapers for iPhone!, FaceBooth for iPhone Free

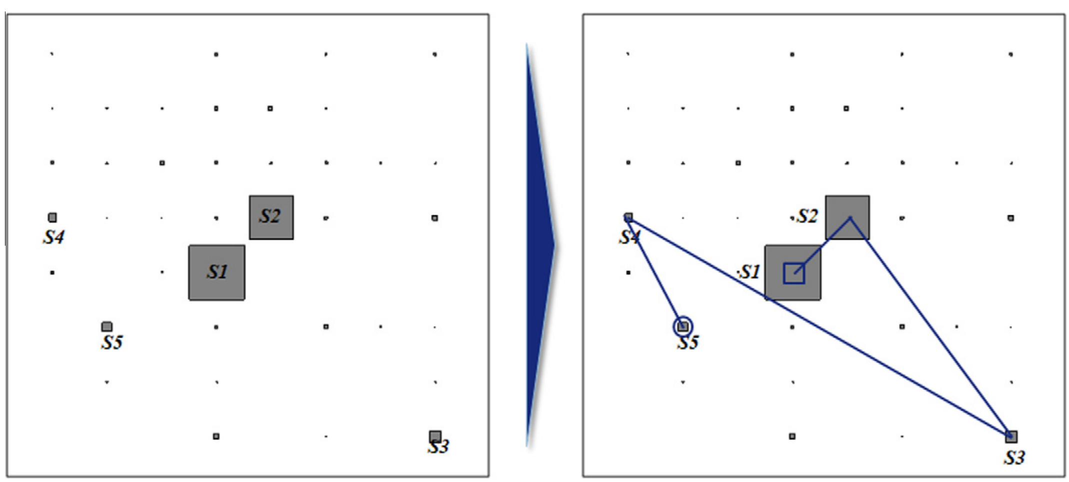


Fig. 7. Service cluster map (left), service sequence map (right) (from 2009 to 2011).

Table 5
Derived service trends for 3 years (from 2009 to 2011).

Group	Characteristic	Description	Mobile application services
S1	Entertainment	Creating different version of pictures or customizing photos	Sports Brush, Bobble Buddy, iJuly4th
S2	Utility	Providing useful functions by integrating camera	Smart Counter, PhotoFTP5, Alford Calc
S3	Social communication	Sharing photos or information with friends or family to survey	iRate Dogs Pro, iRate Bunnies Pro, iRate Tats Pro
S4	Photography	Providing skills and tips for photography	Photography Tips from QuickPro, Viewfinder Pro, Digital 201 from QuickPro
S5	Utility	Providing functions such as timer, thermal vision effect	SnapTimer Lite, Camera Timer + Lite, Thermal infrared camera

result. If more detailed information is required, one can increase the number of grids in order to derive more specific and detailed clusters. It should be noted that the generalization or specification of result does not solely depends on period determination.

Table 6
Comparison of period determination.

Comparison	Shorter period (e.g. 1 year)	Longer period (e.g. 3 years)
Purpose	Analyzing specific patterns	Analyzing general patterns
Distance of clusters	Relatively close	Relatively distant
Result	Specific	General

7. Conclusions

In spite of the growing importance of analyzing dynamic service trends, especially in mobile application services, most of the previous studies about service trend analysis have been focused on the traditional services and qualitative approaches. Therefore, this paper proposes a GTM-TT service map that can help us understand service trends, automatically and objectively. The detailed process of the proposed approach is presented, and a case study of camera technology-based mobile application service is conducted to illustrate the proposed approach. A JAVA program is first developed for collecting data from a data source and constructing a database. Multivariate time series data are then constructed with the aid of text-mining technique and domain experts. Thirdly, a dynamic service map is developed by executing a GTM-TT algorithm. Finally, interpretation of the resulted GTM-TT service map is conducted.

The main contributions and potential applications are as follows. First, the proposed approach can be employed for dynamic service trend analysis, ranging from the identification of service trends to the monitoring dynamic change path of service trends. Next, it is possible to understand the service trends at the service level as opposed to the company or industry level, which could be applicable to various research domains. Finally, this is an intelligent and pioneering approach that can analyze and visualize service trends and the dynamic change path of them, unlike previous qualitative approaches.

This study is an exploratory one and more extension and/or elaboration in terms of methodology and application will be required in the future. Among others, the following issues may be considered in ensuing research. First, information loss occurs during analysis since the GTM-TT service map is developed based on the chronological keyword vectors. Although the keywords are extracted by repetitive trial between text-mining technique and domain experts, some missing keywords or redundant keywords may existed. Therefore, further studies need to develop a more systematic approach for keyword extraction and validation of the extracted keywords. Second, the validity of this approach necessitates more testing work employing other service documents, which will be indispensable for gaining external validity. Finally, the whole process needs to be systemized and automated. Although an automated supporting system has been developed, there is still considerable scope for further work to enhance operational efficiency. These topics would be fruitful areas for future research.

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