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Using Web Mining and Perceptual Mapping to Support Customer-Oriented Product Positions and Designs

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Abstract. In recent years, many e-commerce websites provide consumer feedback functions and social networks, allowing customers to share their purchasing and usage experiences online. Companies collect and analyze information from customers' reviews through the platform to understand the customers impressions of the products they purchased. Online customer reviews has been widely regarded as an important source of information influencing customers buying decisions. In addition, online customer reviews help companies to redesign their products with key features that better positions to target customers in promising market sectors. This research uses online customer reviews as the business intelligence (BI) corpus. After determining the source webpage of customer reviews, a web crawler is needed to collect customer review text. Afterwards, computer-assisted text mining, clustering analysis, and perceptual mapping are applied to develop a formal methodology to compare similar products in a given domain. In this research, the consumer electronic sector is studied. Mobile phone customer reviews are web crawled, collected, mined, and analyzed. The study assists mobile phone manufacturers to understand the voice of customers in both positive and negative perspectives of post-purchasing experiences. The customer-preferred product functions, hardware/software/app features, and price positions, as key business intelligence, are derived for new product designs and market launches.

Keywords. Web crawling, Web mining, Clustering analysis, Perceptual map, Market positioning

Introduction

According to the report of Internet World Stats in November 2015, there are more than three billion Internet users in the world, which account for 46% of the world population [1]. As e-commerce grows, more and more people purchase products through the Internet [2]. E-Marketer, an independent market research company, predicted that business-to-consumer (B2C) e-commerce sales worldwide will reach about $1.9 trillion in 2016 and increase about 13% compared with 2015 [3]. In addition, the emergence of advanced shipping and payment options influences the growth of B2C e-commerce

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sales, while major brands now are actively exploring new international markets that leverage online rapid channel fulfillment and transactions [4].

Online shopping create emerging business opportunities. Companies are competing to create more effective Internet business processes. As the e-commerce websites mature, they provide user-friendly interfaces for customers to place an order, pay for products, and track the order. When customers receive the products, e-commerce websites provide a review platform for customers to share their shopping experience. As a result, sellers are able to analyze the customer's experience, which facilitates the use of customer feedback to redesign products or services in adapt or create products which meet expectations. When customers are satisfied with their products, they will be more willing to trade with the seller again [5]. On the other hand, potential customers can also use the review platform to determine whether the product meet their choice criteria [6].

In order to let customers write down genuine comments reflecting their post-purchase experience, many e-commerce websites allow customers who have already purchased products submit reviews. An open and anonymous space to express satisfaction and dissatisfaction provides a less biased report of the purchase process. Online customer reviews have been widely regarded as an important element in the customer decision-making process [7]. Furthermore, online customer reviews affect potential customers' perception of products and influence the sales of product [8].

To understand the customer's experience, companies collect numerous customer reviews to search for information that can be used to create and maintain strategic advantage by monitoring the value proposition. This research collects e-commerce customer reviews by using a web crawler. After data compilation, customer reviews are mined, clustered and analyzed. Then, the research use perceptual maps to compare the capability and pricing of competitor's products. The difference of many product reviews can be observed via data visualization. This research develops a way to help companies efficiently understand the voice-of-customers and guide strategic decision making to re-design products and make new product prices. The paper is organized as follows. Section 1 reviews and discusses the background literature. The methodology and case implementation are described in Section 2. Finally, the concluding remarks are provided in Section 3.

1. Literature Review

In this section, the literature related to web crawling, text mining, cluster analysis, and perceptual mapping are discussed.

1.1. Web crawling

Web crawlers are a system which seek specific web page data to download and are one of the main components of web search engines. Web crawlers aggregate massive numbers of web page data through the Internet for later processing by web search engines. The data are indexed and the downloaded pages are identified by hyperlinks. Therefore, users can efficiently find the web pages which match the queries using web search engines. Web crawlers are used for a variety of purposes. Some periodically collect large sets of web pages and save the data for posterity [9]. Web data miners use web crawlers to collect data for statistical analysis [10].

Researchers collect data from web pages to analyze customer purchase data or reviews. Bross acquires hotel reviews from Tripadvisor.com and digital camera reviews from Amazon.com, Epinions.com, and Buzzillions.com to extract and detect product aspects described in customer reviews [11]. A web crawler is used to collect customer purchase data from www.gonsen.co.kr and analyzed customer demographic variables and segment customers by lifestyle [12]. Xiang et al. obtain customer reviews from Expedia.com with a web crawler to explore the relationship between hotel guest experience and satisfaction [13].

1.2. Text Mining

Text mining is frequently as a means to structure and automatically detect information such as trends from unstructured text [14]. Text mining can extract valuable information and guide organizations toward effective solutions [15]. There are several components to text mining including text segmentation, summary extraction, stemming, keyword identification, topic detection, taxonomy generation, term clustering and document categorization. With these components, unstructured text documents are transformed into knowledge [16].

People using the Internet to leave a history of their personal shopping experiences, product views and often write opinions. These online usage trails help researchers to understand the consumer behavior of customers which improves current products or services. Customer reviews and store advertising are collected from three American pizza stores on Facebook and Twitter and text mining is used to explore the customers' emotions and responses from advertising [17]. Researchers use text mining and content analysis to explore the determinants of customer satisfaction for hotel reviews [18]. Digital cameras reviews are collected from Testfreaks.com and a rule-based approach system and text mining are used to extract and identify critical product features [19].

1.3. Cluster Analysis

Clustering is a common method for statistical data analysis, which groups similar objects into the same cluster without pre-definition. The objects in a cluster are very similar to one another and very different from the objects in other clusters [20]. It is a type of unsupervised machine learning, which is used to derive the structure of the data sets and does not require labelled training data or any pre-assumptions [21].

Clustering algorithms often divided into two categories, including partitioning methods and hierarchical methods. The process of partitioning methods generates a single partition of the data in an attempt to recover natural groupings of the data sets. Partitioning clustering includes k-means, k-medoids, k-mode, and genetic k-means algorithm (GKA). Hierarchical methods are characterized by the tree structure which establishes the course of the analysis. There are two approaches used for hierarchical methods. One is agglomerative and the other is divisive. Hierarchical clustering includes Ward's method, balanced iterative reduction and clustering using hierarchies (BIRCH), and clustering using representatives (CURE) [22].

1.4. Perceptual Mapping

The concept of product positioning was presented in early 1972 which is an important element of marketing strategy. Product positioning is affected by several factors such

as product characteristics, consumer characteristics, company's marketing strategy, competitors, and customer perceptions [23]. Product positioning is used to identify the customers' view of product and assists companies in comparing their product with competitors' products. Companies implement new marketing strategies to achieve a desired market position [24].

A perceptual map is used with product positioning to depict customer perceptions and product characteristics (e.g., product price, quality, attribute rating). Perceptual mapping helps to visualize consumer perceptions of product alternatives. Companies identify the market gaps and explore alternative designs using perceptual mapping [25].

2. Methodology and Case Demonstration

The methods used in the research are mentioned in this section. The research applies web crawling, mining and perceptual mapping to collect and analyze e-commerce feedbacks as customers' post-purchasing experiences. Thus, customer-oriented product positions and design improvement using updated online customer reviews can be implemented. There are five formalized steps in the research including data collection via web crawling, data preprocessing, text mining, clustering analysis, and perceptual mapping.

In the data collection process, the online customer reviews are used as raw data. The target e-commerce website and product are selected as the case product and the data is retrieved by the web crawler and exported to a database. Low meaning words and phrases are deleted in the data preprocessing and the text mining technique is applied to extract key terms. Clustering analysis devides the customer reviews into groups that are meaningful or useful. Finally, perceptual mapping visualizes cunsumer perceptions of product alternatives.

2.1. Data collection

In the research, the customer reviews of Amazon.com were used as the data source. Amazon.com was chosen because it is the most popular e-commerce website, which represent a large sample of online EC customers. Besides, Amazon.com restricts and verifies that the purchase reviews can only be keyed into the systems by customers who have purchased specific products at Amazon. After selecting target website, the research selects ASUS ZenFone2 (type: ZE551ML) mobile phone as a specific product in the case study. The customer reviews pages addressing ZenFone2 post-purchasing opinions are used as the web content for analysis. In the customer reviews page, the research captured customers' review date, stars, title, and opinion text using the web crawaler tool, WebHarvy (2016). This research collected 1,914 ZenFone2 customer reviews which were writen during May 18 to November 4, 2015. All extracted data are exported by WebHarvy to a CSV-file for further text mining and subseqent analysis.

2.2. Data preprocessing

After the data collection process, low meaning words and phrases are deleted. For example, in Amazon, if a customer does not write the review title, the system automatically uses the customer star level (e.g., five stars or four stars) to fill in the review title field. Therefore, the research deletes these characters. The customer

reviews are divided into positive and negative reviews using established rules. In this study, four and five stars reviews belong to positive reviews. On the other hand, one to three stars reviews belong to negative reviews. In addition, if a review mentions both pros and cons, the research divides the review into positive and negative reviews.

2.3. Text mining

This research uses the statistical software R to extract the key terms in both positive and negative reviews [26]. The data must be preprocessed including word segmentation, stop words removal, and stemming. Second, calculate the normalized term frequency-inversed document frequency (NTF–IDF) of each terms. After that, delete the terms which are low meaning and select the key terms by sequencing the value of NTF–IDF. This research selected 150 key terms of each positive and negative reviews.

2.4. Clustering analysis

After selecting the key terms from positive reviews and negative reviews, the research uses K-means clustering algorithm to cluster the customer reviews. In clustering analysis process, delete the review without the key terms and calculate the cosine similarity to understand correlation between all pairs of comments. A total 1,213 sets of positive reviews categorized into the three groups and 483 sets of negative reviews categorized into the four groups are calculated by R-Squared (RS) and root-mean-square standard deviation (RMSSTD).

According to the clustering analysis of the positive key terms, cluster 1 reviews mostly discuss about the customer's emotion, the overall of mobile phone appearance, and performance. In cluster 2, the reviews focuses on the battery which can be charged fast. The reviews also mentioned that the app, performance, appearance, camera, signal and connection of mobile phone. The reviews of cluster 3 focuses on the price of the product. It also discusses about the mobile phone performance, customer's emotion and behavior. The brief result of the positive key terms clustering are shown in Table 1.

Table 1. The summary result of the positive key terms clustering.

Cluster 1 (89 reviews)		**Cluster 2 (446 reviews)**		**Cluster 3 (678 reviews)**	
Category	Key terms	Category	Key terms	Category	Key terms
Emotion	love	Battery	battery, battery life, charge	Price	price, phone price, money, great price, cheap
Appearance	size, big	Software	app	Performance	fast, perform
		Performance	perform, fast		
		Appearance	button, big, size, slot	Emotion	happy, love, satisfy, love asus
Performance	perform, quality, fast	Camera	camera	Behavior	recommend, high recommend
		Signal and Connection	sim, call, dual sim, lte		

On the side of negative key terms, cluster 1 mainly discusses about dissatisfied the customer service of replacement or repairs. In cluster 2, the reviews focuses on the signal and connection of sim card or network. Its also mentioned the appearance and bad performance of mobile phone. As regards cluster 3, reviews complain to the battery (can not remove battery and battery drain fast) and the bloatware. Furthermore, its

mentioned that some customers were not satisfied with the design of power button. Cluster 4 reviews focuses on the mobile phone screen and touch function and indicates the camera and bad performance such as mobile phone freeze or heat up. Signal and connection, customer's emotion and phone accessories are mentioned in cluster 4. The abbreviated result of the negative key terms clustering are summarized in Table 2.

Table 2. The summary result of the negative key terms clustering.

Cluster 1 (20 reviews)		**Cluster 2 (40 reviews)**		**Cluster 3 (139 reviews)**		**Cluster 4 (284 reviews)**	
Category	Key terms	Category	Key terms	Category	Key terms	Category	Key terms
Service	service customer-service customer	Signal and Connection	sim sim card lte network	Battery	battery battery-life charge power remove drain	Screen	screen touch
						Camera	camera
						Performance	freeze heat restart
Behavior	replace repair	Appearance	slot plastic	Software	app bloatware	Signal and Connection	bluetooth internet call lte miss
		Performance	stop defect hot stop-work	Appearance	button power-button	Emotion	disappoint
						Accessories	earphone case protector

2.5. Perceptual mapping

Collecting the customer reviews of competitors' products and extracting key terms to compare and analyze product positions is the mainly function of perceptual mapping. Three competitors' products are collected to compare including Sony Xperia M4 Aqua Dual, LG G3, and Samsung Galaxy Alpha. The price and camera are selected as two variables in the study. For draw the perceptual map, the average of highest and lowest price for each product is used in place of the real price because the purchased price can not be collected on Amazon.com. The related information including the product's average price and camera features are integrated in Table 3.

Table 3. The comparison of the case and competitors' products.

Product	**ASUS ZenFone 2**	**Sony Xperia M4 Aqua Dual**	**LG G3**	**Samsung Galaxy Alpha**
Total reviews	1696	107	461	241
Positive reviews	1213	76	364	197
Negative reviews	483	31	97	44
Time to market	May 2015	June 2015	May 2014	September 2014
Period of reviews	2015/5/18 to 2015/11/4	2015/7/17 to 2015/12/22	2014/7/10 to 2015/12/21	2015/2/27 to 2015/12/18
Avg. price (USD)	264	249.99	320	349.99
Rear camera	13 Mega-Pixel	13 Mega-Pixel	13 Mega-Pixel	12 Mega-Pixel
Front camera	5 Mega-Pixel	5 Mega-Pixel	2.1 Mega-Pixel	2.1 Mega-Pixel

The research uses NTF–IDF value of related key term to draw the perceptual map. Besides, the NTF–IDF values from negative reviews will be negative values. In this case, the research would draw the perceptual map by using the NTF–IDF value of the word "camera." The two dimensions perceptual map displays in the box-and-whisker plot is shown in Figure 1. The box plot is a standardized method of displaying the distribution of a dataset based on the five number summary including minimum, first

quartile, median, third quartile, and maximum. Box plot also can be used to compare several different populations. In the box plot, the line in the box indicates the median and the top and bottom lines of the box indicate third and first quartiles. Therefore, 50% of the sample polutation fall inside the box. In addition, the lower and upper bars represent the lower 2.5% and the upper 97.5% of the distribution. The outliers are plotted as points in Figure 1. Due to the box plot of Sony is relatively tall and lower site than others, it represents that customers hold inconsistent opinions about the camera feature and reviews of Sony camera wouldn't better than the others. As regards the box plot of ASUS, more positive reviews of camera features than negative ones because it located approaching the positive region. ASUS has lots of outliers and negative outliers are more than positive ones. This might indicate that ASUS could pay more attention to these negative comments.

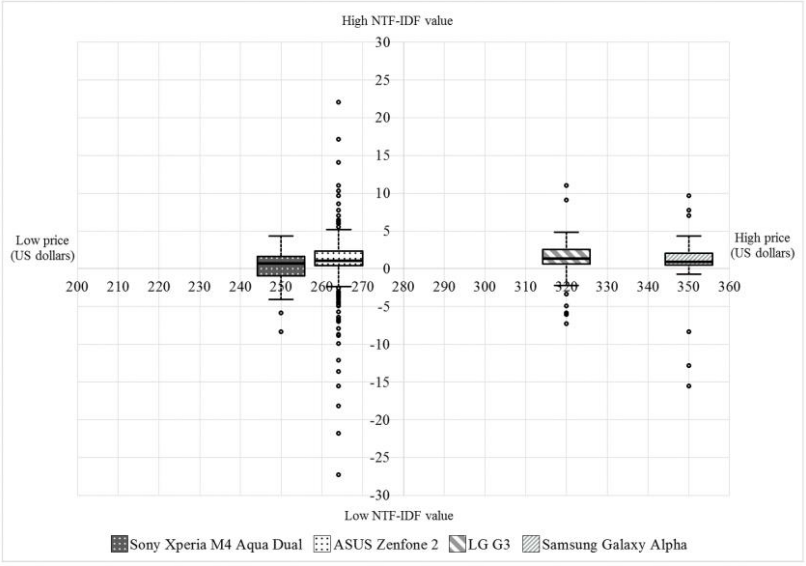

Figure 1. Perceptual map with the box plot (price vs. camera).

The proportion of the four products reviews related to key word "camera" is shown in Figure 2. To determine whether there is a significant relationship between the brand and the reviews with key word "camera" or not, the research uses chi-square test of independence. Chi-square test of independence could be used to examine two variables' association. The hypothesis test for H_0 is that there is not a significant association between the two variables, and H_1 is that there is a significant association between the two variables. The related mathematical formula is shown in Equation 1.

Using the number of reviews which mentioned the "camera" and the number of reviews which don't mentioned the "camera" to calculate the chi-square test statistic $\chi^2 = 23.5653$, with $df = 3$ and $\alpha = 0.05$. This chi-square distribution had threshold of 7.815. Since the value of test statistic (23.5653) was more than threshold value, we should reject H_0. Under the significance level of $\alpha = 0.05$, the study verifies products may have some association with the status of reviews.

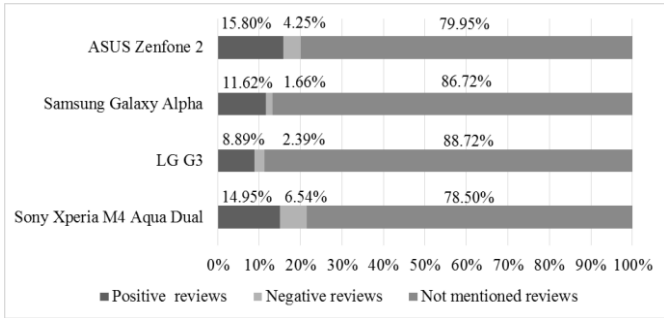

Figure 2. The proportion of reviews related to key word "camera."

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij}-E_{ij})^2}{E_{ij}} \tag{1}$$

$$O_{ij} = n_{ij} \text{ and } E_{ij} = \frac{n_{i.} \times n_{.j}}{N}$$

The research uses Based on the proportions of reviews related to key word "camera" (Figure2), this study uses Z test to compare two population proportions and calculate the Z test statistic (Z_s). The mathematical formula is shown in Equation 2. The hypothesis test for H_0 is $p_1 - p_2 \geq 0$, and H_1 is $p_1 - p_2 < 0$.

$$Z_S = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}\hat{q}(\frac{1}{n_1}+\frac{1}{n_2})}} \sim \mathrm{N}(0,1) \tag{2}$$

$$\hat{p} = \frac{n_1\hat{p}_1 + n_2\hat{p}_2}{n_1 + n_2} \quad \text{and} \quad \hat{q} = 1 - \hat{p}$$

$\hat{p}_1$ is the proportion in sample 1. n_1 is the size of sample 1.

Under the significance level of $\alpha = 0.05$, when $Z_s \leq -1.645$, there is enough evidence to reject H_0 . The value of Z_s and the results of Z test are shown in Table 4. As the results of Z test, ASUS is significant larger than LG and Samsung based on the percentage of the positive reviews with key word "camera." Furthermore, Sony cellphone is significant larger than LG cellphone. On the other hand, ASUS is significant larger than LG and Samsung based on the percentage of the negative reviews with key word "camera." Sony is also significant greater than LG and Samsung cellphone.

Table 4. The results of Z test.

Product($\hat{p}_1$) / Product ($\hat{p}_2$)	ASUS ZenFone 2	Sony Xperia M4 Aqua Dual	LG G3	Samsung Galaxy Alpha
ASUS ZenFone 2	-	(P) -0.2337	(P) -3.7542*	(P) -1.6890*
		(N) 1.1257	(N) -1.8402*	(N) -1.9344*
Sony Xperia M4 Aqua Dual	(P) 0.2337	-	(P) -1.8794*	(P) -0.8638
	(N) -1.1257		(N) -2.2109*	(N) -2.4022*
LG G3	(P) 3.7542	(P) 1.8794	-	(P) 1.1513
	(N) 1.8402	(N) 2.2109		(N) -0.6319
Samsung Galaxy Alpha	(P) 1.6890	(P) 0.8638	(P) -1.1513	-
	(N) 1.9344	(N) 2.4022	(N) 0.6319	

Note: *: Significant ($\alpha = 0.05$), reject H_0 ; (P): positive reviews; (N): nagetive reviews.

The research suggests that ASUS improves the design of cellphone camera, battery, screen, and connection technology. The decision makers and developers should reduce the bloatwares or let users remove the battery by themselves. The customer service can be examined and verified to make them feel satisfied. the system of mobile phone can be enhanced to keep it working stably and prevent the heat up. Since the reasonable price of ZenFone 2 has much praise from the customers, ASUS should keep using the strategy of parity price to create competitive advantage for the new generation product. Sony Xperia M4 Aqua Dual is a stronger competitor's product than others since there are no significant differences between their percentage of the positive reviews. The research suggests that ASUS should pay more attention on the trend of Sony. Furthermore, the average prices of LG G3 and Samsung Galaxy Alpha are higher than ASUS ZenFone 2, while their camera features are not as good as ZenFone 2's, ASUS can consider increasing the price of future products or improve other weaknesses first.

3. Conclusions and Future Research

The results of this study can be used as a reference for enterprises to efficiently understand customer experience and feeling from a lot of online reviews. Though the post-purchasing experiences of the consumers, the company finds the direction of product redesign to improve constantly. The methodology of this research discover the customer-preferred product functions and features to understnand the differnece between other competitors' products.

In the future, this research will implement the heterogeneous information network to develop a method which assists companies to forecast the customer needs. Using different types of objects and interactions to show the relationship between all the objects to represent an abstraction of the real world. The research hopes that the forecast from heterogeneous information network method will help companies to seek new potential customers.

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