BEYOND OPINION MINING
How can Automatic Online Opinion Analysis Help in Product Design?

Ying Liu
Dept. of Industrial and Systems Engineering, Hong Kong Polytechnic University, Hong Kong SAR, China

Keywords: Opinion Mining, Sentiment Analysis, Quality Function Deployment, QFD, Product Design, Design Informatics.

Abstract: The rapid development of WWW, information technology and e-commerce has made the Internet forums, e-opinion portals and personal blogs widely accessible to consumers. As a result, nowadays it has become extremely popular for consumers to share their experience, point out their preferences and concerns with respect to a specific product on Web. These online customer reviews possess vital information that product designers can gain insights of their customers and products, and make improvements accordingly. However, the sheer amount of data, their distributed locations and the inherent ambiguity of human language have challenged designers greatly. In this paper, we aim to outline an intelligent system that is able to first automatically gather global online reviews with respect to certain products interested, identify the product features and customer requirements, and most importantly relates them to the product's engineering characteristics through quality function deployment (QFD), a tool that is widely used by product designers in the customer-driven design paradigm. Meanwhile, we also highlight the challenges and relevant research issues in order to fulfil such an ambition. As a pioneer study, we believe that this research will greatly help designers in the era of global competition and e-commerce.

1 INTRODUCTION

Very recently, the rapid development of Internet, information technology and e-commerce has made the online forums, e-opinion portals and personal blogs widely accessible to consumers (B. Liu & Chang, 2004). As a result, nowadays it has become extremely popular for consumers to share their experience with the products, point out their preferences and concerns on Web. In the last few years, we have witnessed an enormous interest on automatic online opinion analysis in the major research forums like SIGKDD, WWW, SIGIR and CIKM (Ding & Liu, 2007; Ding, Liu, & Zhang, 2009; Jiang & Yu, 2009; Qi et al., 2008). Furthermore, the attention on opinion analysis has also been quickly spread from its original target at product reviews of particularly consumer products to many other fields, like movie review analysis (Zhuang, Jing, & Zhu, 2006), political and legal issues (Lu et al., 2009; B. Yu, Kaufmann, & Diermeier, 2008), blogs (Bossard, Généreux, & Poibeau, 2009; Jack & Frank, 2007) and so on, with an ultimate goal to better understand the preferences of the "consumers", e.g. product end users, movie audiences, travellers and even the potential ones.

As a matter of fact, take the pioneer work on the analysis of online customer reviews as an example (B. Liu, Hu, & Cheng, 2005; Popescu & Etzioni, 2005), these reviews are vital in at least two senses (Y. Liu, Lu, & Loh, 2007):

- On the one hand, product designers can gain more insights from the analysis of these review documents concerned about not only their customers and products but also their competitors' customer groups and products. Strategic adjustment as well as technical improvements can be made accordingly.
- On the other hand, these reviews often become the major sources that will guide potential consumers in their purchase decision making. The general perception that potential consumers gathered from such comments will highly possibly affect their final decision in selecting a specific brand and model.

Therefore, it is imperative to assist designers in processing, understanding and taking advantage of such information, although the sheer amount of data

Liu Y.
BEYOND OPINION MINING - How can Automatic Online Opinion Analysis Help in Product Design?.
DOI: 10.5220/0002860203130318
In *Proceedings of the 6th International Conference on Web Information Systems and Technology (WEBIST 2010)*, page
ISBN: 978-989-674-025-2

and their heterogeneous nature, distributed locations and the intrinsic nature of language ambiguity are all nontrivial issues.

In the customer-driven design paradigm, quality function deployment (QFD) is one of the essential tools to interpret customers' requirements (voice-of-the-customer), relate them to various engineering characteristics and eventually output the specifics of engineering requirements, e.g. target values (Cohen, 1995). In fact, as a widely used tool, QFD has a rich application foundation in industry, from conceptual design to process planning, and from consumer product design to construction project management (Chan & Wu, 2002).

However, existing studies on opinion mining focus mainly on feature identification and extraction and its sentiment analysis (Ding, Liu, & Yu, 2008; Ding et al., 2009; Gamon, Aue, Corston-Oliver, & Ringger, 2005; Minqing Hu & Bing Liu, 2004; S.-M. Kim & Hovy, 2004; Nitin & Bing, 2008). In literature, it has not been reported how design community can actually benefit from such efforts in opinion mining. In this paper, it is of our interest to bridge these two communities and demonstrate how designers can take advantage of these largely untapped sources of customer need information in a way that they are familiar, i.e. through QFD. We trust the outcome of our research will offer design personnel the agility to handle the large amount of valuable online information more effectively and efficiently.

This paper is organized as follows. In Section 2, we focus on the review of status quo of both opinion mining and quality function deployment. The overall system architecture is explained in Section 3 along with our research plan. Section 4 lists the challenges and research issues that we are interested. Section 5 concludes.

2 RELATED WORK

2.1 Opinion Mining

In the past few years, there has been an obviously rising interest on the topic of automatic parsing and analysis of online customer reviews in various major research forums. Hu and Liu proposed a method that uses various word features, including occurrence frequency, part-of-speech tags and synonym set in WordNet (M. Hu & B. Liu, 2004). While they called it a summarization, their basic idea is to identify the pair of a noun word and its nearest opinion word. Popescu and Etzioni have proposed the OPINE system, which uses relaxation labeling for finding the semantic orientation of words (Popescu & Etzioni, 2005). Their work focuses more on the identification of opinion orientations, e.g. favor or disfavor. Zhung et al. have also applied some similar strategies on the analysis of movie reviews (Zhuang et al., 2006). Ding et al. have proposed a holistic lexicon based approach by using external evidences and linguistic conventions to identifying the semantic orientation of opinions (Ding et al., 2008), and later on a further work on product entity discovery and entity assignment (Ding et al., 2009). Su et al. have studied a mutual reinforcement approach to deal with the feature-level opinions with a goal to discover hidden sentiment association from Chinese Web pages (Qi et al., 2008). Recently, an iterative reinforcement scheme based on improved information bottleneck (Weifu & Songbo, 2009), a lexicalized hidden Markov model based learning framework (Wei & Hung Hay, 2009) and also summarization approach (Bossard et al., 2009; Zhan, Loh, & Liu, 2009) have also been reported.

Other related studies include sentiment analysis and subjective classification, for example, using a word sentiment classification approach (S.-M. Kim & Hovy, 2004), a bootstrapping process to train a sentiment classifier (Gamon et al., 2005; Riloff, Wiebe, & Wilson, 2003), a unsupervised approach coupled with Bayesian classifier (H. Yu & Hatzivassiloglou, 2003), an extraction pattern learner and a probabilistic subjectivity classifier using only un-annotated texts (Wiebe & Riloff, 2005), an approach utilizing the linguistic constraints on the semantic orientations of adjectives in conjunctions (Hatzivassiloglou & McKeown, 1997), a WordNet approach using semantic distance from a word to "good" and "bad" in WordNet as the classification criteria (Kamps & Marx, 2002), a latent semantic analysis based approach where cosine distance is introduced (Turney & Littman, 2003), and finally an approach using semantic factors (Osgood, Succi, & H.Tannenbaum, 1957) and some syntactic information in the feature sets of support vector machine (Mullen & Collier, 2004).

2.2 Quality Function Deployment

Originally introduced in Japan in the late 1960s (Akao, 1990), quality function deployment (QFD) has gained international acceptance and has become a widely used tool in the paradigm of customer-driven product design and manufacturing (Chan & Wu, 2002; Cohen, 1995). Through the House of Quality (HoQ), customer requirements are identified and related to product engineering characteristics,

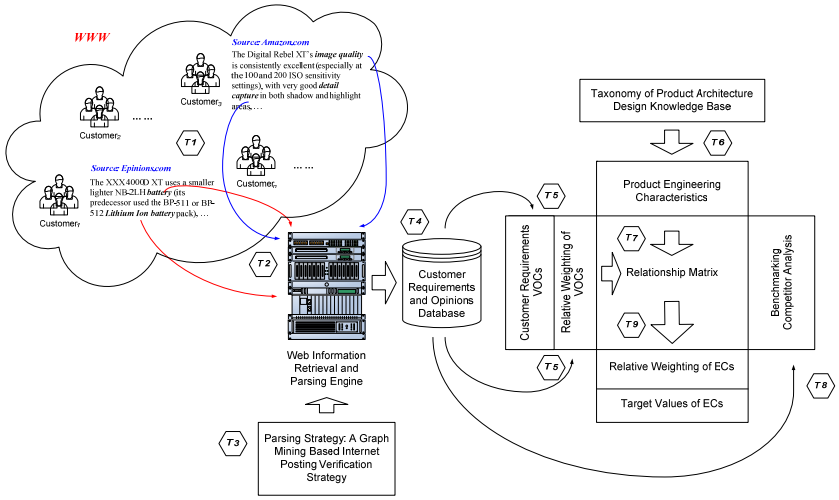

Figure 1: The system architecture of the proposed system.

product planning, part deployment and even manufacturing operations .

Recently, the analytic hierarchy process (AHP) (Saaty, 1980) had been introduced to handle the design concept variations and to calculate the relative importance of customer preferences (Fung, Popplewell, & Xie, 1998). The AHP methodology basically establishes a design concept hierarchy with prioritized subordinates and then decomposes the linguistic based customer requirements into different levels of subordinates and alternatives reliably and consistently according to their correlation (Saaty, 1980). Due to the intrinsic ambiguity of human language and the substantial degree of human subjective judgment involved in the voice of the customers as well as the identification of engineering features in product characteristics and their association (K. J. Kim, Moskowitz, Dhingra, & Evans, 2000), it had been argued that linguistic variables expressed in fuzzy numbers seem more appropriate for describing those inputs in QFD (Chen, Fung, & Tang, 2006). This is in contrast to the previous efforts where the input variables are assumed to be precise and are treated as numerical data only (Grifn & Hauser, 1993; Gustafsson & Gustafsson, 1994). Some recent research efforts reported mainly focus on taking advantage of fuzzy set theory (Zadeh, 1965) in QFD (Harding, Popplewell, Fung, & Omar, 2001; Kwong & Bai, 2002; Temponi, Yen, & Tiao, 1999).

3 SYSTEM FRAMEWORK

From the previous literature review, in summary, while the importance and value of online customer opinions are well perceived, the idea of intelligent processing of such reviews and feedbacks and relate them to QFD, a prevailing tool widely used in the design community as well as industry scenarios, has never been studied before. In order to fulfil such a gap, we propose an intelligent system to tackle this. The system proposed has integrated various latest research topics in data/text/Web mining, information retrieval, machine learning and QFD.

Figure 1 shows the system architecture. Basically, there are four key elements:

- Sources of online opinions and reviews.
- A engine for Web information retrieval and parsing.
- A data warehouse of customer requirements and opinions (orientations).
- A knowledge-based fuzzy QFD module.

In terms of research plan, the proposed project has been divided into two main phases based on the generic nature of tasks at different stages.

In Phase 1, the research and development of Web information retrieval and parsing engine for online reviews will be carried out. the major research tasks include: (1) An information retrieval engine which is able to gather online customer reviews that are of interest; (2) A comprehensive strategy which is able to retain genuine customer opinions by excluding Internet frauds, invited attacks, duplication and so on; (3) A machine learning approach which is able

to parse and identify the salient or obscure product features and customers' concerns with their opinions associated, with or without the assistance of design knowledge base; (4) A multi-facet modeling of information based on relevant ingredients, e.g. brands, features and opinions associated, geographic locations and age groups, whenever the information is available.

In Phase 2, we focus on the research and development of a knowledge based QFD. The major research tasks include: (1) Design knowledge based engineering characteristics identification; (2) Weight computation of product features as well as customer concerns (of the target product); (3) Competitive analysis of product features and their weights (of competitors' products); (4) Functional relationship identification and target value specification of engineering characteristics.

4 CHALLENGES AND RESEARCH ISSUES

The research and development of the proposed intelligent system are challenging in several ways. In the following, we briefly outline some of these challenges and research issues.

- Although, it has become a general perception that online customer reviews are valuable, it lacks of an effective as well as efficient strategy to identify the review sources, gather and further exploit these large quantity of customer need information. This problem is particularly severe when a company is new to a specific market.
- Internet frauds, invited attacks, duplications and many other types of misleading messages with either good or bad comments are serious problems that should be carefully handled. While people in marketing research may not give enough attention to this issue, it is critical in serving product designers to accurately understand the messages from end users. A typical example is that a favourable comment and a critical note questioning certain product features present different values to designers.
- The contents of different customer messages challenge us most. There are quite a few tough issues, to name some: 1) Vague language and different ways of expression, e.g. different vocabulary and terminology, which affects the identification of product features and the subsequent tasks that relate them to QFD. 2) How to tell a comparative review? How to effectively tell the features extracted and correspond them to their original products that are under comparison? 3) Can we rank the posts based on their values of contents with respect to different groups of interests, e.g. designers?
- Most existing QFD studies suffer from a very limited quantity of customer surveys where customers' concerns are underrepresented due to many reasons like cost and confidentiality of data. However, collecting customer need information from Internet, after successfully filtering, will provide a sufficient amount of data samples to represent the "Big Picture" of the product or the potential design scheme that is in the pipeline. This will offer a unique opportunity for further statistical study on customer behaviors and market trends, where a large amount of data is often deemed right. Meanwhile, we also intend to build a multi-facet model where geographic locations and ages are available. This provides an interesting dimension to designers.
- It is also not an easy task to precisely relate different customer opinions extracted to the engineering characteristics automatically. A knowledge mapping needs to be learned from the design knowledge repository to indicate the relations between the features identified and their corresponding product engineering requirements.
- With respect to competitors' benchmarking, while we envision that our system can provide a rare opportunity that it is now possible to gather customer comments about competitors' similar products and it offers designers a possibility to eye on their competitors in a timely and effective manner, it relies on the success of every previous step.

5 CONCLUSIONS

It has been witnessed an increasingly popularity on the analysis of online opinions due to their obvious implications to customer understanding, marketing and sales and product design. In this paper, we highlight the gap existed between the current approaches on online opinion analysis and the expectations from the design community. We argue that one ultimate goal of opinion analysis is actually to offer designers a comprehensive view of customer experience, feelings and most importantly to provide a collection of clues or evidences for designers to better understand the voice of the customer, hence, refine and improve their existing product offerings accordingly. In this paper, an intelligent system that

intends to tackle this has been proposed while the challenges and research issues are outlined. We are certain that the realization of such a system will help greatly in design.

ACKNOWLEDGEMENTS

The work described is currently supported by two GRF grants from UGC, Hong Kong SAR, China (RGC Ref: 520509 and 520208).

REFERENCES

Akao, Y. (1990). *Quality Function Deployment: Integrating Customer Requirements into Product Design (translated by Glenn Mazur)*. Cambridge, MA: Productivity Press.

Bossard, A., Généreux, M., & Poibeau, T. (2009). *CBSEAS, a summarization system integration of opinion mining techniques to summarize blogs*. Paper presented at the Proceedings of the 12th Conference of the European Chapter of the Association for Computational Linguistics: Demonstrations Session.

Chan, L.-K., & Wu, M.-L. (2002). Quality function deployment: A literature review. *European Journal of Operational Research, 143*(3), 463-497.

Chen, Y., Fung, R. Y. K., & Tang, J. (2006). Rating technical attributes in fuzzy QFD by integrating fuzzy weighted average method and fuzzy expected value operator. *European Journal of Operational Research, 174*(3), 1553-1566.

Cohen, L. (1995). *Quality Function Deployment* (1st ed.): Prentice Hall PTR.

Ding, X., & Liu, B. (2007). *The utility of linguistic rules in opinion mining*. Paper presented at the Proceedings of the 30th annual international ACM SIGIR conference on Research and development in information retrieval.

Ding, X., Liu, B., & Yu, P. S. (2008). *A holistic lexicon-based approach to opinion mining*. Paper presented at the Proceedings of the international conference on Web search and web data mining.

Ding, X., Liu, B., & Zhang, L. (2009). *Entity discovery and assignment for opinion mining applications*. Paper presented at the Proceedings of the 15th ACM SIGKDD international conference on Knowledge discovery and data mining.

Fung, R. Y. K., Popplewell, K., & Xie, J. (1998). An intelligent hybrid system for customer requirements analysis and product attribute targets determination. *International Journal of Production Research, 36*(1), 13-34.

Gamon, M., Aue, A., Corston-Oliver, S., & Ringger, E. (2005). *Pulse: Mining customer opinions from free text.* Paper presented at the Proceedings of Advances in Intelligent Data Analysis VI, 6th International Symposium on Intelligent Data Analysis, IDA 2005, Madrid, Spain.

Grifn, H., & Hauser, J. R. (1993). The voice of the customer. *Marketing Science, 12*, 1-27.

Gustafsson, A., & Gustafsson, N. (1994). *Exceeding customer expectations.* Paper presented at the Proceedings of the Sixth Symposium on Quality Function Deployment.

Harding, J. A., Popplewell, K., Fung, R. Y. K., & Omar, A. R. (2001). An intelligent information framework for market driven product design. *Computers in Industry, 44*(1), 49-63.

Hatzivassiloglou, V., & McKeown, K. R. (1997). *Predicting the semantic orientation of adjectives.* Paper presented at the Proceedings of the eighth conference on European chapter of the Association for Computational Linguistics, Madrid, Spain.

Hu, M., & Liu, B. (2004). *Mining and summarizing customer reviews.* Paper presented at the Proceedings of the 10th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, Seattle, WA.

Hu, M., & Liu, B. (2004). *Mining Opinion Features in Customer Reviews.* Paper presented at the Proceedings of the Nineteenth National Conference on Artificial Intelligence, Sixteenth Conference on Innovative Applications of Artificial Intelligence, AAAI 2004, San Jose.

Jack, G. C., & Frank, S. (2007). *Opinion mining in legal blogs*. Paper presented at the Proceedings of the 11th international conference on Artificial intelligence and law.

Jiang, M., & Yu, B. (2009). *Proceeding of the 1st international CIKM workshop on Topic-sentiment analysis for mass opinion*, Hong Kong, China.

Kamps, J., & Marx, M. (2002). *Words with attitude.* Paper presented at the Proceedings of the First International Conference on Global WordNet.

Kim, K. J., Moskowitz, H., Dhingra, A., & Evans, G. (2000). Fuzzy multicriteria models for quality function deployment. *European Journal of Operational Research, 121*, 504-518.

Kim, S.-M., & Hovy, E. (2004). *Determining the sentiment of opinions*. Paper presented at the Proceedings of the 20th international conference on Computational Linguistics.

Kwong, C. K., & Bai, H. (2002). A fuzzy AHP approach to the determination of importance weights of customer requirements in quality function deployment. *Journal of Intelligent Manufacturing, 13*(5), 367-377.

Liu, B., & Chang, K. C.-C. (2004). Editorial: special issue on web content mining. *ACM SIGKDD Explorations Newsletter, 6*(2), 1-4.

Liu, B., Hu, M., & Cheng, J. (2005). *Opinion observer: analyzing and comparing opinions on the Web*. Paper presented at the Proceedings of the 14th international conference on World Wide Web.

Liu, Y., Lu, W. F., & Loh, H. T. (2007). *Knowledge Discovery and Management for Product Design through Text Mining - A Case Study of Online*

Information Integration for Designers. Paper presented at the Proceedings of the 16th International Conference on Engineering Design, ICED'07, Paris, France.

Lu, s, S., Paula, C., M, rio, J. S., Eug, et al. (2009). *Automatic creation of a reference corpus for political opinion mining in user-generated content*. Paper presented at the Proceeding of the 1st international CIKM workshop on Topic-sentiment analysis for mass opinion.

Mullen, T., & Collier, N. (2004). *Sentiment analysis using support vector machines with diverse information sources.* Paper presented at the Proceedings of Conference on Empirical Methods in Natural Language Processing (EMNLP).

Nitin, J., & Bing, L. (2008). *Opinion spam and analysis*. Paper presented at the Proceedings of the international conference on Web search and web data mining.

Osgood, C. E., Succi, G. J., & H.Tannenbaum, P. (1957). *The Measurement of Meaning*: University of Illinois.

Popescu, A.-M., & Etzioni, O. (2005). *Extracting Product Features and Opinions from Reviews.* Paper presented at the Proceedings of Human Language Technology Conference and Conference on Empirical Methods in Natural Language Processing, HLT/EMNLP, Vancouver, B.C., Canada.

Qi, S., Xinying, X., Honglei, G., Zhili, G., Xian, W., Xiaoxun, Z., et al. (2008). *Hidden sentiment association in chinese web opinion mining*. Paper presented at the Proceeding of the 17th international conference on World Wide Web.

Riloff, E., Wiebe, J., & Wilson, T. (2003). *Learning subjective nouns using extraction pattern bootstrapping.* Paper presented at the Proceedings of the seventh conference on Natural language learning at HLT-NAACL 2003, Edmonton, Canada.

Saaty, T. L. (1980). *The Analytic Hierarchy Process*. New York: McGraw-Hill.

Temponi, C., Yen, J., & Tiao, W. A. (1999). House of quality: A fuzzy logic-based requirements analysis. *European Journal of Operational Research in Engineering Design, 117*, 340-354.

Turney, P. D., & Littman, M. L. (2003). Measuring praise and criticism: Inference of semantic orientation from association. *ACM Transactions on Information Systems (TOIS), 21*(4), 315-346.

Wei, J., & Hung Hay, H. (2009). *A novel lexicalized HMM-based learning framework for web opinion mining*. Paper presented at the Proceedings of the 26th Annual International Conference on Machine Learning.

Weifu, D., & Songbo, T. (2009). *An iterative reinforcement approach for fine-grained opinion mining*. Paper presented at the Proceedings of Human Language Technologies: The 2009 Annual Conference of the North American Chapter of the Association for Computational Linguistics.

Wiebe, J., & Riloff, E. (2005). *Creating subjective and objective sentence classifiers from un-annotated texts.* Paper presented at the Proceedings of Conference on Intelligent Text Processing and Computational Linguistics (CICLing), Mexico City, Mexico.

Yu, B., Kaufmann, S., & Diermeier, D. (2008). *Exploring the characteristics of opinion expressions for political opinion classification.* Paper presented at the Proceedings of the 2008 international conference on Digital government research.

Yu, H., & Hatzivassiloglou, V. (2003). *Towards answering opinion questions: separating facts from opinions and identifying the polarity of opinion sentences.* Paper presented at the Proceedings of the 2003 conference on Empirical methods in natural language processing.

Zadeh, L. A. (1965). Fuzzy Sets. *Information and Control*(8), 338-353.

Zhan, J., Loh, H. T., & Liu, Y. (2009). Gather Customer Concerns from Online Product Reviews - A Text Summarization Approach. *Expert Systems With Applications (ESWA), 36*(2 Part 1), 2107-2115.

Zhuang, L., Jing, F., & Zhu, X.-Y. (2006). *Movie review mining and summarization*. Paper presented at the Proceedings of the 15th ACM international conference on Information and knowledge management.