Cluster Computing
https://doi.org/10.1007/s10586-018-2174-3

An integrated approach for knowledge management in the context of product innovation

Yuan Deng[1] · Congdong Li[1] · Dong Wang[2]

Received: 29 December 2017 / Revised: 10 February 2018 / Accepted: 13 February 2018

Abstract
Companies use social media to communicate customers has been increasing recently. By analyzing the content generated by users online, companies obtain the information about market and use in product management and innovation, improving the competitiveness of enterprises. As the emerging of growing user-generated content (UGC), how to achieve effective information extraction and transform into product knowledge has posed a challenge to the enterprise. In the context of smart phone product innovation, with data fetched from websites and provided by the enterprise, by using natural language processing and semantic Web tools, this paper proposes an integrated method of innovation knowledge management based on UGC, which provide a systematic solution for the interactive innovation knowledge management.

Keywords Knowledge management · Product innovation · User-generated content · Integrated approach

1 Introduction

Recent years, the increasing popularity of social media has provided a platform for consumers to publish their views and experience of a product or service, which is known as user-generated content (UGC) that contains a wealth of products or service feedback information [1]. By analyzing the contents, enterprises could obtain the valuable information such as product competitiveness, quality, flaws, and market dynamic, which provides decision support for enterprise product or service management [2].

The research on extracting product and market information from UGC becomes popular in recent years. However, abstract useful information from UGC, which contained heterogeneity, scarcity and large-scale data [3], is a costly and difficult task for enterprises. Especially incorporating the latest information into the enterprises' existing knowledge base, has become a new challenge [4]. This means an open knowledge management system is needed to enhance the market intelligence processing capability of enterprises, dealing with the massive real-time data of UGC.

According to this problem, we discussed the process of knowledge discovery, convert and management in UGC, with data fetched from websites and provided by the enterprise, by using natural language processing (NLP) and semantic Web tools, we propose an open knowledge integration management approach based on UGC in multi-agent interaction environment. The main contributions are as follows: (1) propose a model for knowledge integration management based on UGC, (2) propose a knowledge expansion method according to the real-time information extracted from UGC, (3) apply them to the innovation of smart phone products.

2 Literature reviews

2.1 Information Extraction of UGC

According to the data type of the UGC, it can be divided into structured data (such as rank, score, etc.) and unstructured data (such as text information, image, etc.) [5]. Structured data mining technology has been widely used in product and market analysis; however, in despite of

✉ Dong Wang
wangdong@gzhu.edu.cn

[1] School of Management, Jinan University, Guangzhou 510632, People's Republic of China

[2] School of Management, Guangzhou University, Guangzhou 510006, People's Republic of China

Published online: 14 March 2018

rich information contained, unstructured data, especially text information, may be difficult for mining and analysis, which often requires a large manual participation [6]. The commonly used text mining method is mainly to "identify, extract, manage and integrate and make use of knowledge in an effective and systematic way" from the content [7]. A semi-automatic user opinion analysis method based on keyword is proposed in literature [8] for the release and audit of mobile application. By extracting the internet user's comment, the keywords are divided into a subset. On this basis, the similarity analysis of key words and other words is conducted. The recommendation system is researched deeply in literature [9], and the user reviews are sorted out by text subject classification, opinion and emotion analysis.

UGC contains the evaluation of product features, while scholars, on how to identify the product features in the text, have proposed several methods: (1) one that based on part-of-speech statistics, such as counting the words that frequently appear in specific domain, while these words will be accepted as terminology rules in a specific corpus, and then identify the product feature description mode in the corpus [10], (2) one that based on grammar structure, such as mining algorithm on rule-based feature, and extracting the syntax structure according to the vocabulary rule of the composed sentence, while modified nouns can be used as the characteristics of candidate product and adjectives as the feature view [11], (3) one that based on language morphology. The using custom of language is ignored in the rule-based algorithm, therefore, some research, on this basis, has put forward association rule mining algorithm with the syntax format [12]. At the same time, the extraction of product features in text is often associated with emotional analysis, for which to first judge the emotional tendencies of a specific feature in the content, second to show the "feature-view" by pairs and finally to establish intuitive connection between emotional tendencies and product features [13].

Current research provides plenty of methods in content mining, but there still lack of study on system method of knowledge management in dynamic environments, it makes the intelligent processing costly and inefficient of continuously obtain useful information from large-scale corpus of UGC, which enterprises can hardly afford.

2.2 Knowledge management

The method of textual semantic similarity is used to formally express the innovative knowledge, realizing the intelligent management and utilization of the innovative knowledge [9]. Based on the analysis of user knowledge, an ontology model is constructed to the formalized expression of user knowledge, which makes the enterprise fully understand the user's needs [14]. The establishment of a semantic-based integrated management platform has been proposed in literature [15], to achieve smart acquisition, expression and sharing of user knowledge in the process of product innovation. In literature [16], research on how to achieve formalized expression of product innovation knowledge by building domain ontology in the interactive innovation environment, is conducted. In literature [17], the potential semantic indexing method is used to identify the user's innovative ideas in the social media, attempting to find the best ideas from users, and to provide support for the choice of the enterprise innovation scheme.

Literature [18] points out that the core of innovative knowledge management is the problem of heterogeneous data integration across the source. Through the knowledge expression process, the semantic annotation of the data is tagged, which support the reusability and interoperability of domain knowledge, thus, sharing of innovative knowledge could be achieved within a given range. As a result, semantic Web technology has gradually become a common technology of knowledge integration [19]. Based on the OWL (Web Ontology Language), Resource Describe Framework (RDF) and XML (eXtensible Markup Language), a format paradigm based on standard integration function is provided, and the knowledge release, integration and interpretation are much more flexible through sharing, unified semantics marking [20]. In order to meet the needs of multi-agent interaction in the internet environment, scholars have begun to pay attention to the linked ontology data (LOD) and its application in knowledge integration management. In literature [21], how to create semantic association between different data sources in the Web environment in the best practical way, has been discussed. It is proposed that the network resources may be transformed into machine comprehensible semantic data network, making the use of network resources more intelligent.

For the problem of multi-agent cross-domain knowledge integration, the framework and methods of the enterprise knowledge system integration has been proposed in literature [22], in which the enterprise elements are to be abstracted into knowledge elements and transformed into BOX (Bill of X, X list) semantic units, and through task traction and procedure-oriented method the enterprise knowledge expression structure and the management mechanism model may be constructed dynamically. On this basis, the literature [23] has proposed a semantic-BOX model based on semantic Web technology for the complexity, heterogeneity and disorder of sub-domain knowledge elements in cross-domain integration process, achieving the overall integration of multi-enterprise and multi-domain knowledge in the semantic space; In this paper [24], a multi-dimensional semantic X-list (Multi-S-

BOX) method has been proposed for cross-domain knowledge integration management and service requirements, and the interoperation and order of S-BOX in different domains are combined with the secondary integration of the distributed inference, which may support cross-domain knowledge integration and collaborative decision making [25].

The current research has a comprehensive study of knowledge integration management, the models, methods and technologies, especially in internal incorporation between the enterprises' management systems. But there are still research gaps in dynamic information exchange between external and enterprises' system in dynamic process, such as interactive innovation, how to extend the knowledge integration system according to real-time information, and using the up-to-date market intelligence to help support decision making, in other words, an open knowledge integration system is needed in big data era.

Inspired by the above research, this paper will use the open source of domain knowledge as the basis for identifying and extracting user content. On the basis of Multi-S-BOX model architecture, we propose an interactive knowledge integration management framework and method to support multi-agent interaction. The structure of this paper as follows: the first part introduces the related research work. The second part introduces the interactive knowledge integration management framework; the third part introduces the automatic matching of the UGC and intelligent expansion method of the interactive innovation knowledge; the fourth part gives a description combined with the smart phone product description. In the fifth part, the limitations of this paper are analyzed and discussed.

3 Research design

3.1 An innovative knowledge integration management framework based on UGC

In the open innovation environment, it is the core of the interactive innovative knowledge management to extract the information expressed by the user in the interactive process, and to transform and expand the existing knowledge base of the enterprise. Based on its good integration performance, this paper adopts Multi-S-BOX as the underlying architecture of enterprise innovation knowledge management, and further builds the interactive innovative knowledge integration management framework U-IMIIK (UGC-based integrated management of interactive innovation knowledge, U-IMIIK), as shown in Fig. 1. Based on the UGC, the framework combines the automatic matching of integrated user knowledge with the intelligent extension of the interactive innovation knowledge ontology.

The UGC mining layer, composed of different sources of heterogeneous data acquisition, pre-processing, knowledge matching and other functions, constitutes the external interaction layer of the U-IMIIK. In this layer, the customer-generated content in different social media is to be collected in real time. The hot fields and keywords therein are to be mined, then are to be matched with the open source domain knowledge base, identifying the domain knowledge contained in UGC.

The internal processing layer of the U-IMIIK, composed of the enterprise domain knowledge and its ontology list Multi-S-BOX, forms the enterprise's existing knowledge management system. Base layer extraction and abstracting common and special characteristics of single domain knowledge combine to build domain knowledge S-BOX; extracting the mapping relationship between S-BOX and constructing Multi-S-BOX to integrate the orderly association between S-BOX should be able to provide basic support for cross-domain knowledge integration and service matching.

The intermediate exchange layer of the U-IMIIK, composed of the enterprise domain knowledge expansion and its ontology list, user knowledge and its ontology list, forms the interactive innovation knowledge management. This layer, by adopting the method of interactive innovation knowledge base as expansion, constructs the domain knowledge on the basis of the customer-related data which is extracted from UGC and extracts its mapping relation, which will form customer knowledge and ontology list. Meanwhile, knowledge construction is to be conducted and the mapping relation to be extracted from the data that is related to the product innovation, forming the enterprise knowledge expansion and ontology list.

As the methods and steps of domain knowledge ontology list construction is mentioned in [23, 24], we will not discuss further more in this paper.

3.2 Intelligent extension of interactive innovation knowledge

3.2.1 Knowledge extension

The evolution of knowledge in the process of interactive innovation has posed a requirement for the knowledge ontology extension technology, that is to say, with the passage of time, customer groups and market demand are changing, and new knowledge is generated constantly; at the same time, the enterprise groups located in the application end of the interactive innovation knowledge are also changing. The traditionally manual knowledge ontology construction method, which is based on domain experts, has become the bottleneck of domain ontology expansion ability. The data islands that are characterized by closed

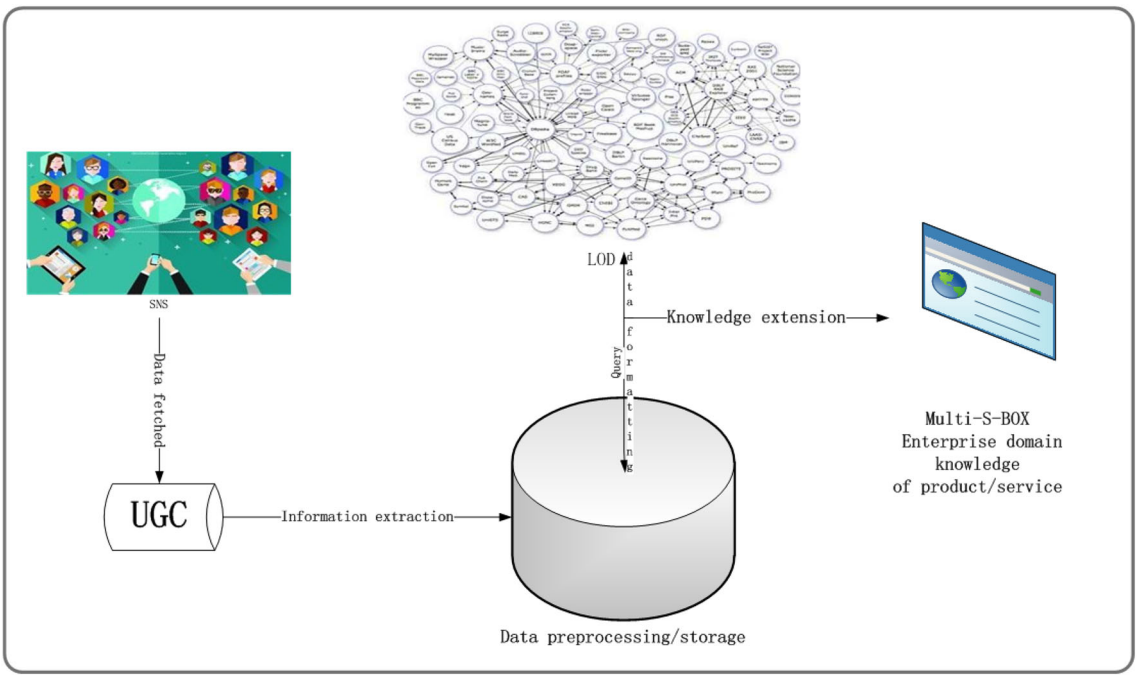


Fig. 1 U-IMIIK framework

data are obviously not in line with the demand of dynamic matching between knowledge sharing and collaborative task in the enterprise. Therefore, this paper presents a semantic-based intelligent expansion method of the interactive innovation knowledge. This method may provide knowledge and intelligent management to support knowledge ontology expansion. By transforming domain knowledge ontology resources into RDF and domain knowledge ontology instance into associated data, the knowledge integrated management between information sharing and exchange among enterprises is provided. Based on the knowledge integration of existing Multi-S-BOX, the knowledge contained in UGC is increased, and the knowledge base is intelligently expanded in real time. Its function from the bottom up includes data conversion, associated data generation, ontology expansion/construction, Multi S-BOX expansion, as shown in Fig. 2.

Based on the knowledge mining, the ontology of the interactive innovation knowledge is to be constructed and transformed into the domain knowledge of the product/service. The knowledge source and the knowledge content are to be transformed into RDF triples as enterprise linked data. From the identifier standard RFC 5147 (the media type of the URI fragment identifier is text/plain) and used the LOD (such as DBpedia, YAGO2, and ZOL mobile evaluation data in Chinese) as the domain knowledge etymology reference, the LTP-Cloud (Language Tool Platform) and other tools are to be adopted for data processing. Then the acquired knowledge is conversed into OWL/RDF, and here the hidden information from the UGC resources that is composed of massive, heterogeneous data may be found and be transformed into the domain knowledge, which should be able to provide decision-making basis for the interactive innovation of the enterprise.

3.2.2 Knowledge extension process

The key of knowledge extension process is to compare product knowledge contained in UGC with existing product knowledge base, and add new knowledge to original knowledge base through lexical similarity and generic relation mapping. Then tag, transform into RDF triples as linked data, turn the rough data into open resources of product knowledge.

Step 1 data conversion

(i) Extract information from the UGC, rank them in accordance with importance, and determine the threshold of conversion ranking.

(ii) Select the extracted information which ranks above the threshold, by taking vocabulary as a unit and adopting LOD naming algorithm. If there is a corresponding item in LOD, the concept, attribute, instance and conceptual relationship are to be extracted, and the extracted information is to be transformed into RDF subject–object–predicate triple.

(iii) If there is no corresponding item in LOD, the similarity between the concept cosine distance is calculated based on the relationship between the concepts. If the similarity threshold is exceeded, the *Same As* relationship

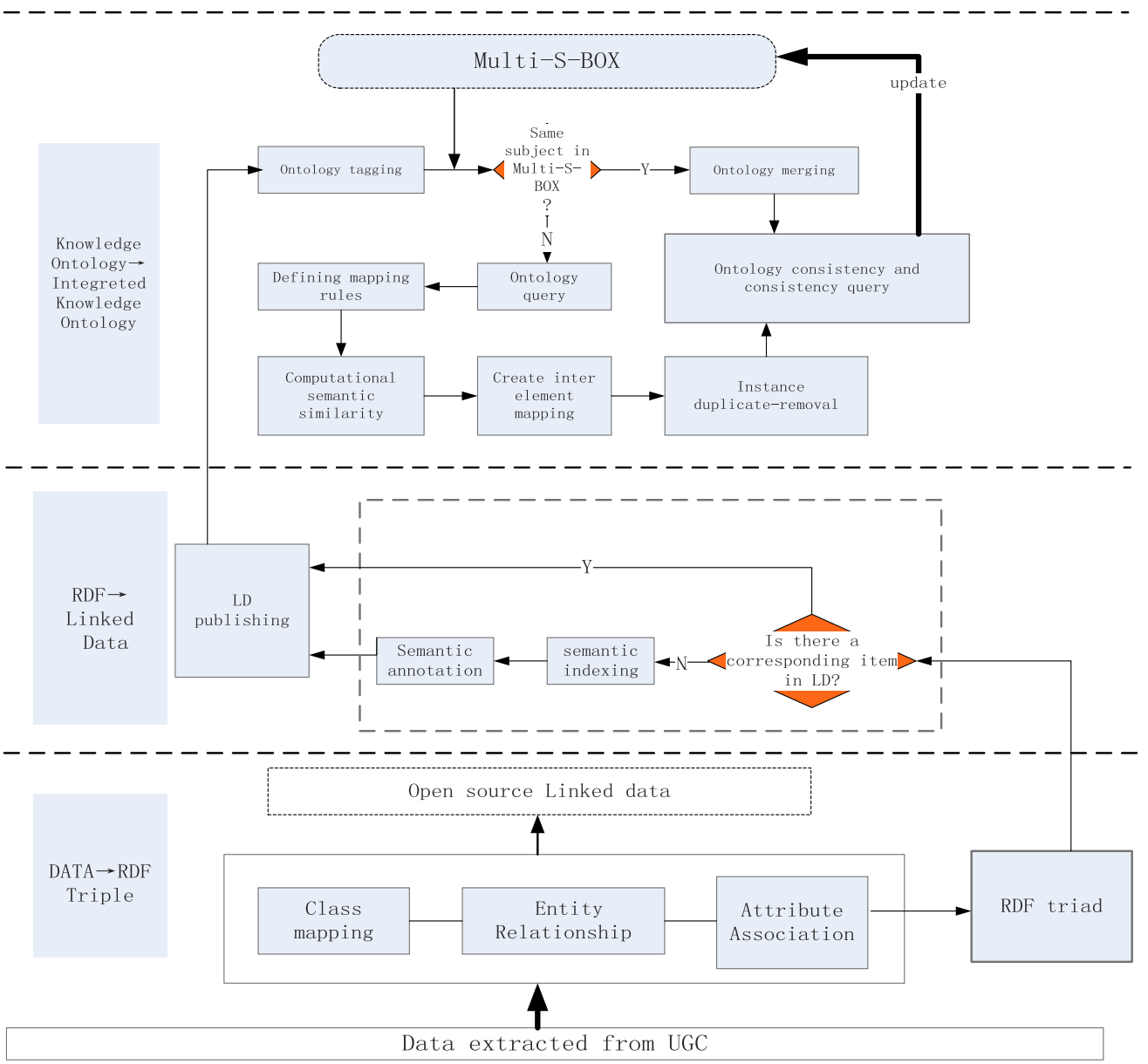


Fig. 2 Approaches of interactive innovation knowledge extension

is to be used to define and generate the RDF triples. If the threshold is not exceeded, then category analysis is further conducted to determine the inheritance and before–after relationship between the concepts, and the triples are thus generated.

Step 2 generation of linked data

(i) The triad and LOD and other open source data are to be queried correspondingly in accordance with the subject–object–predicate. If there is a corresponding item, the item is associated with the external data set and the URL external resource link is generated, from which the linked data will be formed.

(ii) If there is no corresponding items between the triad and open source linked data set, then conduct the semantic extraction, gain access to potential semantic relations, and do the semantic annotation.

Step 3 ontology extension/construction

Enter the linked data mentioned above,

(i) If the rules, axioms and constraints have been completed, the ontology forms and the semantic annotation is to be carried out.

(ii) If the rules, axioms and constraints are not complete, adopt the semantic annotation technology layer by layer from the similar class of the S-BOX top-level concept, determine the definitions of class-genus-face-slot and

create instances, the ontology forms and semantic annotation is to be carried out.

Step 4 Multi S-BOX extension

Comparing the above-mentioned ontology with the enterprise Multi S-BOX, if it already exists, merge the ontology through deduplication; If not, the mapping between concepts should be constructed according to the semantic similarity of the concept. If the similarity is below the threshold, the mapping between the source ontology instance and the target ontology instance should be established and the ontology be merged. If the similarity is above the threshold, a new S-BOX ontology unit is to be generated.

It should be noted that, UGC data types are diverse, and the above content has demonstrated the intelligent extension method by an example of text data, in which the common technology, tools and algorithms include: (1) text processing technology and tools, by adopting NLP technology and LTP-cloud toolkit of Harbin Institute of Technology [26], (2) semantic linked data conversion method, by adopting LOD naming recognition algorithm proposed in literature [27], and identifying the implicit knowledge items in UGC, (3) semantic annotation, by using the technology proposed in literature [27, 28] to carry out ontology semantic annotation, (4) generation of new ontology unit or list in the Multi S-BOX, by using the method proposed in literature [23–25].

4 Application and discussion

In this section, we will discuss the application of the above methods in the innovation of knowledge management with case study, in the context of product innovation in smart phone industry.

4.1 Application

4.1.1 The Context of Application

In the application example of the smart phone products, the text mining is conducted in UGC, from which the information about the users' comments on the theme, keywords and the evolution of their characteristics are acquired. The results of user reviews are then to be compared with the innovations and improvements of the two products, to see which of integrated aspects in the new product configuration reflects the knowledge from UGC. The process of transforming of text mining results into interactive innovation knowledge and resources is also to be demonstrated.

In the instance, model N4 and N5 of a brand mobile product are selected as objects, user comments which are collected from the Jing-dong Mall, ZOL mobile phone evaluation network (professional website), and the official micro blogging of the brand mobile, and user comments collected on the other four different brands of mobile phones (H \ K \ M \ W) are used as a comparison group. Using the mobile phone product features and attribute classification in ZOL mobile phone evaluation network as open source domain knowledge base, a keyword list of the product feature and attribute is thus formed. Product characteristics and attribute description words marked by the product bill of material (BOM) are used as the product knowledge expression, and the UGC of the two products is excavated by keyword clustering analysis, LDA theme classification algorithm and word frequency statistics.

4.1.2 Text mining

In this paper, we use Crawler to fetch the related comments of N4 and N5 mobile phones in social media, and carry out the text mining by corpus preprocessing–word frequency statistics–keyword recognition–theme classification. (1) Document data preprocessing, data cleansing, elimination of duplication and noise in the data. Delete the user's repeated submissions or forward the comments and treat them as a comment; data building, by extracting multiple attributes in the data, such as comment date, geographic location, release source, and so on. (2) NLP in the text preprocessing, through n-gram grammar word segmentation (such as binary grammar like screen, navigation, power consumption); ternary grammar like tempered film, fingerprint; quaternary grammar like ceramic fuse body, systematic operation and so on, one can delete words that are not related to the description of the phone (such as "the amount of 1980 yuan", stop words, and retain the special vocabulary that describes the mobile phone knowledge (such as wifi, NFC, MIUI, etc.), then count the word frequency. (3) Key words clustering and text theme classification description, by combing with reference product design knowledge the key words clustering analysis is conducted: (1) description of mobile phone body (ceramic body, tempered film, screen, fingerprint keys, etc.), (2) description of mobile version type (such as VIP, high-end, standard, etc.), (3) description of mobile appearance (such as black, white, black edging, slim, etc.), (4) description of mobile function (such as system operation, navigation, NFC and others), (5) description of mobile faults or defects (fever, not smooth, power consumption, etc.). Here keywords and theme matrix are to be built and LDA algorithm is to be adopted to classify and describe topics and keywords.

4.1.3 Results and analysis

A total of 457,239 words has been extracted for 15,786 reviews. The LDA algorithm has been adopted to analyze the semantic consistency of the subject in terms of the concurrent frequency of the *n*-gram words in the narrower words (like eight words) to classify the UGC in terms of topics and to identify the corresponding user emotions. Hot themes, keyword frequency statistics and emotional distribution are shown in Fig. 3.

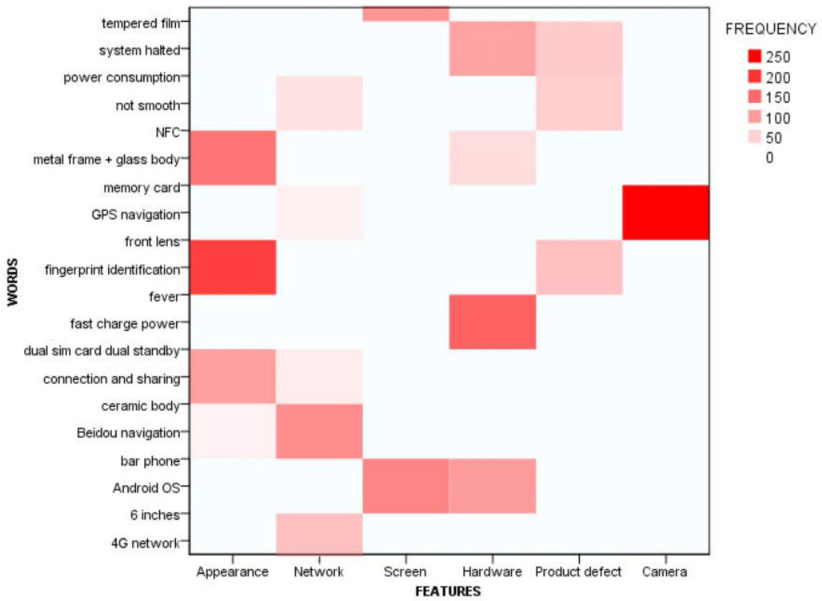
From the total number of user comments, the overall distribution of the theme is obtained. After comparison to the similar products, this brand product is in the highest degree of attention, and gets more positive evaluations. A further combing of the hot themes of N4, N5 mobile phones in the UGC shows users' more emphasis on the model, the fuselage and the screen while less on the battery and the application, which is illustrated in Fig. 4.

According to ZOL mobile phone evaluation network subdivision standard, the product knowledge keywords, high-related sentences and product feature mapping contained in the hot themes (top 8) of N4, N5 in the UGC were under statistics, as shown in Table 1.

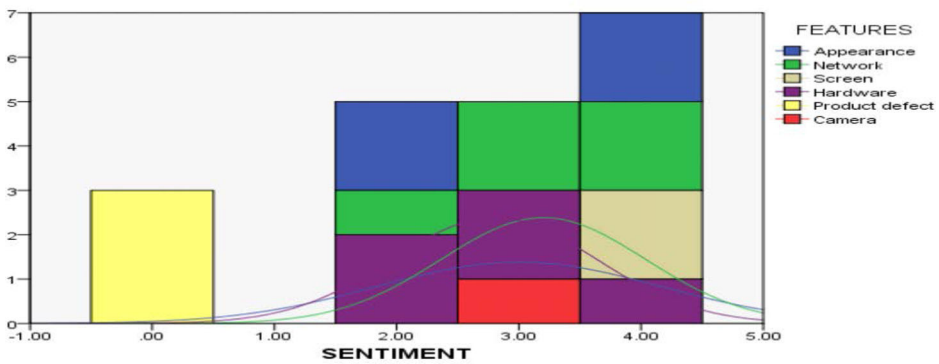
The main elements in BOM about the "system function" in N4, N5 products, product design knowledge and user comments mining results are under comparison, combing that the theme and keywords of the one which has higher attention but is not reflected in the enterprise BOM, as shown in Table 2.

4.1.4 Text mining results transform into domain knowledge

The implied product knowledge extracted from the UGC mining in the above, which is not included in the existing



a Theme composition and hot spot of website



b Topic contribution and sentiment distribution

Fig. 3 Hot themes, keyword frequency statistics and emotional distribution of UGC. **a** Theme composition and hot spot of website, **b** Topic contribution and sentiment distribution

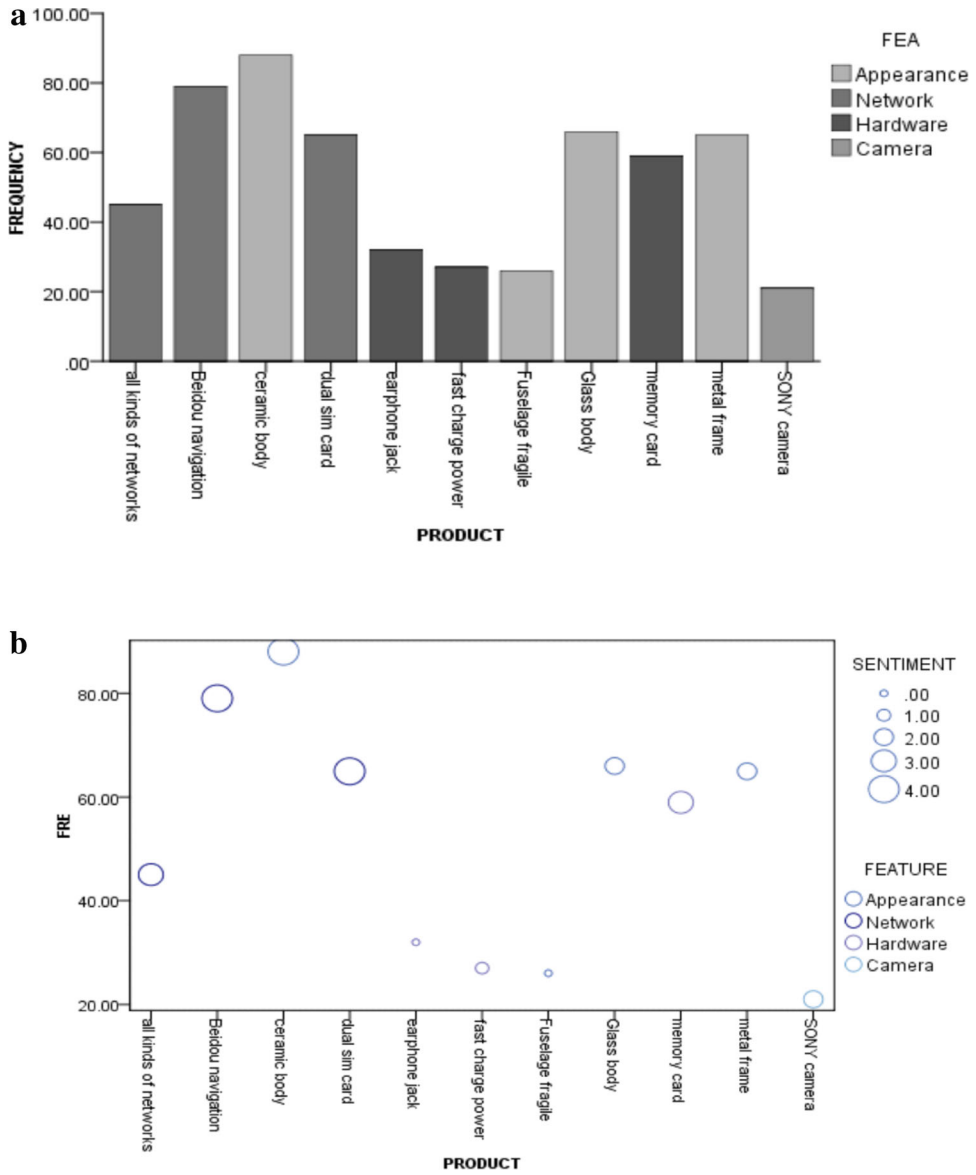


Fig. 4 Theme distribution of product N4/N5 in the UGC. **a** Hot issues of Product N in Q&A, **b** Topic distribution of hot issues in Q&A of Product N

enterprise knowledge base, will be built into the user-product knowledge ontology and transformed into product domain knowledge. The text source and the content are to be transformed into RDF triples as enterprise associated data. From the identifier standard RFC 5147 (the media type of the URI fragment identifier is text/plain) and used the ZOL mobile evaluation network data as the domain knowledge etymology reference, the acquired knowledge is to be constructed into OWL/RDF.

In the case of the "Beidou navigation" included in the T1 theme in Table 2, the UGC mining result is transformed into the product knowledge ontology, and the original user comment text from Jing-dong Mall is transformed as the linked data resource, as shown in Fig. 5.

With the above conversion, enterprises can use the SPARQL query tool to repeatedly call the text mining data results and carry out cross-comparison, or search external data resources through the link, or find the hidden mode from the massive, unstructured user generated text information and converse them into the domain knowledge elements, and further build interactive product innovation S-BOX, achieving intelligent expansion of enterprise product domain knowledge.

4.2 Discussion

The above case shows the application of U-IMIIK model in theme mining and knowledge extraction of smart phone

Table 1 Product knowledge hidden in the hot themes of N4, N5 in UGC

Topics	Commonly used keywords	High-related UGC	Product feature mapping
T1	Appearance and body	Beautiful and exquisite appearance, all metal body, comfortable feeling	Appearance
T2	Photo	Favorite black and white camera, good shooting-out, praising large aperture mode	Camera
T3	Screen	Tilt-down screen side, troublesome phone filming; terrible red screen	Screen
T4	Battery	WeChat using, and surfing will cause fever, but not be burning. While in the shooting when the mobile phone temperature is increasing seriously and power consumption has soared	Hardware
T5	NFC	No NFC, the secondary card does not support 4G	Internet tools
T6	Button and interface	Menu and other keys are actually on the screen, and that big chin suddenly pierces into the eye, why the button can not be in the bottom of the border	Service and support
T7	Screenshot	Slow screenshot, and the screenshot gesture is using the knuckle to hit the screen twice, to tell the truth, hitting by the knuckle is hard to use	Service and support
T8	Application	App not downloaded from the mobile application store will flash back	Service and support

Table 2 Differences between enterprise product knowledge and user-focus theme

Topics	Commonly used keywords	High-related UGC	Product feature mapping
T1	Navigation	Why the Beidou navigation system is not installed the whole series?	Service and support
T2	Appearance, body	Perhaps with ceramic fuselage, the heat radiation will be much better…	Appearance

products, first we using NLP tools to extract the information, then we use the words similarity to set the mapping between the user's focuses and the parameters of the product, after cross-comparison step with the open source domain knowledge, the existing product design and the BOM core elements, we use the OWL/RDF technology to transform the result of the mining into product knowledge and further integrate them into the linked data. As the output of the extraction–transformation–loading process, the knowledge mining result in UGC enriches the existing knowledge base of enterprises, and a dynamic updating process of enterprise knowledge management is also accomplished. In the mentioned process, there are two aspects needed for further discussion: (1) each data source site and each user's UGC are weighted by the same level in the paper, but in actual use, the credibility, attention, size of different sites vary, and there also exist a leading and following relations among the users, which will affect the subject-knowledge ranking, and further affect the enterprise product knowledge base updates. (2) We focus on issues of product knowledge contained in UGC, the information related to user behavior in the UGC was not discussed here, but this part of the content is closely related to users' sentiments and opinions about the brand image of products, it may also affect the feedback of a niche market for product innovation in a given period of time in the future. These two factors will affect the scope of both knowledge conversion and extension.

With the two factors mentioned above, in the follow-up study, we consider to use the customer behavior and product characteristics data for comprehensive analysis, launching a specific product and service innovation for specific user groups to ensure the quality of enterprise product knowledge updating content. At the same time, the UGC of different brands of smart phone products will be collected to enrich the corpus, gain access to a more comprehensive industry product data and user knowledge; the acquisition cycle will be lengthened for mining the hidden pattern of products and user needs evolution and observing the competition of the products in the same industry in a longer time; the application of the linked data in the enterprise-user interactive innovation knowledge integration should be further constructed, so as to provide more precise support for the enterprise product innovation decision-making.

5 Conclusion

In the era of big data, it becomes a hotspot of the academia and industry to achieve product/service innovation using users-generated content in the social media. Research on

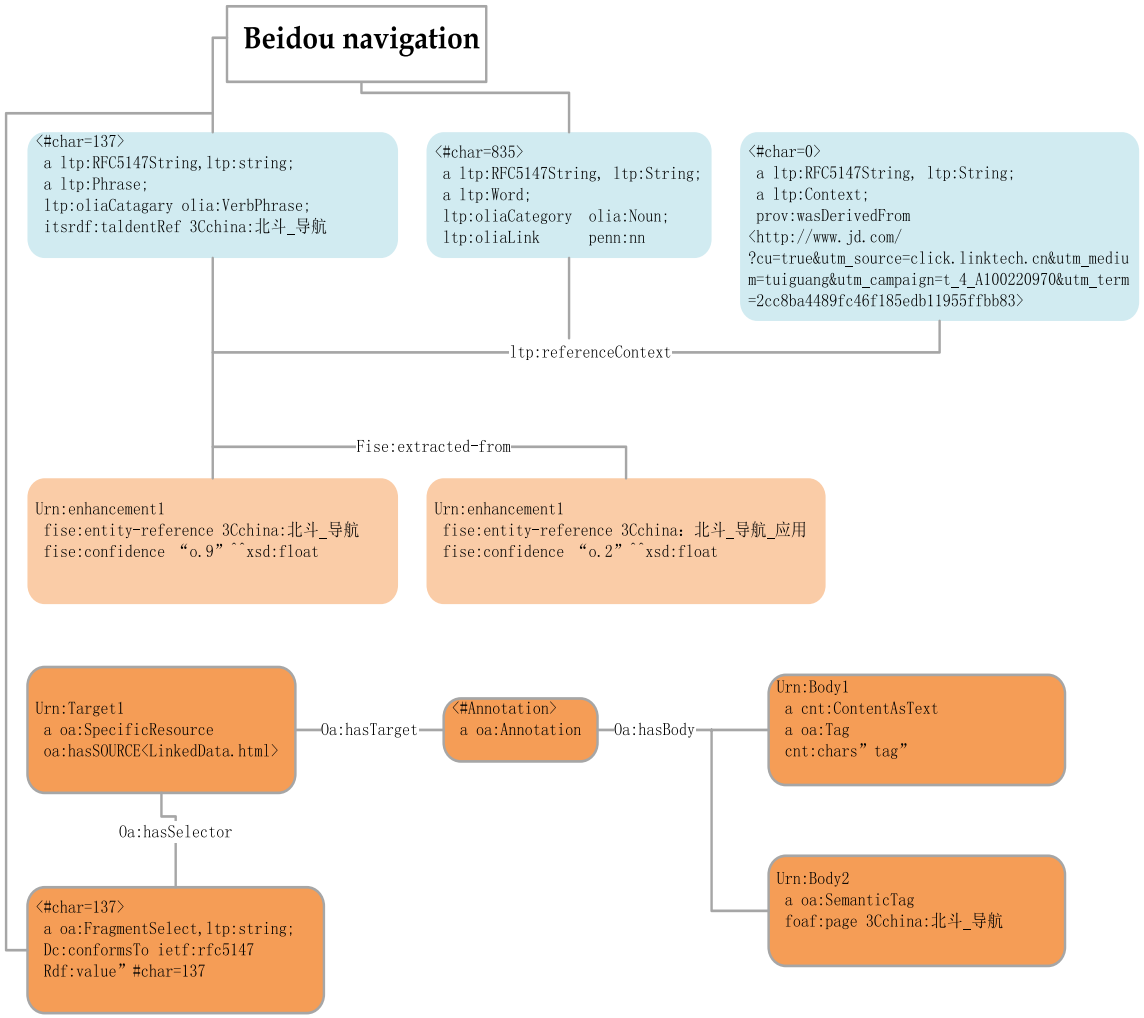


Fig. 5 Acquired content be converted into OWL/RDF

how to mine the UGC has been paid increasing attention. While less is still on the research on the way to realize the knowledge management system which embodies the dynamic extension of interactive innovation knowledge, which may make it difficult to support the mining and intelligent processing of innovative knowledge contained in a large number of UGCs for the enterprise. Current research emphasizes more on mining customers' needs, while less on dynamic information exchange between users and enterprises in the process of interactive innovation. Also, the research on the specific method that dynamically integrates the customer knowledge and domain knowledge derived from the enterprise is rare.

Accordingly in this paper, we proposed an integrated management framework for interactive innovation knowledge based on UGC, which should be able to provide the systematic approach for the enterprise to systematically process the UGC and transform it into innovative knowledge. And this is also an extension of Multi-S-BOX model proposed in literature [23–25], in big data context. Use the technology of text extraction, we discussed the novel approach using the open source linked data in identifying the product/service innovation knowledge, which contained in the hot issues customers concerned. This would be a specific approach in enhancing the efficiency and accuracy of marketing and customer knowledge management, as the usage of linked data in enterprises and complex tasks that proposed in literature [27, 28]. We also discussed an intelligent method of innovative knowledge expansion, which allows the dynamic updating of enterprise domain knowledge based on UGC and linked data, and turns the UGC into RDF triples as the instance and resource of innovation knowledge. The model and method we proposed in paper provides efficient and systematic approach for enterprises in knowledge discovery, extraction, transformation, and integration from massive structured and unstructured data of UGC, it also provides an

effective solution for the enterprise to update the knowledge integration system in the dynamic environment.

Acknowledgements The research is supported by National Natural Science Foundation of People's Republic of China (71672074).

References

1. Alan Wang, G., Liu, X., Wang, J., Zhang, M., Fan, W.: Examining micro-level knowledge sharing discussions in online communities. Inf. Syst. Front. **17**, 1227–1238 (2015). https://doi.org/10.1007/s10796-015-9566-1
2. Lee, M.K.O., Cheung, C.M.K., Lim, K.H., Sia, C.L.: Understanding customer knowledge sharing in web-based discussion boards: an exploratory study. Internet Res. **16**, 289–303 (2006)
3. Wang, G.A., Jiao, J., Abrahams, A.S., Fan, W., Zhang, Z.: Expert rank: a topic-aware expert finding algorithm for online knowledge communities. Decis. Support Syst. **54**(3), 1442–1451 (2013). https://doi.org/10.1016/j.dss.2012.12.020
4. Fan, W., Gordon, M.: The power of social media analytics. Commun. ACM **57**(6), 74–81 (2014). https://doi.org/10.1145/2602574
5. Goel, S., Hofman, J.M., Lahaie, S., Pennock, D.M., Watts, D.J.: Predicting consumer behaviour with web search. Proc. Natl Acad. Sci. USA **107**, 17486–17490 (2010)
6. Gomaa, W.H., Fahmy, A.A.: A survey of text similarity approaches (2013, April). http://research.ijcaonline.org/
7. http://research.ijcaonline.org/volume68/number13/pxc3887118.pdf
8. Brar, G., Rossi, G.D., Kalamkar, N.: Predicting stock returns using text mining tools. In: Mitra, G., Yu, X. (eds.) Handbook of Sentiment Analysis in Finance, pp. 214–227. Optirisk Systems, Chennai (2016)
9. Abrahams, A.S., Fan, W., Wang, G.A., Zhang, Z., Jiao, J.: An integrated text analytic framework for product defect discovery. Prod. Oper. Manag. **24**(6), 975–990 (2015). https://doi.org/10.1111/poms.12303
10. Jiang, M., Cui, P., Wang, F., Zhu, W., Yang, S.: Scalable recommendation with social contextual information. IEEE Trans. Knowl. Data Eng. **26**(11), 2789–2802 (2014). https://doi.org/10.1109/tkde.2014.2300487
11. Jin, X., Zhou, Z., Lee, M., Cheung, C.: Why users keep answering questions in online question answering communities: a theoretical and empirical investigation. Int. J. Inf. Manag. **33**(1), 93–104 (2012). https://doi.org/10.1016/j.ijinfomgt.2012.07.007
12. Spangler, S., Kreulen, J.: Mining the Talk: Unlocking the Business Value in Unstructured Information. IBM Press, Indianapolis (2008)
13. Wang, G., Liu, X., Fan, W.: A knowledge adoption model based framework for finding helpful user-generated contents in online communities. In: Proceedings of 30th Second International Conference on Information Systems, Shanghai, China (2011)
14. Yassine, A.A., Bradley, J.A.: A knowledge-driven, network-based computational framework for product development systems. J. Comput. Inf. Sci. Eng. **13**(1), 65–83 (2013). https://doi.org/10.1115/1.4023166
15. Li, X., Tian, Y., Smarandache, F., et al.: An extension collaborative innovation model in the context of big data. Int. J. Inf. Technol. Decis. Mak. **14**(1), 1–23 (2014). https://doi.org/10.1142/s0219622014500266
16. Smith, F., Storti, E., Taglino, F.: Towards semantic collective awareness platforms for business innovation. In: Advanced Information Systems Engineering Workshops, pp. 226–237 (2014). https://doi.org/10.1007/978-3-319-07869-4_21
17. Wu, J., Guo, B., Shi, Y.: Customer knowledge management and IT-enabled business model innovation: a conceptual framework and a case study from China. Eur. Manag. J. **31**(4), 359–372 (2013). https://doi.org/10.1016/j.emj.2013.02.001
18. Martinez-Torres, M.R.: Content analysis of open innovation communities using latent semantic indexing. Technol. Anal. Strateg. Manag. **27**(1), 1–17 (2015). https://doi.org/10.1080/09537325.2015.1020056
19. Chen, T., Shao, Y., Han, Y.: Collaborative Innovation Model Research Based on Knowledge-Supernetwork and TRIZ, pp. 1169–1174. Springer, Berlin (2015). https://doi.org/10.1007/978-3-662-43871-8_169
20. Lezcano, L., Sicilia, M.A., Rodríguez-Solano, C.: Integrating reasoning and clinical archetypes using OWL ontologies and SWRL rules. J. Biomed. Inform. **44**(2), 343–353 (2011). https://doi.org/10.1016/j.jbi.2010.11.005
21. Feigenbaum, L.: Semantic Web Technologies in the Enterprise (2006). http://www.thefigtrees.net/lee/blog/2006/11/semantic_web_technologies_in_t.html
22. Latif, A., Hofler, P., Stocker, A., Saeed, A., Wagner, C.: The linked data value chain: a lightweight model for business engineers. In: Proceedings of International Conference on Semantic Systems, 2009
23. Li, C., Xie, T., Tang, Y.: GMVN oriented S-BOX knowledge expression and reasoning framework. J. Intell. Manuf. **25**(5), 993–1011 (2014). https://doi.org/10.1007/s10845-012-0722-x
24. Li, C., Xie, T., Tang, Y., Cao, C.: Integration methods based on the multidisciplinary semantic bill of X for the manufacturing demand caused by emergencies. Comput. Integr. Manuf. Syst. **21**(4), 1063–1076 (2015)
25. Li, C., Xie, T., Tang, Y.: Knowledge expression and service on demand process reasoning framework of manufacturing system based on SWRL. Comput. Integr. Manuf. Syst. **19**(1), 187–198 (2013)
26. https://www.ltp-cloud.com/
27. Hyland, B.: Preparing for a linked data enterprise. In: Wood, D. (ed.) Linking Enterprise Data, pp. 51–64. Springer, New York (2010)
28. Graube, M, Ziegler, J., Urbas, L., Hladik, J.: Linked data as enabler for mobile applications for complex tasks in industrial settings. In: Emerging Technologies and Factory Automation, pp. 1–8 (2013). https://doi.org/10.1109/etfa.2013.6647948

Yuan Deng received her M.S. Degree in Management from Guangxi University in Nanning, China. She is currently a Ph.D. Candidate in Jinan University. Her research interest is mainly in the area of system control and information management.

Congdong Li received his Ph.D. Degree in Management from Tianjin University in Tianjin, China. He is currently a Professor in Management School of Jinan University. His research interest is mainly in the area of integrated system management and industrial engineering.

Dong Wang received the B.S. Degree from Hainan University, Haikou, China, in 2006, the M.S. Degree from Guangdong University of Technology, Guangzhou, China, in 2008, and Ph.D. Degree from Jinan University, Guangzhou, China, in 2013. He is currently a Lecturer of Guangzhou University, Guangzhou, China. His research interests are business intelligence, data mining, information systems and behavior economics.