DATA PAPER

Constructing a Scene-Based Knowledge System for E-Commerce Industries: Business Analysis and Challenges

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ABSTRACT

Online marketers make efforts to sell more products to their customers to increase turnover. One way to sell more products is to ensure that products belonging to the same scene are offered together. As such, it is beneficial to categorize products into different groups and tag them to particular, defined scenes. The mechanism of building relationships between products and scenes is called "scene-based knowledge system construction". The construction of a scene-based knowledge system is usually based on business operators' expert knowledge and past experiences, which often causes product categorization to be inaccurate. Hence, in this paper, we discuss the importance and necessity of constructing a scene-based knowledge system, analyze it from a business perspective, and discuss its challenges.

1. INTRODUCTION

In global e-commerce, businesses compete for markets, products, customers, marketplaces, sellers, and even operational technologies to increase their profits and overall turnover [1]. Every e-commerce business, especially the large-scale ones, such as Alibaba [2], expends great efforts to prompt consumers to buy more products from online shopping sites. One of the strategies they use is to ensure that multiple products

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belonging to the same particular scenario, or scene, are displayed to the customers so that they may purchase more products. This is also called "item-binding sales [3]". In this mechanism, when a customer searches for a certain product, other products that share the same scene with that product are shown to the customer, which may make the customer select and purchase more items. To make this mechanism successful, retailers need to determine scenes for products; in other words, we need to categorize products into different groups, in which each group is tagged by a particular scene. In this paper, we call this "constructing a scene-based knowledge system".

Scene-based knowledge system construction is important for three reasons: 1) it provides detailed information on the relationships between products and scenes; 2) it can be used to make recommendations to buyers or customers when listing products for them, so that they can avoid a new product search; 3) it helps to bind relevant items together for online shop owners to display products, so that they can sell more products and hence, increase their profits.

Existing ways of constructing a scene-based knowledge system usually rely on expert knowledge and past experience of business operators in grouping products into different functional categories [4,5,6]. These methods do not yield a consistent or accurate scene-based knowledge system because they are not generalizable. In addition, relationships between products and scenes are highly dependent on the specific business scopes and requirements formulated by e-commerce businesses; hence, it is difficult to categorize products into groups by particular scenes. Consequently, we need more fine-grained methods for constructing a scene-based knowledge system for e-commerce businesses. In order to propose better methods, we should first understand the business reasons for constructing a scene-based knowledge system for e-commerce businesses. Subsequently, we need to clarify its business requirements, business goals, and business value, followed by an examination of its challenges [7]. In addition, we should also propose potential solutions to address these challenges. In this paper, as such, we make a business analysis of scene-based knowledge system construction by discussing its business reasons, requirements, goals, and value, and we list its challenges and attempt to address these challenges by proposing potential solutions.

The research contributions of this paper are as follows: 1) formulating the official definition of a scene-based knowledge system for e-commerce businesses, which can be used by any e-commerce corporation in the world; 2) making a detailed business analysis for the construction of a scene-based knowledge system, by analyzing its business reasons, business requirements, business goals and business value; 3) providing a thorough list of challenges faced in scene-based knowledge system creation for e-commerce industries, followed by explanations for each challenge and analysis; and 4) proposing a series of potential solutions that can be applied to addressing these challenges, which can be widely used by e-commerce businesses worldwide.

The remainder of this paper is organized as follows: Section 2 discusses the background. Section 3 discusses related works. Section 4 presents a motivating example. Section 5 conducts a business analysis for scene-based knowledge system construction. Section 6 lists the challenges with scene-based knowledge system construction and Section 7 provides potential solutions to the challenges. Section 8 provides a discussion, and finally, Section 9 provides a conclusion and delineates future work.

2. BACKGROUND

This section consists of two aspects: 1) the definition of a scene-based knowledge system in e-commerce businesses and 2) the current usage of the scene-based knowledge system in e-commerce industries worldwide.

2.1 Definition of a Scene-Based Knowledge System

In order to understand and define the term "scene-based knowledge system", we should understand the core words: "scene" and "knowledge system". A scene refers to a scenario where a particular customer makes a certain purchase for a certain purpose, and a knowledge system refers to the type of knowledge that is represented by certain relationship information between two entities, such as the relationship between products and scenes. For example, a pair of basketball training shoes is used in the scene of playing basketball.

First, we need to formally define the word "scene". Specifically, the scenes in this study are shopping scenes. While other research works [8,9,10] define shopping scenes as shopping scenarios where people purchase products in order to meet shopping requirements, such as living needs or educational needs, we define scenes using the 4-W principle. The 4-W principle consists of four aspects: 1) when, 2) who, 3) where, and 4) what. This means that a certain person (who) does something (what) in a certain location (where) at a certain time (when). It is not necessary that all four Ws are present in a scene; however, the "what" must be present in it. The other three Ws (when, who and where) can be combined with what, either separately or jointly. For instance, a scene can be "who does what", "when it is done", "where it is done", or "who does what where and when". A shopping scene is equivalent to the shopping purpose because the scene can be reflected in the reason why a customer wants to buy a particular product. For example, the purchase of a pair of basketball training shoes belongs to the scene of playing basketball and it is used for playing basketball. Hence, according to our definition, a scene is formulated as shown:

$$\text{Scene} = \text{Tuple(What)} \cup \{S_w \mid S_w \in \text{Tuple(When, Who, Where)}\}. \tag{1}$$

Next, we should formally define the term "knowledge system". According to the existing works in knowledge graphing, a knowledge system refers to a certain type of knowledge infrastructure that represents complete relationships among multiple knowledge nodes [7, 11, 12]. In the context of e-commerce businesses, we define a knowledge system as the information that depicts relationships between two knowledge entities, e.g., products and scenes. We subsequently use this knowledge system to describe the knowledge architecture within the e-commerce industry.

Finally, we need to provide the definition of the complete term "scene-based knowledge system". This term is defined as the data-oriented knowledge architecture that contains all of the mapping relationships between the two entities of products and scenes. Usually, a knowledge system is regarded as a paradigm that generally depicts the entities and relationships between entities in a high abstraction level. Since this scene-based knowledge system is for the purpose of serving all business services and activities within e-commerce industries, such as Alibaba Group, we use the term "knowledge system" to imply the deep

functionalities and insights of the use of our product–scene relationships. We denote the scene-based knowledge system as SBKS, and it can be defined as:

$$SBKS = \{Tuple(Product, Scene) \mid Product\ is\ used\ in\ Scene\ \&\ Scene\ includes\ Product\}. \tag{2}$$

2.2 Current Usage of Scene-Based Knowledge System in E-Commerce Businesses

Several global e-commerce corporations based in China, such as Alibaba Group and JD.Com, have constructed scene-based knowledge systems [2, 13]. They apply scene-based knowledge systems to many areas, including shopping guidance, product recommendations and item-binding sales [2, 13]. By using this strategy, profits have risen by a substantial amount, overall turnover has greatly increased, and customer satisfaction has improved. The "Tiny Eastern Courtyard" product developed by JD.Com [13] can be used as an example to illustrate. This product was developed by JD.Com so as to increase the number of user visits, user page clicks and the user purchase rate of its online shopping application (app). It contains more than 1,300 shopping scenes, of which 200 are formally used by the front side of the app [13]. JD used a combination of intelligent algorithms and business operators' operational strategies to review the scenes that should be used and manually built the relationships between each product and scene. Then, it applied the constructed scene-based knowledge system on the functionalities of product recommendations and shopping guidance. By doing so, its user visit number increased substantially, and the purchase rate of its products also increased. This product has, therefore, gained a strong positive reputation within JD.Com Group [13].

Alibaba's shops are another example that can be used to clarify the current usage of a scene-based knowledge system; multiple products with various functionalities and purposes are displayed on the main page and the details pages of each shop. When a customer browses the products listed in an online shop, it can be difficult to find all products that belong to the same scene, requiring extra time in looking for other products belonging to the same scene. In order to solve this problem, Alibaba Group developed two applications by constructing a scene-based knowledge system: an app called "Have Good Things" and another called "Must-Buy List" [2]. The former product is used for making recommendations to customers looking for products belonging to the same shopping scenes, and the latter is used to provide insightful shopping guidance to customers who are not very certain about what products they should buy [2]. The use of these two apps have led to an increase in the number of user visits, the number of page clicks, and the purchase rate of Alibaba Group's online shops [14].

3. RELATED WORKS

Since we intend to employ several machine learning techniques to address some of the challenges of constructing a scene-based knowledge system for e-commerce businesses, we will first discuss some works related to applying machine learning methods to solving financial and commercial problems. These works include using machine learning techniques to determine share market prices, to forecast financial time series, and to predict the price of crude oil [15]. These works are related to our research in terms of using machine learning to determine a product's scenes and analyze information about the product's properties and the scene's characteristics and mining the relationship between them.

3.1 Share Market Price Prediction with Artificial Neural Networks

In 2011, researchers from Shahjalal University of Science and Technology (SUST) proposed a mechanism of predicting the stock market price based on artificial neural networks [15, 16]. This mechanism addressed a significant challenge which is related to the insignificant relationships between the share market chaos system's variables and the share price [15, 16]. They applied the traditional multiple layer perceptron (MLP) model on the neural network, and relied on the back propagation (BP) mechanism to compute and update the weight values of the intermediate inputs and outputs [15, 16]. The main drawbacks with this mechanism are as follows: 1) the neural network only used two hidden layers and there was no explanation for it, and they did not make any comparison between the performance of using two hidden layers and using more hidden layers; 2) the share market's variables which were used in the neural network only considered the information about the financial situation of the company, without considering other important features, such as customer size or launch time [15, 16]. Moreover, the proposed method was evaluated with only one company and tested against only two sets of input data, and the validity of the method was not fully proved [15, 16].

3.2 Financial Time Series Forecasting with ANNs

Artificial neural networks (ANNs) were identified as the most powerful and useful machine learning technique for the prediction of financial time series in the stock market by researchers from the Bond University, Australia [15, 17]. While the other methods used for such a prediction were majorly based on evolutionary and optimization-based technologies, people would prefer to employ and intensify established ANN models with new training algorithms or would like to combine ANNs with emerging technologies into hybrid systems [16, 18]. However, it is still unclear how the real-world constraints can impact the accuracy of financial time series forecasting and stock index prediction. In addition, we should also investigate whether investors' risk-return tradeoff can be improved or not [15, 17].

3.3 Crude Oil Price Prediction with ANN-Q

An artificial neural network quantitative (ANN-Q) model-based approach for predicting the price of crude oil was proposed by researchers from the University of Manchester in 2010 [15, 18]. The framework proposed in this research addressed a significant challenge with crude oil price prediction: the price of crude oil is linked with a large set of factors and the changes of these factors may impact the price of crude oil to a large extent. Crude oil is a major product that has a high level of volatility in the world [15, 18]. By leveraging and analyzing a total of 22 key factors which can impact the price of crude oil, researchers proposed an ANN-Q model [15, 18]. For the purpose of developing a better model, the data related to these key factors were further divided into three categories: large impact, medium impact and small impact [15, 18]. The Backpropagation Neural Network (BPNN) was utilized for input variables training [15, 18]. In the simulation based experiments, the acceptable accuracy of the proposed method was monitored progressively, and the results show that the accuracy could be improved by better tuning the parameters of the model [15, 18].

4. A MOTIVATING EXAMPLE

In this section, we present a motivating example to explain why constructing a scene-based knowledge system for e-commerce businesses is beneficial. With a developed scene-based knowledge system, a set of business requirements and operational strategic goals can be fulfilled by applying the system to an e-commerce business solution, such as product recommendations and item-binding sales. The motivating example is illustrated in Figure 1.
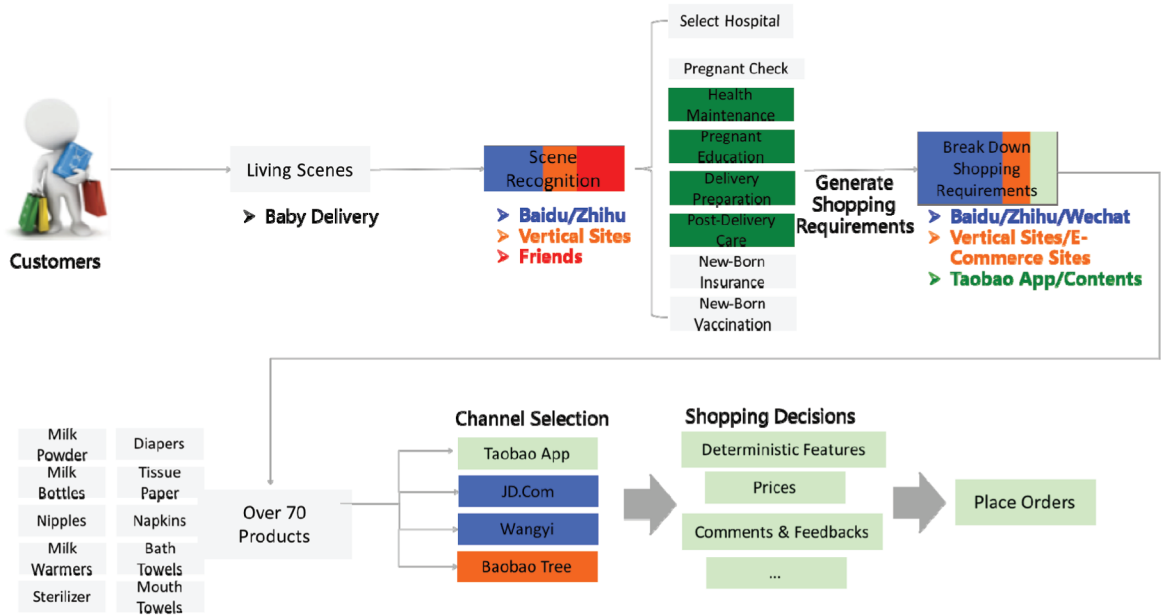

Figure 1. A motivating example.

A customer is attached to several life scenes, and one of them could be the birth of a baby. The scene of the birth of a baby consists of several subsidiary scenes, and hence, the customer needs to make a scene recognition for this main scene. After analyzing the subsidiary scenes of the main scene, the customer observes that it can be divided into several child scenes: selecting a hospital, getting a pregnancy scan, prenatal education, making preparations for the birth, post-delivery care, buying newborn insurance, and ensuring that newborn vaccinations are given to the baby. Then, based on these sub-scenes, the customer can generate many main shopping requirements that break down into several child-related requirements. This is performed with the assistance of online applications, such as Baidu, Zhihu and WeChat; vertical sites; e-commerce sites; and the Taobao App. Subsequently, based on these sub-requirements, the customer determines that they need to purchase more than 70 baby products, including milk powder, diapers and milk bottles. Next, the customer needs to select proper shopping channels from the candidates list, such as the Taobao App, JD.Com, NetEase, and Baobao Tree. Then, the customer makes shopping choices by analyzing the deterministic features of the products, considering product prices, studying the comments

and feedback of the products, and so on. Finally, the customer decides what to buy and places orders for those products. In the above story, we can see that many products belong to the same scene and the same subsidiary scene. If we combine the products belonging to the same scene/sub-scene together and put them into a category tagged by a certain scene, then the customer will find it easier and more convenient to place orders for products that belong to the same scene. As such, the construction of a scene-based knowledge system is a necessary element in e-commerce sales for the arrival of a new baby.

5. BUSINESS ANALYSIS FOR SCENE-BASED KNOWLEDGE SYSTEM CONSTRUCTION

This section contains a detailed business analysis for the construction of a scene-based knowledge system. Specifically, we provide the business reasons supporting the development of a scene-based knowledge system, formulate its business requirements, illustrate its business goals and discuss its business value.

5.1 Business Reasons for Constructing a Scene-Based Knowledge System

Based on our past experience as well as the expertise of business professionals from other e-commerce organizations, we present eight reasons for a scene-based knowledge system to be constructed. These eight reasons are: 1) the information about the categories of the shopping scenes helps e-commerce businesses better understand the complete scenes (e.g., the shopping scene for baby care includes purchasing infant food, planning infant wellness, and purchasing infant clothing, among other shopping tasks); 2) if features of online products are analyzed in a scene-oriented manner, the business stakeholders will have better ideas about which scenes online products belong to (e.g., basketball shoes' features should include weight, materials, durability and color); 3) the online shopping systems need to know the manner in which online products should be put together and how these categorized products can be sold to their customers in just one round (e.g., the basketball shoes and the basketball shorts should be bound together for sale); 4) the number of user visits and page clicks as well as the purchase rate of the online shops are highly related to the scene-based products' categorization mechanisms (e.g., after binding the basketball shoes and the basketball shorts, the overall click rate on these two items and the sales of these two items increased); 5) for customers, the quality of their shopping experience should be improved; this is closely related to whether related products are categorized according to their scenes and purposes (e.g., if the basketball shoes are bound with basketball shorts, customers regard the site as a convenient way to shop for basketball gear); 6) the total profits and overall turnover of an e-commerce businesses can be increased by using strategies, such as product recommendations and item-binding sales that rely on the construction of a scene-based knowledge system (e.g., selling only the shoes brings less profit than selling both the basketball shoes and basketball shorts); 7) there is a lack of standardization in the relationships between online products and shopping scenes among e-commerce businesses worldwide, and hence, these businesses do not have a unified mechanism to categorize their products based on particular scenes; 8) the current definition of the scene-based knowledge system is not formalized and the usage of scene-based knowledge systems is not standardized among the various e-commerce businesses in the world.

5.2 Business Requirements for Constructing a Scene-Based Knowledge System

We also formulate the business requirements for constructing a scene-based knowledge system for e-commerce businesses. The following are the six requirements: 1) the scenes and shopping purposes of all customers that shop on online shopping sites should be enumerated daily in a complete manner to ensure we observe shopping scenes that are important for making e-commerce decisions; 2) the definition of scenes and the relationships among various scenes must be determined in a clear and accurate manner; 3) the mapping relationships between each online product and each scene must be accurately and precisely determined and those relationships must be easy to understand; 4) the multitude of products that can belong to an identical scene must be properly defined; 5) if a product can belong to multiple scenes, then all scenes must be determined; and 6) the constructed scene-based knowledge system must be stored in a proper form in a reasonable location to be easily accessed.

5.3 Business Goals for Constructing a Scene-Based Knowledge System

The business goals of constructing a scene-based knowledge system are as follows. First, the system can be used by all e-commerce businesses in a generalizable way; different e-commerce businesses are able to treat it as a standardized tool to make business decisions. Second, it can be used by all worldwide e-commerce businesses to develop sophisticated functionalities of online shopping applications. Third, it will greatly increase user visits and page clicks on online shopping apps through improved product recommendations and item-binding sales; and finally, it will substantially increase purchase conversion rates, overall profits and total turnover.

5.4 Business Value of Constructing a Scene-Based Knowledge System

The business value of constructing a scene-based knowledge system is three-fold: 1) it provides a standard for organizing and managing products, scenes and their relationships for all e-commerce businesses worldwide; 2) it helps to achieve business goals, such as total user visits, user page click rates, user purchase rates, business profits and turnover; and 3) it sets a good example for e-commerce businesses and companies in other domains for building and using a knowledge system that is closely related to business strategy.

6. CHALLENGES

In this section we list eight constraints in this project of constructing a scene-based knowledge system for e-commerce as follows.

1). The determining of scenes is not a straightforward process because there is no standardization of what "a scene" really entails. There is no previous work that can be referenced to help us understand the internal properties of scenes. Therefore, we have to determine the definitions based on the understanding of our own e-commerce corporation's contextual information and business strategies.

2). There is no existing work on the method to systematically define and formulate a scene-based knowledge system; hence, we lack references to describe and formulate the system. As such, we must rely on our own context and business scope to systematically formulate the definition and use this definition to construct the relationships between products and scenes.

3). The core aspect of a scene is "a thing", but the definition of "a thing" is quite unclear and different people have different opinions about what a thing is. Moreover, the relationship between a thing and other aspects of a scene is not always straightforward.

4). It is difficult to describe or model an individual customer's shopping requirements. Sometimes a customer may not know the actual reasons why they wish to buy something. Shopping requirements can be quite complex, which makes it complicated to model shopping requirements.

5). The definition of scenes is based on the understanding of operational rules; however, operational rules are difficult to define because different business operators have different standards on managing rules and rules often come in various forms. Hence, it is challenging to define them in a generic way.

6). It is also exacting to determine the relationship between each product and each scene because it is based on a full and global understanding of all products and their features and all scenes and their properties. This takes a relatively long time and substantial human efforts; it is difficult to automate this process.

7). It is difficult to verify the accuracy of the determined relationships between products and scenes as it requires manpower and considerable human efforts. It largely depends on the business scope and requirements of the e-commerce industry. Even if we use automation mechanisms to speed up this process, it is not guaranteed that the determined relationships will be accurate enough.

8). The mechanism used to construct a scene-based knowledge system must be generalizable to all e-commerce businesses in the world. This is demanding because different e-commerce businesses have different characteristics, products and product categories.

7. POTENTIAL SOLUTIONS

In order to address the abovementioned challenges, we propose potential solutions to solve each of them. These solutions are described as below:

1). To solve the challenge related to the definition of scenes, we propose to make a business study on all the purposes our customers have in buying certain products. We can model these drives and attempt to mine the shopping scene information from the purposes. More specifically, we should determine all aspects of a scene and clarify which aspects are the core aspects and which are secondary.

2). To solve the challenge related to the knowledge system definition, we propose to review the business requirements and operational requirements of our own e-commerce corporation to understand the type of knowledge system our firm requires to determine all features and aspects that are needed in formulating the definition of a knowledge system.

3). To solve the challenge of the definition of "things", we propose to summarize all objective entities within the purposes of online shopping tasks conducted by all types of customers and try to determine the patterns that model each entity. As a result, the "things" will be the models in the form of proper patterns.

4). To solve the challenge of modeling shopping requirements, we propose to first gather historical shopping requirements of all existing customers, either manually or in an automated manner, and subsequently use data analytics methods to perform data mining and statistical learning on these data to discover the correct way to model user shopping requirements. This model should be stored in such a manner that it can be reused by external parties.

5). To solve the challenge of defining the operational rules, we propose to determine a formal way of expressing an operational rule. To express an operational rule properly and correctly, we should be certain about what factors are included in the rule and how to organize these factors to form a scientific and model-oriented paradigm to record the operational rules.

6). To solve the challenge related to the determination of the product–scene relationships, we propose to use a combination of two mechanisms: 1) using machine learning to generate and classify scenes and 2) having people check the conformance of the operational rules. First, we generate a scene for each product; second, we determine whether the generated scene is proper for the product according to the conformance checker.

7). To solve the challenge related to the accuracy of product–scene relationships, we propose to apply cross validation on the determined output of the relationships between products and scenes. Specifically, we can use 10-fold cross validation, where we divide the data set into ten sections, use nine of the ten sections for data training, and use the remaining section for data prediction to calculate the prediction accuracy. Performing this procedure ten times until each of the ten sections has been evaluated, we then compute the average amount of the ten accuracy values and verify whether this average value is large enough.

8). To solve the challenge of generalizing the system, we propose to first summarize all products and scenes for each of the worldwide e-commerce businesses and subsequently build the relationships between products and scenes for each e-commerce business, using the data for each e-commerce business for a small scene-based knowledge system. Next, we will unite all knowledge systems together to form a larger, centralized scene-based knowledge system. Different e-commerce businesses will be able to use the same centralized knowledge system to develop their own strategic solutions for their applications so as to fulfill their respective business goals.

8. DISCUSSION

In reality, the construction of a scene-based knowledge system is only one of the many strategies that can be used to fulfill the business goals and requirements of e-commerce businesses in the world. Other strategies may include marketing solutions, such as intelligent red packets [9], intelligent coupons, intelligent price determinations [6] or price discounting mechanisms. We argue that a scene-based knowledge system is more viable than other strategies because we firmly believe that the purposes behind customers' purchases of certain products are fundamental to successful e-purchasing.

While a scene-based knowledge system can be used to realize business goals, such as increasing the number of user visits, page visits, purchase rates, and overall profits and turnover, it can also offer other benefits to e-commerce businesses, namely strengthening their reputations and helping with business expansions. Thus, it is vital and significant for global e-commerce businesses to set up resources to construct scene-based knowledge systems.

9. CONCLUSION AND FUTURE WORK

Every online shop owner is dedicated to selling more products to customers to increase the total turnover. One method of achieving this is to ensure that products belonging to the same scene are grouped together. As such, firms must categorize products into different groups that are tagged by particular scenes. We call the determination of the relationships between products and scenes "scene-based knowledge system construction". The existing methods of constructing scene-based knowledge systems are typically based on the business operators' expert knowledge and past experience, which results in inaccurate product categorization. Hence, in this paper we make a detailed business analysis of scene-based knowledge system construction, discuss its challenges, and propose potential solutions to these challenges.

Our future work includes the following tasks. First, we intend to propose a formal method to construct a scene-based knowledge system, implementing and evaluating it using real-world scenarios. The method will be a combination of potential solutions to challenges delineated in Section 7. It must be fine-grained and generalizable for different types of business requirements and cater to multiple e-commerce industries in the world. Second, we need to determine other business requirements that the scene-based knowledge system should support and check whether our methodology is able to fulfill those requirements.

AUTHOR CONTRIBUTIONS

This work was a collaborative effort among all authors. M. Fu (hanhao.fm@alibaba-inc.com, corresponding author) is the main writer for the research project. Q. Chen (lapu.cq@alibaba-inc.com) W. Lin (weijiang.lw@alibaba-inc.com), P. Wang (wp146049@alibaba-inc.com), and W. Zhang (lantu.zw@alibaba-inc.com) provided insights and information in the business analysis section the challenges section, and the methodology section of the paper. All authors made meaningful and valuable contributions in revising and proofreading the resulting manuscript.

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