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Conceptualization of Natural Language-Based Product Configurators for New Product Development in Apparel

Wasana UDUWELA[a,1], R K J DE SILVA[b], Thashika RUPASINGHE[c], and Lochandaka RANATHUNGA[d]
[a] *Department of Computer Science, The Open University, Sri Lanka*
[b] *Department of Textile and Apparel Engineering, University of Moratuwa, Sri Lanka*
[c] *MAS Capital (PVT) Limited, Battaramulla, Sri Lanka*
[d] *Department of Information Technology, University of Moratuwa, Sri Lanka*

Abstract. Digital technologies enable apparel manufacturers to unlock solutions for new product development (NPD) challenges faced during the Covid-19 pandemic. A Product Configurator (PC) is the key to Mass Customization (MC) as it can employ to elicit customer requirements, which is essential in successful NPD. Even though some online PCs exist in apparel retail and product development, no one could gather customer requirements and deploy them in the NPD. This paper conceptualizes a Natural Language Processing (NLP)-based PC on eliciting customer requirements based on a systematic literature review and a basic concept of Design Space Analysis. Finally, it is contended that this knowledge can apply in relevant software development to modernize apparel design, development and online retail.

Keywords. apparel industry, new product development, mass customization, natural language processing, product configurator

1. Introduction

Modern customers prefer to personalize style, fit and colour of the clothes they buy according to their requirements, therefore Mass Customization (MC) is demanded to meet the diversified needs of individual customers [1]. MC is the process of providing unique products for customers at an affordable price [2], and digitalization revamps the MC strategy. Also, the COVID-19 pandemic shows a significant demand for MC in the apparel industry [3]. Recent statistics show that digital channels are being used by 13% of new customers for the first time, and this trend will further develop even during the post-COVID-19 pandemic [4]. Therefore, apparel organizations are under intense pressure to provide MC through digital channels [5]. Therefore, companies should ensure that their digital technologies support customer interaction and New Product Development (NPD) through MC. Configurators are the standard interface businesses use for customer interaction for NPD and their primary function is to enable product developers to demonstrate different potential variabilities in products. In addition, customers should also be made aware of possible configuration capabilities [6].

[1] Corresponding Author: Wasana Uduwela, Department of Computer Science, The Open University of Sri Lanka, Sri Lanka, E-mail: wasana@ou.ac.lk.

The NPD process in MC seeks information exchange between the customer and manufacturer. Conventional PCs consist of a set of predefined components or attributes that consider the customer's choice of features as input, and limit customer requirements to these predefined components [7]. However, customers are heterogeneous in preferences and needs [8] and customers may not possess the necessary expertise about an unfamiliar product [9], therefore NPD is a complex task with existing PCs for non-specialists customers [10]. Consequently, the final configuration will differ from the actual requirements and will lead to increased NPD cycle time and cost [10].

Natural Language (NL) based PCs are applied in other industries to improve customer interaction during product design and manufacturing. Recent studies are focused more on providing actual perceptual intentions and needs of the product in NL [7], as there is a discrepancy between customer requirements and product offerings through PCs. There are no such NL-based PCs in apparel, therefore this study conceptualizes this technology in the apparel context. NLP is an automated manipulation of NL by software. It is a way for machines to understand human language. Typically, human produce NL is unstructured and NLP can be used to understand the context and content of this data so that a large amount of information can be found [11].

As a result, this study will be necessary as a preliminary study to explore the features of PCs including NLP, specific to the apparel industry. The paper aims to develop a conceptual model capable of NLP for PCs for NPD in apparel to improve the requirements elicitation during the MC process. The key objectives of this paper were to: (1) identify the best features of the PCs proposed in the literature review to develop an effective mass customized NPD in apparels; (2) to review online apparel PCs for available features to communicate customer requirements; (3) to develop a conceptual model based on NLP.

2. Methodology and Research Design

To achieve the first objective, a comprehensive literature review on PCs was conducted. It was based on content analysis to extract the problems and suggested solutions. The purpose of using content analysis as a research method is to increase understanding of PCs' barriers to effective NPD and to become aware of suggested improvements [12]. Inductive content analysis was used as no previous study dealt with the objective of this study and previous knowledge is fragmented. With this knowledge, a review of existing online apparel PCs was conducted to learn about their available features to communicate customer needs. Afterwards,

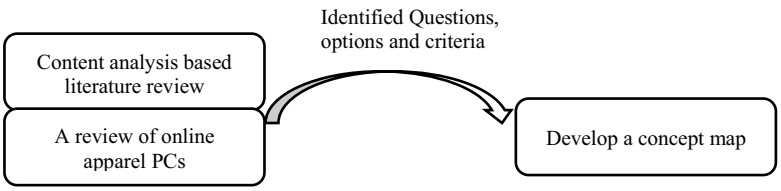

Figure 1. Literature Review methodology used to develop the conceptual model

gathered knowledge about PC improvements was organized into a concept map by using QOC (Question, Options and Criteria). Finally, the conceptual model was developed based on the findings. Figure 1 summarizes the research design.

2.1. Search and selection strategies

To conduct the literature review, the search string (mass customization OR mass personalization OR co-design OR product development) AND (configurator OR configuration system) was used to collect papers published from 2005 to 2021 on the theme of interest from the following databases: Google Scholar, IEEE explore, ScienceDirect, and SpringerLink. Since, we could not find any NL-based online PCs for NPD in the apparel industry and wanted to develop the proposed conceptual model using other best practices, the word "natural language" was not considered as a keyword. This covers 16 years of research in this field. A study was excluded if it was: 1) written in a language other than English; 2) not available online for download, and 3) Duplicates were not considered if an article was found in more than one database. Reports, book chapters / sections, conference articles, theses, and peer review articles were considered for the review. Table 2 summarize the total findings.

Table 1. Sources of literature

Name of the database	Total number of articles identified
Springer Link	652
IEEE Explore	10
Science Direct	20
Google Scholar	38
Total	720

2.2. Content Analysis

The key findings of all the collected papers were included in the content analysis. The primary codes were taken as follows; "Problems" discussed in the papers, the "option" suggested by the papers and "criteria" concerned about the features. These codes were taken from the QOC (Question, option, and Criteria) approach that focuses on representing the most basic concepts of Design Space Analysis. Design Space Analysis is an approach to describe design rationale. Design Rationale is a representation for explicitly documenting the reasoning and argumentation that make sense of a specific artifact [13]. The main constituents of QOC are: Questions-identifying key design issues, Options-providing possible answers to the Questions, and Criteria-for assessing and comparing the Options [13]. Precisely, QOC depicts the reasoning behind a system design. Therefore, this study clearly identifies the proposed solutions to improve PCs by avoiding problems using QOC. For this reason, the identified issues of PCs are represented as questions (problems) and the proposed suggestions and features were categorized under options and criteria respectively.

2.3. Review of online PCs and Concept map development

A review was conducted to explore the features already implemented in the apparel industry to communicate consumer requirements using popular online apparel PCs and some literature. Afterwards, the findings of the content analysis and the review were summarized into a concept map to fulfil the main aim of the research. Concept mapping was mainly used to summarize information obtained from a single source and synthesize information obtained from different sources. This paper concludes with a conceptual model for apparel PCs based on NL.

3. Results and Discussion

3.1. Details of Included and Excluded Studies

Firstly, (29) articles that were not written in English and (8) articles which were inaccessible to download were excluded from the study. Afterwards, by reading the title, all duplicate and irrelevant articles by reading title and abstracts were excluded from the study, which was a significant number (468). Next, reading the abstracts, (154) articles about the PCs related to non-consumer goods were also ignored. Online consumer goods customers are not a specific audience like those of non-consumer goods. Therefore, the approaches suggested in non-consumer goods are specific and may not be suitable for the consumer goods audience. The remaining articles (61) had to be read in their entirety as it was not clear whether reading the abstract met the inclusion criteria. From the remaining (61) articles, (52) articles were excluded as their discussions were limited to the following: the relationship between PCs and MC, the absence of PCs and its' features, PCs related to non-consumer goods (the abstract fails to explain the product clearly).

3.2. Results and Findings of literature review

Finally, the analysis of the literature review included only nine references (see Table 2). They have been conducted on PCs in general and different types of products have been used for their validation (for example computers). Among those nine articles, five articles were published as parts of books and three were published in journals. The remaining article was presented at a conference proceeding.

According to the selected papers, many researchers have conversed on user-assistance because configuration conflicts can arise when providing customer-specific product requirements [14]. That being so, separate studies have been conducted to offer solutions to different types of problems that affect meeting the exact needs of the customer through PCs.

Table 2: Key findings of the literature review

No	Ref.	Problem	Option	Criteria
1	[7]	Customers do not have the *necessary domain knowledge about the product*.	Takes requirements in NL.	Build a map from a review of online product specifications, and then use it to transform customer needs in NL into product specifications.
2	[14]	*Conflicts occur due to too strict requirements given by customers* (ex: requesting invalid configuration)	Recommend the corrective actions	Removing selected components or adding new features are suggested by the system
3	[15]	Ranges of *customizable products are vast and complex, due to a number of features and options* of configurators and the many constraints that exist between them.	Help the user interactively by defining the product step by step.	Help customers in configuration process to make choices, one step at a time, by using partially defined products.
4	[16]	*Too many choices in the customizing process increase the task complexity for consumers*	Provide a set of default templates to customers	Firstly, the customer must select a template most similar to their preferences. Secondly, customers can refine the template according to their exact requirements.

5	[8]	The *vast number of choices may lead to mass confusion*	Provide the options of the product according to the cluster where the customer belongs.	Initially, the corresponding cluster is identified for each customer. Then configuring process is carried out. The scale of each group is smaller than the original attribute choice set.
6	[17]	New products need to be designed with early integration of end-user requirements. An efficient way to do this is *directly integrating the end-users in the design process by giving an experience.*	Facilitate the customer to immersion and control of the design of the product by gaining experience	Provide a digital tool that allows customers to perform design tasks directly and modify virtual prototypes (mixed reality).
7	[18]	The high *product variety of MC induces a high complexity*. • As *customers are not technical engineers, and have less experience,* they are often confused and unable to choose the best product for their needs.	• Personalization at the Interaction and Presentation Level • Personalization at the Content Level	• Requirement communication in NL • Degrees of freedom in navigation • Domain-specific interaction styles • Presentation style (personalized content and interaction) • Customized configuration steps and configuration dialogue. • Provide hints, explanations and reasoning. • Result presentation (ex:- options to refine requirements, monitor configuration process and rate it)
8	[19]	Customers d*o not know their needs beforehand*, C*onsumers do not have technical knowledge about the product.*	Increase the usability of configuration technologies.	• Customize the customization process. • Provide starting points • Support incremental refinement • Exploit prototypes to avoid surprises • Teach the consumer (personalized diagnoses, and explanations)
9	[20]	*Understanding customer needs is becoming the essential preliminary remark for the successful design and implementation of products.*	To Conversion between customer needs and product configuration in NL	• Express product demands by the use of NL and the automatic conversion between customer needs and product

Lack of customer knowledge about the products is one of the main challenges. Accordingly, NL-based dialogues between the customer and the PCs have been proposed to communicate the product requirements [7], [18], [20]. It has been proposed as a solution to the difficulties of understanding customer needs.

However, PCs with options create a high level of complexity for the customers, as they are usually inexperienced and therefore are often confused and unable to choose a product/option that best suits their needs [18]. Also, due to the varying needs of different customers, higher product variants are offered as a set of options within the PCs, as PCs with options are capable of generating product variants of the customer. As a result, there is a great need for a more user-friendly configuration design to improve the choice navigation process of the PCs with options [7]. Typically, each customer has a preferred set of product properties. Customizing the product from the beginning could make it difficult for the customer to design the needed effect. Yet, a default template provides a prototype to modify and meet their final needs [16]. Chevalier & Servant (2012) [15] has suggested a solution for configurators to define a product step by step for the same

difficulty. Therefore, the product options are limited for each step, minimizing the hassle for customers when choosing options. More advantages can be gained by offering product options according to the cluster belonging to the customer [8]. However, the product options given in PCs should be organized according to customizable dimensions, such as options for fitting, aesthetics, and functions [21]. Another way to change the interaction-style based on the customer would be to change the degree of freedom concerning navigation. This includes the ability to try different options for product features with or without any support [18].

Usually, customers prefer different communication-styles depending on their domain. Therefore, domain-specific interaction is needed to minimize the complexity of PCs [18]. Similarly, immediate feedback through hints on customer suggestions and a personalized presentation (content and interaction) has been suggested in mitigating the complexities of many choices. For example, the layout of the interface and language style are considered in the presentation design [18]. Moreover, many studies have suggested that personalized presentation is required for configurators to deliver an effective configuration [18], [19]. Moreover, presenting the configuration (outcome) is also essential for effectiveness [18]. These solutions are proposed to reduce the complications caused by more options and assist customers with less domain-knowledge about the product.

During the configuration process, the user is repeatedly asked to select or enter one or more values to refine the configuration. This process is repeated until all the required product components are chosen and each user is asked the same questions in the same order. However, this is problematic because customers have difficulty selecting the best options due to the lack of domain knowledge. Therefore, the customization process is required with personalized dialogue and steps of action [18], [19].

Customers often have neither the technical knowledge of the product nor a specific idea about their requirements. More sophisticated explanation -mechanisms are needed to assist customers and support them in increasing their product domain knowledge. As suggested by Blacker et al. (2004) in their study, both PCs and the advisory system are technically segregated, they must be integrated into an overall interactive system that assists customers in the requirement elicitation process. Similarly, the integration of PCs with options and an NL-based advisory system will enhance customer requirement elicitation. In addition, providing reasons is a treatment for the unresolved user -needs [18], [19]. Moreover, providing options to define the start-up process is one solution the customer will see as a start-up plan that allows the configuration process to continue [19]. For example, one user of a bra configurator prefers to start with a specification of the bra-type, whereas another user prefers to specify the price as a parameter with the highest priority.

Visualizing the result of the configurator should be as close as possible in the configuration process as it enhances trust while providing an experience to the customer [18]. In this context, it is essential to visualize the impact of different decision options on the final configuration results (exploit the prototype) [19]. Thus, a visual presentation of the product should be available in every step of the customization [21], and the PC needs to recommend corrective actions to generate valid configurations. Corrective actions such as removing selected components or adding new features should be suggested by the system[14]. Support of sensitivity-analysis is needed to identify trade-offs between different properties and alternatives to the current configuration [19]. The same solution, suggesting correct actions, was proposed as a solution to the problem that occurs when

some requirements are strict, and the customer does not have a clear idea of the requirements [14].

Mixed Reality is a new concept to meet the total needs of the customer by enhancing user interaction with digital tools. It allows end-users to immerse themselves in a virtual environment (immersion) and interact with a virtual prototype to modify (or control) simultaneously [17]. De Silva, Rupasinghe, & Apeagyei, (2018) [22] also suggested that customer interaction with modern digital tools is essential for effective NPDs.

3.3. A review of the online apparel PCs

'Nike By You' is one of the most popular online PCs in footwear which uses user-centric design and development [7]. The key aspects of 'Nike By You' was examined in this study. In this example, customer requirements were gathered using choice navigation provided on the website. The PC has already implemented most of the criteria suggested in the literature review except for personalization and communication. 'Nike By You' provides many templates, and customers can initiate the NPD process by selecting one. Also, these templates have been categorized into different clusters, for example, by sports, and by size. Moreover, customers can launch their product search according to their requirements. Likewise, the customer has a degree of freedom in navigation and does not request to follow a sequential product selection process. However, the 'Converse' shoe brand provides fifteen steps to guide in customizing a shoe, and it can start with any action. In customization, 'Nike by You' PC does not provide personalized explanations for each step. It provides additional information about the selected product for user reference. Nevertheless, existing PCs are not interactive and do not provide immediate personalized feedback for user inputs. However, options are available to refine the choices if needed. The PC generates quality digital prototypes for each customization simultaneously for each modification [21]. Additionally, Nike is updating its app with a newer reality tool called 'Nike Fit', which can measure a user's feet and sell a sneaker that fits the user [23]. Its content's configuration layout and presentation is user-friendly [21]. However, 'Nike By You' does not present configuration features and information in a personalized manner. All the settings and information of 'Nike By You' is related to the footwear industry, and similar interactions can be experienced in other PCs such as 'Converse', and 'Mi adidas'.

On the other hand, the analysis discovered that the co-designing of a new product is limited and not flexible in these existing PCs. There are no options to communicate their real needs freely on the online PCs. For example, changes need to be made to the shoe's shape, material changes, location changes of the given logos and symbols, level of comfort (high, medium, low), and so on. If the PC has enabled NLP, the customer can communicate the real needs of new products in NL, and the PC can guide the customer by giving personalized advice, as communication takes place in a physical store.

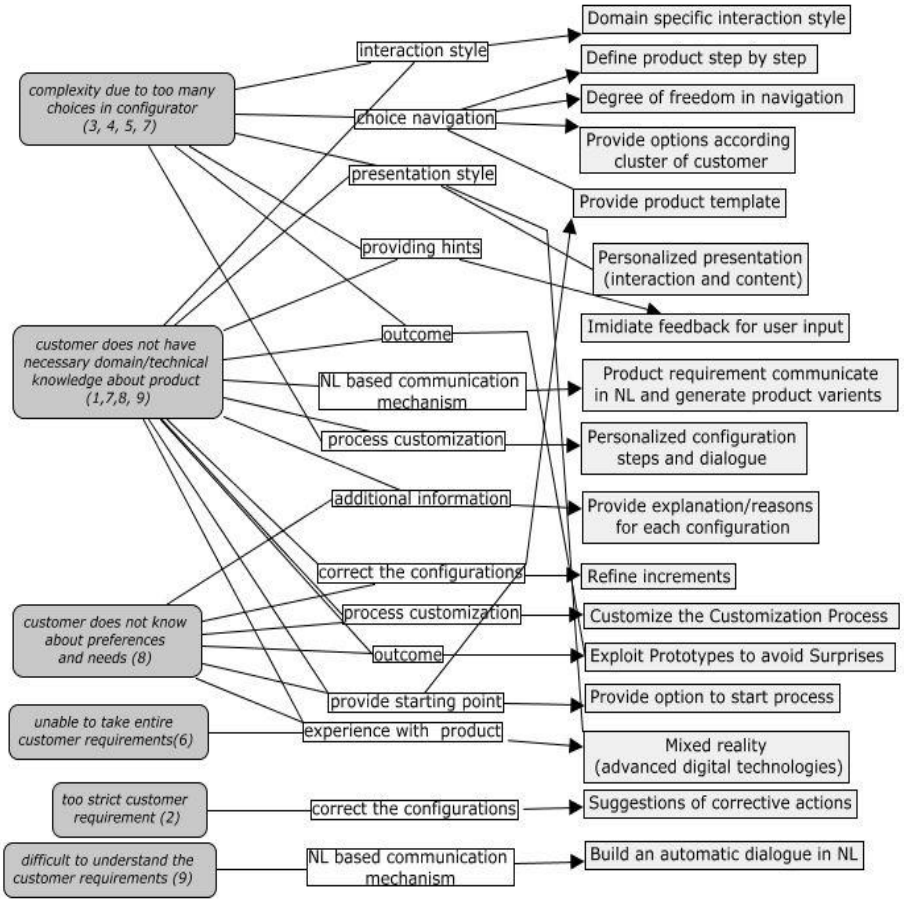

Figure 2. Concept map developed based on QOC by using findings

4. Conceptual model development for an NL-based PCs for the apparel industry

The concept map developed clearly shows the significant challenges in the requirement elicitation process with PCs which are as follows: 'customer does not have the necessary domain knowledge of products, 'complexity due to too many choices in configurator', 'customer is unaware of requirements', 'configurator is unable to take full customer requirements', 'too strict customer requirements', and 'difficulty of understanding the customer requirements.

However, the literature discusses two methods used by PCs to elicit the requirements of new products. The most common method used by today's PCs is choice navigation (options), even in the apparel industry. There are several solutions discussed in the literature to enhance the choice navigation approach, and a summary of them can be found in Figure 3. The second method is to take the customer requirements in NL, which should be customized. Thus, the customer can freely communicate the needs without confining

them to a component-selection process [7]. Also, NL dialog support provides product domain knowledge to the user [18].

Irrespective of the approach to elicit the requirements, it is vital to present the result/prototype of each step to make the decisions about the configured product. Because the customer does not interact with the physical product, visualizing the prototype as part of the configuration process is necessary to give the customer a real sense of the product [6]. If requirements are refined, options should be provided for corrective actions. It is essential, as it is difficult for customers to communicate the proper needs in the first place [22]. The findings of the study proved that every step of the configuration process requires explanations and reasoning to eliminate the challenges faced by the customer and to meet the correct requirements to improve PC usability [6]. Hints are the other option to provide immediate feedback for customer inputs, which are additional information for the customer. The new trend of current PCs is to improve the requirement elicitation process by providing technical support to enhance the customer experience. Technologies like virtual reality and augmented reality enable collaborative apparel product development with the customer [22].

The PC should provide a starting point to ease the configuration process for the customer, and it can be achieved by giving templates with options to start the process. Finally, the presentation style of all provided options should be considered to elicit customer requirements effectively. The literature has proven that the personalized environment enhances the results of the configuration process [18]. Moreover, it should warrant the ability to customize the customer specific configuration steps provided in NL. Furthermore, integrating the proposed enhancements of the PCs with NL communication will increase customer support in the process of requirement elicitation. These findings are conceptually modelled and depicted in Figure 3.

5. Discussion and Conclusions

Digital NPD and launch with MC will be the key to success in the future apparel industry with the new trends of customers. An NPD model for MC has already been developed for the apparel industry, and advanced technologies have been proposed to elicit user requirements [22]. However, web technologies capture customer requirements in many industries and PCs play the leading role. However, the proposed NPD models for MC did not specifically consider how PCs could be used effectively to meet customer needs on the web. This has become a necessity with the changes brought forth by the COVID-19 pandemic as well. Although some studies have already shown the importance of the web-based PC for apparel MC, they are limited to fulfilling several customer needs [1]. Further, no systematic PCs were established in NPD of the apparel industry to elicit customer requirements in NL effectively. Therefore, the proposed conceptual model with the suggestion to process and elicit the customer requirements given in NL will be a new era in the future of the apparel industry.

A content analysis based literature review and a review of popular online apparel PCs was carried out to extract salient features of PCs. Based on the findings, a conceptual model was built to indicate key features of PCs to elicit the customer requirements in NPD of apparel. The significance of the NL-based requirement elicitation was discussed using some established online platforms applied in the footwear industry. More importantly, this paper suggests a PC based on NLP for NPD in apparel to minimize the problems at requirement elicitation with PCs. Furthermore, it proposes that the dialogue in NL between the customer and the PC should be personalized, during which it should

be generated automatically according to customer- responses. However, the PC should be able to create the product variants from the requirements given in NL.

Thus, it allows customers to freely meet their needs as they are not limited to a set of options available on a PC. Additionally, the customer does not need to know about the PC user interface with options like in traditional PCs [24]. The provision of free communication in NL will supply product developers a great opportunity to get an idea of the market trends equally. Besides, the issues in developing and implementing the NLP-enabled PC may justify future research. At last, the proposed digital platform will augment the apparel business after the cessation of the COVID-19 pandemic.

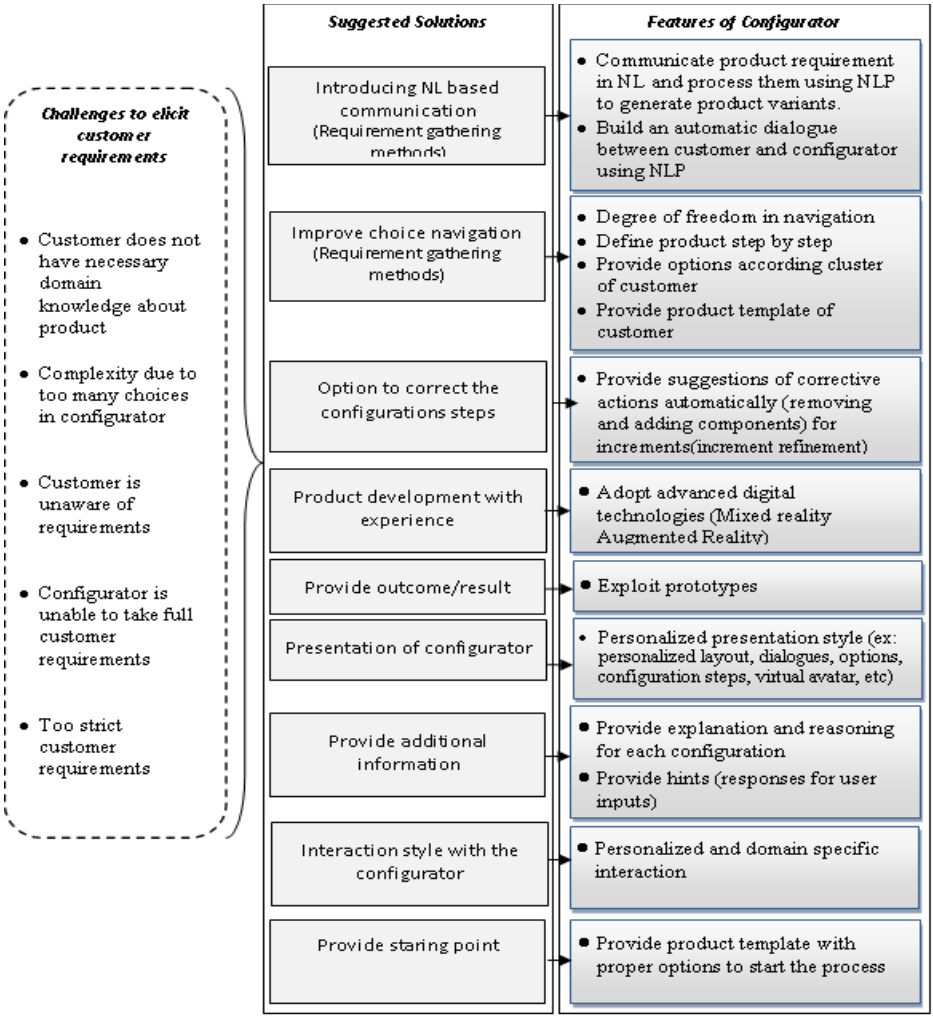

Figure 3. A conceptual model of an NLP-based PC for the apparel industry

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