DEVELOPMENT OF AN INNOVATIVE E-BUSINESS MODEL FOR ONLINE SHOES SHOPPING USING SMARTPHONE-BASED 3D SCANNING TECHNOLOGY

Yul Oh and Dongsoo Kim*

Department of Industrial and Information Systems Engineering
Soongsil University
369 Sangdoro, Dongjak-Gu, Seoul 156-743, Korea
*Corresponding author: dskim@ssu.ac.kr

ABSTRACT. *This paper presents an innovative e-business model for online shoes shopping based on the 3D scanning and personalization technologies. The comprehensive structure of the proposed e-business model includes customers and customers' value proposition, products and services, business processes, required resources, revenue models and so on. Personalization and mass customization concepts are applied to the proposed e-business model. Although there are a few commercialized personalization or mass customization services for online shoes shopping such as NIKE iD and mi Adidas services, it is not easy for customers to find shoes that fit to their feet well. The new e-business model applies smartphone-based 3D scanning technology that can capture 3D foot models of customers easily. The proposed system can recommend the most appropriate shoes to the customers by comparing captured 3D models and 3D data models of shoes stored in the product database. In this way, the newly proposed e-business model can enhance users' experience of online shopping and improve their satisfaction level.*
Keywords: e-Business, Business model, Personalization, Mass customization, Online shoes shopping, Smartphone-based 3D scanning

1. **Introduction.** Lots of companies have applied mass customization in order to provide unique value to their customers in an efficient manner [5]. Advanced information technology and the Internet enable flexible work processes of build-to-order or make-to-configuration [2]. Therefore, they can customize products or services for individual customers in large volumes at a relatively low cost due to the technologies and flexibility in production processes.

Personalization is the process of providing differentiated services or information according to the characteristics of customers. For example, Amazon, the king of online retailer, recommends potentially interesting products to users based on their search history, click-stream behavior, and transaction history [2]. All the information is managed as customer profiles, and it can be used to generate and provide personalized services.

In this paper, we present a new online e-business model of recommending the most appropriate shoes that can fit to customers' feet well using readily available 3D (three dimensional) scanning technology [3,6]. 3D foot model of a customer can be acquired conveniently by a 3D scanner or a smartphone camera and it can be added to the customer's profile. Using the profile, the proposed system can suggest the best fitting shoes without trying on the shoes in person, which can reduce product returns due to the size mismatch and ultimately improve users' satisfaction.

The remainder of this paper is organized as follows. Section 2 reviews research backgrounds and related work. Section 3 presents the proposed e-business model for online shoes shopping. Section 4 describes the core algorithm of the proposed system. Finally, Section 5 offers conclusions.

2. **Backgrounds.** This section describes the backgrounds of this research and reviews related work. A business model refers to a business method for a company to generate revenues, which enables the sustainability of the company [2]. It is very critical to identify the customers of a business model and the values that the business model can provide to them. Also, the products and services and required resources and related business processes should be considered comprehensively in order to implement the business model properly.

3D foot scanning for shoe customizing was proposed by Rout et al. in 2010 [6]. They addressed a growing trend of introducing customized shoes to satisfy diverse customer styles, fit, and comfort needs. They discussed the basic concept and methods for retrieving the best fitting shoe-last based on the 3D foot scan of the customer. A shoe personalization technique via a smartphone-based 3D foot scanning App was proposed by Menato et al. in 2014 [4]. The authors presented an ongoing research project for developing the 3D foot scanning App. They argued that fitting should be regarded as a must-have customization dimension in order to add more value of personalized products. A low cost 3D foot scanner for customized sports shoes was introduced by Taha et al. in 2013 [10]. They proposed the low cost scanner by integrating Microsoft XBOX Kinect and a foot scanner rig.

Although there are a few commercialized personalization and mass customization application cases of online shoes shopping such as NIKE iD [8] and mi Adidas [9], it is not easy for customers to find shoes that fit to their feet well. In order to buy well-fitting shoes, touch-and-feel evaluations at a pre-purchase stage are required, because they are experience goods [7]. However, it is impossible to perform touch-and-feel evaluations properly when we buy shoes in online shopping malls.

Previous researches have been focused on the technology development rather than the development of a comprehensive and innovative e-business model, which will be discussed in the next section.

3. **e-Business Model for Online Shoes Shopping.** In this section, the structure of the proposed business model including customers and customers' value proposition, products and services, the business process, required resources, revenue models is described.

Customers have difficulties in finding well-fitting shoes in e-commerce shopping malls such as Amazon.com and Zappos.com. Even, when customers shop shoes through these globally well-known online retailers, they cannot know exactly whether selected shoes may fit to their feet or not. If the delivered shoes do not fit well, they return them to the seller, which causes inefficiency and inconvenience. Therefore, if an online shopping mall can suggest well-fitting shoes to a customer by considering the exact 3D foot model of the customer, it can have competitive advantages over its competitors.

The target customers of the proposed business model are customers who want to buy shoes in online shopping malls. They can easily find well-fitting shoes which are recommended based on their customer profiles, and the possibility of returning shoes will be decreased significantly. Also, online shoes shopping malls can provide better services to their customers using the proposed system. 3D foot models acquired by 3D scanners or smartphone cameras can be included into the customers' profiles in which demographic information, transaction history, search history, and clickstream behavior are stored.

We analyzed overall business processes such as 3D shoe model acquisition process, and shoes recommendation process. Figure 1 depicts a 3 way collaboration business process of the proposed e-business model based on BPMN (Business Process Model and Notation) [11]. The collaboration process diagram shows two participants, which correspond to each separate pool. A customer acquires 3D data model of his or her feet and transfers it to the server using the smartphone App. The customer can select well-fitting shoes with the help of the recommendation server, order shoes, and make a final decision.
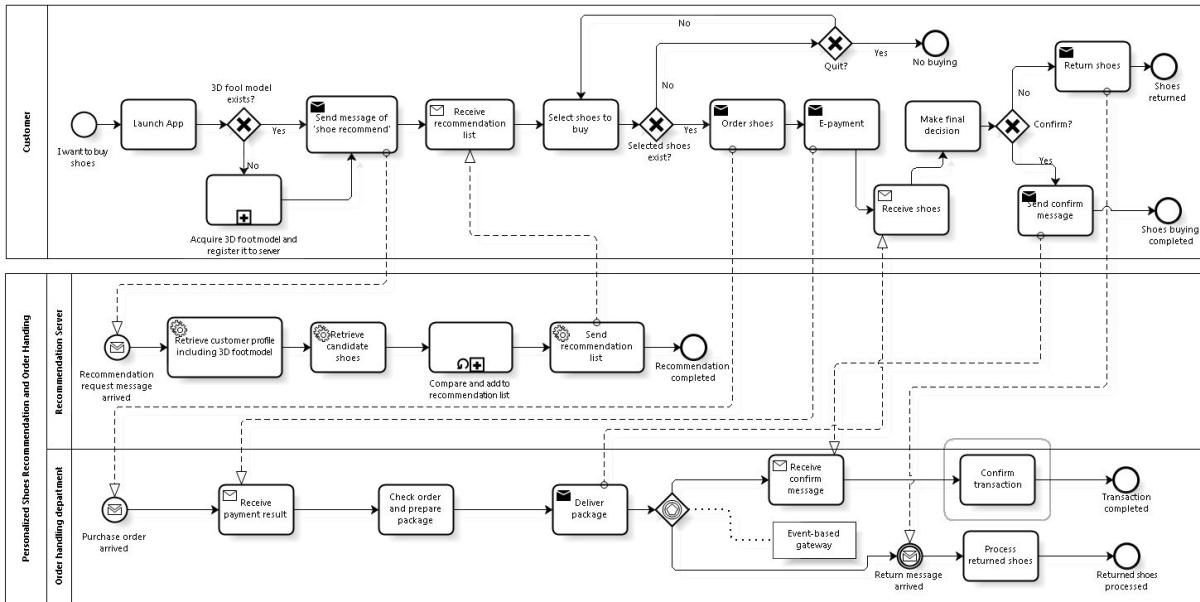
FIGURE 1. Collaboration business process model

The other pool shows personalized shoes recommendation server and order handling process. The shoes recommendation server retrieves the customer's profile which includes the customer's 3D foot model, and extracts candidate shoes based on the customer's preference, clickstream behavior, and transaction history. And then, the server compares the customer's 3D foot model and 3D shoes models extracted, and sent the recommendation list to the display screen of the customer. Order handling department that receives an order from the customer handles the order and delivers shoes to the customer. Thanks to the shoes recommendation server, the possibility of returning shoes would be decreased significantly. In this lane, an event-based gateway is used in order to model a situation of exclusively detecting whether 'confirm message' is arrived or 'return message' is arrived.

Figure 2 shows the '*Compare and add to recommendation list*' sub-process in the '*Recommendation Sever*' lane. It performs the comparison algorithm of the proposed e-business model, and add only well-fitting shoes to the recommended list. The sub-process is a standard type looping activity, so it is repeated until there are no candidate shoes.
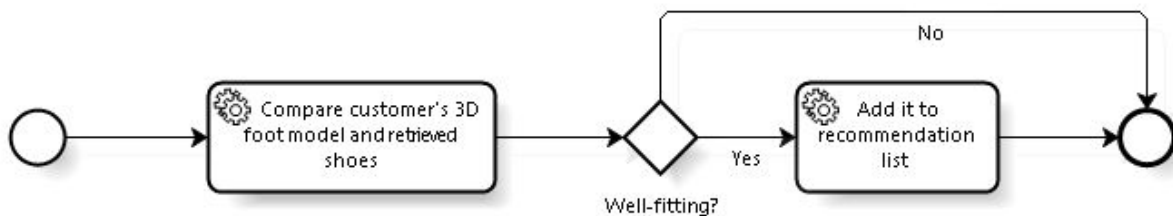

FIGURE 2. Sub-process of 'Compare and add to recommendation list'

Considering the time spent in performing the looping sub-process in Figure 2, the collaboration business process model in Figure 1 can be modified as follows. After the recommendation server retrieves and recommends candidate shoes without considering the 3D size, the customer selects shoes that he or she wants to buy. And then, the recommendation server performs the comparison task and visualizes the comparison result as shown in Figure 5.

In order to implement the proposed e-business system and operate it properly, lots of resources are required. First of all, a smartphone App that supports 3D foot data

acquisition needs to be developed and the recommendation module based on the 3D foot data should be designed and implemented systematically. Also, hardware and network equipment, application developer, and operation personnel are required.

The organization's supply chain includes the participants or pools shown in Figure 1. In addition, shoes manufacturers can play an important role in extending the business model covering the mass customization concept. The customers, the online retailer and/or manufacturer collaborate in order to provide personalized services using the application, recommendation server and product database of shoes.

Currently, there is no competitor that provides exactly similar services. However, there are some companies that provide attractive services to their customers. For example, Shoemarker, ABC Mart, Lesmore, Amazon, and so on have specialized shoes recommendation systems, but all of them do not consider actual 3D models of shoes and foot. The revenue models incorporated in the proposed e-business model include advertising fees and subscription fees for premium services. In addition, the revenue can be increased by reducing the possibility of shoes returns.

4. **Comparison and Recommendation Algorithm.** This section presents the comparison and recommendation algorithm and an example case of the proposed system. The core part of the developed algorithm is to define the 3D data model of a foot composed of 3 dimensional points. The space is 3 dimensional (400mm × 200mm × 200mm). The 3D foot data can be acquired conveniently using smartphone cameras. Figure 3 shows an example of the 3D foot data modeling.
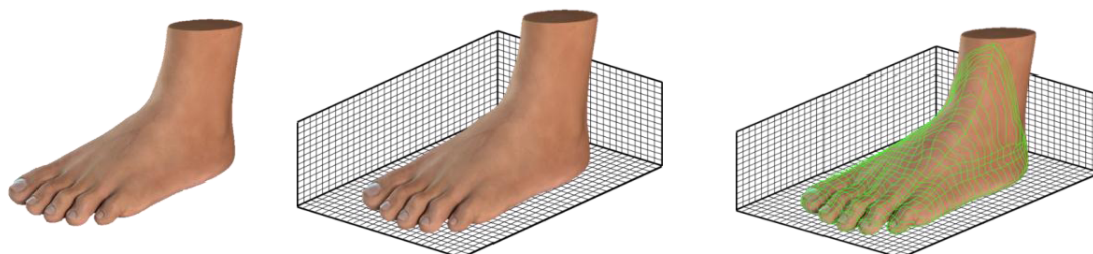

FIGURE 3. 3D foot data modeling

In addition, inner structures of shoes are stored in the product database as 3D data models as shown in Figure 4. Of course, the elasticity of shoes should be reflected while defining the 3D data models of shoes stored in the database.
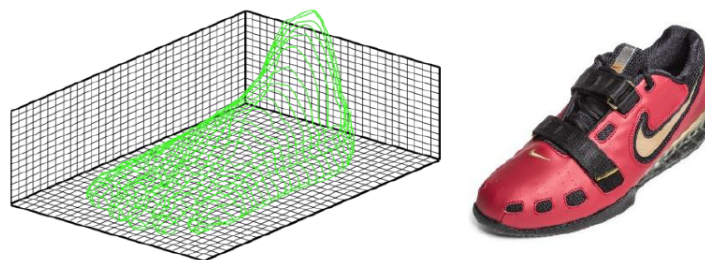

FIGURE 4. 3D inner structure of a shoe

The 3D data model of a customer can be used to retrieve proper shoes that fit to the feet of the customer by comparing the two 3D models; *GeoNum* – 3D foot model of a customer, and *ShoesNum* – 3D data model of the inner side of a shoe. The gap between the two models can be displayed visually in the 3D data model as shown in Figure 5, which enables the visualization of the difference or the level or severity of size mismatch appropriately.
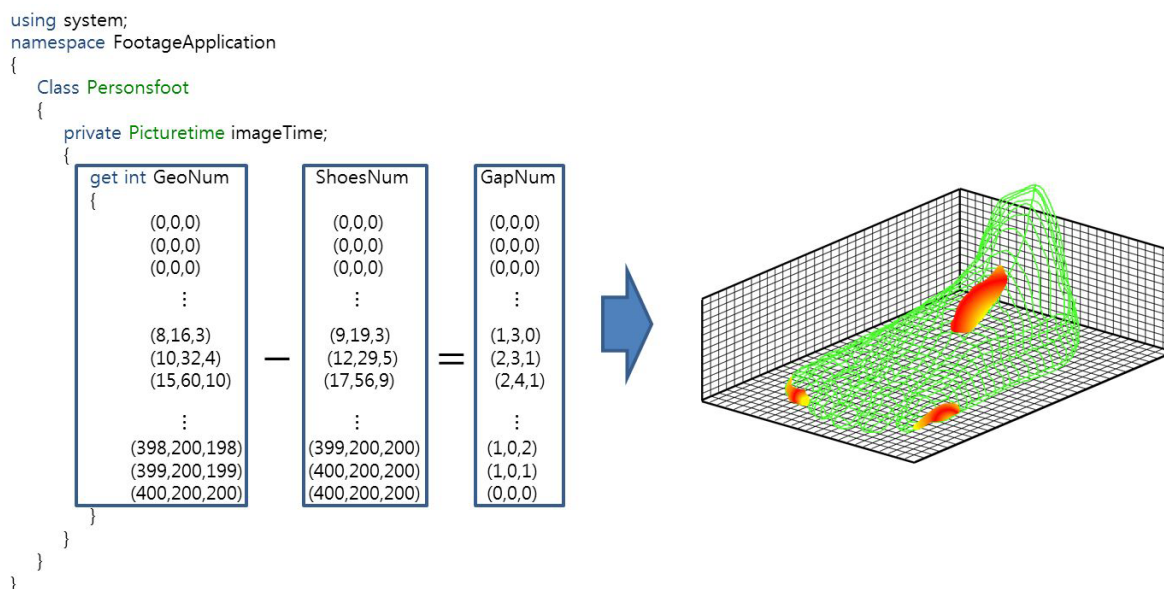
```
using system;
namespace FootageApplication
{
    Class Personsfoot
    {
        private Picturetime imageTime;
        {
```

get int GeoNum	ShoesNum	GapNum
{		
(0,0,0)	(0,0,0)	(0,0,0)
(0,0,0)	(0,0,0)	(0,0,0)
(0,0,0)	(0,0,0)	(0,0,0)
⋮	⋮	⋮
(8,16,3)	(9,19,3)	(1,3,0)
(10,32,4)	(12,29,5)	(2,3,1)
(15,60,10)	(17,56,9)	(2,4,1)
⋮	⋮	⋮
(398,200,198)	(399,200,200)	(1,0,2)
(399,200,199)	(400,200,200)	(1,0,1)
(400,200,200)	(400,200,200)	(0,0,0)
}		

FIGURE 5. Comparison algorithm and visualization of the comparison result

5. **Conclusions.** We applied a smartphone-based 3D scanning and personalization technologies to an innovative e-business model of online shoes shopping. 3D scanning technology enables customers to capture accurate 3D models of their feet using smartphones. According to the captured 3D models, the proposed system can recommend the most appropriate shoes to customers effectively. The components of the proposed e-business model including customers and customers' value proposition, products and services, business processes, required resources, revenue models and so on are presented in detail. In addition, the comparison and recommendation algorithm and an example case of the proposed system are described.

Using the customer profiles that include 3D foot models, the proposed system can suggest the best shoes to the customers, which can reduce product returns due to the size mismatch and improve users' satisfaction level. Therefore, the proposed e-business model can advance existing personalization methods for online shoes shopping.

In the future, applications of the proposed e-business model to practical online shopping mall and verification of the benefits of the proposed system are required. In addition, a premium service of manufacturing 3D customized shoes can be included in the extended e-business model.

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