

# Web-based Exercise Machine Customization and Simulation

YanQiong Zhou<sup>1</sup>, XiangJun Zou<sup>1,2+</sup>, Lufeng Luo<sup>2</sup>, Jun Lu<sup>2</sup> and Zhi Li<sup>3</sup>

<sup>1</sup>Nanhua University, Hengyang Hunan 421001, China

<sup>2</sup>The College of Engineering, Agriculture University of South China, Guangzhou 510642, China

<sup>3</sup>Tiana Fitness Games Corp. Dongguan, 523808, China

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**Abstract.** A frame of the Web-based exercise machine customization and simulation system is proposed first, and the flow of work of the system is analyzed. Then the paper adopts the modeling technology Pro/E and Virtual Reality technology as the three-dimensional display technology to realize the online customization according to customers' taste, embeds Agent design system into the performance function of Virtual Machine to realize the three-dimensional dynamic simulation based on variable and real-time interaction, and proposes an user-based mathematical model for preference entropy to solve the multi-attribute decision problems with uncertain information and satisfy the design preference of users. The development of the system platform provides a new way, means and platform for meeting customers' small lot, great varieties and high quality needs. The system which is already used in some enterprises, has improved their core competencies and efficiency.

**Keywords:** exercise machine, web-based, customization, preference entropy, virtual reality

## 1. Introduction

Today, exercise machines are taken more seriously as the understanding of self-health care grows and the requirement of sports increases. At the same time, the exercise machine market has formed a certain scale and its competition is fierce. With the development and popularity of networks, a number of product show and sale websites for exercise machines have been established and have generated a certain social and economic benefits. But, most of these websites adopt text, graphics and flash animation as the main ways of product show and lack human-computer interaction, so customers can order on the internet but not customize<sup>[1]</sup> and also can't sufficiently know the outward appearance and performance of products, and the effect of product show and sale on the internet is restricted.

Virtual Reality (VR) Technology is a computer simulation system that can create a virtual world, that is to say it can make use of computer to simulate an environment into which people can be immersed<sup>[2]</sup>. Through the net and VR Technology, the three-dimensional models of exercise machines can be shown so fully on the internet that can make customers have a sense that they are in an exercise machine shop, can have an all-directional examine on products, and can make colour, texture and shape customization according to their taste. Obviously, the product show on websites based on VR can meet customers' requirement of individuation better, and is better for improving products' competitive advantage on market. So the paper proposes a VR-based online product customization and simulation system to make up the deficiencies of the traditional product show and sale websites which lack human-computer interaction and can't show product fully.

## 2. Structure of the customization and simulation system

The Web-based exercise machine customization and simulation system is designed according to the B/S Model, which is made up of the Browser, the Web server and the DB server, as shown in Fig. 1. Through the Browser (for example, IE), customers can know products, interact with product models and make color, texture and shape customization according to their taste. If a customer isn't satisfied with one part's shape, he can select the model that he likes best among the models provided by manufacturer, and his selection will

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<sup>+</sup> Corresponding author: XiangJun Zou. Tel.: (86)020-31511682.  
E-mail address: xjzou1@163.com.

be reflected on the product model directly. At the same time, the information about every customizable part's color, texture and shape will be reflected in the customization list in the form of text. When he finishes customization, he can submit the customization list immediately, and he also can save the list in Html format to submit latter.

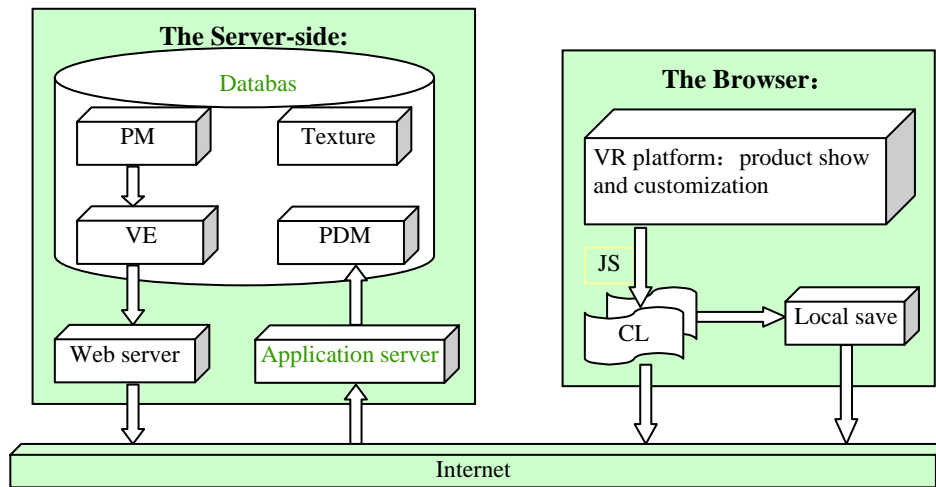


Fig.1: Structure of the customization and simulation system

In the Fig1, PM stands for product model, VE stands for virtual environment, CL stands for customization list, and PDM stands for product data management.

### 3. Key technologies for the Web-based customization and simulation

#### 3.1. Creation of exercise machine model

1. Geometry modeling: The paper adopts Pro/E as the modeling tool. Each part is modeled alone first, and each model has its coordinate system. Then put these alone part models together in the world coordinate systems created by us to get the desired product model. The process of the creation of product model is the process of mapping real objects to a product model database.

2. Model optimization: The paper adopts polygon reduction as the optimization strategy. The ground rules of three-dimensional model creation is using polygons as few as possible to express models of the same appearance. But the surface data used to describe models has redundancy, and the assembly of models modeled alone normally generates redundant data in some invisible places<sup>[3]</sup>, such as bearing, bolt, and junction of two models. Removing the redundant data won't influence the visual effect of models, but greatly reduce the complexity of models.

3. Import product model into virtual environment: Take physics modeling first, including light treatment, colour treatment, and texture treatment, etc. Then realize human-computer interaction.

#### 3.2. Tree structure of model database

The tree data structure which can reflect clearly the hierarchical relation between each component is adopted to manage product models. For example, the part of running machine has two kinds: customizable part and un-customizable part, and the un-customizable part models are assembled first, then the customizable part models, so the tree structure of running machine model database can be described as the Fig. 2:

#### 3.3. Realization of human-computer interaction

In virtual environment, the Node which is the basic unit of the realization of interaction consists of the type of node and the field and field value which is used to describe Node's attribute. The interaction in virtual environment resulted from the change of field value is realized by sensor nodes, event drive and route mechanism<sup>[4]</sup>.

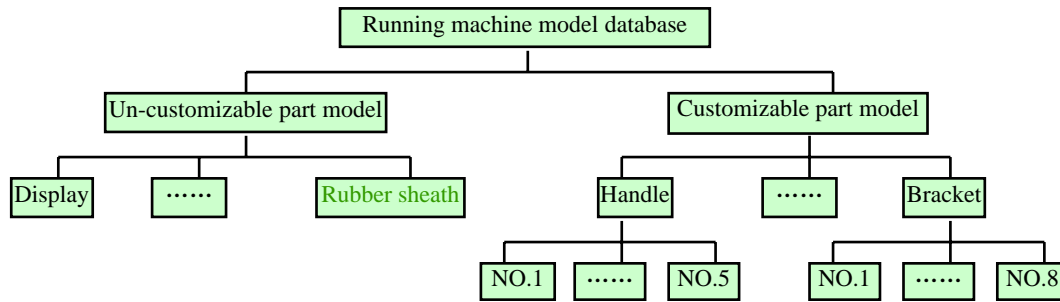


Fig. 2: Structure of running machine model database

The field of Node has four types: EventIn, EventOut, exposedField and field. The event which is the data information transferred between the fields has two types: EventIn and EventOut. A Node sends out an event by the field EventOut or exposedField, and other Nodes accept the event by the field EventIn or exposedField to change their own state. The route which is the connector of fields realizes the transfer of an event (as shown in Fig. 3). Users send out instruction by sensor nodes, and the instruction is transferred by the route and accepted by relative nodes through the field EventIn or exposedField. These nodes may change the state of virtual environment, or continue to send out events by the route, and the human-computer interaction is realized finally.

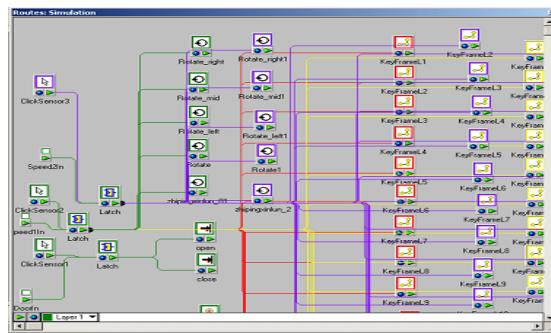


Fig. 3: A part of the route mechanism of running machine

### 3.4. Realization of the communication between EON application and html

In the EON virtual environment, routes can be created and deleted dynamically by the programme based on the Script node or EON SDK, and the communication between application and html also can be realized. Embed the EON application into the html file in the form of plug-in first, than adopt JavaScript or VBScript to program to realize the communication. When customers make customization, the information of products about color, texture and shape on the websites will be modified dynamically.

If we define three nodes named HModel, HColor and HTexture, which have the ability of accepting events, to save the information about shape, color and texture of the handle of running machine, the information can be reflected on the website through the following code:

```
<script language="javascript" type="text/javascript">
<!--
Function EON_OnEvent (e, v)
{
.....
if (e == 'HModel')
document.H_Model.value = v.toString ();
else if (e == 'HColor')
document.H_Color.value = v.toString ();
else if (e == 'HTexture')
```

```
document.H_Texture.value = v.toString ();
.....}
//--></script>
```

### 3.5. Decision model for user preference

The preference knowledge of multi-user system has uncertainty and inconsistency, and we should minimize the possibility that the result of multi-user decision is inconsistent with the preference knowledge. So adopt the entropy which is introduced into the thermodynamics in 1865 as an important concept to measure their conformity to make uncertain multi-attribute decision effectively. The value of the entropy can be used to express the degree of the uncertainty of probabilistic system. In virtual environment, if the number of the event of the behavioral system of users is n, the Average preference knowledge of each event can be calculated according to the following type:

$$H = -\sum_{i=1}^n p_i \log_2 p_i$$

There, H is represents the preference entropy, pi is represents the probability of the event i. The preference knowledge of users is certain when the value of the H is equal to zero and uncertain when the value is larger. The Agent design system can solve the multi-attribute decision problems and the uncertain decision problems according to the preference of users.

## 4. The application example

The user interface of the system which should be compact, easy-operate and strong- interactivity provides the instructions for customers, so customers can lightly make color, texture and shape customization, if they follow the instructions, and the information about product will be displayed in the corresponding textbox, as shown in Fig. 4.

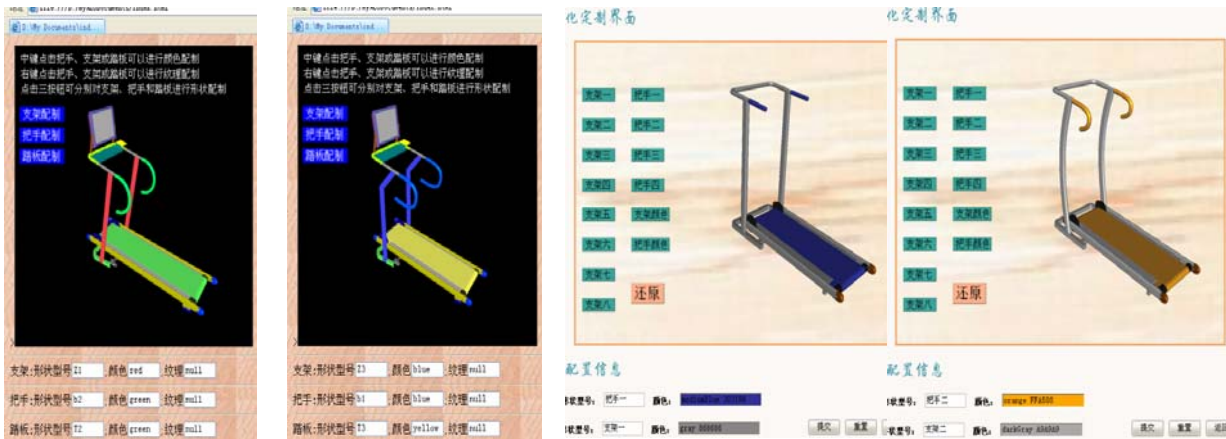


Fig. 4: Customization of running machine

## 5. Conclusions

Adopting the modeling technology Pro/E to realize the creation of product models, the virtual environment based on EON to realize the network transmission of 3D models and the human-computer interaction, the programme based on JavaScript to realize the communication between the EON application and html and the database technology, the paper developed a Web-based running machine customization and simulation system successfully. The system combines many functions in one, such as product show online, collaborated design and individuation customization, and realizes the three-dimensional dynamic simulation based on variable and real-time interaction and the behavior communication and data updates of the human-computer interaction. With the system, customers can customize products according to their taste through the Browser (for example, IE) and their shopping thirst is greatly excited, the manufacturers can promptly learn the requirement of customers, and the competitive advantage on market of products is improved.

## 6. Acknowledgements

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