What virtual reality can offer to the furniture industry

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ABSTRACT

The U.S. furniture, home furnishings, and textile industries are faced with threats from less expensive imports and as a result must become more strategic with regard to consumer preferences, effective marketing, and supply chain management. As a significant market for textiles, the sustainability of furniture and home furnishing industries is vital to the U.S. textile industry. This paper focuses on the furniture industry. The sustainability of the furniture industry lies on product variety, mass customization, and speed to market based on understanding of consumer preferences. Authors suggest Virtual Reality as a viable tool that may offer ultimate solutions to many identified problems that the furniture industry faces. Finally, the authors propose the Virtual Reality Integrated System (VRIS) as an innovative way for the U.S. furniture industry to more effectively address this situation and ultimately gain a more competitive stance in the furniture marketplace and, as a result, have positive impact on the textile industry.

Keywords: furniture industry, textile industry, virtual reality, virtual prototyping, market research, e-commerce

Introduction

The United States furniture and home furnishings industry, which is a $125 billion market, is currently faced with significant business failures (Richardson, 2000; Buehlmann & Schuler, 2001; Spalding, 2001). The U.S. household furniture industry is struggling to survive as China becomes the dominant furniture exporter to the United States, accounting for one-third of U.S. furniture imports (Schuler & Buehlmann, 2003). Furthermore, the furniture industry has a large impact on the textile industry that supplies upholstery fabrics. As a significant market for textiles, the sustainability of furniture and home furnishing industries is vital to the U.S. textile industry. Since the U.S. furniture industry cannot compete with Chinese imports on cost alone, the industry must become more adept at responding to consumers' tastes and personal needs through the integration of effective marketing and supply chain management.

To date, the U.S. furniture industry has been unable to deploy effective marketing strategies that grasp those significant market opportunities, primarily because the industry does not understand consumers' furniture buying behaviors. Except for a few manufacturers who have branded retail outlets such as Ethan Allen, La-Z-Boy, Thomasville, and Bassett, most do not have direct channels to consumers. As a result, the industry has difficulty in researching target markets to understand what furniture consumers like and dislike and why.

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In this paper we propose innovative ways to reinvent the furniture industry by suggesting solutions that Virtual Reality (VR) can offer to the U.S. furniture industry. VR is a computer simulation that uses 3-D graphics and devices to provide an interactive visual experience. Web-based virtual reality can offer indirect but realistic visual experiences for evaluating furniture to see whether it matches other furniture items and decoration. It can simulate a realistic shopping environment and is equipped with special features that allow consumers to examine products closely and evaluate the overview.

Due to advanced computer technology, 3-D desktop VR has become an affordable system and is readily accessible to Internet users. The furniture industry could benefit from these VR features to understand market needs and wants. To explore possible solutions for the furniture industry, we reviewed characteristics of furniture buying decisions, VR technologies, current applications of VR in various industries, and the benefits of VR to the furniture industry. In conclusion, we suggest a research and development framework using VR technologies for furniture and home furnishing industries.

Furniture Buying Behaviors

The decision making process in furniture buying is complex, involving the consideration of constraints such as budget, available space, time investment, disposal of currently usable items, match to existing furniture, and lifestyle (Applied Research & Consulting LLC, 1999). In addition, because of the significant expense and long product lifecycle of furniture, consumers have to make difficult trade-off decisions about important factors such as price, style, quality, and functionality. Furthermore, after the choice is made, consumers often feel unsure about whether they made the right choice. Consumers frequently ask questions: Will it fit in the room? Will it work with the rest of the furniture and décor of my home? This uncertainty, which

results from consumers' inability to try out furniture combinations in a real setting, keeps consumers out of the furniture marketplace or makes them delay purchase decisions.

Furniture retailers also face challenges in meeting consumers' demands. Because consumers are looking for furniture that represents who they are, furniture retailers have to carry a wide selection to meet customer expectations. However, traditional brick-and-mortar furniture retailers are limited by the bulky nature of the product, space limitations, and diverse consumer tastes, ending up with a significant amount of inventories (Tewary, 2003; Spalding, 2001). As a result, many U.S. furniture retailers such as Heilig-Meyers downsized or went out of business (Richardson, 2000; Schuler & Buehlmann, 2003). Furniture manufacturers have the same problem. Every year furniture manufacturers present slightly different styles at furniture markets while keeping the old product lines (Schuler & Buehlmann, 2003). Because they do not know which styles consumers will accept, furniture manufacturers end up with an enormous number of different products resulting in the costs of holding huge inventories. To make matters worse, customer dissatisfaction with the long delivery process is a discouraging factor for the furniture industry.

The Internet has become a powerful tool for information gathering and communication affecting a fast growing population of online shoppers and markets. While the online market promotes significant sales for many types of products such as clothes, books, and CDs (Cole, Suman, Schramm, Lunn, & Aquino, 2003), the growth of furniture e-commerce sites has been very slow. In addition to the complicated decision making process described earlier, furniture sites must overcome the lack of realistic triability for comfort testing and tactile experience and the inconvenience and high costs of delivery and return processes. Although Internet-based furniture retailing is not a significant retail channel, the Internet can play an important role by providing satisfactory

information about products (Schuler & Buehlmann, 2003). For the furniture industry, it can stimulate purchasing intention whether the actual sales are made online or at brick-and-mortar stores. On the other hand, understanding customers' preferences and decision-making behavior can contribute to better product development, marketing, and distribution management for the industry.

The use of web-based VR technology can be an effective way to get consumer feedback on items in the market. It can also be used to enhance product design and development before manufacturing. Web-based VR can offer consumers realistic product trials without the temporal and physical constraints of brick-and-mortar furniture stores (Sanna, 2001). VR technologies offer dynamic interaction with objects by allowing users to zoom in, zoom out, move, rotate, change object attributes, etc. The biggest problem in furniture purchases is the inability of consumers to see the product in their home setting. Shopping at brick-and-mortar stores does not solve this problem because consumers still cannot match choice alternatives with their currently owned items and home decor. However, realistic triability, including close inspection of individual furniture and combinations of items, can be obtained when the furniture

and the environments are all generated in three-dimensional real-time interactive computer graphics. Thus, VR is a viable tool that may offer ultimate solutions to many identified problems that the furniture industry is now facing.

Towards Affordable Virtual Reality (VR)

The term Virtual Reality (VR) is used by different people to mean many different things. VR is commonly understood as a computer simulation that uses 3D graphics and devices to provide an interactive experience. To some people, the definition of VR is limited to "immersive VR system" where it uses special input/output devices such as Head Mounted Displays (HMD), Data Gloves, 3D Audio, or multiple large projective displays (e.g. CAVE) to enhance users' realistic experience. To others, VR refers to real-time interactive 3D graphics technology in general so that it has different types of system environments including immersive VR or non-immersive VR. 3D graphic technology has advanced in both hardware and software, so that non-immersive VR is available on affordable system environments including home PCs. Figure 1 and 2 shows specialized hardware for immersive VR systems. Projection based immersive VR systems use large wall-mounted displays (Figure 2).

Figure 1. Head Mounted Displays (HMD) and Data Glove.

Figure 2. Projection based immersive VR system : CAVE :Cave Automatic Virtual Environment(left), Curved Wall (middle), 3D Stereo glasses(right)

VR systems have attracted significant attention because they can create realistic experiences. The characteristic of VR experience has identified as "presence," the subjective feeling of being more involved with the virtual world (Biocca, Li, & Daugherty, 2001; Freeman, Avons, Pearson, & IJsselsteijn, 1999; Li, Biocca, & Daugherty, 2001). Although high-end immersive VR systems are designed to give the users a sense of presence in a virtual environment (Ijsselsteijn, de Ridder, Freeman, & Avons, 2000), users can also experience some of the sensation of presence with Desktop VR to a certain degree. Besides its affordability, other advantages of non-immersive desktop VR include: rapid development of the software, efficient information sharing, collaboration through the Internet, and ease of use. The same software techniques are used for both immersive and non-immersive systems.
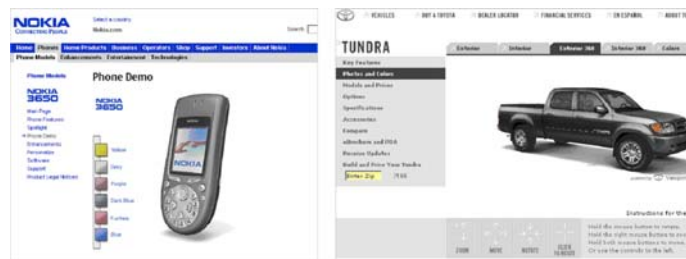

Figure 3. Non-immersive VR for Product Demo and Customization

Regardless of display type, as a result of a VR system, a real or imagined environment can be experienced visually in the three dimensions of width, height, and depth with interactivity in real-time. VR applications have been used in a variety of areas: education, architecture, industrial design, engineering, military training, medicine, virtual science laboratories, etc. Some use the term "Virtual Environment (VE)" to emphasize the experience rather than enabling technology or to avoid an oxymoron in the term Virtual Reality. While VR and VE are often used interchangeably, Web 3D particularly refers to VR on the Internet via non-immersive Desktop VR systems. As VR has become available on the web since the debut of VRML (Virtual Reality Modeling Language) in 1994, VR technologies have been adopted quickly in e-commerce (Figure 3). In this paper, we focus on Web 3D, a type of non-immersive VR that enables online users to experience computer-generated product simulations or

environments with near real time control of the viewpoint and product attributes. These VR features offer users the opportunity to explore virtual objects at levels of detail that are appropriate to evaluation activity (Hurwicz, 2000). VR allows Internet users to obtain a virtual shopping experience similar to a real shopping experience. We refer to this experience as "Virtual Experience." This paper focuses more on the experience of VR than the technology.

Related Application Areas of VR

1) Virtual Prototyping for product development

VR technology allows users to assess conceptual designs, analyze products before they are manufactured, check functionality and aesthetics, and modify designs without physical prototypes. Virtual prototyping uses VR techniques for design evaluation and presentation based on digital models instead of physical models (Dai et al., 1993). Physical prototypes are normally very time consuming and expensive to produce. Furthermore, only a limited number of participants who are physically present can assess the physical prototypes. The automobile industry has used the virtual prototype to cope with the limitations of physical prototypes (Figure 4). With virtual prototyping, the automobile industry has developed better designs, tested functional aspects, and detected design flaws during the product development process thus reducing costs and time to market new models.

Figure 4. Virtual Prototyping of Automotive Interior
University of Michigan Virtual Reality Lab

VR also has been used as an advanced presentation technique in the fields of architecture and interior design. Recent attempts have used it in early design stages such as collaboratively reviewing design ideas (Kremer, 1998; Daily et al., 2000; Zorriassatine, Wykes, Parkin, & Gindy, 2003). For assembly tasks, VR is known to be superior to other forms of representation (Boud, Baber, & Steiner, 2000). In the housing sector, networked VR-supported design tools have been used for collaboration between clients and demonstrators (Figure 5). Matsushita (Panasonic) developed the Kitchen Planning Support System (KiPS) to enable customers to design a kitchen by assembling components. This VR system has been extended to an application of a networked VR-supported kitchen design system (Fukuda, Nagahama, & Nomura, 1997).
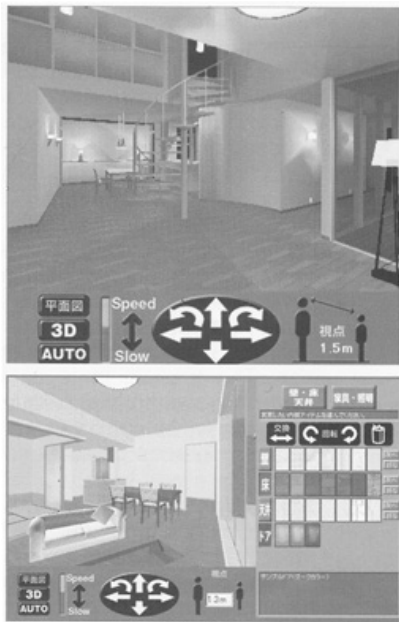
Figure 5. Matsushita's VR-supported design tool

2) Online Customization and Review tool

VR brings product information to online shoppers and salespeople at retail stores quickly and easily. Online customization, which started from the online PC market, is found to be a major compoment of success in financial performance and productivity (Barua, Konana, Whinston, & Fang, 2001). The term 'mass cutomization' means mass production on the one hand vs. products tailor-made for individual tastes on the other (Mello, 2001). In the PC industry, the best-known mass customization success is Dell computer, Inc. A study (Barua et al., 2001) found that Dell became the world's leading direct computer supplier by taking advantage of the power of customization of products and services through the Internet (Figure 6). In the motovehicle industy, a few companies are letting customers specify features they want while reducing the delivery times for custom products (Figure 7). Forrester Research predicts that built-to-order sales will account for 21 percent of all new car sales by 2010 (Mello, 2001).
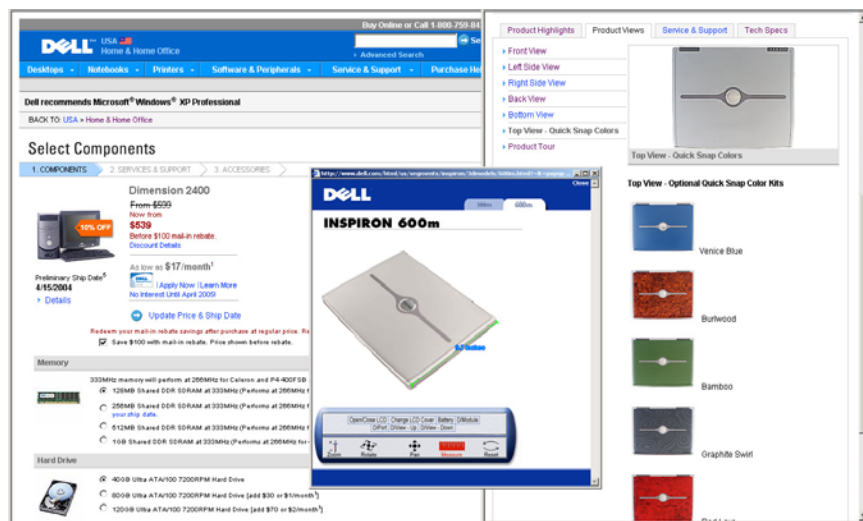

Figure 6. Dell's mass customization system : Specification customization (left), VR product viewer (middle), Cover color samples(right)
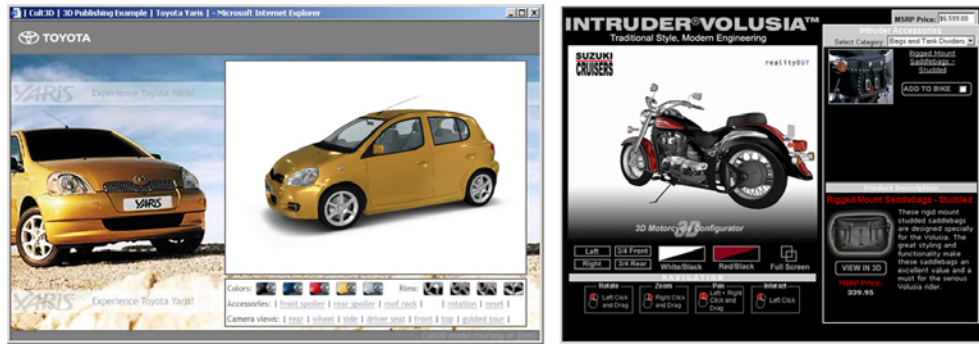
Figure 7. Toyota Yaris T-Sport Virtual Showroom, Suzuki Configurator for retail stores

Figure 8. My Virtual Model by Lands' End

Mass customization offers service and achieves a greater level of customer satisfaction. Customers take advantage of self-guided selection and configuration tools to choose products and options. VR technology surrounding mass cutomization increased dramatically with the advent of the Internet. Customizing gives consumers the ability to see how their products will appear (Figure 7). Customization using VR eliminates the guesswork for consumers even if a million options are available on the item.

VR offers useful features which make customization more efficient:

- Real-time 3D interactive views allow users to rotate, tilt and magnify product images to closely examine them from all angles
- Communication among viewers in different locations is possible
- Digital data storage capacity allows an unlimited number of products

- Perception of size, layout, and match with multiple items is easily obtained
- Compatible data format with other VR display systems allows conversion of the information to kiosk type for retail stores or wall-mounted display for group presentations, etc.

3) E-commerce

Consumers traditionally search for product information in advertising and experience or try products in a physical store. The strongest appeal of e-commerce to consumers is convenience and effectiveness of information searching. Looking for product information on the Internet is the most important predictor of online buying behavior (Bellman, Lohse, & Johnson, 1999). Online shoppers who find enough product information to support their purchase decision-making are more likely to buy the product. The downside of buying online is that consumers cannot try out the product. It is not easy to market products for which consumption involves emotions and touch as indicated by the high return rates in sensory product retailers (Rosa & Malter, 2001). The greatest value of VR in e-commerce is that it allows people to visually assess product performance and aesthetics prior to purchase. Experience via VR reduces perceived risk prior to purchase (Klein, 1998). Lands' End offered on-line shoppers 'My Virtual Model' that imitates a dressing room at stores (Figure 8). The virtual experience of trying-on-clothing increased sales conversion rates (Haeberle, 2002).
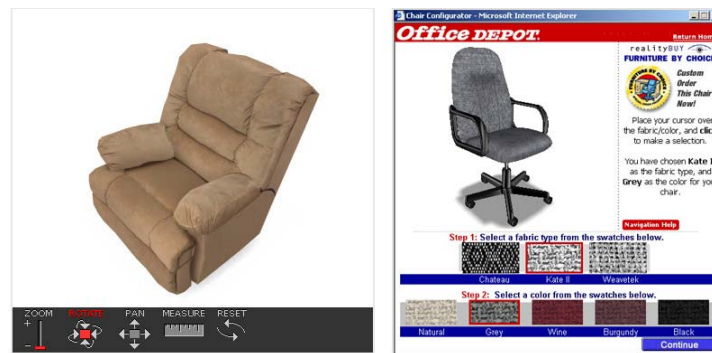
Figure 9. Photo Realistic Visualization and Customization
options :
Technicon (left) and Office Depot Chiar Configurator(right)

The benefits of VR are significant for products that are highly customizable. The benefits are even greater for products that are especially bulky. It is impossible for retail stores to carry a wide selection of bulky products that meet an individual consumer's different tastes. Furniture is the product category that fits both of these criteria. Information gathering is difficult because each store carries different products. Because products are not standardized, information collected from magazines and TV commercials is often not useful. Consumers often cannot find an item at local stores that they saw in a magazine. The ideal solution to this problem is VR, which provides both information and product experience. VR facilitates learning about products by exploring virtual models at levels of detail while providing consumers realistic views of each product's options including finishes, fabrics and colors. It also allows online shoppers to obtain a virtual shopping experience, which is similar to a real shopping experience. An office furniture retailer, Office Depot, effectively used VR and increased their sales (Figure 9). However, residential furniture manufacturers and retailers are far behind the office furniture industry. Although VR has become a mature technology in areas where it was adopted early, its use is limited in the home furniture industry.

Consumers do not buy furniture for their home through online shopping because testing of physical comfort and tactile elements are critical for their buying decisions. Many furniture e-commerce sites such as furniture.com, beHome.com, Goodhome.com, Living.com, and furniturefind.com were not successful as evidenced by their financial losses (Fowler, 2002). Although Ethan Allan, one of most successful furniture marketers, is currently operating an e-commerce site, its performance does not justify the implementation costs because of channel conflicts between e-commerce operations and retail stores and significant shipping costs. Instead of direct selling to consumers, company websites should work to provide information to consumers. More importantly, integration of operations between e-commerce and bricks-and-mortar stores should be allowed to provide convenience and reduce costs. Without implementing strategies for reducing costs embedded in complex furniture supply chains, e-commerce for furniture cannot be successful even with the benefits of realistic experience offered by virtual reality technologies.

Suggested VR Applications for the Furniture Industry

Interactive 3D visualization as a medium for conveying product information and exploration for virtual experience

provides significant values to furniture shoppers. Although furniture shoppers

Figure 10. Possible VR applications and their linkages in the furniture industry

cannot evaluate tactile experience and physical comfort, VR offers visual evaluation that physical retail stores cannot offer because of limited space and inventory. The current state of desktop VR generates only visual experiences. However, visual sense plays the most important role in perceptions because style or look is the most important feature in furniture evaluation. Although price is always an important feature considered for furniture purchase, the best-priced furniture item will not be considered if it is not the look that the consumer wants. Companies such as Ethan Allen, Pottery Barn, and Pier 1 Imports are successful, not because they present a sofa, but because they create look. The success is brought from turning a furniture brand into a lifestyle brand (Tischler, 2003).

Most people have difficulty envisioning how furniture will look in a room. VR allows the consumer to experience the product as if it were in place and to experiment with different fabric, color, and other attributes. Virtual experience brings the sense of presence and confidence to viewers in accepting the product information presented (Biocca et al., 2001; Freeman et al., 1999; Li et al., 2001; Li, Daugherty, & Biocca, 2002). The presence feelings are important for furniture shopping where consumers look for sensory experience and emotional aspects. Consumers express their best and favorite

sense of themselves through furniture and home furnishing items and rely on their feelings to make buying decisions. Thus, VR is the best medium that creates emotional experiences through virtual experiences. Holbrook and Hirschman (1982) propose that product use such as furniture consumption should incorporate enjoyment and fun into what they call an "experiential view" of consumption. Virtual experience engages people in effective product learning and enjoyment experience. It has been found that people spend 50% more time in a web site that offers interactive 3D images. The number of pages viewed also increases significantly after VR product demos are introduced (Hurwicz, 2000).

Based on the premises that 3D VR facilitates visual evaluations and creates virtual experiences by simulating realistic consumption experiences, we propose VR applications that can improve the performance of the furniture industry. Figure 10 presents linkages of VR applications: Virtual prototyping, online customization, E-commerce, retail stores, and market analysis tools. We believe virtual prototyping for product development and market research are feasible applications to the current furniture industry. Without innovative manufacturing, supply chain, and distribution, however, customization for integrating furniture retail stores and E-commerce operations is impossible to apply to the industry. The U.S. furniture industry is behind other industries such as automobile and computer industries in applying innovative business concepts and technologies. It has a long way to innovate its operations in manufacturing, supply chain management, and distribution. Thus, we focus our discussions on feasible VR applications: prototyping for product development and market research.

1) Virtual Prototyping for Product Development

The recent growth of fast network accessibility and Web 3D technologies, such as VRML, Java 3D, etc., have motivated affordable VR based tools for various needs

in many areas. In addition, industries using CAD/CAE/CAM (Computer Aided Design/ Engineering/ Manufacturing) can easily take advantage of the potential in effective communication via real-time interactive 3D visualization. Product data produced from CAD systems, which are in digital format, provide a good basis for VR tool development.
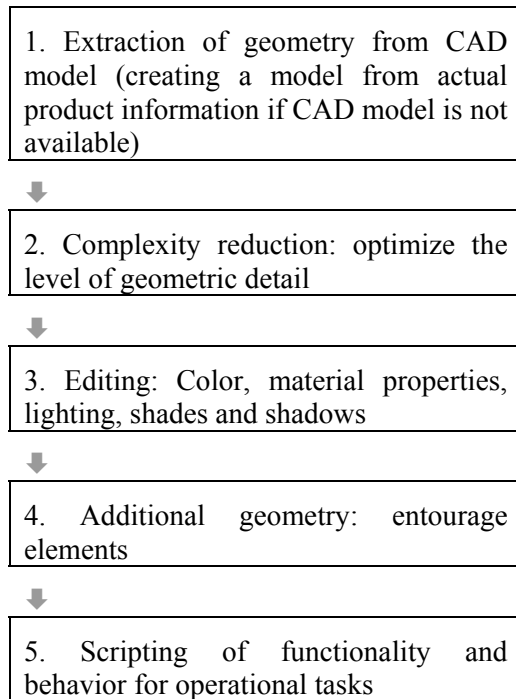
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┌─────────────────────────────────────┐
│ 1. Extraction of geometry from CAD   │
│ model (creating a model from actual  │
│ product information if CAD model is   │
│ not available)                        │
└─────────────────────────────────────┘
                 ⬇
┌─────────────────────────────────────┐
│ 2. Complexity reduction: optimize    │
│ the level of geometric detail         │
└─────────────────────────────────────┘
                 ⬇
┌─────────────────────────────────────┐
│ 3. Editing: Color, material          │
│ properties, lighting, shades and      │
│ shadows                               │
└─────────────────────────────────────┘
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│ 4.  Additional  geometry: entourage  │
│ elements                              │
└─────────────────────────────────────┘
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┌─────────────────────────────────────┐
│ 5.  Scripting  of  functionality and │
│ behavior for operational tasks        │
└─────────────────────────────────────┘
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Figure 11. VR prototyping tool design process

Virtual prototyping can change the furniture product development process in a way that saves costs, reduces time to market, and increases responsiveness to taste changes. Virtual prototyping relies on virtual reality tools for analysis of designs. Figure 11 shows the general steps for developing VR prototyping tools applicable to furniture product development. First, 3D furniture models are created using 3D modeling software such as 3D Studio Max, FormZ, Maya, etc. When CAD models are available, the data can be used with modification. In order to support real-time simulation, the file size of the 3D geometry models should be as small as possible. Therefore, the level of geometric detail should be optimized by complexity reduction in either 3D modeling software or VR authoring software. Third, surface attributes (e.g. texture, color, lighting, shadows) are assigned to the 3D models and a room for the furniture models is designed to provide a realistic background. 3D models programmed with object behaviors enable viewers to interact with the 3D virtual prototypes from database. Figure 12 presents a virtual prototype for residential furniture developed by the research team at [the Midwestern University]
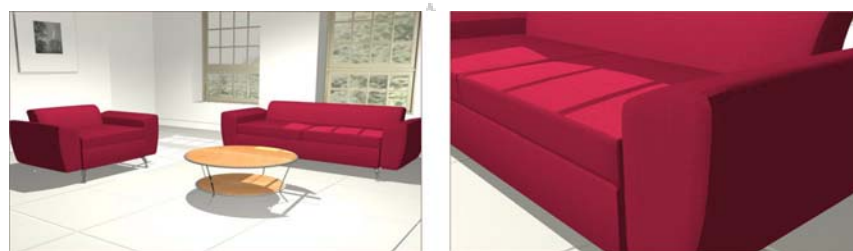

Figure 12. Virtual Prototype : Overview (left) and close-up view (right)

Currently, a few commercial products have been developed for furniture and interior layout configurations (Figure 13). Although they are considered as virtual prototyping tools in a sense, their main feature is in layout configuration, which does not require high quality graphics.

When creating virtual prototypes for home furniture, quality graphics must allow close examination of the items as well as an overview of the room. Overview or zoom-out features give a sense of scale in addition to harmony with other items in the same room.

Figure 13. System furniture and interior layout configurators: Technicon Virtual Showroom (left), Office Depot office Designer (middle), Outline 3D(right)
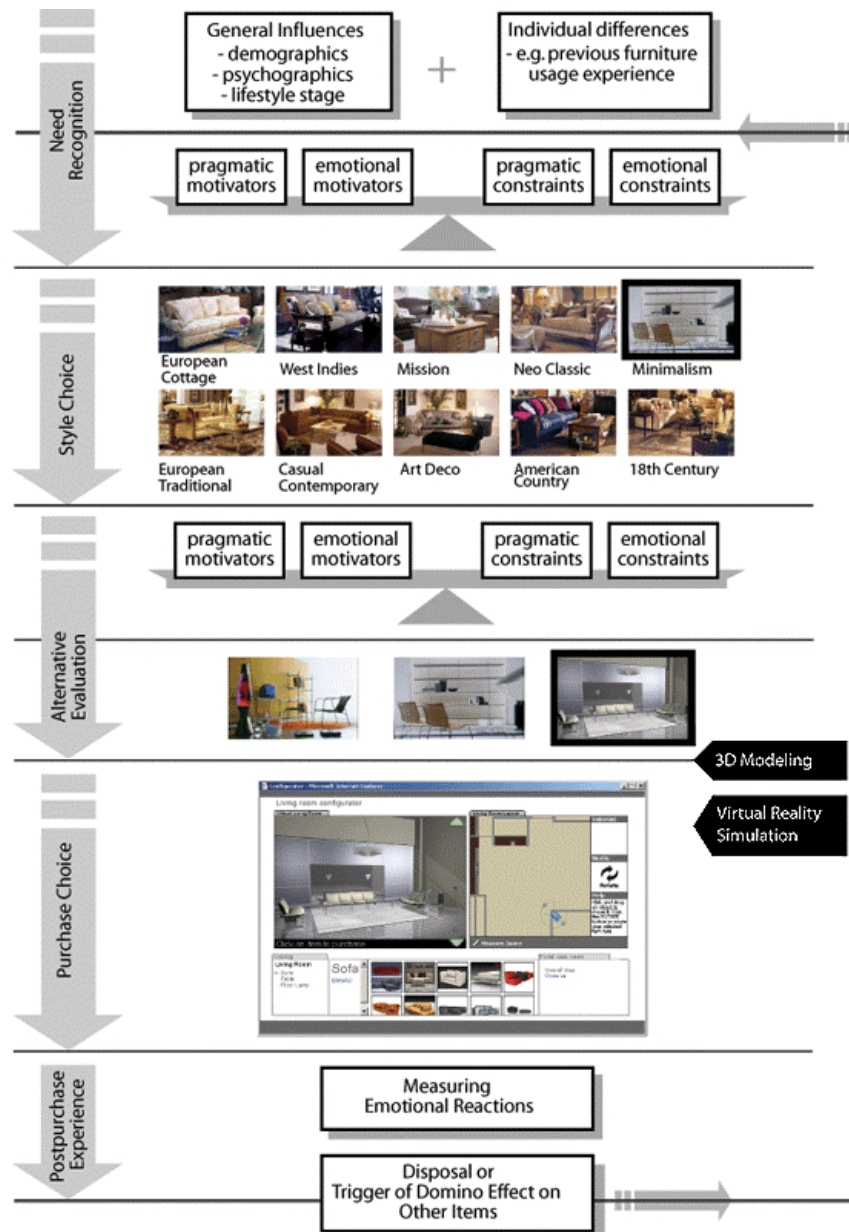

Figure 14. Consumer Decision Processes for Furniture and Home Furnishings

2) Market Research

Although VR has been implemented within customization for effective visualization of products, there have been only a few attempts to use VR technology for market research or decision-making research. VR has great potential as a market research tool for understanding consumer preferences and behaviors. With advanced technology, market research tools can be integrated with online customization. Data, automatically gathered by tracking users' behavior, can contribute to a better understanding of consumers' needs and wants. Market trends can be analyzed from the obtained data. With customization options integrated with market research, manufacturers can understand consumers' preferences and supply products in response to predicted demands.

Understanding consumers' preferences on the appearance of products is crucial when manufacturers introduce new products to market. Because consumers are confronted with a large number of functionally identical products, aesthetic quality through visual inspection and comparison becomes a critical factor in the purchasing decision (Maxfield, Dew, Zhao, Juster, & Fitchie, 2002). The use of realistic virtual prototypes can accurately assess consumers' acceptance of the products. Manufacturers can identify those elements that enhance the chances for consumers' acceptance (Tseng, Jiao, & Jun, 1998).

The research team at [the Midwestern University] is developing a first-of-its-kind, Internet-based virtual reality system that maps and understands the complex decision-making processes individuals use. To create relevant virtual environments, furniture decision-making processes are reviewed as shown in Figure 14. The furniture decision-making process begins with style choice. The furniture style choice imbues the purchase process with excitement and expectations. However, because consumers go though a lengthy decision-making process involving a compromise between what they want and what they realistically can have, the initially preferred style does not necessarily lead to the final choice. As consumers choose their preferred style, they narrow their options or alternatives. In this stage, constraints that consumers face play a significant role in evaluating alternatives.
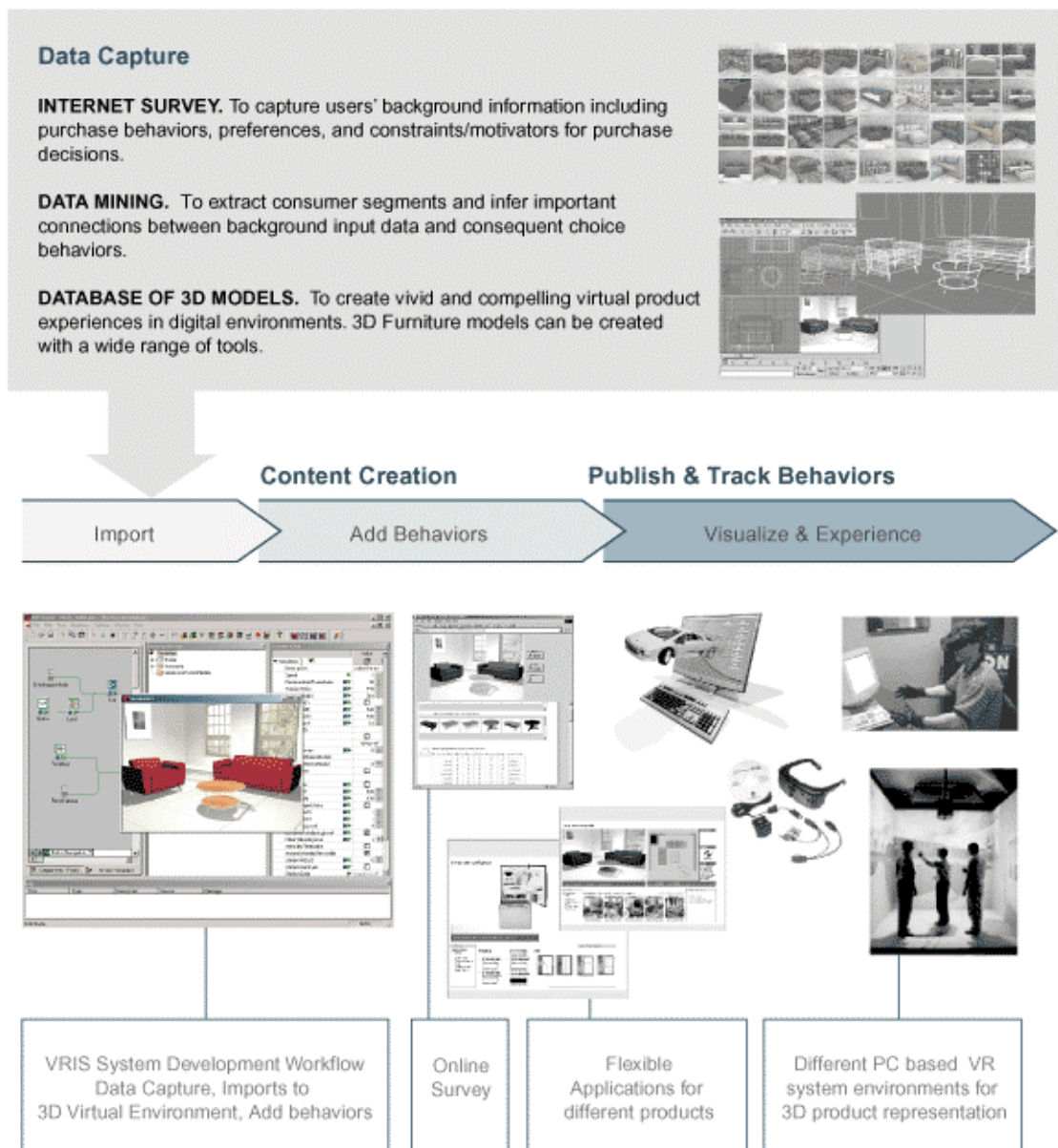
Figure 15. Architecture of the VRIS

To test such a complex decision-making process, the Virtual Reality Integrated System (VRIS) is designed. VRIS simulates this entire decision-making process by allowing viewers to set up their own room with given furniture items by responding to prompts from the system. VR allows users to choose furniture pieces, drop them into a virtual room, manipulate colors, and fabrics, then place different items in the scene and assess the combination based on an instantly changeable yet realistic layout of the room. It allows online users to experience simulated products visualized in three-dimensional space. With sophisticated data gathering techniques that involve database and interactive Internet survey capabilities, the VRIS is designed to capture how people evaluate alternative choices under constraints and what information people rely on for making the final decision.

Figure 15 shows the overall architecture of the VRIS. An Internet survey will be designed to capture users' background information including purchase behaviors, preferences, constraints, and

motivators for purchase decisions. The survey is incorporated with the VR showroom so that the two different interfaces (i.e. VR showroom and questionnaire) are seamlessly communicating with each other. 3D furniture models for the VR showroom is created or modified from CAD models and then stored in the database. Virtual 3D models are programmed to interact naturally with users. In addition to information collected from the survey questions, automated mouse tracking data from using VR to search, match, and examine products also extract information about connections between input data and viewers' interactions. Once the VRIS development is complete, the same contents can be converted for immersive VR displays with 3D stereo projection walls or head-mounted display devices in order to provide a stronger sense of 'being there'.

Conclusions

The demands for furniture and home furnishing items will continue. Furniture is an important part of our life and consumers want to express who they are through how they live. However, today's consumers want high-quality, low-prices, and customized products that meet individual needs. The competition among U.S. firms has ceased to be strictly based on price--they cannot compete against cheap imports of commodity products. The competition, then, lies in product variety and speed to market. There are tremendous opportunities for product differentiation and customization. Success will depend on consumer acceptance of the products offered. Understanding consumer preference is, therefore, crucial to the survival and success of the industry. According to research from Accenture on consumer attitudes toward innovation, opportunities for furniture companies can be realized by enhancing their relationship with customers and making new offerings more meaningful to consumers (Furniture Today, Nov., 4, 2002). The survey also suggests that market research and offering of innovative products are crucial for long-term stability of

furniture companies. The appearance of attractive new products adds significant value to the product by increasing the quality of the user's experiences (Kotler & Rath, 1984; LaChance-Porter, 1993).

It is vital to provide early consumer feedback so that firms manufacture furniture that will be acceptable to consumers. The understanding of consumers' decision processes and obstacles that consumers face along with the processes is critical to the success of the industry where many upholstery furniture companies operate in the domestic market under the make-to-order policy. Market research tools that utilize virtual realities will help identify those elements that enhance the chances for customer's acceptance. In addition, understanding what designs are rejected by consumers adds tremendous value to companies because it saves costs by minimizing inventory and distribution overloads. Informed design and management are essential in order for the furniture industry to survive and succeed. This paper proposed VR as a viable means to reach these goals. Versatile features of advanced prototyping and market research tools will enhance competitiveness of the furniture industry. Under the assumption that manufacturing and retailing can be integrated, VR prototyping and market research offer the furniture industry a tool for reinventing the furniture industry.

We envision the future of residential furniture industry as follows. Consumers go online, try new furniture items, test the look of the room with new furniture items, and experience consumption before making a decision. The furniture choice made by consumers or mass customized furniture is available for pick-up at local stores after physical testing and tactile evaluation. For customers visiting a retail furniture store, a sales person creates a virtual room, e.g. living room, bed room, etc., and then adds or modifies furniture items. A variety of options in materials on one item is simulated in the virtual showroom instead of storing a number of the same furniture pieces to show options. That way, customers can still directly experience the sample item. In

addition, the information collected though customer interactions is used to make product assortment and inventory decisions for stores.

To make this happen, the furniture industry participants--manufacturers, suppliers, distributors, retailers, and market researchers—need to work together to identify opportunities and test innovations. Market research tools, such as VRIS proposed in this paper, can be effectively used for those purposes. Future work includes further development and test of the market research tool. We believe that there is great potential for applying the VR integrated marketing research tool in the furniture industry. Enormous efforts are necessary both in the research community and in the industry to further explore its usages in practical contexts.

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