

Networked VR System : Kitchen Layout Design for Customers

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Abstract

In this paper, we present our Virtual Reality (VR) technology application, a networked VR-supported design system of a kitchen layout. This networked VR system was developed on personal computers to allow customers to design at home. With the VR system, customers can have a pseudo-experience of their "virtual kitchen", modify the design of the kitchen, and make decisions by being provided with a good idea of their potential purchase. The VR system will also play an important role in user interface in the House Design Advisory System. This system, which we are currently developing, will give advice on house design, as well as on kitchen layout design, according to the customers' diversified lifestyles.

Category: applications

Keywords: Kitchen Layout Design, Virtual Reality, Internet, WWW, VRML, VRML Browser, script, RDB, EUC

1 INTRODUCTION

The changing needs and values of today's consumer have had a significant impact on the sales and manufacturing process. A customer must get the necessary goods in the required quantity when needed. But when the goods desired by many users are diversified, the manufacturer has a difficult time coping with the increased workload. Changing only the production system cannot deal entirely with the situation: the corresponding sales system, including marketing, distribution, and information services, must also be improved.

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Nowadays, computer technology is advancing at a rapid rate. The development of a total production system incorporating CAD, CAM, and CAE is now possible. This technology also permits movement from mass production to the production of a variety of goods in small quantities. At present, however, most computer-aided manufacturing is geared towards mass production, unable to handle one-of-a-kind products. The specifications of these products should be easily changed to accommodate individual customer's needs. To execute this concept, virtual reality (VR) [1] technology can be employed.

VR allows customers to examine a design and make changes at an early stage in the process [2]. Examples of VR applications are to be found in design, prototype, and space layout planning, as well as in teleoperations, operator training, and entertainment [3]. Furthermore, the VRML (Virtual Reality Modeling Language) [4] allows VR to become widespread to home.

We have developed a software application to construct a whole house or living space in the virtual world and to experience it by applying Virtual Reality technology. In the virtual house we can pre-check the appearance, convenience, safety, level of comfort, and other factors such as temperature, air flow, and noise from outside as simulation results.

2 KITCHEN LAYOUT DESIGN AND VIRTUAL REALITY IN THE SHOWROOM

One of Matsushita's strongest product lines is the "System Kitchen," a custom-planned and built kitchen combining our cabinets and appliance units. Customers can choose from over 30,000 kitchen unit products and an infinite number of possible kitchen layouts. They must make many detailed and difficult decisions when specifying the layout of their new kitchen.

The kitchen planning process is detailed in Figure 1. When an interested customer comes to the showroom, a person, we call the "kitchen planner", first explains the kitchen products' description using catalogues and displays. Using pencil and paper, the kitchen planner next draws a rough layout according to the customer's wishes. Then a floor plan, an elevation view, a perspective drawing, and a written estimate are created on a CAD system based on the rough sketch.

This initial design of the customer's kitchen is specified on a SUN-based CAD system called MATIS (Matsushita Amenity Total Interior System). The MATIS database includes approximately 30,000 of Matsushita's kitchen products as well

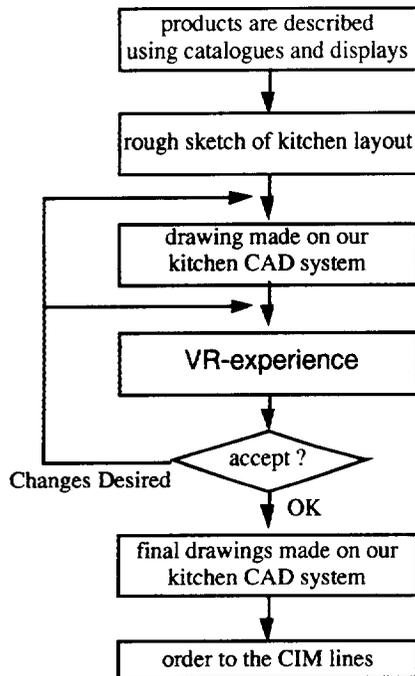


Figure 1: System Kitchen Planning Process

as data on customers' kitchen designs. This customer data includes fields for room dimensions, cabinet placement, standardized parts' information, special order information, etc. At this early design stage, customers can see floor and elevation plans, but no VR walk-through capability is provided. Sometimes there are many discrepancies between the system kitchen actually manufactured and the customer's original idea.

Our VR system helps to eliminate these mistakes. Using Virtual Reality technology we can create, "Virtual Products," or imaginary digital representations of products which are not yet produced but illustrate the intended functionality of the products to present to our customers. Customers can have a clear concept of their potential purchase and also take part in the design process of the product through experiencing a "Virtual Product." In our VR system, the kitchen design made on the MATIS system is transferred to the VR system for presentation of the "virtual kitchen" to the purchaser.

The next time the customer comes to the showroom, they can experience many aspects of their kitchen with our VR system. The customer can check their own kitchen and decide if it matches their idea of how the kitchen should be. The customer can also modify the design of the kitchen, if needed. Details of the VR experience are described below. Once the customer approves the kitchen layout design, final approval and appliance drawings are made and the other is sent to the Computer-Integrated Manufacturing (CIM) lines.

3 OUR PREVIOUS VR SYSTEMS

We have already developed our VR systems named ViVA (Virtual Reality for Vivid A&I space system) and KiPS (Kitchen



Figure 2: Presentation of ViVA system

Planning-Support System), and have been in practical use in Matsushita's Showroom from 1991.

3.1 Overview of ViVA

The ViVA system was developed to allow customers to pseudo-experience their custom kitchen in 1990 [5]. The ViVA system is based on a VPL RB2 system with custom software linking the system to MATIS CAD system. An Apple Macintosh CPU is used for real-time control, and Silicon Graphics' 220GTX and 310CGX are used for rendering the left and right eye images. The user interacts with the virtual world through EyePhones and a DataGlove. Cabinets can be opened, dishes moved, and 3D spatialized sounds can be heard. In 1994, we made progress to widen the territory from a kitchen to a whole house, to develop human interface to check the house utility and the multi display large screen which more than 30 persons can participate in together at the same time [6]. As a result, customers can share the "virtual house" with the large cylindrical screen and HMD (Head-Mounted Display) watching the "virtual house" from the same viewpoint at the same time (Figure 2). The stereoscopic view is experienced through the use of polarizing glasses.

ViVA had been in practical use in Matsushita's Shinjuku Showroom in Tokyo from 1991 until 1994. Although the VR system interfaced properly with our kitchen CAD system, the hardware of the ViVA system was expensive (Over US\$500,000), so the system was not adopted for our nationwide showrooms. Owing to the recent performance improvement and the cost reduction of personal computers, we have developed a new VR system which operates on personal computers [7].

3.2 Overview of KiPS

KiPS was developed on personal computers (PC-AT clone) and replaces our previous VR system named ViVA. KiPS has

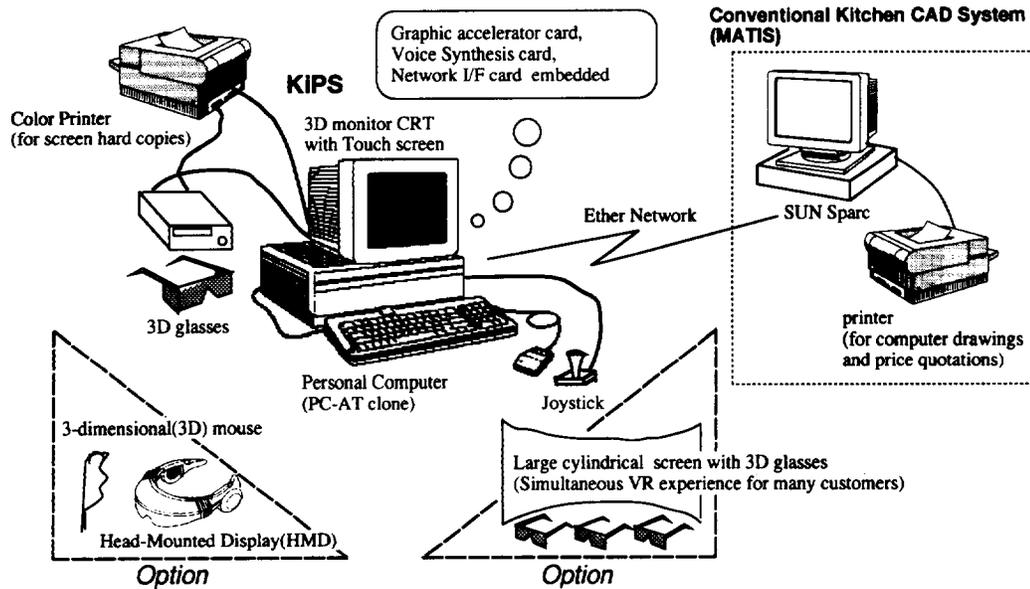


Figure 3. Hardware Configuration of KiPS

made it possible to achieve hardware cost reduction and a user-friendly interface. KiPS is based on a Sense8 Corporation's World Tool Kit [8]. The hardware cost for User-friendly interface devices like joysticks and touch screens allow novice users to experience the VR environment more easily. Though the detail, rendering resolution, and frame rate under the KiPS system is not as fine as under the ViVA system, the new system provides enough rendering performance for customers to have a good idea of their kitchen layout design.

As an option, an HMD and 3D-mouse can be connected to the system for an immersive VR experience. And, to allow participation in the VR experience by several persons, a large cylindrical screen can be introduced for simultaneous VR-experience for many customers on an optional basis. Figure 3 shows the hardware configuration of KiPS.

KiPS has been in practical use in Matsushita's three showrooms in Tokyo, Yokohama, and Osaka since October in 1994. More than a hundred customers experience our new VR system every month (as of the second half of the fiscal year 1995). But as KiPS is stand-alone system, it cannot be adopted at home.

4 PUTTING VR SYSTEMS ON THE INTERNET

We extend the VR system to be accessed on the Internet and to correspond to the changing needs and values of consumer. The system works this way. First, customers design the layout of their new kitchen by themselves at home and have clear design images before they come to the showroom. Then they design in detail with the person, we call the "kitchen planner", at the showroom.

Recent progress in personal computer and network technology makes it possible to realize this design system. Making this system Internet-accessible, customers can be provided with the user-friendly VR system and supported in their decision making. Apparently, they need a system with user-friendly interface, low cost, and cross-platform supported to experience the VR environment more easily at home because they may have no knowledge about kitchen design and computer technology.

Though there are some similar pages on the Internet, there are no practical use. The system for a practical use must adapt more involved, high-level requests of users.

The followings are typical steps of the initial kitchen design at home:

Process1: A customer decides the basic plan. The following items will be checked:

- budget
- the plan of the room
- kitchen layout ("I"-shape, "II"-, "L"-, "U"-, "peninsula"-, "island"-)
- included appliances (a refrigerator, a cupboard, a microwave oven, a toaster oven, and a dining table, etc.)

Process 2: He/She selects each component product and makes the first plan. The following items will be selected:

- cabinets, a counter, a sink, faucets, a dish dryer, a range, and a hood

Process 3: He/She reviews the first plan, exchanges unmatching products, and coordinates the final plan. The following items will be performed:

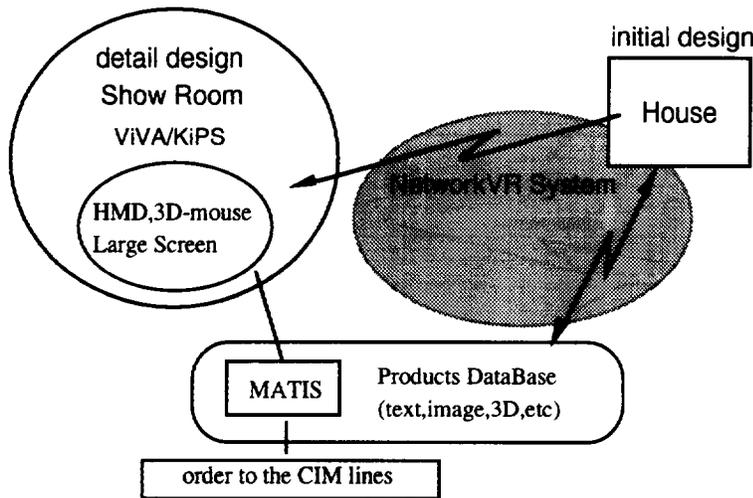


Figure 4. Network VR System

- the change of color and texture (cabinet doors, a floor, a wall, a ceiling, a tile, and a counter)
- the change of cabinets
- the check of space

As the items to be checked in the process 1, are normally very difficult to decide for a customer who is not professional, right now a system is under development employing a Genetic Algorithm (GA) [9] or an Artificial Life (AL) that makes kitchen design candidates and gives advice according to the customers' needs. For the time being these items are discussed and designed with the "kitchen planner" in the showroom. This paper deals with process 2 and 3. The meteoric development of the VRML (Virtual Reality Modeling Language) is one of the most important standards developments in graphics and internetworking [10]. As an informal, intense, open, and collaborative design process has worked, the VRML, its browser, and its converter are cross-platform supported and many of them are freeware. These features considered, it goes without saying that the VRML is placed as the basic language of our new VR system. The VRML describes not only 3-D worlds but also many functions such as hyper-link and script. The followings can be realized in using the VRML functions:

- Using the Anchor node, the information such as a size and a price of component products can be added. We can make hyper links between a 3-D object and a text, an image, a movie, a sound, and other 3-D objects.
- Using the Inline node, the necessary 3-D objects can be read from other database on the Internet.
- Using the Sensor or Interpolator node, the function of each component product can be explained effectively. For example, cabinet doors can be opened and closed.

- In the final process, the design environment is needed to coordinate their own kitchen design interactively. Using the Script node, the new palette for color or texture can be shown.

Using these functions of the VRML, we developed the new VR system that is Internet compatible.

5 NEW VR SYSTEMS FOR CUSTOMERS

5.1 Reviewing Reality of the VRML

In addition to our VR systems (ViVA and KiPS), we have already developed our Computer Graphics system named A&iDAC (A&i Design Advice & Counselling). We have been in practical use for catalogue and design since 1990. We have gotten an obvious idea through the practical use for 6 years. The idea is that it is of no practical use, however a system is very excellent, unless it makes the representation of a reality. Therefore we checked the representation of a reality of the VRML before developing our new system.

We used a kitchen model as prototype. The wireframe models in the CAD system are translated to DXF (Data eXchange Format). We used two converters named DxfToIv and ivToVRML that convert from DXF to VRML format [11]. Then we authored materials, textures, lights, viewpoints, and hyper links using the "WebSpace Author" by Silicon Graphics Inc.

The VRML can set Ambient Color, Diffuse Color, Specular Color, Emissive Color, Shininess, and Transparency of a material. We used the values of CG system because we have had a lot of knowledge and data about materials. We set six parameters of each material, prepared three level models based on the data size, and checked the representation of a reality on the cross-platform such as UNIX, WindowsNT, and PowerMacintosh. Table 1 shows the platforms. Table 2 shows the models. Figure 5 shows the result of each browser on the cross-platform. The new VR system is compared with the previous VR systems in Table 3. The representation of a reality of the VRML is as fine as that of the previous system, ViVA. In this test the VRML browser named Live3D on PowerMacintosh shown 140,000 polygons, maximum value.

Though realtime interactive performance on a personal computer is low, the VRML can make good use of reviewing initial design by using the existing photograph together at home

5.2 Planning Process at Home

We have outlined the design process at home in the forth chapter. In this paragraph, we deal with the process 2 and 3 more in detail and development of the new VR systems. Figure 7 shows the process 2 and 3.

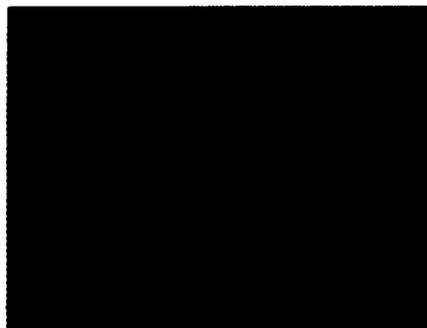
The process 2 is:

Table 1: Platform

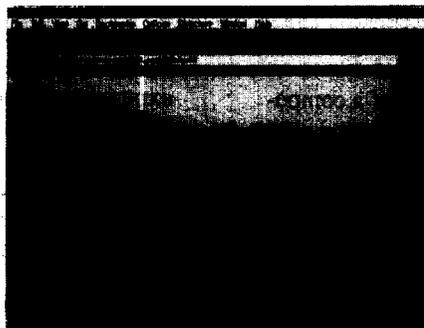
	SGI indigo2 MAXIMAM IMPACT	WindowsNT Micron Pro Magnum MGP/V 200X	PowerMacintosh PowerMacintosh 9500/132
CPU	R4400 250Mz	Pentium-Pro 200Mz	PowerPC 132Hz
OS	IRIX5.3	WindowsNT3.5.1	MacOS7.5.2
Memory	128MB	64MB	130MB(Netscape:30MB)
HDD	2GB	2GB	2GB

Table 2: Model

	LIVING, DINING & KITCHEN all.wrl	WITHOUT LIVING liv.wrl	WITHOUT LIVING & KOMONO kom.wrl
POLYGON	140,389	109,707	56,256
VRML1.0	11,985,174	8,597,807	4,814,278
GZIP	2,303,137	1,569,120	829,436
VRML2.0	24,782,460	17,757,281	9,906,020
GZIP	3,340,416	2,394,324	1,232,890



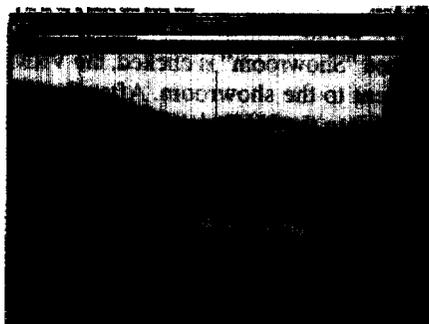
SGI / Webspacer



WindowsNT / CosmoPlayer



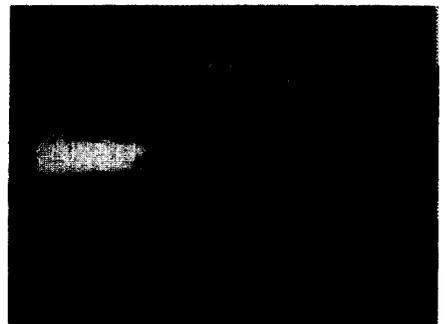
WindowsNT / Live3D



PowerMacintosh / Live3D



cf.) VIVA



cf.) CG(tbt)

Figure 5. the expression of browsers (platform/browser)

	New VR Systems	ViVA	KIPS
platform	UNIX, Windows, PowerMacintosh (Cross Platform Supported)	2x Graphic WorkStation(SGI) & Macintosh	personal computer(PC-AT clone) SUN(for wireframe-solid conversion)
input devices	mouse	data glove	touch screen, joystick (option: 3-dimensional mouse)
output devices	Display (option: Large screen)	Head-Mounted Display	touch screen & Liquid Crystal Display-shutter glasses (option: Head-Mounted Display, Large screen)
hardware cost		US \$500,000-1,200,000	US \$20,000-70,000
VR software	VRML	VPL's RB2	Sense8's World Tool Kit
average no. of polygons in a frame		190,000	1300
rendering resolution	1280 x 1024(max)	1280 x 1024	640 x 400
frame rate (frames/sec)		7-8	3-6
stages used in the Kitchen planning	design of the initial plan (at home)	approval of the final plan (showroom)	design of the initial plan & approval of the final plan (showroom)

Table 3: Comparison of New VR System and Previous VR System

- The interface on the World Wide Web appears.
- A customer looks at the interface and selects each product interactively (1).
- If he/she wants to know the more information of a component product such as a function, a price, a size, and a photograph, he/she can see by clicking the product name. The detailed information including behavior are shown using multimedia (2).
- Each component product is selected over and over. When all products are selected, he/she may click the button named "finished!".
- The selected products are represented (3). If he/she wishes to experience the virtual world, he may click the button named "VR". Then he/she can experience the virtual world and review the first design with the existing photograph together (4).

In this process, to explain the requested product flexibly, the interface on the World Wide Web is linked to the RDB (Relational Database) on Macintosh via CGI (Common Gateway Interface) [12].

The detailed information is needed to be represented not only by texts and images but by 3-D models that a customer can review interactively. Using the Sensor or Interpolator node of the VRML, cabinet doors can be opened and closed.

The process 3 is:

- According to the process 2, a customer can review the kitchen design through the experience of the virtual world.
- If he/she wants to replace a component product, a design alternative palette is appeared by clicking the product in

the virtual world (5). When he/she selects a favorite product in the palette, it is loaded from a database on the network so that he/she can review the new design through the experience of the virtual world.

- This process is continued over and over. When he/she finishes the design review process (6) and wishes to design in detail further, he/she may click the button named "Showroom". Then the VRML data is sent to the showroom from his personal computer (7).

The available VRML browsers, which are freeware on the Internet, can only examine a object and walk through the virtual world. But in this process, it is necessary for a customer to design more interactively in the virtual world. In this system, using the script node of the VRML, a design alternative palette which is a user-friendly interface can be appeared by clicking the product in the VR world.

When the button named "Showroom" is clicked, the VRML data of a final plan is sent to the showroom. After that, the VRML data is converted into the ViVA data. A customer designs in detail considering a budget and planning with a person, we call the "kitchen planner", in the showroom. He/She can experience the VR walk-through with ViVA or KiPS to review his design. As a customer have previously designed at home, he can have a concrete planning image when he comes to the showroom. As a result, he can have a more fruitful discussion with the "kitchen planner" and be more satisfied with the result in the showroom than before .

6 CONCLUDING REMARKS

Our new VR system was developed on cross-platform sup

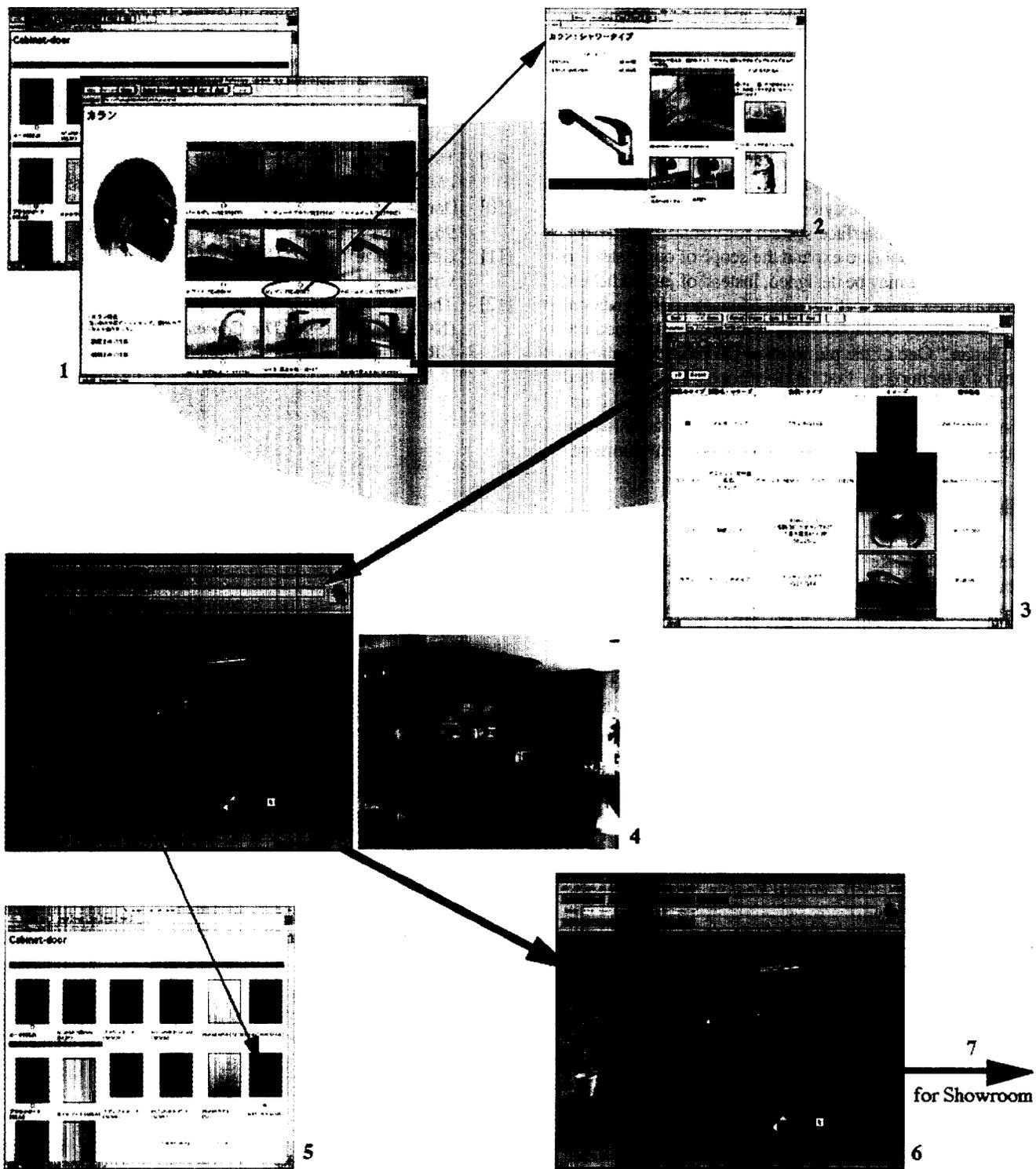


Figure 6: design process at home. 1) A customer looks at the interface on the World Wide Web and selects each product interactively; 2) If he/she wants to know the more information of a component product, he/she can see by clicking the product name; 3) When all products are selected, they are represented; 4) He/She can experience the virtual world and review the first design with existing photograph together; 5) If he/she wants to replace a component product, a design alternative palette is appeared by clicking the product in the virtual world; 6) When he/she selects a favorite product in the palette, it is loaded from a database on the network; 7) After designing, if he/she wishes, the VRML data is sent to the showroom; Gray Area) A system is under development employing a GA or AL.

ported including personal computers, and make it possible to put our VR system on the net and to achieve a low cost and a user-friendly interface. The system allows our customers to have a good idea of their potential purchase and also take part in the design process of the kitchen layout at home.

As we develop a system employing a Genetic Algorithm (GA) (Holland, 1975) which makes kitchen design candidates, presents them to customers, and gives advice according to the customers' diversified lifestyles, this system will play an important role as a user interface system for virtual experiences. Furthermore, our goal is to expand the scope of our system so that an entire home may be designed, instead of just a kitchen. Matsushita is now participating in the Ministry of International Trade and Industry of Japan (MITI) project nicknamed the "House Japan." One of the purposes of the project is to make a survey of a technology that flexibly copes with diversified lifestyles and to propose and develop manufacturing and supply systems for house materials and components to realize high quality life and preservation of the global environment.

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