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Innovations of Kansei Engineering
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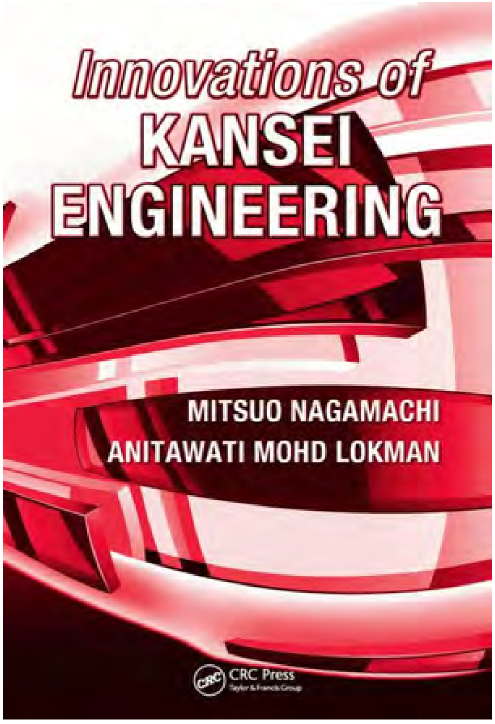

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The Emergence of Kansei Engineering

1.1 Developing a Product That Is Valuable for Consumers

Like the roll of waves, our economy booms and busts alternately. When times are good, consumers will be in the spending mood and buy products. It is during bad times that the value of a product is tested.

There is something in a good product that captures people's interest. A good product is more appealing to consumers in terms of its price as well as its function, shape, and color. It is a product that represents consumers' needs and has Kansei incorporated into it. Such products will sell even during bad times.

Some consumers' needs and Kansei do change with time, and some do not. Currently, consumers' Kansei is *products that have valuable content*, which means *good products that are comparatively inexpensive*. First of all, what does the word *valuable* or *good* mean? It means that the product is made from the consumers' point of view and to please the consumers. There are products that have been developed based on a company's perspective, which assumes that people will buy the product because they think it is convenient or reliable. Surprisingly, the company does not really understand the consumers' viewpoint, and this causes those products to fail in the market and appear to be disappointing. Developing products that get into the deep layer of what consumers actually want will enable good products and valuable products to be supplied into the market.

What does *undervalue* mean? It is not merely that the price is low. Most Japanese consider themselves middle-class and above. Additionally, due to the rapid increase in the standard of living during the last decade or so, and the optimistic mood of the bubble economy, the Japanese are imbued with a feeling of "classiness." Since this feeling does not diminish, they will not buy products that do not support their high standards of living. The Japanese have grown up with the sense that they live a life that makes a clear distinction between things that do not really need quality and things that require good functionality. Even though a product is good, if it has too many unnecessary functions, it won't capture the attention of today's consumers. Also, it does not mean that a product is good if it is inexpensive. The consumer's sentiment is, "I will buy the product if it is good and the price is reasonable for its quality." What is *good*, and what is *undervalue*? These are the two important issues for those who will be involved in future product development.

There are two directions in product development. One is the *product-out* concept, and the other is the *market-in* concept. The gist of product-out is that a company proactively produces and sells products they consider good, while for market-in, the idea is to develop products from the viewpoint of the market, that is, the consumers.

There were days when companies had substantially grown with the product-out concept, but those were the days when consumers did not have enough knowledge, and they were often naive when choosing products. Since then, many companies have attempted various ways to shift from the product-out concept to the market-in concept. However, they were not able to be objective in market-in product development, until today.

Nowadays, consumers' cabinets are flooded with goods. There is no more space to cram in new goods. Consumers themselves have become a great deal smarter. They have developed to a point where they consider such things as what makes them look beautiful, what improves their individual character, and how a product enhances the value of life. If future product development does not strategize the market-in concept, consumers will turn their backs on it.

We incorporate Kansei to win over consumers. We used to hear the term *user friendly*. In recent years, the terms *consumer-centered* or *human-centered* have emerged. In the years to come, Japan will face a tremendous challenge due to its aging society. It's a known statistic that, in the near future, one out of four persons will be over 65 years old. Development of products that are easy to use and appreciated by people, including the elderly, is human-centered product development. *Human friendly* is a term that describes this. In the future, environmental or similar problems will also be related to product development. The trend of product development that carefully considers the well-being of humankind and harmoniousness with the entire world and the environment will become focal.

1.2 The Emergence of Kansei Engineering

Kansei engineering is a technology that unites Kansei (feelings and emotions) with the engineering discipline. It is a field in which the development of products that bring happiness and satisfaction to humans is performed technologically, by analyzing human emotions and incorporating them into product design.

Sometime around 1970, I visited manufacturing companies regularly. I could see that people were being encouraged more and more to make purchases due to the healthy economy, and companies responded with mass production of goods. However, I foresaw that people would stop buying when their cabinets became overfilled. If this happened, perhaps only the good product, that is, the good-quality product, would win over consumers. However, since the good-quality products are long lasting, the market flow would then become slow. Then, it crossed my mind that perhaps only the products that consider people's feelings, that is, the products that people really want and desire, will sell. Then, there will be an era when products are made to express one's personality. Thus began the Kansei era, in 1970, followed by Kansei engineering research.

The flow of the emergence of Kansei engineering is shown in Figure 1.1. The left column of the figure shows the consumer's desire, while the right column shows the corresponding activity at a company. Companies must develop products that correspond to the change in people's feelings and emotions in order to survive. They should employ a product development strategy that anticipates people's feelings and emotions. The Kansei era emerged about 20 years after I first started to ponder it, and it is predicted to continue indefinitely. Maybe it will continue forever, or perhaps it is more reasonable to think that the form of Kansei expression will change in accordance with the changing times.

Let's say we name the product that was produced using Kansei engineering technology the Kansei product. The Kansei product is not an expensive product or a high-end product. It is also not something that emphasizes good looks, appearance, or style. The Kansei product refers to that which can actualize the needs and emotions, considering functions and shapes, and

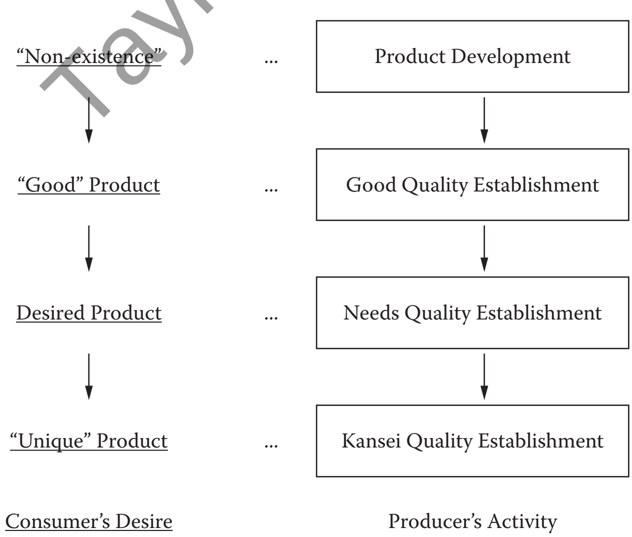

FIGURE 1.1
The concepts underlying the emergence of Kansei engineering.

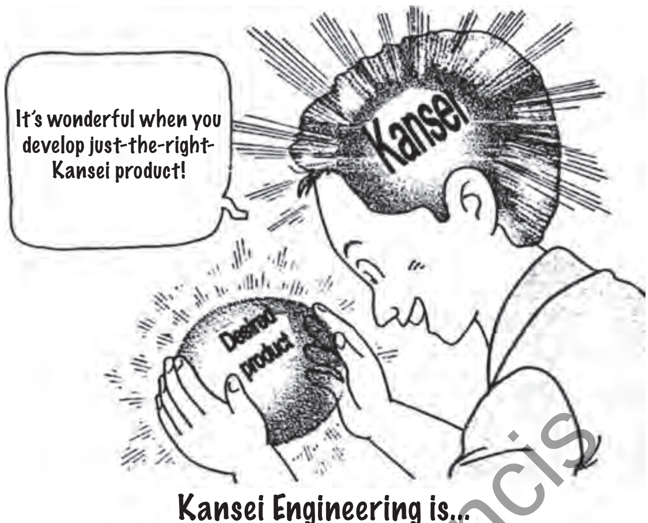

FIGURE 1.2
The purpose of Kansei engineering.

also whether the consumer would want that product and what the product offers.

For example, we can realize the product that elicits Kansei simplicity in a video tape recorder (VTR) that has buttons that are clearly visible and makes recording easy, or a telephone that does not have complicated functions but enables the user to perform necessary functions easily (Figure 1.2).

In implementing Kansei engineering, it is important to investigate the people's Kansei. When Kansei information is properly collected and analyzed, it can then be translated into a technical design. Even in the engineering field, there are cases where new technology will be required in order to actualize Kansei. In such cases, many patents and models of new techniques will appear. Product development that utilizes Kansei engineering will not only produce diverse products that are friendly to people but also be an impetus for new technology development. In this sense, we could also say that Kansei engineering is a new technology in the new era.

1.3 What Is Kansei?

Before we consider the main subject of Kansei engineering, let me first explain the principles of Kansei.

According to the *Shin meikai* Japanese dictionary by Kindaichi Kyosuke et al., Kansei is "intuitive mental action of the person who feels some sort of impression from an external stimulus." In the psychological definition, Kansei refers to the state of mind where knowledge, emotion, and passion are harmonized; "people with rich Kansei" are full of emotion and passion, and able to react adaptively and sensitively to anything.

The term *Kansei* used in Kansei engineering refers to an organized state of mind in which emotions and images are held in the mind toward physical objects such as products or the environment. For example, concepts such as luxurious, elegant, flashy, and young, as in "that product is a bit luxurious and elegant," or "those clothes are flashy and young looking," are all Kansei impressions of products. The term Kansei used in Kansei engineering in most cases takes the form of an adjective, but it may also be a noun, as well as foreign words written in *katakana*.

However, since Kansei is all about the image held in one's mind, it is therefore expressed using various media, such as words, facial expressions, or drawings in order to make others understand. It is still unknown whether the expression itself matches the image in the other person's mind. This is an issue to be considered. From the beginning, the difficulties in measuring something like Kansei have been apparent, since it deals with a person's mental attributes. We ask people to express an image using common, everyday words. There is no English word that translates exactly the meaning of Kansei. If it still has to be translated, *psychological feeling* can be used. However, since this term causes more confusion, today the original Japanese word—Kansei—is used. Likewise, we use the term *Kansei engineering* in English. Sometimes in Kansei engineering, people are asked to express their Kansei in words upon seeing products, or regarding products they want to buy in the future or products that are not yet available. These are called Kansei words.

In Kansei engineering, some Kansei terms reflect the times and do change occasionally, such as trend-related Kansei, while others virtually do not change at all, such as fundamental Kansei (colors, etc.). Additionally, cultural differences among countries cause differences in the Kansei itself, and some Kansei are similar and yet still different in the expressed Kansei words. Careful attention is required when applying Kansei engineering in this matter.

1.4 Kansei Is Something Comprehensive

When you say, "It is an elegant dress," upon seeing someone's garment, you feel a Kansei of *elegant* as your impression of the whole dress. However, when we talk about fashion design, the impressions for one-piece and a suit will be different. Furthermore, type of collar, number of buttons, and pocket design will give different impressions. For skirts, depending on what types they are and even the material used, the overall implied Kansei will be different.

When we think of an article of clothing, we can imagine the breakdown of its elements (or parts) such as (1) overall style, (2) upper piece type, (3) collar style, (4) numbers and position of buttons, (5) pocket design, (6) type and length of skirt, and so forth. The composition of these elements will elicit certain Kansei. A slight difference in buttons will generate different Kansei. Different numbers of pleats in a skirt will elicit different Kansei. Much Kansei exists even within the elements themselves, and each individual element affects the overall Kansei.

Besides being an overall or comprehensive impression, the elements of Kansei are the subject of Kansei as well. Therefore, in performing product development using Kansei engineering technology, the following procedure is necessary:

1. Break down the design into separate elements.
2. Interpret the Kansei of each element.
3. Design the overall product.

It is important to grasp in advance which of the dozens of elements are having a great influence on the overall Kansei, and then to pay attention to those elements and incorporate them into the product design. This is illustrated in Figure 1.3.

Let's say, when we break down the elements of product A, we identified elements a_1 through a_7; and from a statistical analysis of those elements, we found that a_5 and a_7 greatly affect certain Kansei. This is called degree of contribution. This means, in order to incorporate the specific Kansei in product A, we should incorporate the elements a_5 and a_7 into its design.

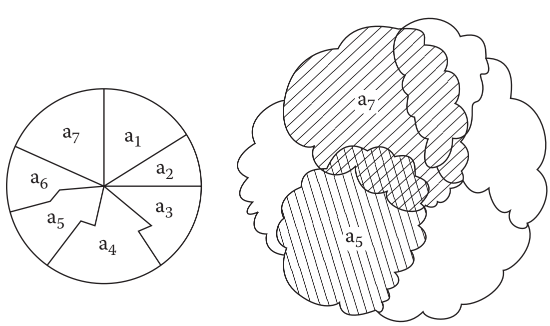

FIGURE 1.3
Kansei is something like the right figure, the element as a whole with indistinct boundaries, rather than the left figure, a mosaic of elements.

1.5 Good Product Evokes Humans' Kansei

Good product refers to a product that is designed to matched the hidden Kansei signature of the consumers. When consumers find such a product, they will be very impressed and feel, "Wow, what a great product!"

If 60–70% of the Kansei product matches with the consumers' Kansei, and the balance of 30–40% of the Kansei is in the realm of something new and excellent, the consumer will become very impressed and believe that it is an excellent product. Of course, this will be a motive for buying. The 60–70% of Kansei can be analyzed in a Kansei engineering study, and the remaining 30–40% will depend on the creativity of designers and research and development (R&D) personnel. This kind of percentage is important. For example, even if the product matches 80–90% of the consumers' Kansei but could not elicit a feeling of novelty or creativity in the consumer, it will be perceived as a clichéd product. Conversely, if the portion that matches the consumers' Kansei is 10–20%, and the balance of 80–90% is the result of creativity from R&D, it will be perceived as a future-oriented product, which consumers do not want to have around. Concept cars or costumes that appear quirky belong to this category of products.

Product R&D personnel must keep their sights on the product development that evokes consumers' emotions. In order to do that, they must strategize to concentrate on grasping the content of the consumers' Kansei at the current moment.

However, they should not forget that a product that evokes consumers' emotions also lifts consumers' Kansei to the next level. Consumers will develop a kind of Kansei intelligence as they come into contact with the product, and the Kansei level will develop. Therefore, the next level of product development must tune in to the increased Kansei level. Otherwise, the product will fail to evoke consumers' increased Kansei, and the new product will disappear from the market. In this sense, product development is ultimately a kind of battle to improve consumers' Kansei level.

Good product development means developing a product that evokes consumers' Kansei. Also, this makes consumers somehow attuned to the Kansei and causes improvement in their level of Kansei. We need to be careful not to forget this, because forgetting may cause failure in the strategy to continuously evoke consumers' Kansei in the next product development after a market success, thus causing the product to disappear completely from the market.

There is another general rule related to evoking consumers' Kansei. In the discipline of psychology we have the Weber-Fechner law. As shown in Figure 1.4, making the vertical axis the Kansei increment and the horizontal axis the stimulus increment, in order to increase the same value of Kansei increment, ΔK, while the stimulus is small, increasing it at almost the same portion will result in an increase of ΔK. However, when the Kansei level becomes higher and stimulus is not increased, we will not get the ΔK

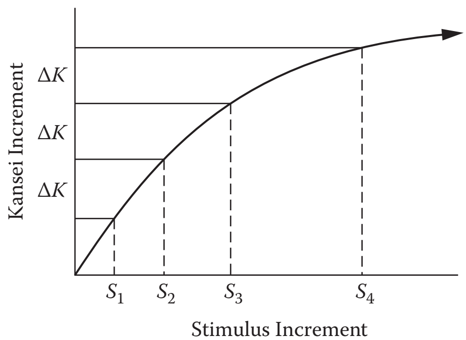

FIGURE 1.4
Relation between stimulus (device) and Kansei increment.

of Kansei increment. In other words, between Kansei (K) and stimulus (S), there is a logarithmic relation, as described in the following:

$$K = C \log S \text{ (C is a constant)}$$

This is the Weber-Fechner law.

In the field of Kansei engineering, this can be described as follows. Let's say we have product B. It can be a television or a refrigerator or whatever you wish to imagine. I want to raise the Kansei level of product B one rank higher, which is ΔK, to impress consumers and thus contribute to sales. So, let's assume that I have increased the stimulus from S_2 to S_3 and achieved the target. This means that I have added a few functions or made it look nicer. Of course, since the development costs have increased as well, the price will be higher.

After a few years, if we want to increase ΔK of Kansei for the same product and evoke the impression again, we have to make an even greater effort than last time to increase the stimulus from S_3 to S_4, and throw extra investment into development. If we want to differentiate the Kansei point of high-end television, such as Gao or Teio, from conventional televisions, we have to produce *big* Gao or *big* Teio, otherwise consumers will not be impressed.

I hope you understand how complicated it is. After some time, a phenomenon occurs: consumers turn away from the product. It is not an easy task to develop Kansei products that impress consumers all the way since they will soon learn and become smarter. We should not forget the Weber-Fechner law. It also works in the product's Kansei.

1.6 Corresponding Development and Sales in Kansei

If we look at previous bestsellers, we will have a better understanding of the consumers' Kansei, and incorporating it into a product will make it sell well. For example, Sharp's camera-type VTR LCD ViewCam is a product that made the company's VTR share jump from only a few percentage points to 20%. This was the result of extensive analysis of consumers' four dimensions of pleasures: shooting pleasure, watching pleasure, face-to-face pleasure, and the pleasure of playing on the spot. The results of the analysis were then incorporated into the product's design technology.

What I want to emphasize here is that if we only focus on matching consumers' Kansei in the development of the product itself without correspondingly considering the point of sales, we will fail, even though we produce a good product. For example, when the homemade bread machine first launched, all the newspaper promotions that it would surely become a hot seller tremendously helped sales. This is because the product had incorporated the consumers' Kansei of *gourmet consciousness* and *premium feeling*, and consumers could then bake delicious breads at home. However, after a while, the sales suddenly stopped. Upon investigation of the root cause, companies found that, since the flour was sold at electrical appliance stores and was packed into unattractive boxes, this contradicted the product's image of stylish housewives, making them resistant to buying. Consumers' Kansei had been effectively utilized in the product development but not to the distribution point. On the other hand, the product was selling well in the United States.

Asahi Beer has achieved great success with its Super Dry line because Kansei has been utilized correspondingly in both product development and sales. R&D personnel focused on developing a new beer. They sensed that the Kansei of consumers' taste were *robust* and *crisp* and confirmed this with a survey of 5000 consumers. Since the two tastes contradict each other, it was very difficult to actualize the product. However, the brewers perfected a skill that smartly uses yeasts related to each taste to accomplish the Super Dry.

Before that, Asahi Beer's market share was as low as 8.9%—at the rock-bottom level—and it was promoting a company-wide corporate identity (CI) movement for a revival. To achieve that, they had launched a new product campaign all over Japan, starting simultaneously from Sapporo and Kagoshima. At that time, their general employees banded together and focused their efforts on sales. A CI committee member suggested that if they buy all of the old Asahi beers from vending machines around the city, the new product will reach consumers faster. So, the employees hunted all the old Asahi beers on Saturdays and Sundays. As a result, the general consumers got a taste of Super Dry earlier than they otherwise would have, and there they outshone all other companies. Perhaps the only drawback was that the employees also consumed the old beers they had bought!

It is necessary to take corresponding actions in Kansei implementation between the product development point and the sales (marketing) point. Automakers were the first to implement Kansei engineering intensively. Even though they have come out with excellent products based on

Kansei, it is uncertain whether the car dealers are practicing sales activities correspondingly. When customers are looking at a new product and they show interest in a certain part, if the salesperson can explain how the R&D personnel made an effort to include Kansei in that aspect, it will touch the hearts of consumers (Figure 1.5).

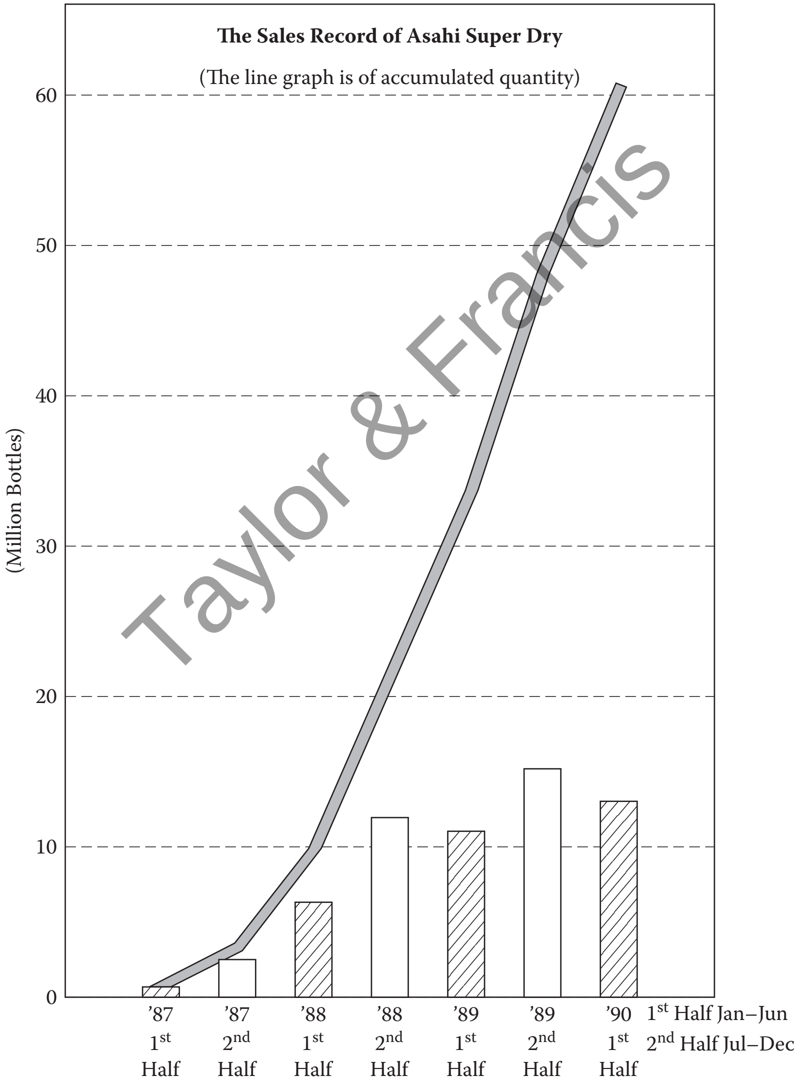

FIGURE 1.5
Volume of sales extended because sales activity is corresponding with Kansei product.

5

Kansei Engineering Type II Application Cases

5.1 HULIS

HULIS, short for *human living system*, was the first Kansei engineering system. Until its introduction, I saw many conflicts between homeowners and builders. For example, the wallpaper that the owner had in mind, based on a small sample, was totally different from the actual wallpaper provided. The architect did not really make an effort to fulfill the owner's desire. I created a system that translates the consumer's (owner's) Kansei to a house design. That is HULIS.

There are a few concepts in HULIS. Instead of beginning the house design with a room arrangement, HULIS begins by asking the consumer what kind of living he or she imagines, and then creates a design that can actualize the imagination. It is based on the notion that room arrangement constitutes the output of a lifestyle.

HULIS is made up of seven elements: (1) appearance, (2) structure, (3) entrance, (4) Japanese-style room, (5) Western-style room, (6) kitchen, (7) bathroom. The owner will begin with the appearance: "What kind of house do you want to live in?" If the image in mind is, "I want to live in a house with a gorgeous and tough appearance, and my budget is XX," then we input the Kansei words *gorgeous* and *tough*. HULIS has rules and a database for appearance, so it will generate the inference mechanism and display a graphic inferred from these Kansei words.

HULIS will then proceed to the entrance design: "How do you want the entrance to look?" If the answer is a *tough* and *massive* entrance, the HULIS computer will display an image of an entrance that looks tough. This continues through the last element, the bathroom. After the image for each home element is input using words, the overall house design is determined (Figure 5.1).

This Kansei engineering system (HULIS) will be a powerful weapon for an interior designer. Normally, a customer who wants to build a house has an image of what kind of house he wants to live in. HULIS is a system that can demonstrate the image realistically. By providing the HULIS result to the contractor, we are able to realize a result that satisfies all three parties—the user,

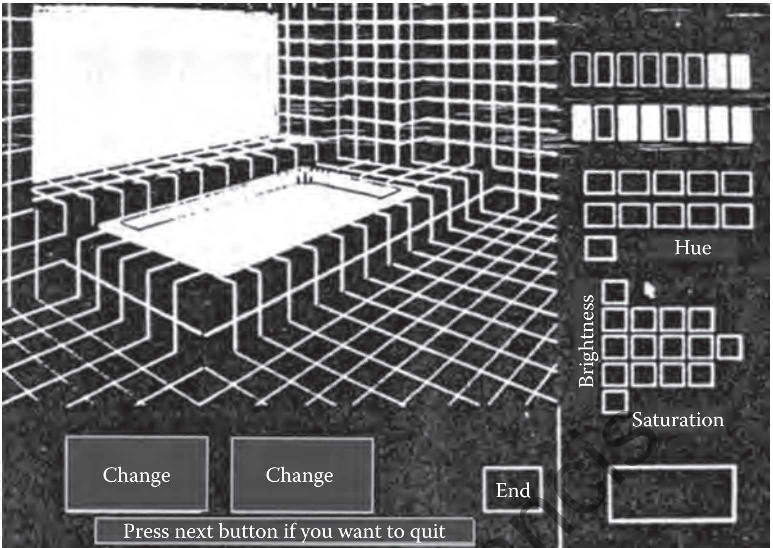

FIGURE 5.1
The output image (color) of bathroom from HULIS.

the architect, and the interior designer, who acts as the middle man. Actually, HULIS is a boon to the interior designer, who acts as an intermediary, taking care of the customer's image and influencing its realization (Figure 5.2).

If HULIS is developed to perform the following functions, it could become the second version, HULIS-II:

1. It will perform the inverted shadow calculation based on data of the land map brought by the customer and its surroundings, using software loaded into the computer. The land map is scanned, and the area will be automatically read. Next, based on the inverted shadow calculation rules (artificial intelligence), which are embedded into the computer, the system will calculate the effective three-dimensional space within which the house can be built.
2. Input the budget that the customer can allocate for the whole project. This will directly affect the quality of the building or available options.
3. The customer will be asked to talk about his lifestyle. The keywords are picked up and input into the system. For instance, "We are a family of four: my wife, our high school-age son, and our junior high school-age daughter, and me. My wife is also working in a company, and both of us are at the management level, so sometimes we come home a bit late. Saturday nights, we usually go out for dinner, but every one or two months we invite friends to come over for dinner and karaoke…"

FIGURE 5.2
Illustration of the use of HULIS.

From their living styles, annual income, and family structure, based on the embedded artificial intelligence rules, the system will infer how many rooms are needed for the children and how many rooms are needed overall, how the rooms should be arranged, how the entrance and guest room should be, how big the bathroom should be, and many other elements. The computer will propose a building structure such as the arrangement of rooms that matches the customer's lifestyle, and it will explain the reason as well. The customer will get a few proposals, and the proposals can be amended at the customer's request.

4. Back to HULIS, input images related to each room such as appearance, structure, entrance, Japanese-style room, Western-style room, kitchen, bathroom, and so on. The size and interior of each room will be inferred and determined using the Kansei engineering technique.
5. Consider the budget, perform the overall inference, display in color the architectural drawings (three views), room arrangement, and the Kansei of each room, together with the budget.
6. The cost calculation and detailed construction drawings will be printed, but of course these are not for the customer to see.

The customer will bring home the three-dimensional drawings generated in Step 5 and the family will discuss the contents. If everything is to the family's liking, the family will place an order.

By utilizing the inference using artificial intelligence, HULIS-II has bilateral merits allowing it to propose a design that can realize the lifestyle desired by the family, the family can have further discussions right away, and the family is able to participate in the design process.

Part of HULIS-II has been used by a construction firm, and it has been highly praised. We can get much more interesting results if we combine this Kansei engineering system with virtual reality. I will touch on this later.

5.2 FAIMS

FAIMS (fashion image system) is a computer system that uses Kansei engineering to decide the dress for female university students, as explained in Chapter 4. It is embedded with a database of all-season suits and one-piece outfits for female students. When the Kansei words describing the dress female students want is input, the clothes that suit their images will be displayed.

First, the computer will ask, "What image of dress do you want?" The user will input the words, like *cute dress* or *intellectual dress*. FAIMS will perform the inference by utilizing the Kansei words database and knowledge database, and then display the finalized dress design.

The computer will extract 50 types of dress design in one shot for the first word, but it will only show the highest-scoring option. If the user thinks the design does not fit her image, she can view other options, one after another—the second highest, the third, and so forth through the 50th. She can also change certain parts that do not suit her taste.

FAIMS can be expanded to the higher scale FAIMS-II. When we performed biometric measurement to 51 items of a dress using about 400 female university students, we found that all the measured values can be reproduced with three body measurements: height, chest, and iliac crest angle. By using these measured values, we can classify the female university students' body shapes into 10 types. In other words, we found that with three body measurements we can determine the body shape, and Kansei engineering can be applied to each shape as needed. We are able to create the image of *tall and cute* or *medium-built and cute* designs using Kansei engineering.

In FAIMS-II:

1. Height, chest, and iliac crest angle are measured. The computer will infer the person's body shape and turn it into an image.
2. The image of the desired dress is input using words. The computer will utilize the database and infer the dress that is logical to the Kansei word.

3. The inference result in Step 2 is fitted to the body shape inferred in Step 1.
4. The derived Kansei engineering graphic is displayed on the monitor and then verified as to whether it fits the customer's image. Partial alteration can be done on the computer.
5. If the customer is satisfied, FAIMS-II will output the pattern that matches the person's body shape and the desired image. The rest is just producing the actual dress.

FAIMS-II has been constructed only up to the step of identifying body shape and designing using the image. Integrating these two parts still remains an issue.

5.3 Entrance Door Kansei Engineering System

We have codeveloped the Kansei engineering system for entrance door design with Tateyama Aluminum Industry Co., Ltd. The objectives are to provide front doors that can satisfy customers who look for aluminum sash doors by asking them to express the Kansei that they have, and to build a support system that enables the R&D personnel to perform new product development appropriately and efficiently.

According to Kansei engineering procedures, the process started with extracting Kansei words related to the aluminum sash door. The marketing staff and designers cooperated in extracting the words. After extracting quite a large numbers of Kansei words, we held a discussion with the designers. This resulted in narrowing it down to 40 pairs of Kansei words.

The next step was collecting door samples, including the sash doors of other makers. We ensured that various designs were included, and we collected 82 slides of sash doors. We showed the slides to interior coordinators and the staff designers, a total of 77 people, and asked them to perform an evaluation using the aforementioned 40 pairs of Kansei words.

Among the identified basic shapes of aluminum sash door are those shown in Table 5.1. Additional considerations are the door's color and many other detailed characteristics. Table 5.2 shows some of them arranged into item/category related to 82 types of doors. The results of Kansei evaluation for each door were analyzed using quantification theory Type I, and then stored in a database for the Kansei engineering system.

The system structure for the entrance door Kansei engineering system (EDKES) is shown in Figure 5.3. Basically, it is almost the same as HULIS and FAIMS. The difference is the design database expresses the Kansei words database with HULIS, images database with FAIMS, and doors graphics

TABLE 5.1

Examples of Item/Category for Aluminum Sash Door

1. Frame type	(1) Single door (2) Double door (3) Double panel (4) Double leaf
2. Fanlight	(1) Door fanlight or Frame fanlight (2) No fanlight
3. Lattice	(1) Horizontal (2) Vertical (3) Crossed (4) No lattice
4. Door structure	(1) Top curve (2) Door curve (3) Top point (4) Flush (5) Others
5. Muntin	(1) No muntin (2) One piece (3) Two pieces (4) Three or more pieces
6. Glazing bar	(1) No glazing bar (2) One piece (3) Two pieces (4) Many pieces
7. Cross rail	(1) Have (2) Don't have
8. Double cross rail	(1) Have (2) Don't have
9. Clove	(1) Downward clove (2) Upward clove (3) Don't have

TABLE 5.2

Part of the Item/Category for Aluminum Sash of Entrance Door

Item	Category	Sample																								
		26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Frame Type	Single Door		●			●	●		●		●		●		●			●						●		●
	Double Door	●						●		●				●			●		●		●		●		●	
	Double Panel			●	●							●				●						●				
	Double Leaf																			●						
Fanlight	No Fanlight	●			●	●	●		●	●	●	●		●		●		●			●	●		●	●	
	Door Fanlight		●	●									●		●								●			●
	Frame Fanlight							●									●		●	●						
Door Color	White						●	●							●		●	●			●		●			
	Grey	●										●				●										
	Black									●				●								●				
	Pastel				●				●										●							
	Brownish		●	●		●					●		●							●				●	●	●
Lattice	No Lattice	●	●	●	●	●		●	●	●	●	●	●		●	●	●	●	●	●	●		●			●
	Horizontal																									
	Horiz. & Vert.													●								●			●	
	Crossed																									
	Others						●																	●		
Door Structure	Top Rail	●	●	●		●			●	●				●			●			●		●	●	●	●	●
	Top Curve							●			●		●		●											
	Door Curve																									
	Top Point						●																			
	F-oblong											●				●										
	F-others																									

with EDKES. When the Kansei word for the desired door is input to the EDKES that has been built up to process it, an image of the inferred door will be displayed on the computer.

EDKES can be set up and used in a marketing office, where a customer can use it to visualize the desired door. By putting together the assembly parts, we can set up the desired door that he wished for, giving the customer a sense

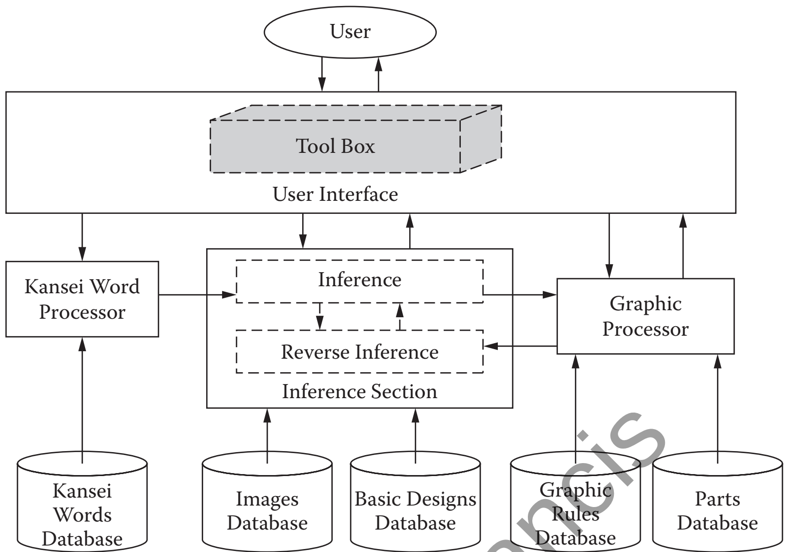

FIGURE 5.3
System structure for EKDES.

of satisfaction. Additionally, EDKES has been configured to automatically record the Kansei words chosen by the customers. This input will be helpful in enhancing the development process of entrance doors in the future.

Another interesting point about EDKES is that, by giving a specific Kansei word and the information on the doors' item/category, which is the attribute of the design, to a designer, a totally new product can be produced. In one example, the attributes (design elements) of an entrance door for the Kansei *simple* door were as follows:

1. Door structure—Vertically long flush
2. Frame type—Single door
3. Door color—Gray
4. Muntin—Two pieces

The designer used this information and a short while later produced a drawing. After experimenting with many other Kansei words, we got many new door designs. A subsequent interview with the designer revealed that if they get this kind of information, they don't have to take the trouble to think about so many things. While visualizing the Kansei word's image, the door design attributes pop up in a designer's head with almost no effort. The designers proved that such an approach is a very effective development technique.

5.4 Kansei Engineering System for Car Interior

Many types of software have been developed in Kansei engineering. Another kind of extraordinary application is in passenger car design, for which we have developed a few Kansei engineering systems that are being utilized. KEES-D (Kansei engineering expert system-D), which I am going to describe here, is a design support system tailored for car interior design.

I have mentioned that Kansei engineering is a technology that translates Kansei words like *elegant*, *beautiful*, *luxurious*, and so on to product design, and I have explained the application in detail. What I am going to explain now refers to car interiors, but it is more specific to *spacious feeling*, *relaxed feeling*, *tightness feeling*, *narrowness feeling*, and the like—the kind of comfort related to the size of the interior. In this sense, it is a little bit different in terms of characteristics compared with the Kansei that I have mentioned previously.

There is a constraint to the size of a car. A design can be praised as good if it can psychologically give the sense of *spacious* to the driver and other passengers even with a size constraint. For cars that provide satisfaction through speed, like a sports car, a good design is one that can make the traits of a sports car be felt more strongly by creating a sense of narrowness rather than spacious. However, in order to materialize the Kansei such as *spacious feeling* into the design, we need to know the interior factors that contribute to the spacious feeling. This can be discovered using Kansei engineering. Furthermore, by utilizing the result, it is also possible to build a computer system that can realize or diagnose the spacious feeling. KEES-D is a Kansei engineering system that was researched and developed for these two objectives.

We started with the initial objective, which was to analyze the Kansei of a car interior. The research began with the extraction of Kansei words. A few hundred words were collected, and with the help of designers as car professionals, 100 adjectives that are logical to use to describe a car interior Kansei were selected and given their respective antonyms so that they could be used in the form of the SD scale. We prepared a 5-level rating scale (Figure 5.4).

Next, since the target was small-sized passenger cars, we prepared 20 small-sized cars with 1000–1500 cc engines, and had them evaluated using the aforementioned 100 Kansei words on the SD scale. The evaluators were individuals involved in car manufacturing, with a total of 41 persons of both genders. This is how we got the Kansei data for the small-sized car interior.

On the other hand, regarding the car design, we promoted the design elements identification process—what has been referred to as the item/category classification process. The car designers must put a lot of effort into this process. Therefore, we briefed them in advance about Kansei viewpoints and how to determine the item/category. This is the most important point

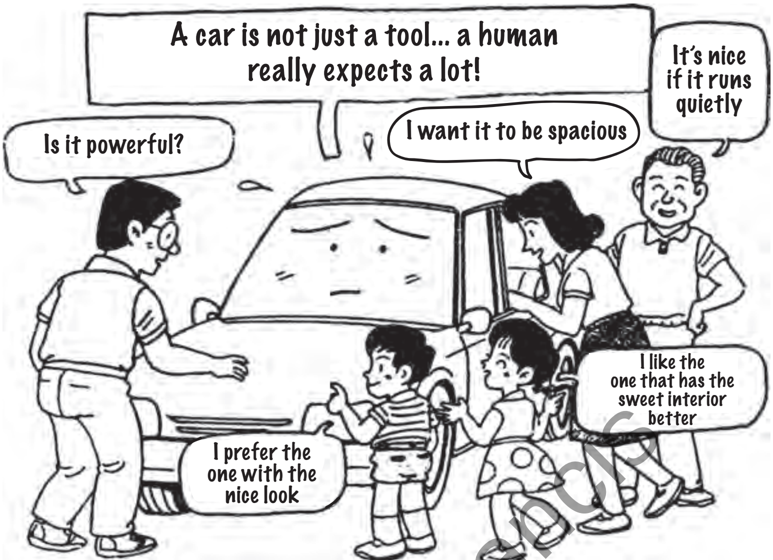

FIGURE 5.4
Car Kansei engineering.

in Kansei engineering. If there is a mistake in controlling how people classify the thing they see, we won't get a good result during the statistical calculation. In this research, we obtained 224 types of item/category for the car interior design.

The computer architecture of KEES-D was built as in Figure 5.5. This Kansei engineering system itself has software that analyzes quantification theory Type I and a checker that performs a dependency check before the analysis. These points are fundamentally different from the existing Kansei engineering systems. The dependency check means all the items are checked to see if they can be handled independently or not (i.e., if overlapping occurs at some points between items, it is called dependency), and if statistical analysis is possible or not.

First, we applied the quantification theory Type I to the design evaluation result using the 100 Kansei words to grasp the relativity between the image and item/category. By checking the data, we confirmed that *spacious feeling*, *relaxed feeling*, *tightness feeling*, and *narrowness feeling* relate greatly to the interior dimension. Hence, we extracted only the data related to these four Kansei phrases and the interior dimension data, and then constructed a database system as in Figure 5.5.

A designer who wants to examine the *spacious feeling* of a small-sized passenger car using only the interior dimensions will sit down in front of a computer with KEES-D installed and run the KEES-D. Initially, the KEES-D will show a display and ask the designer to input the dimensions. In this example,

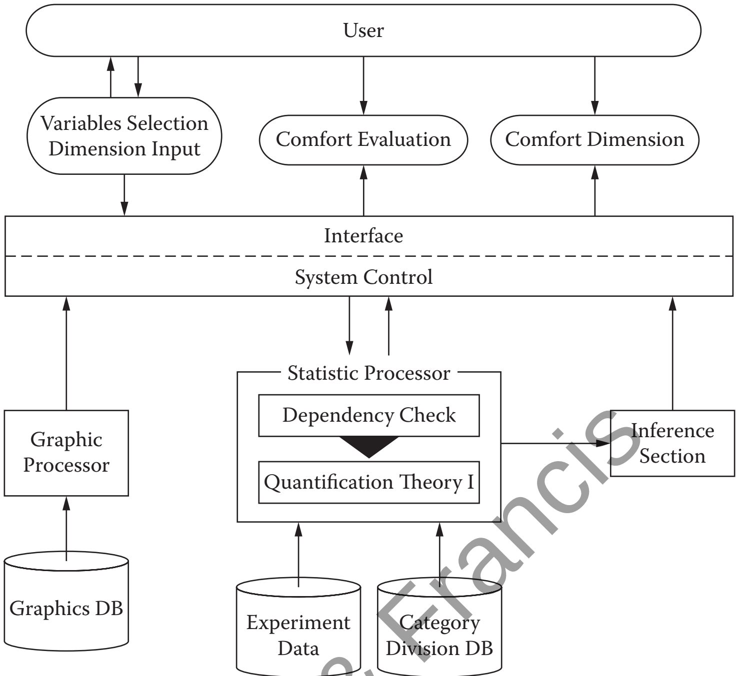

FIGURE 5.5
Schematic diagram of KEES-D.

they are XL 38 (the distance from the driver's eye to the bottom end of the left pillar) and W 20 (the horizontal width from the eye to the car's center line), and the predetermined dimensions are input. Next, a few diagrams will be displayed one by one, and dimensions are input for each diagram.

When all the inputs are completed, the KEES-D statistic processor, as shown in Figure 5.5, will execute. First, it will perform the dependency check, then recall the experiment data and perform quantification theory Type I (Figure 5.6). After the specified process is performed, based on rules defined in the inference section, the spacious feeling will be evaluated using the input dimensions.

In this case, the score for *spacious feeling* is 65 points, while the score for *tightness feeling* is 63 points. This tells us that the interior dimensions give a certain degree of feeling for both spaciousness and tightness. The KEES-D also has a description feature that explains how it gets the score.

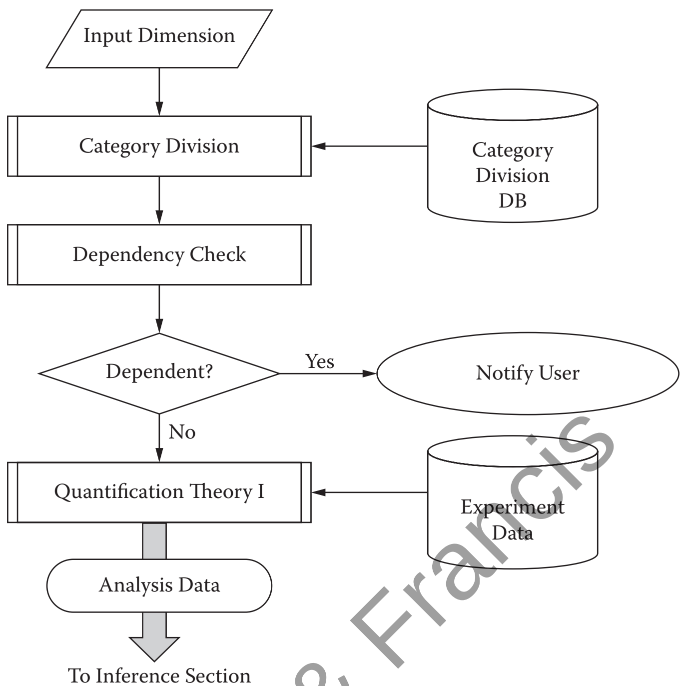

FIGURE 5.6
Flowchart of the statistical processor.

7

Virtual Kansei Engineering: Kansei Engineering Type IV

7.1 What Is Virtual Reality?

We often see the term *virtual reality* in newspapers and magazines. Virtual reality refers to a computer-generated virtual world that is very close to reality, and simulated experiences that closely resemble the real world.

Computer hardware has evolved tremendously and become a lot less expensive. This has made possible the creation of the three-dimensional virtual world, and the virtual, simulated experience in computers. In virtual reality, we are able to act freely of our own will, and this is basically different from dreams that are beyond our control.

The easiest way to demonstrate an example of virtual reality is with the flight simulator for pilot training. The outside world visible to the pilot is the approximate image of a runway and other items that are created using computer graphics, and the image will respond to the operational changes in the cockpit. With the complex operation of hydraulic devices, gravity changes that are similar to changes in reality are applied to the cockpit to give the feeling of takeoff and landing. All these are being controlled from a computer. With the flight simulator, which has been developed using state-of-the-art technologies, there is an advantage of being able to greatly reduce the number of field trainings. In fact, quite a big portion of pilot training is now done using the simulator.

The main reason simulators are used for pilot trainings is that aircraft are an expensive commodity, and accidents caused by inexperienced pilots might result in heavy losses, including human lives. Another reason is that besides being able to simulate the rule-based flight using computers, training for emergency situations is also made possible by simulating emergency circumstances.

Why is virtual reality good? Compared with actually creating a real object or situation, creating it as a computer image is cheaper. On top of that, since these are computer images, there are no repair and maintenance costs. Also,

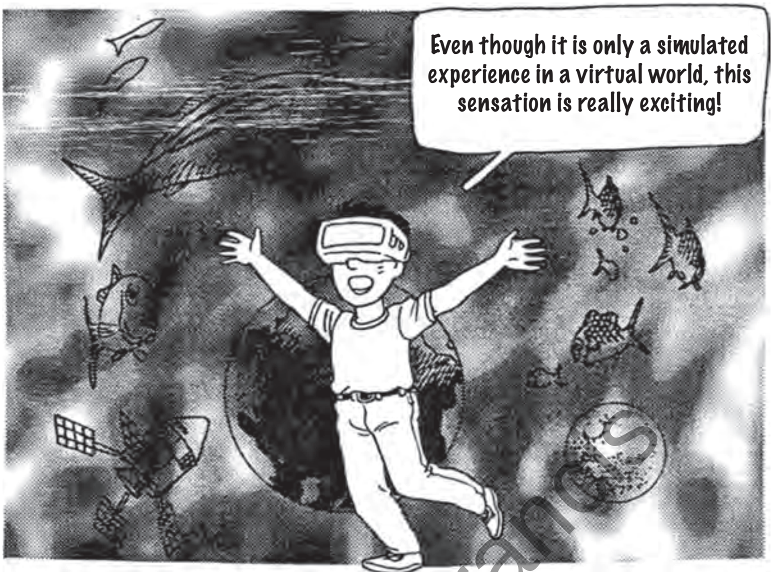

FIGURE 7.1
Virtual reality and Kansei engineering.

by utilizing the simulated experience, the human experience of a situation using computer technology is like a walk-through of the actual situation.

In the virtual reality field, many companies are involved in developing hardware and software, which include a computer to handle images and software, an HMD (head-mounted display) to show three-dimensional images in front of the user's eyes, data gloves to hold or to operate the items in the images, and a tool for image creation (Figure 7.1).

Basically, the graphics created using a tool for computer graphics are alternately projected to the left and right displays of the HMD in a slightly shifted form. Users can blend into the image, which is in a three-dimensional space, and with hand movements over the data glove, simulated experiences such as catching something or turning on a faucet in the virtual world are possible.

7.2 Virtual Kansei Engineering

Virtual Kansei engineering is a technology that integrates virtual reality and Kansei engineering. Hiroshima University and Matsushita Electric Works Ltd. (MEW) did joint research to develop virtual Kansei engineering as a new technology—the first in the world to combine virtual reality and Kansei engineering.

The virtual Kansei engineering that we developed is a system that provides products that can satisfy customers' needs in purchasing a MEW custom kitchen. First, the customers will describe the lifestyle they dream of. Keywords from the description will be input into the virtual Kansei engineering system. Next, they will be asked to describe the image of the kitchen they want in the form of phrases like *elegant, a bit luxurious,* and *a convenient kitchen*. Kansei words from this phrase will be input into the system. Automatically, the picture of a custom kitchen close to the image described will be displayed on the computer. If customers are roughly satisfied with that, they will step into the virtual reality, put on the HMD and data glove, and enter the custom kitchen that the computer has selected based on the Kansei. Customers can then examine the kitchen by trying to cook, touching appliances with their hands, and turning on the faucet using the data glove. Customers also check the locations of the cupboards, dishwasher, and so on to their satisfaction. Anything unsatisfactory can be amended in the computer.

When a customer is fully satisfied, the design drawing of the custom kitchen will be output and transmitted to the MEW factory. The factory already has its manufacturing system equipped with computer-integrated manufacturing, so the drawing will be incorporated into the production plan, and within one to two weeks' time, the product will be manufactured and delivered to the customer. In this manner, the custom kitchen, which is based on the customer's Kansei and has been virtually experienced by the customer to his or her satisfaction, is manufactured in a short time and will give full customer satisfaction. The particular objective of virtual Kansei engineering to develop products aimed at customer satisfaction through customer participation. In MEW, this is called the *ViVA system*.

7.3 Custom Kitchen Kansei Engineering

The outline of custom kitchen Kansei engineering is as follows.

7.3.1 Computer Memory Content

The first thing that the computer system must know is the customer's kitchen area. The kitchen layout is input in the computer: length and width; position of pillars, doors, and windows; the style of kitchen space; and so on. The computer will separately store in memory the sink, dishwasher, cabinets, and so forth as components.

7.3.2 Selecting Kitchen Style

The customer describes his desired lifestyle in terms of the kitchen. The keywords identified from the description are arranged and inferred based on the rules acquired from experienced kitchen designers, and the style of the custom kitchen is selected. In the rules that the designers have, the kitchen layout is almost completely determined by the income, age, cultural characteristics, and other characteristics of the customer, such as lifestyle. The person's lifestyle especially has a high correlation to the kitchen layout. These kinds of rules are embedded into the knowledge base.

In the next step, the customer describes the image (Kansei) that he has regarding the kitchen. This image will determine the design style of the kitchen. Additionally, the cupboard design, cabinets, wallpaper, and color are also determined.

7.3.3 Virtual Reality

When the computer has determined the design of the custom kitchen, the images are sent to the virtual reality system. By putting on the HMD and the data glove, customers can blend into the computer image. They can move around freely in the system, touch the desired areas, turn on the faucet located at the sink to run water, and check the height of the countertop beside the sink by doing some cutting. They can even open the upper cabinet doors to confirm the cabinet height.

With virtual Kansei engineering, by virtually experiencing everything inside the simulation of our own image, we can confirm the compatibility of our own Kansei product and its usability by direct experience. It is a technology in which the customers participate in the design process to directly achieve their own satisfaction. Such a system that realizes customer satisfaction in combination with virtual reality will probably become standard in future product development.

MEW has recently developed a system where the whole family can share and enjoy the virtual reality. In conventional virtual reality, the simulated experience was not possible without putting on the HMD and data glove. Therefore, only one person at a time could experience it. However, for cases that involve the whole family, like custom kitchen and house design, the design satisfaction through the participation of all members is essential. Based on this point of view, MEW has developed a system that enables many people to participate in one virtual reality. This technology can genuinely be called a participatory design system.

7.4 The Evolution of Virtual Kansei Engineering

Virtual Kansei engineering is being positioned as Kansei engineering Type IV. I can imagine how this new technology can be applied and how it will evolve in various industries. The following applications and evolutions are considerations.

7.4.1 Fields Where Trial Products Are Either Expensive or Require a Long Design Time

The original intention of using virtual reality was to try an actual simulation on a computer to study its competency. It is about building a virtual world such as outer space, an ocean bed, a body's interior, or a town that is going to be designed and built, and examining various issues inside those virtual worlds.

In the field of Kansei engineering, it would be very expensive to actually build a house and conduct testing and studies. Additionally, it is not easy to modify something on an actual building. However, building images in a computer is possible if we are willing to invest some time. As described earlier, since we can execute our own actions, such as opening and closing a door in the virtual world, it is worthwhile to consider virtual reality technology.

House design, custom kitchens, and others mentioned earlier are fields that could utilize this technology in the future. From our viewpoint, since we have already completed the HULIS for housing, it won't be that difficult. Additionally, this technology can also be utilized for passenger car exterior and interior design.

The R&D personnel could go into the virtual world, open a car door, settle into the seat, and check the interior design by touching the steering wheel, audio equipment, and so on, or even check the speed and maneuverability by actually turning on the engine. All these capabilities could be realized in the near future.

Virtual Kansei engineering is also expected to be used in town planning or landscape design, as well as in examining the exterior and interior design of buildings.

7.4.2 Customer Decision-Making

As something that provides a realistic sensory experience in addition to the existing Kansei engineering, virtual Kansei engineering can be utilized as a decision support system to assist customers in product selection.

For example, we could upgrade the FAIMS and develop a Kansei engineering system for a three-dimensional view of fashion. Then, we could input the customer's Kansei to enable the system to display the corresponding image. Another camera could be used to recognize the characteristics of a customer's face. The system could perform biometric calculations, and the customer could put on a dress newly designed according to her image. She can see herself in a three-dimensional space. Any actions she takes would appear in the virtual world. An appearance check can be performed by using this technique as well.

The system that will be described here is not an authentic virtual reality, but we can still use it. For a passenger car, the exterior and interior images could be loaded into a laptop computer, and the salesperson could bring the computer to the customer's home and show the images to all the family members. Using the walk-through technique, they can view the appearance and interior of the cars. This is a tool that can be used in decision-making.

From this point of view, it is possible to build a system to display virtual reality in a portable computer by using Kansei engineering. In the near future, perhaps it will be a trend for salespeople to carry laptop computers loaded with databases. At each customer's home, the salesman would identify the customer's Kansei and input them into the computer. Images would then be displayed, and the customer would be asked to walk through the images and confirm the product. I can imagine such a scenario, and I believe that this one, too, will be realized in the near future.

7.4.3 Education and Training

In the operation of large-scale systems like chemical plants and power plants, a network of advanced systems such as artificial intelligence is set up to help control the system in serving its purpose. However, the operations are being performed by humans, who are sometimes unable to keep pace with technology. Thus, there is a risk of human error. The effects of such error could be massive due to the size of the plant.

When we studied the causes of human error, we found that there are two big factors involved in humans: One is the human's cognition problem, and the other is the emotion problem. As for the former, the larger the scale of the system, the more knowledge and skill required for operation. This cannot be fully covered with specialized training. The possibility of encountering unusual situations during training is minimal. The hidden portion is huge, and this leads to human error due to lack of cognition.

For the latter, emotion, the system is even strengthened intellectually by including artificial intelligence, as the operators are still human. The sudden change of situation would affect the emotion of the operator, causing an emotionally stressed operator to perform incorrect operations, resulting in a human error.

Either way, cognition and emotion are the two primary sources of human error, especially in a large-scale system. In considering these two points in Kansei engineering, and by combining them with virtual reality technology, it is possible to utilize virtual Kansei engineering in developing human error prevention training. This Kansei engineering technique can also be utilized as a diagnosis system for human error occurrence by incorporating it into the large-scale system.

We conducted joint research with a power company for utilizing virtual Kansei engineering for nuclear power plant operating system training. We built an expert system on the emergency procedure guides, and in that system we included a human model that can differentiate and recognize human error occurrences as either cognition or emotion. On the other hand, for virtual reality, in order to enable the power plant operation, we built a three-dimensional panel using images, and the operators can virtually touch the panel.

Then, we simulate an abnormal situation, and the operator will perform the appropriate operation. The human model based on Kansei engineering will analyze the movement and guide the operator to take the appropriate action. Whenever necessary, the reactor condition and auxiliary equipment condition are shown as images in a window to enhance the operator's understanding. In this manner, it is possible to give the operators training that combines the operation and the simulation of an actual situation. Kansei engineering is one kind of human model, and it is also possible to use it as an education and training model.