The Theory of Intelligent Design Decision Making Model on Human-Apparel System Design

Cheng-fang Lai

Institute of Textiles and Clothing Design, University of Fu Jen Catholic University, Taiwan, ROC

Summary

This essay emphasizes on integrating strategic and systemic approach into fashion product design. Intelligent Design Decision-Making（Abbreviated as IDD） Model created by the author has characterized by combining Design Praxeology, Strategic Decision-Making Theory, as well as Cybernetic Feed-back Theory to become a new technique of self-organizing, problem-solving and opportunity-oriented method. IDD Model is an eight-step systemic decision-making procedure to assist system engineers to solve the human factors problems effectively and make more precise and reliable decision than any traditional method. IDD Model, by applying CAEA&D technique, has rapid and automatic functions; it, also by employing Human Factors Lab work, has tendency to produce quantitative and precise decision values. Consequently, IDD Model will be a crucial tool to promote Human-Apparel System Design into a scientific, computerized and automatic era.

Key words:
design praxeology, human-apparel system, strategic decision-making, modeling methodology

1. Introduction

The development of human-apparel system has evolved from apparel-oriented to human-oriented, then to the present system-oriented tendency, whose emphasis is dynamic, faultless concept and method. Thus, the study of human-apparel system has diverted from either human-oriented or apparel-oriented to a complicated integration of humanity software, human-apparel interface, apparel hardware, and operational environment.

It is noticed that the studies of anthropometry, biological mechanics, experimental psychology, and human-factor engineering are drawing more attention, but a strategic integrated system aiming at fashion product design decision-making is still few and far between. Most well-known methods tend to be independent or unsystematic, and require some intuitive approach [1], called as Black Box Process [2], to help in fashion product design decision-making.

This kind of intuitive approach shows low reliability and accuracy for immediate efficiency, and, for long-term efficiency, it demonstrates none of the systematic, scientific, and automatic quality in decision-making. Therefore, it involves the investment of tremendous time, manpower, and resource, and creates difficulty for the control of cost efficiency. In view of this, the author launched into the study of a strategic integrated system aiming at solving the complicated human relevant problems encountered in the process of fashion product designing.

2. The Theoretical Analysis of IDD

The author derives this new IDD concept from Kotarbinski's Praxeological Theory, Bertalanffy's General System Theory, Wiener's Cybernetics, and other scholars' system theories and design praxeological theories, and combines the concepts of their dynamic relevant systems and the technology of design praxeology. Theoretically, the framework of IDD explains the concrete structure of a design problem in the form of dynamic system and uses strategic system control as its means to search for the solution of design problem. This means-end relation is proved to be the optimized theory of action, as well as the important basis for rationalization and systemization of design in Wojciech Gasparski's book [3]. From the afore-said, it is known that IDD virtually consists of three main parts: (1). Analysis of systematic praxeology: this emphasizes design perception as the precondition for problem-solving,

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and explains the entity or phenomenon of the problem's attributes by means of systematic praxeology. (2). Analysis of strategic feedback control: this analysis uses the dynamic optimization of multiple objects to solve the consequential decision-making problems. (3). Integrated decision-making procedure: this studies the approaches which use integrated procedure to search for design decision value.

2.1. The Analysis of Systematic Praxeology

Systematic Praxeology uses systematic theory to explain the design action and design approach in praxeology. Basically, if the human-apparel system in a career is problem solving oriented, the action model of its problem-solving is systematic dynamic. If we treat design action as a dynamic system, the action state of the system will vary with time. The main elements of this system are (1) Input (2) Output (3) Change Mechanism (4) Feedback (5) Agent (6) System Environment. The decision-making procedure from the input of factor thru the output of result is the dynamic model of the system. (see Fig. 1)

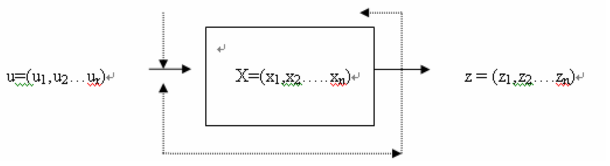

Fig. 1 The Basic Elements of the System

In Fig. 1, Input U = (Ul, U2...Ur), Output Z = (Z1, Z2,...Zm), and State Variable X = (X1, X2...Xn). They are all expressed in quantitative forms. Designer has to go thru the procedure from Change Mechanism to Agent in order to get Output Z for Input U. The system State Variable X = (X1, X2...Xn) is the Variable combination between U and Z, and the value of n is the dimension of the system. A system with n dimension has n Variables. For the variable combination only the design which uses Input U can decide Output Z.

Basically, the state of a dynamic sys tem at (t + dt) is related to the state of t and the Input at the time (t + dt). That's why a dynamic system is often considered as a significant memory, and the state (or Output) at certain time can not be predicted based on the Input alone. While analyzing a dynamic system, it is important to understand the system stability [4].

An unstablized system can produce an Output which grows with time. Any minor disturbance to System State may result in boundless growth, even system breakdown. Therefore, a stabalized system must be able to produce restrained reaction against a restrained Input. From the praxeological theory, the designer must have the ability to stablize the system in order to reach the objective of the design action or to maintain the desired level. To enable easier understanding of the afore-said systematic praxeology, we can analyze it by dividing design actions into a three-level biearchy. (See Fig. 2) [5,6]

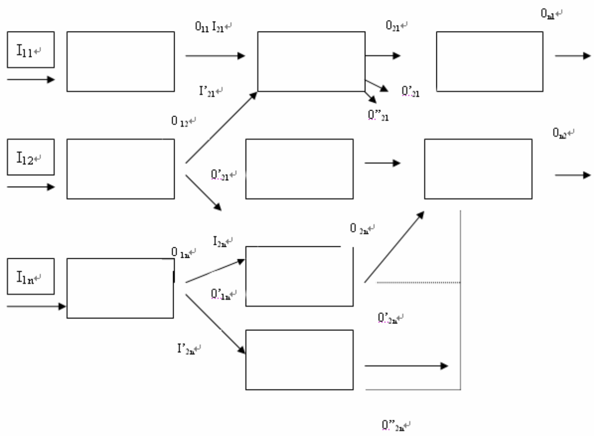

Fig. 2 The Hierarchy of Systematic Praxeology

To analyze systematic praxeology, the hierarchy demonstrated in Fig. 2 can be adopted. Analysis Level One emphasizes "WHAT" the system wants to execute and accomplish, not "HOW" to accomplish it; it is objective-oriented, not direction-oriented. It also emphasizes that any transfer of an Input into Output should be taken as part of the system. Analysis Level Two divides the system into sequential sub-systems. In practice, the subsystems in the second level have much interaction. The input-output relation of each sub-system can be expressed as: Il + i = O1

Therefore, the Input of a sub-system is the Output of its proceeding sub-system. This re-stresses that any change must originate from one of the sub-systems. The total of sub-systems constitutes the whole system, and not any sub-system executes same function as another sub-system. Expressed in mathematic formula, O1 = T (I1). T1 (X) denotes that Input X is transferred by the function of Sub-system i. In another word, the Output from Sub-system i is the result of the Input from Sub-system i and the specific Function T1 which executes sub-system i. Analysis Level 3 decomposes every sub-system into possible answers. Sub-systems in Level 3 may have sub-organized answer combination, but the integrated answer may be the optimal result. Therefore, if the third level of a system is complicated, and the analyses of Level 1 and Level 2 can not be proceeded, there could be tremendous number of answers, which will be difficult to be combined to obtain the most appropriate answer to fulfill the system's objective. Therefore, the analysis of systematic praxeology should start from the initial level, and proceed level by level in order to avoid the risk of premature access to details.

2.2 The Analysis of Strategic Feedback Control

Hubel and Lussow [7] simplified the procedure of design decision-making into five steps: (1). knowing the problem, (2). developing possible solutions, (3). evaluating possible solutions, (4) decision-making - the optimal solution, (5). revising and modifying the solution. The decision-making procedure is the searching for optimal design. Jones (1980) [8] concluded that the design strategy is linear or parallel decision cycle. Therefore, a designer must know and master strategic feedback control in order to improve working efficiency (to propose the most efficient solution in limited time) and to prevent from superfluous decision cycle. Strategic feedback control can be regarded as a three-step feedback control system. Strategy controller uses the result of system feedback for the revision of strategic decision, which constitutes the continual interaction between the planning and the execution of design that makes the design planning be projected according to the outcome of the execution, while the execution outcome of the design also influences (or reflects) design planning. Fig. 3 illustrates the basic theory of this concept.

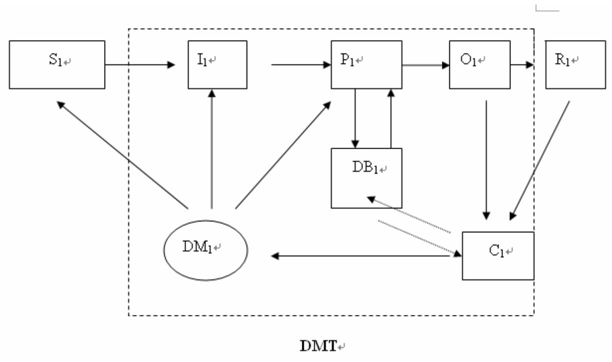

Fig. 3 The Basic Structure of Strategic Feedback Control

DMi is the No. i Decision unit of Design Decision-maker DMT. Ei is the Environment Factor relevant to the No. i Decision unit, Si is Input or Applicable Resource, R, is Output or Outcome, Ii is the Detector of the design decision-maker, Pi is the option of feasible strategy, DBi is Memory, Oi is the execution of the design decision-maker, and Ci is the revised or renovated strategy recombined according to execution outcome so as to help Design Decision-maker adopt to the variation of unpredictable external Environment Factor Ej more efficiently.

According to the structure of Strategic Feedback Control, Design decision-maker not only can use systematic approach to introduce the analysis of symptoms [9] as emphasizing the problem itself, but also can lead Problem to be converted into Opportunities [10], as illustrated in Fig. 4.

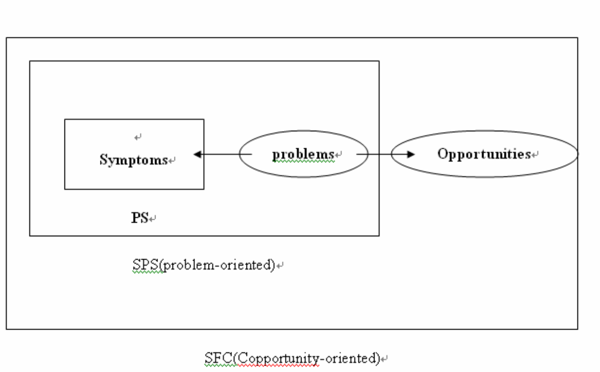

Fig. 4. The Objective of Strategic Feedback Control

2.3 The Analysis of Integrated Decision-making

In a career where the design of human-apparel system is problem solving oriented, the action model for problem-solving is basically a systematic dynamical model; that is to input Problem into Change Mechanism to go through certain revision and combination procedure in order to output Solution. Therefore, the systematic dynamical model can be regarded as a design procedure model. The decision-making procedure of IDD is also a dynamic system, the same as normal system models. Because of the successive circulation of the feedback control (Jones calls this design strategy Cyclic Strategy), the procedure where the Input Factor (material, energy, or information) is processed by Change Mechanism to be transferred into Output, and some Input being fed back as Input (some feedback that has no relation with the system environment is called Direct Feedback; some that enters system environment, goes through change and adjustment, and returns to Input is called Indirect Feedback), also happens in the feedback circuit [11] inside the system until desired or suitable output is obtained. Therefore, the concept of IDD decision-making procedure is the cycling dynamic operation. In procedure, the Change Mechanism between Input and Output is the integration of (Design Opportunity) Do, (Design Transfer) Dt, (Strategic Solution) Ds, (Design Evaluation) De, and (Design Supporting Sub-systems) PSS1, PSS2, PSS3, PSS4, PSS5. In practice, a step in any stage (i.e. each small square in Fig. 5) has the ability to solve problems independently. And when all steps axe integrated, it also has the ability to solve problems. The other characteristic of IDP is that the step of decision-making procedure can reach the most appropriate step by means of DSS2 (Strategy Controlled Decision). In another word, when IDD is adopted, a designer doesn't have to go all design problems through the detailed steps stated afore in order to solve them (to obtain strategic solution). Some simple design problems can obtain suitable strategic solution without going thru every step. Famous methodologists like Jones [12], Owen [13] consider this optimal self-organizing design system the most efficient and timely method. The execution of IDD steps and the function of Design Supporting Sub-systems can be further explicated as the following:

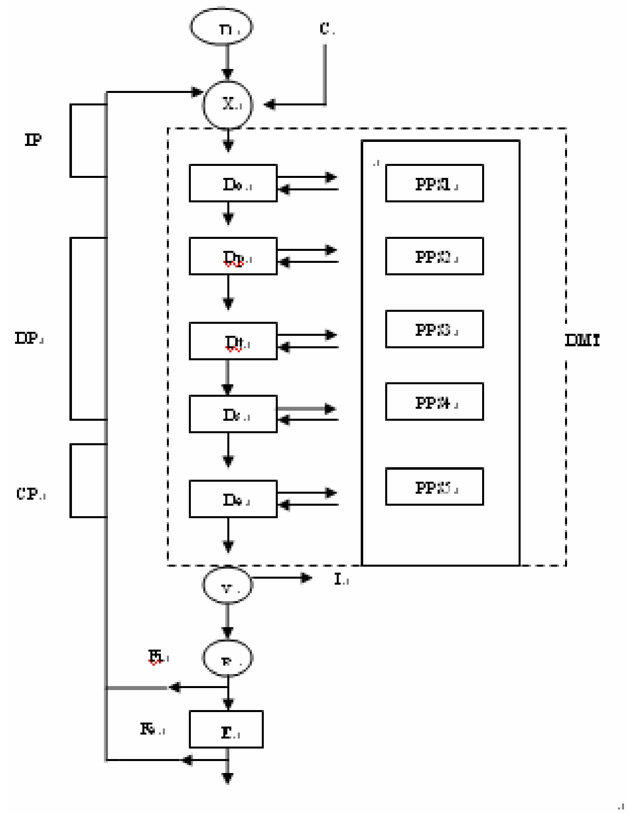

Fig.5 The decision-making procedure of IDD

2-3-1 Input (D)

A system that wants to obtain an desired effect must input an desired variable; this is called Decision (D) Input. However, not all Inputs are desired Inputs. Some Inputs that are disturbing factors from Context have nothing to do with the purpose of the system, and will reduce the operation and efficiency of the system when input into the Change Mechanism of the system. These Inputs are called Context (C) Input.

2-3-2 Output (R)

When the result of a system obtains desired or relevant Output, it can enter the system in next stage (production system). However, not all Outputs are desired ones. Those that do not achieve or do not fit purpose are called Incidental (I) Output. When Outputs are revised or cycled inside the system as new Inputs, they are called the Input of Intrinsic Internal Feedback (Fi); when Outputs are revised or cycled under external environment as new Inputs, they are called the Input of Extrinsic Feedback (Fe).

2-3-3 Design Opportunity (Do)

The stage of Do is the seeking and interpretation of design situation. It includes Objective and Restriction, the seeking of Problem and Requirement, the explaining of problems, and the defining of problems. It not only analyzes symptoms and identifies the nature of problems, but also converts problems into design opportunities.

2-3-4 Design Procedure (Dp)

During Dp State, analytic methods are used for the observation and understanding of existing real system, the characteristic being actually or imaginatively decomposing the whole into small parts or basic elements; then synthetic methods are used to derive design criteria and to create feasible ideal system from the analysis result. Analytic methods provide desired proofs, while synthetic methods lead creativity and aspiration into desired direction. Dp is composed by problem analysis, simulation analysis, need analysis, operation analysis, human-apparel function analysis, variable criteria analysis, policy establishment, criteria establishment, and the establishment of possible solution rules (principle solution). The analysis and synthesis procedure of Dp has iterative nature.

2-3-5 Design Transfer (Dt)

Dt is the stage where high-levelled creativity combines with rational decision-making [14], its characteristic being that Dt is converted into the combination of divergence and convergence when design action has enough divergence [15].

2-3-6 Strategic Decision (Ds)

Ds is to decide the most achievable strategy among feasible strategies. Ds is often influenced by decision-maker and decision situation. Therefore, Ds is the stage to choose the most rewarding, most desired design proposal (or the design proposal that fits most decision criteria) 1, 2, . . .n , according to the decision-maker's mission and objective, and the change in internal/ external environment and technology.

2-3-7 Design Evaluation (De)

De is the finalization, the qualification, and the evaluation of the new system's application. The Quantitative Attributes of human-apparel system design consist of hman (the physical, the physiological, sense criteria), apparel (material, function), environment (immediate environment and surrounding environment), interface (human-apparel, human-working space, human-environment), and economical attributes. The Qualitative Attributes contain user's behavior, need, and fondness, as well as behavioral, social, and cultural factors. In order to achieve the purpose of Convergence [16], De's coordination with PSS3, PSS4, and PSS5 can enhance the effect and efficiency of its execution.

2-3-8 Design Praxeological Supporting Sub-system PSS1

PSS1 establishes design relevant information database (including filed information from all stages), material (hardware and raw material), and energy (manpower and drive power) To make PSS1 easier to understand, hierarchic structure is the most visualized. Its ranking and subordinating of PSS1 structural factors is effective and efficient to help decision-making in each stage.

2-3-9 PSS2

PSS2 includes internal and external feed-back control, strategic decision-making, and strategy control. Feedback control aims at input/output control, strategic decision-making supports the control in Ds Stage, while strategy control points to procedure control, so as to decide on the following strategies: linear strategy, branching strategy, adaptive strategy, incremental strategy, cyclic strategy, or random strategy. Therefore, PSS2 strategic control decision-making is a self-organizing design system. Its overall evaluation according to the relation of external criteria and the partial result of Strategy itself has the characteristic of dynamic self-organizing strategy.

2-3-10 PSS3

PSS3 is human-apparel relevant descriptive study, experimental study, or evaluative study. The purpose of descriptive study is to generate basic data to describe the attributes of specific people (users). Optional variables are criteria variables (CVs) and subordinate variables (SVs). The purpose of experimental study is to test the effect of some variables on human behaviors. The tester operates one or more variables (Independent variables) to evaluate the effect of behavior (derived variables DVs), while other variables are controlled (controlled variables CVs). The purpose of evaluative study is to evaluate the effect of product or system. The evaluation criteria include (1) system-describing criteria, (2) operation-executing criteria, and (3) humanity criteria. In Dp, Dt, and De Stages, PSS3 exerts supporting effect to solve human-apparel problems, and decides the general strategy for the proceeding of PSS3, as illustrated in Fig. 6.

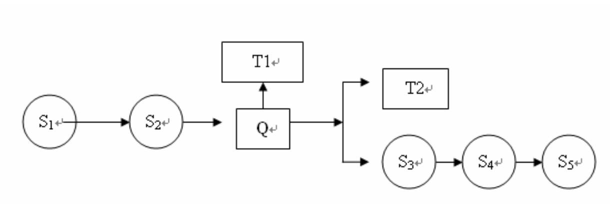

Fig. 6 The general strategy that solves human-apparel Problem with PSS3

The first stage (SI) is to test if the product system and utilization feature are acceptable to humanity function. The second stage (S2) is to specialize any humanity factor. Q is to judge against criteria. If there is no conflict against criteria, the option is T1, and the design continues to develop; if conflict exists and the fitness is absolutely none, then the option is T2 and the design should return to the initial stage (DO) to revise the objective; if conflict exists with no proper human factor for application, then Stage 3 (S3) is entered to develop strategy to solve human-apparel problem. Stage 4 (S4) is human-apparel relevant study (descriptive study, experimental study, or evaluative study). Stage 5 (S5) is the evaluation of result and the extension of application to actual situation, which is the purpose of PSS3.

2-3-11 PSS4

PSS4 uses computer to simulate the analysis and the design of human-apparel system. The computer simulation of human-apparel system (CAEA & D) has been developed for thirty years. The Landing Signal Officer developed by Boeing Co. may be the pioneer of computer's simulation of human's physical activity [17]. PSS4 uses computer science to provide fashion product designer with various computerized Human Model to help human-apparel interface study. At present five programs are in popular use: (1) Cyberman, developed by Crysler Co., (2) Combiman, by NASA (3) Sammie, developed by Nottingham University, U.S.A., and commercialized by Compeda Co., (4) Boeman, by Boeing Co., and (5) Buford, by Reckwell International Co., California, U.S.A. [18]. Because of the improvement of Personal Computer's function, Biomechanics in U.S.A. developed Ergobase simulant program and database [19] in 1988. There are also stimulant computer programs of human-apparel system in the academic design field of Taiwan. For instance, foot-cast simulant program [21], developed by Professor Chan Chien-fu of National Cheng Kung University in 1988. Though PSS4 can make use of existing simulant software, the special situation of human-apparel system has made it necessary to adopt specially designed program for computer simulation. This is also the characteristic of IDD PSS4.

2-3-12 PSS5

PSS5 is meant for the establishment and utilization of rule-based professional system. The most famous rule-based professional system of modern time is the HPP of Stanford University in 1974. Rychener's research in 1985 [22] also points out that professional system has wide potential in solving design problems. At present, accessible product-design relevant professional systems include (1) the original professional system in Lisp language, developed by Kinoglu, Riley, and Donath [23], (2) the professional system developed by Oxman and Gero [24], (3) the professional system in symbolic logics, developed by Kim and Suh [25], (4) the professional system which uses external design to support procedure, developed by Chang, Lin, and Leonard , and (5) the professional system OWTS, developed by Professor Chan Chien-fu [26] with PCPLUS. The characteristic of PSS5 is the development of good professional system, the ability to make judgement (almost) as accurately as anthropologist, and the source of the knowledge being the experience of mankind. IDD's PSS5 provides the feasibility of design's introduction and programization, its purpose being the establishment of the knowledge base of experience rule. The ideal professional system of product design is the one that simulates experience and the real knowledge of anthropologist in order to solve the problems encountered in product designing

3. Conclusion

From this research article we can find that every step in IDD is very trivial and delicate. But triviality and delicacy are the requisite for accurate decision value. IDD will not be necessary for solving simple problems, but it will be a sharp weapon against complicated problems. All in all, IDD is not only an integration of basic science, but also, in fashion product design, an effective method for the study of human-apparel system by applying scientific data. It is the author's sincere hope that the outcome of this article can expedite the union of the experience of human-factor engineers, psychologists, project engineers, fashion product designers, value engineers, and style engineers to create higher-leveled product, so as to promote the position of human engineering and fashion product design in Taiwan as well as offshore, thus, to improve the life quality in our society.

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Cheng-fang Lai received the B.A degree in international management from the University of Chong Jong at Tainan in 2005. Currently, she is working toward the M.A degree and also serves as a research assistant at textiles and clothing design institute in Fu Jen Catholic University. Her academic interests include computer aided apparel design. design support system, fashion design and human-apparel interaction.