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A Survey of Product Design based Kansei Engineering

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Abstract: *With the escalating demand for personalized products and emotional experiences among consumers, Kansei Engineering has emerged as a core product design methodology centered on emotion quantification-design mapping. Based on 612 valid literatures selected from the Web of Science Core Collection spanning 1978 to 2025, this paper systematically reviews the research progress in this field: it combs through the three-stage evolutionary context (Germination Period, Volatile Development Period, and Boom Period), presents the global research landscape with China, Japan, and South Korea as the core and multi-faceted participation from Europe and America, and identifies four core research themes: basic theories, technological innovation, industrial applications, and user services. At the application level, it focuses on elaborating the integration paths of Kansei Engineering with technologies such as deep learning, genetic algorithms, and text mining, as well as its practical applications in product scenarios including algorithm-driven design, data-driven automated design, and product semantic design, along with service optimization, cross-border e-commerce logistics, social robots, and hybrid vehicle design. Future research needs to strengthen the exploration of cross-cultural emotional needs, promote the in-depth integration of advanced technologies with traditional design concepts, and explore the immersive applications of virtual reality/augmented reality (VR/AR), so as to help create innovative products with stronger emotional resonance and market competitiveness*

Key Word*: Kansei Engineering; Web of Science; Survey; Citelnsight.*

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I. Introduction

As modern consumers increasingly demand diversified and personalized products, product design has evolved from merely fulfilling functional needs to prioritizing emotional engagement. This shift has given rise to Kansei Engineering. This field focuses on capturing and understanding users' emotional responses to products, integrating these emotional elements into design processes to create user experiences that resonate emotionally.

Numerous studies demonstrate how Kansei Engineering integrates with technologies like deep learning, genetic algorithms, and neural network models, unlocking groundbreaking innovation in product design. For example, extracting emotional patterns from online product reviews or analyzing consumer reactions through deep learning methods enables designers to better understand users' emotional needs, thereby shaping more emotionally resonant product designs.

Moreover, Kansei Engineering is widely applied across various sectors, from industrial machinery to home delivery services. This trend stems not only from the growing consumer demand for emotional experiences but also from its ability to significantly enhance product market competitiveness, enabling businesses to better meet user needs.

However, Kansei Engineering is not without challenges. How to accurately capture and understand the emotions of users, how to effectively integrate these emotional factors into the design, and how to ensure the perfect combination of emotional design and function are the hot and difficult issues in current research.

This paper provides a comprehensive review of recent advancements in product design and Kansei Engineering, with a focus on exploring the application of various technologies and methodologies in product design along with their strengths and limitations. Through in-depth analysis of these studies, we aim to offer readers a thorough understanding while providing valuable references for future research and practical applications. In the following sections, we will detail different Kansei Engineering approaches and technologies, analyzing their effectiveness and value across various application scenarios.

II. A survey of publications on Kansei Engineerings

2.1Kansei Engineering Concept

Kansei Engineering, proposed by Japanese scholar Masaaki Nagatani in the 1970s, is a product design methodology centered on human emotional experiences[56]. Its core concept involves quantifying users' subjective perceptions of products into analyzable data, then establishing mapping relationships between emotional vocabulary and design elements through statistical modeling to achieve the integration of emotion and engineering. The approach typically includes steps such as emotional vocabulary extraction, design variable definition, user evaluation experiments, data analysis, and model validation, often employing techniques like semantic difference scales, factor analysis, partial least squares regression, and machine learning. Widely applied in automotive, consumer electronics, packaging, interface, and spatial design, Kansei Engineering enhances product emotional resonance and brand value. Its strengths lie in scientifically translating ambiguous emotional needs into quantifiable design decisions, though it also faces challenges like cultural differences, sample bias, and limited model extrapolability. Fundamentally rooted in a "human-centered" design philosophy, Kansei Engineering drives the transformation of product design from function-oriented to emotion-oriented approaches, reflecting the contemporary trend of integrating scientific rationality with humanistic sensibility in design.

2.2Publication status of Kansei Engineering research

2.2.1 literature reference

The literature data for this study was sourced from the Web of Science Core Collection, which includes three sub-databases: SCI-EXPANDED, SSCI, and A&HCI. The collection covers classic literature and cutting-edge research from Japan, South Korea, Europe, and the United States, spanning from January 1978 to November 2025. The search was conducted using the keyword 'Kansei Engineering' in English, with document types including Articles and Reviews. After screening, 612 valid sample documents were obtained.

2.2.2 Posting trends

The publication trend of the field of Kansei Engineering has developed from long-term silence to fluctuating development and finally entered into explosive growth, reflecting the maturity process of the field from theoretical exploration to technical empowerment and industrial application (Figure 2.1), which can be divided into the following three stages:

The Germination Period (1978–2000): During this phase, publications remained exceptionally low, consistently in single digits or near zero. This indicates that Kansei Engineering had not yet gained widespread academic attention, remaining in the conceptual proposal and preliminary exploration stage. It also shows that after Japanese scholar Masaaki Nagata proposed the theory in the 1970s, research efforts were limited to a narrow scope.

The Volatile Development Period (2000–2018): Academic publications showed a gradual upward trend with notable fluctuations. Two minor peaks emerged between 2004 and 2010, followed by a decline around 2010. After 2010, the volume entered a fluctuating upward trajectory, reaching approximately 25 papers per year by 2018. This phase reflected the growing recognition of Kansei Engineering in academia, though research momentum remained constrained by technological advancements and expanding application scenarios, failing to achieve sustained explosive growth.

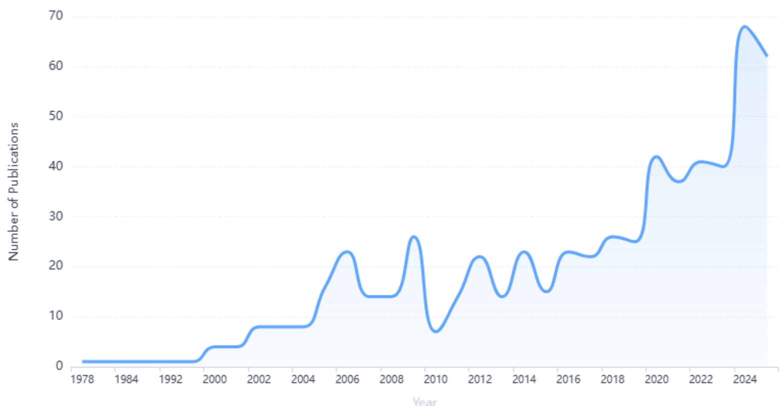

Figure 2.1: Publication trends of Kansei Engineering

The Boom Period (2018-present): The number of publications experienced a steep growth surge, surpassing 60 articles after 2024 and continuing to climb. This phase's explosive growth was primarily driven by two key factors: Technologically, the integration of AI technologies like machine learning and deep learning with affective engineering significantly enhanced the efficiency of quantifying emotional needs and mapping design elements. Practically, the trend of product design shifting toward "emotional experiences" has fueled a surge in demand for research and practical applications of affective engineering across industries including manufacturing, services, and cross-border e-commerce.

2.2.3 Author information

After literature screening and inspection, there are 1363 core authors in the field of Kansei Engineering, which can be divided into three periods according to the development stage and research contribution of the discipline:

The foundation period of the discipline (1970s-1990s): led by Japanese scholars, the theoretical system was initially established

The pioneering figure in this phase was Sankyo Nagatake, who first introduced the concept of "Kansei Engineering" in 1970. By quantifying users' emotional needs and translating them into product design parameters, he laid the theoretical foundation for this discipline. His research focused on emotional design in automotive and residential fields, with seminal papers like "Kansei Engineering and New Product Development" and "Sensory Product Science" establishing his reputation as one of the most cited scholars in the field.

At this time, the authors of the papers were highly concentrated in Hiroshima University and other institutions in Japan, and the research had a strong industrial orientation, which established the core logic of emotional quantification and design transformation for the subsequent development of the discipline.

Expansion period (2000-2018): Scholars from multiple regions participated, and research methods diversified

The application scenarios of Kansei Engineering have expanded from industrial design to service and e-commerce sectors, demonstrating a Japanese core with global diffusion characteristics. Japanese scholars form the core force: Taiyuki Arai focuses on Texture Kansei Engineering, introducing sensory analysis into food design to expand disciplinary boundaries; Sanso Nagachi continues existing theoretical frameworks, deepening applications in automotive interiors and human-computer interaction. Korean and Western scholars are gradually gaining momentum: Korean researchers Kang YH and Uranues C. delve into automotive styling and user experience studies, while Western scholars integrate Kansei Engineering with emotional design theories to promote interdisciplinary development. In China, researchers like Li Zhi from Guangdong University of Technology explore its integration with artificial intelligence and blockchain to inject technological innovation. During this period, the number of authors increased significantly, narrowing the gap in publication volume among top researchers, reflecting the diversification of research groups and the trend of decentralized research directions (Figure 2.2).

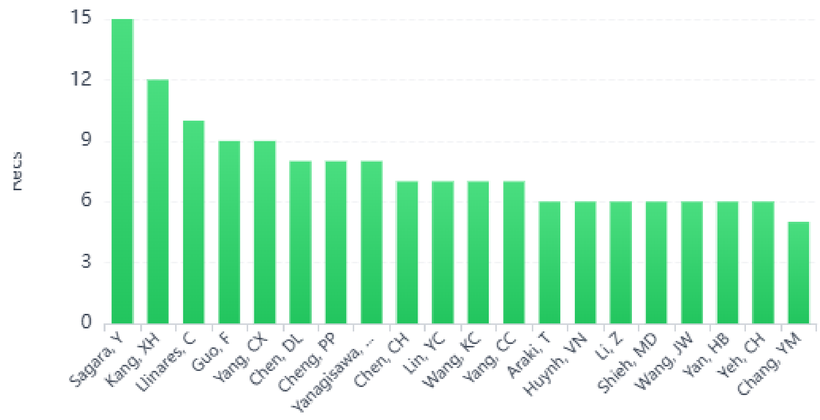

Figure 2.2: Publication authors of Kansei Engineering

Rapid Growth Period (2018-present): Global collaboration accelerates, with interdisciplinary authors emerging

In recent years, affective engineering has deeply integrated with machine learning and big data, with the scale of publications and cross-disciplinary collaboration showing explosive growth. Technology-driven scholars such as Anaki T and Hyunh VN focus on the application of deep learning in emotional quantification, optimizing the mapping efficiency of affective vocabulary and design elements. Interdisciplinary teams from the University of Tokyo and Keio University have combined neural networks to develop affective design systems, advancing intelligent research. The proportion of publications by scholars from China, South Korea, and Europe has significantly increased, with Li Zhi's team in China emerging as a new growth pole in the field of affective engineering + intelligent manufacturing. In 2018, the author community experienced explosive expansion, narrowing the gap between top and mid-to-lower tier authors, highlighting the innovative vitality of the field. From a single Japanese author group to a global multidisciplinary network, the development of authors has kept pace with disciplinary evolution, and will extend to interdisciplinary and industrial sectors in the future, driving paradigm upgrades.

2.2.4 Issuing country and organization

The sample data involves 44 countries related to affective design research (see Figure 2.3), with a distribution pattern that is predominantly centered in East Asia, featuring multiple participations from Europe and America, and gradually expanding globally. A clear regional pattern emerges in affective design research: East Asia serves as the absolute core, where China, Japan, and South Korea form a dense research network. China leads in large-scale research volume and cutting-edge fields such as algorithm-driven design and multimodal data fusion, with a total of 347 related papers published, including 77 from Taiwan, ranking first in publication volume. Japan leverages its disciplinary origins to deepen foundational theories in automotive and home appliance affective design, while South Korea focuses on emotional interaction in smart products and builds a collaborative ecosystem. Europe and America participate from multiple points, with Germany, Spain, and the UK emphasizing theoretical exploration, and the United States in North America focusing on cross-cultural research and technological empowerment, forming a complementary pattern. Other regions gradually expand, focusing on local industrial applications. This pattern reflects East Asia's early-mover advantage and the complementary value of Europe and America, with future new scenarios driving research from regional dominance to global collaboration.

In terms of institutional contributions, 514 institutions have conducted research on affective engineering within the literature review scope. National Cheng Kung University leads with 27 publications, followed by East China University of Science and Technology (26), National Cheng Kung University (18), University of Tokyo (17), and Polytechnic University of Valencia (16). This highlights the trend of international collaboration (Figure 2.3).

The institutions are mainly comprehensive and science and engineering universities, with obvious interdisciplinary characteristics. East China University of Science and Technology combines engineering with perceptual engineering + intelligent manufacturing, while the University of Tokyo relies on design and psychology to quantify users' emotional needs. Chinese forestry and science and engineering universities form characteristics in product design, ecological design and other specific scenarios.

The academic landscape reveals a tiered leadership structure: National Cheng Kung University and East China University of Science and Technology form the first tier (≥25 publications), pioneering cutting-edge research; Nanchang University and the University of Tokyo constitute the second tier (12-18 publications), specializing in regional characteristics and international theories; Guizhou University and Keio University belong to the third tier (8-12 publications), driving niche innovations. This framework reflects the integration of East Asian academic traditions with global technological trends, propelling the field's evolution from theoretical exploration to industrial application.

Figure 2.3: National and regional distribution in the field of Kansei Engineering

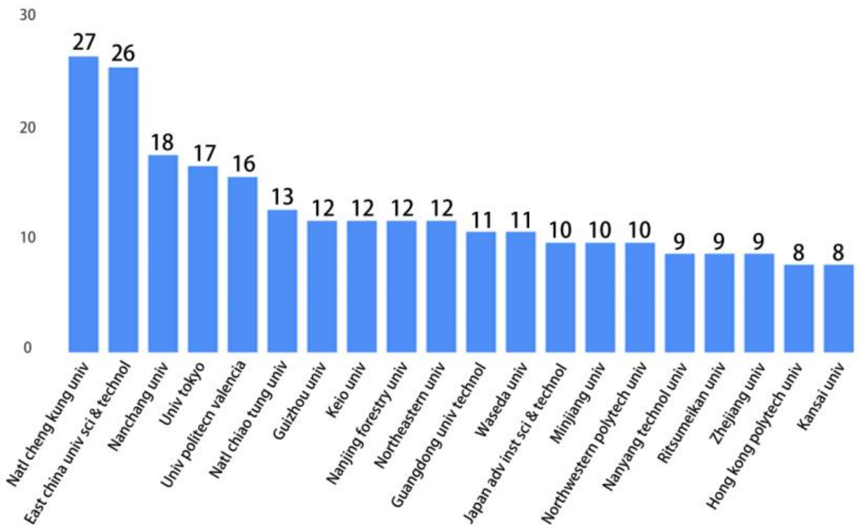

Figure 2.4: Metrology of Research Institutions in Kansei Engineering (Recs)

2.3.The research topic of Kansei Engineering

Kansei Engineering research focuses on capturing the core logic of "sensory needs-technical quantification-scenario implementation" of users, forming four core directions of basic theory, technological innovation, industrial application and user service, constructing a complete academic framework and promoting the evolution of the discipline to the system innovation paradigm (Figure 2.5).

The foundational theory serves as the discipline's cornerstone, focusing on defining, categorizing, and quantifying emotional attributes. By clarifying the dual nature of emotions and refining classification systems, it employs techniques like semantic differentiation, factor analysis, and neural networks to address the challenge of quantifying emotional needs. Technological integration represents the core growth driver, leveraging deep learning, VR/AR, and big data to achieve intelligent emotional analysis, immersive evaluation tools, and precise need identification. This transformation propels the discipline from manual research to AI-driven operations. Industrial applications form the primary implementation scenarios, spanning automotive, consumer electronics, and home furnishings, while expanding to agricultural products, cultural innovation, and medical devices, achieving comprehensive coverage from industrial manufacturing to consumer markets. User services transcend product boundaries by focusing on precise need alignment, exploring diverse cultural emotional preferences, integrating traditional aesthetics, and extending into service scenarios to elevate the entire emotional experience journey (Figure 2.6).

Figure 2.5: Cloud map of research topics in Kansei Engineering

Figure 2.6: Key word cloud of Kansei Engineering

2.4.The disciplinary field of Kansei Engineering and the characteristics of citation network

2.4.1 disciplinary field

The field of Kansei Engineering adopts a three-dimensional framework integrating core carriers, technological support, and multidimensional interdisciplinary integration. Through theoretical convergence and methodological complementarity across disciplines, it evolves from design tools to a systematic innovation paradigm. Engineering serves as the core carrier, with mechanical engineering and manufacturing engineering transforming users' sensory requirements into tangible products, acting as crucial bridges for translating emotional concepts into practical applications (Figure 2.7).

Computer science and material science constitute the dual support of technology: the former uses machine learning to quantify emotions and realize intelligent mapping of design and requirements; the latter excavates the association between materials and emotions and provides material basis.

Cross-disciplinary expansion: Quantifying the connection between human experience and emotion through ergonomics, supporting commercialization with management science, and enabling sustainable design through environmental science. The future requires deeper integration with the metaverse and generative AI, strengthening interdisciplinary collaboration between psychology and sociology, and building a comprehensive ecosystem of technology, design, and humanities.

2.4.2 characteristics of citation network

The citation network of Kansei Engineering intuitively reflects the inheritance of disciplinary theories, technology integration and cross-domain collaboration, and presents four characteristics: basic literature anchoring, core clustering differentiation, regional association imbalance and stage dynamic evolution, which confirms the development trajectory of the discipline from a single technology to an interdisciplinary paradigm.

Basic citations form the core framework of the network by connecting knowledge hubs through seminal literature: Japan's Nagakuchi Sanso's 1995 paper defining the logic of sensory demand-design transformation (over 2,000 citations), the U.S. Osgood's work on semantic differentiation, and China's Luo Shijian's 2007 paper integrating international theories with domestic cases (over 240 citations), which collectively support the expansion of subsequent research.

The core clusters form three major concentric structures: the Japanese cluster, centered on automotive design and human-computer interaction, exhibits high inter-citation rates among corporate literature; the China cluster branches into two subgroups—emotional imagery design and data-driven design; the European cluster, centered on the University of Nottingham in the UK, focuses on industrial mechanical emotional safety design, with inter-cluster connections established through foundational hubs.

The regional association exhibits an imbalanced pattern of East Asia core-global radiation: high-density mutual citations within East Asia, China literature extensively cites Japanese and domestic core literature, with South Korea serving as a regional intermediary; weak connections between East Asia and Europe and America, while other regions rely on core area literature and remain at the periphery of the network, which stems from the divergence between East Asia's early-mover advantage and the focus of European and American research (Figure 2.8).

The evolution of citation networks has undergone three distinct phases: The initial phase (1978-2000) exhibited a linear structure with sparse nodes. The developmental phase (2000s-2018) saw the formation of three clusters encompassing China, Japan, and Europe, though cross-domain citations remained limited. The explosive growth phase (2018-present) transformed the network into a multidimensional structure, incorporating interdisciplinary literature and significantly enhancing cross-regional and cross-disciplinary connections. Collectively, these patterns demonstrate the discipline's evolution from Japan's sole dominance to becoming an East Asia core with global participation, and from engineering-oriented research to multidisciplinary integration. Looking ahead, the network will further dismantle regional barriers to establish a balanced global collaboration framework.

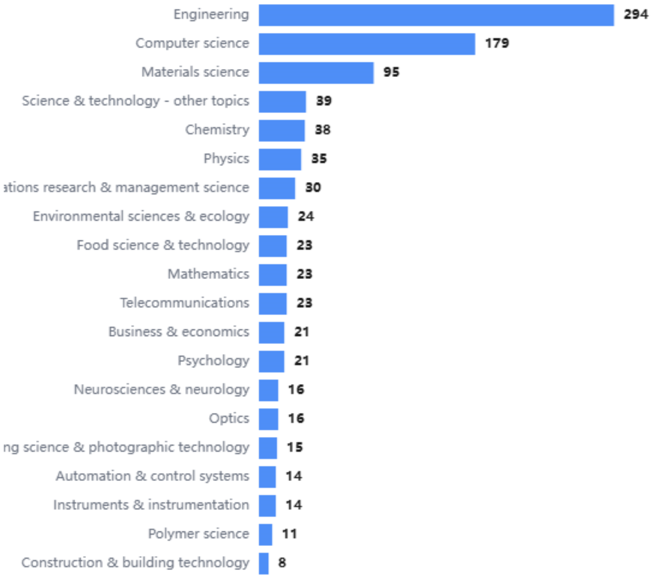

Figure 2.7: Publication of Kansei Engineering-related Articles (Recs) Across Disciplinary Fields

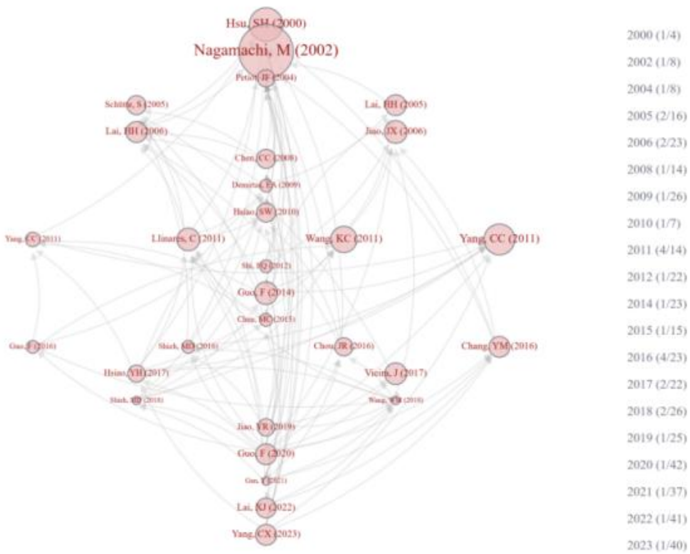

Figure 2.7: Cited network relationships in the study of Kansei Engineering

III. Application of Kansei Engineering in product design

3.1 Algorithm-based product design

Product design is a vital field dedicated to fulfilling consumer needs and expectations. With technological advancements, transforming consumer perceptions and emotions into design elements has become a critical challenge. In highly competitive market environments, companies must deeply understand consumer preferences to create more appealing products. In recent years, algorithm-based product design approaches have gained significant attention. These methods aim to provide designers with more intuitive and accurate design references by computing and simulating consumer cognition and emotions.

The 2005 study[1] primarily focused on the design of rocker switches used in vehicles. This research emphasized how engineering attributes influence users 'perception of rocker switches. The study found that factors such as the switch's neutral position, contact points, shape proportions, and surface characteristics significantly affected users' subjective impressions of its robustness, precision, and design. Additionally, the study validated the temporal consistency of the 7-point rating scale in perceptual engineering.

In 2006, Hh et al.[2] proposed a novel user-centered design methodology that translates user perceptions into product element design. Through experimental research on mobile phones, the study investigated how product form and color individually and collectively influence product image. By employing perceptual engineering and neural networks, the research identified optimal combinations of product form and color, providing designers with a database containing 16,777,216 color options to better create products that meet user needs.

The 2010 paper[3] focused on integrating genetic algorithms with perceptual engineering to analyze product styles, translating consumers' psychological concepts into linguistic variables. The study employed a MATLAB program to simulate consumer reasoning and minimized cognitive dissonance between virtual and physical models through 3D CAD simulations.

By 2018, Hf et al. [4] further explored how to integrate Kansei Engineering with deep learning for product innovation. They proposed a framework that could transfer style images' colors, patterns, and other elements to product shapes in real time. To capture user preferences, the researchers combined Kansei Engineering with backpropagation neural networks to establish a mapping model.

These four papers all highlight the significance of algorithm-based product design, exploring how to translate consumer perceptions and emotions into design elements.[1] focuses on specific product features like the rocker switch design, while[2] examines broader approaches to integrating form and color for design optimization.[3]introduces genetic algorithms to identify optimal product configurations.

Design solutions; while[4] integrates deep learning technology to make product design more intelligent and automated. In general, these studies demonstrate the potential of algorithm-based product design, but each paper has its own unique approach and application field.

3.2 Data-driven automated design

Data-based automated design is a hot research area in recent years. This direction aims to use data-driven methods, such as machine learning

This methodology employs machine learning, text mining, and sentiment engineering to automate or semi-automate product design. It effectively addresses the subjectivity and uncertainty inherent in traditional design processes, delivering more objective, precise, and efficient outcomes. Below is a summary of representative papers in this field:

In 2005, a paper proposed a method based on Grey Relational Analysis to determine the optimal design combination of product form elements that match a given product image[5]. This method primarily investigates the relationship between product form elements and product image.

The system identifies the most impactful elements for a given product image. Experimental studies show that neural network models outperform genetic programming models in performance.

In 2010, Cc et al. introduced Support Vector Regression , an advanced machine learning method, to predict consumers' emotional responses to product form designs[6]. The study employed Real-Coded Genetic Algorithm to determine optimal SVR training parameters, and compared its performance with SVR and Backpropagation Neural Network using 5-fold cross-validation. Experimental results demonstrated that SVR outperformed BPNN.

In 2018, a study developed a case-based approach that integrated text mining and sentiment engineering (KE) to analyze online customer reviews and extract preferences[7]. The model combined text mining with KE to identify key descriptive sentiment terms from real customer feedback, which were then used to predict consumer-preferred product designs.

In 2019, a study explored the feasibility of developing an emotion engineering system based on rough set probability statistics, which could link sentiment analysis from customers with continuously collected online images[8]. The research resulted in a new five-phase emotion engineering process that systematically incorporates user feedback and suggestions throughout all design stages.

In 2020, a study proposed an integrated decision-making system for product image design optimization based on Kansei Engineering experiments[9]. The system first uses a quantitative decision model to predict the product's overall image, then applies a utility optimization model to achieve a multi-objective product image.

In 2023, Zh et al. aimed to improve Kansei Engineering methods to align with the trend of affective design in the big data era[10]. They conducted text data mining on online product reviews, calculated fine-grained emotions, and proposed an innovative Kansei Engineering design process.

From the comprehensive analysis of these papers, it is evident that all studies focus on data-driven approaches to product design. While sharing the common use of machine learning or text mining techniques for data analysis and processing, each paper proposes distinct methodologies and models to address specific design challenges. For instance,[5] employs grey relational analysis, [6] utilizes support vector regression, while [7] and [10] integrate text mining with Kansei Engineering, though their implementation methods differ. [8] and [9] emphasize the integration of Kansei Engineering with product design. Collectively, these studies provide a wealth of theoretical frameworks and practical methods for data-driven automated design, demonstrating the broad application potential in this field.

3.3 Consumer-oriented product development

In product design, Kansei Engineering is a vital methodology that focuses on consumers 'emotional responses and needs. Its core objective is to transform these emotional demands into tangible design elements, thereby creating products that better align with users' emotional expectations. Numerous studies have employed diverse approaches and techniques to explore and understand consumer emotional needs, with researchers actively applying these insights to practical product design.

In a 2003 study, researchers applied Kansei Engineering principles to investigate steering wheel design, exploring how to translate users 'emotional responses into design elements[11]. A 2005 study proposed an Kansei Engineering-based approach for camera design optimization, emphasizing the connection between design and user emotions[12]. The same year, another study used Kansei Engineering methods to examine smartphone form design, investigating the relationship between user preferences and product design[13]. A 2007 research further explored the core concepts of Kansei Engineering, aiming to better understand consumers' emotional needs[14]. In 2009, a study combined

In 2010, researchers integrated Kansei Engineering with rough set theory to develop a novel product design optimization method[15]. Subsequent studies demonstrated the practical value of Kansei Engineering in automotive applications through experimental validation[16]. A landmark paper in 2010 emphasized the critical role of consumer emotional needs in product development, proposing an emotion-engineered optimization framework[17]. The following year's research explored Kansei Engineering's application in web design[18]. In 2012, a groundbreaking study combined Kansei Engineering with fuzzy logic theory to create an innovative design methodology[19]. A 2013 investigation focused on mouse interaction patterns, revealing correlations between product design and user emotional responses[20]. The 2014 research further validated emotion-engineered optimization through empirical testing[21].2015 saw a comprehensive analysis of automotive applications, demonstrating how to translate user emotional demands into design elements[22].2016 introduced a hybrid approach integrating Kansei Engineering with set analysis[23].2017's review highlighted practical implementations of Kansei Engineering in product design, proposing strategies to better satisfy user emotional needs[24]. The 2018 study concluded with an emotion-engineered optimization method validated through empirical research[25]. In 2019, multiple studies explored the application of Kansei Engineering in various fields, including mouse and automotive applications[26,27,28,29,30]. In 2020, a paper proposed an emotion engineering-based product design optimization method and conducted empirical research[31]. In 2022, studies explored the application of emotion engineering in the exterior design of new energy vehicles[32], while another study introduced a virtual reality-based emotion engineering design approach[38]. In 2023, a paper proposed an image generation algorithm-based product design method to meet users' emotional needs[39].

Comparing these papers reveals a common focus on understanding and addressing users 'emotional needs through Kansei Engineering. All studies highlight that product design should better reflect users' emotional expectations to enhance market competitiveness. The key differences lie in the methodologies, technologies, and research subjects employed. For instance, some studies concentrate on automotive or electronic product design, while others explore Kansei Engineering applications in other fields.

3.4 Consumer-perceived product semantic design

In product design, consumer-perceived semantic design represents a crucial research direction. Product semantics explores how to study the symbolic nature of artificial forms within product usage contexts, applying this knowledge to industrial design. Due to its subjective nature, this specific dimension of user needs proves challenging to articulate, quantify, and evaluate. Below is an analysis of several representative papers in this field:

In 2004, Jf proposed a comprehensive approach to evaluate product semantics[40]. This methodology integrates usability testing with classic marketing and decision theory techniques, including multidimensional scaling, semantic differential, factor analysis, pairwise comparisons, and Analytic Hierarchy Process. The integrated framework provides designers with a tool to understand and specify the semantic aspects of requirements, rank new product prototypes based on their proximity to an idealized "perfect product," and identify specific semantic dimensions requiring improvement. To demonstrate the approach, the authors conducted usability tests and applied it to the design of table glass cups.

In 2007, C. et al. employed perceptual engineering to analyze customers 'emotional responses to real estate promotions[41]. This methodology enables identification of key independent attributes that characterize buyers' perceptions of specific properties. By ranking these attributes based on their impact on overall evaluations, we can quantify their relative importance. This approach facilitates the development of quantitative models predicting comprehensive assessments through symbolic attributes. Furthermore, it allows for detailed comparative analysis of the strengths and weaknesses of competing properties.

A 2011 study investigated the relationship between Head-Up Display image design and drivers' emotional responses[42]. The research first employed factor analysis and cluster analysis to identify representative emotional factors from a large semantic space. In the second stage,

In this section, a predictive model was developed using Type 1 quantitative theory to establish the relationship between perceptual factors and Head-Up Display physical image design attributes. Finally, the model's validity and feasibility were evaluated through testing with two commercially available HUD display images.

These three papers share a common focus on understanding and evaluating consumers 'perceptions and emotional responses to products through various methodologies. Each employs distinct approaches and techniques—including factor analysis, semantic differential analysis, and quantitative theory—to achieve their research objectives. The key differences lie in their specialized focuses: the first paper examines how to assess and define semantic components in product design; the second investigates predicting real estate sales success through Kansei Engineering; while the third explores customizing HUD display interfaces based on drivers' emotional and sensory experiences.

3.5 Emotional Design in Multidimensional Variables

In the current fiercely competitive product market, product design has shifted from a product-oriented approach to a market-oriented one, and then gradually towards a customer-oriented approach. Therefore, it is of high necessity to study users' emotional needs triggered by the multidimensional design variables of products. Based on Kansei Engineering, this paper proposes a systematic emotional design method for product hardware interfaces, which can be used to design products that respond to users' emotions. On the basis of representative paired sensory image words and multidimensional key design variables obtained through consumer-oriented technologies, the KE model is established. Finally, the integration of the KE model and genetic algorithm is adopted to find near-optimal design solutions. This method has been effectively validated in mini digital cameras and can be applied to various design cases to optimize product emotional design.

Kansei Engineering transforms consumer perceptions and needs into design elements, while genetic algorithms optimize solutions through systematic search. This synergy enables designers to balance emotional user requirements with practical design feasibility. By integrating paired sensory imagery with multidimensional design parameters, the approach achieves precise identification of emotional needs, thereby providing targeted guidance for product development.

The strength of this approach lies in its dual focus on product functionality and performance while emphasizing how products should address users 'emotional needs. In today's market, merely meeting functional requirements is no longer sufficient to attract consumers; products must also possess emotional value that resonates with them. Therefore, this emotion-driven design methodology, which integrates Kansei Engineering and genetic algorithms, offers designers a fresh perspective for creating products that truly connect with users.

The angle helps them better understand the needs and expectations of users, so as to design more attractive products[43].

3.6 Kansei Engineering in Service

Kansei Engineering in service design focuses on how products and services fulfill and evoke customers' emotional needs. By analyzing how customers perceive and react to products or services, these techniques aim to enhance customer satisfaction and boost the appeal of offerings. Kansei Engineering approaches like the Kanoma model and Kansei Engineering play a pivotal role in product design and service delivery.

A seminal 2008 study [44] introduced a robust design methodology integrating the Kanoma model to optimize combinations of form elements. This approach significantly enhances customer satisfaction while elevating product aesthetics across multi-criteria evaluations. The Kanoma model serves as a powerful tool for mapping performance metrics to customer satisfaction, resolving trade-offs in multi-criteria optimization by identifying key satisfaction drivers. Through systematic analysis using this framework, a weight adjustment process establishes optimal weights for each product criterion to achieve desired satisfaction outcomes. This prioritization mechanism ultimately drives customer satisfaction improvements through strategic standard alignment.

The 2011 paper[45] introduced an integrated framework combining the Kanoma model and Kansei Engineering, applied to service contexts. The Kanoma model was embedded within Ke to demonstrate the relationship between service attribute performance and customer emotional responses.

The kanoma model categorizes service quality attributes into three main types: mandatory [m], one-dimensional [o], and attractive [a]. This study presents a case study involving 100 guests staying at luxury 4-5-star hotels.

When comparing the two papers, both explore how to utilize the Kanoma model to understand and meet customers 'emotional needs. Both emphasize the Kanoma model's role in identifying key criteria and enhancing customer satisfaction. The key difference lies in their focus: the first paper[44] primarily centers on product design, integrating grey relational analysis with Taguchi's methods to optimize subjective quality and multi-criteria characteristics; while the second paper[45] focuses on service delivery, introducing Kansei Engineering to comprehend and fulfill customers' emotional demands. These two studies provide valuable insights into applying similar methodologies across different contexts (product design and service provision) to improve customer satisfaction.

3.7 Sentiment mining of online product reviews

Sentiment mining in online product reviews has become a hot topic in current research, focusing on extracting and analyzing emotional information from consumers' written evaluations to understand their attitudes and preferences toward products. Traditional methods rely on manual approaches like questionnaires and surveys to identify product features and emotional preferences, then correlate their relationships. However, this is a one-time, labor-intensive, and time-consuming process. With the rapid development of e-commerce and social media, consumers frequently write reviews after purchasing products to describe their feelings and experiences, providing abundant data resources for sentiment mining.

In 2018, a research paper proposed a method integrating text mining and sentiment engineering to automatically extract and summarize product features and corresponding emotional responses from online product descriptions and consumer reviews[46]. This approach not only effectively identifies emotional opinions about product features but also developed a prototype system that visualizes product characteristics, emotional attributes, sentiment keywords, and their relationships. This innovation not only assists consumers in making purchasing decisions but also helps manufacturers understand both their own products and competitors' offerings, providing valuable insights for product development.

In 2019, another paper focused on extracting emotional opinions from customer product reviews and classifying them into seven pairs of emotional attributes (such as like-dislike, beautiful-unattractive, soft-hard, small-large, useful-useless, reliable-unreliable, recommend-unrecommend)[47]. Traditional sentiment engineering methods primarily employ questionnaire surveys to collect and interpret customer emotional responses. However, this process requires active participant involvement, making it suitable only for relatively small-scale operations. To address this limitation, the paper proposes an heuristic deep learning approach that achieves over 86% accuracy, surpassing the baseline method.

Both papers highlight the significance of automated approaches in sentiment mining and the potential of using online product reviews as data sources. The key distinction lies in their methodologies: The first paper[46] emphasizes integrating text mining with Kansei Engineering to extract and summarize product characteristics and emotional responses, while the second paper[47] focuses on extracting and categorizing emotional opinions from customer reviews. Notably, the latter paper also addresses challenges in traditional Kansei Engineering methods, such as participant engagement issues, by adopting deep learning techniques to achieve automation.

3.8 Design of cross-border e-commerce logistics

Cross-border e-commerce logistics design has emerged as a research hotspot in recent years. With the rapid growth of cross-border e-commerce, the demand for and importance of logistics services have been steadily increasing. To enhance service quality and customer satisfaction, many researchers have begun exploring the integration of emotional intelligence into logistics operations.Methods such as process and data mining technology are introduced into the design of logistics service, in order to provide more intimate and efficient service based on the real needs and feelings of customers.

The 2011 study focused on trade design for plastic and rubber industry exhibitions, employing the Delphi method and perceptual engineering for booth design[48]. Through fuzzy product positioning, appropriate booth design principles and procedures were established, with the proposed methodology applied to commercial exhibition design. The research results demonstrated the feasibility of the proposed approach. In 2015, Mc et al.

investigated home delivery services , noting that intensified competition in this sector necessitated greater emphasis on continuous service improvement and differentiation[49]. This study integrated perceptual-related features to develop new HD designs, providing a technical framework for service design in the service industry. The 2017 research addressed the rapid development of cross-border e-commerce, highlighting increased demand and importance for cross-border logistics services[50]. Additionally, the study showcased text mining techniques for analyzing online content related to CBLs, offering examples of leveraging perceptual engineering and online content analysis to generate creative ideas for the service industry. A 2018 study proposed an integrated service design methodology combining perceptual engineering and data mining[51], demonstrating how integrating different service attributes could influence customer-perceived responses to foster positive usage intentions. A 2020 paper demonstrated how quantifying perceived Kanō appeal services impacts perceived emotional satisfaction .and employ TRIZ to develop innovative approaches for sustainable services[52]. These studies highlight the importance of Kansei Engineering in sustainable service development, emphasizing reduced contradictions and kansei authentic meaning.

By comparing these five papers, it becomes evident that they all explore how to enhance service design and quality through Kansei Engineering and other methodologies. The common thread is their emphasis on addressing customers' authentic needs and emotional experiences to deliver more considerate and efficient services. The key distinction lies in their specialized focus on specific domains—such as trade booth design, home delivery services, and cross-border logistics—each proposing tailored solutions and technical approaches. While variations exist in research methodologies, technological applications, and empirical studies, all papers have made significant contributions to improving service quality and customer satisfaction.

3.9 Social Robots and Hybrid Vehicle Design

Social robots and hybrid vehicle design have emerged as a hot research area in industrial design in recent years. With technological advancements, people's demands for product aesthetics and functionality continue to rise. As emerging technological fields, social robots and hybrid vehicles have become focal points for researchers focusing on their visual design, human-machine interaction, and emotional elements. Against this backdrop, how to integrate modern technologies like deep learning and Kansei Engineering to create designs that better meet consumer aesthetic preferences and emotional needs has become the core challenge in this field.

In 2011, a study introduced a hybrid Kansei Engineering system as an expert system, which leverages multiple emotional responses to advance product form design[53]. The hkes comprises a forward Kansei Engineering system and a backward Kansei Engineering system.

Although hybrid systems like hkes have been applied in various fields, most existing methods are limited to single-objective optimization rather than multi-objective optimization. To address this limitation, this study integrates Support Vector Regression and Multi-Objective Genetic Algorithm into hkes.

In 2021, a research paper proposed an emotion-based design methodology utilizing Kansei Engineering techniques and Deep Convolutional Generative Adversarial Networks[54]. The approach first evaluates the aesthetic appearance and emotional preferences of social robots through Kansei Engineering methods, then builds upon this foundation.

A dataset of handcrafted social robot images was used to train a DCGAN model for automatically generating new design images. Another study focused on the exterior design of hybrid vehicles, exploring the relationship between customer visual sensitivity and the morphological design of hybrid vehicles[55]. Deconstruct the appearance of hybrid vehicles using morphological analysis, and establish the mapping relationship between product design features and emotional quality through Kansei Engineering.

When comparing these three papers, they all focus on integrating Kansei Engineering with modern technological approaches in product design. The common thread lies in their emphasis on the importance of emotional and aesthetic elements in product design, while attempting to capture and understand these aspects through technical means. The distinctions are as follows: The first paper primarily explores how to incorporate multiple emotional responses into product design; the second paper emphasizes generating new design images through deep learning techniques; while the third paper concentrates on the exterior design of hybrid vehicles, investigating the mapping relationship between product design characteristics and emotional quality.

IV. Summary and Outlook

The fields of product design and Kansei Engineering have gained significant attention in recent years, with the core objective of achieving more humanized and emotionally resonant product designs by integrating technological means with consumers' emotional needs. The research priorities and methodologies in this field can be observed from the provided papers.

Numerous studies have adopted genetic algorithm-based product form design models, along with methodologies integrating grey relational analysis and neural network frameworks. These approaches aim to optimize product imagery, enhance perceived quality, and better address users' emotional needs. Furthermore, deep learning and text mining technologies are widely applied in product design to extract and utilize affective insights from online reviews, thereby gaining deeper understanding of consumer sentiment patterns.

As a vital tool in product design, Kansei Engineering enables designers to better understand consumers' emotional responses, thereby optimizing product design. For instance, studies have proposed an Kansei Engineering approach based on online product reviews, as well as an emotional evaluation method utilizing natural language processing technology and priority multi-attribute decision analysis.

In addition, with the development of big data technology, data-driven design automation has also been widely applied in product design. These methods provide designers with more precise design guidance by analyzing large volumes of data, thereby improving design efficiency and quality.

Future research directions could focus on the following aspects: First, further exploring how to integrate advanced machine learning technologies with traditional design philosophies to achieve more efficient and user-centric product design. Second, enhancing research on consumers' emotional needs across different cultural contexts to meet the demands of the global market. Additionally, with the development of virtual reality and augmented reality technologies, how to apply these innovations in product design to deliver more immersive experiences remains a promising area for exploration.

In conclusion, the fields of product design and Kansei Engineering still have great potential for development in the future. With technological progress and a deeper understanding of consumer needs, we can expect this field to bring more emotionally resonant and innovative product designs to consumers.

References

[1]. Simon Schütte , Jörgen Eklund . Design of rocker switches for Work-vehicles—an application of Kansei Engineering. Applied Ergonomics, 2005, 36(5): 557–567.

[2]. Hsin-Hsi Lai ,Yang-Cheng Lin , Chung-Hsing Yeh , Chien-Hung Wei. User-oriented design for the optimal combination on product Design. International Journal of Production Economics, 2006, 100(2): 253–267.

[3]. Shih-Wen Hsiao , Fu-Yuan Chin , Shu-Hong Lu. Product-form design model based on genetic Algorithms. International Journal of Industrial Ergonomics, 2010, 40(3): 237–246.

[4]. Quan Huafeng , Li Shaobo , Hu Jianjun. Product Innovation Design Based on Deep Learning and Kansei Engineering. Applied Sciences, 2018, 8(12): 2397.

[5]. Hsin-Hsi Lai , Yang-Cheng Lin , Chung-Hsing Yeh. Form design of product image using grey relational analysis and neural network Models. Computers & Operations Research, 2005, 32(10): 2689–2711.

[6]. Chih-Chieh Yang , Meng-Dar Shieh. A support vector regression based prediction model of affective responses for product form Design. Computers & Industrial Engineering, 2010, 59(4): 682–689.

[7]. Ming-Chuan Chiu , Kong-Zhao Lin.Utilizing text mining and Kansei Engineering to support Data-driven design automation at conceptual design Stage. Advanced Engineering Informatics, 2018, 38: 826–839.

[8]. Cristina Nardin Zabotto , Silva Sergio Luis da , Daniel Capaldo Amaral , Costa Janaina Mascarenhas Hornos , Benedito Galvão Benze. Automatic digital mood boards to connect users and designers with kansei Engineering. International Journal of Industrial Ergonomics, 2019, 74: 102829.

[9]. Lei Xue , Xiao Yi , Ye Zhang.Research on Optimized Product Image Design Integrated Decision System Based on Kansei Engineering. Applied Sciences, 2020, 10(4): 1198.

[10]. Zhenghong Liu , Jiafu Wu , Qipeng Chen , Tao Hu.An improved Kansei engineering method based on the mining of online product Reviews. Alexandria Engineering Journal, 2023, 65: 797–808.

[11]. Shan H Hsu , Ming C Chuang , Chien C Chang. A semantic differential study of designers' and users' product form perception. International Journal of Industrial Ergonomics, 2000, 25(4): 375–391.

[12]. Mitsuo Nagamachi.Kansei engineering as a powerful Consumer-oriented technology for product Development. Applied Ergonomics, 2002, 33(3): 289–294.

[13]. Hsin-Hsi Lai , Yu-Ming Chang , Hua-Cheng Chang. A robust design approach for enhancing the feeling quality of a product: A car profile case Study. International Journal of Industrial Ergonomics, 2005, 35(5): 445–460.

[14]. Jianxin Jiao , Yiyang Zhang , Martin Helander.A Kansei mining system for affective Design. Expert Systems with Applications, 2006, 30(4): 658–673.

[15]. Yaang-Cheng Lin , Hsin-Hsi Lai , Chung-Hsing Yeh.Consumer-oriented product form design based on fuzzy logic: A case study of mobile Phones. International Journal of Industrial Ergonomics, 2007, 37(6): 531–543.

[16]. Hongbin Yan , Van Nam Huynh , Tetsuya Murai , Yoshiteru Nakamori. Kansei evaluation based on prioritized Multi-attribute fuzzy target-oriented decision Analysis. Information Sciences, 2008, 178(21): 4080–4093.

[17]. Lianyin Zhai , Li Pheng Khoo , Zhao-Wei Zhong. A rough set based decision support approach to improving consumer affective satisfaction in product Design. International Journal of Industrial Ergonomics, 2009, 39(2): 295–302.

[18]. Ezgi Aktar Demirtas , A.Sermet Anagun , Gulser Koksal. Determination of optimal product styles by ordinal logistic regression versus conjoint analysis for kitchen Faucets. International Journal of Industrial Ergonomics, 2009, 39(5): 866–875.

[19]. Carmen Llinares , Alvaro F.Page. Kano's model in Kansei Engineering to evaluate subjective real estate consumer preferences. International Journal of Industrial Ergonomics, 2011, 41(3): 233–246

[20]. Kun-Chieh Wang. A hybrid Kansei engineering design expert system based on grey system theory and support vector Regression. Expert Systems with Applications, 2011, 38(7): 8738–8750.

[21]. Chih-Chieh Yang. A Classification-based Kansei engineering system for modeling consumers'affective responses and analyzing product form features. Expert Systems with Applications, 2011, 38(9): 11382–11393.

[22]. Yuexiang Huang , Chun-Hsien Chen , Li Pheng Khoo. Products classification in emotional design using a Basic-emotion based semantic differential Method. International Journal of Industrial Ergonomics, 2012, 42(6): 569–580.

[23]. Yuexiang Huang , Chun-Hsien Chen , Li Pheng Khoo. Kansei clustering for emotional design using a combined design structure Matrix. International Journal of Industrial Ergonomics, 2012, 42(5): 416–427.

[24]. Fuqian Shi , Shouqian Sun , Jian Xu. Employing rough sets and association rule mining in KANSEI knowledge Extraction. Information Sciences, 2012, 196: 118–128.
[25]. Meng-dar Shieh , Yu-En Yeh. Developing a design support system for the exterior form of running shoes using partial least squares and neural Networks. Computers & Industrial Engineering, 2013, 65(4): 704–718.
[26]. Jyh-Rong Chou. A Kansei evaluation approach based on the technique of computing with Words. Advanced Engineering Informatics, 2016, 30(1): 1–15.
[27]. Yu-Ming Chang , Chun-Wei Chen. Kansei assessment of the constituent elements and the overall interrelations in car steering wheel Design. International Journal of Industrial Ergonomics, 2016, 56: 97–105.
[28]. Fu Guo , Wei Lin Liu , Yaqin Cao , Fan Tao Liu , Mei Lin Li. Optimization Design of a Webpage Based on Kansei Engineering. Human Factors and Ergonomics in Manufacturing & Service Industries, 2015, 26(1): 110–126.
[29]. Meng-dar Shieh , Yu-En Yeh , Chih-Lung Huang. Eliciting design knowledge from affective responses using rough sets and Kansei engineering System. Journal of Ambient Intelligence and Humanized Computing, 2015, 7(1): 107–120.
[30]. Joana Vieira , Joana Maria A. Osório , Sandra Mouta , Pedro Delgado , Aníbal Portinha , José Filipe Meireles , Jorge Almeida Santos. Kansei engineering as a tool for the design of In-vehicle rubber Keypads. Applied Ergonomics, 2017, 61: 1–11.
[31]. Meng-dar Shieh , Yongfeng Li , Chih-Chieh Yang.Comparison of Multi-objective evolutionary algorithms in hybrid Kansei engineering system for product form Design. Advanced Engineering Informatics, 2018, 36: 31–42.
[32]. Yiru Jiao , Qing-Xing Qu. A proposal for Kansei knowledge extraction method based on natural language processing technology and online product Reviews. Computers in Industry, 2019, 108: 1–11.
[33]. Wonjoon Kim , Taehoon Ko , Ilsun Rhiu , Myung Hwan Yun. Mining affective experience for a kansei design study on a Recliner. Applied Ergonomics, 2019, 74: 145–153.
[34]. Yongfeng Li , Meng-dar Shieh , Chih-Chieh Yang. A posterior preference articulation approach to Kansei engineering system for product form Design. Research in Engineering Design, 2018, 30(1): 3–19.
[35]. Fu Guo , Qing-Xing Qu , Mitsuo Nangamachi , Vincent G.Duffy. A proposal of the Event-related potential method to effectively identify kansei words for assessing product design features in kansei engineering Research. International Journal of Industrial Ergonomics, 2020, 76: 102940.
[36]. Tianxiong wnag , Meiyu Zhou. A method for product form design of integrating interactive genetic algorithm with the interval hesitation time and user Satisfaction. International Journal of Industrial Ergonomics, 2020, 76: 102901.
[37]. Xinjun Lai , Sheng Zhang , Mao Ning , Liu Jianjun , Chen Qingxin. Kansei engineering for new energy vehicle exterior design: An internet big data mining Approach. Computers & Industrial Engineering, 2022, 165: 107913.
[38]. Xing Liu , Suixian Yang. Study on product form design via Kansei engineering and virtual Reality. Journal of Engineering Design, 2022, 33(6): 412–440.
[39]. Chaoxiang Yang , Fei Liu , Junnan Ye. A product form design method integrating Kansei engineering and diffusion Model. Advanced Engineering Informatics, 2023, 57: 102058.
[40]. Jean-Francois Petiot , Bernard Yannou. Measuring consumer perceptions for a better comprehension, specification and assessment of product Semantics. International Journal of Industrial Ergonomics, 2004, 33(6): 507–525.
[41]. Carmen Llinares , Alvaro Page. Application of product differential semantics to quantify purchaser perceptions in housing Assessment. Building and Environment, 2007, 42(7): 2488–2497.
[42]. Shana Smith , Shih-Hang Fu. The relationships between automobile Head-up display presentation images and drivers' Kansei. Displays, 2011, 32(2): 58–68.
[43]. Guo Fu , Liu Wei Lin , Liu Fan Tao , Wang Huan , Wang Tian Bo. Emotional design method of product presented in Multi-dimensional variables based on Kansei Engineering. Journal of Engineering Design, 2014, 25(4–6): 194–212.
[44]. Chun-Chih Chen , Ming-Chuen Chuang. Integrating the Kano model into a robust design approach to enhance customer satisfaction with product Design. International Journal of Production Economics, 2008, 114(2): 667–681.
[45]. Markus Hartono , Tan Kay Chuan. How the Kano model contributes to Kansei engineering in Services. Ergonomics, 2011, 54(11): 987–1004.
[46]. Wang Waiming , Li Zhi , Tian Zonggui , Wang Jiawen. , Cheng Meina. Extracting and summarizing affective features and responses from online product descriptions and reviews: A Kansei text mining Approach. Engineering Applications of Artificial Intelligence, 2018, 73: 149–162.
[47]. Wang Waiming , Wang Jiawen , Li Zhi , Tian Zonggui , Eric Tsui. Multiple affective attribute classification of online customer product reviews: A heuristic deep learning method for supporting Kansei Engineering. Engineering Applications of Artificial Intelligence, 2019, 85: 33–45.
[48]. Ming-Shyan Huang , Hung-Cheng Tsai ,Tzu-Hua Huang.Applying Kansei engineering to industrial machinery trade show booth Design. International Journal of Industrial Ergonomics, 2011, 41(1): 72–78.
[49]. Mu-Chen Chen , Chia-Lin Hsu , Kuo-Chien Chang , Man-Chi Cjou. Applying Kansei engineering to design logistics services – A case of home delivery Service. International Journal of Industrial Ergonomics, 2015, 48: 46–59.
[50]. Yu-Hsiang Hsiao , Mu-Chen Chen , Wei-Chien Liao. Logistics service design for Cross-border E-commerce using Kansei engineering with text-mining-based online content Analysis. Telematics and Informatics, 2017, 34(4): 284–302.
[51]. Cheng-Ta Yeh , Mu-Chen Chen. Applying Kansei Engineering and data mining to design Door-to-door delivery Service . Computers & Industrial Engineering, 2018, 120: 401–417.
[52]. Hartono Markus. The modified Kansei Engineering-based application for sustainable service Design. International Journal of Industrial Ergonomics, 2020, 79: 102985.
[53]. Chih-Chieh Yang. Constructing a hybrid Kansei engineering system based on multiple affective responses: Application to product form Design. Computers & Industrial Engineering, 2011, 60(4): 760–768.
[54]. Gan Yan , Ji Yingrui , Jiang Shuo , Liu Xinxiong , Feng Zhipeng , LiYao , Liu Yuan. Integrating aesthetic and emotional preferences in social robot design: An affective design approach with Kansei Engineering and Deep Convolutional Generative Adversarial Network. International Journal of Industrial Ergonomics, 2021, 83: 103128.
[55]. Kang Xinhui. Combining rough set theory and support vector regression to the sustainable form design of hybrid electric Vehicle . Journal of Cleaner Production, 2021, 304: 127137.
[56]. Mitsuo Nagamachi.Kansei Engineering.ToKyo:Kaibundo Publishing , 1989