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EXPLORING THE KEER KNOWLEDGE LANDSCAPE OVER THE PAST DECADE

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ABSTRACT

The aim of this paper was to systematically explore the knowledge landscape of papers presented at KEER conferences over the last decade. We collected all papers published in conference proceedings between 2010 and 2020. We (i) used a text mining pipeline to extract, clean, and normalize keywords from the Title and Abstract fields, and (ii) created a co-occurrence network reflecting the relationships between keywords. The network was then characterized at different levels of granularity (static analysis vs. time slice analysis and whole network vs. node-level analysis). The exploratory analysis showed a stable expansion of the network over time. The cluster structure revealed several groups of keywords that did not change over time and reflected both domain-specific and method-specific topics of research in Kansei engineering.

Keywords: *Kansei engineering, science-of-science, knowledge mapping, network analysis*

1 INTRODUCTION

The field of Kansei engineering is well known and has been demonstrated in various case studies since its introduction in 1970. In the early 2000s, Kansei engineering has attracted great interest from researchers worldwide. The popularity of research on the consideration of user emotions and feelings in product design led to the establishment of organizations such as European Kansei Group (EKG) and the creation of a conference, namely Kansei Engineering and Emotion Research (KEER). The KEER conference has been held every two years since 2007 and is organised by the Federation of 4 Regional Kansei Research Associations. Thus, KEER is the first global Kansei association (JSKE, Taiwan Institute of Kansei, EKG, and MAKE). Each KEER conference includes about 100-170 papers, which is a large amount of valuable data. Kansei

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engineering relies primarily on established methods and techniques, but new topics are also important for the future of the field.

The objective of our research was to investigate the state of the art in KEER proceedings over the last 10 years (2010-2021). We focused on topics, applications, and tools that appear in complete articles (proceedings) available online. We used web search/text mining to explore the content. Later, we classified the result into thematic clusters. Through the analysis, we gained a deeper understanding of what research interests have emerged in the last decade related to the field of Kansei engineering academic development.

1.1 Knowledge landscape over past decade

The development of Kansei engineering and its research is still an ongoing process and the subject of interest of many researchers around the world. According to Lokman (2009) Kansei engineering (KE) is consisted of eight techniques: Type I: Category Classification, Type II: KE Computer System, Type III: KE Modeling, Type IV: Hybrid KE System, Type V: Virtual KE, Type VI: Collaborative KE, Type VII: Concurrent KE and Type VIII: Rough Set KE. Besides the general structure, KE types can be divided into computational and non-computational (Ahmady, 2008). Ahmady (2008) has grouped category classification (type I), Virtual KE (type V) and collaborative KE (type VI) as non-computational while KE computer system (type II), hybrid KE (type IV) are considered as computational. Each type of KE has its own specific complexity in extracting data on the semantics and product features side, but the main methodology consists of the same steps. Based on all KE types a common Kansei framework was developed by Simon Schütte (2005). In addition, Levy (2013) provided an overview of the history of Kansei engineering (KE) and explained a theoretical structure of three subfields describing the production of physical artifacts: KE, Kansei Science (KS), and Kansei Design (KD). According to Levy (2013), KS builds on brain science, particularly cognitive neuroscience and psychophysiology, and draws on related philosophies. The term Kansei design is used to characterize the KE work that leads to actual industrial products. This approach has been implemented at Toyota Motor Europe (Levy, 2013).

KE is applied in various product areas, such as consumer goods (e.g., cosmetics, food, fashion, automotive, electronics), digital industries, and services (Bidin et al.2018). Recent studies confirm that KE is strongly present in the automotive and electronics industries (López et al. 2021). To better analyse observed product parameters, KE studies often categorise the product by attributes or characteristics such as shape, size, colour, material, surface, and price. Products or services trigger different senses in users (smell, sight, hearing, touch). For this reason, we find the above product attributes (scent, visual, auditory or tactile sensation) explored with KE. Within similar academic fields often associated with KE, such as Affective and Emotional Engineering (Levy, 2013), there is no strict demarcation. Even the tools and techniques used to measure user feedback are widely used in the aforementioned fields. User perception of products in KE is studied with tools we find in other research fields (mathematics, computer science, psychology, mechanical engineering, etc.)(Schütte, 2006). However, capturing and evaluating user's feeling is still highly subjective. Therefore, tools that measure kansei should be suitable for processing uncertain and unstructured data (Nagamachi et al. 2006). A previous study found that the most frequently represented concept in KEER 2014 was "Kansei," followed by "emotion," "participant," and "product" at the same level (Omhover & Bouchard, 2014). It is not surprising that the three most important components of KE are represented at the same level. Since KE and its application is not a new method, we examine what themes emerge and what is trending. The goal of our research was to examine the popularity of KE research directions over the past 10 years.

We have examine the knowledge landscape and major research topics addressed at KEER conferences. To identify the individual topics and the relationships between them, we conducted a topic analysis of KEER proceedings from 2010-2020.

2 METHODOLOGY

In this section we present the data workflow and explain the computational methods. The work is generally based on three consecutive steps: (i) collection of the KEER corpus and pre-processing of the documents, (ii) extraction of keywords and their representation in the form of a network, which finally allows us to (iii) perform a cluster analysis and describe research topics consisting of closely related keywords/keyphrases.

2.1 Data collection

We have created a machine-readable corpus of all research papers included in the KEER Conference Proceedings from 2010 to 2020. The paper starts with basic metadata (i.e., author list, title, subtitle, abstract, and list of keywords) on a title page and continues with the main body of the paper following the IMRaD structure (i.e., introduction, methods, results, and discussion). In line with our previous experience in natural language processing, we used the abstract field of the paper for keyword extraction, where the abstract provides an optimal tradeoff between the runtime of the extraction process (i.e., lowest with full text and highest with title) and the accuracy of the extraction process (i.e., lowest with title and highest with full text). Although the papers in the proceedings are structured according to a common document template, we found a high degree of variation due to the different document styles and word processors used by the authors. Therefore, we made two assumptions to ensure that the document parser could correctly match the abstract: (i) the abstract field starts on the first page of each paper, and (ii) the abstract text is positioned between the first occurrence of the word "Abstract" and the first occurrence of the word "Keywords".

KEER conference proceedings are published online in PDF format. The PDF file was first processed using the command line tool "pdfseparate" to split the entire document into separate PDF documents, one for each conference paper. In the next step, we processed all the collected documents using the "pdftotext" tool to create a normalized plain text representation of a document. This allows us to extract the required (meta) data: (i) the unique identifier of the paper (composed of the publication year of the conference volume and the page number of the title page) and (ii) the text in the abstract field. Before further analysis, the free text was lemmatized using the English lemmatization list from the lexicon package in R.

2.2 Keyword extraction and co-occurrence network construction

The collected abstracts were further processed to extract meaningful keywords and keyphrases. For this task, we used the KeyBERT algorithm, a state-of-the-art keyword extraction method based on a deep neural network model. KeyBERT uses BERT embeddings to extract words and phrases that are most representative in a given abstract (Sharma & Li, 2019). Unlike classical methods that usually rely on simple frequency counting, KeyBERT uses contextual information during extraction. This processing step ends with up to five most representative keywords extracted from each abstract.

The keywords and keyphrases were then arranged into a co-occurrence network, a comprehensive yet easy-to-understand technique for representing knowledge in a given domain. The co-occurrence network consists of nodes and edges (links), the former referring to the keywords/keyphrases and the latter to the (undirected) relationships between them. A link between a pair of keywords/keyphrases is established if they both originate from the same abstract.

2.3 Co-word analysis and strategic diagram

In the third step, we explored the co-occurrence network in terms of cluster structure. We define a cluster as a research topic (i.e., research theme), consisting of tightly linked keywords. Formally, a cluster is a subnetwork of keywords only weakly connected to other clusters.

The topic analysis is based on the work of Callon et al. (1991), who proposed two measures, centrality and density, to map a specific research area. Centrality represents the relatedness of a given cluster of keywords to other clusters, while density refers to the interaction of keywords inside a particular cluster.

Considering both measures, we can draw a strategic diagram to represent the structural landscape of a given research area. In a strategic diagram, the x-axis denotes centrality and the y-axis refers to density. The plot is centered by the mean of both axis values, dividing the strategic diagram into four types of research behavior. Each cluster can thus be given a qualitative interpretation depending on which quadrant a particular cluster appears in. These types can be described as follows:

1. *Motor topics.* Clusters in quadrant I are characterized by high centrality and density. Such clusters are well defined and have been conducted over a long period of time by already well-formed groups of researchers.
2. *Niche topics.* Clusters in quadrant II exhibit low centrality but high density. Such clusters are characterized by high homogeneity (i.e., they have strong internal connections). However, they are isolated from other clusters (i.e., they have weak external links).
3. *Emerging or declining topics.* Clusters in quadrant III are defined by both low centrality and low density, and relate to either new (i.e., emerging) or disappearing research topics.

4. *Basic topics.* Clusters in quadrant IV have high centrality and low density and thus combine transversal and very general research topics. These clusters are important for a particular research community, but they are not well developed.

Data processing and statistical analysis was performed using custom Bash, Python, and R scripts. The programming code to reproduce the results is available from the authors.

3 RESULTS

In this section, we first present a global research landscape of KEER knowledge as extracted from conference proceedings. We then describe the basic features of the keyword co-occurrence network. Finally, we discuss the results of the strategic diagram.

The keyword co-occurrence network (2010-2020) consists of 5,941 nodes and 16,833 undirected edges (Figure 1). For visualization purposes, we prune the network and select only the 200 keywords with the highest frequency and limit the minimum frequency of the selected keywords to five keywords.

Next, we divide the network into two time slices. The network for the 2010-2015 period is shown in Figure 2, and the network for the 2016-2020 period is shown in Figure 3. Co-word analysis was performed for both time periods. Clusters with representative keywords are summarized in Table 1 and Table 2.

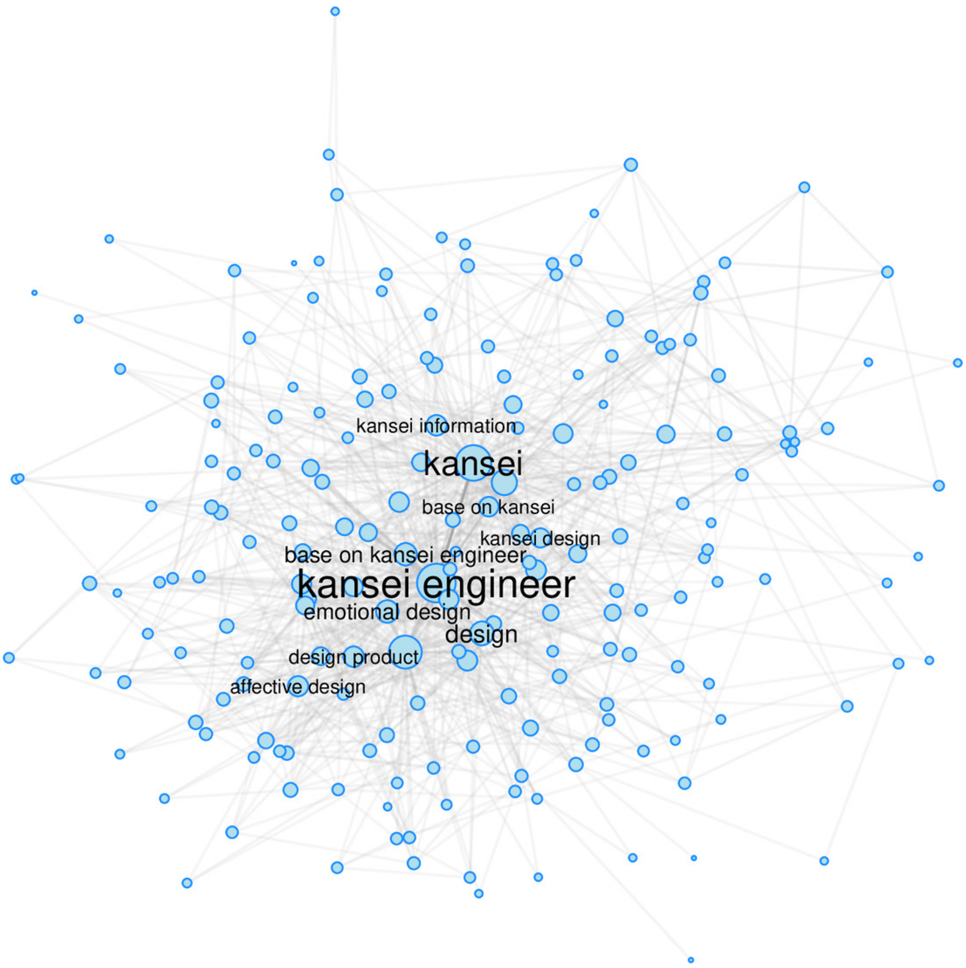

Figure 1. Keyword co-occurrence network generated from lemmatized keywords and keyphrases extracted with KeyBERT model from KEER conference proceedings (2010-2020)

3.1 KEER research topics in years 2010– 2015

On a strategic diagram in Figure 2, quadrant I contains a motor cluster called "Design". This cluster is characterized by high centrality and density. This means that the cluster relates to scientific topics that are well developed in this area and represent an engine of progress.

The quadrant II indicates research topics that will become driver topics in the future. In this quadrant we find three topics labelled “Traditional Japanese Craft”, “Fuzzy Inference” and “Tactile Feeling”.

The quadrant III contains a single research theme called “Robotics”. This cluster is characterized by low centrality and density. One could say that this theme is well developed. It is probably the research theme that was predominant in the earlier stages of development but is now considered mature.

The last quadrant IV could be described as a space of clusters with high centrality but low density. We find here designations such as: “Kansei Engineering”, “Kansei Information” and “Product Design”. These clusters are related to the fundamental themes represented in the KEER proceedings.

Figure 2. Strategic diagram summarizing the thematic clusters for the time interval 2010–2015

Table 1. Clusters by size and the most frequent keywords for the time interval 2010–2015

Cluster name	Cluster size	Frequent keywords
Kansei Engineering	495	kansei engineer, kansei, kansei word, kansei design, rough set, fuzzy, kansei factor, communication, impression
Product Design	271	product design, base on kansei engineer, kansei engineer system, emotional design, design process, product designer, design element, affective design, product development, design attribute
Kansei Information	263	kansei information, image retrieval, base on kansei, kansei evaluation, kansei model, kansei image, kansei quality, human kansei, neural network, retrieval system
Design	168	design, affective engineer, usability, affective, kansei information process, mobile phone, genetic algorithm, affective response, affective compute, color design
Traditional Japanese Craft	63	traditional japanese craft, kansei retrieval, virtual reality, kansei retrieval method, traditional japanese craft object, propose, japanese craft
Robotics	60	robot, human emotion, emotion, mobile robot, facial expression, face robot
Fuzzy Inference	28	fuzzy inference, fuzzy model, music, subjective criterion deviation, musical expression
Tactile	10	Tactile, tactile sense

Note: The extracted keywords are lemmatized.

3.2 KEER research topics in years 2016– 2020

On a strategic diagram evaluated from network partition 2016-2020 (Figure 2), quadrant I contains a single motor theme called “Virtual KE”. This cluster is characterized by high centrality and density. This means that the cluster relates to scientific topics that are well developed in this area and represent an engine of progress.

The quadrant II indicates research topics that will become driver topics in the future. In this quadrant we find three topics labelled “Robotics”, “Mobile & Web & Garment Design”, and “Usability”.

The quadrant III is empty. The last quadrant IV could be described as a space of clusters with high centrality but low density. We find here designations such as: “Kansei Word”, “Car Design & Service Quality”, “Product Design & AI”, and “Color Package & Design”. These clusters are related to the fundamental themes represented in the KEER proceedings.

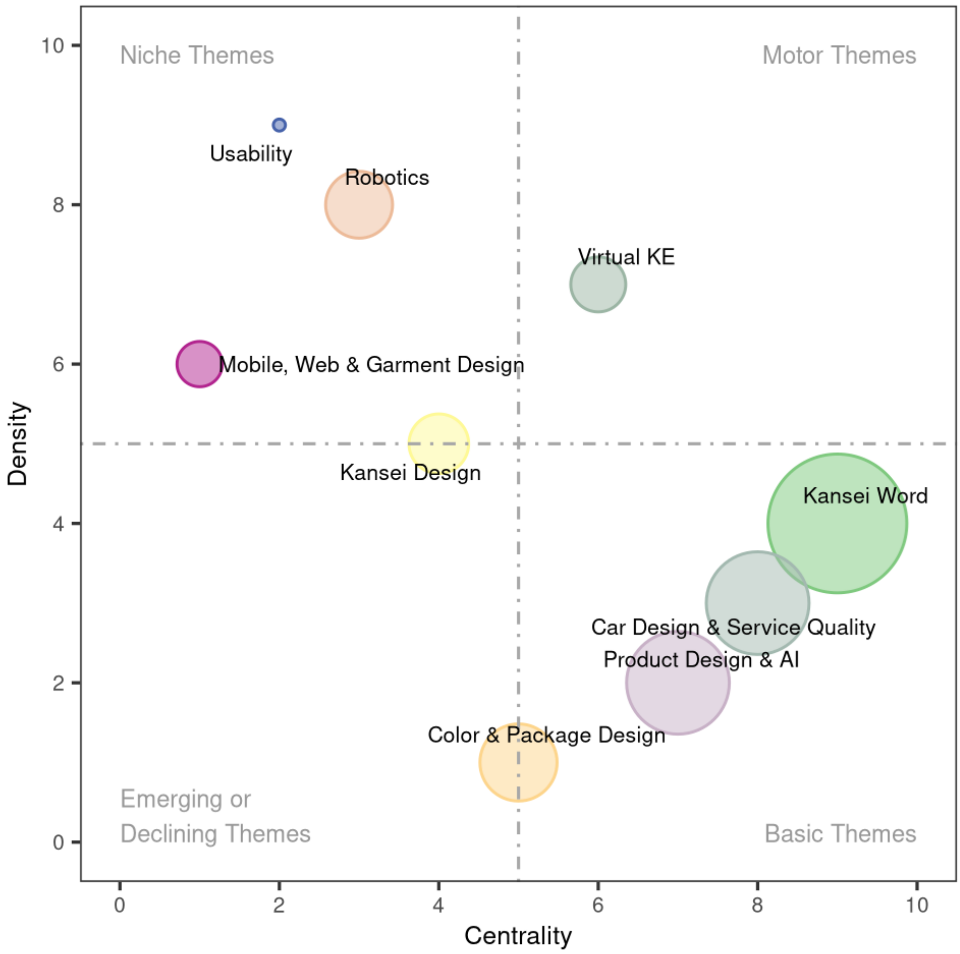

Figure 3. Strategic diagram summarizing the thematic clusters for the time interval 2016–2020

Table 2. Clusters by size and the most frequent keywords for the time interval 2016–2020

Cluster name	Cluster size	Frequent keywords
Kansei Word	282	kansei engineer, kansei word, kansei evaluation, kansei image, text mine, kansei attribute, kansei analysis, kansei adjective, user interface, aesthetic design
Car Design & Service quality	155	kansei, affective, customer satisfaction, kansei retrieval, kansei value, design product, car design, customer emotion, service quality, emotional satisfaction
Product Design & AI	155	product design, design, neural network, artificial neural network, product designer, product development, product model, interactive genetic algorithm
Color & Package Design	90	base on kansei engineering, color design, package design, kansei engineering system, kansei engineering method, kansei engineering approach, color, consumer emotion, product color design
Robotics	70	robot, kansei engineering methodology, emotion, user experience, human emotion, robot interaction,
Kansei Design	58	design element, kansei design, aesthetic, customer kansei, design process, kansei model, kansei factor
Virtual KE	51	affective design, service design, affective engineering, virtual agent, affective attribute, virtual learn environment
Mobile & Web & Garment design	39	emotional design, mobile learn material, cloth design, website design
Usability	21	usability, usability evaluation

Note: The extracted keywords are lemmatized.

4 CONCLUSION

Based on the results, we managed to identify the driving, niche, emerging or declining, and fundamental themes of KEER in the period 2010-2020. We have divided the strategic diagrams into half of the decade to better understand the consistency of each cluster. In the 2010-2015 quadrants II we find four themes labelled "Traditional Japanese Craft, Fuzzy Inference, and Tactile Feeling." Interestingly, there are different thematic clusters in 2016-2020, and the basic themes for quadrant II are related to Robotics", "Mobile & Web & Garment Design", and "Usability". Probably, the implementation of Kansei engineering in product types has changed due to technological development and global trends. We can find that the most important words that have been frequently used in the last ten years are "Kansei Adjectives, Kansei Evaluation, Kansei Attributes, Impression". We believe that these keywords are more frequently mentioned because they are the basis of Kansei engineering methodology. The broader application of Kansei engineering is apparently shifting to intangible products such as services and digital product design, with an emphasis on AI. According to our results, we assume that robotics-related topics will continue to play an important role in the future of Kansei engineering. Because our study was limited to KEER proceedings, a literature review of scientific papers that used KE would likely provide clearer information about the future direction of the discipline. The authors suggest conducting additional searches for scientific articles in relevant journals for the same time period.

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