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USE OF MACHINE LEARNING TECHNIQUES IN THE KANSEI ENGINEERING SYNTHESIS PHASE

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Kansei engineering is one of the main methodologies for the emotional design of products. This technique aims to relate the properties of the product or service to the sensations perceived by users. A classic application of this methodology requires different phases, among which are the choice of the product domain, the definition of the semantic space and properties, the elaboration of the synthesis, the validation and the construction of the model and validation. The popularization of artificial intelligence techniques, including machine learning, has led many authors to use these mathematical models in the synthesis phase. This paper analyses the main machine learning tools used in the synthesis phase of kansei engineering, as well as the relevance of their use, based on the property space previously described.

Keywords: kansei engineering; machine learning; emotional design; artificial intelligence; engineering project.

UTILIZACIÓN DE TÉCNICAS DE APRENDIZAJE AUTOMÁTICO EN LA FASE DE SÍNTESIS DE INGENIERÍA KANSEI

Una de las principales metodologías para el diseño emocional de productos es la ingeniería Kansei. En esta técnica se pretende relacionar las propiedades del producto o servicio con las sensaciones percibidas por los usuarios. Una aplicación clásica de esta metodología requiere distintas fases entre la que se encuentran la elección del dominio del diseño, la definición del espacio semántico y de propiedades, la síntesis, la validación y la construcción del modelo. La popularización de las técnicas de inteligencia artificial, entre las que se encuentra el aprendizaje automático, ha llevado a muchos autores a utilizar estas herramientas en la fase de síntesis. En este trabajo se analizan las principales herramientas de aprendizaje automático usadas en la fase de síntesis de ingeniería kansei, así como la adecuación de su uso, en base al espacio de propiedades previamente definido.

Palabras clave: ingeniería kansei; aprendizaje automático; diseño emocional; inteligencia artificial; proyectos de ingeniería.

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1. Introduction

There is a growing interest in design based on user experiences (Hartono, 2020). In a context where products more than satisfy the functional needs for which they were designed, the sensations associated with the use of products and services are increasingly important (Zamora-Polo, De Las Heras, & Luque-Sendra, 2021).

Among the methodologies that have been widely used in the field of experiential design is Kansei Engineering. This methodology was proposed by Nagamachi (1992) and aims to quantitatively relate the characteristics of products with the sensations generated by them. The term kansei does not have a direct translation in English (Coronado, Venture, & Yamanobe, 2021), this term comes from the union of the kanji "kan" which means sensitivity and “sei” which means characteristics, quality, nature. Kansei methodology has sometimes been associated with emotional design, but it goes beyond that. In fact, Nagamachi relates it to the impression gathered by the senses or psychological feeling (Nagamachi, 2010; Nagamachi & Lokman, 2010).

The Kansei methodology has been widely used in a wide variety of products and services, for example: vehicles (Kang, 2021; Lai et al., 2022), furniture design (Kobayashi & Fujita, 2021), website design (Guo et al., 2016), sustainable services (Hartono, 2020), etc.

There are different types of application of the Kansei methodology (Coronado, Venture, & Yamanobe, 2021; Felgueroso Fernández-San Julián et al., 2011):

Type I: Categorization, the identification of product characteristics is carried out, usually without the use of computer tools, using surveys targeted at the market segment to be accessed.

Type II: Kansei Engineering System, computer tools are used to choose the best options for product design.

Type III: Hybrid Kansei Engineering System, these systems allow explaining the relationship between kanseis and product features, as well as predicting what will be the responses in the form of kanseis from new experiences of new product features.

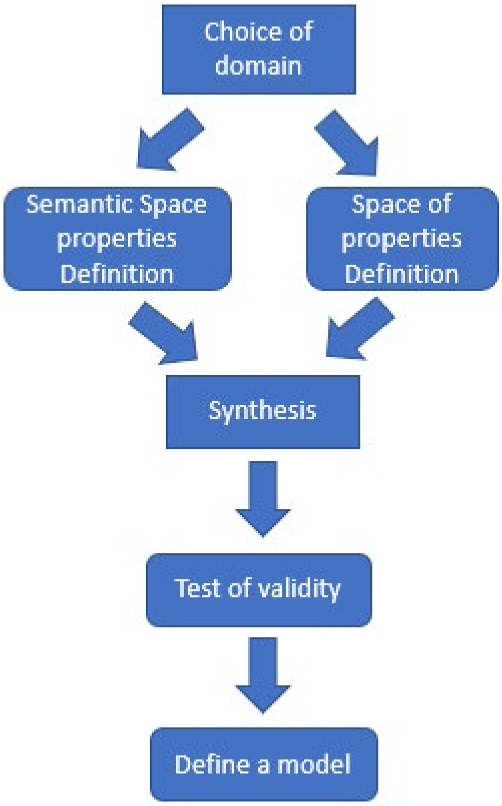
Type IV: Predictive mathematical model, by building complex mathematical models it is possible to obtain a relationship between kanseis and product properties allowing both forward and backward evaluation.

Type V: Use of virtual reality in the field of Kansei Engineering

Type VI: Collaborative design via the Internet, using group work and concurrent engineering methodologies.

Figure 1 shows the procedure proposed by Schütte (2005) for the application of kansei methodology. The choice of the domain requires both the definition of the market sector and the characteristics of the new product to be manufactured. The kanseis can be structured hierarchically, which is why an attempt can be made to discover the structure present in the data (definition of the semantic space). For the grouping of the different kanseis, the knowledge of experts in the field or the use of statistical tools such as principal component analysis, factor analysis and the use of neural networks, cluster analysis or the theory of quantification (Types II, III and IV) can be used. Subsequently, the definition of the property space must be carried out, which represents the most important characteristics that mark the identity of the product and that can lead to a change in the valuation of future users. In the synthesis space, the aim is to obtain the existing relationship between the property space and the semantic space, for which manual methods can be used, such as the identification of categories (type I kansei), or the use of statistical tools such as linear regression, quantification theory (type I) or more advanced procedures such as genetic algorithms, fuzzy logic, etc. The final objective is to define a mathematical model on which to operate in order to obtain the design that optimizes user assessment.

Figure 1: Procedure proposed by Schütte (2005) for the application of kansei methodology



As previously mentioned, in order to carry out the synthesis in the type IV Kansei methodology, it is necessary to create a mathematical model that attempts to correlate the properties of the product with the users' assessment. One of the tools of artificial intelligence, machine learning, can be used to create these models.

Artificial intelligence is the ability of computers to think automatically (Kaplan & Haenlein, 2019). In the classic computer programming process, it is the human being who indicates the strategy to solve the problem, while in artificial intelligence, on the other hand, the machine itself automatically obtains the knowledge based on data provided by the user (Bosch Rué, Casas Roma, & Lozano Bagén, 2019).

Machine learning (ML) is the ability to learn automatically based on the data provided. ML is a branch of artificial intelligence (Bosch Rué, Casas Roma, & Lozano Bagén, 2019; Goodfellow, Bengio, & Courville, 2016) and its use is becoming popular for a large number of applications: smart city management (De Las Heras, Luque-Sendra, & Zamora-Polo, 2020), images classification (Bosch Rué, Casas Roma, & Lozano Bagén, 2019), recommender systems (Portugal, Alencar, & Cowan, 2018), credit scoring (Teles et al., 2020), etc.

Among the strategies of machine learning, in supervised learning, the system is fed with training data, and it attempts to deduce a function that meets the previously established data. On the other hand unsupervised learning has no training data and the system attempts to fit the model to the observations. (Bosch Rué, Casas Roma, & Lozano Bagén, 2019).

The tasks typically addressed by machine learning are classification, which seeks to categorize data, regression, which is a continuous classification, and clustering, in which there are no defined classes and the algorithm groups the data according to their affinity (Bosch Rué, Casas Roma, & Lozano Bagén, 2019).

The application of machine learning techniques is neither straightforward nor simple. Among the problems usually encountered in these applications are overfitting and underfitting, the limitation of training and test results, the selection of models that adequately fit the phenomenon being analyzed, etc. In this sense, the implementation of these models could be considered an art. In this paper, the use of machine learning tools that are being used for product design through the use of Kansei Engineering is analyzed.

The structure of the following sections is as follows: in the next section the objectives of the work will be described, then the methodology will be detailed, the results will be presented and discussed in the fourth section. Finally, the conclusions of the work and future lines of work will be detailed.

2. Objectives

The main objective of the paper is to analyse the use of machine learning tools for product design through the Kansei Engineering. To this end, the following secondary objectives will be addressed:

1. To analyse the evolution of the use of these tools in the scientific literature.

2. To study the different sources for the training of machine learning models in the field of Kansei Engineering.

3. To categorise the various machine learning techniques commonly used in the field of emotional product development.

4. To detect future lines of work in this field.

3. Methodology

In order to achieve the above objectives, an analysis of the scientific literature in the field of kansei engineering and machine learning has been carried out. The search was carried out in the Scopus bibliographic database (Elsevier, 2022). This database was chosen because of its wide scientific coverage and because it is the database in which the proceedings of the International Congress on Engineering and Project Management are indexed (AEIPRO, 2021).

The time period analyzed was restricted to the last 5 years (2017-2021), in line with other previously published works (Anand & Amor, 2017; Luque et al., 2020; Zamora-Polo et al., 2019), and the search was conducted on 1/02/2022. The sources used included all documents registered in the bibliographic database including articles, conference proceedings and book chapters, and the keywords used were the following, including in the tittle, abstract and keywords: (kansei AND engineering)) AND (machine AND learning).

Hermeneutics has been used to analyze texts. This tool, originally applied in the study of sacred texts (Palmer, 1969), has been used in fields such as philosophy, pedagogy (Lozano et al., 2017; Zamora-Polo & Sánchez-Martín, 2019) and technical research (Luque et al., 2020). The aim of this tool is to achieve a deeper understanding of reality, based on the reading of previously published texts (Heidegger, 2009).

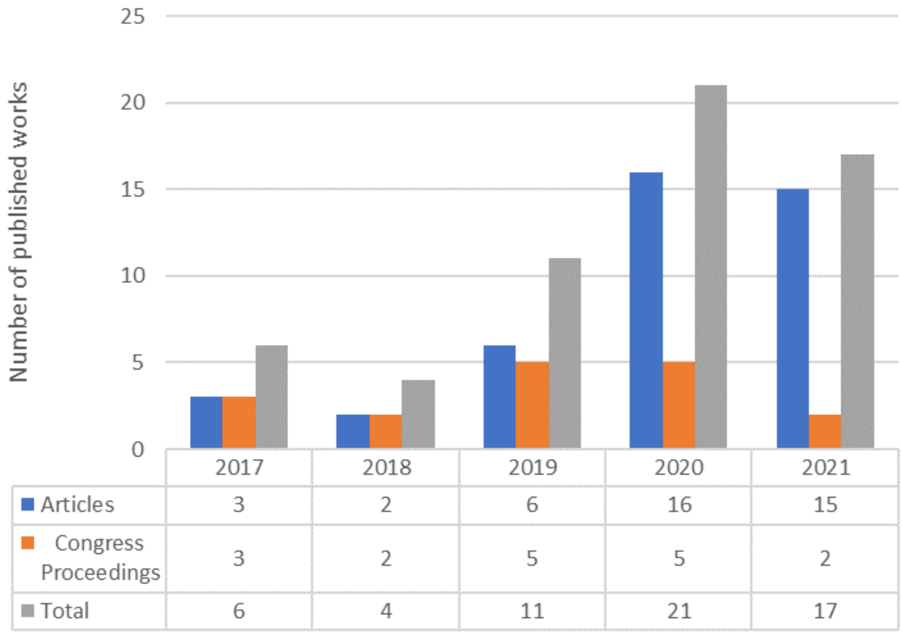
4. Results and Discussion

4.1. Evolution of the number of published papers

The total number of analyzed articles amounts to 66 articles. Among these articles, 6 articles were discarded because they were out of scope (false positives), despite having been included in the search, they did not effectively develop the use of machine learning techniques in Kansei Engineering, and another article was rejected because it was written in Japanese. This brings the number of papers finally studied to 59.

Figure 2 shows the historical evolution in the number of papers in the last 5 years (2017-2011) in the chosen topic. As it can be seen, there is a growing trend in the interest of the subject in the scientific literature.

Figure 2: Number of scientific publications analyzed in the period 2017-2021

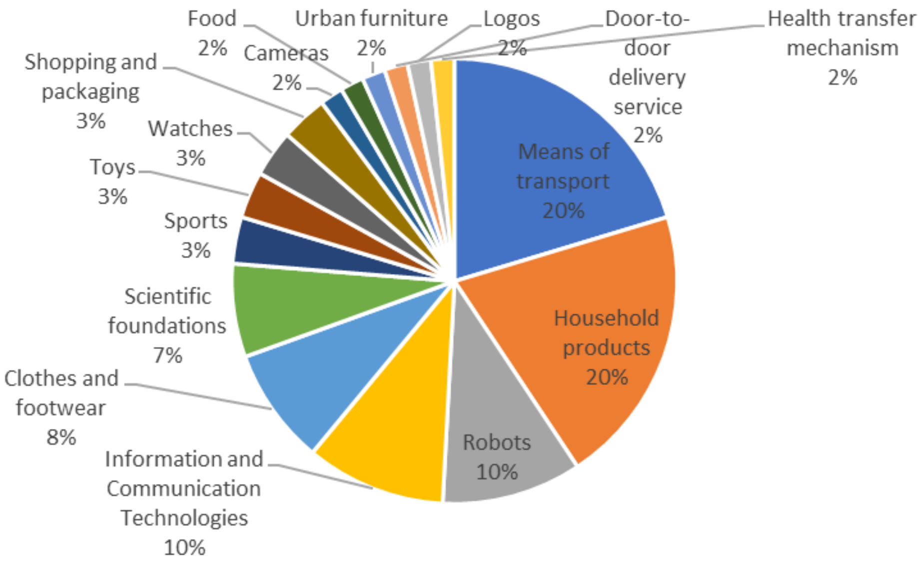


From the data expressed in Figure 2, a reduction in the number of articles published in the last year (2021) can be observed. This may be due to the effect of the COVID 19 pandemic on the scientific literature. Previously published work found a very considerable decrease in scientific publications deposited on platforms such as bioRsiv (Abramo, D'Angelo, & Mele, 2021). The reasons given in this paper range from the closure of research centers, workloads due to confinement care and the extra effort needed to attend to virtual teaching in the case of university teaching (Abramo, D'Angelo, & Mele, 2021). In addition, the outbreak of the pandemic has undoubtedly hindered communications, decreasing the possibility of travel and scientific meetings. Despite the proliferation of online scientific events, a drastic reduction in the number of papers presented at conferences can be observed in 2021.

4.2. Kansei engineering applications

Figure 3 shows the sector of application of Kansei Engineering in the analyzed articles.

Figure 3: Areas of application of Kansei Engineering in the sample of articles surveyed



As can be inferred from Figure 3, among the sectors with the most papers published are the means of transport.

The aspects studied in these works cover topics such as car ergonomics (Kikumoto, Kurita, & Ishihara, 2021), SUV car design (Dong et al., 2021), general aspects of cars (Guo et al., 2020; Li & Zhu, 2020; Su et al., 2020), or the service of car-sharing platforms such as UBER (Ali, Wang, & Riaz, 2020). Other articles deal with air transport such as the design of aircraft cockpit (Chen et al., 2021) or airports (Hartono, 2020), bicycles are also analyzed (Chiu & Lin, 2018), and special attention is devoted to the use of electric bicycles (Wang et al., 2021; Wang & Zhou, 2020) or accessories such as bicycle helmets (Li et al., 2021). The design of sustainable means of transport is a major challenge (Cruz-Rodríguez et al., 2020) with a major impact on the industrial sector. In fact, one of the first applications of kansei engineering was in the automotive sector (Kang, 2021).

The domestic sector is on a par with the previous sector in terms of the number of publications. The design of furniture such as: cradles (Akgül et al., 2021; Akgül et al., 2020), chairs (Zuo & Wang, 2020), sofas (Xue, Yi, & Zhang, 2020), lamps (Fan et al., 2018), vases (Li, Shieh, & Yang, 2019; Shieh, Li, & Yang, 2018) or thai ceramic (Kittidecha & Yamada, 2018), frying pan handles (Shinoda et al., 2019) or spoons (Laohakangvalvit, Achalakul, & Ohkura, 2017). The design of wallpaper for rooms (Ishihara et al., 2020) or instruments such as drills (Li et al., 2021) are also addressed in the studied works

The next sectors with the same number of publications are robots and Information and Communication Technologies (ICTs). Among the former are the design of social robots (Coronado, Venture, & Yamanobe, 2021; Ding, Cheng et al., 2021; Gan et al., 2021; Sejima, Sato, & Watanabe, 2021), robots for children (Liu et al., 2019) and robots for assisting the elderly people (Bidin et al., 2017). In the field of ICTs, aspects as diverse as the design of peripherals (Jiao & Qu, 2019) and mobile phones (Yang et al., 2020), the design of video game icons (Cao, Watanabe, & Ono, 2021), mobile phone applications (Fischer, 2020), virtual reality (Fu et al., 2020), web pages design (Hadiana, 2018) or alerts in the field of computer security (Razali et al., 2019) can be found.

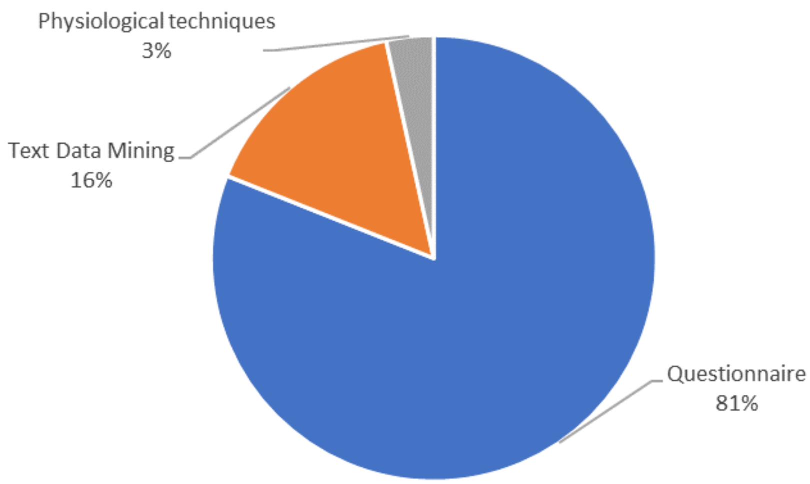
The design of clothing and footwear has been the subject of much research, including men's and women's clothing (Jiang et al., 2021; Quan, Li, & Hu, 2018), the design of shoes (Zairan Li et al., 2017), women's handbags (Chu, Chang, & Lin, 2020) and the images on T-shirts (Chen & Cheng, 2021).

Among the topics less covered in the studies analyzed are the design of sports equipment (Chu, Chang, & Lin, 2020; Ding, Zhao et al., 2021), toys (Chan et al., 2020; Wang et al., 2018), watches (Li et al., 2018; Suzuki et al., 2019), shopping and packaging (Aprilia et al., 2020; Wang et al., 2019), food design (Fukumoto & Hanada, 2019), cameras (Wang & Chin, 2017), logos (Zhu, Cao, & Li, 2017), urban furniture (Wei, 2019) and the design of services such as door-to-door (Yeh & Chen, 2018).

4.3. Tools for collecting user opinions

One of the fundamental issues for the application of machine learning techniques is to have an adequate set of data from which knowledge will be extracted. There are various strategies for obtaining user opinions, including the use of questionnaires, determination based on physiological signals such as electroencephalography, electrocardiogram, etc., or text data mining using natural language processing tools. Figure 4 shows the percentages of papers with a practical application depending on the procedure for acquiring user feedback.

Figure 4: Frequency of use of various tools for obtaining users' opinions



As it can be seen in the figure above, the most widely used technique is the questionnaire (81%), despite the weaknesses that will be discussed later, this methodology can ensure a certain number of valid data, that users meet certain characteristics and that the conditions under which the evaluation is carried out can be controlled by the research team. The average number of data available from the research studies analyzed is 117.66 respondents. However, there is a large variability in the number of surveys ranging from 5 (Yang, Shi, & Wang, 2020) to 655 survey participants (Li et al., 2021).

One of the main problems with the use of questionnaires is that they are time-consuming to complete (Chan et al., 2020). To overcome this limitation, several strategies have been proposed. Firstly, some authors recommend limiting the number of responses required to the number of items, setting the necessary ratio at 1:5 (5 valid questionnaires for each item in the questionnaire) (Zhu, Cao, & Li, 2017, 2017); on other occasions, the models to be evaluated have been distributed among groups of participants surveyed (Li et al., 2021), so that respondents do not evaluate all the products but only part of them. Another option proposed is to reduce the number of products that are used for the evaluation, either by selecting the sample (Akgül et al., 2020; Ding, Cheng, et al., 2021; Fu et al., 2020; Li, Shieh, & Yang, 2019) or by starting from a sample of products and identifying the conditions of the products a posteriori (Čok, Vlah, & Povh, 2022; Li et al., 2018; Wang & Chin, 2017; Xue, Yi, & Zhang, 2020).

Questionnaires are sometimes completed by students (Čok, Vlah, & Povh, 2022; Ding, Cheng, et al., 2021), but they are not the only sector targeted by the product under study. Sometimes the genders are not justifiably balanced, as in the case of women's clothing (Quan, Li, & Hu, 2018) or women's handbags (Chu, Chang, & Lin, 2020), but sometimes there is a gender bias that is not in principle reflected in the percentage of users who demand the product (Čok, Vlah, & Povh, 2022; Gan et al., 2021; Kikumoto, Kurita, & Ishihara, 2021).

Regarding experimental techniques that require physiological measurements, such as eye tracking (ET) and electroencephalogram (EEG), the number of subjects participating in the studies is usually smaller. Among the analyzed studies analyzed, only two articles fall into this category. In the first one, written by Yang et al., (2020), ET and EEG are used in combination and 12 students participate in the study. In the second article, a total of 26 subjects participate in the EEG study for the evaluation of the kansei words defining SUVs cars (Guo et al., 2020). Obviously, the use of this type of methodology is more costly than the use of questionnaires, as it requires the use of equipment that is not always accessible to research teams. For this reason, its use is more limited than the alternative of using a questionnaire.

To overcome the problems associated with the use of tools that require user interaction (questionnaires and physiological techniques), one trend is the use of user-generated comments (Jiao & Qu, 2019; Lai et al., 2022; Z. Li et al., 2020). User comments can be taken from social media (Ali, Wang, & Riaz, 2020; Chan et al., 2020) or e-commerce sales platforms (Jiao & Qu, 2019).

In these cases, the number of available data available to carry out the research is very diverse. Thus, Aprilia et al. (2020) used 44 phrases to train an instrument that categorizes them into three groups: aesthetic, functional and environmental. Most of the works used a larger number, Li et al. (2020) and Wang et al. (2018) analyzed 200 reviews of toys with at least 10 reviews per toy, Wang et al. (2019) analyzed 900 reviews of products with at least 20 reviews, Ali et al. (2020) analyzed Facebook comments of Uber users from 3853 reviews, they classified mobile phone applications from 38752 opinions expressed by users and they categorized the applications into basic, intermediate and advanced, Jiao & Qu (2019) used 10000 reviews of 10 computer mice. Sometimes a relationship is sought between reviews and product images as in Suzuki et al. (2019), where 1936 images of watches were used. Finally, Chiu and Lin (2018) used 4459 reviews of bicycles with at least 50 comments as a preliminary step for the determination of the kanseis.

4.4. Machine Learning and statistics tools for synthesis

In this section, the most used strategies to carry out the synthesis phase in the kansei methodology are analyzed. The methodologies will be analyzed according to the data acquisition instrument used.

4.4.1. Machine Learning and statistics techniques for questionnaires

Generally, a relationship between users' opinions and product characteristics is sought, for this purpose it is necessary to convert categorical variables into dummy variables. In many cases, the first steps are to calculate the reliability of the questionnaire by using Cronbach's Alpha coefficient (Gan et al., 2021; Hadiana, 2018), correlation analyses between variables (Gan et al., 2021) or the use of descriptive variables (means, standard deviation, etc.) (Gan et al., 2021; Mat Razali et al., 2019). In many cases, the models used are linear in nature (linear regression) (Fu et al., 2020; Gan et al., 2021; Hartono, 2020; Liu et al., 2019; Shirafuji et al., 2018; Zhang et al., 2020). Although the most used tools were originally linear, the strongly non-linear character of the results and the advance of computational techniques have led to the proliferation of non-linear mathematical models (Ding, Cheng, et al., 2021).

There are a multitude of machine learning tools that are used in this phase of kansei Engineering: back propagation neural network (Chen & Cheng, 2021; Zairan Li et al., 2017; Quan, Li, & Hu, 2018; Wang et al., 2021; Yeh, 2020), classification and regression tree (CART) (Ding, Zhao, et al., 2021; Li et al., 2018; Sakornsathien, Sinthupinyo, & Anuntavoranich, 2019; Wang & Chin, 2017), decision trees (Kittidecha & Yamada, 2018; Sakornsathien et al., 2019; Yeh & Chen, 2018; Zhang et al., 2020), rough set kansei (Akgül et al., 2020; Li & Zhu, 2020; Zairan Li et al., 2017), fuzzy linguistic (Akgül et al., 2021; Yang et al., 2020), logistic regression ((Ding, Zhao, et al., 2021; Li et al., 2018; Sakornsathien, Sinthupinyo, & Anuntavoranich, 2019; Yeh & Chen, 2018), grey fuzzy model (Xue, Yi, & Zhang, 2020), random forest (Sakornsathien, Sinthupinyo, & Anuntavoranich, 2019), Naive Bayes (Sakornsathien, Sinthupinyo, & Anuntavoranich, 2019), deep learning (Sakornsathien, Sinthupinyo, & Anuntavoranich, 2019), support vector regression (Li, Shieh, & Yang, 2019; Li et al., 2018; Shieh, Li, & Yang, 2018), class association rule (Kittidecha & Yamada, 2018), ridge regression (Li et al., 2018), multilayer perceptron (Li et al., 2018), support vector machine (Laohakangvalvit, Achalakul, & Ohkura, 2017).

Sometimes the relationship between kanseis and product images is sought. There are several tools available to classify images, such as: radial basis function neural network (Y. Chen et al., 2021), Elman neural network (Chen et al., 2021), general regression neural network (Chen et al., 2021), convolutional neural network (Ishihara et al., 2020; Jiang et al., 2021; Su et al., 2020), deep residual network (Li et al., 2021).

Of the studies analysed, 37 articles (over 45) carry out the analysis of the kanseis without taking into account the characteristics of the users. Among the studies that include user characteristics, the correlation between the assessment of the different types of users is analysed (Cao, Watanabe, & Ono, 2021; Wei, 2019), ANOVA is used to discover differences between groups (Kikumoto, Kurita, & Ishihara, 2021; Yeh & Chen, 2018),. Finally, the inclusion of user characteristics in decision trees (Čok, Vlah, & Povh, 2022; Kikumoto, Kurita, & Ishihara, 2021), using fuzzy mapping-based models (Dong et al., 2021) or creating a specific model based on each interest group (e.g. men and women) (Laohakangvalvit, Achalakul, & Ohkura, 2017) are techniques for incorporating the user characteristics

One of the most important aspects in the use of machine learning tools is the testing of the results by means of a test. In 16 of the articles (out of 45) that address the testing of the model used by testing, a percentage of 70% of the data is usually recommended for training and 30% for testing, which is the case in some of the works studied (Kittidecha & Yamada, 2018; Laohakangvalvit, Achalakul, & Ohkura, 2017; Yeh & Chen, 2018), however sometimes the percentage of data used for the test is somewhat lower (Chen & Cheng, 2021; Chen et al., 2021; Ding, Cheng, et al., 2021; Ding, Zhao, et al., 2021; Dong et al., 2021; Fu et al., 2020; Jiang et al., 2021; Liu et al., 2019; Su et al., 2020; T. Wang et al., 2021; W. M. Wang et al., 2019). Finally, cross validation is sometimes used as an approach (Li et al., 2018; Quan, Li, & Hu, 2018).

After the construction of the models, optimization tools are often used, such as: Deep convolutional generative adversarial neural networks (Gan et al., 2021), spiking neural networks (Ding, Cheng, et al., 2021), genetic algorithms (Fukumoto & Hanada, 2019; Shieh, Li, & Yang, 2018; Wang et al., 2021; Wang & Zhou, 2020). Sometimes the optimum is sought based on the combination of several kanseis, constituting a multi-objective optimization problem.(Li, Shieh, & Yang, 2019; Shieh et al., 2018).

4.4.2. Machine Learning and statistics techniques for physiological measures

Guo et al. (2020) analyzes the kanseis related to the evaluation of SUV cars by studying the electroencephalographic signals of words related and unrelated to the studied phenomenon. The differences are analysed using statistical techniques such as the analysis of means (t-test) and ANOVA. Yang et al. (2020) estimated the score obtained from the kanseis as a function of product characteristics and electrophysiological parameters obtained by ET and EEG using simple linear regression.

4.4.3. Machine Learning and statistics techniques for user generated comments

In most of the works, a supervised classification is carried out in which the text of the opinions is related to certain kanseis (Aprilia et al., 2020; Li et al., 2020; Wang et al., 2019) or to predict the users' rating (Fischer, 2020) The following strategies have been used for these operations: support vector machine, support vector regression, soft-max regression, k-nearest neighbors, classification and regression tree, multiple regression model, logistic regression analysis, deep belief network, MLP artificial neural network, long and short term memory neural network. In other occasions, convolutional neural networks are used to predict the opinion of users based on images, as in the case of Suzuki et al. (2019) where various clock models were analysed.

In order to carry out the test, Aprilia et al. (2020) reserved a number of texts (1/3) to carry out the validation of the study. Most of the authors (Li et al., 2020; Suzuki et al., 2019; Wang et al., 2018; Wang et al., 2019) opted for k-fold cross validation for testing the regression model.

Sometimes the methods used are unsupervised. For example, Ali et al. (2020) used probabilistic latent semantic analysis to cluster the opinions of Uber users expressed on Facebook, Jiao and Qu (2019) analyzed the opinions of mice users using sentiment analysis, to test the results they analyzed diversity, effectiveness and concentration, finally Chiu and

Lin (2018) use data mining to detect the kanseis that are applied in semantic differential surveys.

4.5. Challenges in the application of machine learning to kansei engineering.

One of the key issues in using machine learning tools is that a large amount of data is required, and the data needs to be of high quality. A challenge for future research is to have data that truly reflects the opinion of the target sector. The use of online questionnaires (Li et al., 2021; Li et al., 2018) and the use paid recruitment of users may be valid to increase the number of valid responses (Chu, Chang, & Lin, 2020). In the case of images, small image modifications such as rotation or blurring can be used to increase the sample size.

In the application of kansei methodology, it is sometimes assumed that the people who participate in the experiments give the same meaning to the words used in the experiments (Dong et al., 2021). However, this is not always true. The user's interaction with the product provokes sensations that will be captured by the senses; however, the user's interpretation of this experience is subjective, which passes through the filter of cognitive processing (Dong et al., 2021). Previous studies have shown that the valuation of products differs by age, gender or educational background (Yeh & Chen, 2018; Zuo & Wang, 2020). Incorporating user characteristics into synthesis models is a major challenge. This decision requires more data to perform the calculations.

A decisive aspect for the use of machine learning models is to test the results obtained to check avoiding overfitting and underfitting. Sometimes this aspect is overlooked in the works analyzed, strategies for efficient use of the data must be used, this aspect increases the data needs for the model.

The Kansei Methodology provides models that allow us to predict the users' evaluation of certain sensations offered by the product, however, it is necessary to go deeper into the relationship between these sensations and the purchase decision.

5. Conclusions

As it has been shown in the communication, Kansei Engineering, far from being a closed methodology, with rigidly defined steps and strategies, presents a flexibility that can be very interesting for its application (Coronado, Venture, & Yamanobe, 2021). In this way, knowledge can be extracted by means of different strategies: questionnaires, electrophysiology, analysis of user comments and evaluations, etc.

The use of machine learning is trending topic in the scientific literature. This growth is being observed in the production of scientific papers in which machine learning is used for the synthesis phase in kansei engineering. However, aspects such as the inclusion of user characteristics in the synthesis model, the relationship between kansei and purchase options, as well as technical aspects of valuations such as the definition of new models, the evaluation of models and the optimization of the use of data need to be studied.

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