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Research paper

Customer preferences in car design using kansei engineering and cubic Bezier curve

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Abstract

This study is focused on fulfilling the customer's needs and also the organizations' need to organize their genuine phenomenal awareness to find out the customer outline inclinations before creating a specific item since customer design has turned into the essential worry of the organizations' technique. This study is to recognize and analyze the customers' preferences through car design by using mathematical concept known as Bézier curves. The approach is utilized as a part of the study to distinguish and study the consumer loyalty through the customer's preferences in designing a car. The cars are then categorized into two types which City cars and Sedan cars. These categories are controlled by the eight segments of cubic Bézier function. The customer's preferences towards car design can be denoted through the use of cubic Bézier curves.

Keywords: *Kansei Engineering; Cubic Bezier Curve; Semantic Differential; Car Design; Kansei Words.*

1. Introduction

In improving worldwide aggressiveness, an item improvement and assembling are two critical components for the business to reconsider of what is the best way to deal with the advancement of their items. Kansei Engineering has been utilized for new development and also for design a product [1]. Automotive outline had been examined throughout the years, in Japan, ergonomic and Kansei building techniques had been connected to find favored outline highlights by investigating the connections between plan qualities and client impressions [2]. In this way, with a specific end goal to stay aggressive, organizations ought to extend their plans by creating an item for all clients (speculation) since some of them are not having the capacity to sufficiently fulfil the need of consumers towards what is delivered and given. Creusen and Schoormans [3] clarified the parts of item viewpoint with six components: tasteful esteem, representative esteem, useful esteem, ergonomic item data, consideration attractions, and item order. As indicated by their experimental research, 65% of the respondents selected stylish factors as the explanation behind picking a specific item.

Whereas there are different consumers' needs, the useful and emotional necessities have been perceived to be of essential significance for consumer satisfaction [4]. The main challenge for fulfilling the feeling configuration is to handle on the consumers' emotional needs precisely and in this manner to plan the items that suit with the requirements. Nagamachi [5] has developed Kansei engineering a consumer oriented from innovation focused on the new item improvement. Meanwhile, Kansei is a Japanese word that implied a consumer mental inclination and picture in regards to a new product. Referring to Kansei words, all the consumers are guided to express their emotional needs, their sentiments, and their enthusiastic states. These emotional and sensory needs are then converted into perceptual outline components of the item. Kansei Engineering (KE) is also known as "the interpreting an innovation of a customer's feeling and image for an item into outline components. The most widely recognized method for estimating the Kansei is through words. The words reflect the components of the Kansei. They can simplify as the outer depictions of the Kansei inside a people mind. The encounters with vehicles bring out the feeling reactions in consumers; it is thusly the consumer who assesses the influences inspired by the collaboration with the vehicle, counting the implications appended to the vehicle and the enthusiastic experience [6-7]. Consumers' feelings can be produced through the cautious outline of the vehicle, for instance by determination of inside shading plans, leathers seats, atmosphere control and sound framework [8-9]. Feelings in this manner assume a noteworthy part in buying cars; emotional outline cannot be overlooked by designers [10-11]. Designers are currently extending the semantic approach to deal with configuration by using full of feeling plan parameters. Feelings are therefore important to design. Prior research demonstrated that items can summon forceful enthusiastic reactions. Girard and Johnson [12] have identified that the items can attracted the forceful reactions. Individuals' emotions about items are adapted to be influenced by the outside highlights for example, estimate, shape, shading, and surface. The more pertinent study on encountered items showed among all detects, vision obtained the biggest measure of apparent data passed on by the outside trademark components of an item and the data is the most serious [13].

A Bézier curve is a parametric function that used as a part of computer graphics and other related fields. One of the greatest points of interest of the Bézier curve is that the Bézier curve is additionally arched if the control point is a curved polygon, that is, the component polygon is curved. Likewise, it can portray and express free bends and surfaces concisely and consummately [14]. Furthermore, Bézier curves are parametric curve which are basically adjustable that suitable for some applications.

Several studies have explored Bézier curve in developing a car design. Pales and Redl [15] prescribed that the application of Bézier curve proved to be simple with only the number of control points n and the parameter t of Bézier curve were needed. The real application movement of vehicle in space replaced polygon composed from the line segments of Bézier curve, for which there are not discontinuous points. The curve fitting can be done in a plane or space. This study attempts to explore consumer's emotional responses towards Kansei Engineering and investigate its relationship with Bézier curve in developing a car design. Ultimately, the discovery of this relationship will enable the study to strategize a guideline to create new car design. This aim is in line with the idea of Kansei Engineering that is to incorporate consumer's emotion into car design. The findings of this study will also help the designer to use Kansei Engineering and Bézier curve can be used in producing a profile of car. The next section introduces the methodology, followed by the result and discussion and ends with the conclusion and several recommendations for future works.

2. Methodology

Preliminary test is conducted to find out the related Kansei words. In this study, the questionnaire is created using the Semantic Differential to model the features of car design accordingly to the customer's need. This questionnaire is then distributed to the 66 respondents. The questionnaire contained about the choosing of the Kansei words represented the design profile of cars. Respondents are required to rate each design of the side view of the car design profile according to five Kansei words. Moreover, this rating represents the respondent preference. Respondents are also required to state which the most design profile that they preferred. Table 1 shows a name of 20 car design for front view of City cars whereas Table 2 shows a name of 20 car designs for front view of Sedan cars. Every car is analyzed using GeoGebra software to determine the related parameter to be used in cubic Bézier curve.

Fig. 1 and Fig. 2 show the examples of the car design profiling identification of City Car and Sedan Car and its segmentation used. The segmentation segregated into four quadrants and each quadrant consisted of the side view. The side view is then connected using cubic Bézier curve. In this study, eight curves are applied to offer the visually pleasant in the design. The cubic Bézier function expressed as parametric equation below;

$$Z_n(t) = A_n(1-t)^3 + 3B_n(1-t)^2 t + 3C_n(1-t)t^2 + D_n t \quad (1)$$

Based on the curve variables from 8 curves of 20 cars design that are produced, this study is then continued to determine the overall average values of 20 cars using the normalization average. The normalization is given as;

$$Max - Min = Range\ (IndividualRange) \quad (2)$$

The maximum value from each range of 20 car design are deduct the minimum value to get the individual range. This study is also calculated all of the single range for every parameter Bézier curve. Add all the individual range and find it average to get overall range.

$$\sum \frac{IndividualRange}{x} = overallrange \quad (3)$$

X is the total of range of 20 cars design. Then, the individual range are divided with overall range.

$$\frac{IndividualRange}{0verallrange} \quad (4)$$

Find the max value from result of value after individual range and overall range are divided. The max value are used as indicated to determine the curve. Finally, the segmentation for every parameter of single individual Bézier curve is yielded. The individual minimum of every parameter Bézier curve is then added with the first control point, A. The segmentation denoted by

$$\begin{aligned} Min + A &= W\,(Range1) \\ W + A &= B\,(Range2) \\ B + A &= C\,(Range3) \end{aligned} \quad (5)$$

Tables I and II show the range for Bézier 1 for the 20 car design preference. The steps continue to be repeated for the Bézier 2 until Bézier 8.

Table 1: Name of Car Design for City Cars

No.	CAR BRAND	No.	CAR BRAND
1	Perodua Axia	11	Suzuki Splash
2	Mitsubishi Mirage	12	Toyota Etios Liva
3	Toyota Aygo	13	Opel Adam
4	VW Polo	14	Ford KA Studio
5	Hyundai i10	15	Fiat 500
6	Nissan Micra	16	Geely Panda
7	Aston Martin Cynet	17	Kia Picanto
8	Chevrolet Spark	18	Peugeot 108
9	Datsun Go +	19	Fiat Punto Evo
10	Honda Brio	20	Cherry QQ

Table 2: Name of Car Design for Sedan Cars

No.	CAR BRAND	No.	CAR BRAND
1	Alfra Romeo	11	Kia Quaris
2	Aston Martin	12	Lexus GS
3	Audi A4	13	Mazda 3
4	Audi S6 Avant	14	Mercedes Benz E
5	BMW 5 Series	15	Mitsubishi Lancer
6	BMW F80 M3	16	Proton Preve
7	Chevrolet Cruze	17	Proton Saga FLX
8	Ford Mondeo	18	Subaru Legacy
9	Honda Accord	19	Toyota Camry
10	Hyundai Sonata	20	Toyota Vios

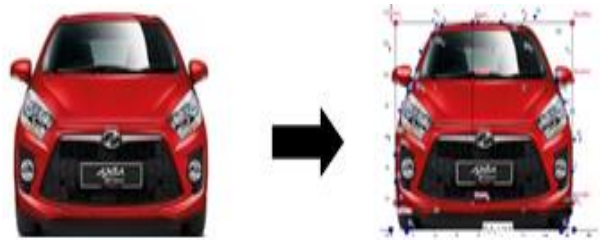
Fig. 1: Profiling Car Design Using Geiger for City Car.


Fig. 2: Profiling Car Design Using Geiger for Sedan Car.

Table 3: Example of A Range in Bezier 1 (City Car)

Car Name	X - Axis				Y - Axis			
	A_1	B_1	C_1	D_1	A_1	B_1	C_1	D_1
Perodua Ayla	1	3	3	3	2	2	2	2
Mitsubishi Mirage	3	1	1	1	3	1	1	2
Toyota Aygo	2	1	1	1	2	2	1	2
VW Polo	3	2	1	1	3	3	3	3
Hyundai i10	2	1	1	1	2	2	1	3
Nissan Micra	1	1	1	1	1	1	1	2
Toyota iQ Asron	2	1	1	1	1	2	2	3
Chevrolet Spark	2	1	1	1	1	1	1	2
Datsun Go T	2	1	1	1	1	1	2	3
Honda Brio	1	1	1	1	1	3	3	3
Suzuki Splash	2	1	1	1	1	1	2	2
Toyota Etios Liva	2	1	1	1	1	1	1	1
Opel Adam	1	1	1	1	1	1	1	2

Ford KA Studio	3	1	1	1	2	2	2	3
Fiat 500	2	1	1	1	1	1	1	2
Geely Panda	2	1	1	1	2	1	1	2
Kia Picanto	2	1	1	1	2	1	1	1
Peugeot 108	1	1	1	1	2	1	1	2
Fiat Punto Evo	1	1	1	1	2	1	1	2
Cherry QQ	3	1	1	1	3	2	2	3

Table 4: Example of A Range in Bezier 1 (Sedan Car)

Car Name	X - Axis				Y - Axis			
	A_1	B_1	C_1	D_1	A_1	B_1	C_1	D_1
Alfa Romeo	2	3	1	1	2	3	4	4
Aston Martin	5	4	2	2	3	4	3	5
Audi A4	3	2	1	1	4	4	2	4
Audi S6 Avant	3	1	4	2	5	4	1	2
BMW 5 Series	3	2	2	1	2	6	4	4
BMW F80	2	2	1	3	2	4	4	5
Chevrolet Cruve	6	4	5	4	3	3	3	4
Ford Mondeo	5	4	2	4	4	3	1	1
Honda Accord	4	1	4	3	2	3	1	1
Hyundai Sonata	5	5	6	6	3	3	2	3
Kia Quaris	3	1	1	2	4	3	6	5
Lexus GS	5	5	6	6	3	3	2	3
Mazda 3	4	3	4	5	4	4	4	6
Mercedes Benz E	1	2	2	1	4	5	4	4
Mitsubishi Lancer	4	1	1	2	1	1	3	4
Proton Preve	5	2	2	1	2	2	2	4
Proton Saga FLX	5	6	5	5	6	4	3	3
Subaru Legacy	2	2	1	1	2	3	2	4
Toyota Camry	3	3	2	1	1	1	1	3
Toyota Vios	1	4	2	1	5	5	3	4

3. Methodology

For the preliminary test, there are 45 male respondents and 21 female respondents, which give 66 as in total. From the 30 Kansei words, the result of Kansei words that the most respondents chosen are Stylish, Safety, Luxury, Sporty and Comfortable. These Kansei words are an improvement approach that converts customers' impressions and sentiments on items. Meanwhile, for the main result, the total respondents are 171 and the gender for the male are 72 and female is 99 respondents. Based on the survey, six car designs for City Car have highest number of choice namely Toyota Aygo (FV1), VW Polo (FV2), Hyundai i10 (FV3), Toyota Etios Liva (FV4), Chevrolet Spark (FV5) and Peugeot 108 (FV6). For Sedan Car, six car designs are Aston Martin Rapid S (FV1), BMW F80 M3 (FV2), Mazda 3 (FV3), Merceredez Benz E Class (FV4), Mitsubishi Lancer (FV5) and Hyundai Sonata (FV6). Every word was analyzed in order to determine each particular word that would give the best representation of designs proposed. Table 5 shows the average analysis for front view of City Car gave the Comfortable value scored the highest average among the six design of cars. This Comfortable is appeared in front view 3. Meanwhile, Table 6 shows the average analysis for front view of Sedan Car. Luxury word gives the highest value in Sedan Car showed in front view 2 and front view 3. From Table 5 and Table 6, we can summarize that the car design that customer preferred based on the ranking number of average analysis. According to Table 7, respondents tend to choose Toyota Aygo (FV1), Hyundai i10 (FV3) and Chevrolet Spark (FV5) for City Car. For Sedan Car, three car designs consisted of the highest Kansei words namely BMW F80 M3 (FV2), Mazda 3 (FV3) and Mitsubishi Lancer (FV5). From these three car designs selected, the range of the three car design is listed out in Table 9 and Table 10. This range is based on the prevoius range in Table 3 for City Cars and Table 4 (Sedan Cars).

After all ranges are listed out (Tables 9 and 10), each value is then collected and employed in Geogebra for a new curve for a car design preferences based on the car design selected. In designing a product, designer must explore the customer's preferences towards the product. Based on the result, we can conclude that the appearance of the car design can influence the consumer choice in different ways. Based on the survey, the choice of customers is also influenced by a colour of the car design. Bright colour attracted more to the respondents. In addition, the amount of male respondents and female respondents are not equaled which having female respondents are 99 and male respondents are 72. It was discovered that females pay more attention for whether the thing fitted into their life than male, this may not exclusively be the situation for machines but also for other item categories [16]. These results were also supported and achieved the idea to find out customer preferences using Kansei words towards car design through the use of Bézier curve. Based on Dekkers [17], it revealed that Bézier curve are a good fundamental for a program or makes a strong numerical and algorithmically establishment where all future works can be used. Therefore, this description can support the findings in this study. The pictures used in this study are in 2D model with small scale, this also affected the choice of respondents because the respondents cannot be seen the pictures in survey clearly. The picture might need a better precision.

Table 5: Average Analysis for Front View City Car

	STYL	COM	SAFE	SPORT	LUX
FV1	3.37	3.30	3.26	3.25	3.06
FV2	2.58	2.88	2.87	2.72	2.47
FV3	3.41	3.57	3.50	3.18	3.22
FV4	2.98	3.04	3.06	2.89	2.80
FV5	3.22	3.51	3.41	3.10	3.16
FV6	2.72	3.17	3.27	2.70	2.86

Table 6: Average Analysis for Front View Sedan Car

	STYL	COM	SAFE	SPORT	LUX
FV1	4.16	4.20	4.28	4.10	4.30
FV2	4.77	4.64	4.55	4.59	4.89
FV3	4.76	4.66	4.57	4.48	4.89
FV4	3.97	3.96	3.99	3.82	3.94
FV5	4.59	4.57	4.45	4.51	4.64
FV6	4.06	4.23	4.20	4.32	4.17

Table 7: Ranking of Average Analysis for Front View City Car

	STYL	COM	SAFE	SPORT	LUX
FV1	5	4	3	6	4
FV2	1	1	1	2	1
FV3	6	6	6	5	6
FV4	3	2	2	3	2
FV5	4	5	5	4	5
FV6	2	3	4	1	3

Table 8: Ranking of Average Analysis for Front View Sedan Car

	STYL	COM	SAFE	SPORT	LUX
FV1	3	2	3	2	3
FV2	6	5	5	6	6
FV3	5	6	6	4	5
FV4	1	1	1	1	1
FV5	4	4	4	5	4
FV6	2	3	2	3	2

Table 9: Range of three Cars for Front View City Car

	X-axis				Y-axis			
FV1	1	3	3	3	2	2	2	2
FV3	2	1	1	1	2	2	1	3
FV5	2	1	1	1	1	1	1	2

Table 10: Range of three Cars for Front View Sedan Car

	X-axis				Y-axis			
FV1	2	2	1	3	2	4	4	5
FV3	4	3	4	5	4	4	4	6
FV5	4	1	1	2	1	1	3	4

4. Conclusion

The objective of this study was to determine the customer preferences by using Kansei Engineering and cubic Bézier Curve. This study has identified that Kansei words can be successfully used to find out the customer preferences towards car design. Comfortable for City Car and Luxury for Sedan Car are the mainly preferred by the respondents whereas in car design, respondents have selected Toyota Aygo (FV1), Hyundai i10 (FV3) and Chevrolet Spark (FV5) for the City Car. Meanwhile for Sedan Car, three car designs that selected by respondents are BMW F80 M3 (FV2), Mazda 3 (FV3) and Mitsubishi Lancer (FV5). This study also described how to use Bézier curve by using Geogebra software in the complex forms. This study started with mathematical equation for Bézier curve, then described some calculation on how to find the range for every Bézier curve. For this study, the range of Bézier curve are determined from Bézier curve 1 until 8. The range of each category in selected car design is identified. The car preferences previously are combined and the new range of cars is also determined. Thus, the new curve of each car types can be developed and known as Bezier 1 until Bezier 8. This study is suggested to create a new curve of car design using the range. The range for front and back view of cars are from Bézier 1 until Bézier 8, meanwhile for side view there are Bézier 1 until Bézier 12. The image or picture also required to be more visible to the respondents by enlarging them.

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