An Approach to Design a Smart Helmet Using Kansei Engineering

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Abstract— Motorbikes have been a great medium of transportation among many people for decades. Nowadays, road accidents are much prominent on roads, and the tendency for motor bike users to get affected by those accidents is high. Owing to the reason that motorbike users are exposed to the outside world, their death rate is at a higher rate. Moreover, there is an increased rate of injury other than the deaths that occur as a result of road accidents. Though there are various helmet designs, they only ensure the safety of the motorbike riders to some extent. Therefore, there is the need to design a smart helmet that secures the lives of motorbike riders. Nevertheless, various smart helmets have been designed for the safety of motor bike riders integrating much more functionalities. This study mainly focuses on designing a smart helmet using the Kansei Engineering principles. This paper presents the design of a smart helmet that involves identifying the motorbike riders' emotions and integrating those results in designing the smart helmet.

Keywords: ***Kansei engineering, smart helmet, human emotions, safety, designing***

I. INTRODUCTION

At present, road accidents have reached a state that has caused fatal injuries and deaths to many people. Therefore, this crucial issue requires greater attention and this must be addressed with design approaches to the helmets that are a major component that secures the lives of motorbike users. Moreover, safety and security are crucial in every aspect of human lives andhen the roads are considered (Divyasudha, et al., 2019).

Among the road accidents, motorbike accidents are increasing rapidly and have caused many deaths to road users. Helmets can reduce the probability of the negative aspects of road accidents (Jesudoss, et al., 2019). Also, it has been compulsory for motorbike riders to wear helmets when they ride on roads and it is essential to force drivers to wear them. On the other hand, the conventional helmets are uncomfortable and inconvenient to use and thus, this results in avoiding the motorbike riders to wear them (Divyasudha, et al., 2019).

The major driving causes for society to move into the use of motorbikes is that bike riding is considered as a fun activity, cheaper to afford, flexible in traffics, and easier to park. This higher usage has also caused the tendency of insecuring the lives of motorbike users. Influence of alcohol consumption and violating traffic rules has been identified as a reason for the fatal accidents that cause on roads (Nataraja, et al., 2018) (Pathak, 2020). Nevertheless, the root cause of the accidents that occur may not be the fault of the motorbike rider but a fault of some other vehicle driver (Gour, et al., 2020).

With the development in every aspect of the fast moving world, the work associated with people increase rapidly and this results in the mental and physical nature of humans result in forgetting the wearing of the helmets (Gudavalli, et al., 2017).

The development of the smart helmet we propose is done basically using Kansei Engineering principles. Kansei Engineering was founded at Hiroshima University 35 years ago and is a strategy that converts the customer psychological feelings into design elements (Kalansooriya, 2016). Also, it can be defined as a branch of Ergonomics that focuses on developing new products based on the demands of the consumer and, therefore, as a consumer-oriented technology (Nagamachi, 1996).

The figure 1 depicts the flow of Kansei Engineering that involves the conversion of human emotions into design specifications.

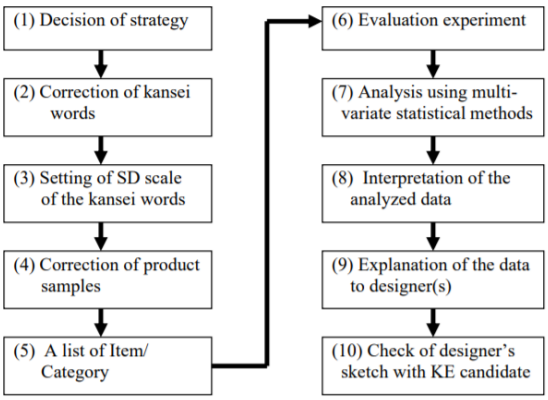

Figure 1. A diagram for the flow of Kansei Engineering
Source: (Nagamachi, et al., 2019)

Section 2 of this paper deals with the related works on smart helmet designing that identify the Kansei words for the proposed system. Section 3 presents the methodology of the proposed smart helmet that involves the Kansei Engineering principles in its approach. Section 4 presents the results of the conducted study and section 5 provides the discussion and conclusion section of this paper.

II. RELATED WORKS

Research done by (Muthiah, et al., 2015) have designed a smart helmet for automatic control with the functionality of security system for the bike rider with the usage of exemplary helmet and maintain the control of headlamps using smart techniques such as intelligent headlamps that are capable of reacting by understanding the movement of rider's face and lead to the rotation of headlights using electric motors with the use of sensors and accelerometer. Improvising the rider's vision and ensuring the safety of the rider are the main objectives that have been focused by this paper with the intention of making a prototype model. It has further concluded that with the project's progress, consciousness would rise for road security for riders.

A smart helmet has been designed by (Nataraja, et al., 2018) where they have focused on two-wheelers instead of four-wheelers as motorcyclists face fatal accidents due to drunkenness, disobeying traffic rules; the main reason, according to them, is not wearing helmets. The suggested system is an intelligent helmet that can detect whether the rider wears the helmet or not. It has also been proposed to add a module to the bike and to the helmet to sync with each other to check whether the rider puts the helmet on. If the helmet is lost, it has provided an android application that can be used for igniting the bike using a password. Also, they have suggested reducing the size of the system by embedded components on the controller and making the system friendly, enduring and economical.

In another research, the researchers (Pathak, 2020) have designed a smart helmet with a motorbike unit for accident and rash driving detection. The helmet unit and motorbike unit are the two units discussed under the project. The helmet unit can detect the pulse rate of the motorcyclist using a pulse rate sensor to recognize whether the motorcyclist has put on the helmet or not, alcohol in exhaling is detected by sensors and further detects the positioning of legs and hands of the motorcyclist. There are GPS and GSM modules in the motorbike unit to direct a message with the location where the motorcyclist faces an accident. There is an accelerometer in both units to distinguish accidents. Rash driving, proceed vehicles towards and from behind are detected by using LIDAR sensor, place in motorbike unit which starts alarming to inform the rider and by the way a text is displayed on the OLED screen.

Researchers (Kanetkar, et al., 2020) have proposed a smart helmet wiper that detects the presence of water droplets over the eye shield through sensors and the wiper starts consequently. Adjusting the speed of the wiper is done automatically by the wiper itself and it integrates a switch at the ear shield that can be used at some instance to stop the functionality of the wiper. The main objectives of this project are to give a clear vision for the motorcyclist in the rain when he is wearing the helmet and thereby reducing road accidents that occur due to lack of clear vision.

Another system proposed by (Sasikala, et al., 2015) has aimed to safeguard motorcyclists through helmet recognition. RF communication

is used to detect whether the rider has worn the helmet and then ignites the engine to start the motorcycle. To avoid unauthorized access, a passkey is provided by the motorcyclist to start the bike.

The smart helmet Raphael designed by (Lokeshwaran, et al., 2020) has added the feature that can automatically dial to the ambulance service at the instance of an accident. Current technologies like smartphones and IoT are used in the system to maximize the system's functionality and lower the overall cost of the system.

The researchers (Rahman, et al., 2019) have designed a smart helmet indicator warning refined oil in a motorcycle with fuzzy logic and sound navigation. Though there is a fuel meter in the motorcycle, motorcyclists need an immediate warning if gasoline runs out due to some breakdown. Therefore the proposed system has the capability of indicating the level of fuel in the tank using the readings taken from buoys in the tank and then sends a voice warning to the motorcyclists through a microcontroller fixed in the tank to the microcontroller fixed on the helmet and then to the speaker attached to the helmet.

The proposed system by (Rahman, et al., 2020) consists of IR for detecting whether the motorcyclist wears the helmet or not, alcohol sensor to detect alcohol level in a breath of the motorcyclists. The system has been designed to prevent accidents and decrease the fatality of accidents by making sense in wearing helmets to ensure the safety of the motorcycle riders.

The objective of the system designed by (Chandran, et al., 2016) is to detect and report accidents to emergency contacts using a cloud-based service. Changeable variations that are taken from using accelerometer values, are sent to the processor and then to the cloud base service. Though the technology used in developing and operating the system does not give many expenses and ensures the protection of the motorists, and the safety of using this technology is not yet compromised. It has been proposed to include the feature of detecting alcohol quantity in the rider's breath in future implementation.

Another research done by (Ahuja & Bhavsar, 2018) has designed a microcontroller-based smart helmet using GSM and GPRS. They have mainly focused on the deaths that occur due to the late arrival of an ambulance or late medical services in case of motorcycles accidents. Therefore, it has included GSM and GPRS with the microcontroller to this proposed system to receive immediate services. The sensors included in the helmet can detect when an accident is met with the rider, then the location is tracked by GPRS and using GSM, an immediate voice message and a text message are sent to the responsible individuals. They have concluded that implementing this project is better for people in rural areas with fewer facilities to obtain police, ambulance, and crowd services.

III. METHODOLOGY

The methodology of designing the smart helmet proposed through this paper is done using the statistical procedure of the Kansei Engineering principles. The following are the basic steps that involve in the process.

1. Gather the Kansei words from the reviewed literature on smart helmets
2. The collected Kansei words are arranged in 5-point Semantic Differential(SD) scale
3. Evaluation experiment using the target group of people
4. Statistical Analysis of the Kansei words obtained from step 3
5. The highest-rated Kansei words are addressed using a questionnaire
6. Analyse the questionnaire results
7. Interpret the results to collaborate with the designers

A. Collection of Kansei words

Table 1. Kansei word collection

Inspiring	Attractive	Durable	Light	Safety
Relaxing	Non-distractive	Creative	Cheap	Trendy
Friendly	Comfortable	Luxurious	Heavy	Sporty
Pleasure	Satisfying	Complex	Unique	Smart
Expensive	Functional	Convenient	Stylish	Modern

Table 1 depicts the 25 Kansei words that are gathered from the reviewed literature based on smart helmet designing that can also be defined ad a new database for a smart helmet. These Kansei words mirror the requirements of the

target users of the smart helmet and help propose new designs.

B. Importance weighting using the SD Scale

Table 2. Total Grades and weighting of Kansei words

Kansei Word	Total Grade	Importance weighting
Smart	155	0.775
Safety	164	0.82
Non-distractive	154	0.77
Comfortable	172	0.86
Friendly	120	0.6
Modern	107	0.535
Expensive	81	0.405
Attractive	172	0.86
Functional	179	0.895
Durable	137	0.685
Unique	95	0.475
Stylish	89	0.445
Cheap	96	0.48
Convenient	104	0.52
Light	131	0.655
Complex	83	0.415
Creative	93	0.465
Relaxing	108	0.54
Trendy	89	0.445
Heavy	75	0.375
Luxurious	90	0.45
Sporty	78	0.39
Inspiring	108	0.54
Pleasure	128	0.64
Satisfying	117	0.585

The 5-point SD scale is used to obtain the evaluations on the collected Kansei words. For easy evaluation, the 5-point SD scale is more suitable (Nagamachi, et al., 2008). Therefore, this SD scale is used in this research for receiving the respondent's preference. In order to determine the importance of each Kansei word shown in Table 1, those words are weighted and the most weighted Kansei words would be addressed in the questionnaire. The weight of each Kansei word is calculated as shown below.

Word weight= (Word's total grades)/ (5*no. of participants)

The Kansei words along with the 5-point SD scale were distributed among 40 motorbike users. Table 2 depicts the grades and importance weightings of each Kansei word in Table 1 that have been analysed through the results obtained from the responses from the 40 participants.

C. Kansei words addressed in the questionnaire

According to the word weights obtained from the importance weighting, the highest scored Kansei words are functional, attractive, comfortable, safe, smart and non-distractive.

D. Questionnaire Formation

The questionnaire prepared consists of four sections where section 1 involves the participants' demographic details, and sections 2, 3 and 4 deal with the functional and non-functional features of the smart helmet. Moreover, the questionnaire focuses on the six Kansei words that scored highest from the importance weighting questionnaire that was distributed in the early stages of the research. The questionnaire was distributed among the same 40 participants who were involved in rating the Kansei words.

IV. RESULTS

A. *Smart Helmet Appearance Analysis*

The smart helmet appearance was divided into three main sections, namely, Shape, Type and Colour.

1) Smart Helmet Shape Analysis: Among the shapes that are more prominent and identified as the head shapes of the individuals, Round Oval, Intermediate Oval and Long Oval were questioned by the participants for their preference. The preference was to be chosen from a five liked scale and according to the importance weighting of the results, the highest preferred shape was identified as the Intermediate Oval.

Table 3. Total Grades and weighting of Helmet Shapes

Helmet Shape	Total Grade	Importance weighting
Round Oval	138	0.69
Intermediate Oval	190	0.95
Long Oval	94	0.47

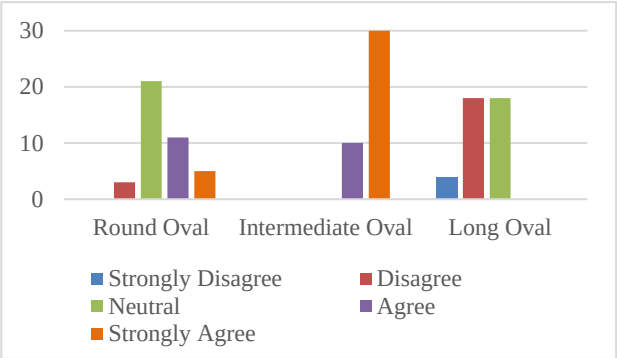

Figure 2. Smart Helmet Shape Preference

2) Smart Helmet Type Analysis: The participants were asked to choose between the Full face and Flip up helmets. According to the participant responses, 67.5% of the participants prefer Flip-up Helmet and 32.5% prefer Full-face helmets. With the flip-up helmet, the rider may use the smart helmet as a normal helmet.

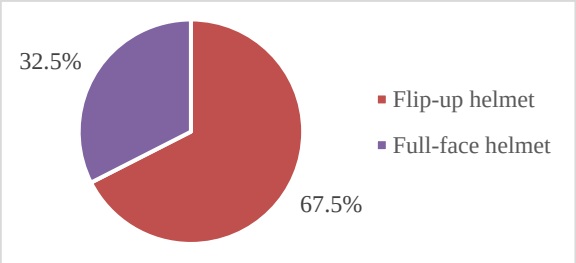

Figure 3. Smart Helmet Type Preference

3) Smart Helmet Colour Analysis: A range of colours was put into a liked scale for the respondents to mark their preference for using the highest preferred colour for designing the smart helmet. The colours questioned were black, ash, dark blue, yellow and white. The highest importance weighting is for the colour black and the value is 0.96. Ash, Dark blue, Yellow and White colours obtained 0.74, 0.765, 0.38, and 0.41 importance weightings respectively. Accordingly, Black colour was chosen for the smart helmet to be designed.

B. *Smart Helmet Material Analysis*

The material analysis was done for the three main components of the smart helmet, namely, Shell, Visor and Liner/Padding.

1) Smart Helmet Shell Material Analysis: The participants were questioned about the Composite material, Carbon fiber, Fiberglass, Kevlar, and Acrylonitrile Butadiene Styrene(ABS) for the shell material of the smart helmet. 55% of the respondents prefer Carbon fiber as the shell material. Carbon fiber has higher durability, scratch and crack resistivity, and its strength is much higher than steel. Also, with carbon fiber, helmets can be made lighter so that much easy to be worn.

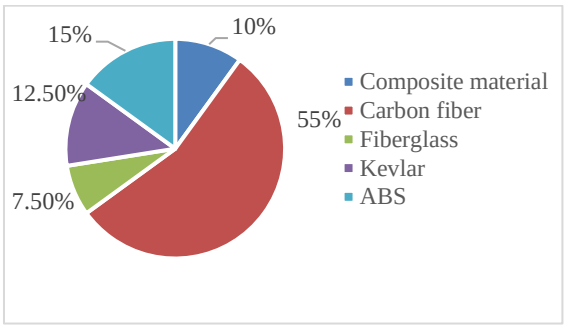

Figure 4. Smart helmet Shell Material Preference

2) Smart Helmet Visor Material Analysis: The participants were asked to choose between the Glass and Polycarbonates as the visor material. 67.5% of the participants prefer Polycarbonates as the visor material. Polycarbonates are with an impact of resistance a much hundreds higher than glass and with higher strength with easy installation.

3) Smart Helmet Liner/Padding Material Analysis: As the Liner/Padding material of the smart helmet, Expanded Polypropylene(EPP) foam, Expanded Polyurethane(EPU) foam, and Expanded Polystyrene(EPS) foam were questioned from the participants and 60% of the participants prefer EPP and EPS and EPU are preferred 20% each. EPP foam is highly durable, multiple impact-resistant with outstanding energy absorption, rigid and lighter.

C. *Smart Helmet Functional Analysis*

In this study, functionalities of the Smart Helmet have been divided into two sections, mainly as the smart helmet features and optional features. This division has been done based on the Kansei Keywords that have been selected at the early stages of the research process.

The optional features include the smart helmet features that are considered optional since Non-distractive is a concern in this study. Therefore, it

is optional for the respondents to select those features for the smart helmet designing.

1) Smart Helmet Feature Analysis: Table 4 includes the features and the respondents' preference as a percentage value for the smart helmet features questioned in the questionnaire. According to the results obtained, the features F1, F2, F6, F7, F8, F9, F10, F11 have been selected to be included in the smart helmet to be designed.

2) Smart Helmet Optional Feature Analysis: Table 5 despicts the results obtained for the optional features included in the questionnaire. From the results obtained, optional feature O2 has been selected for designing the smart helmet. All the other optional features are with less preference as shown in Table 5.

Table 4. Smart Helmet Features and Percentage Preference

Feature	Preference
F1. A/C Integrated	95%
F2. Camera mounted	70%
F3. Airbag integrated	35%
F4. The vehicle ignites only with wearing the helmet	20%
F5. Detecting obstacles in front	42.5%
F6. Alcohol detection and prevent starting the vehicle	92.5%
F7. Smoke detection and alerting	80%
F8. Accident detection and alerting the emergency contact with the location	82.5%
F9. Alerting on over speed	77.5%
F10. Driver drowsiness detection	55%
F11. Battery backup	67.5%

Table 5. Smart Helmet Optional Features and Percentage Preference

Optional Feature	Preference
O1. Bluetooth connectivity with the phone	47.5%
O2. Play and listen to music	87.5%
O3. Make calls	45%
O4. Voice commands	45%

D. *Smart Helmet General Opinion Analysis*

In the final section of the questionnaire, the participants were asked to provide their opinion on the concept of Smart Helmet, whether Strongly Agree, Agree, Neutral, Disagree, or Strongly Disagree. According to the results obtained, it is observed that many participants have a positive idea of the Smart Helmet concept. 22.5% of the participants Strongly Agree and 55% of the participants agree on the concept of Smart Helmet, while 22.5% of the participants stay Neutral.

E. *Smart Helmet Design*

Figure 5 depicts the smart helmet that has been designed following the Kansei Engineering principles as discussed above. As shown in figure 5, the designed smart helmet is a flip-up helmet.

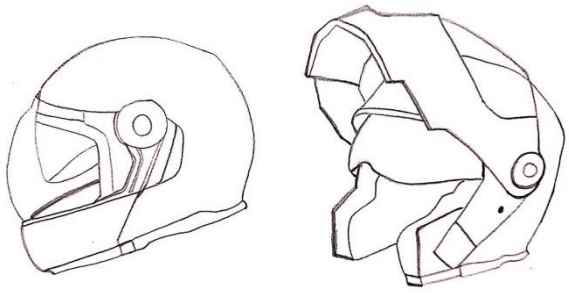

Figure 5. The Designed Smart Helmet

Although the proposed smart helmet is with a feature of A/C integration that requires a full face helmet, since the respondents prefer to have a flip-up helmet, the designed smart helmet is with the option for the user to use it as a flip-up helmet as well. Furthermore, the designed smart helmet will include all the features and functionalities that have been identified in the Results section of this paper.

V. DISCUSSION AND CONCLUSION

The smart helmet concept is being used widely worldwide, and many such brands have taken a position in the helmet designs. Nevertheless, some countries like Sri Lanka still have not given the authority for the motorbike riders to use the smart helmet for their day-to-day ridings and on the other hand, full face helmets have also been banned by the Sri Lankan government for the general use of the bike riders. Despite this fact, when the above study is concerned, it is clear that people have a positive attitude to incorporate smart helmets for their ridings. This study has aimed to incorporate Kansei Engineering principles to the smart helmet design proposed here, which involves human emotions in the design phase.

In fact, the smart helmet concept has greatly assured the safety and comfortability of individuals with the multiple integrated features to provide the functional aspect of the smart helmets. Nowadays, accident prevention is of great concern because many valuable lives are at a higher risk of drunkenness and drowsiness. Therefore, the proposed smart helmet assures the above-discussed issues with driving. Furthermore, as discussed in the Methodology section, many more features have been proposed to be integrated into designing the smart helmet.

However, before incorporating smart helmets for general use, a much authentic evaluation must be carried out to guarantee the safety and efficiency of the motorbike users and other road users. Moreover, individuals must be made well aware of the use of the new technology. In addition, since this paper presents a Kansei engineering approach that identifies the design considerations along with the appearance and the functionalities to be integrated while developing a smart helmet, there is a significant and essential need concerning the health aspects while designing the smart helmet that is proposed here. Therefore, the authors suggest obtaining the ideas of the relevant medical authorities and researchers while developing the smart helmet that is proposed, ensuring the safety of the bike riders who are to wear this smart helmet.

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