Texture assessment of automobile dashboard: An integrated approach to industrial design and ergonomics

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Abstract

In this paper, the main objective is ergonomics evaluation of automobile's dashboard to devise suitable designs based on textures and patterns. Undoubtedly appropriated dashboards' design based on textures might be ended to more driving safety, in which the tactile-real and visual-implied texture of a surface should be considered. In this study, data was gathered by in-depth observation and questionnaires. Expert volunteers who not only used their cars frequently but also were fairly sensitive to the effects of visual and tactile items in dashboard design automobile's manufacturers. Statistical data analyzing shows improving texture in dashboard design has a significant influence on drivers'. The need to take repeated glimpses in order to distinguish the operation of each button will diminish an issue significantly decreasing accident risk. The results show the interaction between the product textures will be ended to users' satisfaction and also product's feature and performance. This study clarifies the significance of dashboard texture, so industrial designers are expected to work harder to make better use of textures in designing product elements

Keywords: *Car console, Design, Ergonomics, Texture*

1. Introduction

The visual appearance of products is a critical causal factor of consumer response and product success. Judgments are often made on the elegance, functionality and social significance of products based largely on visual information. These judgments relate to the perceived attributes of products and frequently focus on the satisfaction of consumer wants and desires, rather than their needs.

Nami (1999) recognized that customer's perception of a product quality is associated with the product texture. Customers perceive a surface quality using multiple sensory modalities, for example, vision and touch, and switch them through an interaction with a product. Human beings often predict modal perceptions using a prior modality, for example, predicting the tactile quality of a product from its appearance before actually touching it (Nami, 1999: 23).

Also, surface texture is going to become one of the most important aspects influence on the vehicle center-console operation (Hakimi, 2010: 12).

According to Landy and Graham (2004), there are some factors which are related to dashboard knobs and controls design such as:

1- Recognition of the element
2- Comprehension of the function
3- Ease of operation
4- Driver attendance and crash risk reduction
5- using pleasure

Facilitating the interaction of the user with dashboard functions associates surface texture. Product surface patterns can be chosen according to the component's particular operation and with the aim of improving the practicality and aesthetics of the constituent (M. Ackerman et al, 2010:36).

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The texture is one of the surface qualities which can act as a visual-tactile medium. It can be actual-felt by touching, or merely visual. The patterns and the templates used to build texture which repeats in the middle-layer of the surface, influence the judgment made about direction and curvature of the surface (Hakimi, 2010:15). Moreover, the material used in the product can also affect its affordance which is specifically related to the performance of the product.

Texture refers to the tactile/real and visual/implied texture of a surface. Patterns based on thought are usually either decorative or used to increase ease of use of products. Each of the mentioned texture patterns suggests its specific purpose besides the chance of improving performance. For instance, microtexture and microtexture are generally recognized as the primary wavelength scopes that influence tyre/road interactions. European certified that increasing macro texture had resulted in the reduction of total accidents, under both wet and dry conditions (Huang, Huang, 2014). Patterns applied on the surface of an automobile tire are to increase road surface and tire friction. Ragged handles of certain tools have their own performance related functions. Patterns inscribed on ATM machine buttons, patterns used in pavements to guide the Visually-Impaired and patterns on door handles are also meant for their own specific purpose. The second type, however, is accidental patterns. Those created by coincidence: e.g. bricks poured on construction sites or sands at the seaside, also the random and unexpected patterns a computer program may create, etc. (Landy, 1991:1011).

Investigating different problems of auto-guidance has been applied by various kinds of methods and analysis such as Fault Tree Analysis. As can be seen obviously in this study based on objectives and conclusion, this method hasn't been applied (Dobrivoje et al, 2014:32).

Such facilities often require driver's visual attention and visual workload has shown significant time reduction of eyes-on-the-road. In this paper, we illustrate and compare two different interaction techniques used by in-vehicle facilities. We refer to these as “Tactile”, and “Gesture Recognition” interactions. Our focus on these techniques is based on their effect on driving. These interaction techniques will be evaluated by 16 subjects in two settings (modes). The results illustrated that “Gesture Recognition” systems enormously affect the number of eye glances and especially gazes the driver needs in order to operate a task. “Gesture Recognition” system still requires rapid eye glances for hand-eye coordination.

human factors engineering play important roles in the design phase (Landy, Bergen, 1991:681).

2. Methods:

In this case-study, the data were gathered by in-depth observation and questionnaires. The purpose of this study is to discover a correspondence between product textures and consumer’s sense, then generating specific guideline for designing in future also we conducted to analyze the cognition difference of visual and imagined haptic inputs based on product texture.

The data were gathered into two phases. In the first phase, questionnaires were distributed among 20 volunteer drivers who had precise interaction with their vehicles in the first phase, the interviews focused on drivers’ behaviors and observations. During the first round of interviews, the designer used questionnaires to collect some data (including time length of driving in daily life, the difference in driving behaviors on weekdays and weekends, using conditions of phones and another mobile device.). The object of these two phases of interviews was getting a sense of user’s driving attitudes and behaviors, and at the same time exploring potential design concepts based on actual car driving activity. In the second phase, questionnaires were distributed among expert volunteers who not only used their cars frequently but also were fairly sensitive to the effects of visual and tactile items in dashboard design.

In this research, we investigated new interaction techniques which aim to make it easier and safer for the drivers to interact with their cars.

3. Effect of texture on the surface product:

The texture is one component of aesthetics which has undeniably role in the function of the product. Although function is the synthesis of form Ergonomic, anthropometry, anatomy, and human factors engineering can play an important role in the design step, texture has implied a substantial role in all these factors (Klatzky et al, 1989:52-53).

The attractiveness of a product depends strongly on how we perceive the product with all our senses in relation to the expected performance of the product. The charismatic sides of a product are normally related to its aesthetics. However, this statement is an oversimplification, since the attractiveness of the product is related to how we perceive the product with all our senses in relation to what we expect to get the product. The products should have something more. Ergonomic, anthropometry, anatomy, and

A. There are three dimensions of texture:

1. Tactile quality of surface

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2. Tactile quality of manipulated three - dimensional substance
3. the visual quality of surface and substance

B. Determinants of texture depend on the medium

C. An aspect of texture:

1. Surface Contour is the deviation from smooth
2. Surface Friction is the resistance to slipping/slide
3. Thermal Character or how surface feels to the touch
4. Hand refers to the tactile qualities of a manipulated three-dimensional substance

Artists may display the texture in their artworks by implying verity of parameters such as selecting different materials, deciding on the distinct size of patterns and by use of various shapes. The texture of the surfaces in a painting, a room, a set, and costumes can change the mood conveyed to the view (Caelli, Julesz, 1978: 93). The same structural design in three different textures can convey three different psychological moods. The texture pattern of a product is directly related to its affordance. Defining affordance as an operation being in agreement with its presenting icons places surface texture among the most influential factors of affordance (Julesz, 1981: 95). Surely, knobs' patterns should be designed according to its function, for instance, among the ATM buttons convex curved surfaces cannot be used by the blind, as this kind of texture decreasing the ATM performance (Figure 1).

Significant biological benefits have been reported (Larsen-Basse, 2004):

• For mechanical seals a 30% reduction in friction, reduced leakage, and 2-10X increase in breakdown load

• Similar friction reductions claimed for automotive piston rings, planar thrust bearings, and some tools

• Another reason in choosing texture patterns for a product is given personality to it. Deciding on a texture pattern for a product can be carried out in a way that attributes the product to a particular group of people or reminds a specific lifestyle (Figure 2-4).

Fig1. Texture applied to ATM for blind person [source: ww.zidbits.com]

Fig2. Designed by RosLovegrove, use of texture intensifies the form [source: www.designboom.com

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Fig3. Zaha Hadid separates space by texture and this usage of textile influences lighting

Fig4. In these speakers, texture is applied for functional reasons

Fig5. Proper usage of texture prevents fingers form slipping

Fig6. Applying texture on interior components decreases glossiness, which leads to a vivid vision when looking at the buttons

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Fig7. Applying texture on interior components decreases glossiness, which leads to a vivid vision when looking at the buttons

Fig8. The 2000 BMW 325i interior (left) and 2013 BMW 325i interior (right)

Shou yuan (2014) certified that most car manufacturers are making great efforts in designing and promoting In-Vehicle Information System (IVIS), which combines traditional car functions with internet radio, social-networking communication and other forms of internet connection. One of the most compelling illustrations of IVIS is the big screen based navigation system. If you compare two same model cars (BMW 325i) from 2000 and 2013(Figure 8), you will clearly notice that the biggest difference between the interior of these two cars is an 8-inch LCD display screen - not only for basic GPS-based map navigation, but also to easily access and display driving information (e.g., real-time traffic conditions, weather conditions, and place of interesting).

However, using IVIS is a big source of car driving distraction and other safety issues. One of the biggest problems with current in-vehicle information system is that when the driver needs to operate the system, they are forced to move their eyes away from the road for a few seconds. Based on the report of the U.S. National Highway Traffic Safety Administration, 20% of injuries and 16% of fatalities are closely related to driving distraction. The research on eye movement shows that for more than two seconds moving eyes away from the road in front will significantly increase the probability of traffic accident occurrence (Yaun, 2014:18).

To overcome these safety problems with existing IVIS, we propose a concept that based on distinguishing texture of different component of the center console (in Vehicle Information System). Although we distinguish distinct texture to each element, try not to produce confusion in the console for the driver. So that we suggest austere workstation for drivers based on texture designing (Yuan, 2014, 21).

Taking into account the advantages of the two newer techniques, “Tactile” interaction seems inferior to the other one. These advantages, however, cannot be a good reason for achievement as long as the driver inattention is an unsolved issue.

4. Results:

According to polls in the first stage, questionnaires were carried out by an analytic method.

For most user interfaces on the desktop, the interface is the primary focus of a user’s attention; the user (or group of users) typically sits at the interface engrossed in the interaction with few external concerns or disturbances. In contrast, for many user interfaces away from the desktop, the interface is only one of several tasks a user must manage and sometimes is secondary to other primary tasks. Numerous examples of such interfaces arise in the domain of driving: drivers frequently interact with in-car interfaces for radios, climate controllers, navigation aids, etc., but vehicular control and safe navigation clearly take top priority. For this reason, the design and evaluation of in-car interfaces require understanding of not only the driver's interaction with the interface but also the effects that this interaction may have on driver performance.

Firstly, their interaction with dashboards of their cars was investigated, while the dashboard components had their default textures. In this stage, users showed hesitation in choosing operations of each button, since there was no distinction index, except the difference in button sizes. In the second stage, data gathering was carried out among expert individuals who were more conscious about effects of visual factors on dashboard design. In this stage, different buttons were separated by extremely distinct textures. The result showed the positive effect of using different textures in dashboard design, while users demanded much fewer and shorter glimpses to find a button or make sure they have chosen the right one. It is obvious that taking fewer and shorter glimpses on the dashboard while driving results in higher safety and less accident risk.

Correct coordination between the mental view of the driver and the dashboard is achieved by assigning different textures to different buttons with different functions, this will assist completing the driver's mental image in a way that the driver needs fewer glimpses on the dashboard to perform a task or check if he has reached for the right button.

Data analyzed by SPSS shows that there is a significant relationship between buttons functions and gazing. Also, there is an associated reflationary between buttons texture and both of layout and also control knobs functions. The statistical analysis shows that there is a significant relationship between console layout and knobs grasping (table 1-2).

Table 1 Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	169.044[a]	36	.000
Likelihood Ratio	115.464	36	.000
Linear-by-Linear Association	35.547	1	.000
N of Valid Cases	100		

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.599	.073	7.410	.000[c]
Ordinal by Ordinal	Spearman Correlation	.566	.082	6.790	.000[c]
N of Valid Cases		100			

Table 2 Chi-Square Tests for Two-Variable of Knob's Performance Based on Skimming and Soft Texture

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	57.457[a]	36	.013
Likelihood Ratio	53.492	36	.030
Linear-by-Linear Association	.871	1	.351
N of Valid Cases	100		

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.094	.107	.932	.353[c]
Ordinal by Ordinal	Spearman Correlation	.086	.101	.852	.396[c]
N of Valid Cases		100			

Table 3 Chi-Square Tests for Two-Variable of Knob's Performance and Texture [source: by authors].

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	54.702[a]	30	.004
Likelihood Ratio	45.274	30	.036
Linear-by-Linear Association	7.543	1	.006
N of Valid Cases	100		

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.108	.094	1.079	.283[c]
Ordinal by Ordinal	Spearman Correlation	.096	.095	.953	.343[c]
N of Valid Cases		100			

Table 4. Chi-Square Tests for Two-Variable of Knob's Layout and Grasping [source: by authors].

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	65.382[a]	36	.002
Likelihood Ratio	38.917	36	.340
Linear-by-Linear Association	.967	1	.326
N of Valid Cases	100		

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.099	.119	.983	.328[c]
Ordinal by Ordinal	Spearman Correlation	-.013	.103	-.129	.897[c]
N of Valid Cases		100			

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Table 5. Chi-Square Tests for Two-Variable of Knob's Layout and Texture

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	65.146[a]	36	.002
Likelihood Ratio	54.836	36	.023
Linear-by-Linear Association	1.780	1	.182
N of Valid Cases	100		

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.134	.128	1.339	.184[c]
Ordinal by Ordinal	Spearman Correlation	.098	.109	.978	.330[c]
N of Valid Cases		100			

Table 6 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2439.714	4	609.928	16.547	.000[b]
	Residual	3501.726	95	36.860		
	Total	5941.440	99			

Table 7 Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	47.871	3.763		12.722	.000
	q5	1.095	.585	.178	1.871	.064
	q7	1.727	.343	.404	5.039	.000
	q8	1.653	.469	.324	3.525	.001
	q10	1.233	.390	.259	3.164	.002

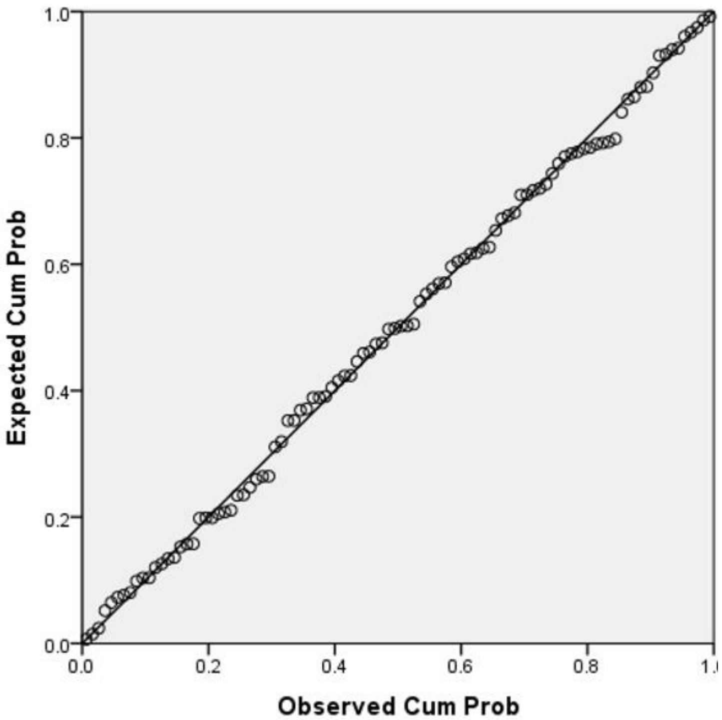

Fig 8. Plot of Regression Standardized Residual Dependent Variable

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5. Discussion:

Nowadays, car design and its elements have a critical role among industrial designers, in this regards drivers behavior assessment and their performance during car driving should be considered as a multidisciplinary science. Furthermore, user interface design in car development is known as the main firm in dashboard design. Also, most humans indicate an exclusive ability in manipulating objects with their hands. Expert manual interaction with an object requires the operator to move his/her hand to the object of interest (the pre-contact phase) and then imply the appropriate fingertip force in order to press the object (the contact phase). In the pre-contact phase, the geometric properties of the object constraint the milestone of the grasp in a way that the digits align with the object surface (Majlund Ba et al, 2008: 1142). In the contact phase, the physical properties of the object determine the fingertip obligatory required for manipulation. Similarly, it has been shown that the textural properties of the object influence the contact phase of apprehension (Zhang et al., 2004:811) Contact with an object provides haptic information regarding its textural properties and this information is recorded to be used in determining the appropriate center-console knob force (Lederman, klatzky, 2009: 56). Nevertheless, vision can provide useful information regarding the object properties before the contact occurs. Visual information can be used to program the required force in advance. This decision is much influenced by user's memorized texture properties.

Considering a car's dashboard as one of the most important factors in defining the technology level of that vehicle, it can be stated that designing dashboards cleverly can contribute much to the car's safety besides its quality. If buttons and switches are easily accessible and making a decision about their function is carried out with ease they can help reducing driver-fault accident risks to a safer level. This issue is directly related to the human factors since the driver can easily find out a button and its function with less distraction from his/her main task which is driving.

Light reflecting from the instrument panel and center console automobile displays is distracting to drivers and necessitates overhanging dashboard designs that take up valuable interior space. A recent trend toward displaying increasing amounts of information with navigation and communication systems has compounded the significance of light reflection. Diffuse textured surfaces are sometimes used at the expense of image clarity and reduction of surface reflection.

Cars are already becoming indispensable parts of human's daily life. However, in the twenty-first century, human's lives are dramatically changed by computer science and technology. In this virtual world, people connect with others and share their resources. Form an Internet-centered perspective, there are still some functions missing in car driving activity.

We consider multi-dimensional controlling: in addition to using buttons, knobs and other physical controls on car console, there should be more flexibility for using texture to each of them. In order to understand and gain deeper insights into driving activities, it is necessary for designers to categorize different driving scenarios. Because the driving activity is one of the most complicated human activities throughout the world, drivers' behaviors are affected by a wide variety of impact factors. Some come from surroundings (e.g. weather, road conditions, traffic order); and some come from drivers themselves (e.g. age, character, and driving habits). All these impact factors join together to influence driving activity. In this article, the target users of IVIS are 25-35 years old drivers.

Over the last twenty years, new technologies have been pushing car design to break old boundaries. On the one hand, these technologies have helped to make driving activity safer and more convenient. On the other hand, these progress in technology gives designers and engineers more flexibility in car design and manufacture. However, these new technologies also cause some problems for drivers. One of the biggest problems is that even though drivers have more control of their cars, the question about how to arrange all these function buttons is becoming a tenacious task for designers and engineers. You can see this on the consoles of new cars, there are increasing numbers of buttons. Because the space of these control areas is limited, the size of buttons and the space between them are becoming smaller and smaller. Figure 13 is a picture of ASX interior (Figure 9); there are more than ten buttons on the console and steering wheel in total. Based on ergonomic theory and driver testing, it is relatively easy for drivers to engage in accidental operation and to cause catastrophic detriment.

Furthermore finding a specific tiny functional button on the console can significantly distract drivers from the road. This array of behavior is a big hidden danger for driving activities (Figure 10).

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Fig9. ASX Console and knobs

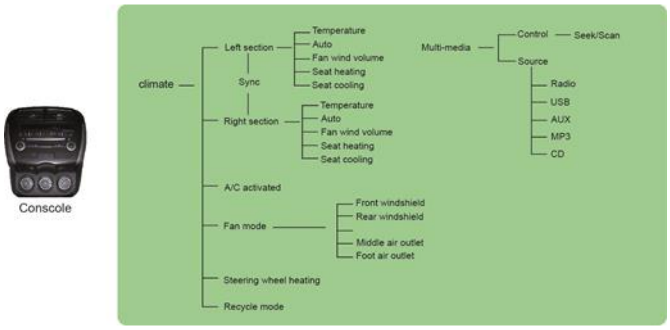

Fig10. ASX Console, knobs and function according to priority of implication

Fig11. Priority of applied texture on car console (source: authors)

6. Conclusion:

In conclusion, it is essential and valuable to redesign all different functions which driver will use on the road to safeguard the driving and alleviate driver fatigue. The redesign is based on four radical principles; first, functions that will be used frequently during driving activity should be the top priority. Second, functions related to driving behavior and safety should be more important than entrainment functions. Third, the gender of users is a substantial principle in order to imply function of the appropriate knob. Four, priority design of buttons on center car console Based on these principles, we redesign all functions in two stages of hierarchy: the most important and frequently used functions are on the steering wheel. In this way, drivers can access these functions at a glance. Secondarily, important functions are placed on the console. These functions are closely related to environmental controls and entrainment systems (e.g. air conditioners and stereo systems). Then we organize all knobs according to distinguishing texture based on this principle and hierarchy role.

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To explain this process further, the activation of the neural circuits is reinforced as a result of being triggered by an input stimulus with a suitable pattern. This postulated mechanism allows the acquisition of complex skills through the merger of a series of discrete movements, which lead to achieving a particular goal.

The resulting “higher-order” behavior might result in “lower-order” movements unfolding concurrently or in rapid sequential order. This can be conceived as a process where ‘higher-order’ models recruit ‘lower-level’ models (in the same way as sub-routines are called within a complex computer program).

This study implies that the routine of using the dashboard depends on four important items:

1- Frequently function of buttons
2- Function related to driving behavior
3- Gender of the driver
4- Design of buttons on the dashboard

The standard for evaluating console interface design focuses on the visual aspects. However, when first-time users are becoming familiar with the whole system, they will pay more attention to how intuitive and smooth of the total workflow is.

All these items can have significant relations with the texture applied to the product. One of the critical factors of designing car-related projects is reality simulation. Because driving experiences and scenarios are really complicated and are affected by multiple factors coming from the outside world and drivers themselves, it is important to simulate the real environment of driving and test initial concepts based on authentic drivers’ behaviors. In order to simulate real visual effects of gender that manipulates the implication function of console knobs.

It seems that male users involve their mental image to use dashboard buttons (including the ones for the stereo, air conditioning, etc.) and would rarely look at the dashboard when performing an operation. A mental image which is the result of factors such as: their intimacy with their automobile’s interior atmosphere, the frequency of use, and their confidence in orientation.

The outcome, however, says something different when it comes to female drivers. Ladies mostly look at the dashboard to operate a task, even if this is a small glimpse before they choose the right button. It can be deduced from the mentioned fact that ladies’ mental image of the dashboard is weaker than that of gentlemen, which is directly dependent on their less frequent use of their cars; while the few female users who drove more frequently were observed to use buttons with shorter and fewer glimpses, just like men.

Another factor is the shape and arrangement of buttons on the dashboard. For instance, in some cars, buttons are completely characterized by clear differences in their shape and size which leads to the creation of a vivid mental image for the driver. In other cars, however, buttons are arrayed on the dashboard in a rhythmic manner. This rhythm practically separates the form of the button from its function, which leads to the function being put into turbulence-as seen specifically in Korean cars. Japanese cars, in contrast, merge the button’s forms into each other in a balanced way, so that design is carried out in a fully function-oriented manner. If these designs are done with more consideration of texture importance, there will be intense effects regarding ease of use, increased the speed of task operating, less driver in-attendance and finally safer driving.

7. Recommendations:

Regarding our study, we suggest textures be used more efficiently in automobiles center-console and dashboard. By analyzing a center console as a case-study, here we presented example ideas as solutions for designing automobile-driver interactions based on the appliance of designed textures (Figure 11).:

1- Priority according to importance: Considering the vital role of “Warning Flash Light” in preventing accidents, dedicating a rough and exaggerated texture would help the distinction of the mentioned button from its neighbors. This will result in helping the driver find the button much faster and with shorter visual distraction or even none.
2- Comprehension of the operation process (of one particular button): As it can be seen on “Rotary Buttons” of today cars, there are several parallel grooved lines to provide a better grip. None of these textures has ever been designed in a way to help the driver with the understanding of the button function. They help your hand not to slip the button when setting the air conditioner to a higher temperature, but never tell you which way you should rotate the button in order to have the expected result. For example, the grooves size may vary rhythmically, the higher the temperature the larger the patterns.
3- The distinction of the function (between different buttons): Some buttons operate when they are pushed, some when they are
4- pulled, others when rotated. All these differences can be translated in the language

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of textures in a way that when the user touches the button he or she figures out the function immediately.

5- Visual impacts: Different textures have different visual reflections. Some textures may nullify the form of an object, some may result in exaggerated forms and some may increase glossiness. When the driver needs a quick glance at a button panel, using a proper texture and material finish for each button according to its function would help to attain a quicker action and a more vivid understanding of the operation.

Taking this study into account and assuming the importance of designing textures in automobile center-console and dashboard components, a list of regulations are suggested in the following:

- Soft texture feels better when touched. Leading to a pleasant soft clicking sound when pressing the button or rotating it would double the effect. In contrast, a drier sound will be more suitable for a hard touch button.
- Textures can be used to identify the importance of a button. It would be better to use coarse textures for critical buttons and friendlier textures for ordinary buttons.
- Textures can be used to identify the sensitivity of a button. The more sensitive a button, the softer and more gentle the texture.
- Cars are much exposed to dirt. They attract germs quickly and have less intention to get cleaned. So designing the textures in a way that they have less chance of collecting dirt would help to have a cleaner interior.
- Automobiles interior buttons are more likely to be damaged on the surface. Scratches, emergency uses, dirty hand and … they all will make buttons amortized. Texture can be useful in hiding these damages from the user's eye.
- Textures with sharp edges and no fillet would age much faster. Sharp edges bear more pressure and friction, therefore will lose their quality faster.
- Textures should combine the operation of the button with the user's sense of touch in a way that the driver understands how one button works without the need for taking a look at the button. Whether the button should be pressed or rotated or another operation is required. This will help distinction of operations of different buttons.
- For buttons which have staged commands and are not just "On" and "Off" ones, it's better to use rhythmic textures which demonstrate the direction of the button.
- Textures can reduce glossiness of the interior components and therefore provide the driver with a vivid vision. This will help the user with seeing and reading the icons and texts.

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