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Review Article

A Study of Trends on Human-Machine Interface Design in Modern Vehicles

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This study aims to analyze the development trends of intelligent device interface improvements, specifically the car dashboards, by applying liquid crystal display technology. The methodology used in this study is mainly a comparison and analysis of the improvements that have been made. The objects in the study were several old version dashboards display instruments that were compared against the improved version of the LCDs. This paper analyses the requirements of car operators, with various proficiency for drivers' information, in enhancing the modern car dashboards displays. Besides, this study further delves into ways through which instrument interface intelligently can be improved to adapt effectively to all kinds of drivers. This study also touches on an analytical view of information targeting drivers. This is a scientific technique to determine the extent of information needed from drivers in different circumstances by having precise or averaged information about the drivers; it is easier to integrate this information into the human interface that helps in these modern car operations. The results of the study show that the current LCD Dashboards are valuable, accurate, precise user friendly, and improved with integrated ICT pieces of equipment. This makes them much better than the older traditional systems of the car dashboards.

1. Introduction

The methodology used in this study is mainly a comparison and analysis of the improvements that have been made, to analyze the development trends of intelligent device interface improvements, specifically the car dashboards, by applying liquid crystal display technology. This study shows that current LCD dashboards have been improved by integrating ICT equipment, which makes them much better than the old traditional car dashboard systems. The study reveals the evolution and improvement of modern vehicle dashboard display systems.

The old dashboard display version mainly consisted of mechanics and several movable parts. This made it difficult for the drivers to handle the cars at times. The rate at which the drivers were to multitask to gain full control of these machines was a daunting task. The rates of traffic jams, low speed, and road crashes were significantly high. Besides, it took a long time for one to learn how to manipulate all the instruments on the car's dashboard fully. With a relatively high number of instruments to read, the information provided by these instruments sometimes failed to reflect the real conditions of the car. There are significant steps that have been taken to improve the ancient dashboards. Nonetheless, for high efficiency to be achieved in this human-machine interface, significant developments were also incorporated, both in design and also efficiency. A milestone change from mechanical to digital intelligence dashboard whose contents keep changing was achieved. As demonstrated by the incorporation of the new displays of LCDs and the future transparent dashboards, this Human Machine Interface has more advantages than disadvantages to automobile Human-computer Interaction and Automobile Human-machine Interface [1]. The flexibility of applying the full liquid crystal technology in the dashboard interface in an automobile is a modern method that is software-dependent [2] with more knowledge of science and technology across the globe. Tremendous improvements have been suggested, and some implemented on ancient automobile products in the right direction in the intelligentization of human-computer interaction. The principle of this change depends on the rapid development and application of corresponding technological advancement, especially in automobile electronics, automobile human-computer interaction, automobile, and human-machine interface. It is projected that several vehicles will fully adopt the liquid crystal display dashboard in the future [3]. This will be integrated by the emergence of varying new dashboard interfaces in the automobile Human-computer Interaction and Automobile Human-machine Interface.

Externally, the design of these brand-new interfaces has a lot of modern development compared to traditional dashboards, suggesting a new requirement for design content and techniques. Besides, there are dynamics in the contents displayed by the new automobile dashboard interface. The displays are variable and diversified-unlike in the traditional mechanical dashboard in which pointers and scale were applied as the generation of hardware. The colors and style of operation are permanent. Furthermore, the liquid crystal display dashboard is a combination of a whole screen [3]. This implies that the kind of pointers, scales, numerals, and texts are simple images displayed and colors whose styles can be changed at will. This helps to meet the demand of different users in different scenarios [2]. It is both entertaining and interactive. Because of the different functions in the display, the dashboard can achieve various functions. For instance, it can display targeted prompts according to various driving procedures and environmental conditions that alert the drivers of the required information. This helps the drivers in quick decision-making. The alert system onboard has been instrumental in helping drivers with poor vision and hearing problems. These warning devices are pivotal in avoiding accidents [4].

The dashboard systems are intergraded with images and audio systems that can be read and heard. This interactive design provides advanced options lacking in old vehicle models. The other important tool in this category is the information demand level interface display. It enables the driver to be flexible, Drivers can make choices promptly, and it also allows for various styles and content according to their taste, driving norms, and varied information required [5]. Sometimes challenges are met in due course of implementing this technology. That is instrument interface cannot fully work out for all drivers.

For most developers to salvage this situation, analytic hierarchy processes have been proposed. Besides simple, effective index weight analysis technique that dwells much on the new liquid crystal display technology in the intelligent development procedure of automobiles, this could help satisfy the drivers' demand that depends on foregoing technology [5]. Furthermore, there is a method that helps in evaluating the demand level of different drivers for varied types of information during driving. From these reviews, it is evident that several changes have been in place to improve the old dashboards to a much better dashboard that is based on the liquid crystal display. There is a possibility of eradication of the traditional dashboard soon if the LCDs are made cheap for all vehicle manufacturers.

2. Related Improvements in Human-Machine Interface Design in Modern Vehicles

Several factors like market demands show advantages of the improved LCD car dashboards. The number of cars sold due to the enhanced dashboards on LCD versions has improved greatly, as shown in Figure 1, along with the market demand for LCDs in different parts of the world for different models. The stiff competition in the market must, therefore, be handled technologically. This is achievable by the introduction of Human Interface Machines, which will be ideal and unique to attract more customers. Besides, Asian countries have the best-growing economy among their rivals worldwide. The growth in the Asian country's economy provides the best business arena and research platform for improved modern vehicles. Through market analysis, the taste for automatic vehicles has taken the day [3], substituting the old manual fashioned vehicles with improved dashboards such as automobile human-computer interaction and automobile human-machine interface. The need to improve their dashboards and other software-related interfaces in the current automated vehicles is greatly a good idea whose time has come [7]. Automated vehicles require a well-integrated human interface that will reduce risks such as accidents through a quick grasp of the information played by the LCD dashboards [8, 9].

Through the improvements of the displays, errors have been greatly reduced since most of the information on the performance of the vehicle is read by machines through a computerized interface system [10]. For this reason, Asian countries like China, Japan, and India have greatly contributed to the improvement that is deemed necessary for the best quality of automobiles they launched in the market. The USA and European car manufacturers have not been underscored in this analysis. The duos have also tried to pump financial and human capital to facelift their modern car production to unmatched standards [5]. I must relate that Russia, Europe, and America produce some of the most sophisticated motor vehicles in the modern world. They boast of their skilled manpower, availability of research funds, and also the staunched willingness to stay aloft among their competitors.

These multifaceted nations have enjoyed producing and selling cars in almost every niche of automobile transport. Their car production cuts across sports, heavy-duty, general transport, military, media, health education, and research. By being capable of extensively researching the current needs, China, America, Russia, Europe, and other stakeholders have played a pivotal role in modernizing their cars [11]. Their industries began by building manual vehicles with too many mechanical systems of display like the pointer speedometer and the oil gauge. These mechanical parts dashboards, with instruments having movable parts, were prone to mechanical breakdown [3]. They also had a short life with low work efficiency. The modern (improved car

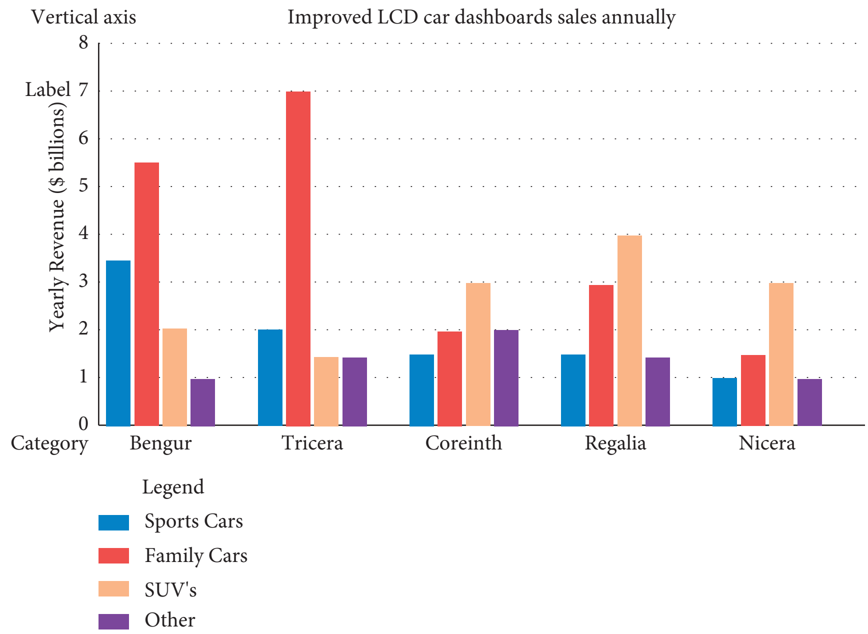

Figure 1: Market demand for LCDs in different parts of the world for different models [6].

dashboards) depend on minimal movable parts. Most of the display mechanisms are electronic-based, and their efficiency is highly improved. Quick readings can be taken at a glance. This reduces the energy spent by the drivers to obtain vital information like engine speed on their car dashboards.

Asian countries have contributed to the development and production of motor cars since the early 1980s. Countries such as Japan, India, China, and Russia are well-known champions of the automobile industry. Due to the growing automobile market, Asian countries have continued to remain relevant in the market to level their production against the USA (Ford), European (British Motor Works) countries, and other parts of the world. The backbone of the economy of these Asian countries is greatly dependent on motor vehicle assembly. Nonetheless, other Asian countries like India and China also offer favorable competition in the manufacture of vehicles in their regions. India produces a good number of its TATA brand vehicles in various models [12]. The market for cars and other heavy-duty automobiles has speedily increased. This is because cars are considered lucrative goods worldwide [3]. With the adoption of this new LCD technology, the dashboard interface design has a lot of importance, aimed to improve, convince, create comfortability, and even lessen driving rules [2]. By doing this, the safety of the drivers and general users is tremendously improved before creating any Human Machine Interface.

Since the advent of the first modern (i.e., digital) automotive display, designers and manufacturers have made significant progress in improving image quality and enhancing device durability [13], facilitating the development of modern automotive HMI designs. Takatoh et al. proposed a new type of optical device with variable transmittance based on the incident angle direction. These devices consist of two liquid crystal devices (LCDs) with a half-wave plate between them, a wide range of transmittances was obtained because no polarizer was used [14]. Yoon et al. [15] proposed a homogeneously aligned liquid crystal device in which the liquid crystal director does tilt as well as twist deformation in a confined area by both vertical- and fringe-electric fields, exhibiting about two times faster decay response time than that of conventional FFS mode with suppressed luminance in the upward direction. In the vehicle display field, the brightness of the backlight is almost more than 10000 cd/m^2, which may enlarge small defects in the display screen to impact display quality. As black uniformity is a crucial characteristic of image quality, Hua et al. [16] reduced the interference stress by controlling the flatness of the backlight and the metal frame, optimizing the design of the buffer strip, and reducing the bending stress by optimizing the structure and shape. The black uniformity of the module was improved by more than 80%. Wang et al. [17] designed a programmable digital power supply TFT liquid crystal display (LCD) screen touch display system based on STM32F7, the system has a clear display effect and fast control response.

3. Research Methodology and Design

3.1. Comparison and Analysis of the Improvements. The research methods were mainly a comparison between old traditional dashboards and modern LCD-based ones. The comparison offered a reflection of the tremendous work done to achieve the current dashboard displays. The popularity of LCDs is due to the high-tech Displays, Customized information, and the true reflection of Information Technology in the application of these great Human Machine interface tools. Up to now, it is premature to conclude that the development is fully done. Nonetheless, the LCD dashboards have a shred of clear evidence to capture the attention of all automobile manufacturers. This technology has proven important due to its unlimited advantages. Factors such as the orientation of the car and the global

Table 1: Comparison between the traditional and the current LCD-based dashboards.

Old car dashboards	LCD car dashboards
Had several mechanical parts	Few mechanical parts
Consumed more electrical power	Consumed less electrical power
Had limited functions	More functions and quite flexible
Manual operations	Dependable on programming
Difficult to operate required more attention	Easy to operate requires less attention
Time-consuming to repair and overhaul	Little time for repair and maintenance
Could not be linked to wireless devices, and the Internet	It can be linked to wireless devices like the Internet

positioning of the vehicles can easily be obtained on an LCD dashboard [18]. The major types of designs available in the market include mechanical meters with LCD Displays, pure mechanical meters, and all LCD.

Furthermore, The LCDs are available in different sizes and measurements, ranging from 4.3 inches to 12.3 inches, depending on their purpose. Wide choices and preferences are well taken care of. The improved versions of car dashboards are integrated with LCDs. The drivers can read the engine temperature, fuel gauge, and speedometer quite easily [19]. The application of computers to program the LCDs is also catered to in the new design. This has also enabled the connection of the current dashboards with wireless devices and even the Internet. The introduction of the touch smart LCDs is also an integral improvement on the car dashboards. The touch screens are easily operated since they don't require many complex mechanical systems. The comparison between the traditional and current LCD-based dashboards is demonstrated in Table 1.

The improved versions of car dashboards are integrated with LCDs. The application of computers to program the LCDs is also catered to in the new design. This has also enabled the connection of the current dashboards with wireless devices and even the Internet.

Among the cars that have adopted the incorporation of the LCDs fully on their dashboard is the EcoJet car. This car runs on a 650-horsepower run by biodiesel fuel. The display is a two-screen mounted on the front part (dashboard). This car entirely depends on the improved dashboard display, which provides basic information about the general state of the vehicle. Microsoft Windows Vista runs the LCDs for the multimedia and navigation control systems. This gives the car an enhanced ability of word processors and the web on the same dashboard. The rare views are also taken care of. The screen can successfully display the rear part of the car, and this display is connected to the camera. The dashboard is quite fascinating and entertaining. The LCDs are fully touch mart enabled. The audio system of this car is embedded with high graphics that can also recognize speech through a series of microphones onboard. This car is a postulation of future vehicles that will fully rely on the improved LCDs. The car borrows a lot of design from the jet airplane. The use of LCDs is not only limited to car displays but general automotive-like high-speed railways [20].

3.2. Evaluation of the Requirements of Car Operators. The operators require displays that can multitask, as shown in Figure 2. The need to display numerous information at once is among the choices and preferences of the current drivers. User-friendliness, entertainment, and beauty are the evaluated factors that the driver requires in their modern LCD dashboards.

3.3. Evaluation of Dashboard Interface in Automobiles. In the early ages (from 1940s to 1960s) of car manufacturing by American companies, the dashboard was less readable. The instruments were chrome-laden and with transparent plastic covers, which at that time were seen as the best methods and styles. The reflection on the chrome surfaces, especially from the sunlight, could even make it difficult for the drivers to take correct readings. This trend continued until the 1980s when wood and chrome were still ramp-ant on building the dashboard displays. Most of the improvements were made in Europe and the Asian-based car manufacturing companies. The dashboards started looking attractive with increased research to make them look much better by these companies. In the wake of the inception of LEDs, LCDs integration in the electronic arena and the possible displays were then made. The current automakers have gone far beyond this age within 20 years. The LEDs and, ultimately, the LCDs have taken the subject of discussion in-car dashboard displays. With the ability to convert the mechanical motion into electrical signals and then into the screens through computer programming, the car displays are much better. The car dashboard displays as major Human Machine Interface increases by adding stylish modern technology in the displays of these machines, as shown in Figure 2 Full interchangeable LCD Dashboard touch smart enabled. The other models of car that included the LCDs on their dashboards were the Audi Quattro. This was a sports car in the early 1990s. The LDC displays in these cars were simpler than the current full liquid crystal displays. The analog systems were reduced in this model in 1991.

Several companies have even gone a notch higher to incorporate the fuel economy gauges in a cluster of some vehicles, e.g., Honda, Mercedes, and British Motor work for companies. This fuel gauge helps in real-time monitoring of these vehicles' fuel consumption, as shown in Figure 3. Further, engine real-time and even mileage readings have been developed in the 2010s to improve the awareness of the drivers on the car performance. These transitions from the ammeters to voltmeters and finally, proper gauges have been developed and improved through the integration of the LCDs and the computer software, as demonstrated in Figure 4. These developments and further improvements have taken time to complete the evolution. With speculations and

Figure 2: Full interchangeable LCD dashboard touch smart enabled [12].

Figure 3: A color-coded fuel economy is not only beautiful but also easy to read: left photo, right column photo [21].

research which is still on to better the dashboard systems, more is yet to be achieved. Car tracking systems have been made possible by this new technology.

Along with influencing factors like the competition for the market, this study also offers a succinct and comprehensive knowledge of the facets like the future of these current developments in the automobile industry [11]. Capturing areas like the market growth for the improved human-machine interface profoundly delves into the crystal liquid display dashboards. Full liquid crystal technology in the dashboard interface in an automobile has a benefit for both the car developers and the car users [5]. The developers are earning cash from their skills and ideas by developing better equipment like the liquid crystal technology in the automobile dashboard interface. Furthermore, car drivers get quality services offered by the designed interfaces while driving, as demonstrated in Figure 3. This is a win-win situation for both the equipment vendors and consumers.

The LCDs in the car display come with various values and functions. Some of the improved display systems help tell the distance between the driver's car and the next car in front. The distances to be estimated by the driver's car can also be adjusted to varied abilities, which helps drivers with high-speed cars to keep safe distances from cars [23]. It avoids accidents since the car drivers can slow down at convenient distances and times, even at sharp bends. Drivers with poor vision have also benefitted from this improved dashboard display [11]. To safely drive, the drivers get the exact distance between the two cars even under poor visibility brought about by the weather. Some of the improved version of these displays is shown below in Figure 5.

LCDs are designed such that their function shifts, the improvement here is that the screen can display some information discretely or as set by the driver, and some situations prompt reverse driving. The strain to turn while the drivers sit to view the back of the car during reverse has also been catered for [24]. The above model LCD is designed in such a manner that during reverse, the display picks the back view movement of the vehicle through some camera at the back. This aids the drivers in making smooth turns by avoiding hitting objects. In modern urban areas, parking a car in front of schools, offices, Walmarts, and even supermarkets has faced a high number of cars with little or no space for parking. It becomes difficult for the lucky ones who get parking spaces again to unpark the car and get to the road [25]. The emergence of this improved version of the Human Machine Interface provided back the vision of the car during

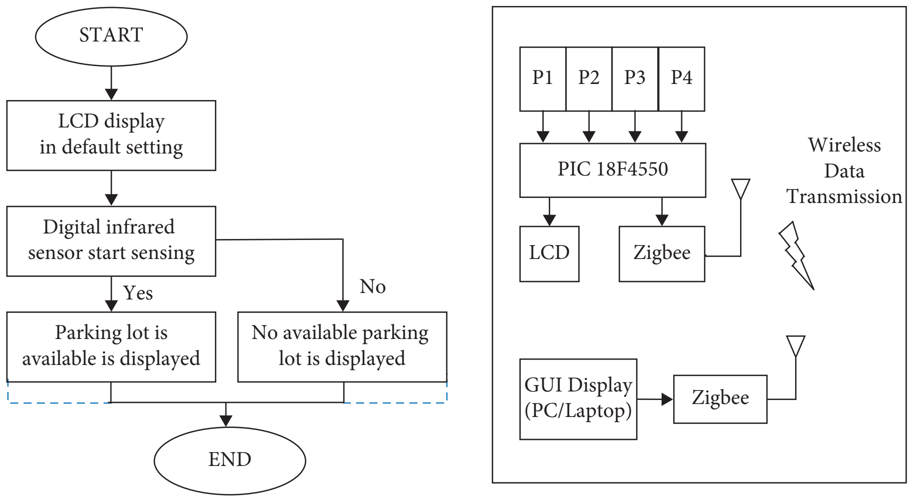

Figure 4: A computerized LCD with android operating systems [22].

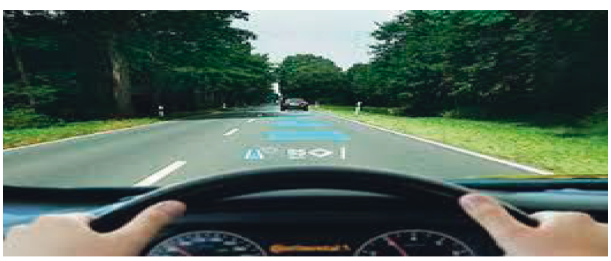

Figure 5: Distance gauge Integrated into the car windscreen for easy reading [4].

Figure 6: Night vision aid LCD [4].

Figure 7: Reverse assistance LCD [26].

reverse. The drivers find it easier to get the car safely in reverse mode. The improved display is shown below in Figure 6 and Figure 7 during usage.

The application of the above LCDs has dramatically improved the efficiency of the current drivers. The need to be increasingly dependable. The interfaces act as an aid to humans both for safety and accuracy. It is not a matter of production, but the main issue is producing quality at speed. It is equally imperative to highlight the improvements in the design of the LCDs. Through active projects, there are several designs of programmable LCDs [27]. Through these designs, they significantly employ the instrument cluster as an important element of the safety automobiles' passive safety channel and systems [28]. This state of art invention shows the driver the situation of the car through some signals. The energy distribution in the car LCDs is also shown below in Figure 8.

The warnings are informed of collision warnings, terrain warnings and portholes, vision and audio support, parking aids, and even adoptive speed controls. There are several eventualities that prompt signal warnings on the dashboard of a car [29]. Moreover, the car dashboard display systems are smaller to cater to all warnings. Therefore, multitasking designs are integrated into the crystal display system that allows the car to send more than one warning per instrument [30]. This design chiefly helps to create more useful gadgets for a small area in the car dashboard. Another important improvement is the incorporation of an integrated instruments cluster, which has more areas to exploit in terms of visual space [31].

The runtime configurations and flexibility are the key priorities that make these designs important too. This ensures that the driver can make changes due to the prevailing conditions of the road (Bellotti et al.). It is quite clear that the designs play a key role in the adoption of this Human Machine Interface in the motor car industry. These adorable communications tools have made driving more desirable and enjoyable, as they limit the energy and tasks of the driver. These communication tools are equally imperative in line with safety and containment. The best part is the existence of research to improve the improved designs through lab road tests [32].

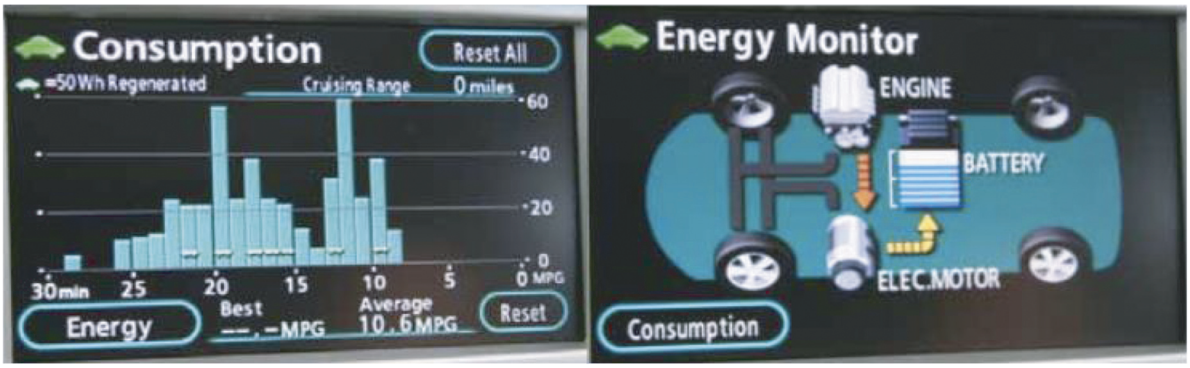

FIGURE 8: Consumption and energy monitor of a modern improved car (generation Toyota Prius, 2010).

The car developers may choose a number of these OS, depending on the requirements of the display systems. Besides, these operating systems also make it possible to bring plug-and-play and wireless devices into the car. Bluetooth, Wi-Fi, and Ethernet can be connected with the LCDs courtesy of the computer science contributions [33]. The computerized display system also helps link the car to the outside world through the Internet. Connecting the dashboards to the 3G and 4G is possible if the dashboard is compliant [34]. This means that the integration of the Operating System dependent LCDs is not only for the beautiful graphical but also a research and interlinking tool altogether. Every opportunity has got a challenge. Despite the praises hipped on the Human Machine Interface, several challenges such as space and overheating in the dashboards due to the circuit boards of these LCDs are the challenges that continue to face their use [29]. The cars and the software developers have endeavored to develop and harmonize both software and hardware that are complacent, small size, and efficient car dashboard LCDs. This technical problem has derailed the full adoption of all LCDs in the current vehicles.

4. Discussion

All this improvement can be achieved through the following techniques: first and foremost, for this behavioral dashboard interface intelligent to be implemented in automobiles, checking the driving conditions is Key [5]. This can be done by analyzing the driver's behavior, and installing all kinds of sensors should be fully implemented; secondly, choosing and deciding which information should be fed onboard computers based on a designer framework adhering to rules and standards. And finally, the information displayed on the dashboard interface should be a man based on the decision-making results.

From the above analysis, the improved car displays by application of the LCDs have indeed brought a turnaround in the automobile industry. These improvements aim to make the use of modern cars as easy as possible. Besides, the development in information technology has equally boosted the Human-machine Interface Systems like an entire LCD car dashboard [12]. In as much as the technology may face challenges in the application. There are many advantages attached to it in the end. This ranges from accuracy to the safety of the road users and the drivers [11]. The fully LCD dashboard was only typical in the luxurious cars that dominated the global market. It is good news to realize that through research, cheap cars are also embarking on adopting all LCD dashboard systems, which shows a milestone improvement that has taken place since the inception of the LCDs [6]. Some challenges come with every bit of technology. For instance, cars that are computer-dependent are also liable for hacking. Cyber-attacks are currently a menace in every sector like health, finance, transport, and communication. With the advent of this crime, it is pretty challenging to develop dashboards that are computer dependable but free from cyber-attack risks. Taxi companies like UBER face technical and crime problems. Another upcoming challenge that drags behind the implementation of the LCD Car dashboards is the maintenance cost that they come. For a long time in history, the development of LCDs has depended on a better research foundation, which calls for funds for starting and maintaining the automakers that integrate the computer and LCD display in their automobiles.

This Human Machine Interface has also improved and speeded up future designs of the expected cars that will be electric and solar energy-dependent. It is also pivotal to acknowledge the roles played by the computer technicians in integrating all LCDs in the car display system through their scientific knowledge and unwavering spirit of the invention. They have made it possible to coalesce computer science and mechanical science to come up with a human-machine interface [29]. Besides, it is pivotal to note that the core of the LCD dashboard displays has been immensely improved through software development in computer science. The backbone of clear communication between LCDs, the car, and humans lie in the operating system, which is computer software. QNX, WinCE, Android, Linux, and Windows operating systems have made it possible to develop the LCD car dashboards display [34]. These operating systems greatly assist in programmable LCDs.

As the terminal information gate of the IoT era, the LCD devices will also extend to the smart area, which is the intelligent display. On the one hand, the display effect will reach the real world and achieve "zero error output." On the other hand, the display equipment can detective the emotional state of human beings and automatically switch the information they present in real-time according to their wishes, and then realize "human-machine interaction" [35].

LCD has many advantages and is the main development direction. However, physical interaction is considered the most reliable and efficient [36, 37]. LCD is susceptible to environmental factors, resulting in unstable performance [37]. With the improvement of technology, these problems will eventually be overcome, and the LCD industry will further develop and play an essential role in human-computer interaction.

5. Conclusion

This study shows that the current LCD dashboards are valuable, accurate, precise user friendly, and improved with integrated ICT equipment. This makes them much better than the older traditional systems of the car dashboards. The result indicates the availability of several improved versions of the car dashboards integrated with LCDs. The application of computers to program the LCDs is also catered to in the new design. This has also enabled the connection of the current dashboards with wireless devices and even the Internet. Therefore, the study reveals the evolution and improvements in the modern car dashboard display systems.

This work focuses on the published liquid crystal display technology, studies the development trend of smart device interface improvement, how to apply the still researched and unpublished liquid crystal display technology into smart devices, achieving high human-computer interaction efficiency and accuracy requires other researchers to investigate further. In recent years, the popularity of keywords such as human-vehicle interaction and autonomous driving has continued to increase, and liquid crystal technology, human-computer interaction technology, sensors, and information technology have continued to develop. These all provide research opportunities for researchers. This work is expected to offer broad prospects for future research and help researchers discover potential opportunities for human-vehicle interactions.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

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References

[1] J. Cannon and H. Hu, *Human-machine Interaction (HMI): A Survey*, The University of Essex, Colchester, 2011.

[2] X. Chen and Q. W. Pu, "Electric vehicles LCD instrumentation design based on emWin," *Instrument Technique and Sensor*, vol. 7, pp. 105–108, 2013.

[3] S. Mingyang and Y. Haiyang, "Automobile intelligent dashboard design based on human-computer interaction," *International Journal of Performability Engineering*, vol. 15, no. 2, pp. 571–578, 2019.

[4] C. Edwards, "Car safety with a digital dashboard," *Engineering & Technology*, vol. 9, no. 10, pp. 60–64, 2014.

[5] L. M. Fu, H. Y. Yu, M. Y. Sun, and J. X. Fan, "The automobile intelligent dashboard design to enhance driving safety," *Advanced Materials Research*, vol. 1079, pp. 1010–1013, 2015.

[6] T. R. Fitch and M. L. Oberpriller, *US Patent No. 9*, p. 235, US Patent and Trademark Office, Washington, DC, 2016.

[7] S. K. Prasad, J. Rachna, O. I. Khalaf, and D. N. Le, "Map matching algorithm: real time location tracking for smart security application," *Telecommunications and Radio Engineering*, vol. 79, no. 13, pp. 1189–1203, 2020.

[8] S. Singh, "Audi was pushing more virtual cockpit clusters with Rightware for next-generation A3, A4, Q7, others," *IHS Technology. Retrieved*, 2015.

[9] S. Gibbs, *Audi Builds Hi-Tech 'virtual Cockpit' into the New TT*, The guardian, Kings Place, London, 2014.

[10] G. M. Abdulsahib and O. I. Khalaf, "Comparison and evaluation of cloud processing models in cloud-based networks," *International Journal of Simulation. Systems, Science and Technology*, vol. 19, no. 5, 2019.

[11] K. Wakunami, P. Y. Hsieh, R. Oi et al., "Projection-type see-through holographic three-dimensional display," *Nature Communications*, vol. 7, no. 1, pp. 12954–12957, 2016.

[12] D. Yee and K. S. Perez, *US Patent No. 9*, p. 898, US Patent and Trademark Office, Washington, DC, 2018.

[13] J. Van Derlofske, S. Pankratz, and E. Franey, "New film technologies to address limitations in vehicle display ecosystems," *Journal of the Society for Information Display*, vol. 28, no. 12, pp. 917–925, 2020.

[14] K. Takatoh, M. Ito, S. Saito, and Y. Takagi, "Optical filter with large angular dependence of transmittance using liquid crystal devices," *Crystals*, vol. 11, no. 10, p. 1199, 2021.

[15] J. H. Yoon, E. J. Seo, S. J. Lee et al., "Fast switching and luminance-controlled fringe-field switching liquid crystal device for vehicle display," *Liquid Crystals*, vol. 46, no. 11, pp. 1747–1752, 2019.

[16] L. X.. Hua, B. J. Ping, X.. Bing, and F. H. Yuan, "Improvement research of TFT-LCD module black uniformity," *Chinese Journal of Liquid Crystals and Displays*, vol. 33, no. 4, pp. 271–276, 2018.

[17] P. J. Wang, F. He, G. P. He, C. Chen, X. Guan, and X. Zhang, "Design and implementation of programmable power display system based on STM32F7," *Chinese Journal of Liquid Crystals and Displays*, vol. 36, no. 7, pp. 973–982, 2021.

[18] B. M. Lim, Y. H. Ko, Y. S. Jang, O. H. Kwon, S. K. Han, and S. G. Lee, "A 200-V 98.16%-efficiency buck LED driver using integrated current control to improve current accuracy for large-scale single-string LED backlighting applications," *IEEE Transactions on Power Electronics*, vol. 31, no. 9, pp. 6416–6427, 2016.

[19] A. D. Salman, O. I. Khalaf, and G. M. Abdulsaheb, "An adaptive intelligent alarm system for wireless sensor network," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 15, no. 1, p. 142, 2019.

[20] F. Railroad Administration, *Information in Cab Displays for High-Speed Locomotives" (PDF)*, US Department of Transportation, Washington, 2005.

[21] Hellwig, *Honda Civic: Unique Gauge Cluster Works Well*, Edmunds, Santa Monica, California, 2017.

[22] L. Shankun, D. Liqian, Z. Qun, and G. Pengcheng, "Design and implementation of vehicle virtual instrument panel and fault diagnosis system," *Computer Applications and Software*, no. 8, p. 52, 2016.

[23] L. Keqiang, "Review of status and prospects of automotive intelligent safety electronics," *Chinese Journal of Automotive Engineering*, vol. 1, no. 1, pp. 5–17, 2011.

[24] G. Q. Zhu, L. Y. Sun, L. H. Sun, and K. Cui, "The analysis of speed instrument danger prompt effect's influence factors," *Industrial Engineering & Management*, vol. 16, no. 4, pp. 129–132, 2011.

[25] T. R. Pryor, *US Patent No. 7,084*, p. 859, US Patent and Trademark Office, Washington, DC, 2006.

[26] *Generation Toyota Prius - 2010 Pictures and Photo Gallery*, , pp. 12–08, Toyota.com, 2009.

[27] F. Bellotti, A. De Gloria, A. Poggi, S. Andreone, P. Damiani, and P. Knoll, "Designing configurable automotive dashboards on liquid crystal displays," *Cognition, Technology & Work*, vol. 6, no. 4, pp. 247–265, 2004.

[28] D. U. A. N. Hong Jie, "The development of a vehicle LCD dashboard based on serial bus," *Microcomputer Information*, vol. 25, pp. 5–1, 2009.

[29] A. Amditis, L. Andreone, K. Pagle et al., "Towards the automotive HMI of the future: overview of the AIDE-integrated project results," *IEEE Transactions on Intelligent Transportation Systems*, vol. 11, no. 3, pp. 567–578, 2010.

[30] G. Takeda and H. Cheng, *US Patent No. 8,913,009*, US Patent and Trademark Office, Washington, DC, 2014.

[31] T. Matsumoto, Y. Nakagawa, K. Matsuhiro, Y. Souda, H. Araki, and K. Ohara, *Improved VHC (Very High Contrast) LCD for Automotive Dashboard Displays*, SAE Technical Paper Series, 1990.

[32] F. Bellotti, A. De Gloria, M. Risso, and A. Villamaina, "AutoGraL: a Java 2D graphics library for configurable automotive dashboards," *Computers & Graphics*, vol. 25, no. 2, pp. 259–268, 2001.

[33] S. M. Choi and J. Van Ee, *US Patent No. 6*, p. 211, US Patent and Trademark Office, Washington, DC, 2001.

[34] S. Y. N. Zhen-zhong, *The Development of Graphical Automotive Instrument Based on the QNX Operating System*, Harbin Institute of Technology, Nangang, Harbin, 2012.

[35] L. Sha, W.. Dan, Y. Z Kun et al., "Key technology trends analysis of TFT-LCD," *Chinese Journal of Liquid Crystals and Displays*, vol. 33, no. 6, pp. 457–463, 2018.

[36] T. Hao, Z. Jianghong, and W. Wei, "Research on human-computer interaction interface design for automobiles," *Journal of automotive engineering*, vol. 2, no. 5, pp. 315–321, 2012.

[37] L. Jianan and A. Abas, "Development of human-computer interactive interface for intelligent automotive," *International Journal of Artificial Intelligence*, vol. 7, no. 2, pp. 13–21, 2020.