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Performance Analysis of Intelligent Vehicle Interactive Chips

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Abstract. Today's automotive intelligent cabin gradually tends to multi-screen, multi-screen interconnection research, design and development, intelligent cabin is being gradually applied to more and more production models, the car has become including LCD dashboard, head-up display, streaming media rearview mirror, intelligent driving assistance, voice recognition control, gesture control and other complex electronic equipment collection. “One core and multiple screens” is the way most car companies build their smart cabins. The design concept’s intelligent cabins are being actively developed and applied by auto parts manufacturers at home and abroad. With the increase of the vehicle screen, the interaction of several screens is enhanced, and the customer's smooth and functional requirements for the vehicle system are improved, the theoretical performance of the vehicle is slowly becoming important. In order to realize the smooth interaction of various modes such as touch screen, voice, face recognition, and gesture recognition in the intelligent cabin, achieve multi-screen linkage, and produce vivid and smooth display pictures, the CPU and GPU computing requirements of the on-board chip will be increased. So, this article will discuss how much performance today's in-car chips need to support the smoothness of human-computer interaction.

Keywords: Human-computer Interaction; Vehicle-engine; On-board chips; Automatic Drive.

1. Introduction

Nowadays, more and more new forces and old car companies have launched a lot of well-configured products on written parameters. The design of intelligent cabin is being actively developed and applied by auto parts manufacturers at home and abroad. ICC intelligent cabin technology based on Intel chip was introduced by Aptiv Company, and has been actually installed on a variety of models such as Changcheng and Volvo and is in mass production. Denso has partnered with Blackberry to provide the Harmony Core solution, which can be mass-produced on Subaru models. Faw company, Neusoft and Intel released the intelligent cabins platform C4-Alfus, which is currently in mass production for Hongqi’s models; Desay SV developed a four-screen interactive intelligent cabins system for the Lixiang ONE models based on Qualcomm 820A on-board chip [1]. And Huawei is in the joint development and launch of the AITO M5 intelligent driving version, which is equipped with their own self-developed Kirin 990A chip.

In the ever-evolving field of automotive technology, automotive and autopilot chips are at the forefront of innovation. These chips have slowly become an integral part of modern cars, providing the basis and security for a range of functions for entertainment and driving. Automotive chips are designed to handle complex tasks associated with vehicle infotainment systems. They support features such as navigation, multimedia playback, and connectivity to mobile devices. For example, Qualcomm's 8155 chip, which is not only about performance, but more importantly, provides a smooth user experience, ensuring that drivers and passengers can get a multimedia experience. The autopilot chip, on the other hand, is the brain behind the vehicle's driving safety features, and it needs to process huge amounts of data from a variety of sensors to support assisted driving functions such as adaptive cruise control, lane-keeping assist, and collision avoidance. Both automotive and autopilot chips are key to the transition to autonomous driving. They not only enhance the entertainment experience, but also guarantee safety and convenience. As new models become more connected and automated, the role of these chips will only become more important, and so will the demand for their performance. The GPU controls the clarity and fluency of the LCD instrument and the central control display, while the CPU in the on-board chip controls many programs while ensuring the fluency and responsiveness of the operation. The CPU and GPU performance requirements of the on-board chip is increasing. There are a lot of inexpensive and well-configured models on the market, but there are many problems in the human-computer interaction experience, such as complications, too much information, over-reliance on intelligent driving and fluency. The car control operating system is mainly responsible for supporting and ensuring intelligent driving. This is an important cornerstone for building an intelligent connected car ecology in the development process [2]. At the same time, the complex interaction modes during driving is unreasonable, those operations would increase the safety risk when people driving. the design of automotive HMI should be simple rather than complicated. Under the premise of clear logic, the fewer levels of interactive logic architecture, the better [3].

So, this study will discuss the performance and fluency problems of vehicle system (vehicle intelligence chip) and auxiliary driving (auto auxiliary driving chip) in recent years, and the relationship between chip performance and the user's daily use fluency. At the same time, this study will show some data from other journal article and data collection websites to prove my opinion.

2. Experimental Presentation, Data Presentation and Data Summary

2.1. A Variety of Major Human-computer Interaction Scenes

The main interactive interfaces functions in-vehicle are Multimedia, navigation, vehicle control, assisted driving.

Multimedia, the driver can control the vehicle multimedia system through the central control screen, such as playing music, listening to the radio, etc., to enjoy the entertainment and leisure driving experience.

Navigation, the driver can set the destination through voice command or central control input, obtain real-time road information and the optimal navigation route, and improve travel efficiency and safety.

Vehicle control, the driver can adjust the temperature, lights, Windows and other equipment in the car through voice commands, to achieve intelligent control of the vehicle, increase the safety and convenience of driving.

Assisted driving, the driver can start or turn off the auxiliary driving function through the steering wheel button, such as automatic parking, adaptive cruise, lane keeping, pilot-assisted driving, etc., so that the vehicle can automatically adjust the driving state according to the traffic environment, reducing the burden of long-distance driving.

2.2. Test Method

As for fluency, the perceived time is different for different users and different scenarios [4], and the subjective fluency is not good as the evaluation standard. Therefore, the following are the objective research and testing standards. The experiment aimed to find the impact of different factors on the performance of a vehicle-engine system.

The dependent variable, which was the primary measure of interest, was the time spent on various tasks within the system. Specifically, this included the time required for multimedia startup, navigation functions (such as map startup and route planning), initiating system settings, and responding to vehicle control switches.

The independent variable, which was manipulated during the experiment, was the type of on-board chip used in the infotainment system. Different chip models or configurations were tested to assess their influence on the system's performance.

To ensure the validity of the experiment and minimize the effects of confounding factors, several control variables were held constant across all experimental conditions. These control variables included the screen size of the infotainment display, the screen's refresh rate, and the transition time set by the system for various animations and visual effects [5].

Test process: The visual algorithm of frame recording is used to test the content response time of the screen, and the operation of the tester's hand is recorded through the infrared touch frame, and then using visual algorithms to analyze changes in the content captured on the screen of the vehicle to measure the content response time. Finally, the reaction time is analyzed according to the operation time and content response time.

2.3. Data Presentation

Table 1. Hardware Data of Test Vehicles [6]

Vehicle Model	Assisted Driving Chips	Vehicle Intelligence Chips	Count	Capacity (TOPS)
BYD Song PLUS EV 2023 Champion Edition 605KM Flagship PLUS	Not released	Qualcomm Snapdragon 820A	1	0.7
Zeekr X 2023 YOU version four seat four-wheel drive	Not released	Qualcomm Snapdragon 8155	1	4
Feifan F7 2023 Advanced Pro	Nvidia Drive Orin	Qualcomm Snapdragon 8155	1+1	254+4
Lotus Eletre 2023 S+	Nvidia Orin-X	Qualcomm Snapdragon 8155	2+2	508+8
Denza N7 2023 Long life performance Max	Horizon J3	Qualcomm Snapdragon 8155	1+1	5+4
Leap motor C11 2023 pure electric 650 smart version	Not released	Qualcomm Snapdragon 8155	1	4
NIO ETET 2023 75kWh	Nvidia Orin-X	Qualcomm Snapdragon 8155	4+1	1016+4
Xiaopeng P7i 2023 P7i 610 Max performance version	Nvidia Orin-X	Qualcomm Snapdragon 8155	2+1	508+4
Voyah light 2023 730km long life version	Not released	Qualcomm Snapdragon 8155	1	4
Xiaopeng G6 2023 700 all-wheel-drive high-performance Max	Nvidia Orin-X	Qualcomm Snapdragon 8155	2+1	508+4
Zeekr 001 2023 WE version 140kh Miles endurance set	Mobileye EyeQ5H	Qualcomm Snapdragon 8155	2+1	48+4

The chips in the test car and its theoretical performance data in the model was shown in the Table 1. “Not released” is mean Internet cannot find any information about this vehicle model. And the “Count” means the number of assisted driving chips and vehicle intelligence chips. “Capacity” means the total theoretical performance for each vehicle model.

Table 2. Main Function Feedback (unit: second) [7]

Vehicle Model	Map Start	Music Start	System Setting Start	Navigation Planning	Music Play	Vehicle Control Switch
BYD Song PLUS EV 2023 Champion Edition 605KM Flagship PLUS	1.45	2.78	1.22	2.92	0.72	0.32
Zeekr X 2023 YOU version four seat four-wheel drive	1.38	2.55	1.15	4.58	0.77	0.34
Feifan F7 2023 Advanced Pro	0.68	2.90	0.72	5.39	1.70	0.49
Lotus Eletre 2023 S+	0	1.53	0.97	3.36	1.26	0.37
Denza N7 2023 Long life performance Max	0	1.80	0.80	3.37	0.96	0.27
Leap motor C11 2023 pure electric 650 smart version	0	5.77	>0.65	3.79	1.03	0.40
NIO ETET 2023 75kWh	0	5.98	0.72	3.99	0.59	0.44
Xiaopeng P7i 2023 P7i 610 Max performance version	0	3.18	1.08	2.66	0.70	0.80
Voyah light 2023 730km long life version	0	3.28	0.32	4.06	0.94	0.28
Xiaopeng G6 2023 700 all-wheel-drive high-performance Max	0	2.60	0.87	3.18	0.52	0.618
Zeekr 001 2023 WE version 140kh Miles endurance set	1.83	1.02	1.07	1.678	0.76	0.43

The reaction time of each model in the main function was shown in Table 2, and the main interface is the map of the vehicle system will be 0 in the map start test.

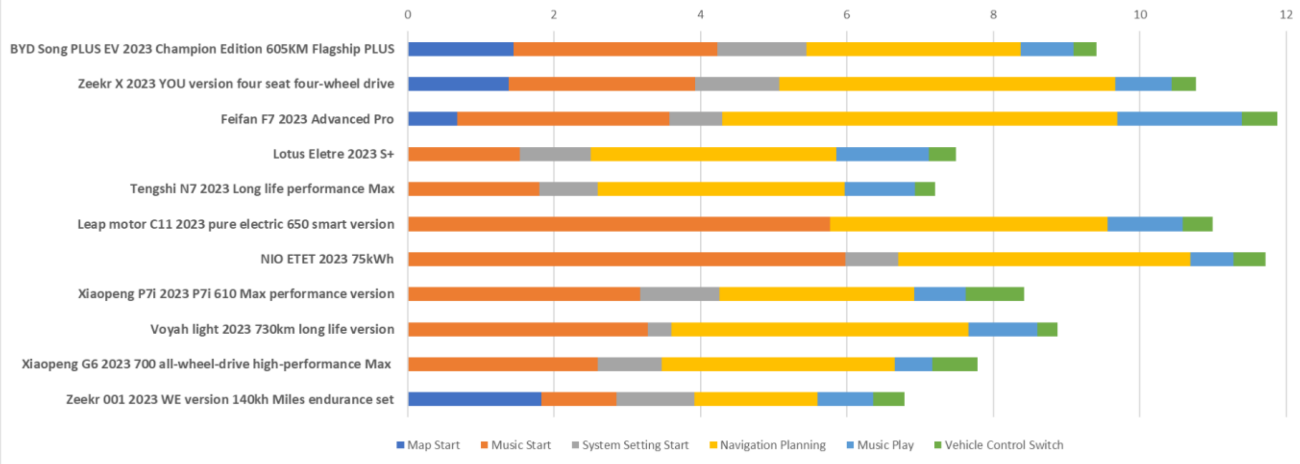

Figure 1. Core Function Feedback Data Analysis (unit: second) [7]

From the bar graph (see Figure 1), the obvious result is that Feifan F7’s test result is the slowest one in the group with “Map Start”. And the NIO ET5T’s test result also the slowest one in the group with no “Map Start”. Zeekr 001’s test result is the fastest one in the group with “Map Start”. Tengshi N7 and Lotus Eletre ’s test result almost both are the fastest one in the group with no “Map Start”.

Table 3. Intelligent Driving Assistance (AEB situation) data (unit: seconds)

Vehicle Model	Software Version	ACC for static fake car (ACC limit speed km/h)	Disappearing front car impact speed km/h)	Children ghost probe (collision avoidance speed km/h)
M5 EV intelligent Driving	HarmonyOS 3.0.0.162(SP3)	120	90	60
Zeekr 001	ZEEKR OS 5.0/ZEEKR OS 5.0.1	120	90	40
NIO ET5T	Banyan 2.0.8 CN	110	80	50
Changan UNI-ViDD	UNIV_IDD_V1,4.00	100	80	50
NIO ES8	Banyan 2.1.0 CNI	110	70	40
Immotors LS7	IMOS 2.3.0(P01MBYOA)	100	80	40
Cadillac LYRIQ	Cadi_r2_theme-20230524-RQBR2-12-SIGNED	100	50	50
Deepal S7 Extended range version	Deepal OS 1.3.2	100	60	30
Xiaopeng G6 Max	Xmart OS 4.3.1	100	60	30
BYD Song PLUS EV	V1.0	70	60	50
Zeekr X	ZEEKR OS 4.5	60	60	30

The maximum speed supported by the AEB system for each model was shown in Table 3. At this test, in the list in Table 2, Zeekr 001 got the highest AEB working speed close behind the M5 EV. The ET5T got the second highest AEB working speed in this test. The BYD Song PLUS EV and Zeekr X got the lowest AEB working speed with similar data. Theoretical performance of the vehicle-engine chips was shown in Table 4, and theoretical performance of the vehicle-engine chips was shown in Table 5.

Table 4. Vehicle-engine Chips Performance

Company	Chips Model	Single Chip Computing Power
Qualcomm	Snapdragon 8155	4 TOPS
Qualcomm	Snapdragon 820A	0.2 TOPS

Table 5. Driving assistance chip performance

Company	Chips Model	Single Chip Computing Power
NVIDIA	DriveOrin	252 TOPS
NVIDIA	Xavier	30 TOPS
Mobileye	Mobileye EyeQ5H	24 TOPS
Horizon	J3	100 TOPS

3. Discussion

As can be seen from the data presented above: In the above table, the performance of the Zeekr 001 is the best performance in the core performance feedback of the car, its chip is Snapdragon 8155 (the old model is 820A), and the Feifan F7 is the worst performance on this list, but its chip is also Snapdragon 8155. While the other better performance and equipped with Snapdragon 8155 Lotus Eletre and Tengshi N7, the two performance is comparable. In Autonomous Emergency Braking (AEB) tests, Zeekr 001 and Zeekr X are equipped with the same chip configuration, but the test results are very different. The chip and total performance of NIO ET5T are higher and perform better in this test, while BYD Song PLUS EV performs downstream in this test.

From this analysis, there are two points in the direction of human-computer interaction in the intelligent cabin. The first is the scheduling problem of the chip manufacturer, and the second is the performance problem of the chip itself.

When each manufacturer uses the same model and the same number of chips, the response to testers is actually very different due to its scheduling and vehicle-machine interface interaction design. the secondary development and adjustment scheduling based on the basic system, the scheduling is different between different models of the same car company and the same chip model, and the scheduling of chip performance between different car companies will have greater differences.

And for the chip performance, in the current von Neumann architecture, the performance of the storage system lags behind that of the processor. The main challenge to improving the compute performance measure TOPs/watt is the power consumption and data processing bandwidth between the off-chip memory and neural network accelerator [8, 9].

For the two mainstream architecture High Bandwidth Memory (HBM) and Domain Specific Architecture (DSA), HBM has two main disadvantages. The first is that has high performance and high cost, because it requires a complex stacking process, its design and integration require high technical requirements. At the same time, Memory is frequently the limiting factor in system performance since graph computing technologies are developing far faster than standard memory [10].

For the DSA, in order to fully use the performance of the hardware, developer must adjust their needs to fit certain application characteristics that may exist in the chip design due to over-optimization. Because of this, it is challenging for present DSA programmability to satisfy the constantly changing requirements of developing applications [11]. The DSA schemes need to be highly coupled with algorithms and hardware, and are suitable for mature AI algorithms, but not for fast iterative autonomous driving AI algorithms. The Computing in Memory structure will be a new development direction. Shim et al. are more optimistic about the integration of memory and believe that it is a solution to the performance defects needed to lead the future advanced intelligent driving [12].

4. Conclusion

From the data presented above, it can be seen that the functional fluency of the vehicle system and the performance of assisted driving depend on two points: The first is the computing power of the on-board chip, and there are two mainstream architectures now. The second is the secondary development of the basic system and its scheduling, scheduling in the same car company with the same chip model between different models there is a small difference, different car companies between the chip performance scheduling will have greater differences. For every car companies that want to improve the performance of their users in terms of vehicle machinery and assisted driving, the first solution is to optimize their own algorithms or use better algorithms and improve the active safety hardware configuration of their models. For the chip performance, although there are 1000 Tops chip parameters now, it does not mean that the chip can play 1000 Tops real performance in practical applications. Nowadays, the performance release of the chip needs to reach a bottleneck in some aspects. In the current von Neumann architecture, the performance of the storage system lags behind that of the processor. High Bandwidth Memory (HBM) has high performance and high cost. And the Domain Specific Architecture (DSA) schemes is not for fast iterative autonomous driving AI algorithms. So, for the future, the two methods of exchange-memory integrated architecture and optimization algorithm and scheduling are effective ways to improve the reaction speed and performance.

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