PAK Publishing Group
Growing Knowledge for Future

Proceedings Book of ICETSR, 2014, Malaysia
Handbook on the Emerging Trends in Scientific Research
ISBN: 978-969-9347-16-0

Enhancement of Instrumented Car Design for Driver Behaviour Research
Changing Driver Behaviour with Instrumented Car Design

Abdullah Sukardi
Malaysian Institute of Road Safety Research, Taman Kajang SentralKajang, Malaysia
Mohd Khairul Alhapiz Ibrahim
Malaysian Institute of Road Safety Research, Taman Kajang Sentral, Kajang, Malaysia
Muammar Quadaffi Mohd Ariffin
Malaysian Institute of Road Safety Research, Taman Kajang Sentral, Kajang, Malaysia

Abstract

This paper describes the development of an instrumented car as a tool for data collection in driver behaviour research. The planning and design stages are explained in detail, including the use of Failure Mode and Effect Analysis (FMEA) approach. The details of system architecture, options for data acquisition and sensors, fabrication, installation, calibration and system level test are also discussed. The paper also highlights new design approaches for a robust system that addresses limitations of instrumented vehicle in driver behaviour research, as reported in previous studies. These approaches include a design and modification of the data acquisition platform which improves the reliability and efficiency of the system. This modification enables measurement of data from various communication protocols such as Ethernet, CANBus, serial, and USB. This improvement has enhanced the capability of the instrumented car in recording various forms of driving behaviour data during actual driving on the road. This paper concludes that the enhancement in the data acquisition system and instrumentation can contribute significantly to driver behaviour research.
Keywords: Instrumented car, Driver behaviour, Multi-channel data acquisition, Naturalistic study.

1. Introduction

Driving is one of the common tasks performed daily by ordinary people. Without noticing it, drivers may put themselves in dangerous situations that can contribute to accident and injuries. Human errors are the biggest contributor of all possible causing factors during a crash [5].. According to the Royal Malaysian Police statistics, in 2011, 3288 fatalities from 15,880 crashes were recorded involving private cars. Despite these alarming figures, Malaysians still prefer to drive rather than opting for public transportation due to the convenience offered by their personal vehicles [1].

Understanding the characteristics of driver behaviours that lead to accidents can contribute significantly to road safety through improvement in vehicle, roadway design and technology utilisation such as intelligent transport system and sustainable transport system approach

Researches on driver behaviours traditionally use methodology such as observation, interview, and survey (self-reporting) to understand and capture a particular driving behaviour and its effect on road safety. These conventional methods were very subjective and have limitation compared to a naturalistic data collection during actual driving events. The results of these studies may not reflect the real answer from the respondents' point of view. This is because the conventional methods are subjected to researcher bias and limitations in the design of self-reported questionnaires. maybe effect of present of observer or problem to understand survey questions. Instrumented car (IC) is a research tool used in a naturalistic study to understand the driver behaviour and evaluate driving behaviours and performances [1,3,7]. An instrumented car is essentially a typical mass produced car that is fitted with sensors and a data acquisition system comprising computer processor and storage devices to record real time data during a driving session.

The data includes the road condition, surrounding traffic and vehicle dynamics that describes the driver's behaviour. Data on the driver physiological response can also be recorded. It is a scientific tool that can provide a wealth of information on driver behaviours and the effects of road conditions, traffic patterns and other factors on driving performances.

Instrumented Cars have been used widely in various research applications to study driver behaviour. In 2002, a study was conducted to understand the car following behaviour in a motorway environment in UK using an IC [4]. The well-known 100 car naturalistic study conducted in the US was made possible by using 100 ICs. An IC was utilized for simultaneous and unobtrusive behaviour recording is on the risky driving behaviour that was reported by Thomas E. Boyce and E. Scott Geller.

Besides drivers' behaviour study, an IC called ARGOS was extensively used to examine objective indices of driving performance of both normal and potentially unfit drivers [7].

One of the limitations of instrumented car reported in previous study [2] is the synchronization of data recorded from different acquisition sources. A typical data acquisition system design usually utilises an independent system for each sensor data, video recording input and vehicle positioning which typically requires independent software for playback and recording function. Another limitation is related to the power source for the system and instrumentation. The power drawn by the devices causes the vehicle electrical system to drain the supply from 12V battery used in a typical car. This will cause the car not able to start at certain times. This interrupts data collection process, causing loss of data. In addition, as the new research requirements become more complex, more types of data are needed in driving behaviours related research. Thus, the data acquisition system requires more input channels to accommodate the different types of data. The current IC is among the first being developed and utilised in Malaysian road safety research. The present paper describes the design of a robust instrument platform to handle multiple types of parameters and to cater the limitations described above. The platform architectures were constructed in a modular form to enable the system to acquire various data simultaneously. The input module was designed such as it can be replaced with another module that has different function to fit in research requirement. It was started with a design concept to fit all current and future potential research.

2. Design Concept

The instrumented car design concept is to have the data acquisition system to be integrated seamlessly with vehicle electrical architecture, allowing for more reliable and robust data collection system. Fig. 1 shows the various devices and instruments that will be fitted to an existing base vehicle.

To ensure the design concept can be fully implemented, few factors were considered and used as a benchmark for design improvement and guideline. Major factors that were consider are lesson learn from previous instrumented car, system robustness and reliability, and other future relevance use of instrumented car.

3. FMEA

Failure Mode and Effects Analysis (FMEA) is a systematic mechanism to recognize and evaluate the potential failure and identify actions which could eliminate or reduce the change of potential failure of a product/process and its effects. The FMEA processes focus on Design FMEA, DFMEA to prepare specification of the instrumented car platform. The instrumented car platform divided into five subsystems, which is input and sensor, communication and linkages, data acquisition, software, and data management.

Figure-1. Instrumented Car Design Concept

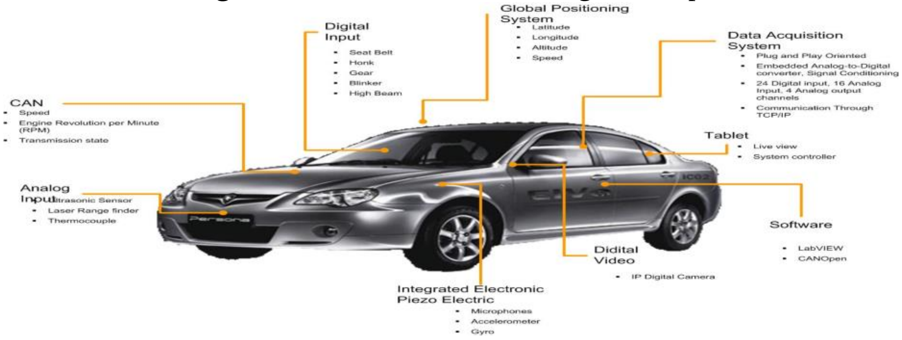


Figure-2. Sub-System for the Instrumented Car

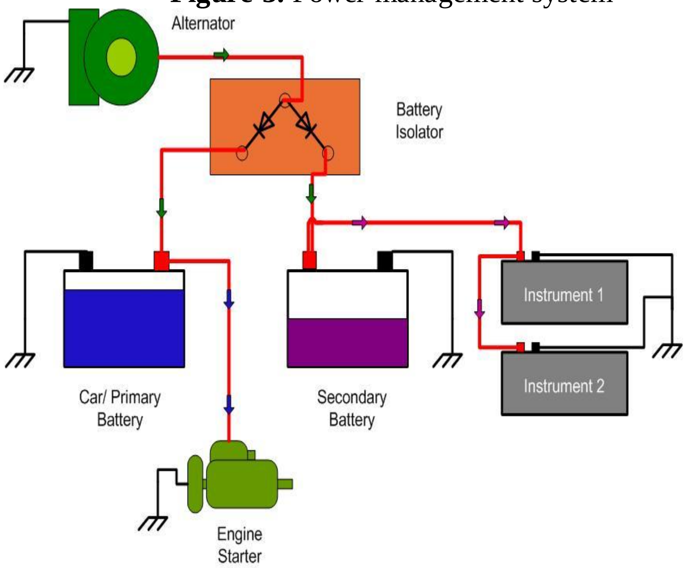
The subsystems analysed according to priority of the system and it is shown in Fig. 2. Each subsystem selection is dependable to previous subsystem. For example, the parameters for input and sensors were considered in preparing the communication and linkages type. This is will affect the selection of data acquisition structure.

4. System Design

Instrumented car system architecture consists of four main elements;

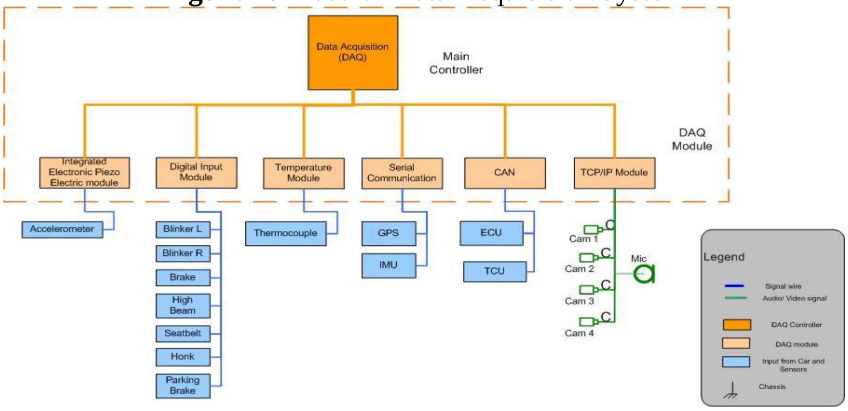
- Continuous and stable power management system to power up all equipment.
- Data acquisition (DAQ) used to acquire and store car information and additional sensor data.
- Additional sensor installed in the car to get driver behaviour or performance data.
- Data storage and analysis software to generate result of respondents' driving behaviour.

Figure-3. Power management system



The power management system used a 12-volt deep-cycle battery to supply electrical power to the system. The battery was installed in parallel with the stock car battery and was continuously charge by a car alternator during engine run. These additional battery and stock car battery were isolated by battery isolator to avoid the batteries discharging simultaneously. Beside 12 Volts supply, the system also provided 240 Volts Alternating Current (AC) for the equipment that required AC supply. Fig. 3 shows power management system that been used in the instrumented car.

Figure-4. Modular Data Acquisition System



The data acquisition selected was most robust platform available in the market; the platform can communicate using multiple protocols such as TCP/IP, Series port, CANBus, and USB. With these multiple protocol, the system can communicate with various type of sensor including analog and digital cameras. Fig. 4 shows data acquisition platform also can handle multiple input and output module such as digital input/output, analog input/output, IEPE, and temperature module. The advantage of the data acquisition system is all modules integrated in one platform, all data can simply synchronise for analysis.

Some driving or environment data cannot be retrieving from car; it will require additional sensors to get more information regarding driving behaviour and performance. Additional sensor, such as laser range finder can measure car's distance with surround object, GPS for positioning and speed, and IMU for vehicle dynamic. These addition sensors will provide more information for data analysis. The sensors parameters ware noted to prepare the DAQ's specification and selection.

The fourth element is data storage and analysis software. These two items are very important to carry out analysis for the final result of an experiment. Data storage importance to ensure collected data will keep safe and useable in future for further analysis. The data analysis software is a tool to enhance and optimise data analysis process.

5. Advantage

Data acquisition platform was constructed in modular form to enable the entire system to be upgraded in the future to meet new research requirements. This platform has multiple communication protocol and it covered most command signal type available in the market.

Respondent informations and system operation trigger is control wirelessly using tablet pc. This function helps in naturalistic study where no system operator presents in car while running an experiment. The tablet pc also works as monitoring equipment to oversee current state of instrumentations.

This development project was focus on data acquisition platform, where the system should be able to record multiple data simultaneously. Currently the system only record car parameter such as engine speed, signal light activation, and etc. Beside that this system also record data from additional sensor such as video, audio, Global Positioning System (GPS) data, and Inertial Measurement Unit (IMU) data. Detail parameters show in the table 1 and 2 below.

6. Conclusion

The instrumented car was designed to have the data acquisition system to be integrated seamlessly with vehicle electrical architecture, allowing for more reliable and robust data collection system. This allows the system to record driver's behaviour and performance while they are driving naturally. In order to prepare the system design, all input parameters, disadvantages of previous system, and future enhancement were considered. The system design has considered most of the relevant research needs for future use of the instrumented car as a tool for data collection. Every possible sensor to capture various driving characteristics and performances was considered during the design stage to determine the data acquisition's specification. The new system is also designed to cater for the expansion of data acquisition platform thus permits possible new addition of sensors in the future without major overhaul of the system required. This new design and improvement is expected to contribute immensely in driving behaviour research.

Table-1. Acquired Vehicle Parameters

No.	Vehicle Information	Parameter
1	Car Speed	Kilometre per hour
2	Engine Speed	Revolution per minute
3	Gear Selection	Gear position
4	Blinker activation	On/Off State
5	High Beam lamp	On/Off State
6	Honk	On/Off State
7	Service Brake	On/Off State
8	Parking Brake	On/Off State
9	Wiper activation	On/Off State

Table-2. Additional Sensor Parameter

No.	Additional Sensor	Parameter
1	Image Sensor	Video and picture
2	voice sensor	Audio sensor
3	Thermocouple sensor	temperature
4	IMU	3-Axis Accelerometer, roll, yaw and pitch
5	Global Positioning System (GPS)	Location/coordinate and travel speed.

References

[1] Abdalla, N., Atiq, R., O.K.R. & Amiruddin, I., (2007). Why do people use their cars: A case study in Malaysia. Journal of Social Sciences, 3(3): 117-122.

[2] Azli, A. Z. A. A., (2010). Challenges and progress: Transforming an ordinary vehicle into an extraordinary research instrument. MIROS Road Safety Conference . Kuala Lumpur: MIROS. pp: 301~311.

[3] Boyce, T. G., (2002). An instrumented vehicle assessment of problem behaviour and driving style: Do young males take most risks? Accident Analysis and Prevention, 34: 51-64.

[4] Brackstone, M. S., (2002). Motorway driver behaviour: Studies in car following. Transport Research Part F, 5(1): 329-344.

[5] Chan, M. P., (2007). An intelligent driving system for automatically anticipating and negotiating road curves. IEEE/RSJ International Conference on Intelligent Robots and System. San Diego.

[6] Proton, B., (2007). Proton persona workshop manual (2007), Selangor. Shah Alam.

[7] Rizzo, M. J., (2002). Instrumented vehicles and driving simulators. Gerontechnology, 1(4): 291-296.