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Hyundai Ioniq Ev Car Acquisition Analysis to Support Vehicle Forensics Activities

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ABSTRACT

An electric car is a motor vehicle that uses an electric motor as the main drive, which is run by a rechargeable battery. Electric cars have several advantages compared to conventional motor vehicles that use internal combustion engines, such as lower emissions, cheaper operating costs, and better performance. This study aims to identify vehicle forensics acquisition techniques in electric cars using OBD ports, by studying vehicle data usage activities. The acquisition focuses on the Hyundai Ioniq EV electric car, the use of the OBD port method in data capture, and focuses on logical acquisition. This evidence can include a history of the location, and connected devices, including sudden braking events, gear shifts, wheel speeds, and vehicle acceleration. The results of this study show that the OBD port can be a source of information in vehicle forensics, and data collection. There were 20 pieces of digital evidence found such as ecus data, telematics data, sudden braking systems, wheel speeds, and vehicle acceleration.

Introduction

The rapidly changing development of computer technology in the last decade has also had an impact on the technology applied to the automotive industry. The development of automotive technology is now increasingly evolving, namely with the existence of electric cars, where the car can store data, and record data about the activity of the vehicle. One of the potentials is to become evidence when an accident occurs. Compared to oil-fueled engines, electric cars produce a lot of torque when running from the moment the car stops, so the acceleration and power of electric cars exceed those of internal combustion engine cars (Firdaus et al., 2023). Electric cars can function as electronic evidence, primary keys (storing data), and potential evidence. Electronic evidence, in the context of vehicle forensics, refers to digital evidence that can be extracted from various electronic systems in the vehicle. The primary key in this context refers to storage in electric cars. A framework will provide a general reference of the investigation process that can be applied to a variety of different cases. In principle, although there are many stages proposed in the digital forensics framework, if you refer to the document from ISO27037 - Information Security Incident Management and ISO27037 - Identification, Collection, Acquisition, and Preservation of Digital Evidence (Didik et al., 2019).

The entire collection of electronic evidence found in electric cars has the potential to become potential evidence in the investigation. This includes data from navigation systems, speed recordings, safety sensors, or vehicle activity logs. This data can be used to identify fraud, check vehicle identities, detect speedometer manipulation, and investigate the activities of vehicles and their passengers (Strandberg et al., 2022). In most cases, logical access to the vehicle system is easier to obtain than physical access which may require disassembly of components.

Logical access can often be achieved through standard interfaces, such as OBD-II (On-Board Diagnostics) on modern vehicles. Generic On-Board Diagnostic (OBD) devices to troubleshoot vehicles that comply with OBD standards. The device displays a real-time vehicle status system and diagnostic trouble codes (DTCs) for different types of vehicles (Niazi et al., 2013). Among them is reading data from the vehicle, such as speed, engine speed, engine temperature, and other information related to vehicle performance. This data can be used as evidence in criminal investigations.

The issue of vehicles with digital evidence is studied by [5] by conducting vehicle system forensics and offering case studies on the acquisition of forensic and entertainment system data analysis on Volkswagen cars. With the increasing digitization of modern vehicles, this study highlights the need for a comprehensive forensic approach to vehicle data, as well as the challenges associated with it. The acquisition method used is by doing a chip-off or physical on the car dashboard. The results of this study include findings related to the types of forensic artifacts that can be found in vehicle entertainment systems, as well as the forensic challenges vehicle systems face.

Meanwhile (Stathers et al., 2022) has done digital evidence capture of modern vehicles and how it can be done in a cost-effective method. Modern vehicles have several computerized components that can be used as proof, such as entertainment systems, airbags, E-calls, and factory assistance, among others. OBD (On-board Diagnostics) software helps investigators read the status of the vehicle's engine and extract digital data from the vehicle. The purpose of this study is to read data from vehicles, such as speed, engine speed, engine temperature, and other information related to vehicle performance using the OBD port.

In the study, there is an acquisition technique point of view on Hyundai Ioniq EV cars by identifying the vehicle system to access the vehicle diagnostic system with the logical acquisition. Digital evidence collection applies the OBD (On Board-Diagnostic) method for vehicle acquisition by identifying the investigation framework that is the reference. The hope is to obtain and explore digital evidence of electronic systems in modern vehicles, especially electric-powered vehicles so that digital evidence can be used as evidence in a case study.

Based on previous research, this study shows that acquisition using logical acquisition through the OBD port on electric cars, such as the Hyundai Ioniq EV, offers a more efficient, practical, and minimally risky method compared to physical acquisition. Logical acquisition enables the collection of relevant and specific data for forensic analysis without the need for physical dismantling of the vehicle, making a significant

contribution to modern vehicle forensics methodologies and expanding forensic applications in electric vehicles. The goal is to obtain and explore digital evidence of electronic systems in modern vehicles, especially electric-powered vehicles so that digital evidence can be used as evidence.

Method

Literature Studies

The literature study stage is carried out to obtain secondary data about the vehicle that is the object of inspection and to recognize the system architecture of the vehicle. Furthermore, the identification of needs is carried out to determine a work environment that suits the research objectives, including the selection of the car to be investigated and the type of hardware required.

Identification of Acquisition Framework

The next stage is the identification of the acquisition framework In principle, although there are many stages proposed in the digital forensic framework, if you refer to documents from the NIJ, there are 5 standard procedures for carrying out digital forensic activities, namely: (1) Policy and Procedure Development (2) Evidence Assessment, (3) Evidence Acquisition, (4) Evidence Examination, (5) Documenting and Reporting. Within the scope of Malaysian legal jurisdiction, one of the references that can be used as a standard is the document from the Standard Operating Procedure of Digital Evidence Collection. In addition, the community of practitioners who are members of SWGDE also created a document on Best-Practices-for-Vehicle-Infotainment-and-Telematics-Systems. In addition, there is also a reference from the Essex Police Department regarding the Procedure of Vehicle Examination and Retention (Sibe & Kaunert, 2024); (Kamal, 2019).

Based on the references obtained, the standard identification carried out can be used as a reference in the creation of a vehicle forensic framework that will be used in the acquisition process. In this case, there are 3 standards that can be used, namely Automotive Process Forensics, NIJ, and Standard Operating Procedure of Digital Evidence Collection. This study focuses on the acquisition phase (Saufi et al., 2019).

Equipment Preparation

At this stage, the equipment prepared is in the form of an OBD-I port for a connection from the car to the device analysis then an analysis device in the form of a Samsung S7 Tablet for acquisition. In conducting research, the process of obtaining data was obtained using the live forensics method with logical acquisition, where data was obtained by acquiring data from an active car, and then data acquisition from the OBD port using OBD-II with Global Diagnostic Software tools.

Artifact Characteristic Analysis

Analysis of the characteristics of the artifacts is carried out to understand the data that has been acquired and evaluate the information obtained from the electric car. Thus, through these systematic methodological steps, this research is expected to contribute to

the proof of digital evidence at the trial as well as become a reference for further research in the field of electric car acquisition techniques (Lacroix et al., 2016).

After the process of analyzing the characteristics of the artifacts, this research will continue with the preparation of a final report on the examination process. The data acquisition stage is also the main focus, where the research will pay close attention to the electric car acquisition process. The initial step will involve the preparation of the necessary interfaces and tools to acquire the data, followed by connectivity and compatibility testing to ensure the successful connection between the acquisition device and the electric car that is the object of the inspection.

Data Acquisition

The research focuses on the acquisition stage of electric cars, the initial step involves preparing interfaces and tools to be used to acquire data. After that, connectivity and compatibility tests are carried out to ensure the success of the connection between the acquisition device and the electric car that is the object of inspection. Furthermore, determining the logical acquisition choice becomes crucial, taking into account the type of data that needs to be acquired and focusing on the primary source of digital evidence such as battery management systems. The data taken is like a recording of data such as speed, mileage, and other instruments. The following are the acquisition steps on a forensic vehicle or forensic vehicle, as shown in Figure 1.

Figure 1
Forensic Vehicle Acquisition Steps

Results and Discussion

At this stage, the determination of the car to be investigated is carried out, the type of vehicle to be used is the Hyundai Ioniq 1. Then Hardware, Samsung Tab S7, OBD-II, and Hyundai GDS software (Tools):

Hyundai Ioniq Ev Car

Table 1
Identification of Car Analysis Needs

	
Vehicle Brand	Hyundai Ioniq EV 1 (2021)
Mileage	373 km (based on NEDC) and 311 km (based on WLTP)
Car Size and Length	Length 4,470 mm x Width 1,820 mm x height 1,475 mm. The wheelbase is 2,700 mm and the distance between the grounds is 150 mm.
Battery	100 kW (136 PS) supplied by 38.3 kWh lithium-ion battery

Samsung Tab S7

Table 2
Analysis Device Needs Identification

	
Procesor	CPU Speed 3.09GHz, 2.4GHz, 1.8GHz Octa-Core
Display	11.0" (278.1mm),

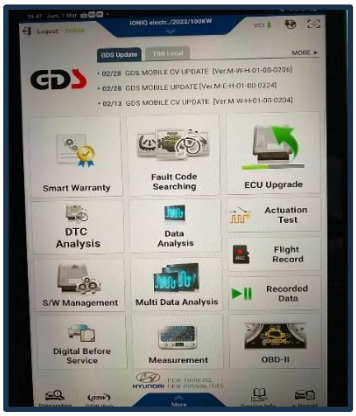
	2560 x 1600 (WQXGA)
S Pen Support	Yes
Storage	128/6 GB
Network	4G LTE
OS	Android
Battery	8000 stomach

Samsung Tab S7

Figure 2
OBD-II

GDS (Global Diagnostic Software)

Table 3
Tools Used



Functionality	Tools for diagnosis acquisition on Hyundai vehicles.

Figure 3
GDS (Global Diagnostic Software)

At this stage, the equipment prepared is in the form of an OBD-II port for a connection from the car to the analysis device, then the analysis device in the form of a

Samsung S7 Tablet for acquisition. In conducting research, the process of obtaining data was obtained using the live forensics method with logical acquisition, where data was done by acquiring data from an active car, and then data acquisition from the OBD port using OBD-II tools was carried out.

Data Acquisition

At this stage, data is obtained from the results of acquisitions in cars that are still active. The car acquisition process is in a lit condition, which is suspected of storing digital evidence, then prepare procedures to carry out the data acquisition stages (Katarína et al., 2021).

After finding the OBD port, the OBD adapter is plugged into the car. When the software recognizes the vehicle, it will display a message on the analysis device indicating that the OBD device has been connected to the car, and once you click OK, the software will automatically configure. Then open Hyundai's GDS (Global Diagnostic Software) software to start acquiring data from the car. The process of picking up involves technicians from Hyundai to acquire the car to comply with the SOP. The results of the acquisition of data from the Hyundai Ioniq EV car revealed the existence of 19 pieces of digital evidence relevant for forensic analysis, covering various parameters such as ECU Data and Telematics Data. Among them, Airbag, PGS, CCM, BMS, VIN, ESPAHB, IBU-TPMS, MCU, OBC, VCULDC, E-SHIFTER, EPB, EPS, BSD-LR, ADM, DDM, PSM, IBU-BCM.

Data Acquisition Analytics

This analysis process uses Global Diagnostic Software to conduct the analysis. This aims to find out the extent to which the software can perform analysis. On the computer analyst side, the data from the car is only on the view or screenshot side of the tool.

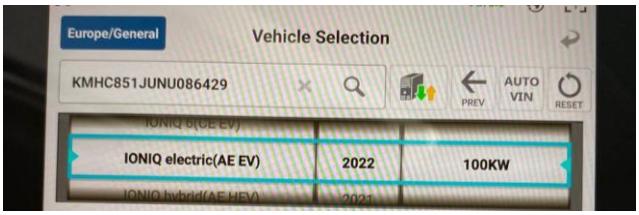


Fig 4
VIN Hyundai Ioniq Ev

Based on Figure 4.5, the results of vehicle identification were carried out on the car. The VIN number is used to identify the vehicle specifically. Each vehicle has a unique VIN number that consists of a series of letters and numbers. Car vehicle type, Hyundai Ioniq electric (AE EV). Then the vehicle model, the sedan. The year of vehicle manufacture is 2022. Vehicle brand, Hyundai Ioniq.

Table 4 Validation of HSSIL Acquisition and Data Analysis

Data Categories	Variable	Feature	Description
Vehicle identification	VIN	✓	KMHC881JU NU086429
	Vehicle type	✓	Ioniq Ev
	Vehicle Model	✓	Sedan
	Year of manufacture	✓	2022
	Vehicle Brand	✓	Hyundai Ioniq 1 Ev
Location Data	GPS Coordinates	x	Features not yet available
	HistoryTravel	x	Features not yet available
Data Sensor	Data Sensor	✓	Good condition
	Navigation System	x	
	Crash Sensor	✓	Good condition
	Telematics Data	✓	Good condition
Data Ecu	Data Ecu	✓	Good condition
Forensic Data	Repair Notes	x	No repair notes yet
	Usage Log	✓	5080 KM
Owner Data		✓	Regional Secretariat of Gorontalo Regency
Data Multimedia	Photos and Videos	x	It cannot be accessed through GDS (Global Diagnostic System).

After analyzing the Hyundai Ioniq EV car from the seven categories of data applied, three features are not yet available, and one feature cannot be accessed on the car. Because this car is the first Hyundai series. In a car without a navigation system, location history data cannot be obtained directly from the vehicle system, which reduces the ability to track vehicle movements in detail. Instead, the focus of the acquisition shifted to other parameters such as sudden braking events, gear shifts, wheel speeds, and vehicle acceleration that remained accessible via the OBD port. Previous research involving

vehicles with navigation systems allowed for a more comprehensive collection of location data and provided a better geographical context for forensic analysis.

Characteristic Analysis of Digital Artifacts

Characterization analysis of digital artifacts involves an in-depth evaluation of data obtained from vehicles to identify patterns, trends, and other important information that can support forensic investigations.

Table 5
Characteristic Analysis of Digital Artifacts

Car Digital Artifacts	Information
Digital Indicator System	Data is stored in a digital format, such as a text file, CSV, or JSON. The data contains information about the vehicle's status, such as speed, battery temperature, and energy consumption. Then the data can be analyzed using various tools and software.
Telematics Data	Telematics data in real-time, including information such as location, speed, vehicle status, and driver behavior. However, this car does not yet have a navigation system feature. Telematics data has a variety of formats and structures, depending on the type of device and system used, in this study the tools used are GDS (Global Diagnostic Software). Then telematics data can be interconnected and connected with various other data sources, such as sensor data. For speed recordings telematics data is generated in real-time, allowing for real-time monitoring and analysis of data.

Navigation System	The navigation system is not available in standard features on the Hyundai Ioniq 1 variant, so drivers may need to rely on maps or third-party apps for navigation while driving.
Audio System	Audio data is stored in digital formats, such as MP3, WAV, or FLAC. Audio data is structured in a file, which contains information about songs, artists, albums, and genres. Audio data contains information about the sounds produced by the audio system, such as music, and phone calls.
Electronic Control Unit (ECU)	ECU data is made up of various parameters and signals that are interrelated, providing detailed information about various aspects of the vehicle's operation. ECU data is generated in large quantities in real-time, allowing for real-time monitoring and analysis of the data. ECU data can contain sensitive information about the vehicle and its users, requiring strong safety protection. ECU data has high value for a variety of applications, such as diagnostics and troubleshooting, vehicle technology development, and automotive forensics.

Analysis of the characteristics of digital artifacts found on the Hyundai Ioniq 1 car, acquired through the OBD port using the logical acquisition method. The digital artifacts found include digital indicator systems, telematics data, navigation systems, audio systems, and ECU data, providing in-depth insight into vehicle usage behavior for

forensic purposes (Whelan et al., 2018). Compared to previous studies by those who used physical acquisition methods to collect data from car infotainment and navigation systems, this study offers a more efficient and less risky approach, the process takes longer and risks damaging vehicle components. Another research uses the logical acquisition method in electric vehicles, This study uses a qualitative approach by analyzing data from available sources, such as VIN (Vehicle Identification Number), ECU (Electronic Control Unit) data, and data from the OBD (On-Board Diagnostics) diagnostic interface. These findings confirm that logical acquisition is an effective alternative in collecting digital artifacts from modern electric vehicles, helping to speed up the forensic investigation process without compromising the quality and completeness of the data obtained as well as the ability to collect comprehensive data without the need for physical dismantling of the vehicle (Jacobs et al., 2017).

Digital Evidence Classification

Based on the results of the analysis after the digital evidence is obtained, a classification is made to match the digital evidence relevant to the incident of the case that occurred. This matching helps in determining relevant data sources to support the investigation of a particular case in the context of vehicle forensics.

Table 6
Classification of Digital Evidence

Data Categories	Variable	Case
Crash Sensor	Airbags	Traffic Accidents
		There was a traffic accident involving a Hyundai Ioniq 1 vehicle. Data from accident sensors can assist investigators in reconstructing the accident, determining the speed and direction of the vehicle when the accident occurred, and understanding the impact and seriousness of the accident.
Telematics Data	Assoc. Prof.	Single Accident
	Ccm	

	Airbags	A Hyundai Ioniq 1 car was reportedly involved in a single accident. Using telematics data, investigators can examine vehicle status such as speed, brakes, and steering position before a collision to determine the causes and factors that may have contributed to the crash.
	Bms	
	Vin	
	Espahb	
	Mother-Tpms	
Data Ecu	Mcu	Engine Breakdown
	OBC	A Hyundai Ioniq 1 vehicle reportedly suffered a sudden engine failure while in use. By analyzing data from the ECU, investigators can explore engine parameters such as temperature, oil pressure, and engine rotation before an event occurs. This information can help determine the possible causes of engine failure and gain additional insight into the overall condition of the vehicle.
	Vculdc	
	E-Shifter	
	Epb	
	Eps	
	BSD-LR	
	Adm	
	DDM	
	Psm	
	Mother-Bcm	
Entertainment System	Digital Indicator System	A car on fire in a parking lot or similar
		A Hyundai Ioniq 1 car was found on fire in the parking lot. By analyzing

		the entertainment system's usage history, investigators can find out if there was any suspicious or abnormal activity before the fire occurred, such as excessive music playback or using potential audio system features.
Data Audio	Audio System	Kidnapping Cases A vehicle was involved in a kidnapping case where the victim reported a suspicious conversation inside the vehicle. By analyzing the audio playback history of the entertainment system, investigators can look for audio evidence that supports the victim's claims and identify the perpetrator or other important information.
Navigation Data	Gps	Vehicle Theft A vehicle was reportedly stolen from a parking lot. Using travel history data from the GPS navigation system, investigators can track the vehicle's travel route to determine its final

	location and identify the vehicle's current probable location.

Based on the results of the classification of digital evidence, from the digital classification of forensic vehicles and the matching of cases with digital evidence on the Hyundai Ioniq 1 car in Table 4.4, it can be concluded that various sources of digital data can be used in vehicle forensic investigations. Each type of data has its usefulness and relevance depending on the case being investigated. For example, the trip history of a GPS navigation system can help determine the location and travel route of a vehicle, while accident sensor data can provide insights into the occurrence of an accident and its impact. In addition, information from audio systems, telematics data, and entertainment systems can also be valuable digital evidence in understanding the activities of vehicles and their passengers.

Compared to previous studies of using physical acquisition, the collection of users' personal data, travel history, and classification of digital evidence in great detail. However, it requires dismantling vehicle components, risks damaging internal systems, and the process takes longer. Another study examined digital evidence classification methods that can be used in traffic accident cases. This study found that the classification method based on the type of data and its relevance to the case proved to be effective. The findings of this study have an important position in the innovation of digital evidence classification. This study shows that classification methods based on data types and their relevance to cases can be used effectively in various types of cases, including the case of the Hyundai Ioniq 1 car.

Conclusion

The acquisition technique of electric cars for vehicle forensics needs, especially in the Hyundai Ioniq EV electric car, using a logical acquisition approach through the OBD port, has succeeded in making a significant contribution to the field of vehicle forensics, 20 pieces of digital evidence have been successfully acquired. Through the identification of the acquisition framework used, researchers can access and analyze the vehicle's digital data, including location history, connected devices, sensor data, telematics data, and ECU data for forensic investigations, but the location history on these cars is not yet available. The digital evidence obtained in this study can only be viewed so that the data from the car cannot be extracted in PDF or other forms. The sensor data contained in this car is still in good condition. Because this car is only used on two events, namely the day of death and the day of the family's wedding. The results of this research are expected to strengthen legal cases, prevent traffic accidents, and create training programs that prepare digital forensics professionals to face challenges related to vehicle data.

Meanwhile, the suggestion in this study is that the GDS (Global Diagnostic Software) software used is not able to read data such as date, time, audio system,

entertainment system, multimedia, voice calls, and video calls, and cannot be extracted. Therefore, it is hoped that for the next research, it will be able to acquire and analyze with other software so that it can display more complete information.

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