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REMOTE VEHICLE DIAGNOSTIC SYSTEM DEVELOPMENT BASED ON THE INTERNET OF THINGS TECHNOLOGY

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Background. Advanced artificial intelligence and IoT gateways are working together in the automotive industry to predict potential vehicle problems by analysing sensor data and optimizing quality control processes. Manufacturers can detect anomalies, improve product reliability, and eliminate manufacturing defects or malfunctions in advance. Predictive analytics also lead to improved fuel efficiency, performance and overall vehicle reliability.

Objective. The purpose of this work is to develop a model for remote diagnosis of vehicle faults using a Raspberry Pi model B microcomputer and a SIM7600G-H GSM module. Configure data modules, install the necessary software and configure it, demonstrate step-by-step actions, and perform diagnostics and testing of this module for data transmission.

Methods. A prototype was created on the basis of Raspberry Pi 4. and provides monitoring of machine operation in remote mode using the SIM7600E-H LTE Cat-4 4G/3G module. The design has small dimensions, easy installation, requires only initial adjustment and has a wide range of improvements.

Results. This prototype uses a diagnostic OBD-II car scanner ELM327 with Bluetooth connection support, a Raspberry PI 4 model B microcomputer with 8 GB of RAM, 4 USB connectors (2 ports type USB3 and 2 ports type USB2), a Gigabit Ethernet port, a USB-C power supply port, and two micro HDMI 4K display connectors. On top of the module there are 48 pins (contacts) with which you can connect modules of different types and directions. The SIM7600G-H communication module is connected to these pins. The last element of the prototype is the SIM card of one of the telephone service providers and the micro SD card, which will act as the main memory element on which the operating system will be written and data will be stored.

Conclusions. The article proposes the development of a device model using Internet of Things technologies, which is capable of providing remote diagnosis of car malfunctions. This model is based on the use of the SIM7600G-H module, which provides data transmission through the mobile network.

The developed model allows you to read data from various car sensors, as well as transfer this data to a remote device for further analysis. This makes it possible to quickly detect malfunctions and make timely decisions on their correction.

Keywords: *Remote control; Raspberry Pi microcomputer; OBD-II scanner; SIM7600G-H module.*

I. INTRODUCTION

Car diagnostic devices are gaining more and more popularity and wide application in the field of car repair and maintenance. Every day, the car manufacturing technology improves and becomes more and more complicated. But most of them are either stationary and require the presence of a master in the car or work at a distance of no more than 10 meters from the vehicle.

The task of implementing Internet of Things technologies for remote car diagnostic systems is becoming urgent.

Automotive IoT enhances vehicle control systems and related functions through the integration of IoT gateways as well as sensors, telemetry units, on-board diagnostic equipment, connected infotainment systems, and automotive network communication equipment.

Automotive IoT integrates Internet of Things technologies into the automotive industry by connecting cars to the Internet and enabling communication between cars, drivers and various external systems. This integration allows data and information to be shared, providing new features and services and increasing overall efficiency and security.

For example, the V2M system is designed to detect hidden defects in the operation of the car. It consists of two electroacoustic sensor modules, which are placed under the bottom of the car, as well as a control unit located between these modules. The system monitors and records operating noises. Records are converted into digital signals that are transmitted to an online server for analysis by algorithms based on artificial intelligence. When any problems or malfunctions are detected, the driver receives a message through a special application.

In new cars, engineers introduce the use of self-diagnosis technologies using on-board computers. Such devices will independently detect an error in the operation of the car and notify the owner of this vehicle. Such improvements simplify the task of identifying the causes of malfunctions and, accordingly, allow you to coordinate with the client to which master you need to contact. But there is still the question of old car models or simpler vehicle configurations. Developing devices to diagnose them, notify the owner and the service center would help a lot of people. Therefore, the creation, testing, and production application of such devices becomes a very urgent task.

II. REMOTE VEHICLE DIAGNOSTIC SYSTEM DEVELOPMENT

Most often, the OBD II connector is used when servicing or during repair process of a car.

OBD devices plug into the vehicle's OBD-II port, which most modern cars have. These devices collect diagnostic data from the car's electronic systems and transmit it wirelessly to a connected device or cloud platform.

Thanks to the fact that cars use this technology to combine sensors located throughout the vehicle, a general and quick inspection of the car is carried out.

The analysis of the problem shows that at the moment the general specialty of car mechanics is divided into areas depending on the type of work. Depending on the specifics of the task, they can deal with: electronics, repair of gearboxes, maintenance and repair of engines, etc. But it all starts with a technical inspection (TI) where scanning of all parts of the car will definitely be used.

In order to simplify the work of engineers and improve the conditions for car owners, the presented paper proposes a device prototype that will help diagnose the work in real time when the car is on the road. The prototype was created on the basis of Raspberry Pi 4. and provides monitoring of the machine in remote mode using the SIM7600E-H LTE Cat-4 4G/3G module. The design has small dimensions, easy installation, requires only initial adjustment and has a wide range of improvements.

Most cars in the budget segment do not have an on-board computer. With the help of this computer, it would be possible to collect more information and data for a faster response and solution to the problem without prematurely bringing the machine to a critical state. This technology can reduce costs and time of drivers. Using an OBD II module that uses data in a numeric code format and sends it to a Raspberry Pi microcomputer that transforms the information and reproduces it using an application.

LTE, GSM and Wi-Fi technologies can be used for this prototype.

The selection of each of the modules takes place according to certain criteria that are required for work. The OBD II module has two options: wired or wireless (Bluetooth/Wi-Fi). One of the options is used to connect to a microcomputer. The choice of control module is based on the capabilities of this module. Raspberry PI has variants with different microcontrollers, number of ports, data storage, amount of RAM memory.

This prototype uses a diagnostic OBD-II car scanner ELM327 with support for connection via Bluetooth, a microcomputer that is used - Raspberry PI 4 model B with 8 GB of RAM, 4 USB connectors (2 ports type USB3 and 2 ports type USB2) , a Gigabit Ethernet port, a USB-C power supply port, and two micro HDMI 4K display connectors. It also has the functionality of an ordinary computer, Bluetooth, Wi-Fi and other small features. On top of the module there are 48 pins (contacts) with which you can connect modules of different types and applications. The SIM7600G-H communication module is connected to these pins. The last thing you need is a SIM card from one of the telephone service providers and a micro SD card that will act as the main memory element on which the operating system will be written and data will be stored.

In general, this model will have a compact size and simple architecture (Fig. 1).

The given scheme can be divided into two parts:

1. In the car - components that are placed in the car and function only when the car is turned on. They read and process all the information, in fact, this is the entire prototype that is being developed.
2. Outside of the car – components that are used to transmit all processed and found problems in the car after starting the engine or at the time of movement.

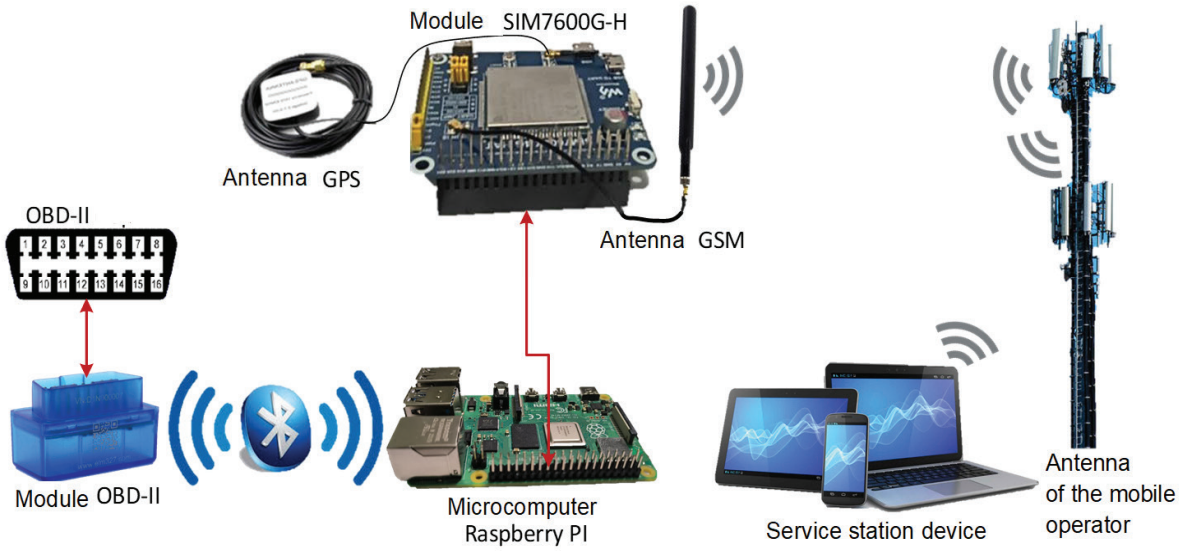

Fig. 1. The architecture of the remote car diagnostics device.

The algorithm of this model is built as follows in Fig. 2. The engine starts and powers the microcomputer and the OBD-II module. The initial start takes a few minutes, as the software that will process the data and redirect it to the remote device needs to be loaded. At the same time, the Bluetooth connection between Raspberry PI and OBD-II takes place. Afterwards, scripts start working on the microcomputer that will send a request to receive data and process it. This procedure is repeated until an error is detected. Problems can be divided into three criteria: urgent solution, minor error, warning. Depending on the type of problem, the messages will come with different notations to make it easier to understand the magnitude of the problem. When a problem is identified, the microcomputer sends a message to the service station. For this, the SIM7600G-H module is connected to the Raspberry, which transmits data by connecting to the nearest antenna of the provider.

The data indicates the problem and, with the help of the GPS antenna, the location of the car.

The following studies were conducted to test the created device:

1. Test operation of the SIM7600G-H module

The first test was carried out using the application IDE. It can be anything compatible with the Raspbian OS. In order not to install something new, the already installed default software development environment in the form of an operating system is used.

2. It is necessary to check the functionality of the GSM antenna. For this, we will also use the prepared "GPS.py" script, which can be found in the "/home/pi/SIM7600X-4G-HAT-Demo/Raspberry/Python/GPS" directory.

To open this script, do the following: right-click on the file, select "open with" and select the IDE application.

This script activates and uses the GPS antenna. It is possible to do this without a SIM card.

3. After few minutes of running, the GPS data should be collected and directly printed into Python Shell every few seconds.

This cycle is constantly repeated, which indicates that if the microcomputer moves, the coordinates will change.

After the test run, it is possible to connect all modules to the car, starting with the OBD-II scanner. Then the microcomputer can be connected to power through the cigarette lighter connector to the charging adapter with the USB connector. In fact, the model is ready to work, all that remains is to start the car engine, establish a connection between the scanner and the microcomputer, after which the car scanning program and the SMS transmission script to the car mechanic's device should automatically start.

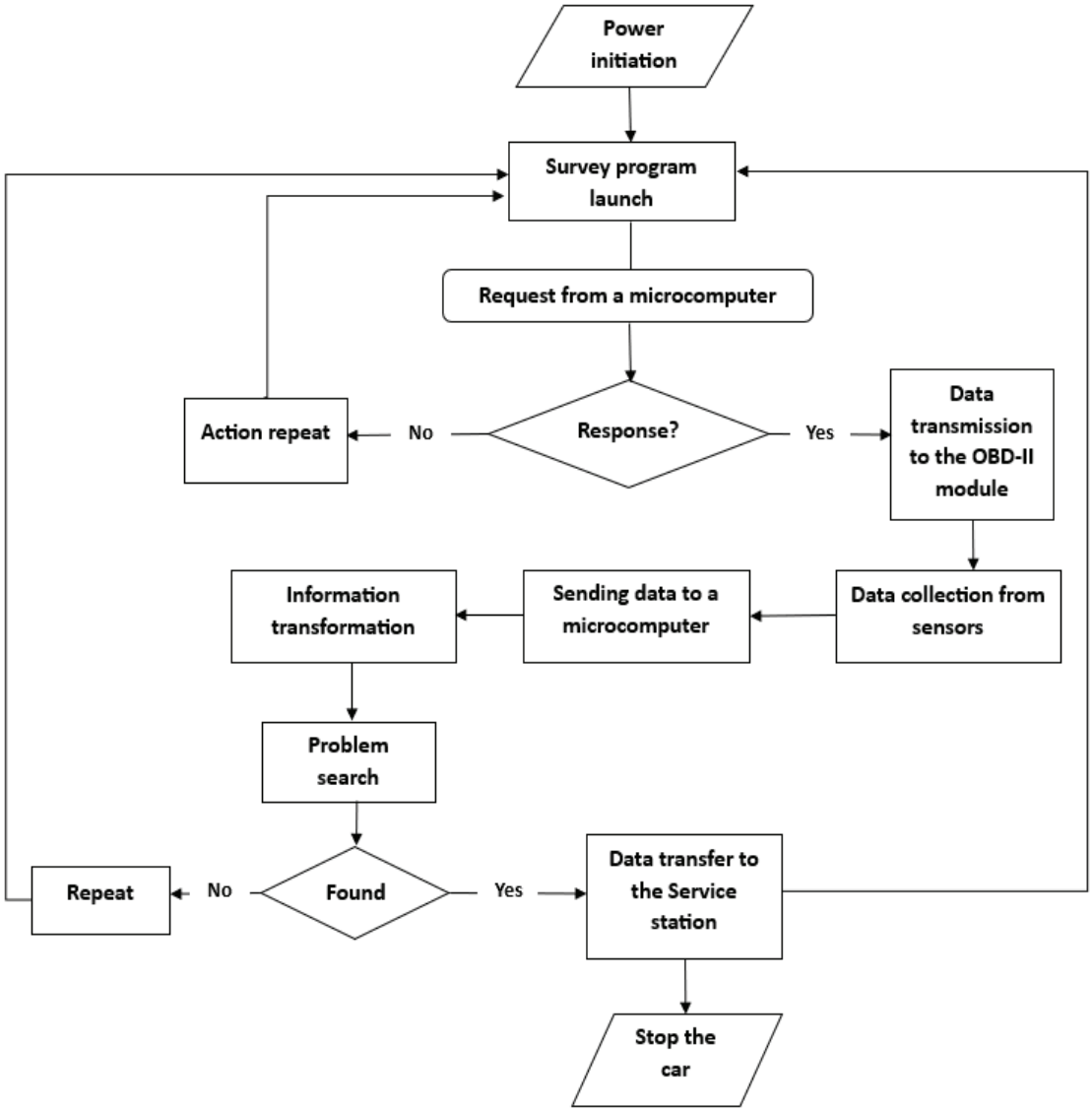

Fig. 2. The working principle of the prototype

Thereafter, the car mechanic needs to open the AnyDesk program on his computer and establish a connection between his device and the Raspberry Pi single-board computer in the car. To do this, a pair connection between OBD-II and the program needs to be established. The first connection must be made manually. Anbox program (Android virtual machine) is used in this case to work with the Car Scanner, which will allow the detailed information about the condition of the car to be displayed.

After launch, only plugins that do not require pairing with an OBD-II scanner will be available.

III. CONCLUSIONS

The article proposes the development of a device model using Internet of Things technologies, which is capable of providing remote diagnosis of car malfunctions. This model is based on the use of the SIM7600G-H module, which provides data transmission through the mobile network.

The developed model allows you to read data from various car sensors, as well as transfer this data to a remote device for further analysis. This makes it possible to quickly detect malfunctions and make timely decisions on their correction.

Using the model for remote diagnosis of vehicle faults has several advantages. First of all, it allows car owners to monitor the condition of their vehicles in real time. In addition, such system allows prompt response to detected malfunctions, which helps to reduce repair costs and avoid emergency situations.

Further areas of research may include improvement of the developed model, taking into account new technological solutions and trends in the field of automotive electronics. It is also worth considering the possibility of integrating the model with other car systems, which will allow for more complete and accurate detection of malfunctions.

REFERENCES

1. S. B. Mogilny, Raspberry PI microcomputer - researcher's tool: Manual. K.: "Talcom", 2014. - 340 p.
2. G. Halfacree, B. Everard, Get started with MicroPython on Raspberry Pi Pico. – Cambridge, 2021. – 139 p. (ISBN: 978-1-912047-86-4)
3. AnyDesk soft. https://pimylifeup.com/raspberry-pi-anydesk/.
4. SIM7600G_SIM7600G-H_Hardware Design _V1.00 / Smart Machine Smart Decision, 2019. – 72 p. Retrieved from https://www.waveshare.com/w/upload/e/e6/SIM7600G_SIM7600G-H_Hardware_Design_V1.00.pdf
5. Raspberry Pi 4 Model B Datasheet Copyright Raspberry Pi (Trading) Ltd. 2024. Retrieved from https://datasheets.raspberrypi.com/rpi4/raspberry-pi-4-product-brief.pdf
6. M. Collier, Basics of architecture Internal things. – Ternopil "Knygarnia Ye", 2016. – 238c.
7. Analytics Perspective. ICIIT 2017. Communications in Computer and Information Science, vol 808. Springer, – Singapur, 2018 – pp. 97 – 99.
8. K. Sharma, A Disaster Management Framework Using Internet of Things-Based Interconnected Devices // Sharma, K., Anand, D., Sabharwal, M., Tiwari, P., Cheikhrouhou, O. and Frikha, T. / Mathematical Problems in Engineering, 2021, pp. 1-21. Retrieved from https://www.hindawi.com/journals/mpe/2021/9916440/
9. S. Moessner, R. Ramaswamy, and S. Tripathi., “Internet of Things (IoT): a literature review // Journal of Computer and Communications, 2015, vol. 03, No. 05, pp. 164–173.
10. T. Henkey, “Future of urban emergency management,” in Urban Emergency Management / Butterworth-Heinemann, Amsterdam, Netherlands, 2018. - pp. 223–236

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Розробка системи віддаленої діагностики автомобілів на основі технології інтернету речей

Проблематика. Удосконалений штучний інтелект та шлюзи Інтернету речей працюють разом у автомобільній промисловості, щоб прогнозувати потенційні проблеми з транспортними засобами шляхом аналізу даних датчиків та оптимізації процесів контролю якості. Виробники можуть виявляти аномалії, підвищувати надійність продукції та заздалегідь усувати виробничі дефекти чи несправності. Прогнозна аналітика також призводить до підвищення ефективності використання палива, продуктивності та загальної надійності транспортних засобів.

Мета досліджень. Метою даної роботи є розробка моделі віддаленої діагностики несправностей автомобіля за допомогою мікрокомп’ютера Raspberry Pi model B та модуля GSM SIM7600G-H. Провести налаштування даних модулів встановити необхідне програмне забезпечення провести його налаштування продемонструвати покрокові дії та провести діагностику і випробування даного модуля для передавання даних.

Методика реалізації. Створено прототип на базі Raspberry Pi 4, що забезпечує моніторинг роботи машини у віддаленому режимі за допомогою модуля SIM7600E-H LTE Cat-4 4G/3G. Конструкція має малогабаритні розміри легке встановлення, потребує тільки початкового налаштування та має широкий спектр вдосконалення.

Результати досліджень. Даний прототип використовує діагностичний OBD-II автосканер ELM327 з підтримкою з’єднання по Bluetooth, мікрокомп’ютер використовується Raspberry PI 4 model B на 8 Гб оперативної пам’яті, 4 роз’єми USB (2 порти type USB3 та 2 порти type USB2), порт Gigabit Ethernet, порт живлення USB-C power supply, та два роз’єми для виводу зображення micro HDMI 4K displeys. Зверху модуля є 48 пінів (контакти) за допомогою яких можна під’єднати модулі різного типу та спрямування. До цих пінів підключається модуль зв’язку SIM7600G-H. Останнім елементом прототипу виступає SIM-карта одного з провайдерів телефонного зв’язку та micro SD карта яка буде виступати в ролі головного елементу пам’яті на якому буде записана операційна система та зберігатимуться дані.

Висновки. В статті запропоновано розробку моделі пристрою з використанням технологій Інтернету речей, яка здатна забезпечити віддалену діагностику несправностей автомобіля. Ця модель базується на використанні модуля SIM7600G-H, який забезпечує передачу даних через мобільну мережу.

Розроблена модель дозволяє зчитувати дані з різних датчиків автомобіля, а також передавати ці дані на віддалений пристрій для подальшого аналізу. Це дає можливість оперативно виявляти несправності та вчасно приймати рішення щодо їх виправлення.

Ключові слова: *Віддалене керування; мікрокомп’ютер Raspberry Pi; сканер OBD-II; модуль SIM7600G-H.*