

Designing Android Software Applying Augmented Reality on the Teaching and Studying of Gasoline Engine Sensors

Nguyen Tan Ngoc *

HCMC University of Technology and Education, Vietnam

* Corresponding author. Email: ngocnt@hcmute.edu.vn

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ABSTRACT

Nowadays, the gasoline engine is still the heart of transportation in Vietnam. The total number of internal combustion vehicle in Vietnam is over 4 million, which is approximately 2.4 million petrol vehicles. The need of knowledge in the vehicle, especially the gasoline engine control system, is vital for maintenance and diagnostic process in this field. This paper is an introduction for applying the augmented reality and smartphone in teaching and studying input signals of the engine control system of gasoline engine in the Vehicle and Energy Faculty, HCMC University of Technology and Education, focusing on sensors. Augmented Reality (AR) is a new way of information sharing and interaction in mobile device (smartphone, tablet, etc.). AR in education brings truly realistic for teaching and learning process. Additional reality provides the unique cognition path with immersive real-life simulations, which help student accesses resources as real and freely as possible especially in the COVID-19 pandemic.

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1. Gasoline EFI system review

1.1. EFI system in the gasoline engine

The gasoline engine obtains power from the thermal energy created via combustion of the mixture between air and gasoline in the cylinder [1, 2, 3]. Unlike the diesel engine, which uses compression-ignited, the gasoline engine uses spark plug to ignite the mixture inside cylinder. In this type of ignited, the fuel is injected and combined with air in the intake manifold before travelling to cylinder. This mixture then ignited by the spark plug, providing power for the operation of engine, which is the heat of vehicle. The engine is not only properly function but also aiming to high power output, high fuel economy and lower emission [1, 2, 3].

To achieve those goals, the gasoline engine must precisely maintain parameters:

- Air-fuel ratio
- Compression
- Spark

From the 1980s, the EFI (Electronic Fuel Injection) system is used to improve the accuracy of control systems via ECM (Electronic control module) [1, 2]. The ECM controls a variety of systems in engine, but we can divide into four sub systems:

- Air induction system
- Ignition system
- Fuel system
- Emission control system

To maintain control all systems above, the ECM must continuously receive and send signal. Signals from sensors are unceasingly collected and evaluated by ECM. After processing, the ECM will send appropriate signals to actuators ensuring the working conditions of engine.

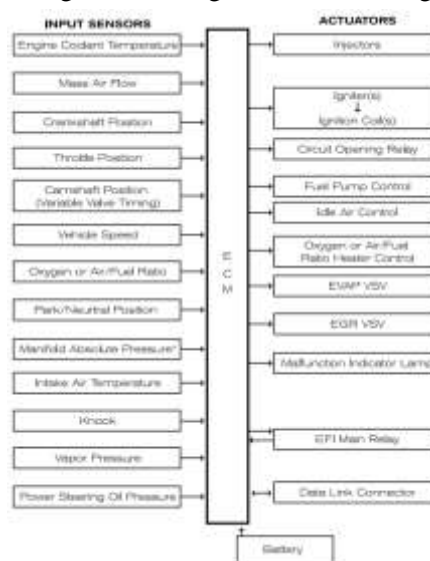


Figure 1. Basic EFI control system [1]

Sensors are used to collect the working conditions of engine and transfer to ECU in the form of voltage. The ECM will constantly monitor and send sufficiently signals to actuators to operate properly.

1.2. Sensors

Sensors convert the physical quantities or chemical quantities into the electric signals and transfer those signals to the ECM for processing [1, 2, 3]. Various sensors are used to collect data from the engine to ensure the properly working conditions, but we can classify sensors into the following groups:

- Temperature sensors
- Position sensors
- Air flow sensors
- Pressure sensors
- Oxygen sensors
- Knock sensors

Temperature sensors collect the temperature of systems for ECM to handle. The ECM will adjust systems based on collected temperatures. It is critical for proper operation of these systems that the engine reach operating temperature and the temperature is accurately signaled to the ECM [1, 2]. One example is the fuel injection system, for the proper amount of fuel to be injected the ECM must know the correct engine temperature. The parameters collected by temperature sensors are engine coolant temperature, intake air temperature, exhaust gas temperature, engine oil temperature and fuel temperature, etc. The temperature sensors are usually a Positive Temperature Coefficient (PTC) resistor, which its resistance dropped when increasing the temperature, fitted inside a housing [1, 2, 4].

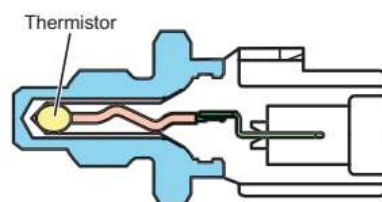


Figure 2. Temperature sensor structure [4]

The ECM collects signals from position sensors to know the position or mode of the components. The parameters collected by position sensors are camshaft position, crankshaft position, throttle, accelerator, etc. The position sensors can be the inductive type, optical type (camshaft or crankshaft), Hall-effect type, variable resistance type, contact switch or MRE type [1, 2, 5].

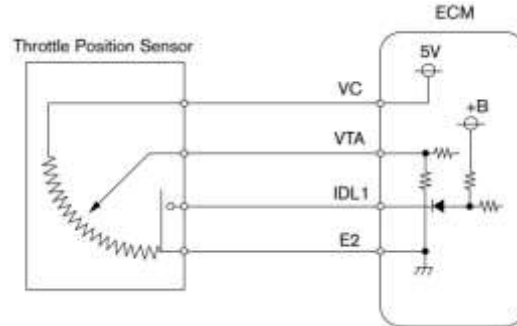


Figure 3. Schematic of the TPS sensor [1]

The air flow sensors measure the amount of air flow through an object into a voltage signal. The ECM will collect and calculate the amount of air in the intake manifold. The air flow sensors can be vane air flow meter, Karman vortex or the Mass Air Flow (MAF) type [1, 2, 4].

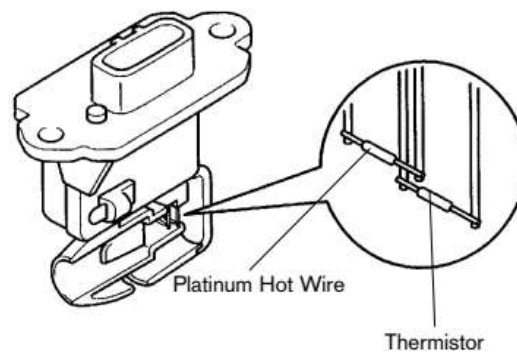


Figure 4. MAF sensor structure [1]

The pressure sensors are used to measure the pressure at the target locations. The silicon chip flexes as pressure changes proportion with the output voltage signal.

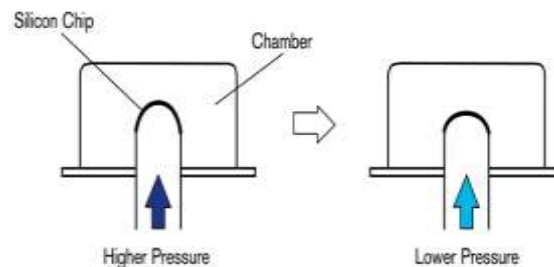


Figure 5. Pressure sensor sensing method [1]

The pressure sensors can be used to measure the Manifold Absolute Pressure (MAP), Vapor Pressure, Turbocharger Pressure, etc.

The oxygen sensors are used to measure the amount of oxygen in samples. There are two main types of oxygen sensor: the narrow range oxygen sensor and the wide range oxygen sensor (A/F sensor). This type of sensor uses chemical reaction within the sensor that creates an electrical output proportional to the oxygen level [1, 2, 5].

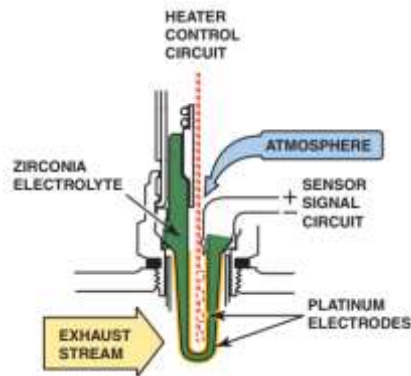


Figure 6. A typical heated zirconia oxygen sensor [4]

The Knock sensor, which is located in the engine block, cylinder head, or intake manifold is tuned to detect a specific frequency. Then, the knock sensor sends the voltage to ECM to detect engine knock and the ECM will have to control the timing of ignition to prevent detonation [1, 2, 4].

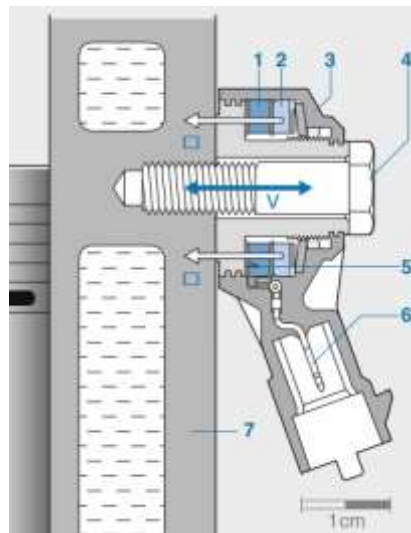


Figure 7. Piezoelectric knock sensors [2]

2. Augmented reality

2.1. Introducing the Augmented reality (AR)

Augmented reality is a new technology that present a virtual world without completely replacing the real world [6, 7, 8]. The four main purposes of AR are:

- Enrich the real world with additional information
- Access full control of view specification
- Consider change in the real world
- The user becomes an active participant in achieving the communicative goals

The biggest benefit of AR technology is that collaborative application. Users can simultaneously view, discuss, and interact with the virtual models and real world. Therefore, AR has proven that it can seamless integration with existing tools and practices. Another advantage is that it can enhance practice by supporting remote and collocated activities that would otherwise be impossible. The access to AR technology is much easier with the arise of smartphone, leading to the popular of applying in education [6, 7, 8].



Figure 8. Apply of AR in industry [9]

2.2. Classification of Augmented reality

Nowadays, it's normal for student to obtain a high-quality smartphone. The introduction of augmented reality will capture the attention of students and force them to use their phone in positive ways under guidance of teacher. Virtual reality is a very complex aspect, so the way user interacts with virtual world. The lessons can become easier or difficult depends on the way student applying augmented reality in each angle, very flexible and not firmly forced student in just one way as tradition methods. In addition, virtual applications are often an open community, so it is very simple for students to comeback after class with new materials in the feedbacks. Because of the variety of augmented reality applications and their expertise in the industry, we can divide augmented reality applications into three categories:

Category 1: Simple, easy to use, more gentle image for the purpose of small-graders from junior high school or less interested in learning. Practical applications:

- **Math Alive:** AR application, requires connection to a computer, smartphone, and pre-printed card provided by the app. This application helps students learn basic math calculations and English vocabulary [6, 10].



(a)



(b)

Figure 9. a: Math Alive [10] and b: Elements 4D [11]

Category 2: Focus on a certain profession with specialized knowledge for high school students and above. Practical applications:

- **Elements 4D:** AR application, requires smartphone that supports the AR application and the pre-printed cards provided by the application. Apps that show students how to react to mixing chemicals in the real world, including app-based lessons on some compounds [6, 11].

- **Anatomy 4D:** AR application, similar to Elements 4D. Application for medical students, showing the internal structure of the human body and being able to interact with objects through applications [6, 12].

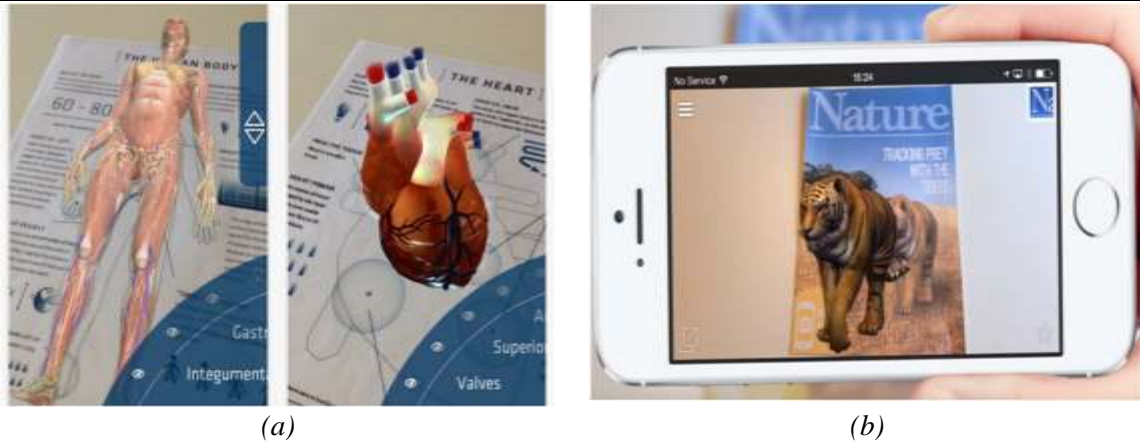


Figure 10. *a: Anatomy 4D [12] and b: Layar [13]*

Category 3: Diverse sectors for users to choose with purpose to add knowledge. Practical applications:

- **Layar:** AR application, designing 3D objects on the web provided by the application, users can then scan the selected image to view the object [6, 13].

3. Design Android application using Augmented Reality for Gasoline engine

3.1. Build-up library

The application will be divided into two parts: 2D and 3D. The 2D part will contain the theoretical contents of the sensors. The 3D part is the Augmented Reality application that helps students interacting with real engine in the faculty workshop.

To build an Augmented Reality application, we need two main components: the background image (Image Target) and the content library (Asset).

The purpose of this application is using for teaching and studying gasoline engine sensors at the Faculty of Vehicle and Energy in Ho Chi Minh City of Technology and Education. Therefore, the image target must be come from the faculty's workshop and textbook. This image must have high-quality and remain constant. The contents must be shortened, and the type of sensors must be matched with the target engine.

Some background images:



(a)



(b)

Figure 11. *a: An engine model and b: Name of the model*



(a)

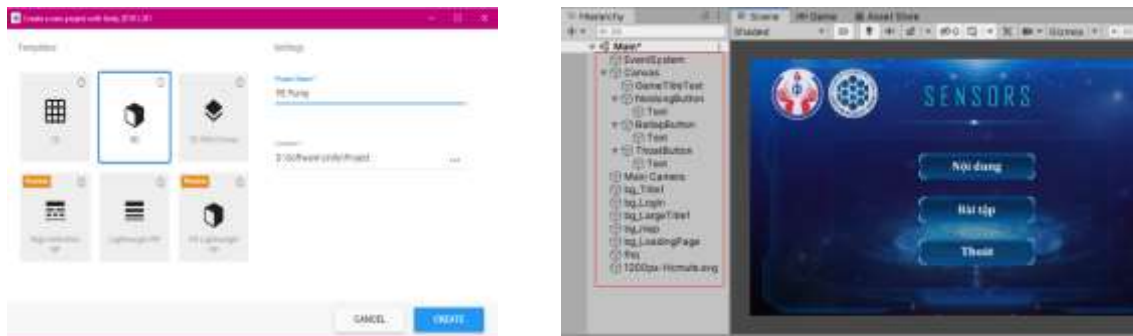
(b)

Figure 12. a: Camry 2002 engine (real vehicle) and b: Throttle position sensor

The model's name doesn't change even if the model is reworked each semester ensuring the application will recognize the image target.

3.2. Design the application

Step 1: Create the platform for application in Unity.



(a)

(b)

Figure 13. a: Choosing platform and b: Design interface



Figure 14. Setup Augmented Reality in Unity

Step 2: Editing and writing codes for the application on Visual Studio.

In Unity, we can prepare some simple codes before writing the application. For example, we can write the code that make the object appears or disappears without specifying which objects. Unity has been designed so that we can add some simple codes to the appropriate position without having to write details in the code, which saves programming time significantly and easy to control the structure of the application. Codes are written by C# in Visual Studio.

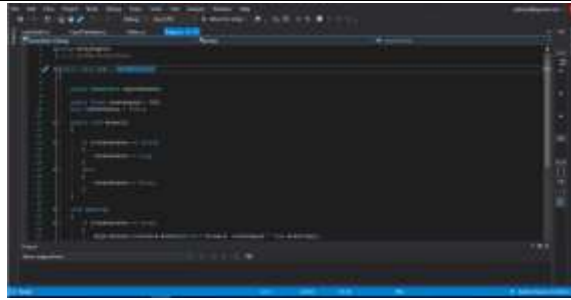


Figure 15. Coding in Visual Studio

The application has two languages, English, Vietnamese, and also has two modes: 2D and 3D. The 2D mode is used simply as an electronic textbook. The 3D mode is used for applying Augmented Reality, capturing the real objects and switch to virtual objects with intervention for learning in the workshop. The editing is mainly focus on pointing out the sensor's location and the type of sensors using in the engine.

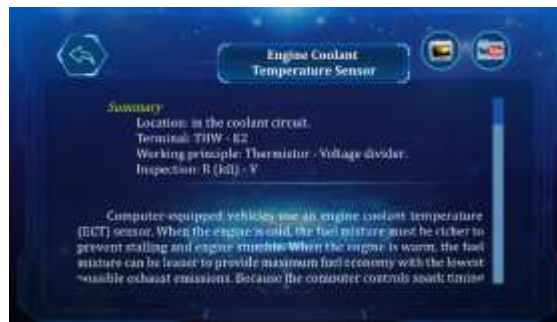


Figure 16. Shortened principle and measurement of the temperature sensor

The application will have the basic functions:

- Contains shortened principle and measurement of sensors
- Contains the actual location in engines
- Contains videos about the simulation and measurement of sensors. Videos are put directly into the application if the size is small and as the Youtube link if the size is large.
- Quizzes to help student consolidate knowledge
- Change from 3D to 2D and vice-versa
- Functions of an application: induction, slide down, slide up, change screen, sound effects, countdown, grading quizzes,

4. Result of application in reality

Using application in reality:



Figure 17. Main screen.



Figure 18. *Sub menu.*

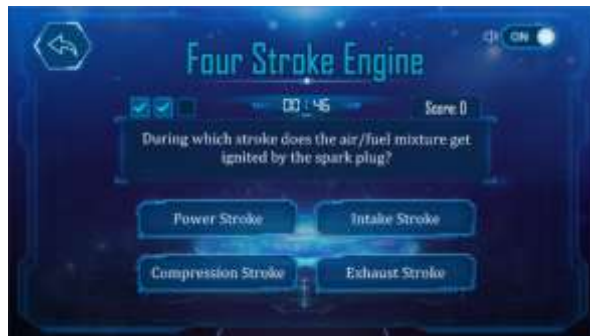


Figure 19. *Quiz in the application.*



Figure 20. *Virtual reality in Camry 2002 Engine.*

When you press the sensor name, the software will switch to the 1 sensor's actual shape and type, along with parameters and measurement methods.

5. Conclusions

The article introduces an overview of AR (Augmented Reality) interactive technology. In this time of pandemic, shortening students' learning time and applying technology on smartphones helps learners and teachers increase initiative in teaching and learning process to cope with all cases.

Some achievements:

- Building the library about gasoline sensors in smartphone.
- Applying Augmented Reality in teaching and learning in the Engine Workshop.

Some disadvantages:

- Lacking the 3D structure of each sensor.
- Augmented Reality is just applied in the engine model in the workshop.

- Student focus on the quiz more than the principle of each sensor

In a time when the education sector of the home country in general and the Ho Chi Minh City University of Technology and Education in particular are promoting self-study, AR application on gasoline engine sensors can help students have something. visual and vivid view of structure, operating principles, real image. Another advantage is that the software follows the curriculum, so students will not be confused and acquired false knowledge, which are easy to happen if they have to learn by themselves on the Internet.

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Nguyen Tan Ngoc. received the B.S. degree in vehicle engineering technology from HCMC University of Technology and Education, Hochiminh City, Vietnam, in 2014 and the M.S. degree in vehicle engineering from HCMC University of Technology and Education, Hochiminh City, Vietnam, in 2016. He is currently pursuing the Ph.D. degree in Smart Robot Convergence and Application at Pukyong National University, Busan, Korea.

From 2017 to 2021, he was a lecturer at the Department of Internal Combustion Engine, HCMC University of Technology and Education, Hochiminh City, Vietnam. His research interest includes the Internal Combustion Engine, Hybrid Vehicle, Electric Vehicle, Engineering Thermodynamics, Automotive Pollution and Control, Alternate Fuels and Energy Systems, Augmented Reality and Visual Reality.