

APPLICATION OF CONTROL, INFORMATION, AND ELECTRICAL TECHNOLOGIES IN AUTOMOBILE STRUCTURE: AN OPPORTUNITY FOR THE VIETNAM AUTOMOTIVE INDUSTRY

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ABSTRACT

Automotive industry is an important economic sector. Cars are produced by the high-tech mechanical industry, this has been causing obstacles for automotive industry in Vietnam, a country with an underdeveloped mechanical manufacturing industry. However, currently some of new technologies such as automatic control, information, and electricity are being applied for automobile structures, which helps reduce the burden on the mechanical manufacturing industry and create jobs for the new industries mentioned above; At the same time, it is an opportunity for the development of Vietnam's automobile industry

Keyword: *Automobile industry, Mechanical technology, Information technology, Automatic control*

1. INTRODUCTION

1.1 The Importance of the Automotive Industry

The automotive industry plays an important role in the economy, it impacts the entire economy, supports extensive supply chains, and generates various ancillary business services. Additionally, it provides employment opportunities for a large workforce; This also serves as a substantial source of government revenue through taxes and fosters innovation through the application of advanced science and technology.

1.2 A Brief Overview of the History of the Vietnamese Automotive Industry

The first automobile in the world, powered by a steam engine, appeared in 1770. Over a century later, in 1876, the invention of the internal combustion engine marked a significant milestone in automotive development. From the first vehicle in 1770, assembled entirely from mechanical technology, to the present day, where nearly 250 years of advancements in electrical, control, and information technology have been integrated into automobile structures, and the imminent complete replacement

of internal combustion engines with electric motors that have existed for nearly 150 years.

1.2.1 The Development of the Vietnamese Automotive Industry

Following the reunification of the country, in 1991, two foreign-invested automotive companies entered the Vietnamese market, leading to the establishment of the Joint-Venture Automobile Enterprise Hòa Bình and Mekong Auto Company. In 1994, three more joint-venture automotive companies were formed in Vietnam with Toyota, Ford, and Chrysler. Subsequently, 16 other automotive joint ventures with foreign companies were established, including Mercedes-Benz, Honda, Toyota, Ford, and Mitsubishi. In 2004, two Vietnamese companies, Vinaxuki and Thaco, were founded. Unfortunately, in 2012, Vinaxuki faced financial difficulties and ultimately closed down, while Thaco became the leading player in the Vietnamese automobile market by 2016. Currently, Vietnam boasts approximately 40 companies involved in vehicle assembly and component manufacturing.

1.2.2. The current status of automotive industry in vietnam

1.2.2.1. An Overview of the Current Automotive Industry in Vietnam

Despite nearly 30 years since the first automotive joint venture was

established, the Vietnamese automotive industry still primarily relies on assembly, with most components being imported.

1.2.2.2. Underdeveloped Support Industries

Many statistics reveal that the localization rate in the Vietnamese automotive industry is significantly lower than that of ASEAN countries, with most products being simple mechanical items.

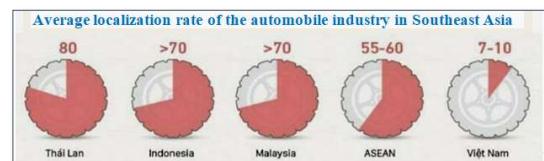


Fig. 1. Localization rate of Automobile Industry in Southeast Asia

(Source: <https://oto.edu.vn/thi-truong-o-to-viet-nam/>)

1.2.2.3. High Car Prices in Vietnam

The importation of complete cars or vehicle components and parts, coupled with various taxes and fees, results in car prices in Vietnam being two to three times higher than in other countries. For instance, small vehicles with fewer than 10 seats are subject to value-added tax (10%), import tax (30-80%), and special consumption tax (35-150%). In addition to these, buyers must also pay various fees, including a registration fee of up to 12% of the vehicle's price.

According to Wikipedia ([2]), the price of a 2020 Toyota Camry in Vietnam compared to other markets is illustrated in Table 01 below:

Table 01. *Toyota Camry 7-seat car prices for consumers in 2022 (USD)*

Japan	America	Thailand	China	Vietnam
28.000	25.000	39.000	~	51.000
	— 35.000	— 51.000	27.000	— 68.000

1.2.2.4 Reasons for the Underdevelopment of the Vietnamese

Automotive Industry As mentioned earlier, most automotive components and spare parts are mechanical products that demand highly specialized technical requirements. Consequently, automotive manufacturing technology requires an advanced Mechanical Engineering sector, which is currently underdeveloped in Vietnam. To illustrate this situation, let us quote an excerpt from an article by an author ([3]):

"According to the Ministry of Industry and Trade's statistics, the current strengths of the Vietnamese mechanical industry are concentrated in three subsectors: motorcycles and motorcycle spare parts; household and industrial machinery; and automobiles and automobile spare parts. These three subsectors account for nearly 70% of the total industrial production value in the country."

However, as a nation primarily rooted in agriculture and having undergone multiple wars, Vietnam's Mechanical Engineering sector remains significantly behind. To illustrate this reality, we refer to Figure 2, taken from the aforementioned article.

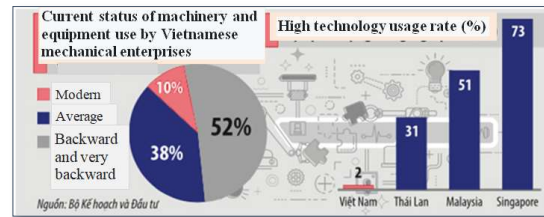


Fig. 2. *Current status of the Mechanical Engineering sector, 2020 data. ([3])*

2. THEORETICAL FOUNDATION

The theoretical foundation for this article includes theories related to automobiles, the technology of manufacturing automotive components and parts, control theory, information technology, and electrical energy. Additionally, the article draws upon the practical situation in the automotive industry and the economic in Vietnam.

3. RESEARCH METHODS

3.1. Information Collection Methods

The information used in this study was collected from textbooks at domestic universities in the automotive industry and selected lecture materials.

The most up-to-date information was obtained from reputable foreign automotive industry websites, such as Tesla, websites of technical universities

(e.g., Hanoi University of Industry), the international online encyclopedia Wikipedia, with articles from reliable authors, and other trusted sources.

Other information was collected from reputable Vietnamese television channels, including VTV1, and scientific and technological magazines published domestically.

3.2. Data Synthesis, Analysis, and Conclusion

After gathering the information, we synthesized, analyzed, and drew conclusions using scientific methods and personal professional experience, supplemented by expert opinions.

4. RESEARCH RESULTS AND DISCUSSION

4.1. Advancements in Control, Information, and Electrical Systems in Automobiles

We are all aware that since the inception of commercial automobiles, electrical systems have been integrated into the automobile's structure. These systems include power generation and storage systems with lead-acid batteries, lighting and horn systems, as well as convenience features such as air conditioning, radios, and televisions.

Subsequently, with the rapid advancement of science and technology, as well as evolving consumer needs, the automotive industry quickly incorporated new technologies into the

structure of automobiles. Notable advancements include automated control and self-diagnosis systems, internal information networks using the Controller Area Network (CAN), traffic recognition and analysis systems, self-driving capabilities, and the transition from internal combustion engines to electric motors. To discuss the opportunities in the Vietnamese automotive industry, let's summarize the recent technologies that have been or are being integrated into the structure of automobiles in recent years.

4.1.1. Automated Control and Fault Diagnosis Systems ([5])

Components of an automated control system in automobiles include sensors, Electronic Control Units (ECUs), and actuators.

In an automated control system, sensors collect information such as temperature, speed, vehicle position, or the status of specific components or subsystems of the automobile. The Electronic Control Unit (ECU) is a key component; it receives data from the sensors, analyzes it, processes it, and sends control commands to the actuators. Actuators then directly affect various components or subsystems that need control, such as the engine, braking system, and steering.

4.1.1.1. Electronic Control Units (ECUs) in Automated Control Systems ([5])

The Electronic Control Unit (ECU) is an electronic circuit responsible for receiving signals from various sensors, analyzing and processing them, and then sending control signals to specific actuators on the vehicle.

There are numerous ECUs on a vehicle, each dedicated to different functions. They are categorized into central ECUs, main ECUs (based on their functional duties), and ECUs for specific components. The main ECUs include:

- **Engine Control Unit (ECU):** This ECU is responsible for controlling the engine's performance and efficiency. It manages the engine's air/fuel ratio, ignition timing, and controls other engine functions such as idle speed control and exhaust gas recirculation.
- **Transmission Control Unit (TCU):** This ECU controls the transmission system in a vehicle, ensuring smooth gear shifts and optimal fuel efficiency. It also manages the clutch, torque converter, and other transmission components.
- **Brake Control Unit (BCU):** This ECU is responsible for controlling the braking system. It monitors the vehicle's speed, brake pressure, and other data to ensure proper and safe braking performance.
- **Body Control Module (BCM):** This ECU is responsible for controlling various comfort and convenience features in the vehicle, such as power windows, central locking, and interior lighting.
- **Suspension Control Unit (SCU):** This ECU is responsible for controlling the vehicle's suspension system, providing improved handling and ride comfort.
- **Climate Control Unit (CCU):** This ECU is responsible for controlling the vehicle's climate control system, such as air conditioning and heating.
- **Navigation Control Unit (NCU):** This ECU is responsible for controlling the vehicle's navigation system, providing the driver with directions and other navigation information.
- **Telematics Control Unit (TCU):** This ECU is responsible for controlling the vehicle's telematics system, providing features such as GPS tracking, remote diagnostics, and emergency assistance.

Some common ECUs for specific components named are: Electronic Fuel Injection (EFI), Electronic Spark Advance (ESA), Idle Speed Control

(ISC), Common Rail Diesel Control (EDC), Electronic Throttle Control System-intelligent (ETCS-i), Variable Valve Timing-intelligent (VVT-i), Auto Emergency Brake (AEB), Brake Assist (BA), Anti-lock Braking System (ABS), Electronic Brake Force Distribution (EBD), Traction Control System (TRC /ASR), Automotive Suspension System (EAS), Electronic Stability Program (ESP), Vehicle Stability Assist (VSA), Active Parking Assist System (APA) ...

4.1.1.2. Structure and Operation of Automated Control Systems

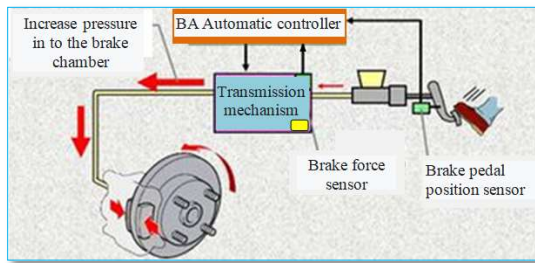


Fig. 3. Operation diagram of Automatic Brake Assist Controller BA

The structure and operation of automated control systems can be illustrated with the example of the Brake Assist (BA) control system (See Figure 3):

- The Brake Assist (BA) system for the pneumatic brake system includes sensors for brake pedal position and brake pedal force, mechanical components of the brake system, and an automated control unit for brake assist.
- When the brake pedal is suddenly pressed, the brake force value is much

lower than in a normal brake application, and the brake pedal force decreases gradually, resulting in inadequate braking force at the wheels. In such cases, the BA system works by increasing air pressure to the brake chamber.

4.1.1.3. On-Board Technical Fault Diagnosis System (ODB)

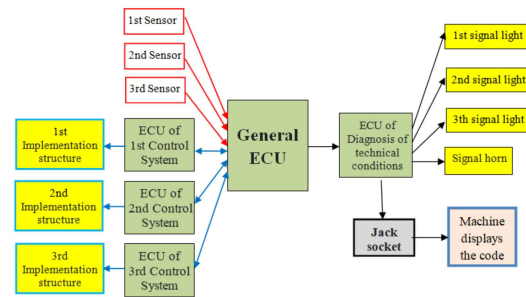


Fig. 4. Diagram linking Control and Diagnostics (ODB) systems on a car

In conjunction with the presence of automated control systems and the CAN network, designers have introduced the On-Board Diagnostic (ODB) system into vehicles for self-diagnosis of technical faults.

The ODB (On-Board Diagnostic) system comprises self-diagnostic ECUs, a Diagnostic Link Connector (DLC), a set of malfunction indicator lights (MIL), and a fault code reader (See Figure 4).

Self-diagnostic ECUs communicate with the central ECU of the vehicle. When a fault occurs, the system signals the malfunction using indicator lights for the driver or mechanic. Modern vehicles can accurately pinpoint faults through the use of a fault code reader,

which connects to the DLC port of the system. Faults are displayed as diagnostic trouble codes (DTCs), aiding in precise diagnosis and repair.

4.1.2. CAN Communication Network in Automobiles ([6])

In the past, automated control systems in automobiles were connected using pairs of electrical wires, running from sensors and electrical or electronic control units (ECUs) to corresponding actuating components. As automated systems in vehicles became more numerous, the wiring systems became complex. A new information network was introduced to replace this, known as the Control Area Network (CAN).

The CAN network is a local control network used for real-time data and signal transmission between ECUs in vehicles, with transmission speeds ranging from 20 KB/s to 1 MBit/s.

Externally, CAN consists of two wires: CAN High and CAN Low (CAN H, CAN L), connected in parallel between various automated control systems. The CAN network connects all nodes (ECUs and sensors), each with a unique ID. Communication is achieved by transmitting and receiving data packets called messages. Each message is assigned to one or more IDs with different priority levels, ensuring that commands within messages are executed in priority order.

4.1.3. Self-Driving Vehicles and Vehicle-Environment Communication ([7], [8])

Self-driving vehicles are automobiles capable of sensing their surroundings and operating on the road with little or no direct human control. The Society of Automotive Engineers (SAE International) categorizes self-driving vehicles into five levels, ranging from partially autonomous to fully autonomous.

4.1.3.1. Components Enabling Self-Driving

Components that make self-driving vehicles possible include:

- A variety of sensors connected to ECUs and actuators of the vehicle's control system, controlled by powerful operating systems such as Windows OLP.
- Road-based navigation signal systems, combined with digital maps and GPS positioning.
- Machine learning systems for vehicles.
- Cybersecurity systems to protect against external intrusions and attacks.

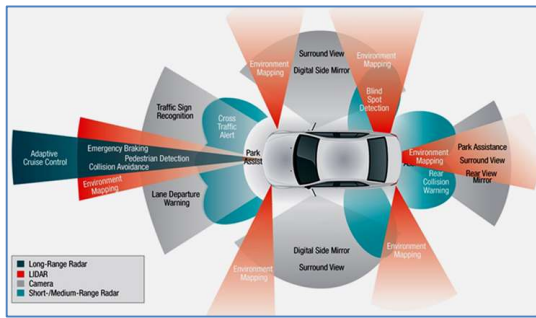


Fig. 6. Sensor types of self-driving cars ([8])

4.1.3.2. Types of Sensors in Self-Driving Vehicles

Various sensors used in self-driving vehicles include:

- **Radar Sensors:** These sensors observe nearby vehicles and objects. There are two types: Short/Medium-Range Radar and Long-Range Radar.
- **LiDAR Sensors (Light Detection and Ranging):** These sensors use pulsed laser light to observe the distance to pedestrians and other vehicles ahead, and they can trigger braking or emergency braking.
- **Ultrasonic Sensors:** These sensors use sound waves to detect vehicle movement, curbs, and other obstacles while parking, typically activated when the vehicle is in reverse.
- **Cameras:** Cameras detect traffic lights, read road signs, warn of lane departures, identify and track pedestrians and other vehicles on the road.

4.1.3.3. Communication of Self-Driving Vehicles on the Road

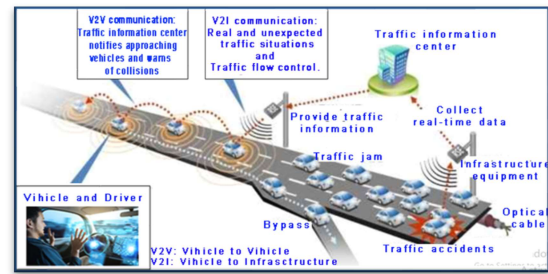


Fig. 7. Year 2030 - Car communication with information system

Once a self-driving vehicle receives a destination, it participates in road traffic automatically, using knowledge it has learned. Its actions are also adjusted based on real-time information received from the traffic information center and real-time sensing of obstacles, pedestrians, and other vehicles on the road (See Figure 6).

Communication between self-driving vehicles and the environment is also used in smart transportation systems.

4.1.4. Electric motors in Cars are an alternative to Internal Combustion engines

4.1.4.1. Preliminary Overview of Electric Motors in Electric Vehicles ([9])

The fundamental difference between conventional and electric cars is that in electric cars, the internal combustion engine is replaced by an electric motor, and some components and

mechanical assemblies are simplified or removed.

The main components of an electric vehicle differ from those in a traditional internal combustion engine vehicle and include:

- **Battery System:** Stores energy for the vehicle, typically using lithium-ion batteries. Thousands of battery cells are grouped and connected to provide power to the electric motor. On vehicles like the Tesla Model S, there can be as many as 7,000 battery cells. Due to the substantial heat generated during operation, a cooling system surrounds the battery modules to dissipate the heat into the environment through a cooling radiator.
- **Inverter:** The inverter is responsible for converting the direct current (DC) from the battery into alternating current (AC). It also adjusts the frequency (f) and current intensity (I) before delivering it to the electric motor, thereby controlling the motor's speed and torque. When the vehicle brakes or decelerates, the electric motor operates as a generator, and the inverter reverses its operation, converting AC back to DC to recharge the battery. The inverter is controlled by the driver and the vehicle's automatic control system.
- **Electric Motor:**

- The electric motor provides the energy to turn the wheels. Electric cars typically use brushless three-phase AC electric motors.
- The motor's speed depends on the frequency of the AC current provided by the inverter ($n=60.f/p$, where f is the electrical frequency, and p is the number of pole pairs). The torque on the motor shaft depends on the current intensity. The operating speed range of electric motors used in vehicles is very wide (0-18,000 rpm), and they operate stably throughout this speed range. This is one of their advantages compared to the technical characteristics of internal combustion engines when used in vehicles.

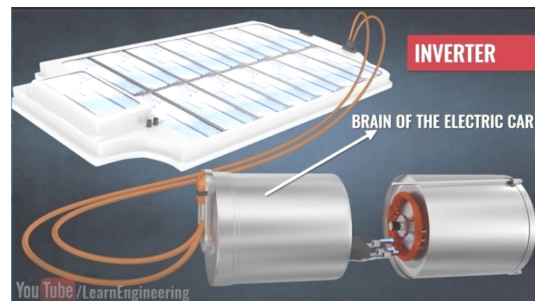


Fig. 8a. Connection diagram of electric battery - converter - electric motor

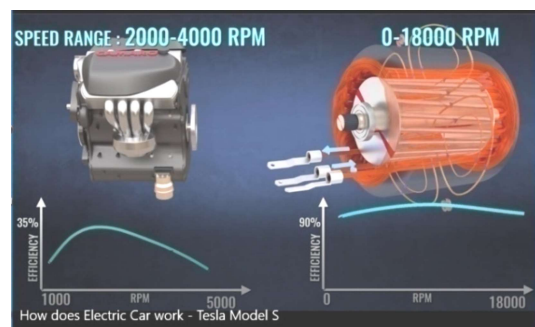


Fig. 8b. Comparison of electric motors and internal combustion engines: Working speed range, graph of efficiency with speed.

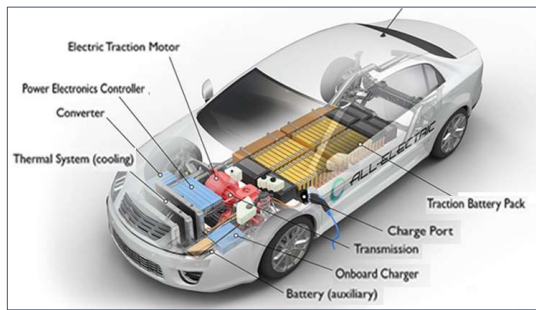


Fig. 9. Description of the structure of an electric car

4.1.4.2. Advantages of Electric Vehicles in Terms of Usability

In addition to the advantage of not emitting harmful gases into the environment, electric motors used in vehicles offer several usability advantages:

- Electric motors have a very wide speed range (0 rpm to 18,000 rpm), with a maximum speed that can be up to four times higher than that of internal combustion engines. They operate stably within this speed range, eliminating the need for mechanical gearboxes or hydraulic variable transmissions to change vehicle speed as in internal combustion engine vehicles.
- Electric motors can reverse direction, eliminating the need for a gearbox to enable a vehicle to move backward.
- During regenerative braking, the vehicle's kinetic energy is converted back into electrical energy and stored in the battery, reducing the complexity of the mechanical brake system.

4.1.4.3. Advantages of Electric Cars in Terms of Mechanical Manufacturing

Replacing internal combustion engines with electric motors significantly reduces the weight and complexity of mechanical connections, eliminating the need for high-tech manufacturing processes for several components:

- The removal of internal combustion engines, which are among the most complex mechanical assemblies in a car.
- The removal of clutches, gearboxes, and hydraulic variable transmissions, which are also complex mechanical components.
- The chassis of a vehicle, which is a large steel structure, undergoes simplification when transitioning from an internal combustion engine to an electric motor, making it more favorable for mechanical manufacturing technology.

4.2 Discussion

4.2.1 Value ratio of components of electric cars (Estimate)

From documents on car configuration, it is possible to estimate the preliminary technology value ratio of a car using an electric motor as follows:

Table 04. Value ratio of components of electric cars (Estimate)

Order	Automotive components	Ratio
1	Common electrical equipment: Lights, horns, air conditioners, televisions, generators and batteries	4%
2	Power system: Battery and charger, electric motor, converter	22%
3	Automatic control system, CAN communication, control software and operating system	24%
4	Mechanical components: Xatxi, tires, mechanical transmission, wheel assemblies, steering, brake, suspension, cooling...	50 %

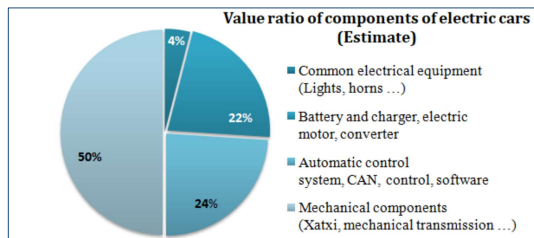


Fig. 10. Value ratio of components of electric cars (Estimate)

4.2.2. SWOT analysis on the ability to develop control, information and electrical technology in the Vietnamese automobile industry

4.2.2.1. Strengths

Vietnam is located in Southeast Asia, an area with an abundant labor force, low labor costs, large consumption demand, and an area where automotive technology is developing; Vietnam currently has abundant science and technology human resources in the fields of electricity, control, and information. The Government has been focusing on developing high technology.

4.2.2.2. Weaknesses

The number of large enterprises manufacturing high-tech products in the fields of electricity, control, and information in Vietnam is not many and most are joint ventures or foreign enterprises.

4.2.2.3. Opportunity

The expansion of application of control, information and electrical technology products into automobile structures has reduced difficulties for mechanical technology in the Vietnamese automobile industry.

4.2.2.4. Threats

Vietnam's opportunity is also the opportunity of many other countries; In fact, currently, automobile technology in

developed countries is racing fiercely in this innovation trend

4.2.3. Author's recommendation (opinion, comments)

The development of the automotive technology industry in Vietnam in the current situation is a matter that policymakers, scientists, and businesses need to discuss. In this article, the author would like to offer some initial opinions as follows:

- To advance automotive technology, in addition to the mechanical engineering sector, the government should concentrate on developing high-tech industries such as automatic control, information, and electric power.

- The automotive technology industry needs to enhance localization by manufacturing high-tech supportive products alongside traditional mechanical products.

- Alongside automotive technology, the government should focus on localizing products like high-tech household appliances (TVs, refrigerators, air conditioners, electric stoves, washing machines), electric bicycles, to create a conducive environment for the high-tech industry.

- The government should actively call for foreign investment to develop fundamental industries such as microelectronics, information technology, and rare earth materials,

serving as infrastructure for the development of high-tech industries, including the automotive technology industry in Vietnam.

- Research institutions, businesses, technologists, and scientists should seize this opportunity to collaborate with the government in the development of domestic automotive technology.

CONCLUSION

From the first car born in the 18th century with a structure made entirely from mechanical products, today automobile structures have been added to many high-tech products in fields such as Electricity, Control and Information, that makes the Automobile Industry no longer reserved for the modern mechanical industry of developed countries, and at the same time opens up opportunities for the Vietnamese Automobile Industry and for the development of Control, Information and Electrical technology in Vietnam..

The content of the article concerns important issues, and is related to activities over the past 250 years and the dramatic changes in recent years in the Automobile industry, while the author's abilities are still limited, the size of the article is also limited, so the above article still has many shortcomings, hope you sympathize.