The Design of Artificial Intelligence Control Platform Embedded with Road Traffic Signal

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Abstract

With a steady increase in the held economic volume per capita in China, the number of cars moves upward with a rise in the economic controllable capacity in both urban and rural areas. On the one hand, the enhancement of purchasing power of automobiles is the direct manifestation of the national economic growth. However, from the perspective of traffic coordination, under the premise of unchanged existing area of roads, more vehicles on the road indicates lower traffic coordination, which is also the direct cause of frequent urban traffic accidents in recent years. In urban roads, intersections are the most frequent street area where traffic accidents and traffic jams occur. For this reason, in line with the direct goal of coordinating the existing traffic diversion efficiency patterns and reducing the frequency of unusual traffic phenomena, it is necessary for the relevant traffic management research and development departments to add the road traffic signal management system based on the artificial intelligence control module into the upgrading of road traffic signal equipment. In order to improve the status quo of urban traffic routes, the article adopts the improved design in the application content of artificial intelligence technology, employs the high-performance ARM9 chip as the processor, and adds some network interfaces in accord with technical requirements. The analysis and solution of the signal hardware design aim to more clearly establish a software development environment. In terms of platform design, the control platform gives priority to the embedded technology. In order to integrate the relevance role of the control system and the platform, the article also specially describes the man-machine interface as a remote console, reducing the technical difficulty of the control platform operation. It is hoped that the technical content in the article will provide some useful materials for the relevant study on road traffic regulation.

Keywords: Road Traffic Signal Machine, Embedded Database, Artificial Intelligence Control Platform Design.

1. INTRODUCTION

1.1 Literature review

In China, the more developed the comprehensive level of a city is, the more motor vehicles it has within the city. Generally, in developed cities, the average area of roads has reached the highest level that can be developed at this stage. For this reason, the increasing number of motor vehicles and the fixed total traffic area will inevitably produce some conflicts (Qu et al., 2017). In terms of China’s regulation measures on traffic routes, on the premise of without changing the quantity of the above two conditions, traffic light can be used to display the signal of the real-time traffic in a fixed way, so as to achieve the role of reorganizing the road traffic conditions. In the meantime, the artificial intelligence (AI) control platform based on the intelligent traffic signal system not only provides the real-time and accurate traffic signal lump display, but also possesses subsidiary functions of traffic regulation such as information display, vehicle speed measurement and parking space guidance. To this end, under the condition that the total road area in domestic cities is passively fixed, the AI control platform using road traffic signal lamps is obviously the best present-day adjustment measure to conduct intelligent control and management of traffic conditions. Therefore, it is not difficult for us to analyze the application advantages contained in its technical capabilities. First, the application of the control platform can reduce most of the expected traffic accidents and cut down the direct data of personal safety and property damage. Secondly, the platform can also improve the actual efficiency of a substantial number of motor vehicles in the process of road regulation (Zhang, 2017). Furthermore, the platform’s traffic control activities can indirectly reduce motor vehicles’ driving time on the road, thereby effectively reducing the traffic pollution in congested cities. For this reason, after a comprehensive description of the literature, it is confirmed that, under the background conditions of the current traffic conditions in China, it is of practical value to design and study the hardware and program structure of the AI control platform embedded with road traffic signals.
1.2 Research objective

In the current national road transport cause, applying high-tech smart devices to the existing technology appears to be the only way to upgrade the skills in the Internet era. For this purpose, in recent years, numerous governments have chosen to apply AI technology to construct an intelligent control platform for road traffic. This study mainly focuses on the intelligent control platform. Firstly, this paper analyzes the technology and decomposes the hardware of the intelligent traffic signal system which is connected with the platform and then gradually explores the concrete content of platform development by means of the programming design and formation of the basic systems. All the research contents involved in this article take the adjustment of the current status of domestic road traffic as the fundamental goal, hoping that the actual value of the platform can have a certain value in upgrading the road conditions.

2. FRAMEWORK OF ROAD TRAFFIC SIGNAL MACHINE SYSTEM

2.1 Basic functional requirements

2.1.1 General Requirements

(1) When the control mode and the timing scheme are under changing conditions, the transition status of the signal machine should be kept within a smooth range. (2) The fixed value of light flash frequency (yellow) should be maintained at 55 to 65 times per second, and the existence time of the on and off of the signal lamp should be in the same state. (3) The same order ratio of light flash (green) frequency and light flash (green) signal on and off should remain at 1:1 (Yang et al., 2017). (4) The duration of red light and green light should be controlled within 3% of the actual range.

2.1.2 Start Timing Sequence

When the signal machine operates, it should first enter the self-test link under the control of the platform. When the system’s self-test is without error, the signal machine should enter directly to the initiating mode: (1) yellow flashes should be the first to enter the signal phase with the hold time of ten seconds; 2) after ten seconds, the state of full red starts with the hold time of five seconds; (3) after five seconds, the signal machine starts running in accordance with the specified mode of the control centre (Jiang and Sun, 2017).

2.1.3 Signal Conversion

The signal sequence for motor vehicles is: red-green-yellow-red; the signal sequence for non-motor vehicles is: red-green-yellow-red; the signal sequence for pedestrians (movement and crossing streets are allowed): red-green-green-flash-red.

2.1.4 Control Mode Conversion

Generally, the AI-based control platform has two alternate options: intelligence and manual (Li, 2013). Under the condition of intelligent control, the status of the traffic light changes within the setting range and cannot be adjusted. Under the manual control mode, administrators can set the minimum time according to the selectable range.

2.1.5 Function Setting

In the embedded state, the setting function of the zone signal machine can adjust the actual content such as parameters through the associated panel, while macro regulation and control requires administrators to manipulate the main console to control the commands.

2.2 Overall Design of Traffic Signal Control System

2.2.1 System Function Layout
In the embedded AI control platform, the system content in charge of the control of the signal area can be divided into two parts: the host system responsible for monitoring and the main body of the signal machine system (You et al., 2015). The following section respectively describes the hardware and software systems in a signalling system. Figure 1 shows the functional layout of the traffic signal control system.

![Figure 1. Function layout chart of traffic signal control system](image)

2.2.2 Hardware Platform of Signal Machine

Before selecting the basic information of platform construction, designers need to analyze the hardware of signal equipment, refine the actual role of each component hardware, and further adjust the platform structure based on the working mode required by traffic roads. Figure 2 demonstrates the structure diagram of the hardware platform system.

![Figure 2. Structure block diagram of hardware system](image)

The following section will compare and elaborate the important basic functions and component versions, and the specific information is as follows. (1) Relative to the signal machine, the core processor plays a comprehensive management and control role. The built version applied in this paper is a 16/32 RISC processor. This module, introduced by Samsung, is powered by coin-cell batteries and featured with software calibration (Li, 2015). (2)
The memory adopts 32M HY57V561620 (two pieces). (3) The detection module in the traffic information monitoring equipment employs the design of single chip microcomputer. The ground sensing coil buried in the ground and the system-controlled circuit constitute the oscillation circuit. The detection standards of passing vehicles are based on the oscillation frequency. Meanwhile, the detection subitems corresponding to the oscillation frequency includes vehicle passing, the speed of vehicles, the types of motor vehicles, the total number of vehicles staying in the fixed road sections and other contents (Chen et al., 2011). (4) In the condition monitoring module, the system applies the form of circuit detection, takes the loop current of signal lamps and the circuit conditions as the orientation standards, and presents the current condition of signal lamps at the feedback intersection by comparing the real-time information with the established circuit condition. (5) The storage is completed by SD cards that store all the information concerning configuration, dynamic and fault within a fixed period of time. Information storage is in the real-time state, and the errors before and after the built-in storage after power outage are negligible. (6) The input and output are all based on the targeted AI platform, and the display is composed of Sharp3.5 touch screen. Manual and hand operation are supported in parameter settings.

2.2.3 Software Platform of Signal Machine

In the development process of the embedded system, we first need to select the software according to its functional content. The system that faces road traffic signals should meet the following conditions: real-time performance, easy transfer, a complete system driver, simple application debugging steps and perfect special features of system compiler. Based on the above information, this paper makes a brief list about the selection of the software system of the signal machine, whose structure chart is demonstrated in Figure 3.

![Figure 3](image)

Figure 3. The architecture diagram of the signal machine software system

3. HARDWARE DESIGN OF SIGNAL MACHINE SYSTEM

3.1 System

The signal machine’s hardware system should process six necessary modules based on the functions: main control, communication, man-computer interaction, extension, drive and detection (vehicle). Figure 4 indicates the modularization block diagram of the entire hardware system.
3.2 Vehicle Detection

In order to attach a certain degree of specificity to platform design, this section will focus on the loop coil detector, which, first, is detection equipment placed under the road surface. It is connected with the control circuit through wire, thereby forming complete detection equipment that monitors the ground vibration frequency (Yang et al., 2014). The classification of its operating principle draws the following conclusion. When a vehicle passes over the road surface with the hypothetical detector, it triggers the detector switch of the loop circuit inductance. In this way, the test equipment can directly calculate the specific number of vibration frequency changes through the sensing device, thereby completing the real-time detection of the vehicle activities and road conditions by comparing the test data and the established data (Wei, 2010). The specific formula is as below.

The current flowing through the coil is assumed to be $I$, and the magnetic flux in each part of the coil is basically the same. The magnetic field strength is:

$$H = \frac{NI}{l}$$

In the formula, $H$— magnetic field strength;

$N$— turns per coil;

$I$— coil current;

$l$— coil length.

The magnetic flux of the coil is:

$$\Phi = BA$$

In the formula, $\Phi$— magnetic flux;

$B$— magnetic flux density;

$A$— looping area of coil.

The relationship between magnetic flux density and magnetic field strength is

$$B = \varepsilon \varepsilon_0 H$$
In the formula, \( \varepsilon_r \)— relative medium factor;

\[
\varepsilon_0 = 4\pi \times 10^{-7}
\]

The inductance of the coil is

\[
L = \frac{N\Phi}{I} = \frac{NBA}{I}
\]

In the formula, \( L \)— coil inductance;

\( N \)— turns per coil;

\( I \)— coil current.

Substitute Formula (3-1), (3-2) and (3-3) into Formula (3-4) and obtain:

\[
L = \frac{\varepsilon_r\varepsilon_0N^2A}{I}
\]

4. PLATFORM DEVELOPMENT AND PROGRAMMING

4.1 Development platform of system software

4.1.1 Embedded Linux

Embedded Linux is a type of operating system, and its technical performance includes open source code, adjustable real-time rate and multi-tasking and other advantages (Zhao and Jia, 2016). Thus, for the moment, embedded Linux is the optimal system platform for the optional operation content of the signal machine. At the same time, the embedded Linux, an enhanced version of its predecessor, adds a number of functions similar to cropping and optimization on the basis of Linux. In view of the current technical mode, the embedded Linux achieves the function content that Linux can not complete, namely running on the embedded computer systems (Li et al., 2009). For this reason, in the current system market, most professionals agree that the application of embedded Linux will continue for at least a very long time. The primary reasons why the AI control platform studied in this paper applies the embedded Linux are its efficient and stable kernel, open source code, and support for a variety of development technology resources.

4.1.2 Construct the development platform

In spite of the obvious application advantages of the embedded Linux, there still exist unfavourable factors such as the limited resources of development board (Shi et al., 2016). To this end, it is indicated that developers can not adopt development boards to complete platform test run and other steps, so designers can choose to indirectly apply cross compiling for debugging. For example, the form of host machine-target machine can be used to make full play to its advantage of being able to select serial port and network port. The selection of host computer generally employs the local host with the built-in Linux operating system. However, in rare cases, Linux server can be applied in debugging (Liu and Luo, 2011). The actual reference host studied in this paper is a preinstalled Windows system with built-in vmware, which has few operational hurdles in terms of functional forms. The editing environment of the host machine should be selected mainly based on the program content of the target machine. The program should be run in the host machine structure, with all the output executable files being completed on the target machine.
4.2 Drive program of hardware device

A fixed port is required to connect the kernel structure and the machine hardware of the operating system, and this port is the device driver. The main functions of the device driver are to reduce the usage time of application program when examining the hardware and to strengthen the immediate efficiency at which the application deals with the hardware, which is the means that directly realizes the hardware device from the perspective of application. Meanwhile, device drivers exist in the kernel structure, and its main function is to initialize the device, but also send data to the hardware (this link can be inverted).

After analyzing the operation sequence of the hardware of the signal machine and the functions to be realized, the I/O expansion module of the signal machine and the driver of AT24C02 were written, which were character device drivers. The following is the open function in the I/O extension module driver, which set GPF4 and GPE5 of S3C2410 as output.

```c
static int s3c2410_io_open(struct inode *inode, struct file *filp)
{
    printk(KERN_INFO DEVICE_NAME": opened.\n");
    __raw_writel((__raw_readl(S3C2410_GPFCON) & (~(0x0f<<8))) | (0x05<<8),
    S3C2410_GPFCON);

    __raw_writel((__raw_readl(S3C2410_GPFDAT) & (~(0x03<<4))),
    S3C2410_GPFDAT); //output--L

    __raw_writel (0x FF, S3C2410_GPFUP); //disable pull-up function
    return 0;
}
```

In order to ensure the versatility of the driver and avoid the conflict of the major numbers during the driver migration, devices were created by using dynamic device numbers. In other words, when a device was created, the system automatically assigned an unused device number to the driver. Signal machine AT24C02 driver create the following equipment:

```c
#ifdef CONFIG_DEVFS_FS
    devfs_mk_dir("signal AT24C02");
    devfs_mk_cdev (MKDEV (AT24C02Major, AT24C02RAW_MINOR),
    S_IFCHR|S_IRUGO|S_IWUSR, "signal AT24C02/%d", 0);
#endif
```

4.3 Primary Control Program

After completing the design of hardware device driver, the development of the master control program of the signal machine was proceeded. Main control program is the operating core of the entire signal machine software system and is responsible for equipment’s configuration, monitoring, control, communications and other work. Its main tasks include: a) the initialization of equipment and configuration parameters; b) the control of signal light colours; c) serial communication and Ethernet communication; d) the generation of intelligent control
schemes; e) man-machine interface maintenance (Liu and Liang, 2013). In accord with the overall design, various tasks of the entire software are completed by different modules, and each module is a sub-thread. The main system operating parameters of each thread are shared. It should be noted that the modification of the shared data needs to add thread locks that must be promptly released to prevent deadlock. Figure 5 illustrates the flow chart of the entire system data of the signal machine.

![Flow chart of system data](image)

**Figure 5.** Flow chart of system data

### 4.4 Communication Protocol of Signal Machine

In order to meet the network requirements of traffic signal machines and to improve the scalability and compatibility of the system, this system integrates the national standard *Data Communication Protocol Between Traffic Signal Controller and Control Centre* and the National Transportation Communications for ITS Protocol in America and defines the communication protocol between embedded traffic signal machine and host computer on this basis. Figure 6 illustrates the structure of communication protocol.

![Protocol structure diagram](image)

**Figure 6.** Protocol structure diagram

### 5. CONCLUSION

Traffic conditions are the direct manifestation of the quality of a nation’s mediation on the society. Traffic accidents should not occur in the daily routines of a country. For this purpose, when the overall strength of China is constantly rising, the coordination of transport abilities must also be enhanced. Only in this way can we achieve
a high degree of value integration in terms of national conditions and social stability. Through the research on the AI control platform embedded with road traffic signal, this paper hopes that the involved technical contents will provide some viewpoints about the platforms for the related personnel of traffic road management.

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