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Embedded Smart Car Security System on Face Detection

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Embedded Smart Car Security System on Face Detection

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Abstract - In this proposed embedded car security system, FDS(Face Detection System) is used to detect the face of the driver and compare it with the predefined face. For example, in the night when the car's owner is sleeping and someone theft the car then FDS obtains images by one tiny web camera which can be hidden easily in somewhere in the car. FDS compares the obtained image with the predefined images if the image doesn't match, then the information is sent to the owner through MMS.

So now owner can obtain the image of the thief in his mobile as well as he can trace the location through GPS. The location of the car as well as its speed can be displayed to the owner through SMS. So by using this system, owner can identify the thief image as well as the location of the car

This system prototype is built on the base of one embedded platform in which one SoC named "SEP4020"(works at 100MHz) controls all the processes .Experimental results illuminate the validity of this car security system.

Key words - *Face detection, Forward feature selection method, ARM (Advanced RISC Machine,),GSM,GPS.*

I. INTRODUCTION

It consists of PC memory unit it stores the different driver image. FDS (face detection subsystem) is used to detect the face of the driver and compare it with the predefined image. If the image doesn't match then the information is send to the owner through MMS. Owner can trace the location through GPS. This system owner can identify the theft image as well as the location of the car.

Traditional car security systems rely on many sensors and cost a lot. When one car is really lost, no more feedback could be valid to help people to find it back. We put forward the face detection technique to be applied in car security system because this kind of technique is effective and fast, and one alarm signal could be given to make an alarm or "call" the police and the host soundlessly with the help of other modules in the system prototype.

Face detection techniques have been heavily studied in recent years, and it is an important computer vision problem with applications to surveillance, multimedia processing, and consumer products. Many new face detection techniques have been developed to achieve higher detection rate and faster. We have introduced an boosted cascade of simple classifiers using Haar-like features capable of detecting faces in real-time with both high detection rate and very low false positive rates, which is considered to be one of the fastest systems.

In this embedded smart car security system, FDS (face detection subsystem) aims at detect somebody's face in the car during the time in which nobody should be in the car, for example, in the night when the car's owner is sleeping. FDS obtains images by one tiny digital camera which can be hidden easily in somewhere in one car. When FDS detects one face in alarm period, one alarm signal will be sent to the control central of the system. An alarm or a "silent" alarm will be triggered according to the use's settings. In silent alarm pattern, no direct alarm will be made, but several modules are working at inform owner and the police several important data, for example, the precise location of the car.

The GPS module obtains the precise locality by parsing received GPS signal. The GSM module can send the information out by SMS (Short Message Service) message, including real-time position of the "lost" car and even the images of "the driver".

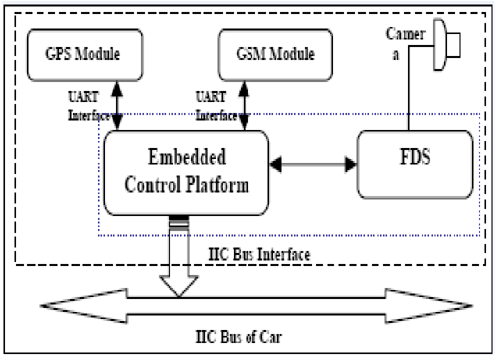

Fig. I: Configuration of the low – cost extendable frame work for Low cost embedded smart car security system

II. FACE DETECTION SUBSYSTEM

A. Cascade Detector

Face detection is to find whether there are faces in one image or not and their positions, and it belongs to "pattern recognition", one hot study spot of computer intelligence. Many methods have been put forward to solve the problem. To speed up the system to meet the real-time ability, we choose the cascade detector method to be part of work bases, which has been proved to be the nearly fastest method of all. A cascade face detector uses a sequence of node classifiers to distinguish faces from non-faces. The proposed face detection method is based on a cascade of simple classifiers to handle each part of one integral image".

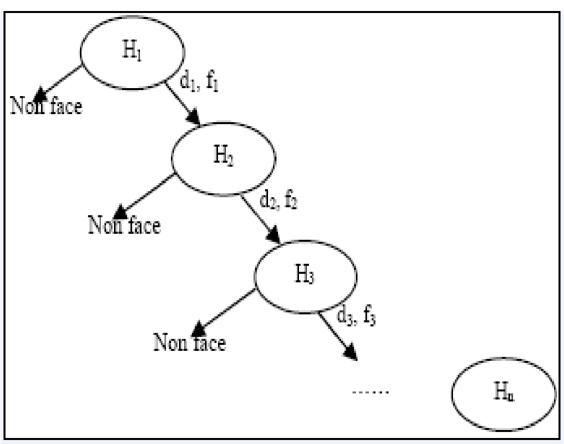

Fig. 2 : Cascade architecture with n nodes.

The main advantage of this kind architecture is its detection speed: a cascade detector can detect faces almost in real time. Every node is a classifier which determines one image block contains faces or not by several "features". So, how to choose those features is the key point.

B. The symmetric direct feature selection

We have proposed one new method called Forward Feature Selection (FFS) to train node classifiers in a cascade which is much faster than the original cascade face detector using AdaBoost.

1) For node n, we are given the nth bootstrapped training set, the minimum detection rate d_n, and the maximum false positive rate f_n.

2) For every feature, j, train a weak classifier h_j, whose false positive rate is f_n. Sort these weak classifiers according to their detection rate and form a classifier pool P with the first s weak classifiers that have largest detection rates.

3) Initialize the ensemble H to an empty set, i.e. $H \leftarrow \varphi$. $t \leftarrow 0$, $d_0=0.0$, $f_0=1.0$.

4) While $d_t < d_n$ or $f_t > f_n$

(a) Find the feature k, such that by adding it to H, the ensemble will have smallest asymmetric cost. The asymmetric cost of the ensemble is defined as its false positive rate plus λ times its false negative rate, in which λ is the cost ratio.

(b) $t \leftarrow t+1$, $H \leftarrow H \cup \{h_k\}$

(c) Calculate the new ensemble's detection rate and false positive rate.

5) The decision of the ensemble classifier is formed by a majority voting of weak classifiers in H, i.e.

$1 \Sigma h_{j}\_H_{h(j)} \geq \theta$

$H(x) = 0$ otherwise

Decrease θ if necessary.

A cost ratio function is used in this method, in which a false negative costs more than a false positive, and make the selection process as "asymmetric". The asymmetric feature selection method is 100 times faster than the original symmetric feature in training process.

Because the car security system would be used inside cars only, the background of images is all very simple. So we can choose many pictures taken in cars as non-face database to help training process produce better classifiers which are more suitable for cars.

C. Face Detection Process

Face detection is to find faces in one image by the trained cascade classifiers. Every node determines whether there are faces in the image according the data in classifiers' data file which is the outcome of training process. As a result, face detection process is a pure calculation process, and most of the results of face detection research papers are obtained by detecting images on personal computer platform. But in the low-cost extendable embedded smart car security system, no powerful CPU could be utilized. In several papers of the recent years, DSP (Digital Signal Processor) or FPGA (Field Programmable Gate Array) are used to speedup the detection process and to meet the real-time target, but the cost of whole system is increased at the same time. In car security system, the demand of "real-time" may not be as rigorous as other application environment, such as to distinguish a criminal out of people in street. Since the driver will not leave the car in a very short time, the car security system have a few seconds to make the judgment of the face is detected, and the period of time is enough long for the car security system to accomplish the face detection process.

To reduce the hardware cost of the car security system, we realize the face detection process in pure software method. All calculations are done on one ARM7 SoC named "SEP4020", with cache and MMU, and its main frequency is 100MHz. To make the detection process more a few optimization ways have been tried.

D. Images from the Camera

In the system prototype, one USB camera is used to catch images in car, and the data are transmitted to FDS module by USB channel, and the data are transferred into jpeg format files by the chip embedded camera before the transmission. Every image is set to be 320*240 pixels in resolution ratio to remain small in size and could be detected fast.

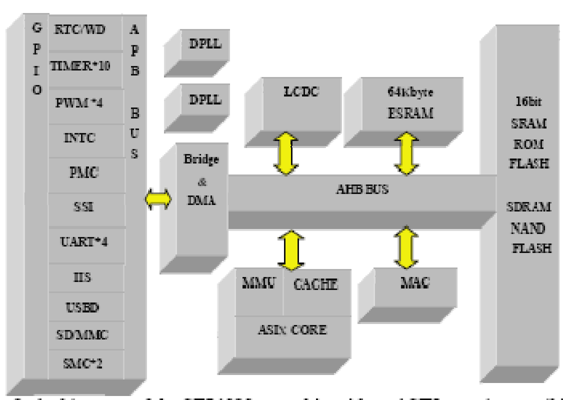

Fig. 3 : Architecture of the SEP4020

III. EMBEDDED CONTROL PLATFORM

The embedded control platform is built on one SoC (SEP4020), SEP4020 works at 100MHz, and there are one 8KB data/instruction cache, one MMU, 64KB ESRAM and many functional modules in it. SEP4020 is one low-power SoC, suitable for industry control systems especially with TFT displays.

All face detection codes are realized by standard C language for achieving better portability to be ported from one chip to another without any change.

Since the face detection process is also done in the chip by pure software method without any other hardware accelerator, we need some ways to optimize the process because low-end ARM chip is not good enough at computing

A. Static distribution of code

Because all calculation will be done by the ARM kernel, the bottleneck of performance lies on the memory access speed. In this memory subsystem, there are some kinds of memory (SDRAM, ESRAM and Cache) with different access speed. Program code and data of images are stored in SDRAM memory out of the SOC chip, which has the biggest size but also be the slowest one. Cache in the chip cannot be controlled directly, and the ESRAM is available for us since the system is turned on. ESRAM is one fast SRAM embedded in SEP4020, and 64KB is a quite large capacity in embedded world to store the most important code.

We collect statistics to pick those kernel functions out by profile tools contained in ARMulator (the instruction set simulator of ARM CO.), then put them into ESRAM when running, by one scattered-loading file which guide the ARMCC (ARM compiler tool) to compile according files with special memory address when the whole project program are compiled into AXF (ARM eXecutable File) format. During the boot process of the program, several assembly codes produced by ARMCC will copy those special codes to special addresses. Those kernel codes will be stored in ESRAM and could be accessed quickly. Consequently, the performance of the system will be improved greatly.

B. Lookup table of parameter data

Cascade of classifiers consist of a lot of parameters, which are the foundation of final decision. On PC platform, these parameters are saved into a file and read out when needed because the CPUs of PC are fast enough. In this low-cost embedded system world, things are not simple like that. If we get the parameters through file system API, a lot of time could be spent because of the indirect process.

Within the SEP4020, there are 64kB ESRAM, which is much faster than the memory out of the chip. To accelerate the process of getting parameters, we locate all parameters into ESRAM by scattering-load manner when the whole project is linked. Every parameter has a fixed memory room (32 bit), and parameters are written into ESRAM in sequence.

When one parameter has been read out at address "A", the next one could be read out at the address "A+4". So a global pointer is maintained to point to the parameter to be read next time, and after the reading operation, the pointer should be plus 1. By the method, parameter data form a sequential lookup table.

Building such a data lookup table in fast ESRAM can improve the data reading process greatly and therefore ease the bottleneck of memory access.

C. The role of cache

It is well know that the high hit rate of cache can greatly improve the performance of the memory subsystem, and the locality of data/code can raise the hit rate of cache. In other words, if code or data are stored in succession, cache memory can work very well to improve the performance of the memory subsystem and the whole system. Fortunately, in this system, image data are stored in SDRAM and parameter data are stored in ESRAM all in succession. So the cache of SEP4020 can achieve very high hit rate. Experiment results show that cache improves the performance more than 20% than the case we shutdown cache memory.

D. Process control

Embedded control platform is one embedded system board, which contains kernel chip, memory, outside interface modules and so on. We choose "μC/OS-II" as the operating system platform because it is "free of charge" and easy to use.

Embedded control platform should control those processes below:

1) Run μC/OS-II;
2) Obtain images from camera by USB;
3) Detect faces in images;
4) Get and handle the data from GPS module;
5) Send messages by GSM module;
6) Control IIC interface;
7) Change settings;

IV. GPS MODULE

GPS technique has been widely used both in military equipments and civil devices in recent years. We choose Jupiter TU30 GPS module to offer the location of the car in time. TU30 has a UART (Universal Asynchronous Receiver/Transmitter), which can be used to communicate with many other embedded devices. It is easy to get a serial of char from TU30 at 9600 bps speed from the UART interface, and the string accords with NMEA-0183(The National Marine Electronics Association) standard. After parsing the string, longitude, latitude, speed and so on of the car can be obtained to judge the precise location of the car now.

V. GSM MODULE

To achieve important information of cars, one GSM module is added into the car security system. Siemens TC35I GSM modem can quickly send SMS messages to appointed mobile phone or SMS server. So the owner and the police can be informed at the first time. If another GPRS module is added in, the image data could also sent to an information server, and the real-time circumstance in the car could be seen.

VI. CONCLUSION

From this we implement image-recognition techniques that can provide the important functions required by advanced intelligent Car Security, to avoid vehicle theft and protect the usage of unauthenticated users**.**

Secured and safety environment system for automobile users and also key points for the investigators can easily find out the hijackers image. We can predict the theft by using this system in our day to day life.

This project will help to reduce the complexity and improve security, also much cheaper and 'smarter' than traditional ones.

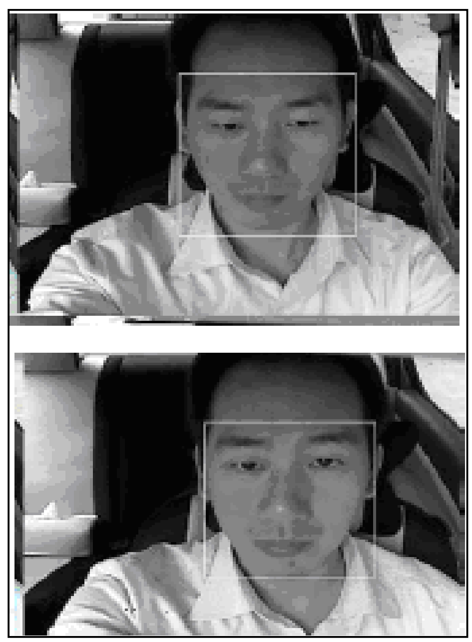

Fig. 4 : Results of face detection in car.

The above fig are those right ones are detection results, which contain one face only because the distance of the camera and the driver. We use timer control module, one functional module of SEP4020 which is precise in microsecond order, to test the face detection speed. Experiment results show that it takes about 6 seconds to detect one 320*240 colored jpeg image by software which is running on SEP4020. It seems to be too long to be used in “real-time” detection, but as discussed in previous chapter, the driver could not leave the seat very soon, so it is also “fast” enough and valuable for a low-cost, low-power and smart car security system without additional hardware modules. During the experiments, we find out that the face detection module cannot detect those faces not in front of camera, for example, when there is a big angle between face and the camera. It proves to us that the detection algorithm cannot detect all kinds of faces, and the camera need to be fixed toward the face of the driver if possible.

Because of the flexibility of embedded system, the embedded smart car security system is extendable for special purposes. The IIC bus interface offer a widely communication bandwidth with the car control system to change data and information, and new functional modules can be easily added to the system to upgrade and enhance it.

In this paper, we propose a low-cost extendable framework for embedded smart car security system, which consists of a face detection subsystem, a GPS module, a GSM module and a control platform. Comparing with traditional car security system, this system does not need any sensor, and cost much less. Digital camera obtains pictures and then compresses them into jpg format. The data could be handled by face detection classifiers to find out faces, which are trained by one optimized AdaBoost algorithm. Several methods have been applied to speedup the detection process, such as the use of ESRAM by distribute the key code into it, and the high hit rate of cache because the characteristics of image files and the data of cascade detector. Experiment results prove that this smart car security system works well, and can be put forward to practical application. We are also considering realize the face detection process by reconfigurable FPGA method to make the whole system suitable for more application conditions.

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