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# Secure and Privacy-Preserving Smartphone-Based Traffic Information Systems

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## Abstract

***Increasing smart phone penetration combined with the wide coverage of cellular infrastructures, renders smart phone based traffic information systems (TISs) an attractive option. The main purpose of such systems is to alleviate traffic congestion that exists in every major city. Nevertheless, to reap the benefits of smart phone-based TISs, we need to ensure their security and privacy and their effectiveness (e.g., accuracy). This is the motivation of this paper: We leverage state-of-the-art cryptographic schemes and readily available telecommunication infrastructure. We present a comprehensive solution for smart phone-based traffic estimation that is proven to be secure and privacy preserving. We provide a full-blown implementation on actual smart phones, along with an extensive assessment of its accuracy and efficiency. Our results confirm that smart phone-based TISs can offer accurate traffic state estimation while being secure and privacy preserving. Traffic congestion deteriorates the quality of life of citizens and contributes significantly to environmental pollution and economic loss. Traffic information systems (TISs)aim at solving this problem by collecting traffic data, producing traffic estimates, and providing drivers with location-specific information. The increasing smart phone penetration, along with the wide coverage of cellular networks, defines an unprecedented large-scale network of sensors, with extensive spatial and temporal coverage, able to serve as traffic probes for TISs. This is a task that cannot be achieved only by relying on the security of the mobile-to-cellular infrastructure communication.***

*Keywords*—***components; pressure sensor, Humidity sensor, temperature sensor, Arm board..***

## Introduction

Embedded systems are electronic devices that incorporate microprocessors with in their implementations. The main purposes of the microprocessors are to simplify the system design and provide flexibility. Having a microprocessor in the device means that removing the bugs, making modifications, or adding new features are only matters of rewriting the software that controls the device. Or in other words embedded computer systems are electronic systems that include a microcomputer to perform a specific dedicated application. The computer is hidden inside these products. Embedded systems are ubiquitous. Every week millions of tiny computer chips come pouring out of factories finding their way into our everyday products.

Embedded systems are self-contained programs that are embedded within a piece of hardware. Whereas a regular computer has many different applications and software that can be applied to various tasks, embedded systems are usually set to a specific task that cannot be altered without physically manipulating the circuitry. Another way to think of an embedded system is as a computer system that is created with optimal efficiency, thereby allowing it to complete specific functions as quickly as possible. Embedded systems designers usually have a significant grasp of hardware technologies. They used specific programming languages and software to develop embedded systems and manipulate the equipment. When searching online, companies offer embedded systems development kits and other embedded systems tools for use by engineers and businesses.

Embedded systems technologies are usually fairly expensive due to the necessary development time and built in efficiencies, but they are also highly valued in specific industries. Smaller businesses may wish to hire a consultant to determine what sort of embedded systems will add value to your organization. An embedded system is a system which is going to do a predefined specified task is the embedded system and is even defined as combination of both software and hardware. A general-purpose definition of embedded systems is that they are devices used to control, monitor or assist the operation of equipment, machinery or plant. "Embedded" reflects the fact that they are an integral part of the system. At the other extreme a general-purpose computer may be used to control the operation of a large complex processing plant, and its presence will be obvious.

The enlargement of micro technology has many Features like size, efficiency and capital. For a large scale device micro fabrication is used because of its smallness, applicability and lessening of material utilization. Micro technology and electronics have great scope of innovation. MEMS can be mounted on the ARM Lpc microcontroller wirelessly. A is the microcontroller proposed in this methodology which has inbuilt ADC conversion. By using MEMS many succession of external components can be eliminated. “Gaining data, storage of data, data filtering, statement interfacing and networking”are included hence it is called elegant included MEMS. MEMS equipment not only makes the utensils much lesser but also makes them much improved. The chief inspiration for this investigation is to make the human-robot interface more flexible and simpler for the user. Static and of low fidelity, with accommodation solely the result of the form and placement of furniture and fixtures. Smart homes aim to extend awareness, increase control over systems, and enhance the security, healthfulness, and safety of the environment through sensing, inference, communication technologies, decision-making algorithms, and appliance control

However, the real-time processing of occupant activity has historically been costly in terms of computing and Memory requirements and often relies on technologies considered intrusive of people’s privacy (e.g., cameras). As a result, these efforts have focused on systems associated with the built environment such as the design and placement of furniture and fixtures. Practical occupant sensing in smart homes remains of low fidelity including such ON/OFF sensor activations as room changes, door openings/closings, appliance actuations, etc.

A logical progression for the use of high fidelity sensing maybe seen in its central importance to assistive robotics. As Green and Walker describe , the notion of assistive robotics frequently conjures images of a self-contained humanoid servant in which all robotic and intelligence challenges have been addressed. Finding this to be an unlikely possibility in the near term and seeking to move beyond the conventional static smart home, we envision an environment containing robotic components that take advantage of the capabilities and higher level thinking of the user to operate in a collaborative manner; working with rather than for the user.

The authors’ past investigations into possible forms and use models for assistive robotics have considered appliances such as a hospital over-the-bed table, continuum surfaces, and intelligent storage for personal items.

## Ease of use

An embedded system is a system which is going to do a predefined specified task is the embedded system and is even defined as combination of both software and hardware. A general-purpose definition of embedded systems is that they are devices used to control, monitor or assist the operation of equipment, machinery or plant. "Embedded" reflects the fact that they are an integral part of the system. At the other extreme a general-purpose computer may be used to control the operation

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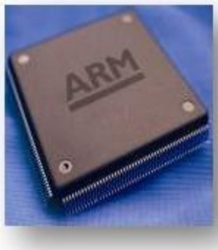
of a large complex processing plant, and its presence will be obvious. All embedded systems are including computers or microprocessors. Some of these computers are however very simple systems as compared with a personal computer. The very simplest embedded systems are capable of performing only a single function or set of functions to meet a single predetermined purpose. In more complex systems an application program that enables the embedded system to be used for a particular purpose in a specific application determines the functioning of the embedded system. The ability to have programs means that the same embedded system can be used for a variety of different purposes. In some cases a microprocessor may be designed in such a way that application software for a particular purpose can be added to the basic software in a second process, after which it is not possible to make further changes. The applications software on such processors is sometimes referred to as firmware.

### Arm processor review:

ARM stands for Advanced RISC Machines. It is a 32 bit processor core, used for high end application. It is widely used in Advanced Robotic Applications. It performs number of instruction in a single cycle compare with other controllers it have advanced features. The Arm CPU with real-time emulation and embedded trace support that combine microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. Due to their tiny size and low power consumption, LPC2141/42/44/46/48 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power.




### History and Development:

- ARM was developed at Acron Computers ltd of Cambridge, England between 1983 and 1985.
- RISC concept was introduced in 1980 at Stanford and Berkley.
- ARM ltd was found in 1990.
- ARM cores are licensed to partners so as to develop and fabricate new microcontrollers around same processor cores.

### Key features:

1. 16-bit/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
2. 8 kB to 40 kB of on-chip static RAM and 32 kB to 512 kB of on-chip flash memory.
   128-bit wide interface/accelerator enables high-speed 60 MHz operation.
3. In- System Programming/In-Application programming (ISP/IAP) via on-chip boot loader software. Single flash sector or full chip erase in 400 ms and programming of
   256 bytes in 1 ms.

### Historical Background

The invention of the transistor at Bell Telephone Laboratories in 1947 sparked a fast-growing microelectronic technology. Jack Kilby of Texas Instruments built the first integrated circuit (IC) in 1958 using germanium (Ge) devices. It consisted of one transistor, three resistors, and one capacitor. The IC was implemented on a sliver of Ge that was glued on a glass slide. Later that same year Robert Noyce of Fairchild Semiconductor announced the development of

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a planar double-diffused Si IC. The complete transition from the original Ge transistors with grown and alloyed junctions to silicon (Si) planar double-diffused devices took about 10 years. The success of Si as an electronic material was due partly to its wide availability from silicon dioxide (SiO2) (sand), resulting in potentially lower material costs relative to other semiconductors.

## Related work:

The use of mobile devices for gathering traffic information is not a new concept; several works indicate the feasibility of an ITS based only on location samples gathered by mobile phones. An early work describes an analytical method for evaluating real-time ITS based on data collected from GPS devices in probe vehicles: a 3-5% of penetration in the traffic flow is enough for adequate traffic estimation. Recent experiments with a system implemented solely on mobile phones show encouraging results for the feasibility and the accuracy of the traffic estimation (compared to that obtained by fixed sensors): a 2-3% penetration of mobile phones running the application in the total car flow suffices for accurate estimation of the average speed. Moreover, commercial navigation applications already integrate location samples from mobile phones in their algorithms for route guidance. However, security and privacy of similar traffic systems remain open challenges and research is conducted in several projects. Successive location updates by a smart phone, even without any identifier, contain spatial and temporal correlation that can be used as indirect identifiers. These can be exploited to reconstruct user paths with tracking techniques. Then traces can be processed and matched in order to infer frequently visited places, e.g., home or workplace, and finally reveal the user identity. To mitigate such threats, several solutions using cloaking techniques or privacy preserving sampling techniques have been proposed. These solutions are complementary to our proposal. In this paper we do not consider this kind of threat against the dataset of location samples. Rather, our goal is to guarantee the anonymity of the location samples and protect the system security. Relevant research in security is conducted for vehicular communication systems. Multiple short-term anonymized certificates, termed pseudonyms, can provide authentication while enhancing location privacy. These certificates are used for a short time and then have to be changed .Group signatures are also proposed, in order to reduce the overhead of pseudonym management. As they are significantly costlier (in terms of communication and computation overhead) than classic public key cryptography, special care must be taken for the overall secure vehicular communications system design. Group signatures are also used in credentials systems such as Idemix that provide anonymity for authenticated transactions to services. In our proposed architecture we will use group signatures; based on initial implementation results.

## GSM

GSM (Global System for Mobile communications) is an open, digital cellular technology used for transmitting mobile voice and data services.GSM (Global System for Mobile communication) is a digital mobile telephone system that is widely used in Europe and other parts of the world. GSM uses a variation of Time Division Multiple Access (TDMA) and is the most widely used of the three digital wireless telephone technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1,800 MHz frequency band. It supports voice calls and data transfer speeds of up to 9.6 kbit/s, together with the transmission of SMS (Short Message Service).

History In 1982, the European Conference of Postal and Telecommunications Administrations (CEPT) created the Group Special Mobile (GSM) to develop a standard for a mobile telephone system that could be used across Europe. In 1987, a memorandum of understanding was signed by 13 countries to develop a common cellular telephone system across Europe. Finally the system created by SINTEF lead by Torleiv Maseng was selected.

In 1989, GSM responsibility was transferred to the European Telecommunications Standards Institute

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(ETSI) and phase I of the GSM specifications were published in 1990. The first GSM network was launched in 1991 by Radiolinja in Finland with joint technical infrastructure maintenance from Ericsson.

By the end of 1993, over a million subscribers were using GSM phone networks being operated by 70 carriers across 48 countries. As of the end of 1997, GSM service was available in more than 100 countries and has become the de facto standard in Europe and Asia.

### Wi-Fi Module

Wireless technology has become prevalent in modern society as it presents a solution to the dilemma of making life easier by breaking down the networking barriers of distance and mobility. In a study of the benefits of wireless LAN conducted in 2001[1], 87% of survey respondents credited WLAN to an increase in their quality of life due to the flexibility and mobility of wireless internet connectivity; moreover, WLAN has been attributed to a 22% productivity increase for end-users. The appeal of wireless networking has resulted in the vast expansion of WLAN infrastructure with millions of public, private, and commercial wireless access points dispersed around the globe. Consequentially, the pervasive availability of wireless network access enables the potential for remote data transfer with a variety of electronic devices by means of embedded serial to Wi-Fi modules. For instance, security and surveillance systems employ serial to Wi-Fi modules to stream surveillance video from remotely mounted security cameras to wired network systems [1]. The following review provides an analysis of the features and cost effectiveness of Wi-Fi modules while highlighting the commercial applications of these devices. Commercial Applications of Wi-Fi Modules Application in Industry.

An increasingly popular application for Wi-Fi modules is in industrial monitoring systems. Emerson Process Management is among several instrumentation vendors developing wireless transmitters for industrial applications. The Rosemount 3051S Wireless Series of Instrumentation features Wireless HART and 802.11 Wi-Fi capabilities for their pressure, level, and flow transmitters.

### Density sensor

Whether for a new or existing installation, the Density Measurement Sensor easily installs on the OPW Magneto strictive Probe. Combining industry-leading accuracy for water, product and density measurement, the Site Sentinel® family Density Measurement Sensor uses a single magneto strictive in-tank probe assembly. The sensor continuously measures the density of the fuel in the tank, providing a measure of even the smallest changes in product quality within the API density range. Fuel density reports can be displayed real-time on the Site Sentinel® family of controllers or exported to an external display. The density readings can be configured to either nominal or temperature-corrected density.

### Traffic network system

Network Traffic Monitor shows you which processes in your machine are causing TCP/IP network traffic, how much traffic that is, and over which IP ports this traffic takes place. For each process it can show detailed information, including the path to the process executable, the remote IP address the process is connected to, and the WHOIS information of that IP address. An animated system tray icon will show you when IP traffic is taking place, and approximately how much. A historic overview can be shown of the network traffic since the application was started, and you can save that info to an Excel spreadsheet or a text file for later examination.

Try Network Traffic Monitor for free and see for yourself how it works. Click here to download a 7 day trial version. Network Traffic Monitor is shareware.

### System overview

The proposed architecture is shown in Fig. 1. The main components of the system are the smart phones carried by each participating driver and the ITS server. A smart phone application calculates the position, using GPS or network assisted positioning such as Assisted-GPS, and it sends location updates to the main server. The server is responsible for accumulating the data, for processing them and for providing feedback to the mobile client. The communication between the mobile application and the ITS server is done through the cellular network the device subscribes to. Based on the updates it receives, the ITS server reconstructs a traffic model and it calculates, in real-time, the proper feedback for guiding drivers. The updated traffic information sent by the server during the journey is presented on the device's screen on top of a map.

### B. Security requirements

Besides the obvious benefits of smart phone-based ITS, its security and the privacy of its users are paramount. System faults, resulting for example in sending false guidance information, can deteriorate or even cause traffic congestion; or, worse even, cause road accidents. Thus, it is necessary to secure the ITS system, to ensure it provides reliable information to drivers. Equally important, sensitive user information, e.g., their identity, must not be disclosed. Towards these goals, we state the following requirements:

**Authentication:** Entities the system must be authenticated (in particular, user smart phones and the ITS server)

**Confidentiality:** Sensitive user information must be kept confidential.

**Message Integrity:** Messages must be protected from alteration and the receiver must corroborate the sender (but not necessarily identify it).

**Access Control:** Only legitimate users must be able toreport their locations to the ITS server and get feedback (traffic information, instructions, etc.).

**Anonymity:** The ITS related actions of the mobile clients must not reveal their identity.

**Unlink ability:** The ITS server or any outsider should not be able to link two or more location updates (samples) by the same client.

The system implements an end-to-end solution between the performance of gesture by a human user and the learned response to gesture by a robotic agent. Modules within the system address each of the constituent challenges described in Section II (sensing, data representation, pattern recognition, and machine learning.

Gesture samples performed by human participants are presented to the system. The samples captured using the Kindest RGB-D sensor are processed and features (DIs) are extracted to form motion descriptors. Descriptors are applied to a GNG based clustered which maps the topology of the input space. A reference node within the GNG cloud is selected for each motion and one of its available responses is executed by the robot agent. A (simulated) human user evaluates the response and provides feedback (or reward). The reward is used to update the action response for future reference. This way, responses are shown to converge according to the user's preference for a given gesture type.

The approach described in this paper seeks to overcome certain limitations of prevailing methods by using non intrusive sensing, learning with the human as teacher through a relatively short-training phase, and learning goal configurations with no prior knowledge of the user's preferences. The remainder of this section details the fixture and algorithms used in pursuit of these contributions.

### Data Collection

Data were collected for three essential hand gestures that were Deemed a baseline command set for the eventual operation of an Assistive robot. Although our approach places no expectation on the user to perform gestures in a particular manner, motion models for These gestures were taken from the ASL dictionary (as demonstrated in to facilitate repeatability. The gestures included come closer, go away, and stop. These three gesture types were seen as a baseline essential collection of commands for an assistive robot. Although the gesture command vocabulary will be increased in future work, these were considered sufficient for this proof-of-concept research.

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The stop gesture requires special treatment since it intuitively suggests that the robot is presently executing an earlier command.

### Implementation

To evaluate our proposed solution, a full working test-bed of the IMS architecture is required. There is one open source implementation of the IMS but, unfortunately, it does not support the GBA architecture. Therefore, we began by implementing the BBS scheme on an Android device in order to validate the feasibility of creating group signatures on such devices with low computational power. For our implementation, we used the Java Pairing Based Cryptography Library (jPBC) , a Java port of the PBC library that provides the mathematical tools for pairing based operations. To initialize the scheme we use the Type A curve generator of the library with the default parameters (160 bit long group order *r* and 512 bit long base field *q*) offering 80 bits of security . The size of the signature is 510 bytes. To reduce computation delays, we use the pre-computation of variables suggested in . Table I presents the time (in sec) needed for one successful sign/verify operation on different Android phones we experimented with. We should note that verification on the client side is not needed, but it is presented here for completeness. Verification on the server side could be an issue, depending on the volume of signatures to be verified (proportional to number of active users). However, batch verification solutions can be applied in this case to enhance performance. As expected, computation delays depend on the CPU of each smart phone. The X10i and HTC Google Nexus One have a 1 GHz Scorpion CPU while the two other ones a 600 MHz ARM 11 CPU. Although delays appear relatively high for this initial implementation, our application can be supported by smart phones. With penetration rates between 3%-5% and depending on the type of road, location sampling every 10 sec is sufficient for providing adequate traffic information. To reduce overhead, calculating a signature on multiple location updates might also be an option, with the mobile client sending to the ITS server less frequently (e.g., once per minute). This approach would be dependent on the level of un link ability of location samples needed (those bundled remain anonymous yet would be trivially linked).

### Existing System

It still requires a large amount of storage space and the performance degrades rapidly when the size of the grid increases.

The term "Euclidean" is used to distinguish these spaces from the curved spaces of non-Euclidean geometry and Einstein's general theory of relativity .The first application is robot arm path planning in which a planar two-revolute-joint robot arm rotates among obstacles. The length of path obtained by our algorithm is the shortest among two other fastest O (n log n) algorithms in the literature.

### Proposed System

A novel O (n log n) near-shortest path algorithm is presented based on the concepts of Delaunay triangulation. It provides the fastest Computing time among the other approaches and only has a 1.43% path distance difference statistically compared to the shortest O (n2) algorithm. The length of path obtained by our algorithm is the Shortest among two other fastest O (n log n) algorithms in the literature. Compared to the other approaches of reduced visibility graph. This safety margin will always result in longer paths than the proposed algorithm.

### Keil software

It is possible to create the source files in a text editor such as Notepad, run the Compiler on each C source file, specifying a list of controls, run the Assembler on each Assembler source file, specifying another list of controls, run either the Library Manager or Linker (again specifying a list of controls) and finally running the Object-HEX Converter to convert the Linker output file to an Intel Hex File. Once that has been completed the Hex File can be downloaded to the target hardware and debugged. Alternatively KEIL can be used to create source files; automatically compile, link and covert using options set with an easy to use user interface and finally

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simulate or perform debugging on the hardware with access to C variables and memory. Unless you have to use the tolls on the command line, the choice is clear. KEIL Greatly simplifies the process of creating and testing an embedded application.

### Projects

The user of KEIL centers on “projects”. A project is a list of all the source files required to build a single application, all the tool options which specify exactly how to build the application, and – if required – how the application should be simulated. A project contains enough information to take a set of source files and generate exactly the binary code required for the application. Because of the high degree of flexibility required from the tools, there are many options that can be set to configure the tools to operate in a specific manner. It would be tedious to have to set these options up every time the application is being built; therefore they are stored in a project file. Loading the project file into KEIL informs KEIL which source files are required, where they are, and how to configure the tools in the correct way.

KEIL can then execute each tool with the correct options. It is also possible to create new projects in KEIL. Source files are added to the project and the tool options are set as required. The project can then be saved to preserve the settings. The project is reloaded and the simulator or debugger started, all the desired windows are opened. KEIL project files have the extension

### Simulator/Debugger

The simulator/ debugger in KEIL can perform a very detailed simulation of a micro controller along with external signals. It is possible to view the precise execution time of a single assembly instruction, or a single line of C code, all the way up to the entire application, simply by entering the crystal frequency. A window can be opened for each peripheral on the device, showing the state of the peripheral. This enables quick trouble shooting of mis-configured peripherals. Breakpoints may be set on either assembly instructions or lines of C code, and execution may be stepped through one instruction or C line at a time. The contents of all the memory areas may be viewed along with ability to find specific variables. In addition the registers may be viewed allowing a detailed view of what the microcontroller is doing at any point in time. The Keil Software 8051 development tools listed below are the programs you use to compile your C code, assemble your assembler source files, link your program together, create HEX files, and debug your target program. µVision2 for Windows™ Integrated.

### Development Environment:

combines Project Management, Source Code Editing, and Program Debugging in one powerful environment.

- C51 ANSI Optimizing C Cross Compiler: creates relocatable object modules from your C source code,
- A51 Macro Assembler: creates relocatable object modules from your 8051 assembler source code,
- BL51 Linker/Locator: combines relocatable object modules created by the compiler and assembler into the final absolute object module,
- LIB51 Library Manager: combines object modules into a library, which may be used by the linker,
- OH51 Object-HEX Converter: creates Intel HEX files from absolute object modules.

### What's New in µVision3?

µVision3 adds many new features to the Editor like Text Templates, Quick Function Navigation, and Syntax Coloring with brace high lighting Configuration Wizard for dialog based startup and debugger setup. µVision3 is fully compatible to µVision2 and can be used in parallel with µVision2.

### Advantages

The proposed algorithm almost outperforms other algorithms in each category from Z Tables except for the path length.

In order to locate the Fermat point of a triangle, the largest angle of the triangle must be less than or equal to 120◦.

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- Ease of controlling.
- Fast response.
- The module can be made into various forms as per the area of application.
- User friendly- One need not to know about the robot, as they can control by hand movement.

## Conclusion and future scope

In this paper, we have presented a new approach toward the development of a gesture-based human–machine interface. An end-to-end approach is presented which maps arm-scale gesture by a human user to a learned response by a robotic agent through repeated applications of user-provided reward. Between these two end points, the constituent challenges are addressed in the areas of sensor selection, data representation, pattern recognition, and machine learning. As a composite approach, the proposed system overcomes many of the shortcomings of previous efforts.

However, it is foreseen that this process would be difficult for an actual human trainer to entertain, since visualization of a robot's configuration as a Cartesian space may be difficult, if not impossible, for higher dimensions. Certainly, a path-planning component would be called for which considers the robot's configuration in light of the geometry of the environment and the social sensibilities of the user (speed, angle of approach, visibility, etc.). As it is implemented here, the proposed approach is seen as practical for mapping of a robot's end effector and, thus, useful for common applications. Segmentation of gestures (*gesture spotting*) is a typical problem in gesture recognition. Although our future work will address spotting, our focus here has been on validation of a real time learning technique that produces desirable outcomes using a human teacher and a simple, binary reward signal.

## Result

The project "Secure and Privacy-Preserving Smartphone-Based Traffic Information Systems" been successfully designed and tested. Integrating features of all the hardware components used have developed it. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit. Secondly, using highly advanced IC's and with the help of growing technology the project has been successfully implemented.

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