Lecture Notes in Electrical Engineering 365

Felix Pasila
Yusak Tanoto
Resmana Lim
Murtiyanto Santoso
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Editors

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Contents

Part I Invited Speaker

1 Computational Intelligence Based Regulation of the DC Bus in the On-grid Photovoltaic System 3
Mauridhi Hery Purnomo, Iwan Setiawan and Ardyono Priyadi

2 Virtual Prototyping of a Compliant Spindle for Robotic Deburring 17
Giovanni Berselli, Marcello Pellicciari, Gabriele Bigi and Angelo O. Andrisano

3 A Concept of Multi Rough Sets Defined on Multi-contextual Information Systems 31
Rolly Intan

Part II Technology Innovation in Robotics Image Recognition and Computational Intelligence Applications

4 Coordinates Modelling of the Discrete Hexapod Manipulator via Artificial Intelligence 47
Felix Pasila and Roche Alimin

5 An Object Recognition in Video Image Using Computer Vision 55
Sang-gu Kim, Seung-hoon Kang, Joung Gyu Lee and Hoon Jae Lee

6 Comparative Study on Mammogram Image Enhancement Methods According to the Determinant of Radiography Image Quality 65
Erna Alimudin, Hanung Adi Nugroho and Teguh Bharata Adji

7 Clustering and Principal Feature Selection Impact for Internet Traffic Classification Using K-NN 75
Trianggoro Wiradinata and P. Adi Suryaputra

8 Altitude Lock Capability Benchmarking: Type 2 Fuzzy, Type 1 Fuzzy, and Fuzzy-PID with Extreme Altitude Change as a Disturbance 83
Hendi Wicaksono, Yohanes Gunawan, Cornelius Kristanto and Leonardie Haryanto

9 Indonesian Dynamic Sign Language Recognition at Complex Background with 2D Convolutional Neural Networks 91
Nehemia Sugianto and Elizabeth Irenne Yuwono

10 Image-Based Distance Change Identification by Segment Correlation 99
Nemuel Daniel Pah

11 Situation Awareness Assessment Mechanism for a Telepresence Robot 107
Petrus Santoso and Handry Khoswanto

12 Relevant Features for Classification of Digital Mammogram Images 115
Erna Alimudin, Hanung Adi Nugroho and Teguh Bharata Adji

13 Multi-objective Using NSGA-2 for Enhancing the Consistency-Matrix 123
Abba Suganda Girsang, Sfenrianto and Jarot S. Suroso

14 Optimization of AI Tactic in Action-RPG Game 131
Kristo Radion Purba

15 Direction and Semantic Features for Handwritten Balinese Character Recognition System 139
Luh Putu Ayu Prapitasari and Komang Budiarta

16 Energy Decomposition Model Using Takagi-Sugeno Neuro Fuzzy 149
Yusak Tanoto and Felix Pasila

17 Odometry Algorithm with Obstacle Avoidance on Mobile Robot Navigation 155
Handry Khoswanto, Petrus Santoso and Resmana Lim

Part III Technology Innovation in Electrical Engineering, Electric Vehicle and Energy Management

18 Vision-Based Human Position Estimation and Following Using an Unmanned Hexarotor Helicopter 165
Jung Hyun Lee and Taeseok Jin

19 The Role of Renewable Energy: Sumba Iconic Island, an Implementation of 100 Percent Renewable Energy by 2020 173
Abraham Lomi

20 Electromechanical Characterization of Bucky Gel Actuator Based on Polymer Composite PCL-PU-CNT for Artificial Muscle 185
Yudan Whulanza, Andika Praditya Hadiputra, Felix Pasila and Sugeng Supriadi

21 A Single-Phase Twin-Buck Inverter 193
Hanny H. Tumbelaka

22 Performance Comparison of Intelligent Control of Maximum Power Point Tracking in Photovoltaic System 203
Daniel Martomanggolo Wonohadidjojo

23 Vehicle Security and Management System on GPS Assisted Vehicle Using Geofence and Google Map 215
Lanny Agustine, Egber Pangaliela and Hartono Pranjoto

24 Security and Stability Improvement of Power System Due to Interconnection of DG to the Grid 227
Ni Putu Agustini, Lauhil Mahfudz Hayusman, Taufik Hidayat and I. Made Wartana

25 Solar Simulator Using Halogen Lamp for PV Research 239
Aryuanto Soetedjo, Yusuf Ismail Nakhoda, Abraham Lomi and Teguh Adi Suryanto

26 Artificial Bee Colony Algorithm for Optimal Power Flow on Transient Stability of Java-Bali 500 KV 247
Irrine Budi Sulistiawati and M. Ibrahim Ashari

27 Sizing and Costs Implications of Long-Term Electricity Planning: A Case of Kupang City, Indonesia 257
Daniel Rohi and Yusak Tanoto

28 Dynamic Simulation of Wheel Drive and Suspension System in a Through-the-Road Parallel Hybrid Electric Vehicle 263
Mohamad Yamin, Cokorda P. Mahandari and Rasyid H. Sudono

29 A Reliable, Low-Cost, and Low-Power Base Platform for Energy Management System 271
Henry Hermawan, Edward Oesnawi and Albert Darmaliputra

30 Android Application for Distribution Switchboard Design 279
Julius Sentosa Setiadji, Kevin Budihargono and Petrus Santoso

Part IV Technology Innovation in Electronic, Manufacturing, Instrumentation and Material Engineering

31 Adaptive Bilateral Filter for Infrared Small Target Enhancement 289
Tae Wuk Bae and Hwi Gang Kim

32 Innovative Tester for Underwater Locator Beacon Used in Flight/Voyage Recorder (Black Box) 299
Hartono Pranjoto and Sutoyo

33 2D CFD Model of Blunt NACA 0018 at High Reynolds Number for Improving Vertical Axis Turbine Performance 309
Nu Rhahida Arini, Stephen R. Turnock and Mingyi Tan

34 Recycling of the Ash Waste by Electric Plasma Treatment to Produce Fibrous Materials 319
S.L. Buyantuev, A.S. Kondratenko, E.T. Bazarsadaev and A.B. Khmelev

35 Performance Evaluation of Welded Knitted E-Fabrics for Electrical Resistance Heating 327
Senem Kursun Bahadir, Ozgur Atalay, Fatma Kalaoglu, Savvas Vassiliadis and Stelios Potirakis

36 IP Based Module for Building Automation System 337
J.D. Irawan, S. Prasetio and S.A. Wibowo

37 Influence of CTAB and Sonication on Nickel Hydroxide Nanoparticles Synthesis by Electrolysis at High Voltage 345
Yanatra Budipramana, Suprapto, Taslim Ersam and Fredy Kurniawan

38 Waste Industrial Processing of Boron-Treated by Plasma Arc to Produce the Melt and Fiber Materials 353
S.L. Buyantuev, Ning Guiling, A.S. Kondratenko, Junwei Ye, E.T. Bazarsadaev, A.B. Khmelev and Shuhong Guo

39 Design of Arrhythmia Detection Device Based on Fingertip Pulse Sensor 363
R. Wahyu Kusuma, R. Al Aziz Abbie and Purnawarman Musa

40 Analysis of Fundamental Frequency and Formant Frequency for Speaker 'Makhraj' Pronunciation with DTW Method 373
Muhammad Subali, Miftah Andriansyah and Christanto Sinambela

41 Design and Fabrication of "Ha (ɲɱ)" Shape-Slot Microstrip Antenna for WLAN 2.4 GHz 383
Srisanto Sotyohadi, Sholeh Hadi Pramono and Moechammad Sarosa

42 Investigation of the Electric Discharge Machining on the Stability of Coal-Water Slurries 393
S.L. Buyantuev, A.B. Khmelev, A.S. Kondratenko and F.P. Baldynova

43 A River Water Level Monitoring System Using Android-Based Wireless Sensor Networks for a Flood Early Warning System 401
Riny Sulistyowati, Hari Agus Sujono and Ahmad Khamdi Musthofa

44 The Influence of Depth of Cut, Feed Rate and Step-Over on Surface Roughness of Polycarbonate Material in Subtractive Rapid Prototyping 409
The Jaya Suteja

45 Adaptive Cars Headlamps System with Image Processing and Lighting Angle Control 415
William Tandy Prasetyo, Petrus Santoso and Resmana Lim

46 Changes in the Rheological Properties and the Selection of a Mathematical Model of the Behavior of Coal-Water Slurry During Transport and Storage 423
S.L. Buyantuev, A.B. Khmelev and A.S. Kondratenko

47 Design of a Fetal Heartbeat Detector 429
Nur Sultan Salahuddin, Sri Poernomo Sari, Paulus A. Jambormias and Johan Harlan

Part V Technology Innovation in Internet of Things and Its Applications

48 Network Traffic and Security Event Collecting System 439
Hee-Seung Son, Jin-Heung Lee, Tae-Yong Kim and Sang-Gon Lee

49 Paper Prototyping for BatiKids: A Technique to Examine Children's Interaction and Feedback in Designing a Game-Based Learning 447
Hestiasari Rante, Heidi Schelhowe and Michael Lund

50 **Tracing Related Scientific Papers by a Given Seed Paper Using Parscit** 457
Resmana Lim, Indra Ruslan, Hansin Susatya, Adi Wibowo, Andreas Handojo and Raymond Sutjiadi

51 **Factors Affecting Edmodo Adoption as Online Learning Medium** 465
Iwa Sungkono Herlambangkoro and Trianggoro Wiradinata

52 **Principal Feature Selection Impact for Internet Traffic Classification Using Naïve Bayes** 475
Adi Suryaputra Paramita

53 **Study on the Public Sector Information (PSI) Service Model for Science and Technology Domain in South Korea** 481
Yong Ho Lee

54 **Digital Natives: Its Characteristics and Challenge to the Library Service Quality** 487
Siana Halim, Felecia, Inggrid, Dian Wulandari and Demmy Kasih

55 **Web-Based Design of the Regional Health Service System in Bogor Regency** 495
B. Sundari, Revida Iriana and Bertilia Lina Kusrina

56 **Security Handwritten Documents Using Inner Product** 501
Syaifudin and Dian Pratiwi

57 **Augmented Reality Technique for Climate Change Mitigation** 511
Ruswandi Tahrir

58 **Cyber Security for Website of Technology Policy Laboratory** 521
Jarot S. Suroso

59 **TAM-MOA Hybrid Model to Analyze the Acceptance of Smartphone for Pediatricians in Teaching Hospital in Indonesia** 529
Oktri Mohammad Firdaus, Nanan Sekarwana, T.M.A. Ari Samadhi and Kah Hin Chai

60 **Development of the Remote Instrumentation Systems Based on Embedded Web to Support Remote Laboratory** 537
F. Yudi Limpraptono and Irmalia Suryani Faradisa

61 **Enhancing University Library Services with Mobile Library Information System** 545
Singgih Lukman Anggana and Stephanus Eko Wahyudi

62 **Multi Level Filtering to Classify and Block Undesirable Explicit Material in Website** 553
Mohammad Iqbal, Hifshan Riesvicky, Hasma Rasjid and Yulia Charli

63 **Query Rewriting and Corpus of Semantic Similarity as Encryption Method for Documents in Indonesian Language** 565
Detty Purnamasari, Rini Arianty, Diana Tri Susetianingtias and Reni Diah Kusumawati

64 **Securing Client-Server Application Design for Information System Inventory** 573
Ibnu Gunawan, Djoni Haryadi Setiabudi, Agustinus Noertjahyana and Yongky Hermawan

Part VI Technology Innovation in Information, Modelling and Mobile Applications

65 **Analyzing Humanitarian Logistic Coordination for Disaster Relief in Indonesia** 583
Tanti Octavia, I. Gede Agus Widyadana and Herry Christian Palit

66 **Surakarta Cultural Heritage Management Based on Geographic Information Systems** 589
Ery Dewayani and M. Viny Christanti

67 **Gray Code of Generating Tree of *n* Permutation with *m* Cycles** 599
Sulistyo Puspitodjati, Henny Widowati and Crispina Pardede

68 **Android and iOS Hybrid Applications for Surabaya Public Transport Information** 607
Djoni Haryadi Setiabudi and Lady Joanne Tjahyana

69 **Games and Multimedia Implementation on Heroic Battle of Surabaya: An Android Based Mobile Device Application** 619
Andreas Handojo, Resmana Lim, Justinus Andjarwirawan and Sandy Sunaryo

70 **Streamlining Business Process: A Case Study of Optimizing a Business Process to Issue a Letter of Assignment for a Lecturer in the University of Surabaya** 631
S.T. Jimmy

71 **Design of Adventure Indonesian Folklore Game** 639
Kartika Gunadi, Liliana and Harvey Tjahjono

72 **Measuring the Usage Level of the IE Tools in SMEs Using Malcolm Baldrige Scoring System** 649
I. Nyoman Sutapa, Togas W.S. Panjaitan and Jani Rahardjo

73 **Enumeration and Generation Aspects of Tribonacci Strings** 659
Maukar, Asep Juarna and Djati Kerami

74 **A Leukocyte Detection System Using Scale Invariant Feature Transform Method** 669
Lina and Budi Dharmawan

75 **The Diameter of Enhanced Extended Fibonacci Cube Interconnection Networks** 675
Ernastuti, Mufid Nilmada and Ravi Salim

76 **Prototype Design of a Realtime Monitoring System of a Fuel Tank at a Gas Station Using an Android-Based Mobile Application** 685
Riny Sulityowati and Bayu Bhahtra Kurnia Rafik

Introduction

This book includes the original, peer-reviewed research papers from the 2nd International Conference on Electrical Systems, Technology and Information (ICESTI 2015), held during 9–12 September 2015, at Patra Jasa Resort & Villas Bali, Indonesia.

The primary objective of this book is to provide references for dissemination and discussion of the topics that have been presented in the conference. This volume is unique in that it includes work related to Electrical Engineering, Technology and Information towards their sustainable development. Engineers, researchers as well as lecturers from universities and professionals in industry and government will gain valuable insights into interdisciplinary solutions in the field of Electrical Systems, Technology and Information, and its applications.

The topics of ICESTI 2015 provide a forum for accessing the most up-to-date and authoritative knowledge and the best practices in the field of Electrical Engineering, Technology and Information towards their sustainable development. The editors selected high quality papers from the conference that passed through a minimum of three reviewers, with an acceptance rate of 50.6 %.

In the conference there were three invited papers from keynote speakers, whose papers are also included in this book, entitled: “Computational Intelligence based Regulation of the DC bus in the On-Grid Photovoltaic System”, “Virtual Prototyping of a Compliant Spindle for Robotic Deburring” and “A Concept of Multi Rough Sets Defined on Multi-Contextual Information Systems”.

The conference also classified the technology innovation topics into five parts: “Technology Innovation in Robotics, Image Recognition and Computational Intelligence Applications”, “Technology Innovation in Electrical Engineering, Electric Vehicle and Energy Management”, “Technology Innovation in Electronic, Manufacturing, Instrumentation and Material Engineering”, “Technology Innovation in Internet of Things and Its Applications” and “Technology Innovation in Information, Modeling and Mobile Applications”.

In addition, we are really thankful for the contributions and for the valuable time spent in the review process by our Advisory Boards, Committee Members and Reviewers. Also, we appreciate our collaboration partners (Petra Christian

University, Surabaya; Gunadarma University, Jakarta; UBAYA, Surabaya, University of Ciputra, Surabaya, Institute of National Technology, Malang and LNEE Springer, Germany), our supporting institution (Oulu University, Finland, Widya Mandala Catholic University, Surabaya and Dongseo University, Korea) and our sponsors (Continuing Education Centre, Petra Christian University, Surabaya and Patrajasa Resort Hotel, Bali).

On behalf of the editors Felix Pasila

Part I
Invited Speaker

Chapter 23
Vehicle Security and Management System on GPS Assisted Vehicle Using Geofence and Google Map

Lanny Agustine, Egber Pangaliela and Hartono Pranjoto

Abstract Global Positioning System (GPS) receiver installed in motor vehicles have been used to track vehicles. The position of vehicle is transmitted via a wireless network using cellular telephone network known as GSM (Global System for Mobile communication). A vehicle that has GPS receiver installed onboard connected with GPRS modem and connected to a computer system in the Internet can be monitored and then provide alert when it travels outside the predefined area. This area is very important for many situations such as city car rental, trucking company to send goods from one city to another and logistic company with many fleets. The system designed here is a module with a GPS and a GPRS already integrated in one module. The output of the GPS receiver is connected to a microcontroller. The microcontroller dictates which data is collected via the GPS receiver and then sends the information to a computer system via GPRS modem. The microcontroller also receives command from the computer system via the GPRS connection and then can acct accordingly, such as change the frequency of geo-coordinate or turn the vehicle engine off if necessary. This device will help the user to track its vehicle via Google Map with the GPS coordinate data sent to the database server every 10. This device will enable the operator to turn off the vehicle engine and one other device onboard the vehicle if necessary. With the feature of Geofence on the Web server using HTML5, a virtual fence has been built around the Google Map and when the vehicle moving outside the fence the user can be alerted either via email or color change on the web page. The device has been tested and shown to be working with all the conditioned mentioned above. The computer system that displays the web page together with the geofence has been developed and shown to be working properly as indicated.

Keywords Vehicle geofence · Google map · Fleet management · GPS assisted vehicle tracking

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23.1 Introduction

Vehicle tracking system using Global Positioning System (GPS) is a system that uses the GPS to locate the geographic coordinate of vehicle was developed previously [1]. The device itself is basically a radio receiver tuned into the frequency of the transmitting frequency of the GPS satellites in which it enables the receiver to compute its geographic coordinate. There are several data sets that can be obtained from the GPS satellites such as the accurate position of the receiver within certain radius, number of satellites received by the unit, speed of the GPS receiver moving, and accurate date/time based on the Universal Time Coordinated). Distance between the transmitting satellites and the GPS receiver is determined by using accurate time lapse between the satellites—which uses very accurate atomic clock—and the receiver using less accurate quartz crystal. Although the crystal clock is less accurate, but the result of the distance is still very accurate up to one meter resolution or less. The signal sent by the satellites includes the timestamp of the signal send and the receiver will determine the distance by measuring the time to travel to the receiver.

Using a triangulation method based on the distance from the GPS satellites, the position of the GPS receiver will be known precisely within a few meters as describe in [1–5]. This can be achieved because the precise position of the GPS satellites is excellent and reliable. Uncertainties of the distance can arise because of several physical phenomena such as temperature gradient on the atmosphere, signal bounce due to objects, and strength of satellites signals received by the GPS receiver. Other data is also obtained from the GPS receiver such as speed of the vehicle moving, heading of the movement of the GPS receiver, accuracy of position, number of satellite signal received, and strength of the signal received.

Data send from the GPS receiver is generally already in digital format and send to a computer or microcontroller using serial connection with signal amplitude of 0–5 V. Format of the data is already standardized using format of NMEA-0183 with the latest standard being version 4.10. Based on the NMEA-0183 standard, the serial data rate of the GPS receiver is 4800 bits per second with 8 bits of data and one stop bit (4800 bps 8N1).Other than sending data via this serial connection, setting of the GPS receiver can be performed via this serial connection. Setting includes the data format, unit of measurement, and time information.

The GPS data obtained from a moving vehicle is transmitted using wireless data network from part of the GSM (Global System for Mobile Communication) also known as cellular telephone. The data component part of the GSM is called General Packet Radio Service (GPRS) can connect to the host computer with speed up to 128 kbit/s which is fast enough for this application. In order to use the GPRS part of the GSM network, a GPRS modem is needed to connect the data portion of the wireless network. The GPRS modem connects to the microcontroller via a serial connection similar to the connection to the GPS mentioned previously.

Figure 23.1 illustrates the system used for Vehicle security and management system on GPS assisted vehicle using geofence and Google map system. There are

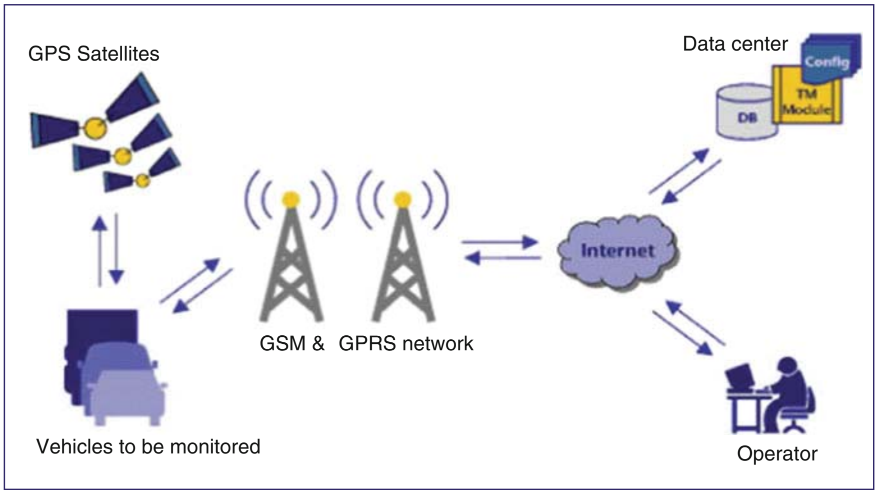

Fig. 23.1 Vehicle monitoring/management system using GPS via GPRS network

GPS satellites to assist the GPS receiver mounted on vehicles to be monitored to find their geographical coordinates. The coordinates of the vehicles are send via GPRS modem using GSM network to the Internet to a computer system—usually in a data center—with database server and web server already installed on the system. An operator—also connected to the Internet—access the server via web browser to access the coordinate data of the vehicles to be monitored. The web server of the computer system with HTML5 capability can provide the geolocation of the vehicle to be monitored on the web page overlaid with the map of the location using Google Map.

The operator has several monitoring privileges and control of the vehicle. Operator can track the vehicle and place a geo-fence around the vehicle and some other features discussed later. With this feature, a vehicle that is going beyond the geo-fence or virtual fence can be displayed on the screen and operator can be visually alerted and then can take action accordingly.

23.2 System Design and Constructions

The system design of the vehicle security and management system in block diagram is shown in Fig. 23.2. There is a GPS module and a GPRS module integrated in one larger module in SIMCOM 908. This system also has a power management module to control the charging of a backup lithium battery which will be used to power the system in case there is a power failure of the main power system. Each of the modules (GPS and GPRS) has serial input/output UART (Universal Asynchronous

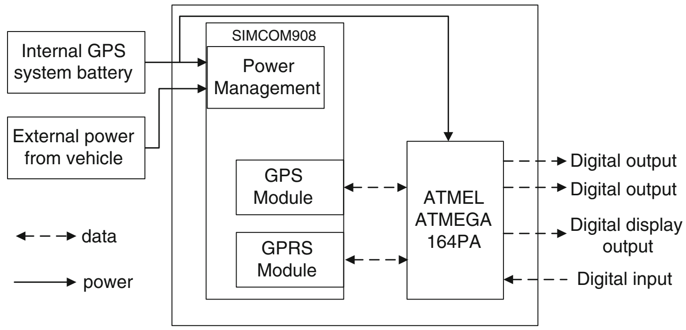

Fig. 23.2 Block diagram of vehicle monitoring/management system using GPS via GPRS network

Receiver Transmitter) in which the devices will send or receive the data. The serial input/output is connected to a microcontroller ATMEGA 164PA which has two serial input/output. All of the modules are powered using the same power supply which is 3.3 V which can be obtained from the external power or from the internal lithium battery.

23.2.1 Global Positioning System (GPS)

Global Positioning System (GPS) is a satellite based positioning, in which there is a need for at least three visible satellites to determine the position—including altitude—of a GPS receiver. The basic method of position determination is trilateration which has been described elsewhere [6–8]. In reality with more than three visible satellites, the accuracy of the position will increase and accuracy can be within 2 m in many situations where there is not much obstruction to the satellite signals. In many situations the signal strength received from the satellites will also improve the accuracy the calculation of the position. On the average without any special antenna a GPS receiver can detect 7–11 satellites at the same time with signal strength between 11 and 25 dB with accuracy of less than 5 m.

Most GPS systems have serial output similar to RS-232 or UART (Universal Asynchronous Receiver Transmitter) and the output format usually comply with the NMEA-0183 output. Serial output of NMEA-0183 compliance device will have character '$' as the first character followed by two characters talker identification such as 'GP' for GPS device. The next identifier after the $GP are three letter-identifier related to the GPS data such as GGA (constant GPS data), GLL (Geographic Position Latitude/Longitude), GSA (GNSS/Global Navigation Satellite Systems Dilution of Accuracy), ZDA (GPS time and date Information), VTG (Course Over Ground and Ground Speed), RMB (Recommended Minimum Navigation Information), and RMC (Recommended Minimum Specific GNSS

Data). The data followed after the three-letter-identifier is data related to the identifier. For example, after ZDA identifier, the time and date data will follow, each data are separated by comma and then the last data is character '*' followed by the checksum data of two characters ended by < CR > <LF > [9, 10].

23.2.2 General Packet Radio Service (GPRS)

General packet radio service (GPRS) is a packet oriented mobile data service available to users of the 2nd generation cellular communication systems global system for mobile communications (GSM). This system developed here uses the 2nd generation instead of the 3G system. In 2G systems, GPRS provides data rates of 56–114 kbit/s [1, 2, 11, 12]. The purpose of this system is to communicate data from the GPS to the computer which is attached to the Internet. Detail connection of a GPRS modem to the Internet is described in details in [1].

Connection establishment from the device to the GPRS network is conducted via a GPRS modem with connection which has a serial connection to computer/ microprocessor. Command to connect to the GPRS network is via Hayes command which is also known as AT+ command (Attention Command) [13–15].

23.2.3 SIMCOM908 (GPS and GPRS Modules in One Unit)

One of the most important modules used in this device is SIMCOM908. It is a module which comprise of a GPS module which is described above combined with a GPRS and GSM modules integrated into one larger module with its function blocks shown in Fig. 23.3a.

As shown in Fig. 23.3a, this module also has a power management module which is utilized to manage internal rechargeable battery. This battery is a backup power in case the external power from the car battery is unplugged and the backup in embedded inside the unit. Charge management unit include the full power recharge if the backup battery is low in power, trickle charge the backup battery for a period of time when it is full, and then stop the charging when the backup battery is completely full. Figure 23.3a also shows that the module has module has complete GPS receiver, complete GPRS packet data connection along with GSM telephone with external SIM card connection for the GSM with 'Mini SIM (2FF)' form factor. The GPS, GSM and GPRS unit are controlled by two different UART port, one UART for the GPS and the other UART for the GSM/GPRS unit. The GSM module is Quad-band with power to the SIM card (1.8–3 V) compatible with providers in Indonesia. Serial port connection support data rate from 4800 to 115,200 bit/second (bps). Figure 23.3b is the photograph of the top side of the

(a)

(b)

(c)

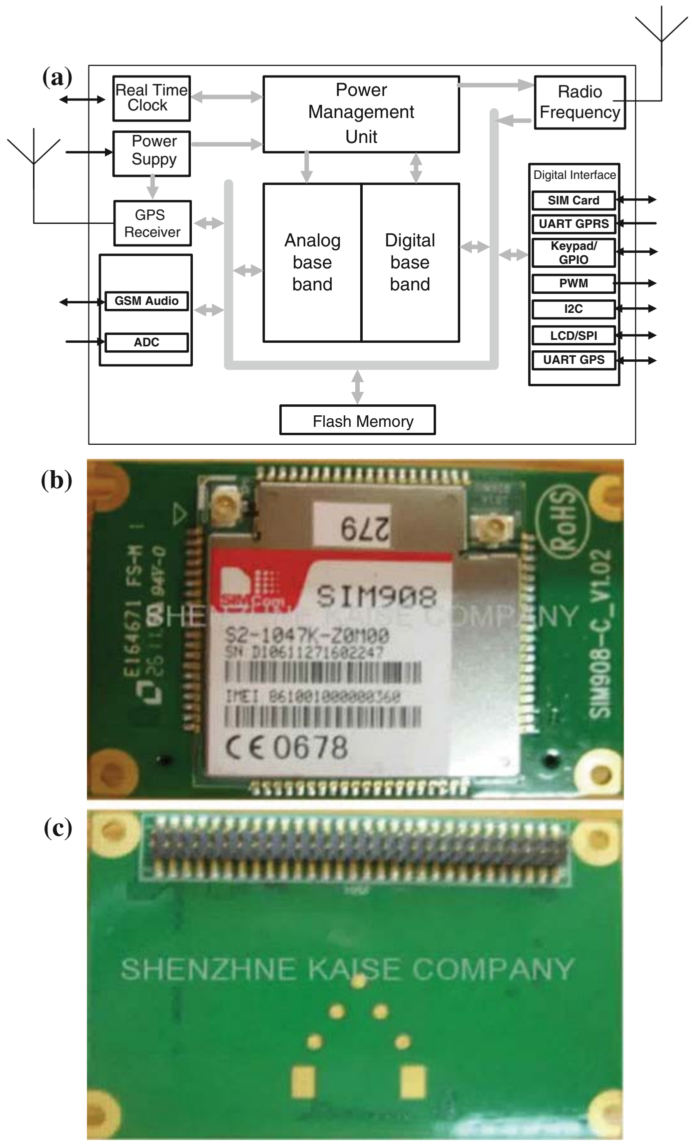

Fig. 23.3 **a** SIMCOM908nfunction block with power management. **b** Top view of SIMCOM908 module with I-Pex antenna connector. **c** Bottom view of SIMCOM908 module with the pin connection to PCB

module and Fig. 23.3c is the bottom part. Antennas for the GSM and GPS module are connected via two different I-Pex connectors on the component side as shown in Fig. 23.3b. The same module is used in previous work [1].

23.2.4 Microcontroller ATMEL ATMEGA164PA

The SIMCOM908 module used for this device has two serial UART connections to control the GPS and GPRS modules. Controlling the sub-system requires two different UART connections that can be active at the same time, therefore a microprocessor with two serial ports will be used. The choice of this system is the ATMEGA164PA. This microcontroller has two independent serial ports that can be programmed for different types of data requirements.

23.2.5 Data Connection to the Server in Internet

Before sending the data, GPRS modem must establish data connection via APN (Access Point Name) which is the gateway to the public Internet. A user needs to know the APN the provider in order to connect, and the information is usually available in the Internet. Connection to the APN will involve sending the user name and the password. Usually the provider will inform the username and password, but it must be programmed first in the microcontroller.

After the establishment of data connection, the system onboard the vehicle will start sending information of its location, speed, heading and other information to the computer system in the Internet which already has MySQL database application software installed. MySQL is a Relational Database Management System (REBMS) capable of handling large amount of data arranged as tables with rows and columns.

Google Maps is a web mapping service application and technology provided by Google free of charge—for non-commercial use—that provides information about geographical region such as road and places. Google Maps uses JavaScript very extensively together with the API key to display the map. Google user account is needed via 'https://developers.google.com/maps/licensing' to obtain the key. After the connection to the Internet, this system has to connect to the proper website to display the location of the vehicle using Google Map. The website is coded into the system is 'www.gpsfence.web.id'.

23.3 Implementation of the GPS/GPRS System and Geo-Fence Web Interface

The vehicle tracking system using GPS and GPRS for data connection has been designed and constructed using all the subsystem mentioned above. The system uses double sided board to conserve space with the SIM908 on one side together

(a)

(b)

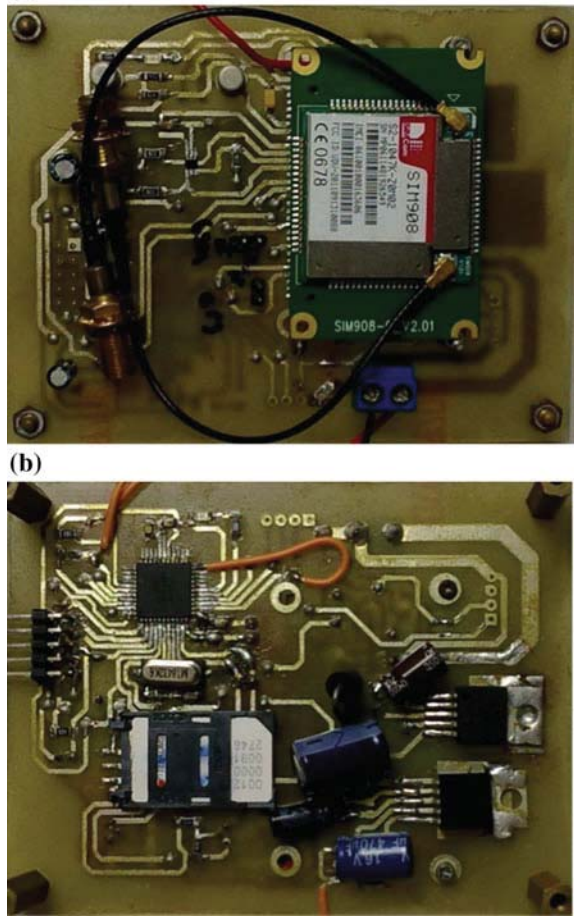

Fig. 23.4 **a** Top side of the GPS vehicle tracking with the SIM908 module shown on top of it. **b** Bottom side of the GPS vehicle tracking with microprocessor and SIM card shown

with several external parts such as output driver and regulator. The top part of the system with the SIM908 module is shown in Fig. 23.4a. Shown also in this figure the pigtail for the antennas, the top part is the GPS antenna connector while the bottom connection is for the GPRS antenna. Figure 23.4b is the reverse side of the circuit board. On this side there is the microprocessor in the form of SMT quad pack together with the crystal and the SIM card holder, and two regulators and on the left-hand side of the board there is an 8-pin header for the programming of the microprocessor via the ISP port of the microcontroller.

The vehicle location information obtained from the GPS is stored in a database file (MySQL) with the data shown in Table 23.1. Other than geographic data, the time, battery condition and vehicle status are also stored in the database and can be

Table 23.1 Parameters saved on the database for the information of the vehicle

Field	Parameter saved
UTC	Time data are taken based on the Universal Time Coordinated time zone
Longitude	Longitude coordinate of the vehicle in signed degree format (DDD.dddd) from −180 East to +180 West
Latitude	Latitude coordinate of the vehicle in signed degree (DD.dddd) from −90 North to +90 South
GPSU	Number of satellites visible to the GPS receiver and used to calculate the position
Speed	Speed of the vehicle in kilometer per hour
Internal battery	Internal battery capacity in percent
External power	Indicator of external battery connection
Relay 1	ON/OFF condition (usually for engine, normally open)
Relay 2	On/OFF condition usually for external alarm or others (normally closed)
Emergency	On/OFF condition of emergency button, normally off/open

recalled from the web by clicking on the marker of the vehicle. The database and also the web interface can be accessed via http://www.gpsfence.web.id.

Data transmission from the GPS to the database is done via GPRS wireless connection which has been discussed previously. Data connection has been tested with all the prepaid GSM network in Indonesia and it has been shown to work properly. For this work, the data connection uses Telkomsel GSM provider with the Access Point Name (APN) coded internally to the microcontroller. The code for the work has been discussed elsewhere [1].

The web page stated on the address above is HTML5 capable and therefore can accommodate geofence and the first page shown is similar to Fig. 23.5. When the location of the vehicle is within the geofence (made with gray color of a quad-angle) the marker is shown red and when the location is outside the fence, then the marker is shown as blue color. Clocking on the market will show that the location is inside or outside the geofence. In this figure the vehicle is monitored using the GPS and shown to be inside the geo fence (four locations) and two locations are outside the fence. The page will also show that the vehicle is outside the fence when the mouse is clicked. When the vehicle inside the fence is clicked, then a window will show that the vehicle is inside the fence as shown in Fig. 23.6.

A vehicle equipped with GPS receiver can obtain its geographical coordinate easily and accurately and the data can be sent to a server in the Internet via GPRS wireless network. The data can then be displayed/overlaid using map to indicate the location of the vehicle and then can be enhanced further by displaying a virtual fence called geofence. With this geofence, the vehicle can be enclosed to be at certain area of operation and when it moved outside the specified enclosed position

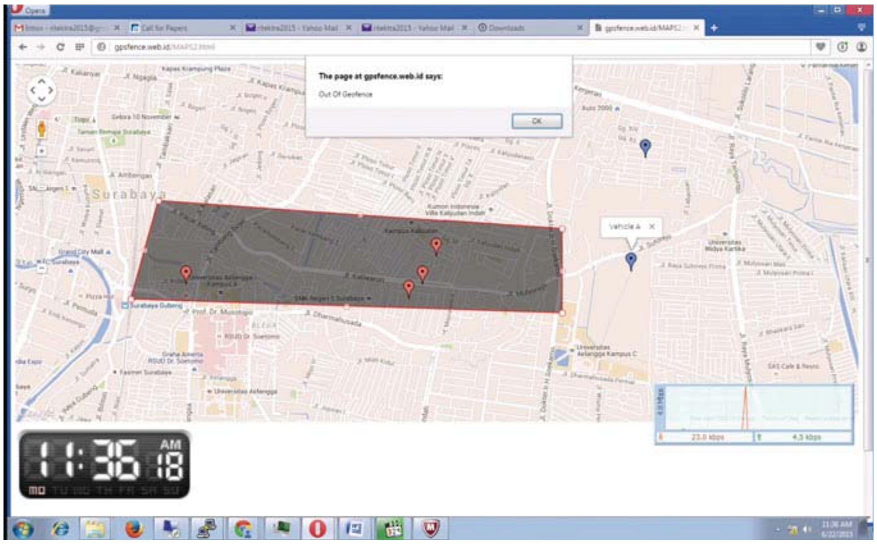

Fig. 23.5 First page of the vehicle tracked inside and outside the geo-fence

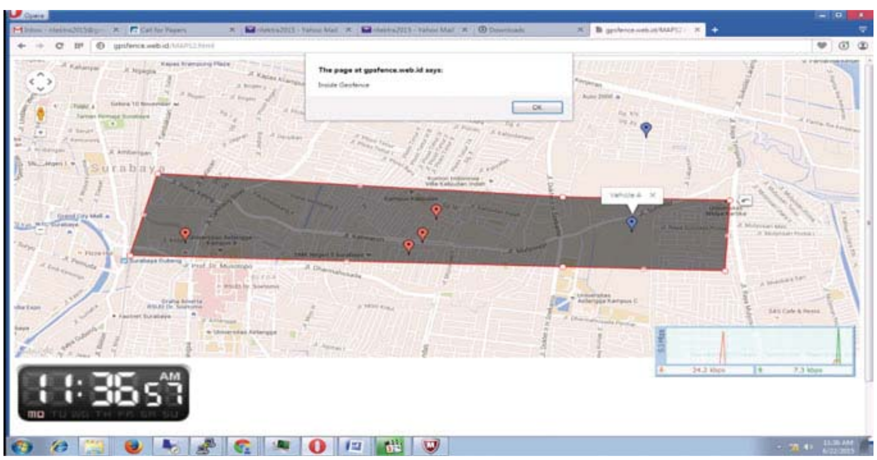

Fig. 23.6 First page of the vehicle tracked inside and inside the geo-fence

an operator can be alerted. With this alert system, the vehicle can be more secured against any wrong doing or any other bad intention and thus the security of the vehicle is enhanced even further (Fig. 23.7).

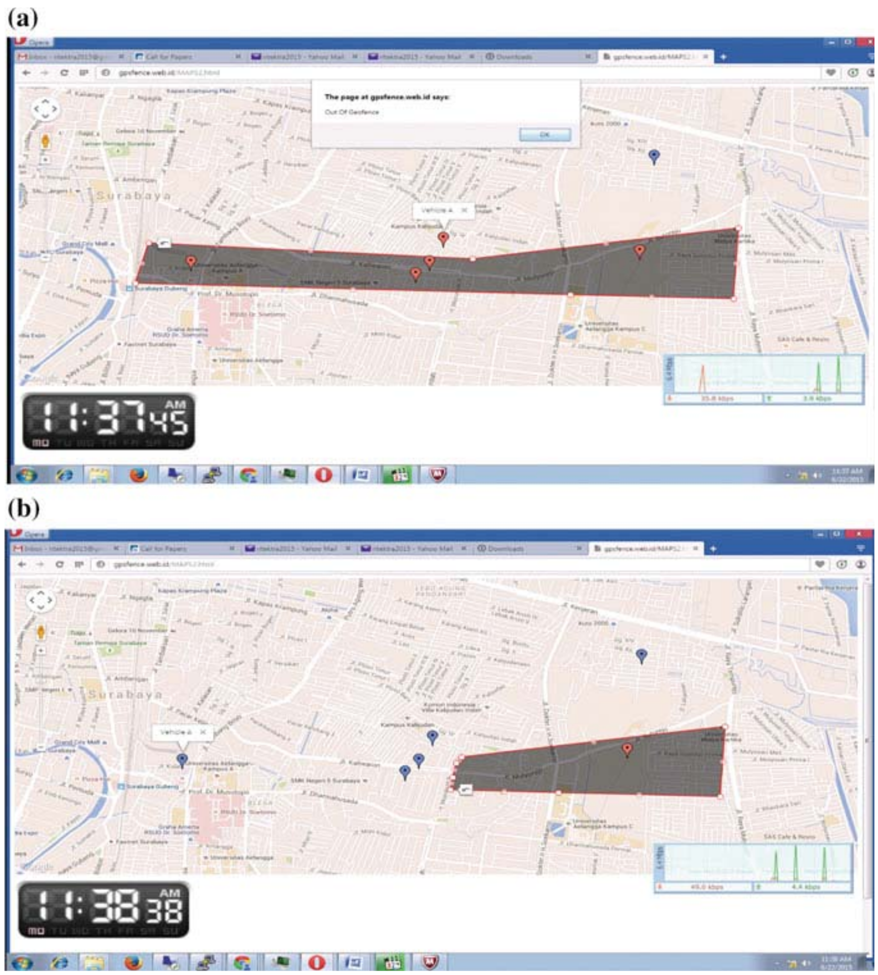

Fig. 23.7 **a** Vehicle is outside the fence after reshaping the geo-fence. **b** Vehicle is inside the fence after reshaping the geo-fence

23.4 Conclusion

This work has shown the work of tracking the vehicle using GPS and GPRS is successful. From the end result of data, they show that the vehicle can be tracked properly using GPS and GPRS. When the emergency button is pressed for more than 3 s the status will be displayed on the web page. Control of vehicle can be carried out by the operator in charge of the vehicle to turn on and turn of the vehicle or part of the vehicle when necessary.

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