

CampusCruise: Campus E-Vehicle Tracking & Management System

M. BARATH KESAVAN¹, K VETTRI SELVAN², M VELMURUGAN³, S VIGNESH⁴

^{1,2,3,4}Department of computer Science and information Technology Kalasalingam Academy of Research and Education Krishnan kovil

Abstract- The Campus E-Vehicle Tracking & Management System (CampusCruise) is a holistic Android-based ecosystem developed in Java and powered by Firebase, designed to revolutionize the management, security, and accessibility of electric vehicle fleets within large institutional campuses through three distinct, interconnected applications. The system is anchored by an Admin Portal, which serves as the command center where authorized personnel use secure email authentication to manage the entire fleet by adding new vehicles with unique identifiers and registering drivers with their personal details, crucially assigning them to specific vehicles within Firestore to establish a clear operational chain of command. The Driver Application acts as the on-ground executor, where registered drivers authenticate seamlessly via phone number and OTP to access their assigned vehicle; upon starting a trip, the app's background service actively fetches and streams precise, timestamped latitude and longitude coordinates from the Android Location Services API to the Firebase real-time database, and continues this transmission until the driver formally stops the vehicle, ensuring location data is only shared during active, in-service periods. On the user-facing side, the User Application provides complete transparency by listening to the live data stream from Firebase and plotting the real-time, dynamic positions of all active fleet vehicles on an intuitive Google Maps interface, allowing users to visually track shuttles without any authentication. To bridge the critical communication gap, the app integrates a one-touch dial feature that retrieves the selected driver's registered phone number from the database and invokes the native dialer, enabling instant voice contact for precise pickups or emergency coordination. By synergizing real-time GPS tracking, cloud-based data synchronization, and role-specific access control, CampusCruise delivers a secure, transparent, and highly efficient solution that optimizes fleet utilization and significantly enhances the daily commute experience for the entire campus community.

Keywords - Android, Firebase, GPS Tracking, E-Vehicle Management, Real-Time Location, Campus Mobility

I. INTRODUCTION

In the rapidly evolving landscape of higher education and large corporate campuses, the demand for smart, sustainable, and secure internal transportation solutions has never been greater. As these institutions expand, often spanning vast areas with multiple facilities, the reliance on electric vehicle (E-Vehicle) fleets for shuttling students, faculty, staff, and visitors has become a critical component of daily operations. However, managing these fleets using traditional, manual methods presents significant challenges. Security vulnerabilities arise from unauthorized vehicle use, operational inefficiencies stem from a lack of real-time visibility into vehicle locations and driver statuses, and user experience suffers from uncertainty regarding shuttle arrivals and the inability to communicate directly with drivers. These fragmented processes create a transportation ecosystem that is often reactive rather than proactive, leading to delays, underutilized assets, and a diminished sense of safety among the campus community. The need for a centralized, intelligent system that can digitize fleet operations, provide complete transparency, and foster seamless communication is therefore not just a convenience, but a necessity for modern campus management.



CampusCruise is a comprehensive mobile technology solution engineered to address these exact challenges

by creating a fully integrated, real-time tracking and management ecosystem. Built natively for the Android platform using Java and powered by Google's Firebase suite, the project is architected around three distinct but interconnected applications, each tailored to a specific user role. The Admin Portal acts as the central nervous system, providing secure, role-based access for fleet managers to register vehicles, onboard drivers, and assign driver-vehicle pairs, creating a master database that ensures operational accountability. The Driver Application serves as the on-ground operator interface, utilizing phone number and OTP-based authentication to verify identity before allowing drivers to start trips, at which point it initiates a background service to continuously capture and transmit precise GPS location data to the cloud. Finally, the User Application democratizes access to fleet information, offering an intuitive, map-based interface where any campus member can view the real-time movement of all active vehicles and, with a single tap, initiate a phone call directly to the driver of a selected vehicle. By weaving together real-time data synchronization, robust authentication, and user-centric design, CampusCruise transforms a disparate fleet of vehicles into a cohesive, transparent, and highly responsive campus mobility service.

II. RELATED WORKS

"Android-Based Transport Tracking and Monitoring System" by A. Krishnan T R et al. (AIJR Proceedings, 2023): This research presents a GPS-tracking application designed for college bus monitoring that utilizes an ESP8266 WiFi module connected to a GPS module to transmit location data to a Firebase real-time database. The system provides students with real-time bus location, designated routes, and estimated time of arrival through an Android app integrated with Google Maps API. The study demonstrates the effective combination of IoT hardware with Firebase backend infrastructure for campus transportation tracking, while also incorporating advanced features such as accident alert notifications to hospitals, engine fault monitoring via OBD diagnostics, and passenger miss notifications. This work validates the architectural approach of using Firebase as the central data synchronization platform for multi-user tracking

systems.

"Real-Time Vehicle Tracking System" by K. Dwivedi et al. (Smart India Hackathon, 2023): This project outlines a comprehensive two-application solution (Admin and User) developed in Java using Android Studio with Firebase Firestore as the backend database. The system enables administrators to manage bus details, station information, and trip configurations through authenticated access, while users can view real-time vehicle locations, routes, and passenger occupancy. A distinctive contribution of this work is the integration of hardware-level monitoring using NodeMCU ESP32 with YOLOv8 image processing to count passengers entering and exiting, addressing issues of corruption and vehicle overloading. The research establishes a validated architecture for role-based access control in vehicle tracking systems and demonstrates the feasibility of combining embedded systems with cloud-based fleet management.

"Implementation of Progressive Web App-Based Applications for Vehicle Tracking Systems" by M. Hasanuddin et al. (IEEE ICSET, 2022): This research explores a multi-platform approach to vehicle tracking by developing a Progressive Web App (PWA) that serves both vehicle owners and law enforcement personnel through a unified interface. The system integrates Internet-of-Things (IoT) devices for location monitoring and incorporates a unique legal framework where vehicle owners can report theft and grant police access to track stolen vehicles. The study demonstrates that PWA technology can achieve native application capabilities while ensuring cross-platform accessibility, significantly reducing development time compared to platform-specific implementations. The dual-interface approach for different user roles provides a relevant precedent for the admin-Driver-User architecture in campus fleet management systems.

"Design and Development of Shuttlefy: A Smart Shuttle System For University of Ghana Campus" by R. Sowah et al. (IEEE ICAST, 2021): This paper presents a comprehensive smart shuttle system specifically designed for university campus environments, enabling students to locate shuttle positions and estimate arrival times through both web

and mobile applications. A significant contribution of this research is the integration of an electronic payment system supporting mobile money, credit/debit cards, and web tokens, allowing cashless transactions for campus transportation services. The study addresses the unique operational challenges of university campuses, including fluctuating demand patterns, multiple stop locations, and the need for real-time communication with diverse user groups. This work establishes important benchmarks for campus-specific transportation solutions and demonstrates the value of integrating financial transactions with vehicle tracking functionality.

"Smart Fleet: IoT-Enabled Electric Vehicle Management for Campus Sustainability" by A. Kohnen et al. (ASU Cox Collaboratory, 2021): This industry-academia collaboration presents a strategic approach to transforming university fleet operations through Internet of Things (IoT) technologies and the ACES model (Autonomous, Connected, Electric, Shared). The research addresses the practical challenges of transitioning an 800-vehicle fleet to electric power, including the \$50 million cost implication and infrastructure requirements for charging stations. The study demonstrates the implementation of advanced network infrastructure including 5G Cellular and LoRa (Long Range networks) to enable smart parking, internet-enabled buses, and comprehensive vehicle tracking. This work provides valuable insights into the institutional and operational considerations of campus fleet management, establishing a framework for sustainable transportation ecosystems that extends beyond technical implementation to encompass policy, infrastructure, and organizational change management

III. IDENTIFY, RESEARCH AND COLLECT DATA

Admin Portal Admin Login

The Admin Login sub-module serves as the secure gateway to the system's management dashboard. It utilizes Firebase Authentication with email and password credentials to verify administrator identity. Upon successful login, the module validates the user's role against Firestore security rules, granting access only to accounts with administrative privileges. This ensures that sensitive fleet

management functions are protected from unauthorized access, establishing a secure audit trail for all administrative actions performed within the portal.

Add Vehicle

The Add Vehicle sub-module enables administrators to register and catalogue new e-vehicles into the campus fleet database. Through a structured form interface, admins input essential vehicle metadata including a unique Vehicle ID, registration number, model type, battery capacity, and operational status. This data is then written to a dedicated 'vehicles' collection in Firestore, creating a master record that forms the foundation for all tracking and assignment operations. The module includes validation checks to prevent duplicate entries and ensures each vehicle has a unique identifier for system-wide reference.

Add Driver

The Add Driver sub-module facilitates the creation and management of driver profiles within the transportation ecosystem. Administrators complete a driver enrollment form capturing personal details (name, contact information), license credentials, and employment status. Crucially, this module includes a vehicle assignment feature that links the newly created driver profile to a specific registered vehicle from the fleet database. This association, stored in Firestore, enables the driver authentication system in the mobile app and establishes the operational relationship necessary for trip tracking and user communication.

Driver Application Driver Login

The Driver Login sub-module is the secure entry point for authorized vehicle operators. It implements a phone number-based authentication flow using Firebase Authentication. The driver enters the mobile number registered by the administrator, receives a one-time password (OTP) via SMS, and upon successful verification, gains access to the app's core functions. This process ensures that only pre-registered and verified drivers can initiate trips, maintaining system integrity and associating the driver's session with their specific assigned vehicle in the database.

Start Vehicle

The Start Vehicle sub-module allows the driver to officially begin a trip and initiate the tracking lifecycle. When the driver activates this function, it creates a new, active trip session in the cloud database (Firestore). This action serves as a trigger for the entire tracking system, marking the vehicle as "in-service" and making its live location available to

end-users. It is the critical manual command that transitions the system from an idle state to an active tracking state, ensuring location data is only shared during operational periods.

Fetch Current Location

The Fetch Current Location sub-module is the core real-time data engine of the application. Once a trip is active, this background service continuously acquires the device's precise geographical coordinates (latitude and longitude) using the Android Location Services API. It then packages this data with a timestamp and the vehicle/driver ID and pushes it to the Firestore database at regular, configurable intervals. This constant stream of updated coordinates is what enables the real-time movement of the vehicle icon on the user's map interface.

Stop Vehicle

The Stop Vehicle sub-module is responsible for gracefully concluding a trip and terminating location tracking. When activated, it performs a final location fetch to record the stopping point, then updates the active trip session in the database to a "completed" status. This action halts the background location service, conserving the device's battery and protecting driver privacy by ceasing all data transmission. The logged stop location and trip duration are stored for administrative review and trip history analytics.

User Application Track Vehicle Location

The Track Vehicle Location sub-module provides the primary user experience of real-time visual tracking. It actively listens to a specific stream or collection in the Firestore database where live vehicle coordinates are published. Upon receiving updates, it renders the position of each active vehicle as a dynamic marker or icon on an integrated map view (such as Google Maps). Users can pan, zoom, and select vehicles to see identifying information, offering complete transparency into the fleet's current status and movement without requiring any authentication.

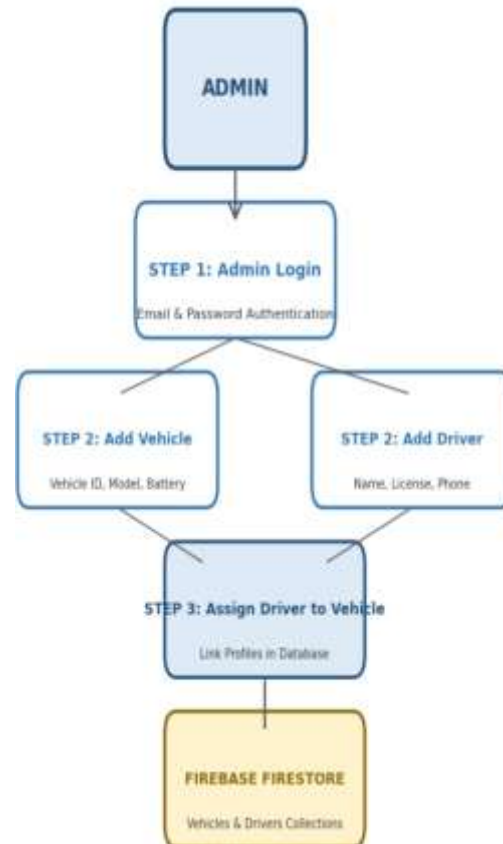
Contact Driver

The Contact Driver sub-module facilitates immediate communication between the user and the driver. When a user selects a vehicle from the map interface, this feature retrieves the driver's registered phone number associated with that vehicle from the database. With a single tap on a "Call Driver" button, it invokes the device's native dialer intent, pre-populated with the driver's number, ready to connect. This direct line provides a crucial channel for

coordinating pickups, providing directions, or addressing urgent needs during the journey.

IV. RESULT & DISCUSSION

ADMIN PORTAL WORKFLOW



DRIVER APPLICATION WORKFLOW



The Admin Portal workflow diagram illustrates the secure, sequential process through which fleet managers establish and maintain the foundational data structures required for campus transportation operations. The workflow begins with Step 1: Admin Login, where authorized personnel authenticate using email and password credentials through Firebase Authentication, ensuring that only verified administrators can access sensitive fleet management functions. This security layer creates an essential audit trail and prevents unauthorized modifications to vehicle and driver records, establishing trust and accountability at the very entry point of the system.

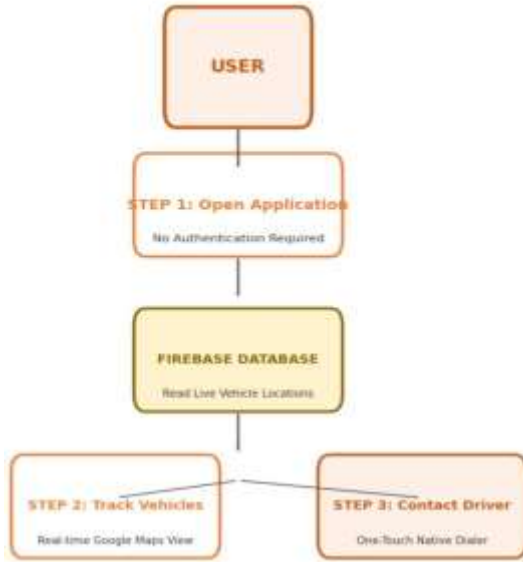
Following successful authentication, the administrator proceeds to Step 2: Add Vehicle, where they register new electric vehicles into the fleet database by entering critical metadata including unique Vehicle ID, model type, and battery capacity. Subsequently, Step 3: Assign Driver to Vehicle creates the crucial operational linkage by associating registered drivers with specific vehicles in the Firestore database. This assignment relationship enables the driver authentication system in the mobile application and ensures that every active trip is properly attributed, creating a complete chain of accountability that extends from administrative

configuration through real-time tracking and post-trip analysis.

The Driver Application workflow diagram depicts the complete operational lifecycle of a vehicle operator, from secure authentication through trip completion and data persistence. Step 1: Phone Authentication implements a user-friendly yet secure entry mechanism where drivers enter their registered mobile number and verify their identity through a one-time password (OTP) received via SMS. This approach ensures that only pre-authorized drivers listed in the admin portal can operate vehicles, while eliminating the need for remembering complex passwords and providing a seamless experience appropriate for mobile users who may be preparing to depart quickly.

Once authenticated, the driver initiates Step 2: Start Vehicle, which creates an active trip session in the Firebase database and marks the vehicle as "in-service" for end-users to track. Step 3: Fetch Location then activates a continuous background service that captures precise GPS coordinates at regular five-second intervals and streams this data to Firebase, enabling real-time vehicle tracking on user maps. Finally, Step 4: Stop Vehicle gracefully concludes the trip by capturing the final location, updating the session status to "completed," and terminating the location service to conserve battery and protect privacy, while simultaneously persisting comprehensive trip records for administrative review and future analytics.

USER APPLICATION WORKFLOW

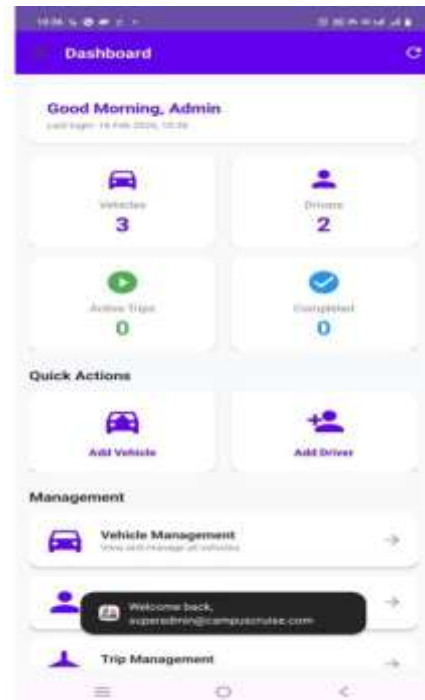
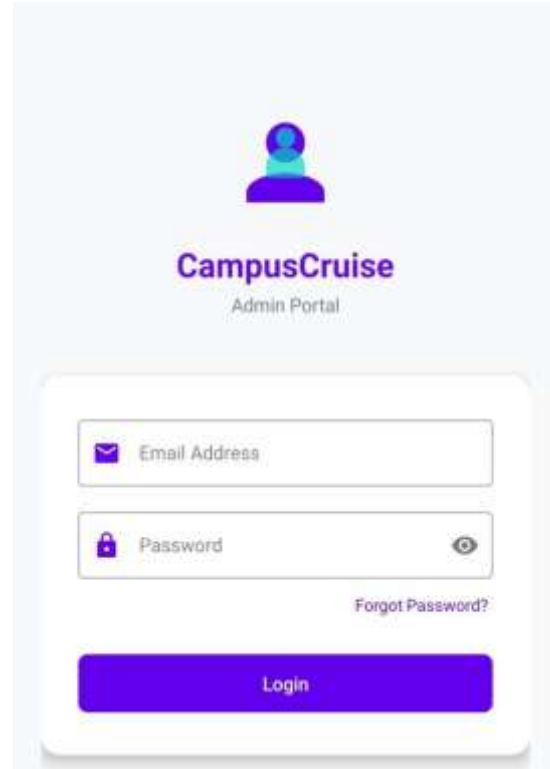


The User Application workflow diagram demonstrates the frictionless, accessible experience designed for campus community members who require real-time transportation information without any registration barrier. Step 1: Open Application allows any user to launch the app and immediately access core functionality without authentication, recognizing that students, faculty, and visitors should not be required to create accounts merely to view shuttle locations. This zero-friction entry point maximizes adoption and ensures that transportation transparency is universally available across the entire campus population.

Upon opening the application, the system connects to the Firebase Database to read live vehicle location streams that are continuously updated by active driver sessions. Step 2: Track Vehicles renders this real-time data on an integrated Google Maps interface, displaying dynamic vehicle markers that move as shuttles progress along their routes, allowing users to make informed decisions about when and where to wait for transportation. Step 3: Contact Driver enhances this visibility with immediate communication capability, retrieving the selected vehicle driver's phone number from the database and invoking the device's native dialer with a single touch, enabling direct coordination for precise pickups, directions to unfamiliar locations, or urgent

communication during active journeys.

V. IMPLEMENTATION



Add New Driver
Register a new driver and assign vehicle

Driver ID

Full Name

Phone Number

License Number

Driver Status

Active

Assign Vehicle

Select Vehicle to Assign

Save Driver

Add New Vehicle

Vehicle ID

Registration Number

Model

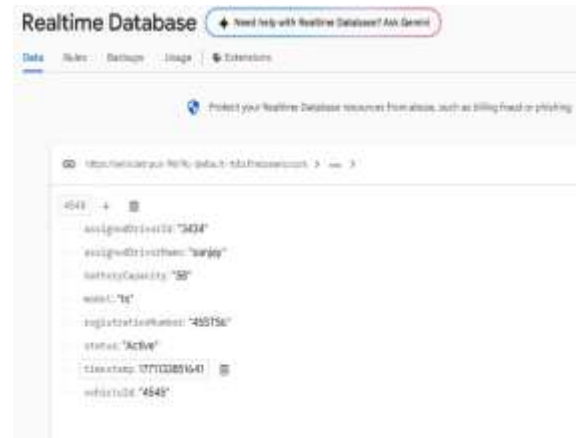
Battery Capacity (kWh)

Vehicle Status

Active

Save Vehicle

Realtime Database



CONCLUSION

The CampusCruise: Campus E-Vehicle Tracking & Management System successfully delivers a comprehensive, three-tier mobile solution that addresses the critical challenges of security, efficiency, and accessibility in modern campus transportation ecosystems through the seamless integration of Android front-end applications with Firebase backend services. By architecting distinct portals for Administrators, Drivers, and Users, the system establishes a robust chain of accountability where fleet managers securely register vehicles and drivers, operators authenticate via OTP and transmit continuous GPS coordinates during active trips, and campus community members visualize real-time vehicle locations on interactive maps while maintaining one-touch communication with drivers for immediate coordination. The implementation of Firebase Authentication ensures role-based access control across all modules, while Firestore and Realtime Database facilitate instantaneous data synchronization that transforms raw location data into meaningful visual intelligence for end-users. Furthermore, the system's ability to persist trip records with comprehensive metadata including start and stop times, routes traveled, and driver-vehicle associations creates valuable historical data for administrative analytics, fleet optimization, and operational auditing. Ultimately, CampusCruise demonstrates that thoughtfully designed, role-specific mobile applications integrated with cloud-based real-time databases can fundamentally

transform campus mobility from a reactive, opaque service into a proactive, transparent, and highly responsive transportation ecosystem that enhances safety, optimizes resource utilization, and significantly improves the daily experience of every campus community member.

REFERENCES

- [1] A. Krishnan T R, A. D. B, G. N, and P. K. V, "Android-Based Transport Tracking and Monitoring System," presented at the AIJR Proceedings, 2023.
- [2] K. Dwivedi, A. Kumar, S. Singh, and V. K. Mishra, "Real-Time Vehicle Tracking System," presented at the Smart India Hackathon, 2023.
- [3] M. Hasanuddin, F. A. Luwinda, and R. Wijaya, "Implementation of Progressive Web App-Based Applications for Vehicle Tracking Systems," presented at the IEEE International Conference on Sustainable Engineering and Creative Computing (ICSET), 2022.
- [4] R. Sowah, S. Amoabeng, N. Dzata, and D. Acqual, "Design and Development of Shuttlefly: A Smart Shuttle System For University of Ghana Campus," presented at the IEEE International Conference on Adaptive Science and Technology (ICAST), 2021.
- [5] A. Kohnen, M. Chester, and K. McKenna, "Smart Fleet: IoT-Enabled Electric Vehicle Management for Campus Sustainability," presented at the ASU Cox Collaboratory, 2021.
- [6] S. S. Pande, S. S. Patil, and S. P. Shinde, "Real-Time Vehicle Tracking System Using GPS and GSM," presented at the International Conference on Inventive Communication and Computational Technologies (ICICCT), 2018.
- [7] M. A. Hoque, M. R. Hassan, and M. S. Islam, "GPS Based Real-Time Vehicle Tracking System," presented at the International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), 2015.
- [8] R. Ramani, S. Valarmathy, and S. Selvaraju, "Vehicle Tracking and Locking System Based on GSM and GPS," presented at the International Journal of Intelligent Systems and Applications, 2013.
- [9] P. Verma and J. S. Bhatia, "Design and Development of GPS-GSM Based Tracking System with Google Map Based Monitoring," presented at the International Journal of Computer Science and Engineering, 2013.
- [10] A. A. Laghari, M. S. Memon, and A. G. Pathan, "Android Based Vehicle Tracking System," presented at the Mehran University Research Journal of Engineering and Technology, 2017.
- [11] S. Lee, G. Tewolde, and J. Kwon, "Design and Implementation of Vehicle Tracking System Using GPS/GSM/GPRS Technology and Smartphone Application," presented at the IEEE World Forum on Internet of Things (WF-IoT), 2014.
- [12] M. F. Saaid, M. A. Kamaludin, and M. S. A. Megat Ali, "Vehicle Location Finder Using Global Position System and Global System for Mobile Communication," presented at the IEEE International Conference on Control System, Computing and Engineering, 2014.
- [13] K. Vidyasagar, G. Balaji, and K. N. Reddy, "GPS Based Vehicle Tracking System for College Buses," presented at the International Journal of Engineering Research and Technology, 2016.
- [14] N. Chadil, A. Russameesawang, and P. Keeratiwintakorn, "Real-Time Tracking Management System Using GPS, GPRS and Google Earth," presented at the International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, 2008.
- [15] A. R. Al-Ali, I. Zualkernan, and F. Aloul, "A Mobile GPRS-Sensors Array for Air Pollution Monitoring," presented at the IEEE Sensors Journal, 2010.