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DETECTION OF FAULTY STREET LIGHTS USING HITCH HIKER

K.SINDHUJA
PG Student
Department of ECE
Rajas Engineering College
Vadakkangulam.
Tamil Nadu. India
sindbaji@gmail.com

S.NAGESWARI
ASSISTANT PROFESSOR
Department of ECE
Rajas Engineering College
Vadakkangulam.
Tamil Nadu. India

Abstract—To avoids road accidents and crimes it is important to rapidly detect and report faulty streetlights to the relevant authorities to keep roads safe. Currently, communities primarily depend on electrical inspectors to check streetlights regularly, which may result in long and unnecessary delays prior to repair. However, a smart system that would incorporate sensors and network modules into every streetlight would be expensive; therefore, it would be nearly impossible to realize this system quickly. In this project, we propose a noninvasive method for detecting faulty lights that involves designing special equipment, called the Hitchhiker, which could be installed on vehicles and would collect information about streetlights intensity. This system would not require the modification of conventional streetlights. The proposed system could be extended to a citywide scale with minimal cost, and could be used as a complementary system for electrical inspectors possibly identifying FSLs sooner and shortening the duration.

***Index Terms*—Detect, fault, intelligent, management, mobile, sensor, streetlights.**

I. INTRODUCTION

After the cancellation of selective availability in May 2000, the accuracy of plain uncorrected global positioning systems is significantly increased. Currently, the main cause of error in plain GPS receivers is imperfect compensation of the ionospheric error. Tests performed in New Zealand show that even a simple code range differential GPS provides significant improvement in accuracy over a plain GPS and can be implemented using low-cost off-the-shelf equipment. A simple statistical model of positioning error estimation is developed and applied on data obtained by measurements in order to verify the findings. Unfortunately, existing MM algorithms show poor performance near a road crossing or in a dense road network. To resolve this problem, based on road traverses and a linear heading-change model, an MM algorithm that considers historical information is proposed. First, a unified point-based MM calculating framework is presented, and the disadvantages of several kinds of existing MM algorithms are also given. After that, a single-line–single-direction road network model is presented, and the MM algorithm is always executed on road traverses instead of a single road so that historical information can be easily kept. By adopting the linear heading-change model, the problem of no analytical solution in the MM that considers heading information is obviated, and the MM ambiguities in road crossings can be greatly removed. With the rapid development of the urbanization process and the expansion of a city's size and population as well, the increasing consumption and electricity cost in lighting deeply intensifies the already uptight energy supply in China. A street lighting system is an indispensable part of an urban infrastructure, and as a part of municipal public facilities, it is closely related to people's daily life. In this paper, the development of a street lighting system technology is described, with the shortages of the current technology pointed out. Comprehensive Kalman filters are implemented to deal with inaccuracy in the different identified possible states an automobile could be found in, which are identified as constant locations, constant velocity, constant acceleration, and constant jerks. Then, the KFs are set up to be part of a interacting-multiple-model system that provides the predicted future location of the automobile.

The system application in streetlight can extend control scope to each lamp reduce in streetlight electricity and maintenance cost, and increase availability of streetlight. Streetlight is an indispensable part of a city's infrastructure, the main function of which is to illuminate the city's streets during the dark hours of the day. It also has a function to decorate street and even has some effects to reduce traffic accident and street crime. So it is important for the public and city governor to guarantee street lighting normal on and off. In the beginning, street lighting was switched on at dusk and switched off at dawn by manual operation, and then the smart controller was used to switch street lighting on and off automatically based on sunrise/sunset times light intensity of controller surroundings at each transformer station. Road lighting management, i.e., finding a faulty street lamp or street lamps blocked by overgrown trees for example, can improve road illumination and reduce traffic accidents. Based on previous

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work, which explores the use of illumination mapsto detect faulty lamps, we present a road lighting management system for detecting significant changes in road lighting automatically. This system is characterized by eliminating any need to modify conventional street lamps. Therefore, the cost is extremely low compared to other approaches, e.g., Wireless sensor network for street lamp monitoring. We design a special embedded system, the Hitchhiker, for installation on fixed-route vehicles, such as shuttle buses, to collect illumination readings along the vehicle's route.

II. PROPOSED SYSTEM

A practical solution is needed to detect FSLs at a low cost and with minimal human labor. We propose a novel method for detecting FSLs: the use of illumination maps. This paper is based on our previous work. An IMapdescribes the illumination intensity in several 2-D locations. Utilizing intelligent wire/wireless streetlights for automatic road lighting management has been difficult. Wireless sensor networks are a promising and widely studied technology that would achieve this goal. The WSN approach dictates that each streetlight must be equipped with a special microcontroller used to measure its working condition. All data are collected and transferred via an RF transceiver to the central data server for managing. The communication method for a streetlight is comprised of two parts: short-range wireless communication for data exchange between streetlights and long-range communication for data exchange from streetlights to the remote data center. Since the distance between streetlights varies from 25 to 50 m, ZigBee, a short-range radio, is normally used with a multihop networking protocol to relay data between poles. Some studies have also suggested adopting PLC as a replacement for wireless communication, enabling more reliable data transmissions. For long-range data communication, GPRS/3G is commonly used to transfer the collected data from the streetlights to the remote data center. The WSN-enabled streetlights have unprecedented applications. Since WSN can transfer data from streetlights to the central server by equipping it with the corresponding sensors, it can be used to determine road traffic and adjust the lighting intensity to save energy if traffic decreases. In addition, a panic button could be installed on the streetlights that would enable people to report traffic accidents or emergencies without having to report their locations, as the location of the streetlight is known by the central server. While WSN-based streetlights have been designed and tested for several years, since every streetlight must integrate a special device for sensing and transmitting data, the cost of modifying conventional streetlights is so high that it is nearly impossible in the short-term. Replacing conventional streetlights with new, intelligent streetlights would cost even more.

Therefore, neither is a practical solution in the near future. This approach uses stationary surveillance cameras installed along roads to capture images of streetlights, and it compares images of the same location taken over several days to determine whether the lighting differs over time. This method does not require the installation of special devices on streetlights. Instead, it involves installing many stationary surveillance cameras that can be very costly if widespread installationsare required. An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular function. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines and toys are among the myriad possible hosts of an embedded system. Embedded systems that are programmable are provided with programming interfaces, and embedded systems programming is a specialized occupation.

Modern embedded systems are often based on microcontrollers but ordinary microprocessors are also still common, especially in more complex systems. In either case, the processors used may be types ranging from rather general purpose to very specialized in certain class of computations, or even custom designed for the application at hand. A common standard class of dedicated processors is the digital signal processor.

2.1. DESIGN REQUIREMENTS

To increase the adoption of Hitchhikers on shuttle buses or taxis, we kept the following requirements in mind when designing the Hitchhiker.

1)It must be a nonintrusive device for the vehicle on which it will be installed. No modification of the vehicle is allowed.

2)The Hitchhiker must be able to run autonomously without human intervention or manual control, and it must not require any effort from the driver of the vehicle.

3)Errors of or damage to the Hitchhiker must not hinder the original service of the vehicle. All maintenance work must be done by us, and not the drivers.

4)The operation and hardware cost of the Hitchhiker must be low to allow for numerous installations without exceeding our limited budget and labor resources. Nevertheless, the Hitchhiker and CP strike a good balance between cost and performance, and they serve as a complementary solution for electrical inspectors.

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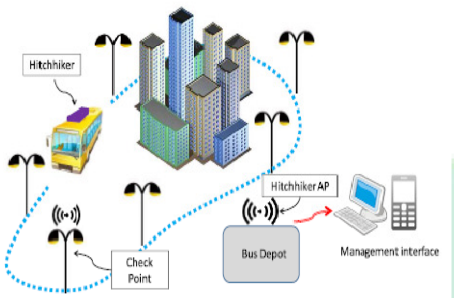

Fig: 1.1 Architecture of proposed system

2.2 .SYSTEM ARCHITECTURE AND DESIGN

In the following, we present our system architecture and discuss the design considerations. It is composed of three types of devices: 1) Hitchhiker; 2) check point; and 3) Hitchhikeraccess point. The Hitchhiker is an embedded system that is installed on the roofs of vehicles, such as shuttle buses or taxis, to collect illumination readings along the route the vehicles traverse. All data from the Hitchhiker is uploaded to the HAP for data storage, analysis, and user query, which allows for the identification of possible locations of FSLs. We designed and implemented a prototype Hitchhiker to demonstrate the practicability of this system.

A. Hitchhiker

The key idea of the Hitchhiker is to take advantage of existing vehicles to carry our specially designed embedded system to collect illumination data along its route. Hitchhiker is installed on the roof of a shuttle bus, and it collects readings of the street lighting, as well as the location and acceleration of the bus. The largeamount of data generated by the Hitchhiker is saved on its SD card. The Hitchhiker's power is supplied by a 12/24 V plug inside the vehicle. The illumination readings from the precise light sensor locations are collected at 10 Hz. All data are stored on the SD card and wait to be uploaded by the NRF24L01P low-power RF transceiver, while communicating with the HAP at the bus depot. The accelerometer detects the acceleration of the vehicle to avoid saving redundant illumination data on the SD, while the vehicle is stopped.

When it is turned ON, it begins to collect data in its data collect mode. It continuously collects GPS locations and illumination intensities at 10 Hz. All data are stored on the local SD card. Meanwhile, the Hitchhiker continuously listens for radio messages from the CP and HAP. If it receives a message from the CP, it simply saves the message on its SD card. This data may be used for later verification and ensures consistency of the illumination intensity of the CP and Hitchhiker. When the Hitchhiker is close to the bus depot, it might receive a message from the HAP and switch to data upload mode. The HAP might schedule the upload of several Hitchhikers.

B. Check Point

Since the Hitchhiker uses one light sensor and one GPS module to collect the light intensities along the route, if the light sensor or GPS module reports inaccurate data, then erroneous IMaps will be generated that wrongly report FSLs.The Hitchhiker must deal with the following reliability issues.

1)The illumination reading from the light sensor may be incorrect due to different weather conditions or dirt on the light sensor.

2)The GPS location may be incorrect due to defective GPS modules, bad weather conditions, or radio interferences. CP is designed to provide the ground-truth of the illumination reading at a specific location.

The CPs design goals are as follows.

1)To provide ground-truth illumination readings in a fixed location so the Hitchhiker can check its light sensor.

2)To provide the GPS location of the CP to verify the Hitchhiker's location.

The following diagram shows the proposed block diagram for this system.

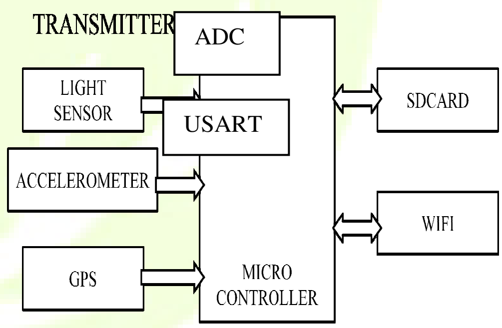

Fig 2.1. Transmitter side

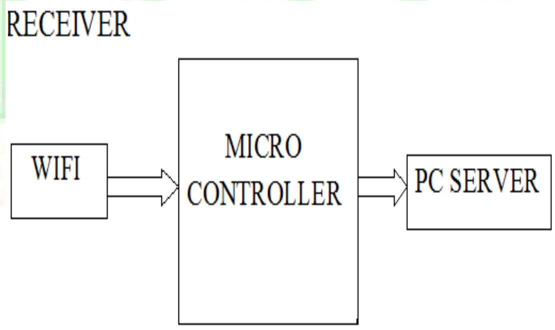

Fig 2.2. Receiver side

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The accelerometer detects the acceleration of the vehicle to avoid saving redundant illumination data on the SD, while the vehicle is stopped. Accelerometer is a device that measures proper acceleration. Proper acceleration is not the same as coordinate acceleration. For example, an accelerometer at rest on the surface of the Earth will measure an acceleration g= 9.81 m/s^2 straight upwards. By contrast, accelerometers in free fall orbiting and accelerating due to the gravity of Earth will measure zero.Accelerometers have multiple applications in industry and science. Highly sensitive accelerometers are components of inertial navigation systems for aircraft and missiles. Accelerometers are used to detect and monitor vibration in rotating machinery. Accelerometers are used in tablet computers and digital cameras so that images on screens are always displayed upright.

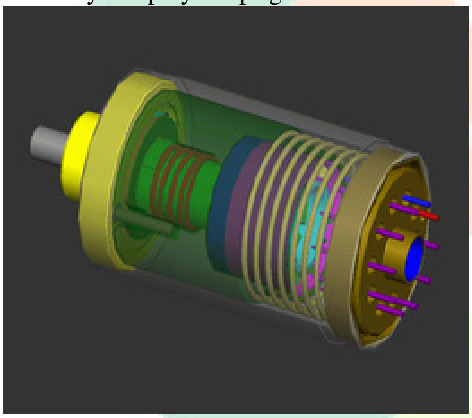

Fig 2.3. Accelerometer

The Global Positioning System is a space-based navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains it, and makes it freely accessible to anyone with a GPS receiver.Global Positioning System (GPS) is a worldwide radio-navigation system formed from the constellation of 24 satellites and their ground stations. The system was initially designed for the operation of U. S. military. But today, there are also many civil users of GPS across the whole world. The civil users are allowed to use the Standard Positioning Service without any kind of charge or restrictions.

Global Positioning System tracking is a method of working out exactly where something is. A GPS tracking system, for example, may be placed in a vehicle, on a cell phone, or on special GPS devices, which can either be a fixed or portable unit. GPS works by providing information on exact location. It can also track the movement of a vehicle or person. So, for example, a GPS tracking system can be used by a company to monitor the route and progress of a delivery truck, and by parents to check on the location of their child, or even to monitor high-valued assets in transit.GPS tracking is the surveillance of location through use of the Global Positioning System (GPS) to track the location of an entity or object remotely. The technology can pinpoint longitude, latitude, ground speed, and course direction of the target. The GPS is a "constellation" of 24 well-spaced satellites that orbit the Earth and make it possible for people with ground receivers to pinpoint their geographic location. The location accuracy is anywhere from 100 to 10 meters for most equipment. Accuracy can be pinpointed to within one meter with special military-approved equipment. GPS equipment is widely used in science and has now become sufficiently low-cost so that almost anyone can own a GPS and many do in a Smartphone, tablet or GPS navigation device. Secure Digital is non-volatile memorycard format developed by the SD Card Association for use in portable devices. The standard was introduced in August 1999 as an improvement over Multimedia Cards, and has become the de facto industry standard. Secure Digital includes four card families available in three different form factors. The three form factors are the original size, the mini size, and the micro size. Electrically passive adapters allow a smaller card to fit and function in a device built for a larger card.

There are many combinations of form factors and device families, although as of 2013, the prevailing formats are full- or micro-size SDHC and full or micro SDXC. The SDA uses several trademarked logos to enforce compliance with its specifications and assure users of compatibility. The Light Sensor is a passive devices that convert this “light energy” whether visible or in the infra-red parts of the spectrum into an electrical signal output. Light sensors are more commonly known as “Photoelectric Devices” or “Photo Sensors” because the convert light energy into electricity. Photoelectric devices can be grouped into two main categories, those which generate electricity when illuminated, such as Photo-voltaics or Photo-emissive etc, and those which change their electrical properties in some way such as Photo-resistors or Photo-conductors.Based on the experimental results, the proposed method can identify changes in illumination and indicate the locations of possible FSLs. To improve the accuracy of the positioning of FSLs, the following issues must be addressed.

A. GPS Positioning Errors and Mitigation

Positioning errors due to the GPS were nearly unavoidable, as we used a consumer-grade GPS module, despite the fact that the GPS modules we used were enabled *differentialGPS* (DGPS) units, we could upgrade the GPS antenna to have higher radio sensitivity. However, positioning errors would still be likely due to external factors, such as weather conditions (i.e., heavy rain orionospheric distortion) or obstacles (i.e., tall buildings). Since the positioning accuracy with DGPS is ~2.5 m, according to the datasheets an expedient approach would be to downscale the resolution of *IMaps* to 0.003 min. This would also increase the portion of overlap among several *IMaps,* therefore helping to identify more regions with significant illumination changes. This also alleviates the issue of data obtained from driving in differentlanes because the illuminations are averaged into a larger cell. Another approach to dealing with GPS positioning errors is to apply a map-matching technique (like a car navigation system) or a trajectory estimation [13] to correct the GPS position. This would avoid unwanted trajectory drifting. However, it requires a precise geographical information system that could provide accurate road maps to correct trajectories. This approach could solve the problem, but might not be available in rural areas, where road maps are usuallyout-of-date and unverified, which presents more challenges to realizing this system.

B. Accuracy of Detecting FSLs

Regarding the accuracy of detecting FSLs, WSN would offer near 100% accuracy because it installs a sensor on every streetlight to measure the light intensity. However, the proposed approach still achieves 80% accuracy and costs thousands of dollars less, according to the results. From this point of view,the proposed solution is valuable and can be deployed soon.

C. System Reliability

In this system, the CP offers a ground-truth for the Hitchhikers to check their own data, including their current locations and light sensors. If the error of a GPS or light sensor is significant, the Hitchhiker will discard the data it collected and call for hardware service. Therefore, the system's reliability is maintained at a level proportional to the number of CPs installed. If high reliability is necessary, more CPs can be installed, but the cost will increase. The proposed approach considers performance, hardware, and deployment costs in the design stage, and can be used as a complementary system for electrical inspectors identifies possible FSLs sooner and shortens the duration of badly lit streets. In addition, it can be extended to a citywide scale at a low cost.

D. Self Diagnosis

It is worth mentioning that we can add a self-diagnostic feature to verify the function of the Hitchhiker and CP. If the Hitchhiker and CP collect light intensity data on sunny days, then regardless of whether the streetlights are working or not, the CP can detect the sunlight and then broadcast this messageto the passing Hitchhiker. The Hitchhiker can then use thismessage to ensure that its reading is consistent with that of the CP, and that the GPS module is working correctly.

E. Other Data Sources for IMap Generation

To generate more accurate *IMaps*, we can extend the function of the CP to log long-term data, which can serve as a reliable data source when generating *IMaps*. We can configure the CP to log the long-term history of light intensity in a fixed location, and then wirelessly download the data from the CP togenerate an *IMap* for the specific location. If certain locations (i.e., street crossings) must monitor lighting conditions very carefully, this approach can provide significant benefits while maintaining the CPs original function.

III. CONCLUSION

The Proposed method is that, through the Hitchhiker, created IMapsand used them to detect possible FSLs. As far as we know, the proposed method is unprecedented in its use of IMapsto find FSLs and in its consideration of cost-effectiveness and non invasiveness. The proposed method has significant advantages as follows. Additional sensors and networking modules do not need to be installed on every streetlight, so the cost is low, meaning that this method could be realized in the near future. The Hitchhiker can be used on fixed bus routes to collect illumination intensity and create IMapsregularly without extra effort or cost.The differences in illumination between IMapscan help determine and report FSLs, reducing the time between streetlight repairs. We plan to install this system on a local fixed bus route to create town-sized IMaps. This system should help detect FSLs and keep roads safer.To generate more accurate IMaps, we can extend the function of the CP to log long-term data, which can serve as a reliable data source when generating IMaps. We can configure the CP to log the long-term history of light intensity in a fixed location, and then wirelessly download the data from the CP to generate an IMapfor the specific location. If certain locations must monitor lighting conditions very carefully, this approach can provide significant benefits while maintaining the CPs original function

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