Fault Light Detection and Identification System using RFID

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Abstract: Identifying the faulty lights in big areas is a challenging process. This paper investigates the current fault light detection solutions. Then, a fault light detection and identification system is proposed to overcome current solutions' drawbacks especially in indoor facilities. The Radio Frequency Identification (RFID) is utilized for the automatic detection and identification of light faults.

1 INTRODUCTION

It is difficult to identify and detect defects in lighting systems in public places with large areas such as airports, hospitals, and streets (Chen and Chou, 2015), (Chien, 2007), (Cho et al., 2015). Also, the need for a skilled person to inspect every light for the possibility of a defect waste time and efforts in addition to the possibility of missing near-faulty lights due to human error and eye fatigue. Therefore, there is a need for an automatic fault light detection and identification system. Unfixed faulty lights increase darkness which negatively affects human's safety.

Different solutions were proposed to detect light faults. In this paper, the proposed solutions are analysed to identify drawbacks of each system. Based on the investigated solutions, a fault light detection and identification system is proposed to overcome current solution drawbacks specially in indoor facilities. This paper utilizes Radio Frequency Identification (RFID) for the automatic detection and identification of light faults.

The rest of this paper is organized as follows. Investigation of current fault light detection systems is elaborated in Section 2. Section 3 illustrates the proposed RFID-based fault light detection and identification system. Section 4 analyses the proposed system while Section 5 concludes the paper.

2 CURRENT SOLUTIONS INVESTIGATION

The first use of Radio-Frequency Identification (RFID) system was used to Identity Friend or Foe (IFF) during World War II (Domdouzis et al., 2007). Since that date, different systems were proposed for human identification, warehouse management, and toll system; to list a few (Muawya et al., 2008)

Different systems were proposed to detect and identify light faults. In (Rajput et al., 2013), an intelligent street lighting system using GSM was designed to resolve the faulty street light issue. The main purpose of this device was to track faulty lamps and send data about this issue to the control centre. The used system required a microchip to be installed on the pole lights. The used chips consisted of a microcontroller along with different sensors, such as CO2 sensor, smoke sensor, light intensity sensor, noise sensor, and a GSM module for wireless data transmission and reception between microchip and primary concentrator (PC). The PC transmitted the controlling action to the microchip. The used system had some weaknesses such as the placement of the microchip in outdoor which affected the lifespan of the microchip due to environmental issues. Also, the high construction cost and required material made the system uneconomical. These drawbacks decreased system's reliability and increased maintenance and installation costs.

In another work, a smart monitoring fuzzy-based fault detection system for malfunction traffic light operation was proposed. The main purpose was to solve the issue in a rural area or small city that did

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not have a traffic monitoring controller. The used system identified three types of fault which are amount of the LED brightness, electrical outage, and physical defect. The system composed a message to be sent to control room. The used system has same issues the GSM-based system Rajput et al. had. Another system (Azura et al., 2013), based on sequence-fuzzy controller, was used to check the LED brightness level. The idea is that for each sequence of traffic light junction and for each pole, only one of the LEDs will be activated while the other LEDs will not be activated. If the LED did not show the correct sequence (Green, Orange, Red), the LED is diagnosed as faulty and the system send the notification to control centre to make action. The used solution was limited to traffic lights only and cannot be implemented in other fault light detection systems.

In (Saleem et al., 2015), a street light monitoring and control system was designed to minimize the time that a workman spends in searching and locating the fault light. The light sensors were placed in all street lights' circuit to switch on and off automatically. Once the lights are switched on, current sensors placed at every light pole were responsible to send light's status to a centralized system using GSM module attached with the circuit. The proposed system was efficient in outdoor fault light detection. However, the system was not economically feasible for indoor big facilities with huge number of light bulbs. Also, not all light bulbs come with circuits to make the solution feasible.

In (Kuo-Hsiung et al., 2016), a G3-PLC-based solution for intelligent street lamp monitoring and energy management was proposed. The main purpose of this system was to detect street lamp issues such as the light is off or missing a wire since it took a long time to solve it. This system had weather resistance, 24-hour automatic monitoring, wide monitoring range, and automatic routing capability to detect every lamp's status such as power consumption, on-off state, and temperature. It had the features of street lamp energy-saving control and multiple alarm modes for users to choose. The management system comprised of street lamps, street lamp monitoring server, and street lamp monitoring client-side. If a street lamp had an open maintenance hole, electricity leak, or did not light, a warning was sent via power lines to the G3-PLC host, concentrator, and the server via GPRS or an SMS short message. The used system was not economically feasible due to using the GPRS and SMS messaging. On the other hand, this system cannot be implemented in indoor places due to the limited ability of this technique to identify faulty lights to a small distance accuracy.

In (Sumathi et al., 2017), an arm-based street lighting system with fault detection was designed to identify street lamps status where a GSM module was used to send messages. Each street lamp was monitored using fault detection circuit. In case of any faulty lamp, the circuit sends the information to the controller which in turn notifies to corresponding maintenance department using the GSM module. A light dependent resistor was attached close to the street lights to detect any bulb faulty condition. The light dependent resistor (LDR) offered a high resistance value thereby making the circuit open. An arm processor checks for this condition only when the corresponding street light is switched ON. When this condition is triggered, the arm processor sends a message to the control room using the GSM modem connected to the processor and thereby had a good management system. One of the main weaknesses of this system is being expensive.

In summary, all the previously discussed proposed systems did not target indoor areas. Also, they require to replace the current used lighting system with the proposed system which takes time and costly and thus hinder the adoption of that system. Table 1 shows a comparison between different fault light detection systems. The comparison is done based on reliability, cost, maintenance cost, lifespan, and indoor suitability.

Table 1: Comparison between different fault light detection systems.

	Reliability	**Cost**	**Maintenance cost**	**Lifespan**	**Indoor suitability**
Rajput et al., (2013)	Low	High	High	Low	Low
Azura et al., (2013)	Moderate	High	High	High	Not applicable
Saleem et al., (2015)	Moderate	Low	Low	Low	Low
Kuo-Hsiung et al., (2016)	Moderate	High	Low	Moderate	Low
Sumathi et al., (2017)	Moderate	High	Low	Moderate	Low

3 RFID-BASED FAULT LIGHT DETECTION AND IDENTIFICATION SYSTEM

In this paper, the Radio Frequency Identification (RFID) is used for the automatic identification of objects carrying tags based on radio-frequency electromagnetic waves transmitted to a receiver (reader). The proposed fault light detection and identification system includes RFID tag, reader, and

light sensor as shown in Figure 1. An RFID tag and the light sensor will be fixed in the lights. When the lights are inactive, the light sensor activates the RFID tag to communicate with the reader through sending ID to the faulty light. The RFID tag uses the Tag Talk First (TTF) protocol to alert the RFID reader that the light is not functioning. The reader sends alerts to the backend system which locates the faulty light based on the database. Finally, a report is sent to the technician to fix the faulty lights.

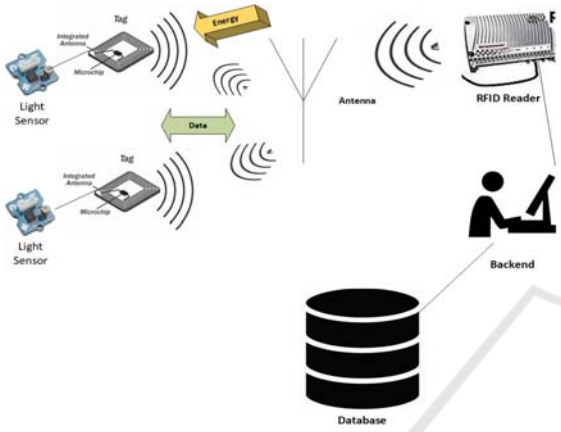

Figure 1: Proposed light fault detection and identification system.

4 FAULT LIGHT SYSTEM ANALYSIS

Several antennae are connected to a single reader to gather data from the RFID tags which makes the proposed system economically feasible. This system can be implemented in indoor areas such as warehouses, airports, hospitals, stadiums, etc. Since the RFID tag is placed indoor, the impact from environmental factors is minimized which should increase the lifespan of the used system. The system also does not require changing the light bulb or the lighting system since the RFID tag and light sensor can be fixed inside the light case. This technique reduces the maintenance costs. Finally, the high durability of RFID tags reduces the required maintenance cost and efforts.

The proposed system showed better results than investigated systems in terms of reliability, cost, maintenance cost, lifespan, and indoor suitability as shown in Table 2.

Table 2: Comparison between proposed and other fault light detection systems.

	Reliability	Cost	Maintenance cost	Lifespan	Indoor suitability
Rajput et al., (2013)	Low	High	High	Low	Low
Azura et al., (2013)	Moderate	High	High	High	Not applicable
Saleem et al., (2015)	Moderate	Low	Low	Low	Low
Kuo-Hsiung et al., (2016)	Moderate	High	Low	Moderate	Low
Sumathi et al., (2017)	Moderate	High	Low	Moderate	Low
RFID-based fault light detection and identification system	High	Low	Low	High	High

5 CONCLUSIONS

The current fault light detection systems are investigated in this paper. The available systems did not target indoor areas, require replacing the current used lighting system with the proposed system, and require time and high cost to implement. An RFID-based fault light detection and identification system is proposed in this paper. The proposed system showed better results than available systems in terms of reliability, cost, maintenance cost, lifespan, and indoor suitability. Future work should investigate security issues of the proposed system such as immunity against eavesdropping, replay, man-in-the-middle, denial of service, and RFID counterfeiting.

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