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Pilot Controlled Runway Lighting System for Energy Conservation

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***Abstract*: The major problem in 21st century is energy crisis mostly the electric energy crisis. The major source of electric energy consumption is lighting source. It is observed that about one third of global consumption of electricity is spent for lighting purpose specially at night at railway station, bus station, at home or at airport for proper reference of airplane for landing or take off to avoid distraction. So, development of more effective lighting source like LED strips to add more advantage such as less power, more safety or efficiently using the existing system.**

***Keywords*: airport, energy consumption, LED strips.**

1. Introduction

Pilot-controlled lighting (PCL), also known as aircraft radio control of aerodrome lighting (ARCAL) or pilot-activated lighting (PAL), is a system that allows aircraft pilots to control the lighting of an airport or airfield's approach lights, runway edge lights, and taxiways via radio.

A. Scope of project

In this project we have decided to only focus our efforts on making the existing airfield lighting of airport more effective in terms of electric power consumption by using LED lights for lighting instead of the florescent lamp and on or off lights of airport runway automatically as per arrival of airplane.

B. Background

The Federal Aviation Administration (FAA) has successfully conducted independent approaches to parallel runways for over forty years using the Instrument Landing System (ILS) navigation and terminal radar monitoring. Some airports, like San Francisco International, can support approximately 60 landings per hour on two parallel runways that are 750 ft. apart using visual approaches, and Simultaneous Offset Instrument Approaches (SOIA) under limited cloud ceiling visual meteorological conditions (VMC). As visibility degrades, the current navigation and surveillance system, as well as the existing procedures, cannot support SOIA approaches, dramatically reducing the landing rate. Several researchers have investigated alternative procedures for Very Closely Spaced Parallel Runway (VSCPR) operations. A number of requirements were identified from these studies, such as cockpit displays, collision prevention systems, precision navigation, communication, surveillance systems and wake information. In addition, Pritchett & Landry explored the parameters and procedures related to VCSPR operations such as separation responsibility and spacing objectives. These studies provided important insight into necessary technologies, information, and procedures for VSCPR implementations. There have been a number of human-in the-loop studies that have explored VCSPR operations.

The Airborne Information for Lateral Spacing (AILS) concept is an example of an investigation of pilot response to VCSPR operations. The concept requires technologies that enable the use of precise navigation and surveillance data, as well as technology for the detection of blunders. Further simulations have been conducted by NASA to examine pilot procedures for paired approaches on runways that are 750 ft apart in instrument meteorological conditions. Enhanced cockpit displays that depict both traffic and wake information were provided to the flight crew for these operations. The results from these investigations revealed that even in the blunder cases, pilot workload was manageable, and an adequate level of situation awareness (SA) was maintained.

C. Objective of project

The aim of study is to develop a pilot controlled runway lighting system. In this work:

1. Runway End Identifier Lights (REIL) - These are installed to provide rapid and positive identification of the approach end of a runway and may be either omni or unidirectional.
2. Runway Edge Light Systems – These are used to outline runway edges during darkness or restricted visibility and white in colour.
3. Taxiway Edge Lights – Outline edges of taxiways during periods of darkness or restricted visibility. They are omni-directional blue lights.
4. Runway Guard Lights – These are installed at taxiway/ runway intersections which enhances visibility of taxiway

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intersections during reduced visibility. It consists of either a pair of elevated flashing yellow lights on either side of the taxiway or row of in-pavement yellow lights.

D. Problem statement

Airports -large and small, use enormous amounts of energy every day and night. Due to the specific use airports serve, it is difficult to develop a new technology that fits in with technology already in place that does not interrupt the daily flows of traffic in and out of the airport. Airports pose a problem because they are nearly always turned on, which creates very large energy consumption and costs. This makes an airport a very good candidate for energy conservation technology.

2. Literature Survey

1. Published in 2019: "Landing of Aircraft Using Integral State Feedback Sliding Mode Control" Ahmad Mahmood, Aamer Iqbal Bhatti, Bilal A. Siddique. Proc. of the 1st International Conference on Electrical, Communication and Computer Engineering (ICECCE) 24-25 July 2019, Swat, Pakistan 978-1-7281-3825-1. Landing is daunting control design problem because it demands high accuracy and precision by pilot. Among the various states to control for stability and landing in an Aircraft, one is its altitude to handle during landing. Since the linearized model of aircraft is considered and is used for altitude control design. For best tracking performance during glide and flare phase, Integral State feedback Sliding Mode Control (ISSMC) is applied, which is based on unit vector approach. To eliminate error between responded altitude and referenced altitude, a dynamic demand first order filter is used. There has been noted a significant improvement in performance as compared with PID control. When comparing the Integral State feedback Sliding Mode Control with PID during landing phase, the ISSMC yields the best response of glide and flare maneuverability for smooth touch down during landing on runway.

2. Published in 2018: "An assistance system for pilot at landing approach" Tatsuo Minohara Proc. of the 1st International Conference on Electrical, Communication and Computer Engineering (ICECCE) 978-1-7281-0649-6. For every civil pilot, the landing approach to the target runway is one of the most difficult operations. The pilot should predict the touch point of landing, the vertical speed, and the horizontal speed at the point. In the most case, there is a wind with some degree of speed through the approach. The pilot should calculate the effect of the wind in the approach. The proposing assistance system in this paper is a display system in which the prediction of trajectory of the approaching civil airplane is forecasted in the synthetic views on a tablet computer. The tablet computer is separated from the control system of the airplane, so that the tablet computer should acquire the positional information and the acceleration values only from the own GPS module and the own acceleration sensors. The practical effectiveness of the proposing assistance system will be evaluated through the usual uses by civil pilots.

3. Published in 2019: "Integrated Pilot and Controller Procedures: Aircraft Pairing for Simultaneous Approaches to Closely Spaced Parallel Runways" Savita Verma, Lynne Martin, Shivangli Sharma, Shobana Subramanian in Ninth USA/Europe Air Traffic Management Research and Development Seminar (ATM2019). Parallel Runway operations have been found to increase capacity within the National Airspace but poor visibility conditions reduce the use of these operations. Previous research examined the concepts and procedures related to parallel runways. However, there has been no investigation of the procedures associated with the strategic and tactical pairing of aircraft for these operations. This study developed and examined the pilot and controller procedures and information requirements for creating aircraft pairs for parallel runway operations. The goal was to achieve aircraft pairing with a temporal separation of 15s (+/- 10s error) at a "coupling" point that was about 12 nm from the runway threshold. Two variables were explored for the pilot participants: two levels of flight deck automation (current-day flight deck automation and auto speed control future automation) as well as two flight deck displays that assisted in pilot conformance monitoring. The controllers were also provided with automation to help create and maintain aircraft pairs. Results show the operations in this study were acceptable and safe. Subjective workload, when using the pairing procedures and tools, was generally low for both controllers and pilots, and situation awareness was typically moderate to high. Pilot workload was influenced by display type and automation condition.

4. Published in 2016: "Runway Automatic Management System of ATC for Air-craft Take-off and Landing" Priyankar Roychowdhury, Shreedeep Gangopadhyay Journal of Aerospace Engineering and Technology ISSN: 2231-038X, JOAET (2016) 52-61 at STM Journals 2016. All Rights Reserved. The existing system of ATC uses a manual system where pilots of air-crafts have to manually contact ATC for requesting permissions for landing or take-off. Air-traffic controllers follow FAA handbook containing a set of rules by which they manage the runway clearance and grant permissions to pilots. But this manual system requires conversation between Air-traffic Controllers and pilots in specific linguistic style. Aviation history shows many accidents have occurred due to misunderstanding of communication between pilots and ATC. Also both pilots and controllers always have to be careful so that miscommunication can be prevented. Furthermore, decision making for take-off or landing and providing runway clearance is a very tough careful job for controllers. But with this Automatic Management System, pilots just have to send requests for take-off or landing by pressing switches and runway clearances will be managed by this system. This paper provides the theoretical back-ground of how such a systemcan be developed. The advantages of this system are accidents due to wrong runway allotment by air-traffic controllers and accidents by misunderstanding of instructions between pilots and air-traffic controllers during landing and take-off are completely removed because there is no verbal communication involved in it. Moreover, the communications and decisions are computerised. The algorithm that will be followed by server after acquiring various data has to be converted into computer program format by using some suitable programming language and stored within the server for subsequent use.

3. Methodology

A. Pilot/Flight Model

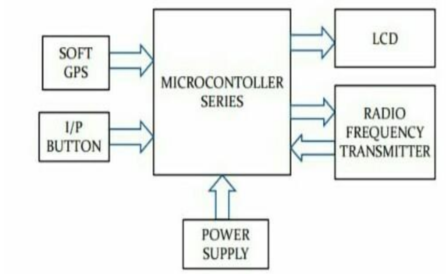


Fig. 1. Block diagram of Pilot/Flight model

The system architecture approach for efficient lighting system for airport runway is as shown in figure 1 consisting of airport runway and runway lights (approach indicator). The lights on runway is controlled as per arrival of airplane [5].

In PILOT PART- input button, soft GPS, LCD, RF transmitter, power supply is interfaced with microcontroller.

1. In order to glow the light, input button is pressed by the pilot.
2. This input signal is detected by the radio frequency/baud rate of 9600.
3. As a result LCD is displayed by showing that the pilot is ready to land.

B. Runway Model

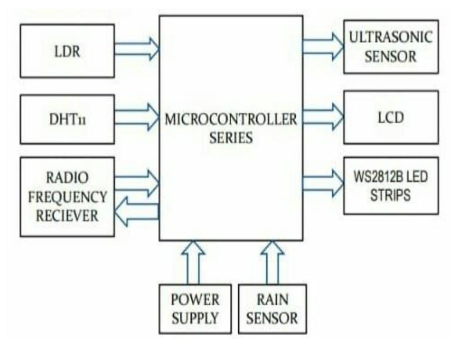


Fig. 2. Block diagram of Runway model

In RUNWAY PART- RF Receiver, DTH11, rain sensor, LDR, power supply, ultrasonic sensor, LCD and LED strips are interfaced with microcontroller.

1. Once the LCD is displayed, the signal is received by the Receiver.
2. Next it consists of 2 LED strips which indicates white and red color. If there is any blockage on runway, the red color led strips are glows indicating that the runway is not free to land.
3. Once the pilot gets to know that the path is not free, pilot goes back to the original position. If there is no blockage, the white color led strips are glows indicating that the pilot can continue their path.
4. Once the pilot continues their path the signals are sensed by using ultrasonic sensor
5. As a result when pilot is near to runway, the LCD is displayed and automatically the runway lights are glows.

4. Implementation of Pilot Controlled Runway Lighting System

A. Block Diagram

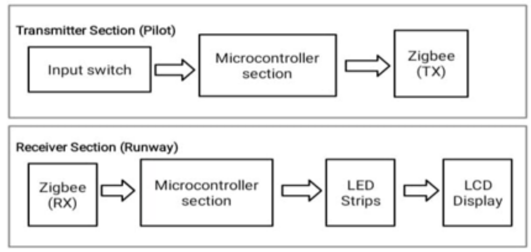


Fig. 3. System block diagram

B. Proposed System/Approach

In this project we have decided to only focus our efforts on making the existing airfield lighting of airport more effective in term of electric power consumption by using LED lights for lighting instead of the florescent lamp and on or off lights of airport runway automatically as per arrival of airplane.

The system architecture approach for efficient lighting system for airport runway is as shown in figure consisting of airport runway and runway lights (approach indicator). The lights on runway are controlled as per arrival of airplane.

1. In PILOT PART, input switch, Rain sensor, RF transmitter, power supply is interfaced with microcontroller (Arduino Nano).
2. In this part, input switch is pressed by the pilot. This signal is sent to the runway part using RF receiver where the LED strips are turned ON automatically for landing.
3. Next pilot detects the Rain sensor and sends the information to the runway part to display that it's raining on LCD.
4. Next LDR sensor detects whether it is day or night mode. When it is night mode, the LED are automatically turned ON.

In RUNWAY PART, IR sensor, Led Strips, Ultrasonic sensor, LCD, Humidity sensor, RF receiver are interfaced with microcontroller (Arduino UNO).

1. In this part, Ultrasonic sensor detects the distance between the edge light and the landing plane. If the distance is less than the threshold value, then the signal is sent to the pilot model and buzzer makes a beep sound.
2. Next IR sensor detects the parking slots of the planes. If the IR sensors are detected, then the slots are filled and displayed on LCD. If IR sensors are not detected, then Slots are empty and displayed on the LCD.
3. Next Humidity and Temperature sensors is continuously monitored to detect weather forecasting and displayed on LCD.

C. Flowchart

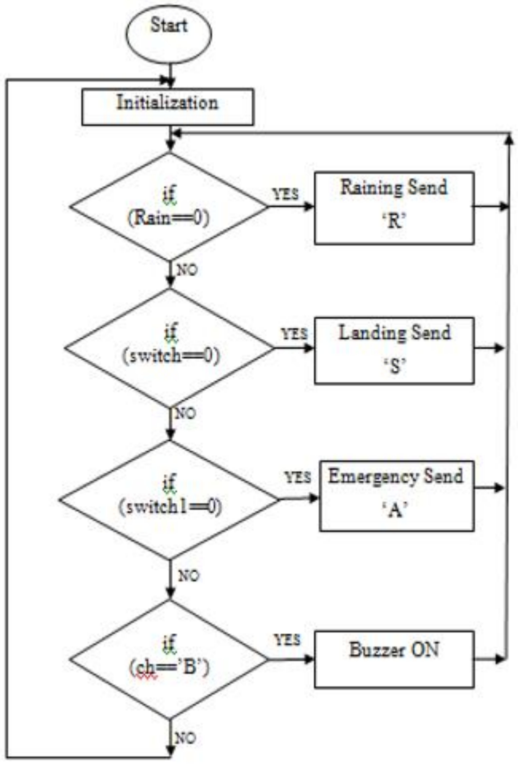
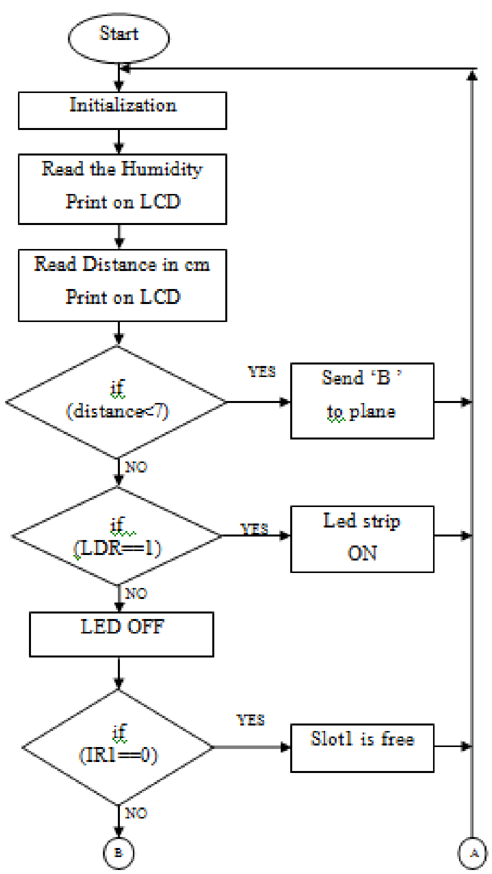


Fig. 4. Pilot Part



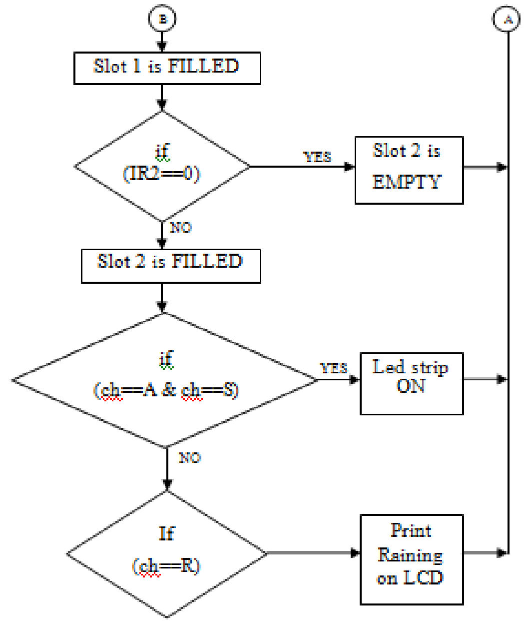


Fig. 5. Runway Part

5. Advantages of Proposed System/Approach

The main advantages of pilot controller is useful at smaller airports, where is not required to light the runways all night, nor to provide staff to turn the runway lighting ON and OFF. This system enables the pilots to activate the airfield lighting only when required, saving electricity and staffing, and reducing light pollution.

6. Result and Future Work

In this project, we propose a virtual controlling of a runway lights that uses LED strips tracking information provided by pilot. This provides virtual interactions directly between pilot and runway without providing any staff to turn the runway lights ON and OFF. The Results of the project are shown below,

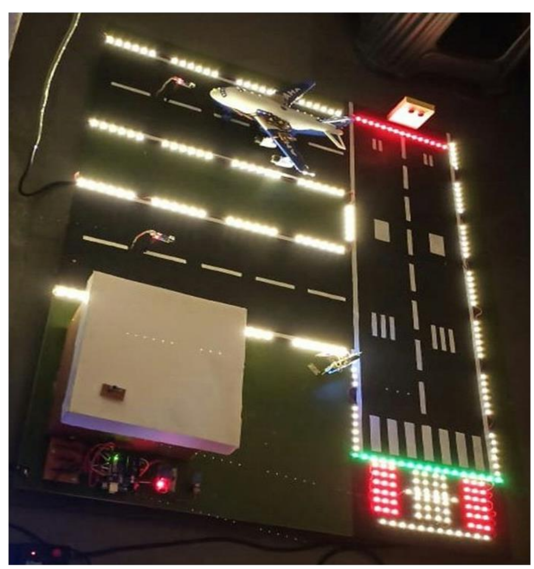


Fig. 6. LED strips turned ON when pilot approaches runway

Fig. 7. LCD display showing both the slots are empty

Fig. 8. LCD display showing slot1 empty and slot2 filled

Fig. 9. LCD display showing slot1 filled and slot2 empty

Fig. 10. LCD display when rain sensor is sensed

7. Conclusion

In this project, we have proposed pilot controlled runway lighting system that uses LED strips, which are used to store the electricity in the airports. Runway lighting may be adjusted at the pilot discretion, which helps the pilot to locate and define the runway and airport environment.

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