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Arduino Based Solar Tracking with Smart Street Light

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ABSTRACT :
In recent years, the demand for energy has been increasing rapidly. A significant portion of electricity in many countries is used for street lighting. Traditional street lighting systems typically operate on a fixed ON/OFF schedule. This project aims to develop an energy-saving streetlight control system that minimizes energy consumption when no vehicles are detected on certain roads. The proposed solution is a cost-effective, Arduino-based solar-powered streetlight system designed for energy efficiency. The primary objective is to implement energy-efficient solar streetlights in smart cities as well as enhance existing street lighting systems in both urban and rural areas. The system includes components such as LDR-based luminaire and driver, a solar panel, charge controller, light sensor, motion sensor, and Arduino microcontroller. The smart streetlights adjust based on the level of traffic and the time of day or night. This paper presents a solution for energy-efficient, automatic street lighting using Arduino, with a focus on reducing energy consumption in current streetlight systems in rural, urban, and smart city settings. The system operates automatically, turning off during daylight hours and functioning only during the night.
Keywords: *Smart LED street lighting; Solar power; Servo motor; Street lighting automation.*

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I. INTRODUCTION:

During daylight hours, solar streetlights capture solar energy, which is then converted into electrical energy by photovoltaic cells and stored in batteries. At night, the stored energy is used to power the lamps automatically. The system includes an automatic control feature, replacing traditional mechanical or electrical timers with more advanced streetlight controllers. Due to insufficient electricity generation compared to the demand for electrical energy, ensuring a stable supply of power is increasingly difficult. Focusing on energy conservation rather than increasing production could be the key to addressing this issue, as saving energy is more cost-effective than generating new electrical power. One effective way to reduce energy consumption is through streetlight monitoring. The objective of a wireless sensor network-based monitoring system is to remotely control the ON/OFF/DIM settings of streetlights, reducing energy usage and maintenance costs while extending the lifespan of the lamps.

As electricity demand grows daily, conserving energy has become crucial. The rapid pace of energy consumption is matched by its production, which is considerable. Furthermore, non-renewable energy sources, which are dwindling, play a major role in electrical energy generation. In the present scenario, as energy consumption increases, either power production must rise, or consumption must be reduced. For instance, there are about 500 street lights along the national highway, each consuming approximately 150W. If these lights stay on throughout the night, and sometimes into the day, the total energy consumption rises to 75,000W. To reduce this substantial energy usage, two techniques can be employed: first, infrared sensors can detect vehicle movement, activating the lights only when necessary, reducing power consumption by 30%. Second, Light Dependent Resistors (LDRs) can detect ambient light levels, ensuring lights remain off during the day, resulting in an additional 20% reduction in energy use. Combining these methods can lead to a 50% reduction in power consumption.

II. MOTIVATION:

Green technologies and smart cities are rapidly becoming a top priority worldwide for improving the future. Smart street lighting systems, which are key to advancing green and environmental goals, play a significant role in this progress. The development of smart cities now relies on technology that integrates wireless connectivity with energy-efficient street lighting. These innovations not only support environmental goals but also enhance city infrastructure by enabling fast detection of malfunctions and enabling quick responses. Street lighting is an essential component of urban infrastructure, primarily aimed at illuminating streets at night. Effective road lighting design should consider various factors, including crime reduction, minimizing environmental impact,

providing affordable public lighting, and ensuring safety for citizens and road users. Additionally, smart city technologies contribute to better response times for maintenance and system issues, ensuring quick repairs when necessary. Streetlights are typically on throughout the night and off during the day, but when there are no vehicles or people on the road at night, these lights are unnecessary. With the ongoing depletion of energy resources, reducing energy usage has become a pressing concern. The limited availability of natural resources could cause significant challenges for future generations.
The Arduino microcontroller system is chosen for its low cost, ease of use, straightforward programming environment, open-source software, and expandable hardware, making it an ideal choice for this application

III. PROBLEM STATEMENT:

Street lights are often left on throughout the entire night, leading to significant energy waste. The amount of electricity consumed daily is considerable, especially considering that some roads, particularly in major cities, may remain empty for extended periods. Given this issue, there is a need to improve the control systems of street lighting to ensure their proper operation while minimizing energy consumption. By implementing smarter control techniques, both energy usage and electrical waste can be reduced. Therefore, it is important to explore ways to decrease the power consumption of solar-powered streetlights.

IV. LITERATURE REVIEW :

[1]. This paper presents the "Street Light Glow" system, which utilizes the latest lighting technologies, including LED lights, and incorporates sensors to detect vehicle movement. The system employs the ZigBee Wireless protocol to maintain a wireless connection between lampposts and control units. Additionally, it uses infrared detection technology to build dynamic control statistics based on traffic flow and automatically adjusts streetlight operation depending on light intensity. The system integrates various technologies, such as power transistors, photodiodes, LEDs, a timer, and traffic flow monitoring.

[2]. This study discusses a streetlight control system that operates automatically, adjusting streetlight intensity based on ambient light levels and using a brightness/dimness algorithm. The system can adapt to seasonal variations and includes a time-based shut-off feature to conserve energy. The entire system is implemented using a PIC microcontroller, which automates the control of the streetlights to further optimize electricity savings.

[3]. This research details the development of a traffic flow-based streetlight management system that efficiently uses solar energy. In this system, solar power, a renewable energy source, is utilized for street lighting. The system uses an 8052 series microprocessor, replacing traditional light bulbs with energy-efficient LEDs, resulting in a significant reduction in power consumption. Sensors placed along the road detect vehicle movement and communicate with the microcontroller to turn the streetlights on or off. Streetlights in this system remain off unless motion is detected, ensuring minimal energy use when there is no traffic.

V. METHODOLOGY :

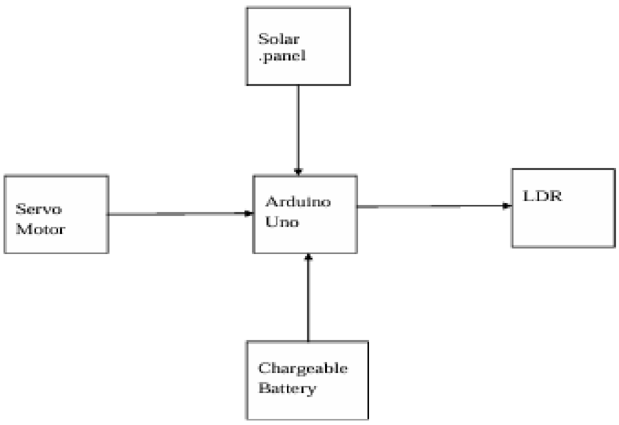

Fig 1: Block diagram of proposed method

The above fig.1 represents block diagram of the project carried out . The main aim is to reduce the power consumption by the street lights, the present situation is like the street lights on the national highway will be switched ON in the evening and OFF in the morning. But the actual timing of these street lights to be switched ON is when there is absolute darkness. With this the power will be wasted to some extent. This project gives the best possible solutions for the power wastage. In our project we are using LDR, whose resistance varies according to the amount of light falling on its surface, this gives the indication whether it is day/night time. The IR sensors have been placed on both the sides of the road which are monitored by microcontroller. The IR'S will be activated only during the night times. If any obstacle that is vehicle or a person crosses IR automatically the light gets brighter till the obstacle crosses to certain distance and then the street light gets dimmer (less brightness). So as mentioned 50% of the power consumption is reduced. In this project we use microcontroller(ATMELGA328P) and a regulated voltage supply of 5V to the Arduino.

1.SOLAR POLAR :

One of the most crucial components of solar street lights is the solar panel, which transforms solar radiation into electrical power. Solar panels come in two varieties: polycrystalline and monocrystalline. Compared to polycrystalline solar panels, monocrystalline solar panels have a substantially greater conversion rate.

Fig 2:Solar panel

2. ARDUINO UNO:

With the ATmega32 family controllers and an Integrated Development Environment for creating and uploading code to the microcontroller, Arduino is an open-source platform built on microcontroller boards. It features input and output pins for connecting to external devices including motors, switches, sensors, and more. Specifically, it features six analog inputs, 14 digital input/output pins, a 16MHz quartz crystal, a power jack, a USB port, an ISCP header, and a reset button. It has all the components required to support the microcontroller. It can be powered by a battery or an AC-to-DC adapter, or it can be supplied by USB. It receives inputs from the LDR, processes the information, and either sends the output directly to LEDS or via a transistor and relay. The FTDI USB to-serial driver chip is not used by the Uno, which sets it apart from all previous boards. Rather, it has the Atmega16U2 (or Atmega8U2 before version R2) configured as a serial-to-USB converter. The SU2 HWB line is pulled to ground by a resistor on the Uno board, which facilitates DFU mode setup.

Fig 3:arduino Uno

3.CHARGEABLE BATTREY :

To prevent batteries from overcharging, a charge controller, also known as a charge regulator, essentially acts as a voltage and/or current regulator. It controls the current and voltage that enters the battery from the solar panels. The majority of "12 volt" panels generate between 16 and 20 volts, so overcharging will harm the batteries if there is no regulation. Then the logical question arises: "Why aren't panels designed to emit 12 volts?" The rationale is that if you do that, the panels will only generate electricity when it's chilly, ideal, and in full light. In most locations, this is not a reliable aspect of the situation.

Fig 4:Battery

WORKING PRINCIPLE:

Solar street lights essentially function by automatically turning on and off at predetermined intervals determined by a controller that regulates the circuit. By the time dusk falls, the voltage drops to about 5V. This instructs the LED light to turn on and draw power. The photovoltaic effect is the basis for how solar lights operate. With the aid of solar cells, solar panels capture sunlight and transform it into direct electrical current, which is then stored in solar batteries for later use using a charge controller. Solar radiation is converted into electrical energy by photovoltaic solar cells. Through the use of a charge controller, the electrical energy that is received is stored in batteries. Typically, charge controllers are employed to safeguard the battery. By utilizing Arduino to provide the necessary time delay, the circuit is made automatic, enabling the light to turn on at night and off during the day. It is doubtful that the solar cells have fully charged if the days have been overcast most of the time. Weak electrical output from these batteries will result from this, which suggests that the lights won't last through the night. However, the photoreceptors will activate to turn on the lights if the sky suddenly gets overcast.

VI. CONCLUSION :

The paper describes an automatic solar panel based LED street lighting system; it integrates latest technology such as LED technology and Renewable Energy Source in order to reduce power consumption, cost and manual controlling method. 20-25% of power consumption and maintenance cost is reduced through this prototype. This street lighting system is appropriate for rural and urban areas. The designed system is flexible, extendable and fully adjustable to user needs. The safest and most economical method of lowering electricity usage is the suggested streetlight automation system. It assists us in eliminating the manual switching issues of today's globe, and more significantly, it makes it simple to reduce primary costs and upkeep. With its cool-white light emission, the LDR uses less energy and lasts longer than lights that use a lot of energy. This system can be improved by switching from traditional LDR modules to solar-based LDR modules in order to transition to new and sustainable energy sources. These effective justifications give this work additional benefits that can get past its current drawbacks. Remember that because of these long-term advantages, the initial investment would never be an issue due to the extremely short return on investment period. Street lights, smart cities, home automation, agriculture field monitoring, timely automated lights, parking lights at hospitals, shopping centers, airports, universities, and businesses, among other locations, can all be readily integrated with this system.

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