Design and development of anti-gridlock system for monitoring and alerting based on automation and image processing

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Abstract: Now–a-days the aggregation of moving vehicles, in any locality or area has increased exponentially, with the current number of vehicles on roads having exceeded all estimates and predictions. Consequently, an increase in traffic density has been observed, leading to a number of road accidents, some fatal, some serious, … Accidents, howsoever minor or major, cause cumbersome traffic jams which throws normal movement as well as life, totally out of rhythm. The rarest of all commodities, precious 'Time' is lost which adds to man's misery and overall stress in life. All of which is avoidable. To provide a solution to the above said problems, an approach has been designed having a smart automated system with smart displays working on the Internet of Things (IoT) and Image Processing. This approach is finely integrated with 4 different technical concepts.The approach consists of the following procedures: (a) It includes a solar panel which tracks the intensity of sunlight, and follows it too, to increase the power efficiency, (b) An automated street light which works on the basis of light intensity to save energy, along with an automatic circuit fault detection with feedback system for the street lights which alerts the public and respective government agency, (c) So as to ensure that the moving vehicles don't cross the zebra crossing when the traffic signal is RED, a cam is used for image processing to detect and alert vehicles/people not to break the rules and thereby avoid accidents and (d) An arrangement to monitor the level of drainage water in sewer lines, to alert the public and the respective authorities when it is almost full and overflowing onto streets / roads resulting in disruption of smooth traffic movement.Thus, the above approach is proposed as a solution to the common problems faced by man on the roads.

Keywords: Smart display, Internet of Things (IoT), Light intensity.

1. Introduction

Every year thousands of vehicles are added and with the infrastructure in cities not keeping pace with it, increasing traffic congestions are the order of the day. Congestion apart, accidents are on the rise, which is compounded during rainy seasons rendering traveling, particularly in cities more dangerous since one also has to deal with power outage on the one hand and roads rendered impassable due to overflow of sewage water onto the road on the other hand. This situation needs cooperative working involving the Traffic Police, the Departments of Water and Sewage Management of the Mahanagara Palike (Municipality) and the state

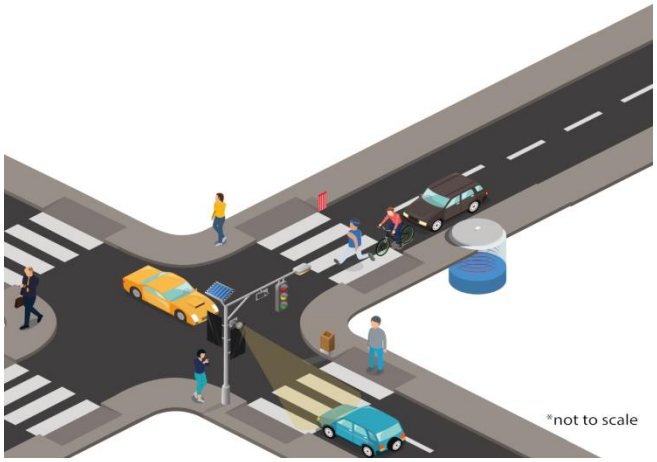

Figure 1Overall Graphical Representation

Electricity Board. The success of such joint action, necessitates that all real time data reaches one Central Control Room, about light on/off state of each electric/signal pole with location information, sewage water level, traffic congestion and crowd gathering/density. Towards this a system is developed which will provide power outage warning in any area at any particular pole, control the traffic at the junction and intimate the Mahanara

Palike as and when sewage water raises above a threshold in sewage system. This would facilitate prompt as well as preventive actions resulting in smooth and uninterrupted movement of traffic as well as public.

Over time, with the advent of technology and the requirement to optimize on resources, it became prudent to have multiple services on the street along with just lighting. Thus, the evolution of Intelligent street poles. Smart poles can vastly improve the telecom infrastructure of the city. Light itself through LED street lighting can provide energy savings to the tune of 50 to 70 percent, with savings reaching 80 percent when coupled with smart automated controls.

The current number of traffic light poles in Bangalore is more than 700 and that of other functionality poles are in thousands. Due to the necessity of many poles for various purposes we are destined to design a smart system for all processes with a goal to reduce the heavy traffic congestions on road, thus reducing the cost and constituting multiple functionalities into a single pole which also reduces the area occupied by multiple poles. "Anti-gridlock system is an urban development vision to integrate multiple Information and Communication Technology (ICT), Internet of Things (IoT) solutions and Image processing in a secure fashion to manage a city's assets". The goal of building anti-gridlock system is to improve quality of life by using urban informatics and technology to improve the efficiency of services and meet public needs effectively.

This idea of Smart automated anti-gridlock system containing multiple functions in a single pole involves design and development a IoT and Image processing based smart system to display, monitor and control the street lights, sewer system, solar trackable solar panels, to detect the distance maintained by the vehicles from the traffic pole and to avoid unnecessary crowd gatherings. The system is designed by using Microcontrollers like Arduino ATmega2560, NodeMCU ESP8266 and Raspberry pi.

Thus, the above proposed system is considered to be a solution to the problem of traffic jams which are known to have a cascading effect. The solution addresses the different root causes of the problem with integrated systems mounted on select poles, interlinked as well as connected to the common control room resulting in proper lighting as well as smooth flow of traffic, not to mention the savings in the reduced number of poles used otherwise.

2. Literature Survey

The first traffic signal was installed at the Town Hall — then, the busiest junction — in 1963 [3]. The junction, in 1962, saw 27,000 vehicles (including 14,000 bicycles and 11,000 automobiles).

But now, a day sees around 1,750 new vehicles registered in the city and the vehicle population in Bangalore has crossed 80.45 lakh, as ionformed by the Transport Commissioner Mr V.P. Ikkeri. Presently the city has 40 surveillance cameras put on various junctions. Out of these, 33 are in working conditions and the others are yet to be connected. This camera is put on an eight-meter-tall pole beside the traffic signals on the junctions. All the cameras are connected through cables (provided by BSNL) with the control room, and it doesn't contain any warning system if the road is flooded.

During the monsoon months of 2017, the Bangalore city was confronted with unexpected torrential rains which caused mass devastating in the area. The heavy rains, specifically on the late night of August 14, 2017, continued till the wee hours of the following morning. The nightlong rainfall caused much havoc on the Bangalore streets, including heavy inundation and tree falls. The floods made the situation in the city on August 15, 2017, look like that of flash floods. Several areas in Bangalore had been inundated with almost knee-level water on the streets. The situation left most of the residents stranded in their homes.

Poorly-lit streets or those without any lighting at all pose a grave danger to Bengalureans, more so women, especially those who do not use motorized forms of transport. They complain of vehicles slowing down next to them and / or people passing lewd remarks and at times chain-snatching also. Women in the city, who have no option but to pass through such treacherous stretches, take each step with a constant fear of danger lurking round some corner. At such times, their only guiding light is the torch in their mobile phones or the headlights of vehicles passing by.

Prof. Pankaj Deshmukh, Vatsal Shah and Mayuri Sapkal from K.J.S.I.E.I.T. Mumbai, Maharashtra in their paper "Multi Function Electric Pole" where they have explained about the solar panel used in the electric poles

which use less electricity. But our key takeaway from this paper was to improve our pole to make it sun-tracking so to catch maximum light.

Yongming Zhang1, Li Li1, Zhe Yan1 and Jiawei Yao in their paper "A Smart Hybrid Pole With Street Lighting And EV Charging Based On DC Micro-Grid And Renewable Energy" where they used automatic lights in the pole which was a hybrid pole. The knowledge gained from the paper we thought of improving by adding the feedback system with a view to notify the status of the automatic lights to the concerned authorities.

Duanshun Li, Anran Cong and Shuai Guo in "Sewer damage detection from imbalanced CCTV inspection data using deep convolutional neural networks with hierarchical classification", [3] proposed a system that uses camera for detection/checking sewage levels and usually cameras are prone to rodents and also require image processing in this case for better results.

Mr.T. Gowdhaman, PG Scholar. Dr.D.Surendran in "Automatic Street Light Control And Fault Detection System With Cloud Storage", [1] proposed a system that uses LDR, Arduino to switch on and off the street lights automatically and reports to the main station.

Poonam A. Kandalkar and Gajanan P. Dhok in "Image Processing Based Vehicle Detection And Tracking System", [2] published a paper in International Advanced Research Journal in Science, Engineering and Technology Vol. 4, Issue 11, November 2017, there idea is to obtain the output image by subtracting second image frame from first image frame in corresponding consecutive frames.

3. Methodology

1.1. Sunlight Tracking Solar Panel:

One of the main features in our project is the solar panel (12V) that adjusts its position according to the intensity of sunlight, unlike all the fixed position solar panels that are currently in use. This task is achieved with the help of servo motor, LDR's and solar panels connected to Arduino mega.

This gives us a huge benefit as it efficiently uses the solar rays not just at certain hours but throughout the day. With this, we can completely harness the solar energy to its maximum thus saving electricity and also making it cost efficient over long periods of time.

1.2. **Automatic Lights and Its Feedback System**:

This idea implementation was done with the use of a LDR which detects the intensity of sunlight(natural light) in the area and if the natural light is poor or of less intensity (in late evenings usually), then automatically the street lights gets turned 'on' and stays 'on' as long as there is poor light and turns 'off' as soon as the natural light begins to get intense (morning), which saves a lot of electricity as the lights are 'on' only when needed and also makes it easy for the technician as there not much of manual process.

The feedback includes checking all the street light conditions by the signals received from the LDR's through the inner part of the LED, by this obtained result the information in form of a message is sent to the respective govt. agency (BESCOM) via GSM module about the failure in the light along with the pole number and all the details which makes it easy for them to track down the light and fix it.

We also include a display that is attached to our pole which displays the details of failed street light using Bluetooth module, giving heads up to the commuters so that they can avoid troubles and accidents due to poor street light.

Algorithm:
Step1: Start
Step2: Check for the intensity of sunlight using LDR1
Step3: if the intensity of sunlight is low or nil go to step4 else go to step2
Step4: Switch on the street lights
Step5: Check for the intensity of street light using LDR2
Step6: if light not glowing go to step7 else go to step5
Step7: Update the light status to BESCOM via text message
Step8: End

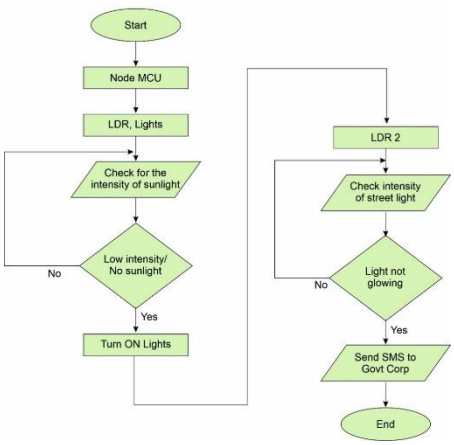

Figure 2: Flowchart of Automatic street lights with feedback system

1.3. Sewer monitoring System:

The common problem faced by the people on roads is the high aggregation of traffic jams in the city. One important reason for this issue is because of the inefficient management of the sewage system which results in overflow of the drainage water on to the road rendering it less usable, creating a foul smell as well as being a source for avoidable diseases.

To have a control over this problem we fix an ultrasonic sensor to the inner part of the sewer cap to measure and monitor the drainage level status.

Once the drainage water reaches a specific peak level, the drain water status is reported to the respective govt. agency (BWSSB division) using Thingspeak open web server. Prompt action by the concerned agency prevents overflow of the drainage on to the road.

Also, during high rain fall there is high chance of water level increase in the roads due to both rain water and overflowing drainage water, so this data of the excess water level is displayed in the android display fixed at the pole using the water level sensor at the road divider, conveying an alert message to the public to carefully cross that flooded lane.

Algorithm:
Step1: Start
Step2: Check the sewer level using Ultrasonic sensor
Step3: If sewer level is above preset limit go to step4 and step7 else go to step2
Step4: Check the sewer level for warning limit
Step5: if sewer level is above warning limit goto step6 else goto step7
Step6: Print sewer level on display and goto step7
Step7: Update the sewer level status to webserver
Step8: End

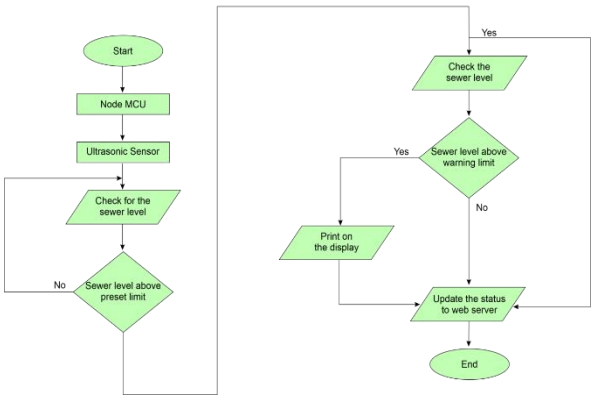

Figure 3:Flowchart of Sewer monitoring System

1.4. **Vehicle detection**:

One of the main causes for the gridlock and accidents are inefficient method of vehicle tracking. A solution for this problem is approached with the help of image processing techniques like OpenCV, TensorFlow.

To solve this problem, we use automated vehicle capturing technique using Raspberry pi as a controller and a NoIR camera to click a picture. The Ultrasonic sensor is used as the input to the controller and when a vehicle violates the traffic rule for crossing the zebra lane when the signal is red is detected by the ultrasonic sensor which then triggers the Raspberry Pi to click the image of vehicle. This image is then further processed using image processing techniques. The offender is identified and necessary action taken by the authorities. This acts as a deterrent for road users from ignoring traffic signals and causing accidents which cause traffic jams.

Algorithm:
Step1: Start
Step2: Check for vehicles crossing zebra lane during red signal
Step3: If no vehicles detected go to step2 else go to step4
Step4: Take picture of vehicle using NoIR camera
Step5: Extract the number plate
Step6: End

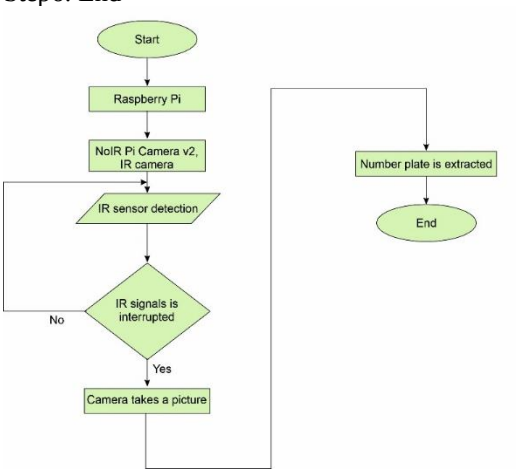

Figure 4: Flowchart of vehicle detection

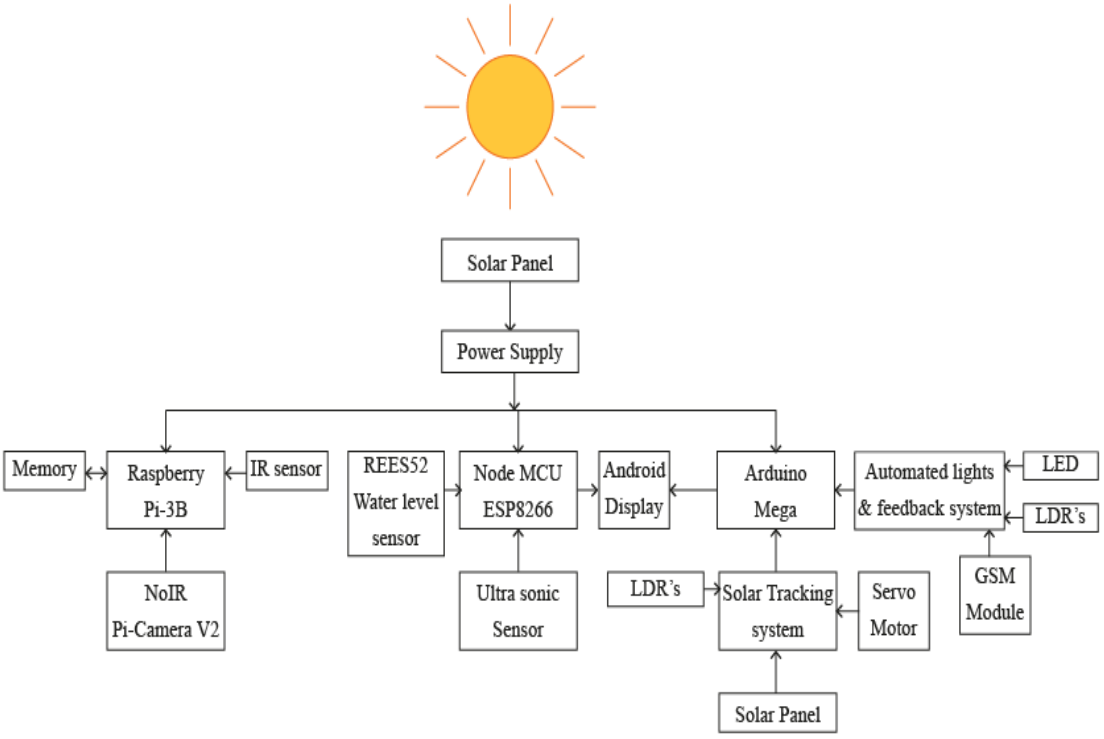

Figure 5:Overall block diagram

4. Implementation

As part of our first solar tracking solar-panel we require solar panel which has the specification as follows:

l no	Parameters	Output Value
	Maximum voltage (Vmax)	13.6V
	Maximum current (Imax)	2.5A
	Output Power	10w-15w
	Short circuited current (Isc)	0.5A
	Open circuited current (Voc)	22.5V
	Maximum Power voltage	19.25 V

The other materials used in the project are Arduino Mega and single board microcontroller NodeMCU ESP8266, servo motors such as SG90 and MG995, sensors such as Ultrasonic sensor, LDR sensor and REES52, and along with it we are using GSM Module and Bluetooth module.

The software which involved are Arduino IDE which is used for coding the microcontroller, Thingspeak webserver which is used for visualizing our output remotely and tensorflow and OpenCV python libraries are used for the coding the vehicle detection algorithm.

5. Applications

- The proposed system can be installed at junction point's at large scale.
- It can be used at universities and office campus to detect the incoming and outgoing vehicles, to automatically switch ON and OFF the lights, and to monitor the drainage related problems.
- The drainage monitoring system can be used to monitor the sewer status city wide.

6. Results

The experiment conducted included four functionalities – Sewage monitoring, Automated street lights and feedback system, Sunlight tracking solar panel and Vehicle detection.

- The sewage monitoring results were observed as follows.

A 5 volt, 15mA supply was applied to ULTRASONIC sensor through NodeMCU digital pins.

The ranging was done using a 10 micro second pulse triggered input and 8 cycles of ultrasound signals at 40kHz.

When the distance value is less than the preset limit the buzzer receives a digital signal as HIGH. All such data indicative of likely disruption in normal life are promptly displayed on the warning screens of the Water and Sewage Board authorities via a ThingSpeak server. Prompt remedial action ensures no disruption of any public or traffic activity.

Figure 6: Sewage Experimental setup

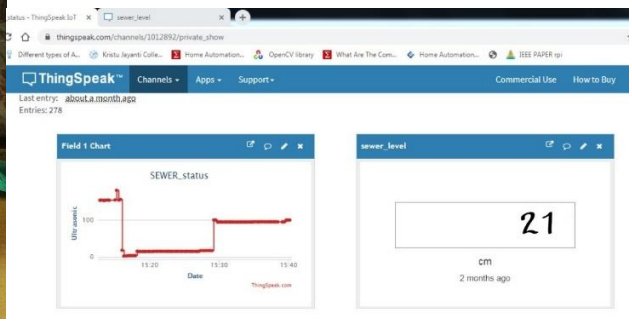

Figure 7: Output of Sewage Monitoring system

- Automated street lights had 3 cases of working.

Case1: When the intensity of sun light is HIGH, the LDR1 resistance was found to be 150ohm, and hence LED received signal as LOW.

Case2: When the intensity of the sunlight is LOW, the LDR1 resistance was found to be 180kohm, and hence LED received signal as HIGH.

Case3: When LDR1 resistance ranges between 100kohm-200kohm, and LDR2 resistance was found to be 180kohm, If LED still receives signal as LOW, and then a message is triggered to Electricity Board authorities about the light status via a GSM module.

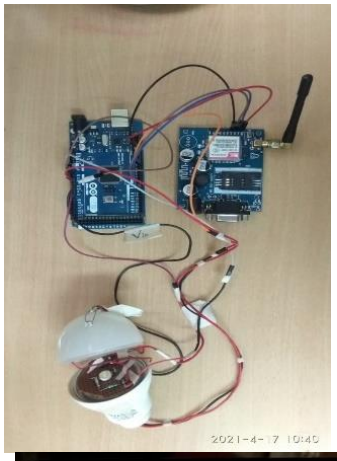

Figure 8: Experimental setup of automatic lights

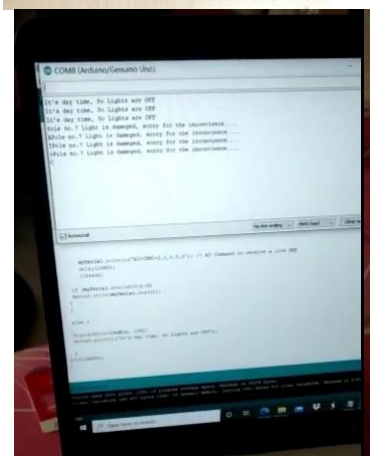

Figure 9: Automatic lights result-1

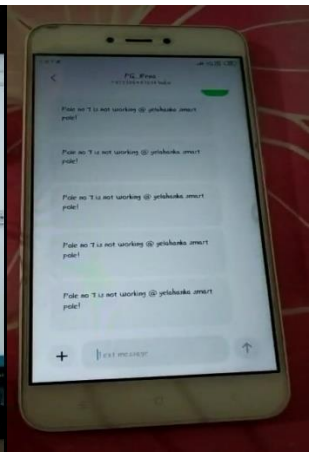

Figure 10: Automatic lights result-2

- Solar tracking panel had 3 cases of working.

Sunlight tracking solar panel had 2 LDR's (LDR1 and LDR2) to trace the maximum solar intensity.
Case1: Resistance of LDR1 at LHS =120ohm and Resistance of LDR2 at RHS =100kohm.
The LDR1 was activated and the servo turns towards the LHS.
Case2: Resistance of LDR1 at LHS =100kohm and Resistance of LDR2 at RHS =120ohm.
The LDR2 was activated and the servo turns towards the RHS.
Case3: Resistance of LDR1=LDR2.
The servo remains to be in rest state with an angle of 90^0 acute.


Figure 11: Case 1 of solar tracking


Figure 12: Case 2 of solar tracking


Figure 13: Case 3 of solar tracking

Vehicle detection included the camera fixed at the smart pole captured the picture of the vehicle when it crosses the traffic signal when the signal is red. After taking the image of the vehicle it extracts the vehicle number which would help the police filing a report on that vehicle. It is said that 'Forewarned is forearmed' and 'Prevention is better than cure'. Implementation of these profound sayings to the last letter is the essence of this paper. State of the art technology is used to be forewarned. Prompt action subsequently prevents disruption of normal life, ensures safety as well as healthy life.

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