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Smart Road Network

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Abstract- The system is a network of stations deployed along the roads in a smart city. Every station is a standalone self-powered system working as an element in a huge network which is responsible for controlling the traffic on the road and improve the quality of road service. It is supposed to turn its lights on only whenever vehicles or pedestrians are existed to save power; warn the speedy vehicles by placing various smart road tools to limit their speeds; monitor the road status, recognize the accidents and call for emergency police; send the whole situation to the city central control office; help in keeping roads pollution-free, help older-aged people and do many other magnificent functions. Our proposed system consists of 5 main subsystems; First, Smart lighting system; Second, Road monitoring and Speed measurement system; Third, Speed Control system (Smart speed bump); Fourth, Emergency USB charger, and Fifth, Off-grid Solar power System.

Keywords Smart Road monitoring, Speed bump, Traffic control, Green power.

I- INTRODUCTION

Today's street lights are being replaced by LED street lighting systems, which consume less energy. Another advantage of LED lighting is that the intensity may be readily adjusted [1]. As a result, movement detection-based smart road light control is simple to be implemented. One of the most critical and high-ticket obligations of the municipality is to provide road lighting. In average cities lighting, throughout the world, may account for 10% to 38% of the total energy cost [2]. Because of its strategic relevance for economic and social stability, road lighting may be a particularly pressing matter for governments in developing nations. Inefficient lighting wastes valuable financial resources, and bad illumination puts people in danger [3]. The cost of road illumination will be dramatically reduced as a result of energy-efficient technology and design mechanisms. Manual management is prone to mistakes and wastes energy, and manually dimming throughout the day is impractical. Furthermore, manually observing the sun shine level in real time is impossible. The use of automated processes management technologies to manage roadways is the current trend as presented in the proposed system here in this article.
The reduction of accidents and increase in safety are two real advantages of the proposed system. According to studies, darkness causes a significant number of collisions and accidents, particularly those involving pedestrians; pedestrian accidents are 3 to 6 times more likely in the dark. The proposed system uses the concept of smartness in speed bumps that are only evoked when the speed limit is exceeded. It is a brilliant way to encourage drivers to maintain this limit. This kind of bumps proves that it doesn't only slow down the vehicle speed but improves the traffic stream [4]. This new system is able to change the driver culture and increase the road safety.
Moreover, Energy is the primary and most universal measure of all kinds of work of human beings and nature. Energy is a crucial commodity in the process of economic, social and industrial development. As conventional energy sources are being depleted day by day, utilization of alternative energy sources is the only solution [5]. The increased power demand, depleting fossil fuel resources and growth in environmental pollution have led the world to think seriously in other alternative sources of energy, such as green power systems, to save this energy as much as possible. The presented system is a self-powered one.
Although multiple image-based car license plate recognition systems are now available worldwide, the development still continues and new approaches for plate character recognition emerge [6-8]. There is still a need to accept a scientific challenge to control traffic and monitor the road status by means of vehicle detection via performing reliable surveillance at various lighting scenarios [9-11].
The proposed system is doing this mission and sending the whole road status to the city central control office using a centralized set of cameras operating within the road network as will be discussed in details in the next sections of this article. The paper is organized as follows: Sect. 2 describes the lighting system including LDR & PIR sensors and their roles; Sect. 3 deals with the smart speed system and the stop distance calculations; Sect. 4 describes the used car plate recognition system; Sect. 5 illustrates the used USB charging unit; the off-Grid solar power unit is presented in Sect. 6. Experimental results are described in Sect. 7. Finally, conclusion and future research directions are presented in Sect. 8.

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II- SMART LIGHTING SYSTEM

The proposed system is aimed to save power and using solar power. Therefore, the lighting system is designed brilliantly so that the road is luminous for vehicles and pedestrians when they cross it; otherwise, lights are off. This is achieved using a central management unit existed at each road pole by the help of LDR and PIR sensors.

1. LDR sensor

Photo-conductive Cells; When exposed to light, these photo devices change their electrical resistance. LDRs are still utilized in a number of applications where it is important to detect light levels, even though they were once used in photographic light meters. The block diagram of the system, that uses this type of sensors, is shown in Figure (1).

- ***Types of available LDR sensors:***

A. **Intrinsic photoresistors**: undoped semiconductor materials, such as germanium or silicon, are used in intrinsic photoresistors. Electrons are excited by photons that strike the LDR and move from the valence band to the conduction band. These free electrons can therefore conduct electricity. The device becomes more conductive and more electrons are released as more light strikes it, which lowers resistance as conductivity increases.

B. **Extrinsic photoresistors**: made from semiconductor materials that have been doped with impurities. Above the current valence band, these dopants or impurities produce a new energy band. As a result of the narrower energy gap, electrons require less energy to move into the conduction band.

- ***How LDR work?***

Light photons are absorbed by the semiconductor lattice and some of their energy is transferred to the electrons as they fall on the semiconductor. This provides enough energy for some of them to break loose from the crystal lattice and conduct electricity. As a result, the overall LDR resistance is reduced.

The resistance of an LDR can vary from roughly 100 ohm in bright sunlight to over 10 M ohm in complete darkness, and this resistance change is transformed into a voltage variation at v_{out} as indicated.

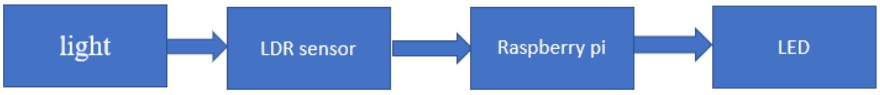

Figure (1): Block diagram of LDR

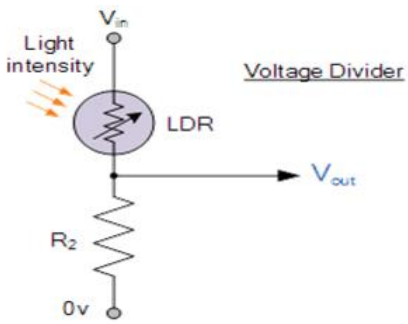

Figure (2): Basic Simple LDR Circuit

The current through a series circuit, as shown in Figure (2), is common and as the LDR changes its resistive value due to the light intensity, the voltage present at V_{OUT} will be determined by the voltage divider following equation

$$v(out) = \frac{v(in) * R_2}{r(LDR) + R_2} \quad (1)$$

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When there is a light, the LDR resistance will be very small about 100 ohms so that v_{out} will be very small so that led will be off. When there is no light, the LDR resistance will be very high about 10M ohms so that v_{out} will be large so that led will be on.

LDRs are inexpensive and frequently used as light sensors. They have many uses such as classifying the presence or absence of light as in a camera light meter. It is used to design street lights (can be merged with a good Arduino starter kit to act as a street light controller). It is also applied to alarm clocks, circuits for housebreaker alarms and light metering. The proposed system, as shown in Figure (3), is self-powered so it is needed to save power by turning lights on only in dark environments.

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Figure (3): Smart lighting by LDR & PIR sensors in the prototype in dark times

2. PIR sensor

An out-of-date lighting system can account for up to half of a normal city's total energy bill. The lights consume 19 percent of worldwide electricity use. The most prevalent sort of motion-sensing technology in lighting and security systems is passive infrared, or PIR. PIR sensors allow you to detect motion by sensing the infrared light, and they are nearly always used to determine if a person or car has entered or exited the sensor's field of view [12]. The most common sensor used is shown in Figure (4).

Figure (4): Ky 032 IR sensor

- ***Why we need IR sensor?***

The proposed system needs the IR sensor for two purposes; First it is used to turn on lights when there is motion in dark only, so when there are vehicles or humans crossing the IR sensor field of view, the road lights will be on. Second the sensor with the aid of the program of the road management unit **(**raspberry pi code in the implemented prototype) is able to detect the speed of vehicles, by knowing the distance between two successive IR sensors and time that the vehicle takes to move from the first to the second.

- ***How does our system work?***

When the vehicle passes in front of the first sensor, the first and second poles will light up and when the vehicle passes in front of the second sensor, the second and third poles lights up, and the first pole turns off its lights, and so on.

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III- SPEED CONTROL SYSTEM (Smart Speed Bump)

Road bumps play a crucial role in enforcing speed limits, thereby preventing the violating speeds. It significantly contributes to the overall road safety objective through the prevention of accidents that lead to deaths of pedestrians and damage of vehicles. The approach presented in this article considers the time that the driver should be alarmed to slow down his vehicle before crossing the used dynamic bump. Figure (5) shows the role of this system among the processes of road monitoring and traffic control**.**

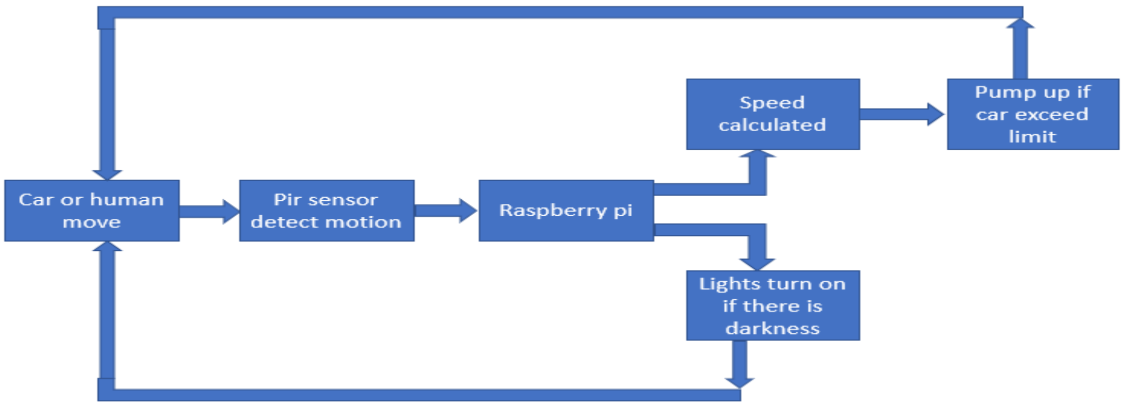

Figure (5): The road monitoring and traffic control processes

The so called 'stop distance', from the point when he receive the alarm to the point that the vehicle speed reaches 20 km/h, is calculated. Material of speed bump is also chosen according to construction material and product's properties.

Top two materials of manufacturing the speed bump:

1. Rubber: It is popular and cost-effective material to manufacture traffic control devices such as bump. Rubber speed bump is usually used in moderate crowded places.
2. Steel: speed bumps can be constructed from steel material to force vehicles to drop its speed significantly.

The rubber speed bump is chosen here as it is a flexible and maintenance-free material so you will not have to be worry about the maintenance from time to another time. This kind of bumps takes only few minutes to get installed on road. It can be installed also for a temporary condition according to traffic control needs then you can remove it. Moreover; its mass reaches to 1200 Kg that it has its effect in reducing the power consumption as will be discussed in the section related to the power calculations.
By comparing between steel speed bump and rubber speed bump in the probability of causing vehicular damage, the steel speed bump is found to be more aggressive than rubber.

- ***Mechanism type used in lifting the bump:***

The proposed system chooses the Scott Russel Mechanism as the optimum one in terms of power consumption and efficiency. It translates linear motion through a right angle. The linkage, as shown in Figure (6), is composed of two links. One link is double the size of the other, and is connected to the smaller link by its midpoint. One of the ends is then connected to something that can generate linear motion, such as a rolling or sliding connection, or another straight line mechanism. Due to difficulty of implementing this type of mechanisms on a small scale suitable for the executed prototype, the Z-carriage or Z-axis mechanism is used as shown in Figure (7).

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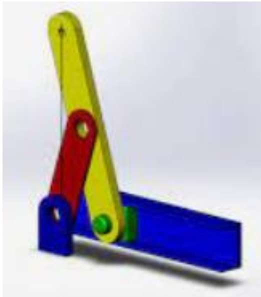

Figure (6): Scott Russel Mechanism

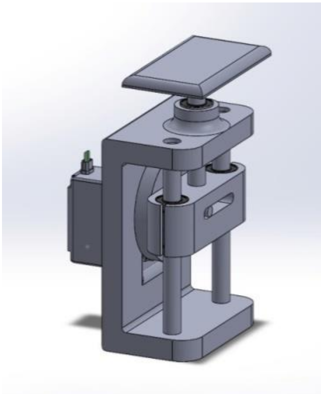

Figure (7): Z-carriage Mechanism used in the prototype

Number of turns, which is counted by the servo motor that is attached to the z-axis mechanism, is needed to be calculated [13].
As the diameter of cam = 2 Cm and the time (T) that the bump will lift up within (as soon as the vehicle exceeds limit of velocity) is considered to be T = 1 Sec from the analysis presented in this section, we find the following:
$\emptyset$ =180 degree, where $\emptyset$ is the angle that cam is turned with it according to angle that servo motor.

$$W = \frac{\emptyset}{T} = \frac{\pi}{1} \text{ Rad/sec} \qquad (2)$$

where W is the angular velocity that cam is moved with. From the equation (2), number of turns, N, is calculated as

$$N = \frac{60\, W}{2\pi} = \frac{60 * \pi}{2\pi} = 30 \text{ Turns} \qquad (3)$$

- ***Stop Distance Calculations:***

When the driver exceeds the limit, a mechanism is activated to lift up the bump over the road plane forcing the driver to slow down. If the bumps are to be deployed along the road on appropriate distances, the multiple stops or delays (that the speedy driver will make) force him to change his behavior. When the driver moves at a certain speed and encounters an obstacle, it takes a specific time to stop based on its speed when he discovers this obstacle on his way.
In this part, the necessary and safe distance will be calculated so that the driver can control its speed before hitting the bump [3].

The stopping distance, also called the braking distance, is the distance a vehicle covers from the time of the full application of its brakes until it has stopped moving. This distance is divided into three stages:

1. **Driver reaction time**: The time required by the driver to identify cars and people on the road, and determine what he can do about that. Then send the signal to the body parts to carry out the reaction (reduce the pressure on the gas pedal, or raise the foot from it, increase the pressure on the gas pedal, press the brakes with the required force, steer the steering wheel, continue as it is. This time takes from 0.5 to 3 second for a person of average age, this depends on the age of the driver, state of mind, preoccupation with talking on a mobile phone, use of alcoholic beverages.

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2. **Brake loading distance**: When the brakes are applied, the brakes do not start as soon as the brake pedal is applied, but there are clearances in the brake line that must be eliminated before the brake load begins (due to the pedal free distance, clearances in the mechanical parts of the brakes, the clearances of the friction linings with the rotor). This time is in the range from 0.1 to 0.2 seconds. These depend on the brake tuning and the technical condition of the brakes.
3. **Brake activation distance**: With the brake pedal still depressed, the brakes slow the wheel and bring the vehicle to a stop. These depend on the vehicle's speed and mass, the technical condition of the brakes on the friction parts, the braking force, the design of the brake system, the presence of the antilock system, the condition of the tires, and the condition of the road.

The sum of the three distances is the braking distance (from the beginning of the recognition of objects on the road until the stop or reach the limit speed). Let us assume that the vehicle is moving with speed of 100km/h, we need to deaccelerate it to 20km/h.

- ***First: calculating Driver Reaction Distance***

This distance does not depend on the type of brake system, brake force, or the presence of the ABS system. However it depends on the mental state and health of the driver and the speed of the vehicle. During that period (the reaction time of the driver) it is moving at a constant speed, and the physical law applies to it:

$$v=x/t \quad (4)$$

Where: x is the distance during that time (meters)
v is the speed of the vehicle (m/s=(km/h)/3.6)
t is the driver's reaction time (average 2.5 seconds)

$$x_1 = v * t = \frac{100}{3.6} * 2.5 = 70m \quad (5)$$

This means that if you are traveling at 100 km/h and a vehicle stops in front of you or there is a person or a pump in front of the vehicle within 70 meters, then there will be a collision between your vehicle and that object at 100 km/h. This does not include the extent of your driving skill, or the strength of the brakes, or the presence of an anti-locking system in the vehicle, or that your car is one of the latest models or one of the most expensive cars; The result is one collision at the speed of the car; and after the collision there will be braking.

- ***Second: calculating Brake Loading Distance***

The brake load distance has an average time of 0.15 seconds and depends on the condition of the clearances in the mechanical couplings, the adjustment of the pedal free distance and the clearances of the friction linings. As t is the brake load time (0.15 sec on average) and from Eq. (4)

$$x_2 = v * t = \frac{100}{3.6} * 0.15 = 4m \quad (6)$$

If the foot is lifted from the gas pedal and placed on the brake pedal, the speed drops below 20m/sec. Therefore, the distance “x_2” is less than 3m. When a vehicle moving at 100 km and encounters suddenly a person, a bump or another vehicle, it may collide in the distance is after the reaction distance and within the brake-loading distance (with a speed < 100 km/h at a distance 70 -75 meters).
The same applies a vehicle of speed of 108 km/h, where the brake loading distance increases to 4.5 meters, and the collision occurs during the distance 150-160 meters at a speed of less than 108 km/h.
It depends on the condition of the clearances in the mechanical joints, the adjustment of the free distance of the pedal and the clearances of the friction linings.

- ***Third: calculating Brake activation distance***

This distance depends on the braking force (the force of pressure on the pedal, the work of the servo, the initial speed of the brake, the condition of the tire and the road, the mass of the vehicle, the presence of the antilock system in the car), and the physical law applies to calculate the brake activation distance:

$$x_3 = \left[(0.278 * t * v) + \frac{v^2}{254*(f+G)}\right] \quad (7)$$

where x is the brake activation distance (meter); t is the driver-reaction time (second); v is the speed of the car in (km/h); g is the grade (slope) of the road, expressed as a decimal. It is positive for an uphill grade and negative for a road going downhill (will be assumed flat and there is no slope); f is the coefficient of friction between the tires and the road. It is typically assumed to be equal to 0.7 on a dry road and in the range from 0.3 to 0.4 on a wet road.

$$x_3 = \left[(0.278 * 2.5 * 100) + \frac{100^2}{254*(0.7+0)}\right] = 125m \quad (8)$$

So, from Equations (5, 6, 8), the total distance needed to alert the driver is

$$x = x1 + x2 + x3 = 70 + 4 + 125 = 199m \quad (9)$$

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According to Motion equations, the deceleration of the vehicle is calculated as a = braking force "F" /vehicle mass "M". The average deceleration of vehicles when the brakes are applied is $a = -2\ m/sec^2$

If a vehicle need to be decelerated from 100km/h to 20km/h with an average deceleration rate $a = -2\ m/sec^2$, the distance x is estimated as following

$$v_f^2 = v_i^2 + 2ax \quad (10)$$

This leads to

$$\frac{20}{3.6}^2 = \frac{100}{3.6}^2 + (2 * -2 * x)$$

$$x = 185m \ (11)$$

IV. CAR PLATE RECOGNITION SYSTEM

Car plate recognition system (CPRS) or Automatic license plate recognition (ALPR) is a system for retrieving license plate information from a captured image or video frame from a sequence of videos. CPRS can help to rapidly collect vehicle information from those who break traffic regulations [11].

It utilizes image processing technology in order to extract and recognize plate number. The extracted information can be used in road monitoring, traffic control and for the aid of general security.

The objective is to detect the speedy vehicles (that violate the limited speed) and recognize their plates using Image Processing techniques. The chosen technique is implemented by a Python-programmed microcontroller (OpenCV and raspberry Pi in the prototype) [14].

When it comes to capturing the plates, three vital steps are required as shown in Figure (8): Car plate detection, Plate segmentation and Character recognition.

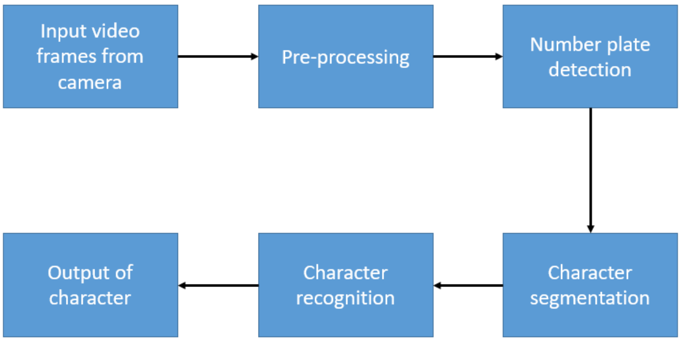

Figure (8): System Block Diagram

The system input is a series of vehicle images captured in the real time by the camera as the processing unit makes the input image ready for detecting and extracting the recognized characters of the plates. The recognition only occurs when the vehicle violates the allowed speed on the road.

The preprocessing is usually done by thresholding (or masking) the image. This eliminates all color information. Most OpenCV functions consider information to be written in white, and the background to be black. Based on a threshold, contours are detected. The threshold is used to avoid detecting contours of unwanted smaller objects that are not vehicles. The object is detected when the contour has four points, so the plate is found.

V - EMERGENCY USB CHARGING UNIT

This part is talking about emergency USB charging ports which provided and mounted on the road poles to allow road users to charge their cellphones in the emergency situations. The charging period is only 3 minutes to help anyone to make an emergency call if his phone battery is empty.

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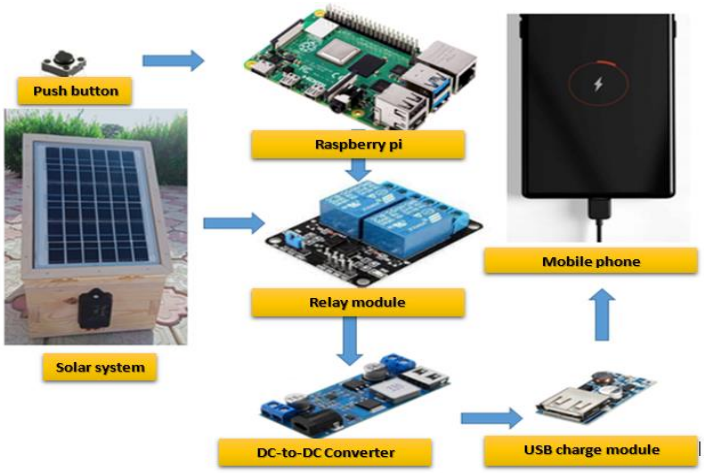

Figure (9): Block diagram of the Charger

- ***Operation*:**

When the user presses on the push button on the road pole, the central processing unit (raspberry pi) starts counting down (from 180 to zero) as a timer that the charger provides the charging current. The relay is switched off (disconnected after ending the predefined allowable charging period) as shown in Figure (9).

- ***Cell phone battery specs:***

Voltage = 3.85 V DC
Average cellphone battery capacity: 4000mAh
Average full charging time: 1hour and 40 mins = 100 minutes

As the charging time of battery (T) $= \frac{\text{Battery capacity (Ah)}}{\text{Charging Current}}$ (12),

From Eq. (12), the charging current $= \frac{4000\ mAh}{1.667\ h} \cong 2400\ mA$
The system capacity for one user (c)

$$c = \frac{4000\times 3\ \text{mins}}{100\ \text{mins}} = 120\ \text{mAh} \quad (13)$$

If there are assumed to be an average of one user needing to charge every hour, so there will be 24 users a day. Therefore the total system (Battery bank) capacity (C)

$$C = 120\ mAh * 24 = 2880\ \text{mAh} \quad (14)$$

The required power $= 2400 * 3.85 = 9.2\ W$
if a power loss of 30 % is considered, the required power $= 9.2 * \frac{100}{70} = 13.15\ W$

- ***Highlights of emergency charger***

The solar powered mobile charging station known to be versatile as it can be used for all types of mobile phones and also used for charging even at night, and easily integrated to the existing street lighting system.

VI- OFF-GRID SOLAR POWER SYSTEM

As a form of renewable energy, the presented system offers many advantages such as safety, reliability, efficiency. The photovoltaic (PV) technology has become an essential topic of global interest to expand clean energy production. The presented system is shown in Figure (10).

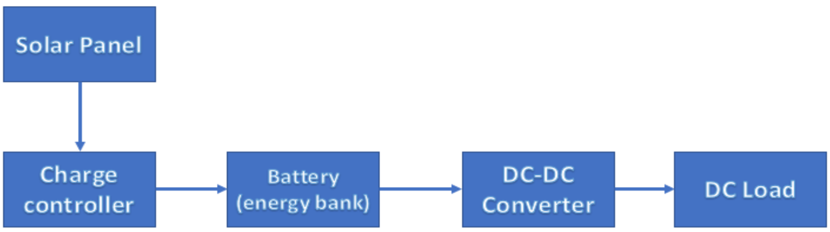

Figure (10): The off-grid solar power system

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1. *Hardware components used in the prototype unit will consume power as:*

1) using 2 Raspberry Pi 3B+ = $2 * 5.65 = 11.3\ Watt$
2) using 2 Raspberry pi camera = $2 * 1.4 = 2.8\ Watt$
3) using 10 IR Sensor module = $10 * 20m * 5 = 1\ Watt$
4) using 12 (5mm) LED =$12 * 20m * 5 = 1.2\ Watt$
5) using 2 LCD (16*2) = $200m * 5 * 2 = 2\ Watt$
6) using 2 Micro Servo = $2 * 550m * 5 = 5.5\ Watt$
7) using 2 Emergency USB charger = $2 * 2.3 = 4.6\ Watt$

Thus, the total power needed for the system = $11.3 + 2.8 + 1 + 1.2 + 2 + 5.5 + 4.6 = 28.4\ Watt$ (15)

2. *Solar Panel*

Polycrystalline solar panel is used due to its advantages as following:

1) The acceptable maximum temperature of polycrystalline solar panels is 85 °C while the acceptable minimum temperature is -40 °C.
2) Polycrystalline solar panels have lower heat tolerance than monocrystalline panels. So, at higher temperatures, these solar panels have lower efficiency than others.
3) Polycrystalline solar panels have a higher temperature coefficient than monocrystalline panels.
4) These panels have a high-power density.
5) They come with a structural frame of their own which makes mounting cheaper and simpler.
6) Polycrystalline solar cells are less expensive than monocrystalline solar cells, but they have a lower efficiency from monocrystalline.

Thus a 10-watt polycrystalline Solar panel is chosen to be used.

3. *Charge Controller*

PWM charge controller: Quite a few charge controls have a "PWM" mode. PWM stands for Pulse Width Modulation. PWM is often used as one method of float charging. Instead of a steady output from the controller, it sends out a series of short charging pulses to the battery - a very rapid "on-off" switch. The controller constantly checks the state of the battery to determine how fast to send pulses, and how long (wide) the pulses will be. In a fully charged battery with no load, it may just "tick" every few seconds and send a short pulse to the battery. In a discharged battery, the pulses would be very long and almost continuous, or the controller may go into "full on" mode. The controller checks the state of charge on the battery between pulses and adjusts itself each time. With a PWM controller, your solar panel system and your battery need to have matching voltages.

4. *Battery*

In stand-alone systems, the power generated by the solar panel is used to charge a battery. The electricity produced by PV modules during the day is supplied to the battery and/or the load. The battery does not act only as an auxiliary support; rather it will provide energy to counter the fluctuations of load at any time. These fluctuations may result when the load demand is higher than the energy received from sun, or vice versa.

Lead acid battery is suitable for our proposed system because:

- It is available in all shapes and sizes and does not require any maintenance.
- It is best in terms of reliability and working capabilities and withstands slow, fast and overcharging.
- It is capable to withstand long term inactivity with or without solvent.
- It offers best value for power and energy per KWH and offers longest life cycle.
- It is inexpensive and simple to manufacture; low cost per watt-hour and ~97% of lead can be recycled and reused in new batteries.
- It offers good performance at low and high temperature and low self-discharge, which is lowest among rechargeable batteries

As a 12V battery is used, 7Ah lead acid battery in our system:

Total needed power = $28.4\ W$

Total power of battery = $7Ah * 12V = 84\ Wh$

Proposed system run time = $\frac{Total\ power\ of\ battery}{Total\ neede\ Power} = \frac{84}{28.4} = 2.95\ h$ (16)

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5. DC-DC step down converter

Is a DC-to-DC power converter that steps down voltage from its input (supply) to its output (while drawing less average current) (load). It belongs to a subcategory of switched-mode power supplies (SMPS) that typically includes at least two semiconductors (a diode and a transistor, though modern buck converters frequently replace the diode with a second transistor used for synchronous rectification) and at least one energy storage component, such as a capacitor, inductor, or the two separately or together. In order to reduce voltage ripple, filters built of capacitors are typically attached to such a converter's input (load-side filter) and output (occasionally in conjunction with inductors) (supply-side filter). Because the voltage across the inductor "bucks" or opposes the supply voltage, it is known as a buck converter as shown in Figure (11).

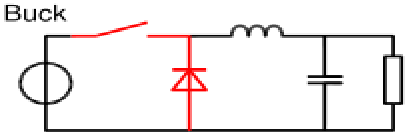

Figure (11): DC-DC Step down converter circuit

A DC-DC step down converter is used here to converting the 12V from a battery down to 5V in order to power an electronic board. Finally, all the elements are connected together.

VII- SIMULATION RESULTS

After several experiments to test the efficiency of the system on two types of car plates at different speeds based on the analysis in [15], it was found as shown in Figure (12) that the recognition rate of the plate numbers, with the camera, is sufficiently faster when using grayscale (white/black) plates or coloured (two colours). However in the case of coloured car plates, the detection accuracy was relatively lower than the white/black ones.

The results also show that the higher the speed of the vehicle (especially above 100 km/hr), the lower accuracy is obviously achieved; therefore the efficiency of the system decreases. The results have been compared to an existing enhanced algorithm for recognizing the plates [16]. It is found that the algorithm in [16] is achieving better accuracy when coloured plated are used. However, the proposed system has higher accuracy in the case of grayscale plates especially in the speeds up to 120 km/hr.

An important note should be mentioned that the system, as a future work and extensive development, can be tailored to recognize the emergency vehicles (such as the ambulance and police cars) and make exceptions for them if they exceed the limit.

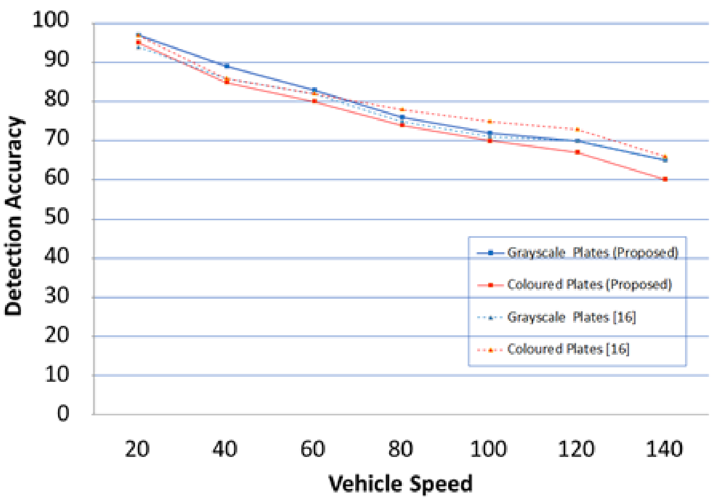

Figure (12): Detection accuracy of recognition system against vehicle speed

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VIII- CONCLUSION

Unlike the conventional road monitoring and traffic control methods, we propose to use the soft information, contained in electronic sensors and optical devices, to control the road lights, control the traffic, and monitor the road status, all in a smart way via a centralized network using the lowest resources and power consumption. The contribution of the paper is not in the used technique of information gathering itself, but in the way that this gained data are processed. The proposed approach achieves a better performance in terms of quality of service and can handle various road situations with the capability to solve the related issues.

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