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Solar Powered Autonomous Emergency Road Signing Waterlogged System in Highways

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Abstract: An emergency road signing system is an important device to prevent road disasters, especially during jeopardize conditions. In this project, it is focused on the shallow depth of water from 10cm to 30cm that can slow down the vehicles or even causes the collision. Arduino UNO microcontroller is utilized to detect the waterlogged and shows the of water depth on the road sign to allow the drivers to make a decision ahead for passing through the waterlogged. Furthermore, ZigBee wireless module is used to interface the sensor and display to increase the movability of the display from the waterlogged location. The system is powered up by the PV panel to support green technology and protect the environment as well. From results, it is found that placing the three signboards before the waterlogged location is more effective for drivers to respond.

Keywords: Solar energy; Road signing system; waterlogged; Autonomous emergency road sign.

I. INTRODUCTION

With the acceleration of urbanization, water logging has become an increasingly serious issue. Road water logging has a great impact on traffic safety [1]. A lot of people are killed every year on road accidents while waterlogged in highways is one of the major reasons. According to U.S. National Weather Service NWS [2], more than 50% of the deaths are caused by flooding.

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It needs just 12 inches (30cm) flowing water to carry off a small car, and 18-24 inches (45-60cm) for larger vehicles. Therefore, we should never underestimate the power of water. When waterlogged occurs, vehicles might collide together if they do not respond quickly. Waterlogged can be caused by several factors such as heavy rain, monsoon seasons, and poor drainage system.

As a result, waterlogged conditions can be hardly prevented as we cannot stop the rain [3]. However, we can let the drivers know or warn them in advance. Drives then can be alerted about the potential or real danger of location where waterlogged is accrued. Emergency crews and highway maintenance personnel can also place signboard across a road when there is possibility for water logging [4].

Malaysians suffer from waterlogged issue almost every year. The main problem of the current road signs is lack of flexibility to give information regarding the water depth level [5]. When drivers don't have any information about the depth of the water level even when they know there are waterlogged ahead and they do not get prior notification about the water level or the road condition, they cannot prepare themselves to reduce the probabilities of road accidents. In this project, our main target is the Drivers in Malaysia. Rainfall commonly happens from October until January annually where the peak rainfall season occurs between November and December. That means waterlogged condition often occurs in this period. As an example, in 2014, there were 6,674 road deaths with a total of 476,196 road crashes [6]. News and results claims that waterlogged is one of the major reasons for the accident that happens on the highways [7].

Solar powered autonomous emergency road signing is a system that can be placed in such places where the possibility of waterlogged is high and may cause any collision when the rain happens. The word 'autonomous' indicates that the system is capable to make a decision for the drivers according to the depth of waterlogged. The system can warn drivers in advance by showing the water level information on the signboards. Besides, the system is self-powered and uses solar photovoltaic energy which makes it so flexible to use in any place.

II. METHODOLOGY

The block diagrams of this project are shown below.

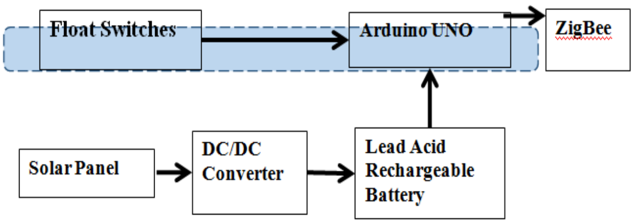

Fig. 1 Block diagram of water level sensing unit

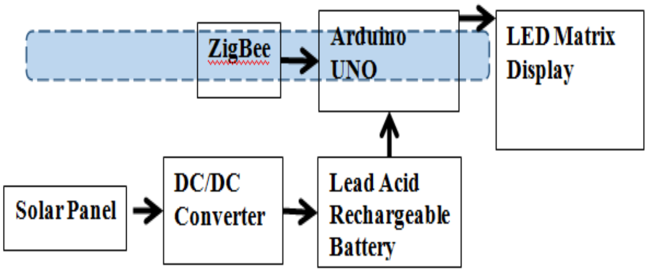

Fig. 2 Block Diagram of the display unit

This project consists of a sensor and the display units. As mentioned before, we need to warn the drivers in advance in order to give them time to respond. Therefore, two sets of the display are implemented where both are communicating with sensor unit wirelessly. Figure 3 shows the flow chart of the water sensing unit. The program starts with detecting the water level. If the water level is equal or more than 31cm the microcontroller sends a signal '3' to both displays. Else, if the water level was between 22cm to 30cm then the program sends signal '2' to the displays. In the same way, If the water level was between 10cm to 21 cm the software sends signal '1' to the displays and signal would be '0' if the water level is less than 10 cm. Therefore, drivers can see the water depth level in advance and keep drive safely for different situations.

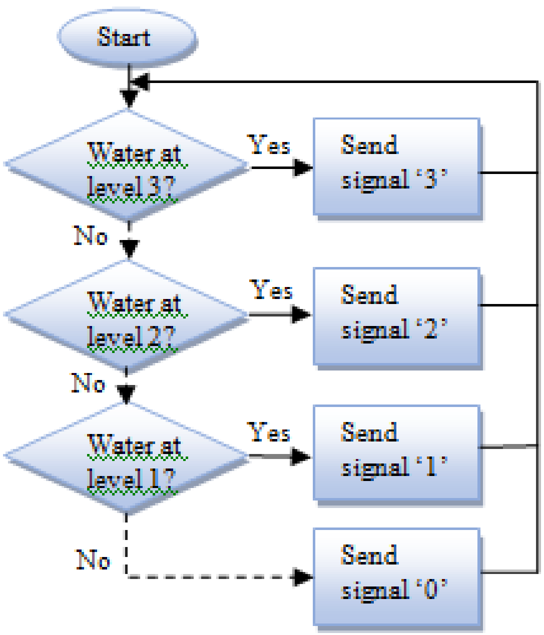

Fig. 3 Flow chart of water sensing unit

Figure 4 shows the flow chart of the display units (i). As mentioned before, the Sensor unit is interfaced wirelessly to the Display units. Therefore, display units will show the water depth level of the related sensor at each time interval. As an example, if signal '3' receives by display units, a 'level 3' message will be displayed on the P10 LED matrix board.

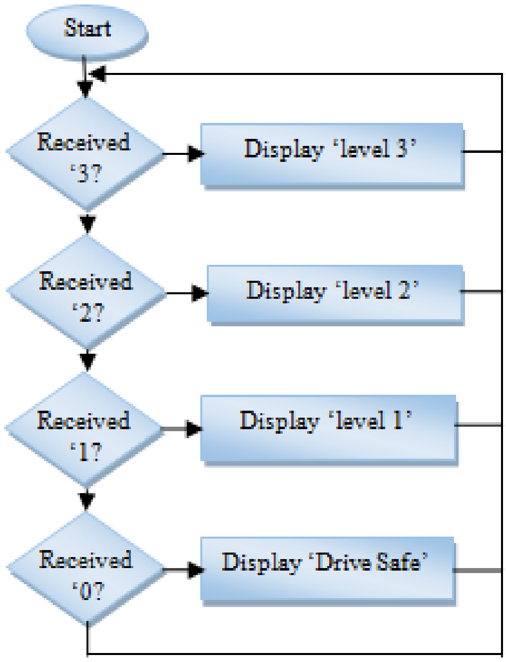

Fig. 4 Flow chart of the display unit

III. RESULTS AND DISCUSSION

As the maximum allowed speed at highways is 120 $^{km}/_{h}$ Therefore, the required distance which is needed for a car with a speed of120 $^{km}/_{h}$ to decelerate to10$^{km}/_{h}$ is measured as below.

$F = m.a$ (1)

$F_{frict} = -\mu mg$ (2)

According to Equating (1) & (2),

$$a = -\mu g$$
$$= -0.4x9.80665m/sec^2$$
$$= -3.92266m/sec^2$$

Therefore acceleration would be $-3.92266m/sec^2$, so the required time to reduce the velocity is calculated by equation 3, where v_f is the final velocity and v_i is the initial velocity.

$$\textit{The time required,} t = \frac{v_f - v_i}{a} \quad (3)$$

$$t = \frac{\frac{2.78m}{sec} - \frac{33.33m}{sec}}{-\frac{3.92266m}{sec^2}}$$

= 7.79 sec

Finally, the required distance to reduce the velocity from 120 $^{km}/_{h}$ to 10 $^{km}/_{h}$ can be measured by Equation 4:

$\textit{Distance,} s = v_i.t + \frac{1}{2}at^2$

(4)

$= 259.64m + (-119.02m)$

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=140.62m

In the same way, the required distance for $20\,{}^{km}/_{h}$, $30\,{}^{km}/_{h}$, and $40\,{}^{km}/_{h}$ will be measured as well. Figure 5 shows the required distance to reduce the speed from 120 ${}^{km}/_{h}$ to different velocities.

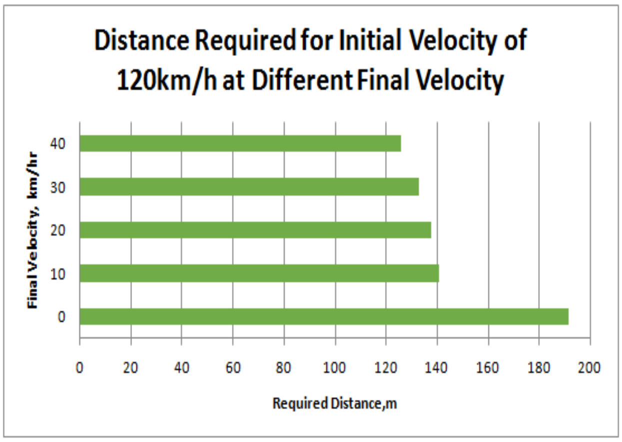
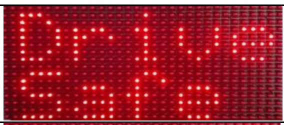
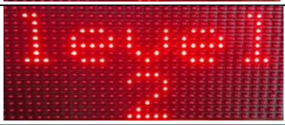


Fig. 5 Graph of required distance for a vehicle to reduce its speed from 120km/h to different velocity range from 0km/h to 40km/h

As mentioned before, the maximum allowed speed at highways is 120 ${}^{km}/_{h}$. Figure 5 shows that at least190 meters is needed to stop the car when the maximum speed is 120 ${}^{km}/_{h}$. However, it is not required to fully stop the car when the driver faces the waterlogged, so, 140 m is chosen to place the signboards before vehicles reach the waterlogged. Figures 6 to 11 show the implemented signboard for waterlogged detection.

Table. 1 Display of LED Matrix board regarding on different water depth

Water Depth	Dangerous Level	Display
<10cm	0	
10cm – 21cm	1	
22cm – 30cm	2	
>30cm	3	

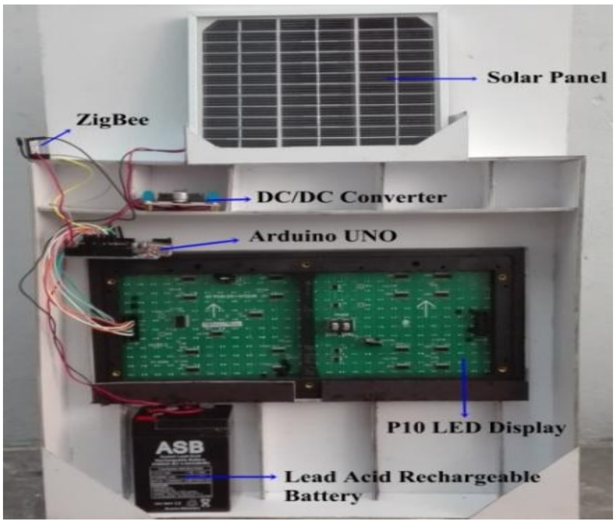


Fig. 6 Structure of display sign board

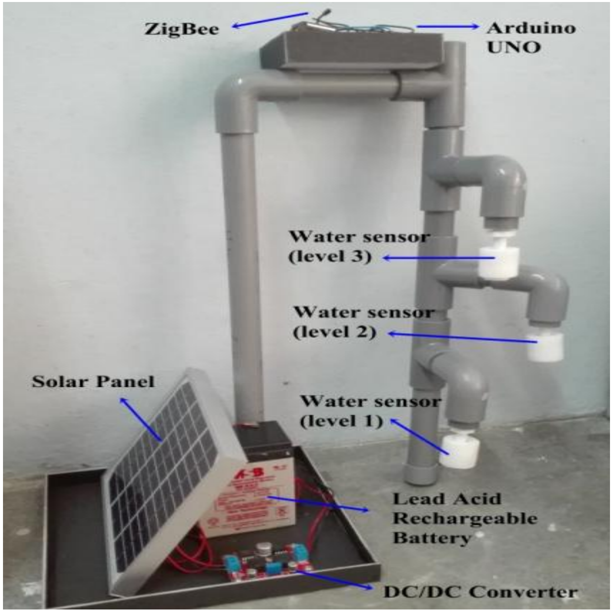


Fig. 7 Structure of water level sensing part

Fig. 8 Construction of the whole project system (when there is no waterlogged)

Fig. 9 When water depth is at first level

Fig. 10 When water depth is at second level

Fig. 11When the water level is at the third level

IV. CONCLUSION

In this project, a low-cost effective signboard to detect the waterlogged has been implemented. The implemented hardware is utilizing solar power as a source of energy; therefore it is so flexible to locate it in different places. The device is able to show different messages based on water depth level. The sign board is placed 140 m before waterlogged situation to give the drivers more time to respond and keep driving safely. It is believed that by placing these informative signboards instead of conventional ones, we can reduce the number of accidences in highways.

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REFERENCES

1. Chen, E. and A.P. Tarko, Modeling safety of highway work zones with random parameters and random effects models.(Analytic methods in accident research, 2014).1: p. 86-95.
2. Weinberger, K.R., et al., Effectiveness of National Weather Service heat alerts in preventing mortality in 20 US cities.(Environment international, 2018). 116: p. 30-38.
3. Archer, M.D. and M.A. Green, Clean electricity from photovoltaics. Vol. 1. 2001: World Scientific.
4. Shams, A., et al., Highway Cross-Slope Measurement Using Mobile LiDAR.(Transportation Research Record, 2018): p. 88-97.
5. Wijnen, W., et al., An analysis of official road crash cost estimates in European countries. (Safety science, 2019). 113: p. 318-327.
6. Shauki, N.I.B.H.A., Dr. Shahnaz Binti Murad Deputy Director General of Health (Research and Technical Support).(JOURNAL OF HEALTH MANAGEMENT, 2015).1.
7. Caya, M.V., et al. Capacitance-Based Soil Moisture Sensor for Irrigation Scheduling Application. (in 2018 3rd International Conference on Computer and Communication Systems (ICCCS). 2018).