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A Study of Parameter Setting for Signal Warning Detector (SWAD)

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Abstract: An employee for road maintenance is a person who ensures safe, clean and accessible roads and highways. They do a lot of works that can expose these workers to the risky conditions as nowadays there were numerous accident involve the highway workers on the road. As the road accident among the highway workers become a concern, Signal Warning Detector (SWAD) was developed to be a part of safety system to give early warning to the highway workers. The objectives of this study are to develop a stable SWAD consist of uRAD sensor and to determine the best parameter setting of the SWAD. The method used for this study was by doing the field test of the SWAD. The test was done at Padang Kawad, UTHM by set up the SWAD at the left lane divided by cones with interval of 10 meter until 100 meter. Then, a car was used to test the ability of the SWAD by drove approaching the SWAD and the data collected when the output of the SWAD activated. According to the result obtained, the uRAD sensor in the SWAD able to detect the presence of the vehicle at a distance that can be consider safe to give the early warning to the PLUS workers so that they can react if a vehicle entering the emergency lane.

Keywords: Highway Workers, Signal Warning Detector, uRAD, Emergency Lane

1. Introduction

Nowadays there are numerous construction worker injuries on the road. Road protection was a top priority challenge for professional traffic engineers and has been thoroughly researched. One aspect that leads to the rise in the number of injuries from day to day is the safety level while working. The safety of road workers cannot be assured by merely placing the safety cone and hazard light in order to protect them from any accident. The safety mechanism needs to be improved by developing a safety system that enhances their safety.

A road maintenance employee is a worker who makes sure roads and highways are safe, clean and accessible. There are a variety of highway and road specialists, including routine procedure works, restoration works and repairing parking flaws. This activity requires physical quality and spends much work time outdoors. Road repair personnel often experience risky conditions, including

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dealing with high-speed cars over long distances, working under unpredictable weather conditions and frequent use of various machinery and instruments of heavy equipment (Ahmad et al., 2016).

The safety system is one of the most significant requirements for ensuring that workers always are safe and not at risk. The frequent injuries in working areas indicates that exposure is dangerous and obvious (ZOLFAGHARIAN et al., 2014). The criteria of safety systems are not enclosed to industries such as factories, ports, warehouses and many more. Instead this should be focused on the roadside especially highways. This is because the roadside always needs to be taken care of and there are many workers doing the maintenance which can cause any unwanted accident or injury.

Based on this field study, the safety detector system is very essential to ensure optimum protection for road employees on highways. In order to control the safety system, it consists of good input, control and output data. The core aspect of this study is the development of a good road worker safety system. Moreover, it may also warn the road worker with the indicated signal. Finally, this system could be capable of reducing road workers' injury rates.

2. Equipment and Methods

2.1 Equipment

A radar sensor name uRAD was used. Basically uRAD is a 3 in 1 sensors. It is able to measure all of the below conditions at the same time:

- Distance: from 0.45 to 100 m with an accuracy of ±0.04 m.
- Velocity: up to 270 km/h with an accuracy of ±0.05 m/s.
- Presence: moving target indicator mode that discards static targets.

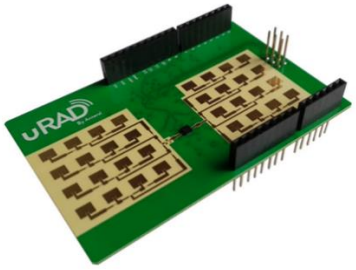

Figure 1: uRAD sensor

The Arduino boards there are a vast variety, but just the Arduino Uno will be addressed. The Arduino Uno is an ATmega328-based microcontroller board (Galadima, 2014). A clear understanding of the Arduino hardware can give a clear understanding on how to adapt an Arduino into a finished product, and what can be kept and not in the initial design (Tawil, 2016).

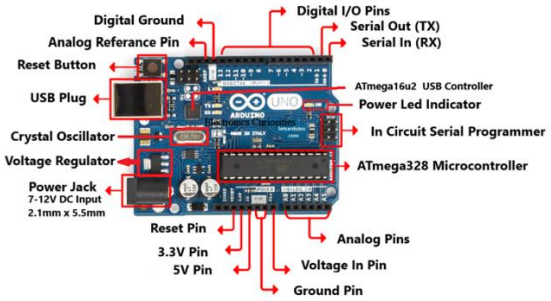

Figure 2: Arduino UNO board

2.2 Methods

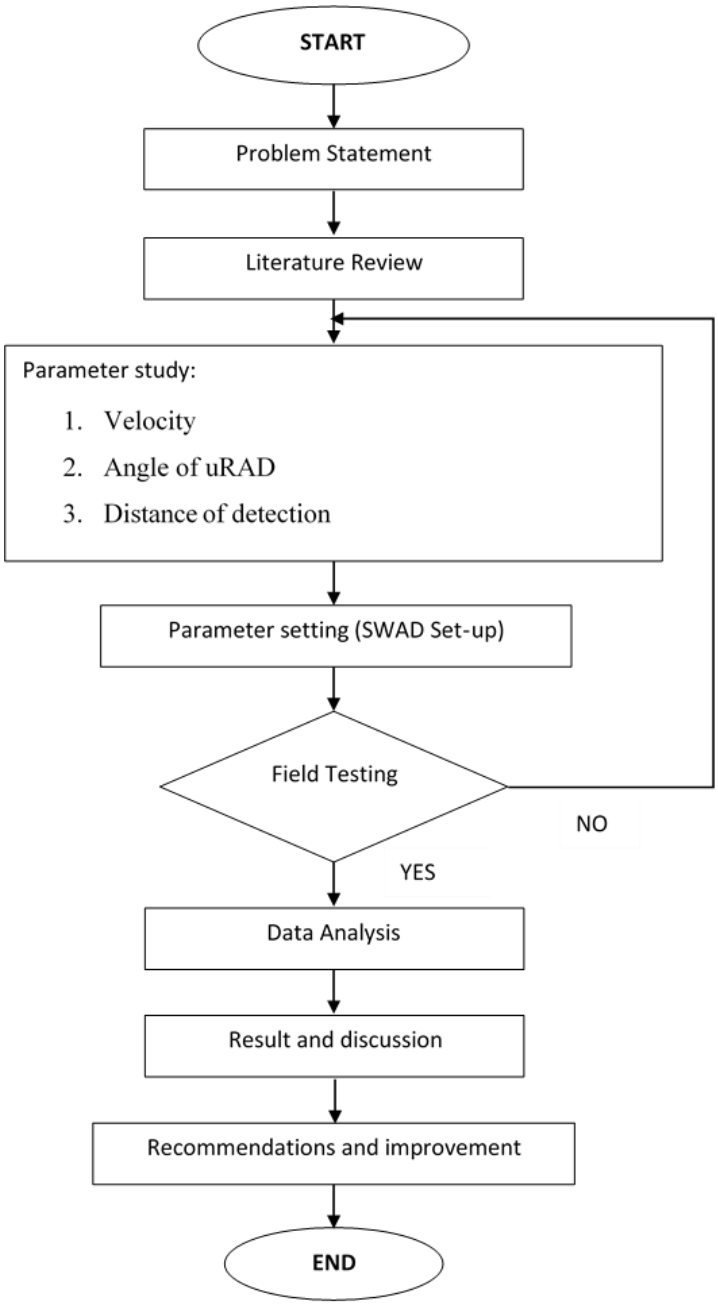

Figure 3: The flowchart of the experimental testing

Table 1: Parameter setting of SWAD

Parameter	Explanation
Velocity	The velocities of the car to be test are 30 km/h, 40 km/h, and 50 km/h. The parameter of velocity set in the programming of this system is at 8.5 m/s or 30.6 km/h. In order to activate the output of the SWAD consist of siren and rotation lamp, the velocity of the car must exceed the parameter that have been set and it indicates that the SWAD detect the presence of the vehicle approaching the SWAD.

Angle of uRAD	The optimum value of angle for uRAD was about in average 13°, 14° and 15°. In this study, the angle of uRAD set in the SWAD casing is 14°. Based on previous study, the farther distance detection was at 14° (Muhamad Hairi Bin Jaafar, 2020)
Distance of detection	The distance between two places is a scalar range measurement and is also known as the range number indicator of the range among objects or points. The distance can be physical or daily based on other criteria, a physical length or an evaluation. The definition of physical distance in mathematics is determined by a distance or a metric function. The distance to be detected by the uRAD sensor is 0.45 up to 100 metre.

2.3 Design of Experiment

The design of the experiment is conducted to find the best result of the test. The design of experiment are based on the angle, speed, and the distance of the SWAD detection. This experiment is conducted at emergency lane and left lane since this experiment need to be done like the real situation on the road. The data collection can seem the ability of the SWAD to detect the presence of the vehicle at certain distance and provide the output from the siren and rotation lamp. Table 2 is designed to collect the data based on the parameter study. This table is used to collect the data for speed 30 km/h, 40 km/h, and 50 km/h.

3. Results and Discussion

3.1 Distance detection at 30 km/h

The distance detection of the SWAD when the vehicle approached the device with 30 km/h speed was around 10 meter to 40 meter as shown in Table 3 and Figure 4. The farthest distance the SWAD can detect at this speed during this experiment was 42.68 meter with 32.18 km/h speed and the output of the SWAD consist of siren and rotation lamp was activated at this time. Meanwhile the nearest distance was 12.99 meter with 30.28 km/h. The data also shown the velocity that less than 30.6 km/h such as 30.28 km/h, 30.42 km/h, and 30.46 km/h were not active the output. The output of the SWAD system was not activated as the velocity parameter that have been set was 8.5 m/s or 30.6 km/h. So, the velocity of the vehicle must exceed 8.5 m/s or 30.6 km/h in order to activate the output of the SWAD. It can be seen clearly even the detection distance was 43.57 meter, the output of the SWAD also not active as the velocity of the vehicle approached the SWAD was 28.26 km/h.

Table 2: Distance detection at 30 km/h

No.	Angle of uRAD (°)	Speed (m/s)	Speed (km/h)	Distance (m)	Activation of Output
1	14°	8.94	32.18	42.68	Yes
2		8.78	31.61	39.07	Yes
3		9.24	33.26	20.35	Yes
4		8.72	31.39	20.17	Yes
5		8.81	31.72	34.11	Yes
6		9.44	33.84	21.35	Yes
7		7.85	28.26	43.57	No
8		8.46	30.46	15.38	No
9		8.45	30.42	19.59	No
10		8.41	30.28	12.99	No

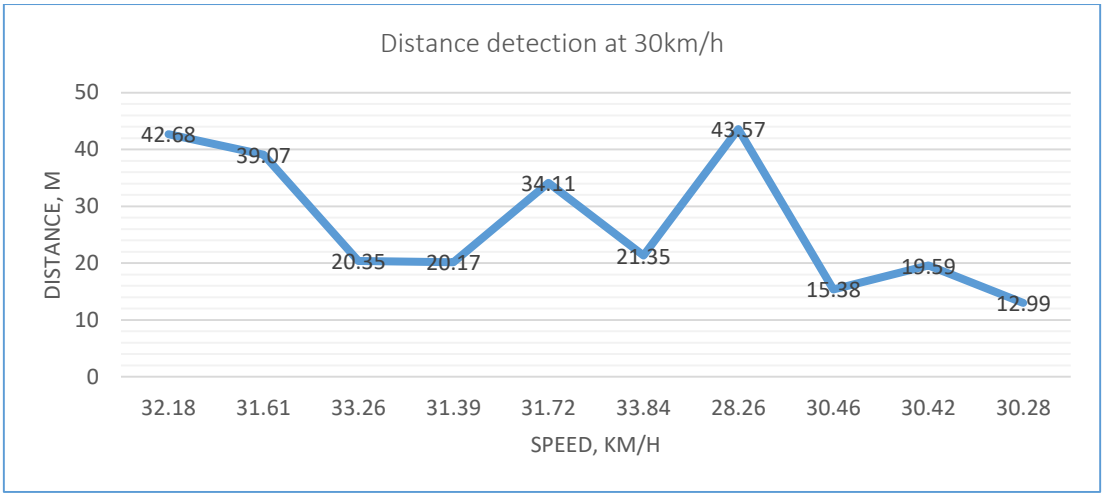

Figure 4: Graph of Distance Detection (m) vs. speed (km/h) at 30 km/h

The detection trend was uneven as illustrated in Figure 4-4, showing the curve for detection distance, m versus velocity, km/h. The distribution of this graph showed that the detection was not at the same level or even distance if the speeds somewhat different.

3.2 Distance detection at 40 km/h

The SWAD able to detect the vehicle approached the device with 40 km/h speed was around 30 meter to 50 meter as shown in Table 3 and Figure 5. The farthest distance the SWAD able to detect at this speed during this experiment was around 52.77 meter with 41.18 km/h speed. Meanwhile the nearest distance was 30.98 meter with 39.74 km/h. In this experimental test, the output of the SWAD was all active as the speed in this experimental test was exceed the value of the velocity parameter that have been set which was 8.5 m/s or 30.6 km/h.

Table 3: Distance detection at 40 km/h

No.	Angle of uRAD (°)	Speed (m/s)	Speed (km/h)	Distance (m)	Activation of Output
1	14°	11.44	41.18	47.52	Yes
2		11.5	41.4	52.77	Yes
3		11.4	41.04	44.44	Yes
4		11.16	40.18	36.03	Yes
5		11.85	42.66	39.52	Yes
6		12.15	43.74	33.6	Yes
7		11.98	43.13	34.04	Yes
8		12.13	43.66	51.2	Yes
9		11.58	41.69	36.65	Yes
10		11.04	39.74	30.98	Yes

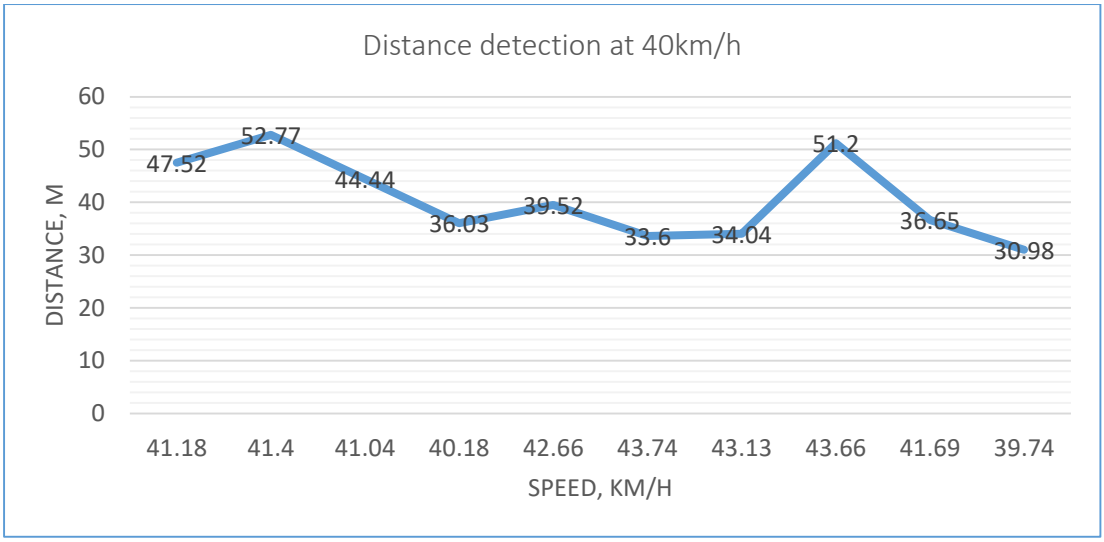

Figure 5: Graph of Distance Detection (m) vs. speed (km/h) at 40 km/h

The trend of the detection was uneven as can be seen in Figure 5 that shown the graph of the distance of detection, m versus speed, km/h. The distribution of this graph shown that the detection was not at the same level or at the same distance although the speeds were slightly difference.

3.3 Distance detection at 50 km/h

The SWAD ability to detect the vehicle approached the device with 50 km/h speed was approximately 20 meter to 50 meter as indicated in Table 4 and Figure 6. The farthest distance the SWAD able to detect at this speed during the tested was about 55.26 meter with 49.64 km/h speed. At 48.53 km/h, 27.81 meters was the closest distance. As the velocity parameter was set at 8.5 m/s or 30.6 km/h, the siren and rotation lamp were all activated during the test because the velocity or speed was exceed the minimum velocity required to active the output.

Table 4: Distance detection at 50 km/h

No.	Angle of uRAD (°)	Speed (m/s)	Speed (km/h)	Distance (m)	Activation of Output
1	14°	13.04	46.91	46.12	Yes
2		13.79	49.64	55.26	Yes
3		13.23	47.63	54.01	Yes
4		14.44	51.98	40.85	Yes
5		14.94	53.78	44.03	Yes
6		13.44	48.38	32.43	Yes
7		13.48	48.53	27.81	Yes
8		14.58	52.48	32.08	Yes
9		13.11	47.2	40.99	Yes
10		14.36	51.96	36.35	Yes

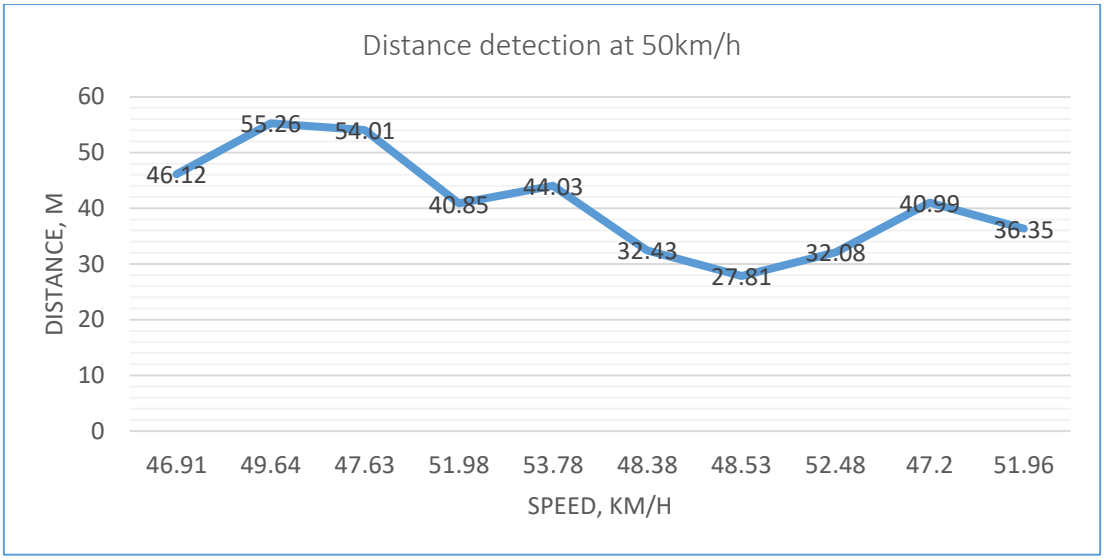

Figure 6: Graph of Distance Detection (m) vs. speed (km/h) at 50 km/h

Based on the Figure 6, it can be seen that the distance detection of the SWAD at speed of 50 km/h can detect the presence of the car up to 55.26 meters which was the highest distance detection among other speed. At average speed from 46 km/h to 53.0 km/h, the trend of distance detection was also seem fluctuated as the data showed the detection was from 20 meter to 55 meter.

4. Conclusion

In conclusion, the objectives of a parameter settings study have been achieved which were to develop a SWAD and to determine the best parameter setting of the SWAD. Some experiment have been run to find the best parameter of the SWAD by studied the distance detection of the SWAD. Based on the result obtained, it can be seen that the SWAD can detect any presence of the vehicle in a range of 20 meter to 60 meter distance at speed of 30 km/h, 40 km/h, and 50 km/h. The result also showed that the output the SWAD consist of siren, rotation lamp, and receiver only active when the car at speed more than 30.6 km/h nevertheless the output of the SWAD does not active. It can be said that the distance was enough to give early signal warning to any PLUS worker that attend any damaged vehicles beyond the SWAD in the same time can improve the safety of the workers..

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