ISSN: 2299-3843, Vol. 52, pp 134-146
doi:10.18052/www.scipress.com/ILCPA.52.134
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Performance Capabilities and Detection Efficiency of Vehicle Backup Proximity Sensors for Narrow Objects

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Keywords: backup proximity sensors; reverse sensors; parking aid; backover accidents

ABSTRACT. This paper investigates performance capabilities and potential safety effectiveness of ultrasonic backup proximity sensors with special attention on cylindrical and cubical shaped narrow obstacles with the dimensions varies from 2.6 cm to 11.0 cm. The experiment was performed using a commercially available parking aid system consisting of two ultrasonic sensors, and a rear bumper model constructed in a laboratory environment together with a test surface divided into grids having cells of 6 cm x 6 cm. It can be observed that there are considerable differences in detection zone patterns when comparing observations for cylinders and cubes even for same dimensions. Using detection zone maps, it can be seen that, when the size of the test objects become smaller, there are large blind spot areas in the space between the sensors and also near the right and left edges of the rear bumper. In average, when reducing the obstacle dimensions from 11.0 cm to 2.6 cm, the detection efficiency changes from 62.6% to 33.1% for cylindrical objects and for cubical shaped objects it was 39.3% to 21.6%. Average detection efficiency is lower than 50% for objects less than 5 cm in dimension irrespective of the object geometry.

1. INTRODUCTION

The principal intention of using a backup proximity sensor in a vehicle came up with the idea of using it as a parking aid when reversing a vehicle in a drive way, garage or any other area [1-4]. Furthermore as mentioned in [2, 3] proximity sensors has been developed as a parking aid while reversing have been publicized as a child safety device. Subsequently this parking aid device became more and more popular among motor designing manufacturers alarmingly. And later on it has been recognized as a safety device for the pedestrians who might be near a reversing vehicle.

Therefore now most of the modern vehicles are consisting of built in backup proximity sensors or rear-view cameras or including both of them. The cost of these devices which is said to be covered the blind zone behind the vehicle, might be much less than the cost of a minor accident [1,2]. When ultrasound sensors are embedded in the bumper of a vehicle it emits high frequency acoustic pulses and monitor the reflected sound from the obstacle. By calculating the time taken to reach the reflected pulse from the sensor, the object's distance from the rear bumper could be measured and as the object is getting closer to the bumper it will indicate by an acoustic tone which would vary with the proximity of the obstacle [4]. On the other hand the drivers would tend to assume that the sensor would always indicate the presence of any obstruct and may tempt to reverse the vehicle if it not giving a warning tone while reversing. Investigations reported in [5, 6] describe the findings that concern driver's reaction to acoustic signals that might be used for backup warning devices.

However effectiveness of proximity sensors as a child safety device is questionable as pointed out in [3] and it has reported that proximity sensors as parking aids alone cannot provide sufficient warning to drivers that a child is in the path of a reversing vehicle. Furthermore as reported in [4], sometimes it is suspicious to assume whether they are capable of covering all the area behind a vehicle. Therefore, even if those vehicle is been consisted of safety devises, they may not detect some area in the blind zone behind a vehicle. Consequently, hazardous situation is still unpredictable even used with backup sensors when reversing the vehicle.

A study reported in [4] evaluated on the overview of main performance parameters of backup proximity sensor systems with clean and dusty sensors such as size and shape of the detection zones, lower detection zones height, sensor system's response time etc… As mentioned in [4] proximity sensors may not be effective for small narrow objects such as poles and also could be affected by weather conditions such as wind or rain. Thus far there are no satisfactory number of researches have been recorded in this area especially how it response for various geometrical objects with different sizes. Nevertheless to identify the effectiveness of these proximity sensor systems in detail which are been used to cover the blind zone behind a vehicle is seemed be time worthy. Recognizing those blind zones which may appear behind a vehicle even it is used with some kind of safety precautions, its effectiveness could be able to develop into further advanced system and will provide more secure to the life of someone which is beyond measurable.

This paper investigates some of the performance capabilities and potential safety effectiveness of ultrasonic backup proximity sensor systems. Furthermore it is expected to investigate the effectiveness of ultrasonic backup proximity sensor systems on obstacles having different geometrical shapes and its dimensions with the help of a rear bumper model constructed in a laboratory environment.

2. EXPERIMENTAL SETUP

The experiment was performed using a backup proximity sensor system consisting of two sensors functions with ultrasonic acoustic waves, which is a commercially available *Parking Assist System*. As specified by the manufacturer the two-sensor system covers a detection range of 0.1~1.5 m with four-stage audible alert buzzer with the 70~90 dB beep volume. Four-stage audible alert buzzer with distinguishable four tones provides the driver a general idea about the position of the obstacle behind the vehicle. Therefore the experimental setup designed in order to map the four alert tones together with change in distance between the obstacle and the sensor. Table 1 gives the tabulated information about the defined five zones as per the distance from the sensor and its corresponding alert tones together with assigned colour codes for the analysis purposes.

Table 1. Four-stage audible alert buzzer tones and its approximate distance from the sensor.

Zone	Distance	Audible alert tone and its colour code		Remark
Zone 1	< 0.3 m	Tone 1		Stop the vehicle
Zone 2	0.3 ~ 0.6 m	Tone 2		
Zone 3	0.6 ~ 0.9 m	Tone 3		Slow down
Zone 4	0.9 ~ 1.2 m	Tone 4		Safe
Zone 5	1.2 ~ 1.5 m			

The experimental set up was built in an indoor area in order to exclude the environmental factors which have not been considered in this test. Furthermore as ultrasonic sensors does not require relative motion between the sensor and the test object as mentioned in [4], sensors were fixed in to a wooden beam instead of a vehicle rear bumper to overcome practical difficulties which may arouse.

A wooden plate was designed to install sensors and sensor locations on the plate were decided as given by the manufacturer. As it claims if the width of the rear bumper is indicated by 'L' then the distance between sensors must be '2L/4' and the sensor installation height from the ground should be 45~65 cm. It is the finest installation guidelines specified by the manufacturer which gives the maximum coverage within the bumper dimensions. In this experiment 144 cm was assigned as 'L' by considering an average width of a rear bumper for commercial cars and the wooden plate was fixed such that sensors were aligned at 55 cm height from the test surface. In order to determine the effectiveness of the detection zone, it has been required to localize the points around the sensors which may detect the test object. Therefore a wooden plate with the dimensions 150 cm x 174 cm was designed as a test surface and it was divided into grids having cells of 6 cm x

6 cm. Rows and the columns of the grid was numbered so that the exact position of the grid could easily be spotted by the means of the grid. Figure 1 shows a photograph of the test setup together with its geometrical information.

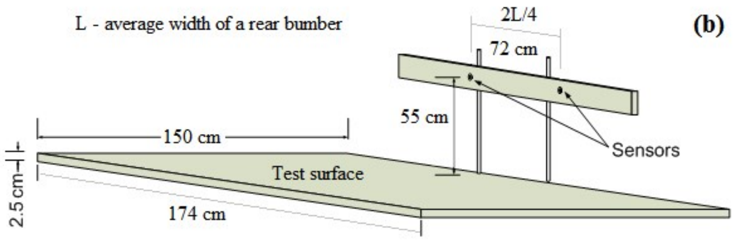

Figure 1. Test setup; (a) Grid image marked with 6cm x 6cm squares (b) Geometric information.

3. METHODOLOGY

In this experiment objects with two geometrical shapes were tested for each shape having five different dimensions. Cubical & cylindrical shaped tubes having the height of 100 cm were used as objects to determine the respective detection zone. Table 2 provides the overview of the test objects used to map the detection zone.

Table 2. Dimensions of the test objects used to map the detection zone.

	Object 1	Object 2	Object 3	Object 4	Object 5
Cylinder Name	*Cylinder 1*	*Cylinder 2*	*Cylinder 3*	*Cylinder 4*	*Cylinder 5*
Cylinder Diameter	11.0 cm	9.2 cm	5.0 cm	4.2 cm	2.6 cm
Cube Name	*Cube 1*	*Cube 2*	*Cube 3*	*Cube 4*	*Cube 5*
Cube Size	11.0 cm	9.2 cm	5.0 cm	4.2 cm	2.6 cm

Each test objects were placed on various grid positions manually on the test surface and observations from the sensor setup (respective alert tone) was recorded on the prototype grid which has been drawn on the record book. In order to increase the accuracy of the data, the experiment was repeated four times as trials by changing the direction of the movement of the test object towards the particular grid location as shown in the figure 2 below. In each observations for each and every location, there was a settling down time of 60 seconds was given, so that the sensor alarm would become stable.

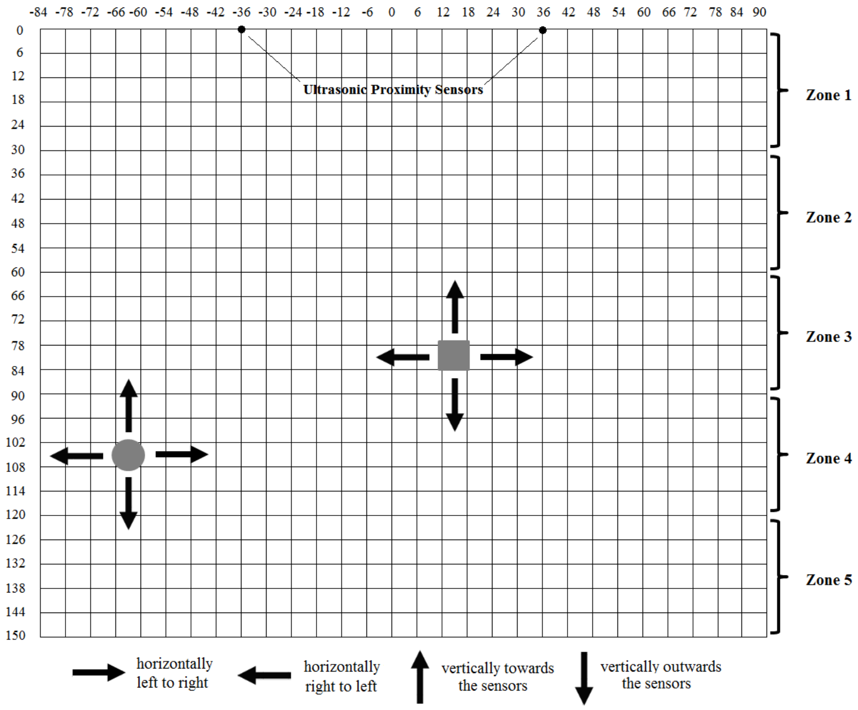

Figure 2. Different ways of moving the test object to generate the detection zone.

4. DATA AND OBSERVATIONS

Figure 3(a)-(d) show the mapped detection zones for *Cylinder 1* in its four trials representing identical prototype grid surfaces covering all five zones and audible alert tones 1-4 indicated by its corresponding colour code as given by table 1.

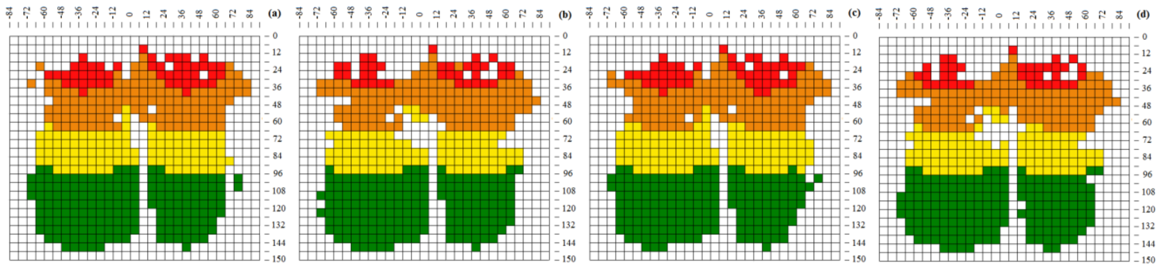

Figure 3. Mapped detection zone for *Cylinder 1* (a) trial 1, (b) trial 2, (c) trial 3, (d) trial 4.

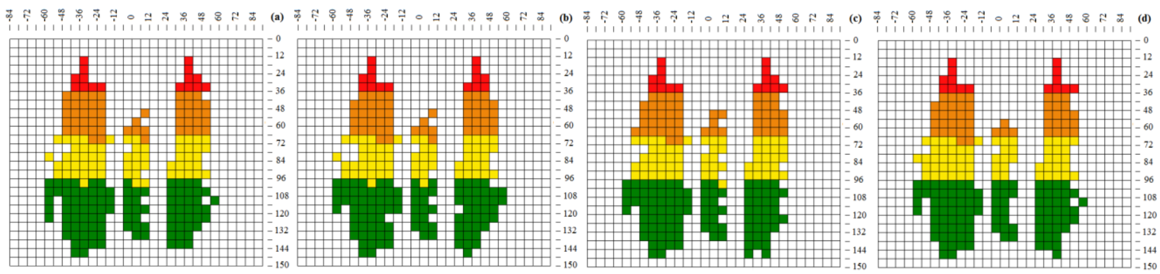

Figure 4. Mapped detection zone for *Cube 1* (a) trial 1, (b) trial 2, (c) trial 3, (d) trial 4.

Likewise figure 4(a)-(d) show the mapped detection zones for *Cube 1* in its four trials representing identical prototype grid surfaces covering all five zones. As it can be observed in figure 3 & 4, corresponding four trials for both *Cylinder 1 and Cube 1* have generated somewhat similar maps for their detection zones. This signifies steady response performance of the tested proximity sensor system and to justify further, tabulated data for distribution of number of detected grid-squares observed in four trials for alert tones for *Cylinder 1*and *Cube 1* are given by table 3.

Table 3. Distribution of number of detected grid-squares observed with four trials for alert tones for *Cylinder 1* and *Cube 1*.

		Cylinder 1						Cube 1					
	Tone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total
Trial 1	1	47	2	0	0	0	49	16	0	0	0	0	16
	2	24	96	0	0	0	120	0	49	3	0	0	52
	3	0	5	97	0	0	102	0	0	59	3	0	62
	4	0	0	0	116	60	176	0	0	0	69	31	100
Trial 2	1	37	0	0	0	0	37	15	0	0	0	0	15
	2	24	98	0	0	0	122	0	48	3	0	0	51
	3	0	4	91	0	0	95	0	0	58	2	0	60
	4	0	0	7	105	61	173	0	0	0	70	32	102
Trial 3	1	45	3	0	0	0	48	16	0	0	0	0	16
	2	26	91	0	0	0	117	0	49	2	0	0	51
	3	0	8	98	0	0	106	0	0	59	1	0	60
	4	0	0	8	107	56	171	0	0	0	69	33	102
Trial 4	1	37	0	0	0	0	37	15	0	0	0	0	15
	2	22	93	0	0	0	115	0	46	2	0	0	48
	3	0	8	91	0	0	99	0	0	60	0	0	60
	4	0	0	8	106	60	174	0	0	0	70	32	102

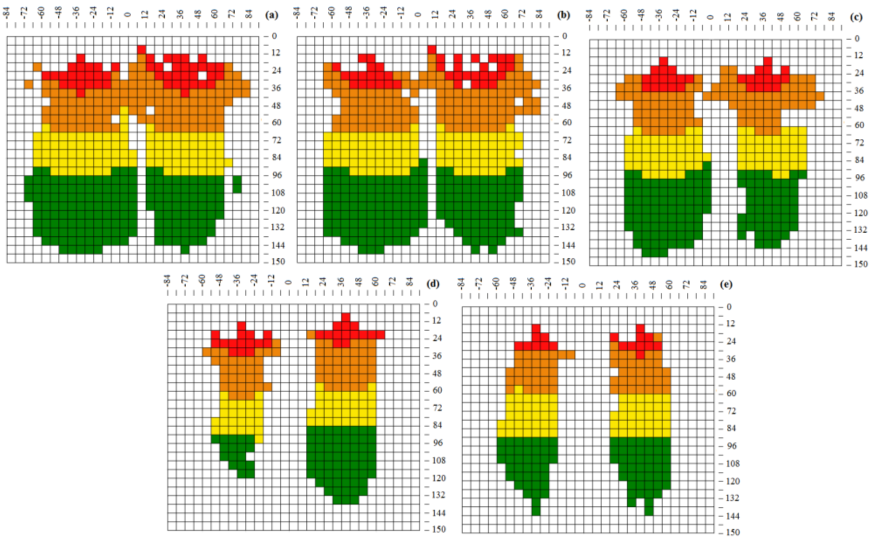

Figure 5. Mapped detection zones for all cylinders at its trial 1 (a) *Cylinder 1*, (b) *Cylinder 2*, (c) *Cylinder 3*, (d) *Cylinder 4,* (e) *Cylinder 5*.

Figure 5(a)-(e) & figure 6(a)-(e) show the mapped detection zones for all cylinders and cubes respectively at its trial 1. It can be observed that there are considerable differences in detection zone patterns when comparing observations for cylinders and cubes even with same dimensions. In both cases when reducing the dimensions from 11.0 cm (object 1) to 2.6 cm (object 5), number of blind spots observed were increased significantly.

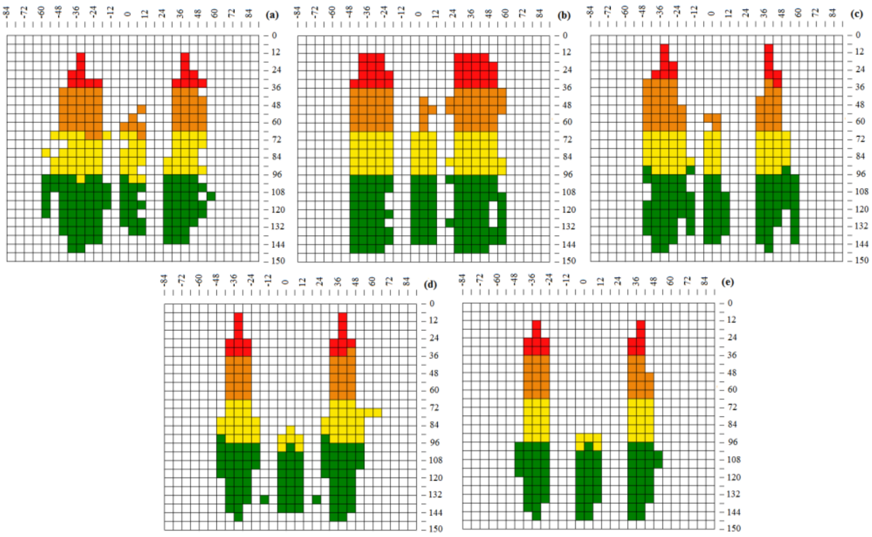

Figure 6. Mapped detection zones for all cubes at its trial 1 (a) *Cube 1*, (b) *Cube 2*, (c) *Cube 3*, (d) *Cube 4*, (e) *Cube 5*.

5. RESULTS AND DISCUSSION

As shown in figure 3 & 4, sensor system has shown a steady behaviour for all four trials throughout the experiment for each and every object. Therefore it was decided to analyze the data on its average basis as one way investigating the performance capabilities as a function of respective alert tones. Distribution of average number of detected grid-squares over five zones for respective alert tones given by the sensor system for both cylinders and cubes on its four trials are tabulated in table 4.

Table 4. Distribution of average number of detected grid-squares over five zones for alert tones for both Cylinders and Cubes.

	Cylinder Average							Cube Average						
Tone		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total
1	Cylinder 1	42	1	0	0	0	43	Cube 1	16	0	0	0	0	16
2		24	95	0	0	0	119		0	48	3	0	0	51
3		0	6	94	0	0	100		0	0	59	2	0	61
4		0	0	6	109	59	174		0	0	0	70	32	102
1	Cylinder 2	40	0	0	0	0	40	Cube 2	33	0	0	0	0	33
2		29	95	0	0	0	124		0	60	0	0	0	60
3		0	4	96	0	0	100		0	0	68	0	0	68
4		0	0	9	108	57	174		0	0	0	65	49	114
1	Cylinder 3	30	0	0	0	0	30	Cube 3	14	0	0	0	0	14
2		23	77	0	0	0	100		0	32	10	0	0	42
3		0	7	76	0	0	83		0	0	54	0	0	54
4		0	0	14	81	44	139		0	0	3	63	34	100
1	Cylinder 4	30	0	0	0	0	30	Cube 4	17	0	0	0	0	17
2		14	43	13	0	0	70		1	30	0	0	0	31
3		0	9	39	12	0	60		0	0	47	1	0	48
4		0	0	20	48	3	71		0	0	2	58	31	91
1	Cylinder 5	18	0	0	0	0	18	Cube 5	13	0	0	0	0	13
2		14	49	0	0	0	63		0	28	0	0	0	28
3		0	13	53	0	0	66		0	0	32	1	0	33
4		0	0	14	59	12	85		0	0	0	49	28	77

Figure 7 (a) & (b) represent the graphical overview of distribution of four alert tones for the average number of detected grid-squares over five zones for *cylinders* and *cubes*. This indicates that there is a possibility of getting an incorrect alert tone even though for each zone having its own alert tone as specified by table 1. Detecting an obstacle and produce an incorrect alert tone means, giving the driver a wrong impression about the exact position of the obstacle. This situation occurs because although the manufacturer has specified four alert tones correspond to the distance to the obstacle, these tones may get mix up at the zone boundaries. As shown in figure 7, danger arises if the system produces tone 2, indicating the object is in the zone 2 when actually the obstacle is in zone 1 which is nearer than the driver think. Hence the driver may not have the necessary time to avoid the collision. However possibility of producing an incorrect tones for cylinders are much higher than for cubes as it can be seen in comparing figure 7(a) and 7(b). Table 5 indicates the performance probability in percentage (%) for giving out the anticipated alert tone in its respective zone for all the tested objects.

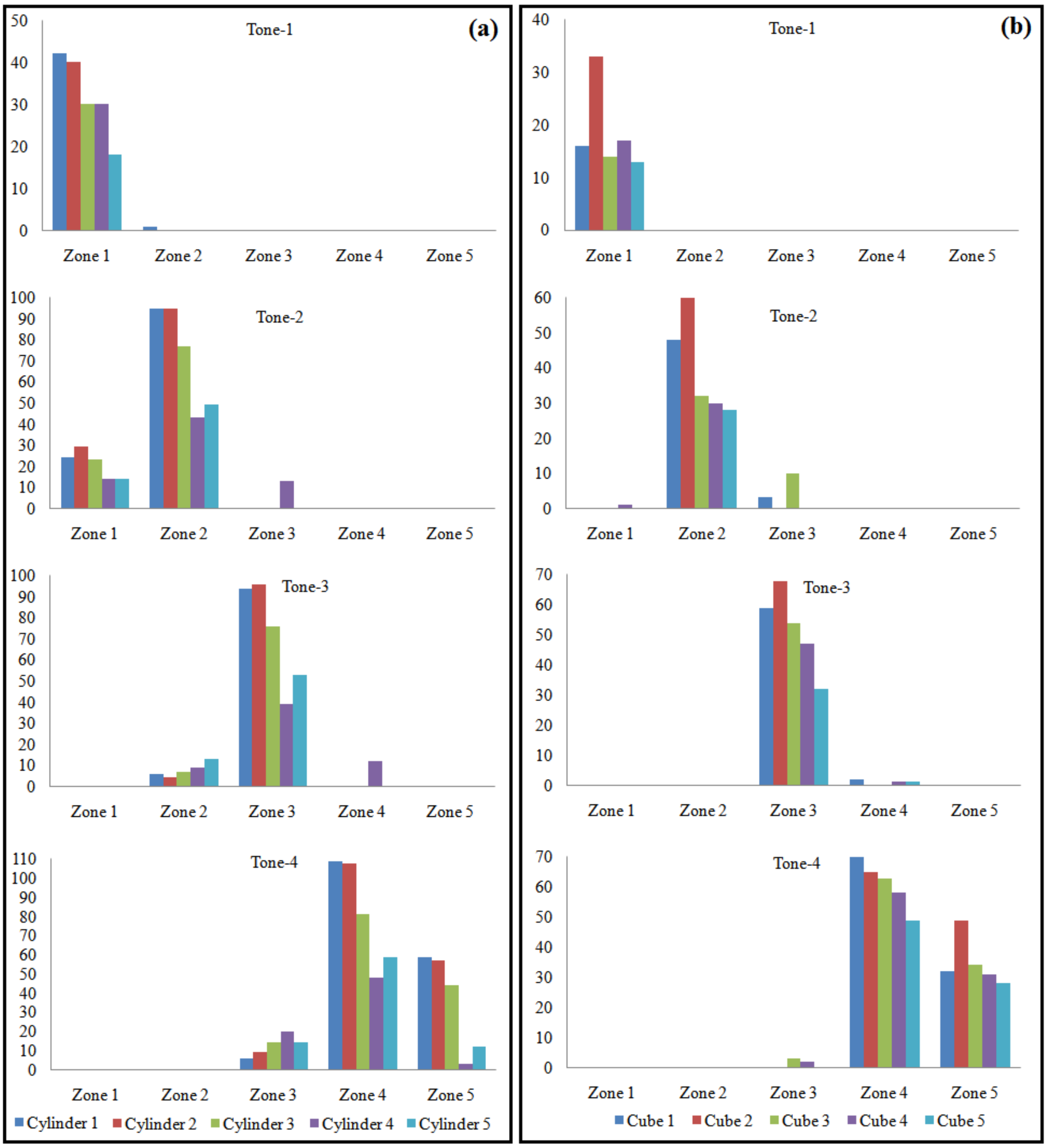

Figure 7. Average number of detected grid-squares in five zones for four alert tones (a) Tone 1-4 distribution for Cylinders, (b) Tone 1-4 distribution for Cubes.

Table 5. Probability of giving out the anticipated alert tone in its respective zone.

	Cylinder 1	Cylinder 2	Cylinder 3	Cylinder 4	Cylinder 5	Cube 1	Cube 2	Cube 3	Cube 4	Cube 5
Tone 1 in zone 1 (%)	97.7	100	100	100	100	100	100	100	100	100
Tone 2 in zone 2 (%)	79.8	76.6	77.0	61.4	77.8	94.1	100	76.2	96.8	100
Tone 3 in zone 3 (%)	94.0	96.0	91.6	65.0	80.3	96.7	100	100	97.9	97.0
Tone 4 in zone 4 & 5 (%)	96.6	94.8	89.9	71.8	83.5	100	100	97.0	97.8	100

Another way of investigating the performance capabilities as a function of respective detection zones considered in this study is to analyse the generated detection maps with its maximum and minimum capabilities for respective test objects. Maximum detection zone map was generated to represent the maximum number of detected grid-squares that was observed by the sensor system and for minimum detection zone map; it was the minimum number of detected grid-squares that was observed. Table 6 and table 7 depict the distribution of number of grid-squares over five zones for both cylinders and cubes on its maximum and minimum capacity as per the response given by the sensor system. Figure 8 express the minimum and maximum detection zone maps for each and every cylinder and cube considered for this study.

Table 6. Maximum & minimum number of detected grid-squares for cylinders over five zones.

		Cylinder Maximum						**Cylinder Minimum**					
Tone		**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Total**	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Total**
1	**Cylinder 1**	54	3	0	0	0	57	30	0	0	0	0	30
2		25	103	0	0	0	128	22	89	0	0	0	111
3		0	6	101	0	0	107	0	2	87	0	0	89
4		0	0	6	113	62	181	0	0	9	101	54	164
1	**Cylinder 2**	42	0	0	0	0	42	37	0	0	0	0	37
2		29	101	0	0	0	130	29	88	0	0	0	117
3		0	4	99	0	0	103	0	3	93	0	0	96
4		0	0	8	108	61	177	0	0	9	107	54	170
1	**Cylinder 3**	32	0	0	0	0	32	28	0	0	0	0	28
2		22	80	6	0	0	108	24	72	0	0	0	96
3		0	6	79	0	0	85	0	9	72	0	0	81
4		0	0	12	83	47	142	0	0	16	80	41	137
1	**Cylinder 4**	34	0	0	0	0	34	27	0	0	0	0	27
2		18	56	0	0	0	74	19	49	0	0	0	68
3		0	8	51	0	0	59	0	13	44	0	0	57
4		0	0	17	52	8	77	0	0	22	41	0	63
1	**Cylinder 5**	19	0	0	0	0	19	17	0	0	0	0	17
2		13	50	0	0	0	63	15	47	0	0	0	62
3		0	14	55	0	0	69	0	13	52	0	0	65
4		0	0	14	60	14	88	0	0	14	57	9	80

By observing these detection maps in figure 8, it can be seen that, when the size of the test objects become smaller, there are large blind spot areas in the space between the sensors and also near the right and left edges of the rear bumper. As it is previously mentioned, the shape of the object always causes these results to change and since the dimensions of the cube matches with the dimensions of the cylinders, total number of grid-squares detected for each dimension at its average, maximum and minimum detection maps can be exemplify as shown in figure 9. When considered the average detection response, both cylinders and cubes showing less detection capabilities as reducing its dimensions even though it was much better for cylinders. Out of total number of 700 grid-squares on the test surface, it was reduced from 436 to 232 for cylinders and for cubes it was from 275 to 151. Similar trend could be observed even for maximum and minimum detection zone maps as shown in figure 9.

Table 7. Maximum & minimum number of detected grid-squares for cubes over five zones.

		Cube Maximum						Cube Minimum					
Tone		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total
1	Cube 1	16	0	0	0	0	16	14	0	0	0	0	14
2		0	51	3	0	0	54	0	46	2	0	0	48
3		0	0	62	3	0	65	0	0	56	0	0	56
4		0	0	0	72	34	106	0	0	0	66	31	97
1	Cube 2	35	0	0	0	0	35	32	0	0	0	0	32
2		0	61	0	0	0	61	0	58	0	0	0	58
3		0	0	70	0	0	70	0	0	64	0	0	64
4		0	0	0	67	53	120	0	0	0	63	43	106
1	Cube 3	15	0	0	0	0	15	12	0	0	0	0	12
2		5	43	0	0	0	48	5	38	0	0	0	43
3		0	0	56	0	0	56	0	0	53	0	0	53
4		0	0	2	64	41	107	0	0	4	63	27	94
1	Cube 4	18	0	0	0	0	18	16	0	0	0	0	16
2		0	31	0	0	0	31	2	30	0	0	0	32
3		0	0	49	2	0	51	0	0	44	0	0	44
4		0	0	1	58	36	95	0	0	3	58	27	88
1	Cube 5	14	0	0	0	0	14	12	0	0	0	0	12
2		0	28	0	0	0	28	0	28	0	0	0	28
3		0	0	32	0	0	32	0	0	31	0	0	31
4		0	0	0	51	30	81	0	0	0	46	26	72

To get a clear idea about the variation in the sensor efficiency with the change in size and geometry of the object, above illustrated results have concluded into a graphical format which is shown in figure 10. Figure 10 shows how the overall detection efficiency varies with the test object size for both cylinders & cubes for its average, maximum and minimum detection zones. It is clearly evident that the detection efficiency of cylindrical or cubical shape obstacles by the ultrasonic backup proximity sensors is decreasing when obstacle dimensions become narrower. In the case of average detection zones, when reducing the object dimensions from 11.0 cm to 2.6 cm, the detection efficiency changes from 62.6% to 33.1% for cylindrical objects and for cubical shape objects it was from 39.3% to 21.6%. In the case of maximum and minimum detection zones, these values were 67.6% to 34.1% & 40.9% to 22.1% and 60.0% to 32.0% & 37.1% to 25.7% respectively. Very important conclusion it can be arrived in this stage is that, for cubical surfaces where a flat surface act as reflection point offer considerably lower detection efficiency than observed for the cylindrical objects with circular type reflection surfaces. These detection efficiencies were calculated by choosing a 150 cm x 168 cm rectangular horizontal hazard area at the rear of the vehicle. According to [1,2] proximity sensors that are designed as a parking aid must have at least 1.5 m typical detection depth and so that the maximum reversing speed is 3 km/h for a 95% collision avoidance level. When considering about the safety, this is a good approach of the sensor because then the driver will be alerted about the obstacle, with enough time, to stop the vehicle in a safe distance. It can be observed that in this study, the maximum detection distances tend to change very rarely with the object size and the shape. The maximum detection distance observed with the sensor for both types of object is 144 cm.

However these backup proximity sensors were designed mainly for child safety and as per the results observed in this study, collision avoidance level for narrow objects is significantly lower than expected. Interestingly this study was conducted by considering the vehicle at rest (0 km/h), just before the vehicle move, while backup proximity sensor system is in action. It is important to mention that since the range does not extend beyond the sides of the rear bumper, the device will be less assist to drivers in preventing backup crashes to objects that are moving into the path of the backing vehicle. Even though efficiency of the sensor system increased with the object size, cylindrical objects showed a rapid variation in detection efficiency with the size of the object, than the cubical ones. Average detection efficiency is lower than 50% for objects less than 5 cm dimensions irrespective of the object geometry. Therefore some of the obstacles like lamp posts, pillars, iron rods, etc... may not detected by the system.

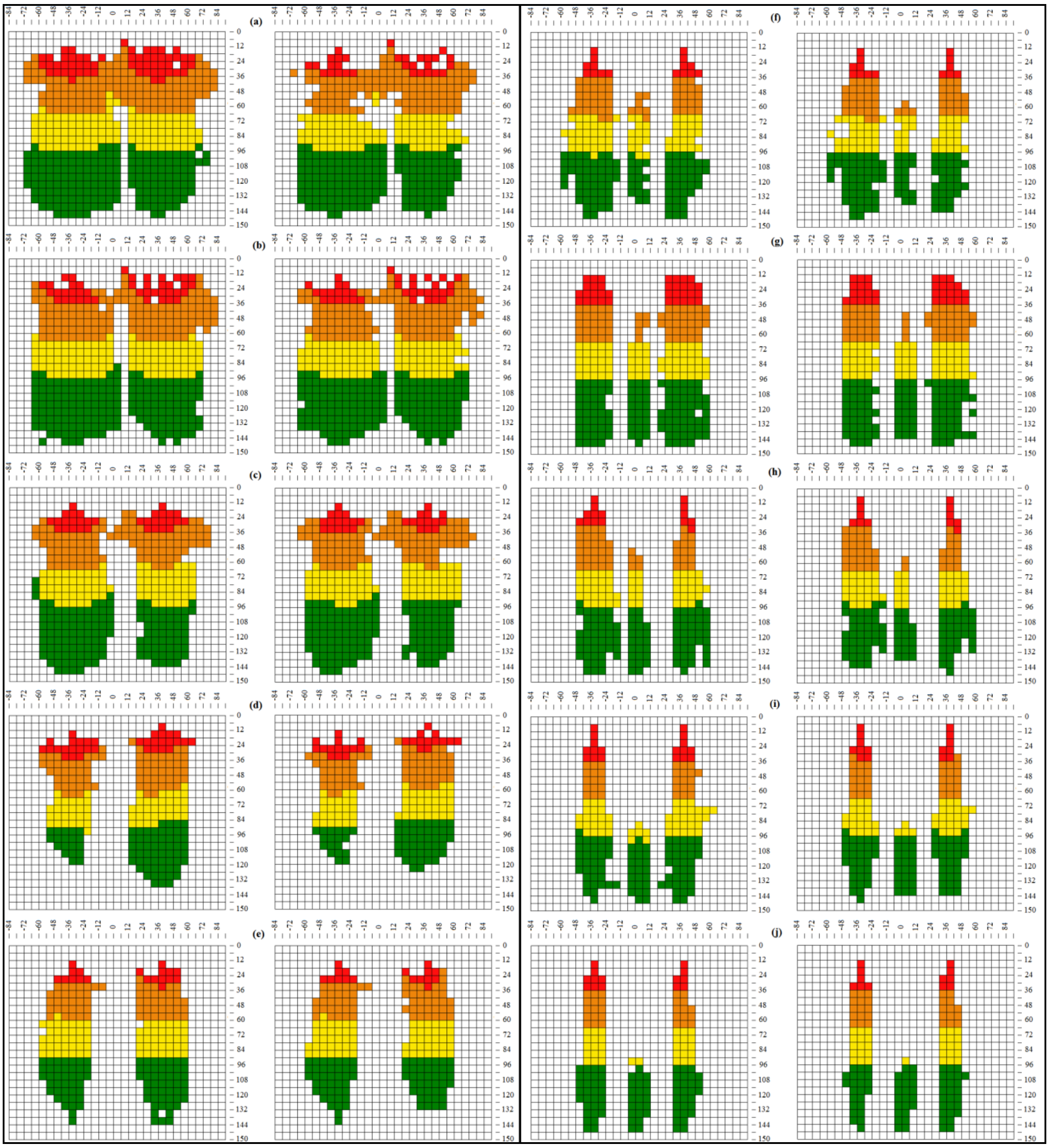

Figure 8. Detection zone maps for all objects; left: maximum detection zones and right: minimum detection zones (a) *Cylinder 1*, (b) *Cylinder 2*, (c) *Cylinder 3*, (d) *Cylinder 4,* (e) *Cylinder 5*, (f) *Cube 1*, (g) *Cube 2*, (h) *Cube 3*, (i) *Cube 4*, (j) *Cube 5*.

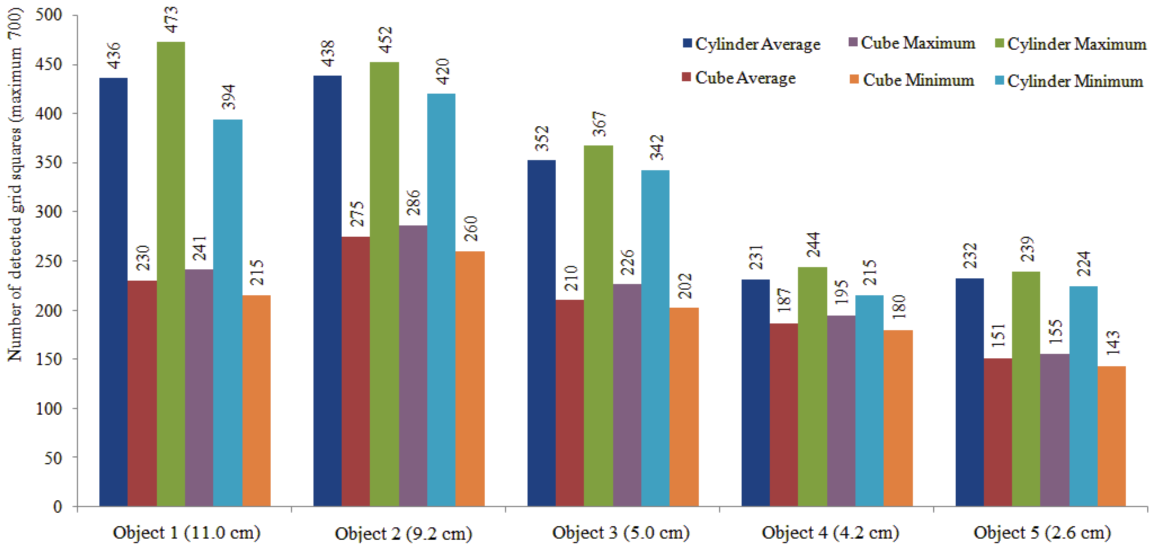

Figure 9. Number of detected grid squares for all five sizes of test objects for both cylinders & cubes for its average, maximum and minimum detection zones.

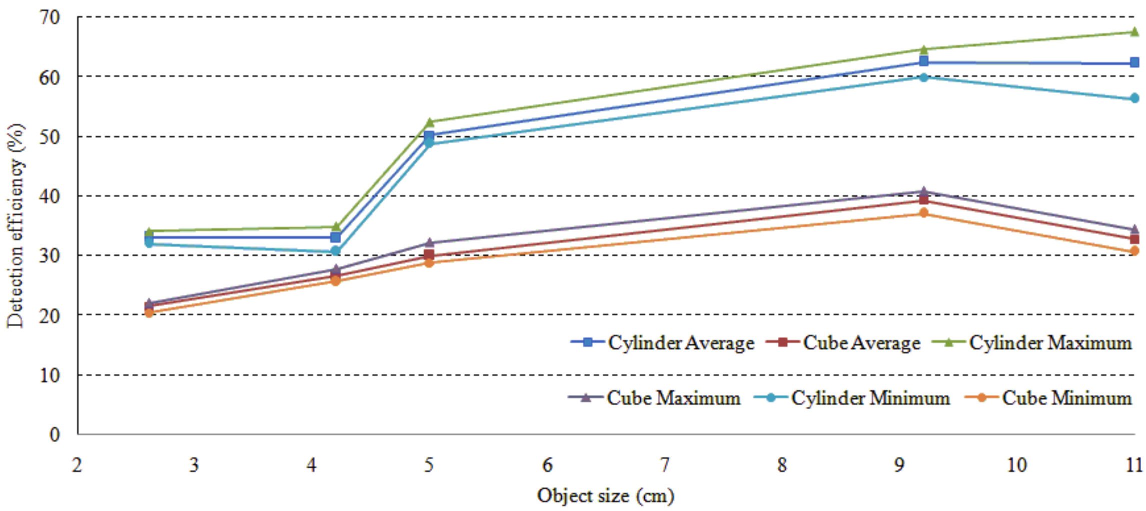

Figure 10. Overall detection efficiency vs. test objects size for both cylinders & cubes for its average, maximum and minimum detection zones.

On the other hand if detection efficiency calculated based on vertical grid-squares as separate detection columns, which is in right angled to rear bumper axis fixed with sensors, it was a different scenario. Figure 11 illustrate the detection efficiency against vertical grid-squares located right angled to rear bumper axis from -84 cm to +84 cm for both cylinders and cubes at its minimum & maximum detection zones. As indicated in Figure 11(a) highest detection efficiency of 72% to 92% observed at the two vertical grid-square columns exactly at right angled to sensor locations (-36 cm & +36 cm) for all the tested cylinders at its minimum & maximum detection zones. This indicates that if cylindrical shape objects located outside these two grid-square columns and even at the middle of the sensor locations (i.e. at 0 cm), efficiency decreases dramatically towards 0%. Similar behaviour could observe for all the tested cubes as shown in figure 11(b) where highest detection efficiency of 88% to 96% observed at -36 cm & +36 cm. Similar to the observation for cylinders, outside the two grid-square columns at -36 cm & +36 cm, detection efficiency decreases towards 0%. However at the middle of the sensor locations (i.e. at 0 cm), unlikely for cylinders, for cubes there was a considerable detection efficiency of 40% to 72% which is clearly visible in figure 11(b).

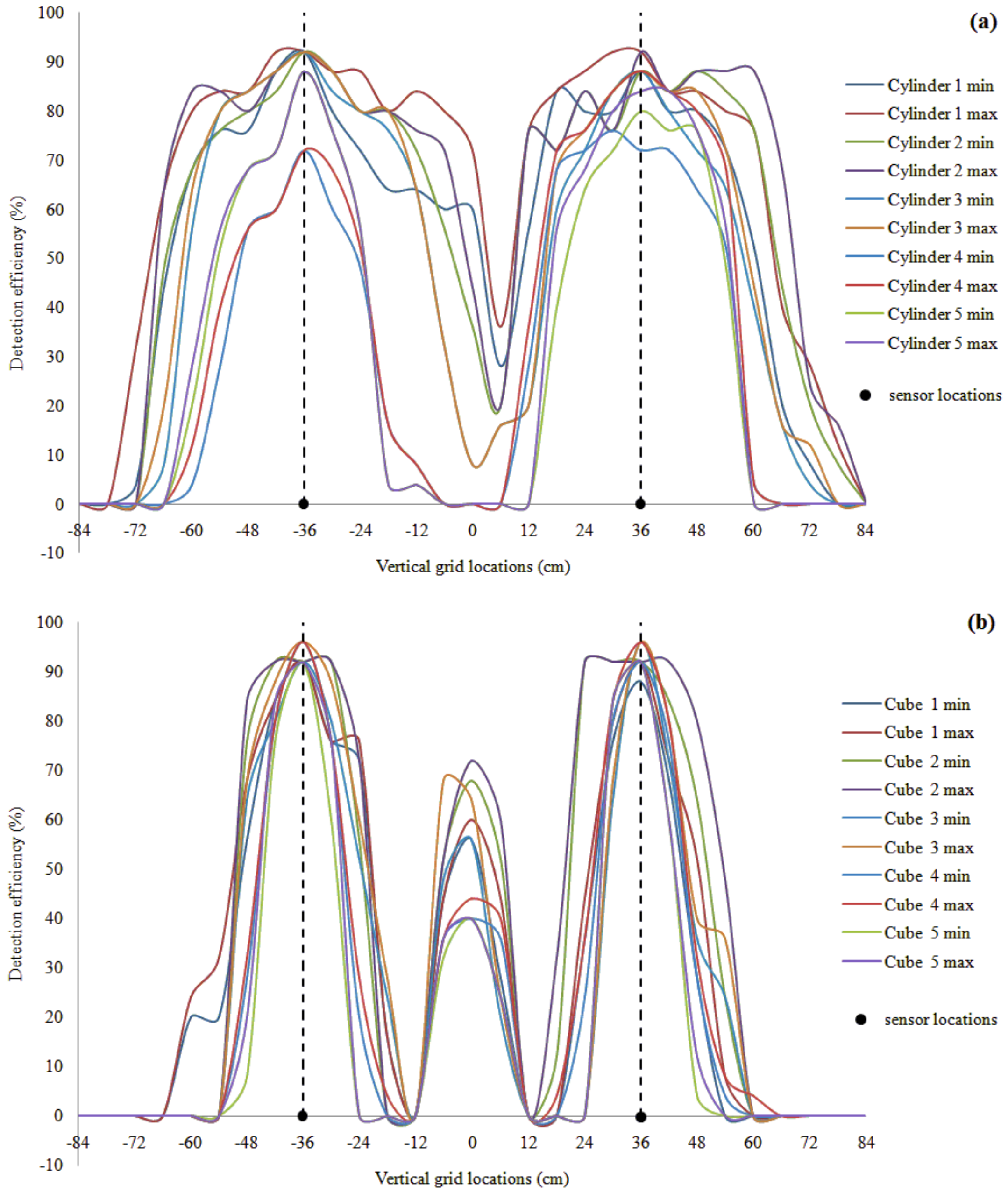

Figure 11. Detection efficiency vs. vertical grid-squares located right angled to rear bumper axis from -84 cm to +84 cm at its minimum and maximum detection zones (a) cylinders, (b) cubes.

Blind spots observed between the areas of the two sensors may be decreased by changing the distance between the two sensors. But when observe the detection zone diagrams it is obvious that, further decrease in the distance between the two sensors may cause in larger blind spots near the two right and left edges of the bumper. Systems with multiple sensors may require to be attached to the bumper to get full coverage on both sides of the car. When analyzing the results that have obtained by the researchers throughout these years up to now, and as per the results observed in this study, it is highly doubtful that a proximity sensor could be developed in such a way which would work as a complete parking assisting aid. A combination of proximity sensor and visual aid is needed to cover all crucial blind spots to the rear of the vehicle. However it will cost more and economical vehicle owners could not afford it. Anyhow even with the parking assisting aid like backup proximity sensors, drivers should be careful by themselves about any movement of the vehicle as this is not a full solution for a hazard prevention tool.

Previous researchers have shown that, the variability in obstacle detection performance by ultrasonic sensors appears to be changed in ambient conditions such as changes in temperature, humidity, wind speed, wind direction, rain etc…[4,7]. Moreover, there are other factors that will have an effect on the sensor system's effectiveness in preventing collisions. For example, it is assumed that once a warning is given the vehicle driver will always react to it immediately. Overall, it would be safe to assume that the real world effectiveness of the systems would be even lower than that estimated by a study conducted in laboratory environment.

6. CONCLUSION

This report gives an opportunity to examine current technology that provides commercial vehicle drivers with warnings of objects located behind the vehicle. The backup proximity sensor system was based on ultrasonic acoustic waves which is a common technology among reverse sensor manufacturers.

According to the study, there is a possibility of detecting an obstacle and produce an incorrect alert tone by giving the driver a wrong impression about the exact position of the obstacle, mainly at the zone boundaries. Tested obstacles having less detection capabilities as reducing its dimensions from 11.0 cm to 2.6 cm and the detection efficiency changes from 62.6% to 33.1% for cylindrical objects and for cubical shape objects it was from 39.3% to 21.6%. Very important conclusion that can arrive is that, for cubical surfaces where a flat surface act as reflection point offer considerably lower detection efficiency than observed for the cylindrical objects with circular type reflection surfaces.

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