Sensor Comparation For Smart Parking System

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Abstract*—Parking is defined as a condition when a vehicle is temporary stored. In big cities, where parking space become more limited. In most of conventional parking system, driver enter parking area, search available parking space and park. Finding one available parking space can be frustrating, particularly during rush hour or weekend, since the driver did not know the exact available space. Some parking service provider count their available space and display it at the entry gate, but this system cannot detect vehicle that already leave the parking space until they reach the exit gate. With the system proposed, driver can reserve a parking space. When the vehicle arrives, sensor detects the vehicle and set the status to be occupied. Sensor can also detect when the vehicle leave the space so the space can be reserved for another vehicle. For the system proposed, four sensors are tested with three different positions. Sensor placement. Sensor proposed must be cheap, reliable, and require minimal maintenance.

***Keywords*—Parallax PING, HC-SR04, Sharp GP2Y0A02YK0F, CT-SL110, parking**

I. INTRODUCTION

The growing number of car industry and increasing standard of mobilization leads to more affordable car price. From 2009 to 2013, number of cars has been increased 45%, and number of motorcycle has been increased to 61% [1]. This rapid growing number of cars causes issues in most of cities. It causes traffic congestion, air and noise pollution, and driver's frustration that can lead to bad behavior and accident. Parking issue became more serious because the limitation of parking space [2]. Price for parking spaces are rising up from time to time.

In most of conventional parking system, driver get a ticket at the entry gate, find available parking space and park, go to exit gate, present or return the ticket, pay the parking fee and get the receipt. Finding one available parking space can be frustrating, particularly during rush hour or weekend [2]. The problem become more complicated because some parking service provider still enter the vehicle even though the parking lot was already full, with expectation during the searching process, there are other users who come out so the empty space can be used by the other vehicle. Some parking service provider count their available space and display it at the entry gate, but this system cannot detect vehicle that already leave the parking space until they reach the exit gate. Available space displayed at the entry gate did not represent real situation. In big or multi-level parking lot, this can cause opportunity loss for people who want to park, as well as profit loss to the provider. While some of parking service provider offer reservation, this system only suitable for scheduled trip. Many of this system also require customer to pay deposit or charge at higher rate.

Previous research describe smart parking system based on secured wireless network using sensor communication to acquire high parking utilization and finding free parking space [2]. Further research use sensor to detect free parking space [4], and driver can reserve free space by SMS [4] [5]. To identify vehicle plate number and other identification, cameras are installed nearby parking lot [6]. Ultrasonic sensor was used to detect vehicle for parking location [7].

The basic operation for the proposed parking system is described as: When a vehicle arrive at the entry gate, a monitor shows the parking lot map. The driver then choose available parking space. System then flag selected space to 'reserved'. When the car enter the designated space, it trigger the sensor and system flag selected space to 'occupied'. When the car exit, sensor release the flag in the system so it can be used for another car. Sensor proposed must be cheap, reliable, and require minimal maintenance.

II. SENSORS

A. Parallax PING))) Ultrasonic Sensor

The parallax PING (PING) sensor is an ultrasonic sensor that provide non-contact measurement. The sensor works by transmitting ultrasonic burst signal at 40 kHz (chirp).

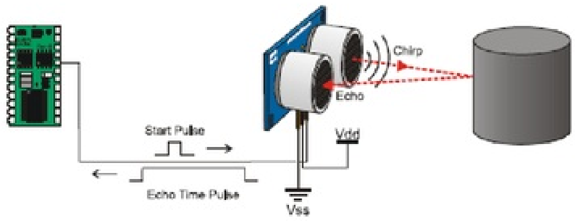

Fig. 1. Parallax Ping Sensor

This signal then travel through the air and if it hits an object, the signal would bounces back echo to the sensor [3]. The sensor uses +5 VDC power supply with 30-35 mA current.

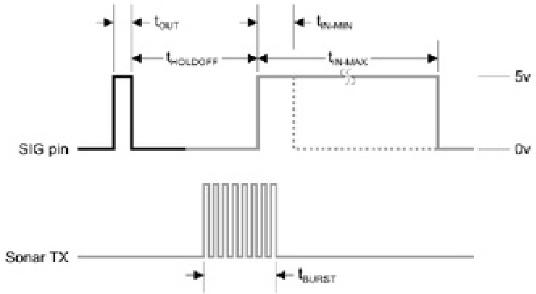

Fig. 2. Parallax Ping Clock Diagram

This sensor has a dimension of 21.3 mm by 45.7 mm and has a thickness of 15.3 mm. This dimension makes it easy to be hidden at the parking space. Price for this sensor varies from IDR.450,000 to IDR.500,000 (US$.31.5 to US$.35.0)

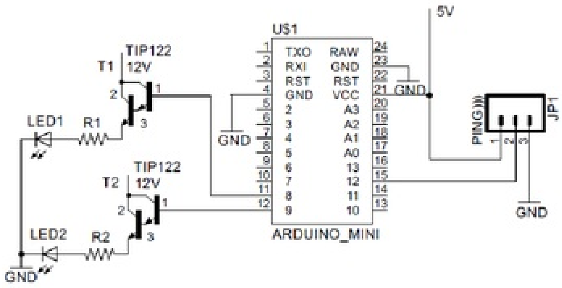

Fig. 3. Parallax Ping Schematic Diagram

This sensor, however has some limitation. Range is limited from 2 cm to 3 meters from the object. Sensor may also fail if the surface of the object detected is reflective , while positioned at shallow angle.

B. HC-SR04 Ultrasonic Sensor

Like the PING, HC-SR04 is an ultrasonic sensor that operates at 40 kHz. It also uses +5 VDC but at lower current, 15 mA [4].

Fig. 4. HC-SR04 Sensor

The sensor has identical dimension with PING, but it has additional pin for Echo. Unlike the PING, this sensor is much more affordable at IDR.17,500 (US$.1.22).

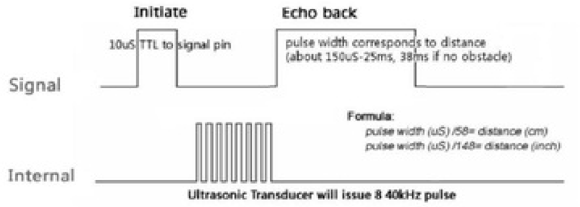

Fig. 5. HC-SR04 Clock Diagram

HC-SR04 can detect object within 2 cm to 4 meters. The sensor also shares similar limitation to detect object at shallow angle.

C. Sharp GP2Y0A02YK0F Infrared Sensor

The Sharp GP2Y0A02YK0F is a distance measuring sensor unit, composed of an integrated combination of PSD (position sensitive detector), IRED (infrared emitting diode) and signal processing circuit. The sensor adopts triangulation method so the variety of the reflectivity of the object, the environmental temperature and the operating duration are not influenced easily to the distance detection [5].

The sensor outputs the voltage corresponding to the detection distance. The sensor uses 4.5 to 5.5 VDC power supply with 33 mA current.


Fig. 6. Sharp GP2Y0A02YK0F Sensor

This sensor has a dimension of 29.5 mm by 13 mm and has a thickness of 21.6 mm. This is bigger than the two previous sensors. Price for this sensor is around IDR.175,000 (US$.12.24).

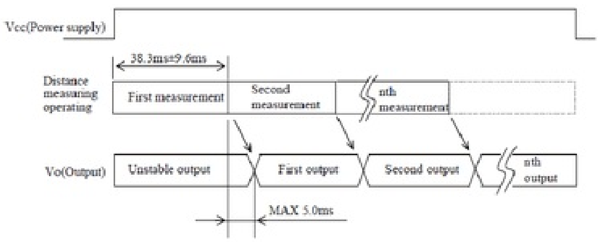

Fig. 7. Sharp GP2Y0A02YK0F Clock Diagram

This sensor uses lens that needs to be kept clean. Range is limited to 20 cm to 150 cm from the object.

D. *CT-SL110 Single Vehicle Loop Detector*

The device is connected to an inductive loop mounted on the road. The device can detect when a vehicle pass over the loop.This device cost around IDR.700,000 (US$.49.00).

Fig. 8. CT-SL110

The device can use 220/110 VAC or 24/12 VDC with 4.5 W power rating. The device has a dimension of 75 x 37 x 110 mm, and reaction time of 10 ms [10] [11].

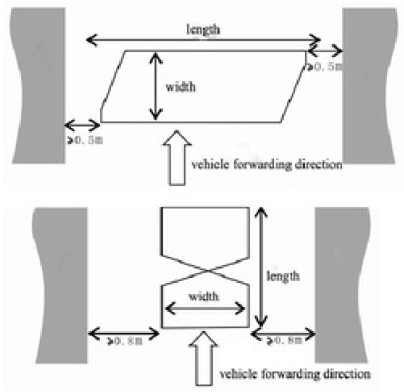

Fig. 9. CT-SL110 Detection Process

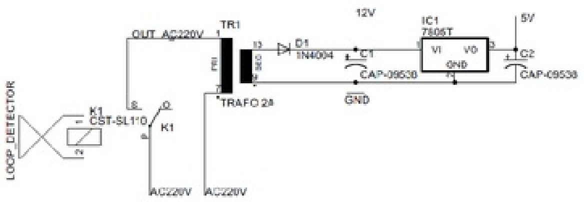

Fig. 10. CT-SL110 Shematic Diagram

III. Detection Scheme

A. *Parking Space*

Parking is defined as a condition when a vehicle is temporary stored. Area where a vehicle park is called parking space [6]. This space, or called *Satuan Ruang Parkir* (SRP) is measured by the effective area for one vehicle to be stored, including surrounding free area and space needed to open the door [7]. Parking area for each vehicle type is regulated as follow.

Type	Parking Area (m)
Passenger Vehicle Type I	2.30 x 5.00
Passenger Vehicle Type II	2.50 x 5.00
Passenger Vehicle Type III	3.00 x 5.00
Bus/Truck	3.40 x 12.50
Motorcycle	0.75 x 2.00

For the experiment, we use Passenger Type 1 SRP (2.30 x 5.00) area.

B. *Sample Car*

There are 89 passenger cars from 13 manufacturers sampled. Main criteria for the sample was their availability and popularity for Indonesian market.

TABLE I. Vehicle Sample

Manufacturer	No. of Vehicle Sampled
BMW	11
Chevrolet	3
Daihatsu	6
Datsun	2
Ford	4
Honda	10
Hyundai	5
Isuzu	1
Kia	6
Mercedes Benz	8
Nissan	7
Suzuki	7
Toyota	19

1) *Ground Clearance*

Ground clearance is defined as the distance between the lower parts of the vehicle to the ground. The tires are not considered to this definition as they are designed to be in contact with the ground. Ground clearance needs to be considered if the sensor is placed under the vehicle.

Cars grouped into their class to determine the average ground clearance.

TABLE II. Average Ground Clearance

Vehicle Type	Average Ground Clearance (mm)
Small Hatchback	169.50
Hatchback	154.00
Minivan/SUV	183.41
Sedan	137.89

Vehicle Type	Average Ground Clearance (mm)
Full Size Sedan	149.50
Pickup Truck	202.17
Average	166.08

2) Car Height

It is possible to place the sensor above the car, so average car height is also calculated.

TABLE III. AVERAGE CAR HEIGHT

Vehicle Type	Average Height (mm)
Small Hatchback	1,530.83
Hatchback	1,518.43
Minivan/SUV	1,741.97
Sedan	1,434.59
Full Size Sedan	1,488.50
Pickup Truck	1,915.71
Average	1,605.01

Most of parking building has no more than 3 meters in height, so average distance between the roof to the car will be 1,350 mm.

C. Sensor Location

Testing was done at outdoor parking space. For each sensor, measurement was conducted 3 times at different place:

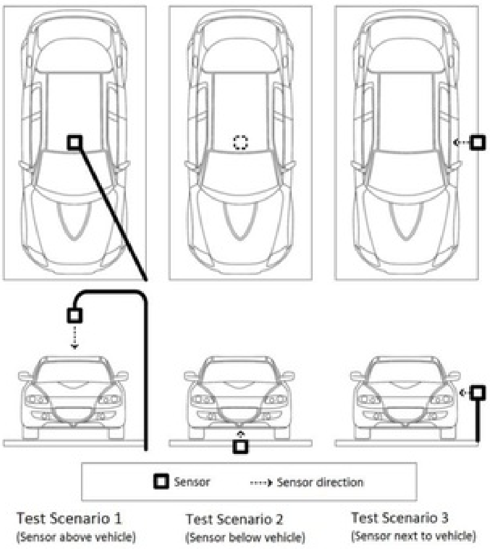

Fig. 11. Sensor Location Scenario

- Above testing vehicle, with sensor pointed down directly to the vehicle (270 degree to the horizon)
- Below testing vehicle, with sensor pointed up directly to the vehicle (90 degree to the horizon)
- Next to testing vehicle , with sensor pointed directly to the vehicle (180 degree to the horizon)

Sensor then placed at different distance with test vehicle to test its detection capability. The distance was set at 10 cm step, starting from 10 to 150 cm, except for test scenario 2 and 3, which is limited to 100 cm to the distance, since further than that, it is considered too far.

IV. TEST RESULT

Below are test result for each scenario. One indicated that the sensor could detect the car as zero indicated that the sensor cannot detect the car.

TABLE IV. TEST RESULT FOR PARALLAX PING SENSOR

No	Distance (cm)	Test Sc. 1	Test Sc. 2	Test Sc. 3
1	10	1	1	1
2	20	1	1	1
3	30	1	1	1
4	40	1	1	1
5	50	1	1	1
6	60	1	1	1
7	70	1	1	1
8	80	1	1	1
9	90	1	1	1
10	100	1	1	0
11	110	1	[redacted]	[redacted]
12	120	1	[redacted]	[redacted]
13	130	1	[redacted]	[redacted]
14	140	1	[redacted]	[redacted]
15	150	1	[redacted]	[redacted]

TABLE V. TEST RESULT SHARP IR SENSOR

No	Distance (cm)	Test Sc. 1	Test Sc. 2	Test Sc. 3
1	10	1	1	1
2	20	1	1	1
3	30	1	1	1
4	40	1	1	1
5	50	1	1	1
6	60	0	1	1
7	70	0	0	0

No	Distance (cm)	Test Sc. 1	Test Sc. 2	Test Sc. 3
8	80	0	0	0
9	90	0	0	0
10	100	0	[illegible]	0
11	110	0	[redacted]	[redacted]
12	120	0	[redacted]	[redacted]
13	130	0	[redacted]	[redacted]
14	140	0	[redacted]	[redacted]
15	150	0	[redacted]	[redacted]

TABLE VI. TEST RESULT FOR HC-SR04 SENSOR

No	Distance (cm)	Test Sc. 1	Test Sc. 2	Test Sc. 3
1	10	1	1	1
2	20	1	1	1
3	30	1	1	1
4	40	1	1	1
5	50	1	1	1
6	60	1	1	1
7	70	1	1	1
8	80	1	1	1
9	90	1	1	1
10	100	1	[illegible]	1
11	110	1	[redacted]	[redacted]
12	120	1	[redacted]	[redacted]
13	130	1	[redacted]	[redacted]
14	140	1	[redacted]	[redacted]
15	150	1	[redacted]	[redacted]

TABLE VII. TEST RESULT FOR CT-SL110 SENSOR

No	Distance (cm)	Test Sc. 2
1	10	1
2	20	1
3	30	1
4	40	1
5	50	1
6	60	1
7	70	1
8	80	1
9	90	1
10	100	1

V. CONCLUSIONS

HC-SR04 and PING sensor have identical performance, but HC-SR04 is more economical in price. Both can be placed above or under the vehicle, but it is more maintenance-less if placed above the vehicle. Sensor placed under the vehicle can be blocked by trashes, prone to liquid such as oil or water from radiator/air conditioner. At indoor parking, the sensor can be attached to the roof. For outdoor parking, under-vehicle sensor considered to be more esthetically better. When using this scenario, proper housing, sealing and routine maintenance should be performed.

CT-SL110 Sensor is more robust for detecting vehicle. It still can detect the vehicle even the sensor covered with object (simulating trash / oil / water). This sensor can be used for indoor or outdoor parking. Even though, this sensor require more power and more expensive than the other sensor tested.

All the sensors tested have response time under one second, but it is recommended that when a vehicle leave the parking space, the system have a delay around 10 to 20 seconds before setting the parking space's status to free. It is necessary to make sure that the vehicle really leaves the space.

ACKNOWLEDGMENT

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