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"Position and Velocity Estimation by Ultrasonic Sensor"

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Abstract: Velocity and position are the most important signals used in industrial controllers such as proportional–integral–derivative controllers. While in some real-time applications like structural control, acceleration measurements are easily accessible via accelerometers. The velocity and position have to be estimated from the measured acceleration. This project proposes a strategy to estimate the velocity and position of neighbor agents using distance measurements only.

I. INTRODUCTION

An ultrasonic sensor transmit ultrasonic waves into the air and detects reflected waves from an object. There are many applications for ultrasonic sensors, such as in intrusion alarm systems, automatic door openers and backup sensors for automobiles. Accompanied by the rapid development of information processing technology, new fields of application, such as factory automation equipment and car electronics, are increasing and should continue to do so. Using its unique piezoelectric ceramics manufacturing technology developed over many years.

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object. Since it is known that sound travels through air at about 344 m/s (1129ft/s), you can take the time for the sound wave to return and multiply it by 344 meters (or 1129 feet) to find the total round-trip distance of the sound wave. Round-trip means that the sound wave traveled 2 times the distance to the object before it was detected by the sensor; it includes the 'trip' from the sonar sensor to the object AND the 'trip' from the objectto the Ultrasonic sensor (after the sound wave bounced off the object). To find the distance to the object, simply divide the round-trip distance in half.

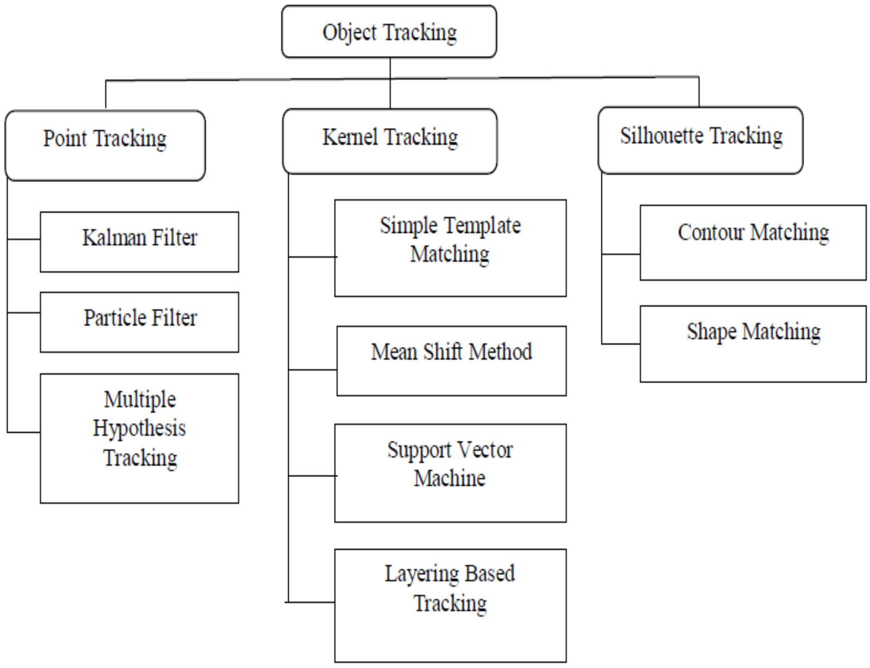
$$distance = \frac{speed\ of\ sound\ \times time\ taken}{2}$$

It is important to understand that some objects might not be detected by ultrasonic sensors. This is because some objects are shaped or positioned in such a way that the sound wave bounces off the object, but are deflected away from the ultrasonic sensor. It is also possible for the object to be too small to reflect enough of the sound wave back to the sensor to be detected. Other objects can absorb the sound wave all together (cloth, carpeting, etc.), which means that there is no wayfor the sensor to detect them accurately. These are important factors to consider when designing and programming a robot using an ultrasonic sensor.

Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. If they strike an object, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo.In this study , a room temperature of 20˚ C is assumed hence the velocity of ultrasound in the air is taken as 343m/s. because the travel distance is very short the travel time is little affected by temperature . it takes approximately 29.15µsec for the ultrasonic to propogate wave through 1cm distance; therefore it is possible to have 1cm resolution in the system.

II. EXISTING METHODS OF OBJECT TRACKING:

Tracking can be defined as the problem of approximating the path of an object in the image plane as it moves around a scene. The purpose of an object tracking is to generate the route for an object above time by finding its position in every single frame of the video. Object is tracked for object extraction, object recognition and tracking, and decisions about activities. Object tracking can be classified as point tracking, kernel based tracking and silhouette based tracking. For illustration, the point trackers involve detection in every frame, while geometric area or kernel based tracking or contours-based tracking require detection only when the object first appears in the scene. Tracking methods can be divided into following categories.



2.1 Point Tracking

In an image structure, moving objects are represented by their feature points during tracking. Point tracking is a complex problem particularly in the incidence of occlusions, false detections of object. Recognition can be done relatively simple, by thresholding, at of identification of these points.

2.2 Kernel Based Tracking

Kernel tracking is usually performed by computing the moving object, which is represented by an embryonic object region, from one frame to the next. The object motion is usually in the form of parametric motion such as translation, conformal, affine, etc.

These algorithms diverge in terms of the presence representation used, the number of objects tracked, and the method used for approximation the object motion. In real-time, illustration of object using geometric shape is common.

But one of the restrictions is that parts of the objects may be left outside of the defined shape while portions of the background may exist inside. This can be detected in rigid and non-rigid objects .They are large tracking techniques based on representation of object, object features ,appearance and shape of the object.

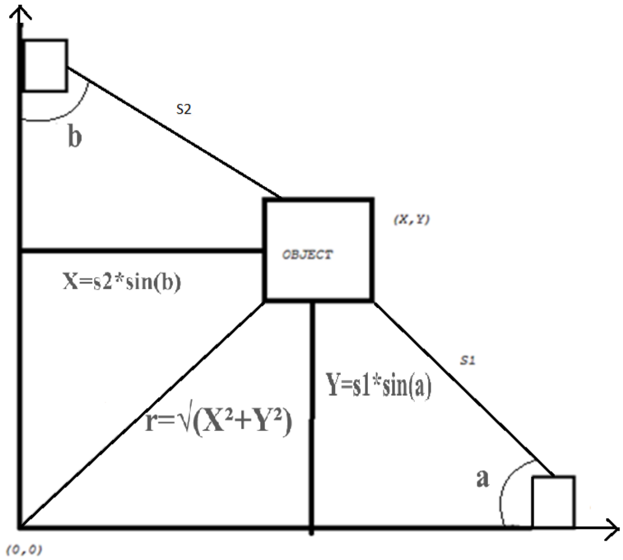
2.3 Silhouette Based Tracking Approach

Some object will have complex shape such as hand, fingers, shoulders that cannot be well defined by simple geometric shapes. Silhouette based methods afford an accurate shape description for the objects. The aim of a silhouette-based object tracking is to find the object region in every frame by means of an object model generated by the previous frames. Capable of dealing with variety of object shapes, Occlusion and object split and merge

III. FIGURES AND TABLES

3.1 Methodology

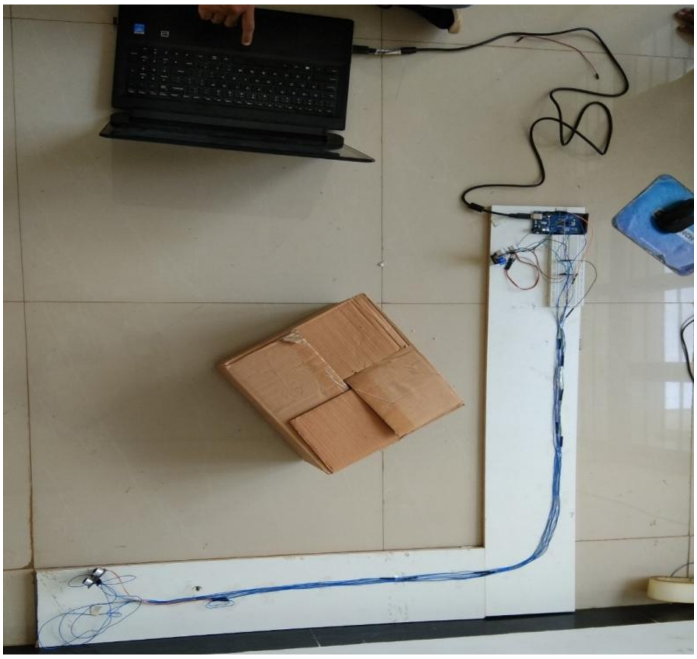
3.1.1 Model



S=(c*t)/2 cm
X=s2*sin(b) cm
Y=s1*sin(a) cm
r=√(x²+y²); velocity = Δd/ΔtΔd =change in position,
Δt =change in time
'a' and 'b' are angles(radian) made by servomotor present at X and Y axis respectively 's1' and 's2' are the distances of object(in cm) with respect to sensors present at x and y respectively.
r distance from origin (cm)
X horizontal distance (X-axis)
Y vertical distance (Yaxis)

3.1.2. Mathematical Model Implemented

Final using of ultrasonic sensor for finding distance is done by mounting ultrasonic sensor on a servomotor where two servomotors are used along with ultrasonic sensor placed at right angles to each other as shown below.



3.2 Position Estimation

Sl no.	Computer time	Time(ms)	S1 (cm)	S2 (cm)	X (cm)	Y (cm)	r(cm)	Angle 1	Angle 2
	A	B	C	D	E	F	G	H	I
20	13:37:53	106278.00	40.55	39.36	65.32	37.13	75.14	60	130
21	13:37:54	107287.00	40.14	42.55	34.08	38.1	51.12	70	120
22	13:37:55	108297.00	39.71	43.47	39.98	39.53	56.22	80	110
23	13:37:56	109306.00	-1	-1	-1	-1	-1	90	100
24	13:37:57	110319.00	40.9	41.94	125.61	39.41	131.65	100	90
25	13:37:58	111329.00	41.82	76.43	0	7.1	7.1	10	180
26	13:38:00	112339.00	66.98	36.47	13.27	14.3	19.51	20	170
27	13:38:01	113350.00	97.53	84.17	12.47	33.49	35.74	30	160
28	13:38:02	114366.00	-1	-1	-1	-1	-1	40	150
29	13:38:03	115381.00	65.26	39.29	54.7	103.5	117.07	50	140
30	13:38:04	116392.00	41.16	42.91	30.1	56.52	64.03	60	130
31	13:38:05	117401.00	40.27	39.42	37.16	38.67	53.63	70	120
32	13:38:06	118411.00	40.09	66.16	37.05	39.66	54.27	80	110
33	13:38:07	119421.00	40.19	40.31	65.16	40.09	76.5	90	100
34	13:38:08	120431.00	-1	-1	-1	-1	-1	100	90
35	13:38:09	121449.00	43.13	87.91	0	7.18	7.18	10	180
36	13:38:10	122461.00	95.1	35.02	15.26	14.75	21.23	20	170
37	13:38:11	123473.00	98.46	83.61	11.98	47.55	49.03	30	160
38	13:38:12	124488.00	-1	-1	-1	-1	-1	40	150
39	13:38:13	125504.00	65.98	39.61	54.86	102.32	116.1	50	140
40	13:38:14	126515.00	41.99	41.91	30.34	57.14	64.69	60	130
41	13:38:15	127524.00	40.24	39.58	36.29	39.46	53.61	70	120
42	13:38:16	128534.00	40.19	43.25	37.19	39.63	54.35	80	110
43	13:38:17	129543.00	40.19	51.99	42.59	40.19	58.56	90	100
44	13:38:18	130553.00	-1	-1	-1	-1	-1	100	90
45	13:38:19	131565.00	42.7	32.03	0	7.11	7.11	10	180
46	13:38:20	132574.00	-1	-1	-1	-1	-1	20	170
47	13:38:21	133595.00	-1	-1	-1	-1	-1	30	160
48	13:38:22	134609.00	59.4	68.15	42.19	86.34	96.1	40	150

3.3 Velocity Determination

Highlighted row indicates the position of object at two different cycles of rotation angles, the change in distance from origin indicates that the object has been displaced from one position to other positionVelocity found for object at two different positions Here velocity is found for marked readings using excel operations of row operation.

13:38:03	115381.00	65.26	39.29	54.7	103.5	117.07	50	140	
13:38:04	116392.00	41.16	42.91	30.1	56.52	64.03	60	130	
13:38:05	117401.00	40.27	39.42	37.16	38.67	53.63	70	120	0.00069
13:38:06	118411.00	40.09	66.16	37.05	39.66	54.27	80	110	
13:38:07	119421.00	40.19	40.31	65.16	40.09	76.5	90	100	
13:38:08	120431.00	-1	-1	-1	-1	-1	100	90	
13:38:09	121449.00	43.13	87.91	0	7.18	7.18	10	180	
13:38:10	122461.00	95.1	35.02	15.26	14.75	21.23	20	170	
13:38:11	123473.00	98.46	83.61	11.98	47.55	49.03	30	160	
13:38:12	124488.00	-1	-1	-1	-1	-1	40	150	
13:38:13	125504.00	65.98	39.61	54.86	102.32	116.1	50	140	
13:38:14	126515.00	41.99	41.91	30.34	57.14	64.69	60	130	
13:38:15	127524.00	40.24	39.58	36.29	39.46	60.61	70	120	
13:38:16	128534.00	40.19	43.25	37.19	39.63	54.35	80	110	
13:38:17	129543.00	40.19	51.99	42.59	40.19	58.56	90	100	
13:38:18	130553.00	-1	-1	-1	-1	-1	100	90	
13:38:19	131565.00	42.7	32.03	0	7.11	7.11	10	180	
13:38:20	132574.00	-1	-1	-1	-1	-1	20	170	
13:38:21	133595.00	-1	-1	-1	-1	-1	30	160	
13:38:22	134609.00	59.4	68.15	42.19	86.34	96.1	40	150	
13:38:23	135622.00	-1	-1	-1	-1	-1	50	140	
13:38:24	136635.00	41.89	41.79	31.12	116.41	120.5	60	130	
13:38:25	137645.00	40.12	41.48	36.19	39.36	53.47	70	=(G41-G51)/(B41-B51)	
13:38:26	138653.00	40.17	43.32	38.98	39.51	55.5	80	110	
13:38:27	139663.00	40.17	95.85	42.66	40.17	58.6	90	100	
13:38:28	140676.00	41.06	94.01	95.85	39.56	103.69	100	90	
13:38:29	141688.00	42.7	31.14	0	7.13	7.13	10	180	

IV. CONCLUSION

Hence by using two ultrasonic sensors mounted on servomotor placed each at right angles are able to give the approximately position and velocity in the given range. Hence velocity and position are estimated from the measured acceleration. Thus this project proposes a strategy to estimate the velocity and position of neighbor agents using distance measurements only.

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- Sensors and Actuator with Arduino
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- Interfacing Arduino with ultrasonic sensor along with servomotor
- Parallax data acquisition software
- Micro epsilon data for excisting distance sensors

Examples follow:
Journal Papers:

[1]. Ravichandran A and Dr. b Kalavathi Multi objects tracking methods based on particle filter and HMM , International Journal for trends in Engineering and technology volume 3 issue 1 –january 2015

Books:

[2]. Getting Started with Arduino(3rd edition)
-Massimo Banzico-founder of Arduino& Michael Shilo