Obstacle Avoidance through Sensors in Human Assist Autonomous Robot

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ABSTRACT
Anautonomous robot has been designed and developed as a human assistant for real-time situation. The autonomous robot is capable to performing different tasks for a human who is physically challenged and unable to move from one place to another. This robot can detect the avoid the obstacle in its path, the control system of robot uses ultrasonic sensor and image recognition to detect the range of the obstacle. The algorithm for obstacle avoidance used for this robot is described. Since the obstacle detection and avoidancedepends deeply on the range finder algorithm and performance of the sensors which are used in the system. The performance and outcome of the obstacle avoidance algorithm techniques are discussed in detail.

Keywords
Autonomous Robot, human assistant system,Sensors, Obstacle avoidance.

1. INTRODUCTION
This paper discusses variouskinds ofmovable robot classification, which is created as an assistant for constant support to meet thebasic needs. Such a machine, assess self-developedrules to many laid upindividuals as well as dipping the number of those in require of transportation and hospitalization regularpresence [12], [13]. The area of the robot would be normally indoor and outdoor plan surface, either in a sickbay or in the house corridor. The restriction is significant since the constant presence of the physically disabledperson being as a controller for the robot’s performance significantly facilitates the design of autonomous control system and make it extraprofitable with other comparable moving robots.
The autonomous robot is designed with three major subsystems: a movable trap, a sensor which is mounted on top of the robot and a computer based programmed system board post next to the physically challenged person. To interact wisely with its surroundings, the autonomous robot utilizes the following sensors and movable devices:

1) Three ultrasonic range finding sensors mounted on the robot chassis to detectobstacles and provide data to avoid obstacle;

2) Micro switchesclose to the robot bumpers to sense collision with obstacles that were not originate out by the array finders;

3) Incremental encoders attach to the wheels to check theincremental location of the robot;

4) Illumination source attach to the fortifications and a revolving light-detecting sensor situated on the robot to inform the complete location of the robot in the room;

5) Energy sensors included into the robot's gripper to make sure correctbehaviour of different objects;

6) A visual camera connects tosupportfor finding and acquirement of substance;

7) A speech detection unit to interpret verbal information intocomputer instructions.

The prototype of the movable autonomous robot is shown in Fig. 1. It comprises the trap which houses the computer command and the electronic hardware and a commercially accessible four-degrees-of-freedom (DOF) devise. The three ultrasonic sensors transceivers and the light-detecting feeler are close to regular of the manipulator such that they can turn about the perpendicular alignment. Fig. 1 also shows the versatile gripper with its included two-DOF strength sensor as well as the floor-level abundant with the micro switches.

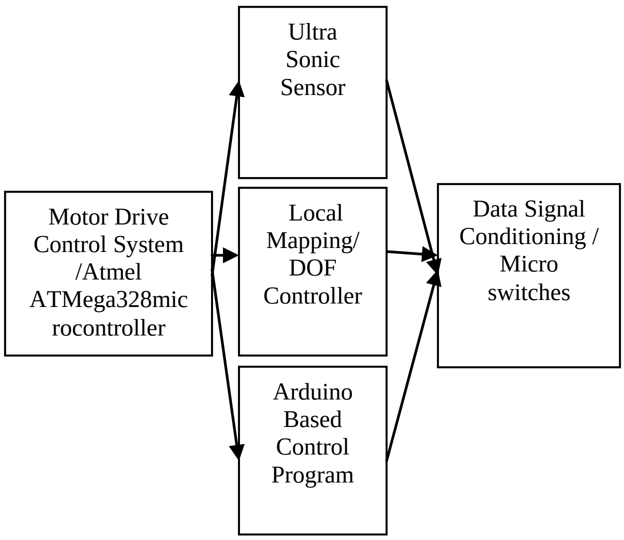

Figure.1. Block Diagram of Autonomous Robot

To move from one position A toanother position B, the autonomous robot operates according to the following approach. At first, the robot rotates about its centre awaiting the robot faces accurately into the track of B. Then the robot moves in a straight line forward awaiting it reaches point B, followed by an additional pure revolution about its centre until the system has the necessary final point of reference [4].
Any action between two specified locations is performed in this succession. The short fall of this technique is that it truly uses only two diverse kinds of action, either a action in a directly line, where both wheels run at the similar angular speed in the identical way, or a revolution about the robot interior, where mutually wheels run at the similar speed but in conflicting guidelines. This plan offers much compensation: it is

comparatively easy yet provides an efficient control structure; it avoids slippage of the wheels; the autonomous robot lane is always expected; and the robotalways engagement through the straight probable space [2].

2. RESTRICTIONS OF ULTRA SONIC SENSORS

Range measurements of Ultrasonic sensor suffer from some basic drawbacks which limit the effectiveness of these equipments in ranging or in any different task demanding high precision in a domestic atmosphere. This type of drawbacks is not linked to the invention of a exact manufacturer, but isintrinsic to the standard of ultrasonic sensor range provider and their regularly used wavelengths

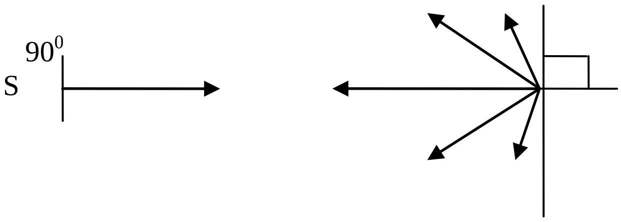

Figure.2. Reflections of sound influence from the flat surface vertical to acoustic axis

However ultrasonic sensor range finding devices play a significanttask in many robotics' applications [7], [11], [15], just a few researchers and scientistappear to pay concentration to their restrictions [12]. In this experimental work, one well recognizeddevice [8], [14], [15], [24], the Polaroid ultra sonic sensorranging kit, was used and expansively performance tested. This part performed up to our potential, except, thisis also subjected to the restrictions which are discussedin next section.

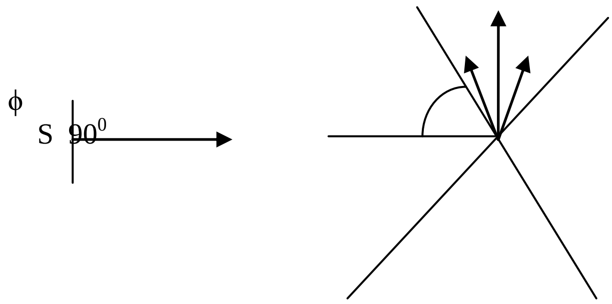

Figure.3. Reflections sound influence are not expected by transducer when angle ϕ is huge

Figure.2. shows one part of the wave frontage, emitted by the ultrasonic sensor transceiver Stoward a equivalent outside area of an obstacle for extra thorough conversation on emission characteristics of the ultrasonic sensor. Most of the echo power is reflected vertical to the surface and will be recognized by S,even as only a little proportion of the power is spread in other directions. However, if the surface of the obstacle is sloping comparative to the acoustic axis of Sas shown in Figure.3 then simply an unnoticeably little amount of power will be reflected toward S. For an autonomous robot function means the obstacle has been recognized/detected.

Obviously, the quantity of reflected echopower depends robustly on the surface formation of the obstacle. To acquireanextremely diffusivereflection from an obstacle, the dimension of the irregularities on thereflecting plane should be similar to the wavelength of the occurrenceecho waves [18]. Polaroid ranging unit, for the range finder sensors are

N = C/F = 340 m/s/50000 H_Z
= 6.8 mm

Were,
N, is the wavelength of the sensor,
C, 340m/s velocity of sound/echo waves;
F, 50 kH_z frequency of the sound/echo waves;

Unfortunately, the house atmosphere comprises mainly much smoother surfaces, such as wood furniture, walls, plastic items, etc. If sensors ranging frequency increases (the wavelength range decreases) of the resonance waves is restricted by the unwanted side effect of a superiorpower dissipation. The maximum angle of tilt ϕisshown in Figure. 3 for a consistentrecognition of a "flat" surface has been said to be about 30^0[15]. In this experimentdiscover that this angle may be increased to 40-45^0 by operational with superior gain of the receiver circuit, even though this causes a decrease in directionality of the measurement and occasional misreading of the calculated distances. However, the directionality problem is moderately accounted for the obstacle avoidance algorithm, whereas the sensor information are easily recognized since they always provide the straightcomputable distance, 25cm, instead of the real distance to the object. These misunderstanding may be leftover simply by discarding any sensor range observation of less than 30 cm. A minorboundary distance information is provided to permit the sensorscovering atmosphere after emission of a echorupture to decompose before the same covering is used to sense reflected echorays. Technically, the maximum value is implemented as a least amount of time interval surrounded by the receiver port is disabled. If the receiver gain is amplifiedexcessively, even approximately completedecomposedsensations will be realised at the end of the least time interval and interpreted as areverberation. A lesseredge on the computable distance must always survive when a transceiver, rather than disconnect transmitter and receiver, is used in the working circuit.

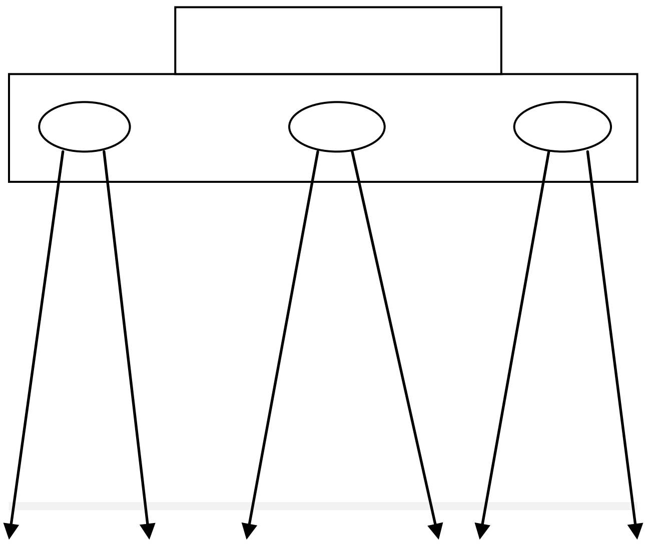

Figure.4. Scan Area by three sensors mounted on top of the Robot

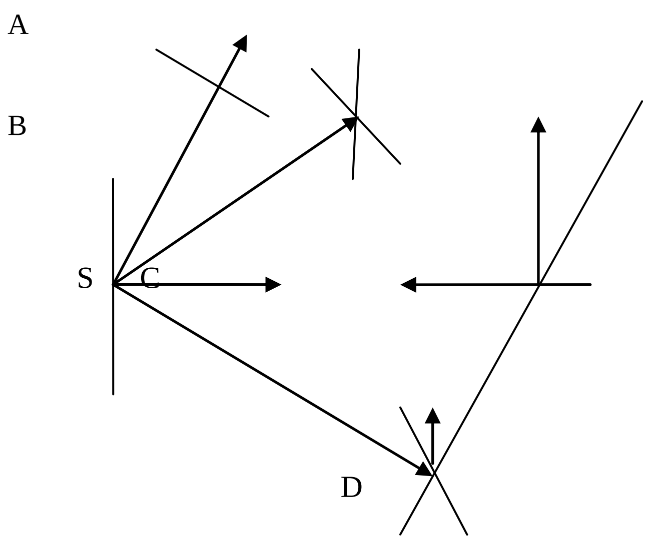

Figure.5. Directional ambiguity for different obstacles due to wide- angle emission cone

Another problem comes when the path to anassured obstacle has to be originatingexactly. The sound wave emission cone is depicted as shown in Figure. 4. The cone has an aperture angle of about 20-30^0, with rising energy substance towards the sound axis. Figure. 5.shows two problems connected to this piece of information. Obstacle Ais at the edge of the acoustic cone and therefore receives only a little quantity of power from S,while its orientation is at a 90-degree angle to the incident echo waves, consequential in finest reflection. Obstacle B,on the other hand, receives extra power from S,being nearer to the audio axis, but the reflection is reduced since of the critical orientation. Therefore, it is not relatively clear that every obstacle or all of the obstacles is detected. A comparable difficulty arises at *C* and D. Here C is on the audio axis but has a less constructive orientation then D. Inthis situation, neither the way nor the distance to the obstacle can be resolute/found exactly.

Clearly, the final conclusion of the problems can be minimized by recovering the directionality of the sensor (i.e., reduction the emission cone). This may be achieved by design a special appliance such as audiolenses [21], [22], [23], or by utilizing communication channel especially designed for high directionality. However, if a broad "field of sight was required, as is the case with a autonomous robot that has to constantly scan the technique in frontage of it, a huge number of "thin beam" the channel (each one indicating into a different direction) would be compulsory. For this function, various designs are known that use [11], and even [20] or [21] ultrasonic range finder sensors.

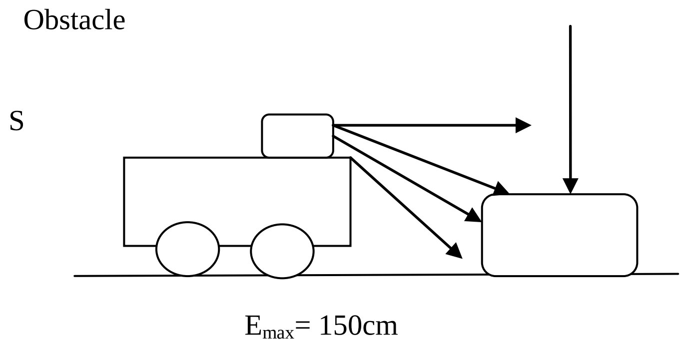

Figure.6. Sensors pointing to detect obstacles on plan surface add uncertainty regarding actual distance to obstacle

In this experimental robot there are only three (rather "wide-angle") communication channel connected to both sides of the area" combined of the manipulator, as shown in Figure. 4. The sensors are mounted at an angle of 35^0 with the prospect which is necessary to sense the obstacles on the smooth surface. This level increases the ambiguity in measurements of distance and direction of obstacles as shown in Figure. 6. Upon detecting aboundaryA,the autonomous robot measures the distance SA which is observably greater than the authentic distance between the robot and the obstacle. Experiments with accidentallyselectedhousehold objects (e.g., table, chair, wall, bed etc.) yielded inaccuracies in the positionof a substance upright boundary of up to 50 cm.

3. THE ULTRASONIC SENSOR IN THE HUMAN ASSIST ROBOT

The movable autonomous robot attempts to achieve any specified aim surrounded in a room without the disabled human interfering. For this reason, a "map" of the motionless obstacles (e.g., table, chair, walls, beds, etc.) is feed into the assisted robot record during a preliminary setup stage, when the autonomous robot is introduced to a new situation. However, additional obstacles (e.g., chairs, tables, bed etc.) may unpredictably block the path of the robot and must then be detected by sensors. In the human assist robot, bumpers with integrated switches as well as the three ultrasonic range finder sensors serve this idea. The final operation of the robot is used in two different modes of operation: scanning mode and measuring mode.

1) **Scanning Mode**

Whenever the autonomous robot moves straight or forward in a plan surface, the scanning mode starts operation. In this mode, range measurement is alternately sampled from allsensors approximately every 50 ms (this corresponds to about 3.2 cm of the human assist robot straight-line trek at highest speed). In this experiment "obstacle alarm" is designed for the robot when the following test results in an "exact":

IF $T_i(k) < UE$ AND $T_i(k) \leq T_i(k-1)$ THEN ALARM

Where, UE, threshold
T_i (k), range reading of communication channel i,
T_i (k-1), previous range reading of communication channel i.

The value for UEhas been determined experimentally as 150 cm, which is 25 cm less than the maximal computable distance (E max in Figure. 6). The rational meaning of an "exact" result for the test is that some obstacle is obstructing the sensors "vision" to the surfaceand that the autonomous robot is getting nearer to this obstacle. This algorithm has verified very efficient in eliminating wrong readings that may arise for different reasons.

2) **Measuring Mode**

The ultrasonic range finder sensors are used in the measuring mode, after the robot has stopped in response to an "obstacle alarm," In this method the robot rotates its joint frame with the ultrasonic sensors connectedto it 80^0 to the left, back to 0^0 and then 80^0 to the right and samples scope readings each2^0. A close-to-far evolution between successivecollections of readings, passing the threshold level of 120 cm indicates the occurrence of aboundary. Since there could be numerous closely located obstacles, the previous detected boundary is measured the only suitable one, thus lumping jointly all directlylocated obstacles. This is reasonable since the autonomous robot could not exceed between these obstacles in any case. If no boundary is detected when scanning to the left or to the right, this situation may arise when the autonomous robot is in front ofa wall, then aboundary is supposed at the tremendous left or right, consequently. Figure. 7shows the experimental results of a left scan, where the autonomous robot is partlyopposite a upright wall (Elmira). As the sensor S_1 is swivelled straight about the centre point C on the path p then it find therange of the obstacle which taken every 3^0. After recalculation of calculated distances to account for the 45^0 tilt of the sensor, as well as for distinction in real distance to the wall, because of path p,points 1-12 are found. Points 1-9 represent reflections from the wall, whereas points 10-12 result from reflections from the floor at the maximal distance D = 150 cm. The close-to- far evolution occurs after point 9, which is therefore acknowledged as the obstacles "left" boundary. Only this point is engaged in recall. A succeeding right scan outcomes are not plotted· in Figure. 7. sampling range readings from sensor S_3 would expose the "right" boundary of the obstacle.

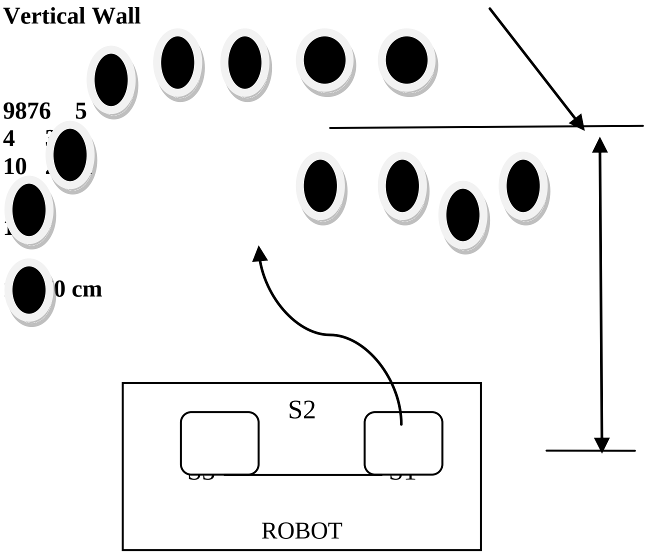

Figure.7. Typical scan of vertical obstacle

There must always be two limits to add an access to the impermanent map. Before applying the latest edge coordinates to the map, the coordinates are distorted to artificially expand the obstacle edge. The formation of the map, as well as the finest path-finding algorithm mentioned afterwards, is widely described in a current research work [5]. This algorithm finds a best possible route (in terms of space) through a area with identified obstacles. Clearly, if the autonomous robot encounters an unpredicted obstacle, optimality can no longer be certain. However, successive application of the path-planning algorithm will take into version the extra obstacle limitations.

4. OBSTACLE AVOIDANCE BASED ON INCORRECT SENSORY DATA

The obstacle avoidance algorithm is finest described with the support of a case. One a lesser amount of successful experiment was selected to imagine as lots of the self-correcting qualities which compose the fundamental design of this algorithm as achievable.

Figure. 8. shows the inactive map of our laboratory (as different to the provisional map which will be extra later as unpredicted obstacles are detected [19]). An X-Y Coordinatestructure is attached to two of the walls. In this case, the walls and one permanent obstacle (a laboratory table) are known to the robot system in proceed (hard lines in Figure. 8). In the computer demonstration the obstacle borders are extended by changing them parallel to the actualborders by a distance equivalent to half the thickness of the robot plus 15 cm as a securityissue. This demonstration is called the organizationroom method [6], [10], [18], [22] and permit the robot tomeasuredminimum distance point. The Figure.8,shows the comer points are numbered and provide as through points for best possible path calculations. Also in Figure. 8, the autonomous robot is shown as viewed from the peak, with its horizontal side pointing forward.

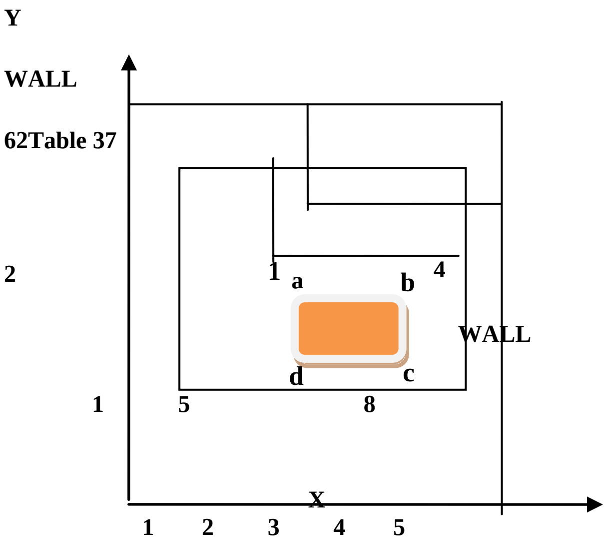

Figure.8. Map of static obstacles

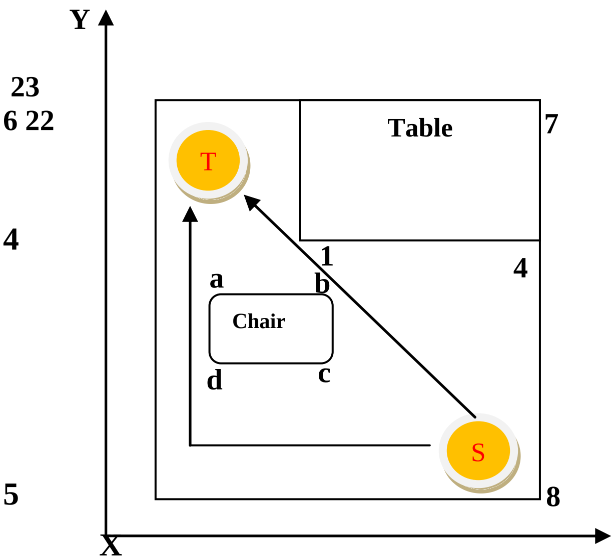

Figure.9. Experimental test of Robot with unexpected obstacles in indoor situation

Figure. 9 discuss about the "history" of the experimental trial of autonomous robot. The experimental test of robot is performed from starting point S to move Target point or final destination point T,but a chair was placed in its path, as shown in Figure. 9. Upon getting the command, the robot turns on the spot (about its centre point), until it towards into the direction of T. Then the robot moves on a straight line toward T. At this time the robot is uninformed about the obstacle (the chair, which is plotted in its realdimension as the rectangle in Figure. 9). At point A the ultrasonic sensor detects the occurrence of the obstacle, and the robot stops. The measuring mode is activated and yields the extended boundary line 9-10. Then, the path-finding routine [5] is called, which suggests detouring the obstacle through 10 to T. The robot moves to 11, turns there until it faces T, and starts moving towards T. Immediately, the ultrasonic sensors concern another "obstacle alarm" and the robot stops at B.Again the obstacle is scanned, this time from a more favourable angle, and the robot comes up with an extraedge line 11-12. This time the path-finding schedule suggests exceeding through 12 to T. Following this way, the robot effectively reaches its target.

The experiment is easily explained that what had happened during test. The first scan of the obstacle by robot, from point A,the sensors get signal only from comer of the obstacle, whereas sides adand ab, due to their poor angle relation to the sensors, did not create a measurable indication. Thus, both the ends were (imperfectly) initiate to be close to a.Therefore, points 9 and 10, which stand for the boundaries after extension, are too near to the actual margins of the obstacle to permit the autonomous robot to effectively detour it. On the other hand, when screening the obstacle from B,side abcreated a fine indication, and the real boundaries aand bwere originated more precisely (and extensive to points 11 and 12).

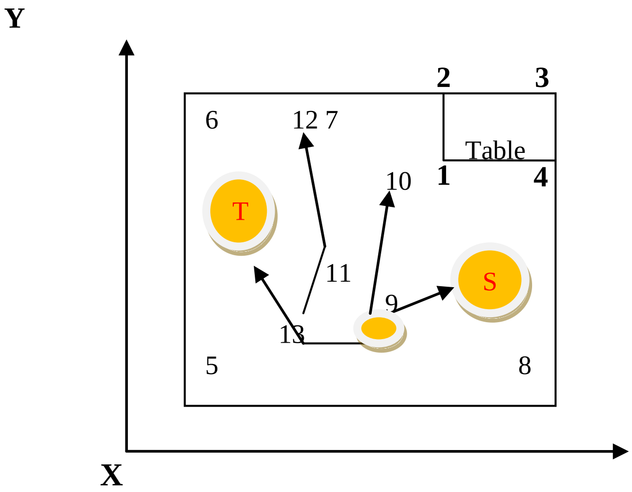

Figure.10. Collision recovery in indoor performance test

Finally, the robot achieved its target from source S to destination point T; it was set in the control command to return back to its previous initial point. The past of this drive is illustrated in Figure. 10. Since boundary points 9-10 and 11-12 are now recognized to the robot central processing unit, the path-planning algorithm takes them into reflection and determines the shortest path to Sto pass through 9. The robot starts its movement by turning on the spot at Suntil it faces point 9, and then starts moving straight forward toward 9. However, the outward pointing legs of the chair are not detected by the ultrasonic range finder sensor, and the robot hits the obstacle with the leftmost part of its front bumper. Notified by the microswitch connected to the bumper, the robot stops within a short distance which is lesser than the distance between bumper and robot body. This, together with the energy-absorbing design of the bumpers, keeps the wheel slippage slightly low (thus retaining strength of inside location in turn), sometime the obstacle hit with its maximum speed. Then, the robot action is very fast and it avoids the collision in very short time. Effective collision recovery schedule moving 40 cm in reverse, turning 35^0 the right, and moving 60 cm straight way. This schedule of the performance test has been found experimentally to be the most effective. Upon carrying out these motions, the robot reaches point 13, well outside of the danger zone. Standing at 13, the path planning algorithm suggests passing through 9 to S,and the robot certainlyachieve its final destination point successively.

Thrashing an obstacle with the robot chassis obviously shows that the obstacle has been mapped incorrectly. Knowledge from past experience, a new limit generate, accounting for this incidence, should be added to themap. The new limit line is defined by point 13 and the boundary neighbouring to this position, point 11.

In an extra performance test runs the robot to move to point Tagain. Based on its formerly acquired information of the obstacle,the path-planning schedule suggests 9-13-T as the smallestachievable path, and the robot reaches Twithout any interruptions.

While theearliercase is considered as a less successful run, there were even bad experiments, especially when numerous "hard-to-detect" variety of obstacles were spottedabout in such a way that the free space between them was about the dimension of the robot thickness. In these cases the collision improvement algorithm showed aninclination to let the robot swing between the obstacles, adding more and more limitations to the map. Since the number of limits in the map advertently influences the calculation time of the path-planning algorithm, it would take the robot numerous minutes to work its approachapproximatelyto the obstacles. To avoid such situations, another algorithm has been included in the program. If the robot found itself cut off from the goal by too many limits, the algorithm would basically wipe out the temporary map and the robot would try all over again. It should be stressed, however, that these are rare cases, caused by artificially produced tremendousproblems aimed at testing the recursively implementationrevival routines. Recursion in this case lends the robot a somewhat inflexibleperformance which leads it, at times after substantialeffort, to its target.

5. CONCLUSIONS

This paper discusses the obstacle avoidance algorithm used for a movable prototype human assist robot. Since the algorithm depends deeply on the experimental test of the ultrasonic range finder sensors, these sensors and the outcome of their restrictions on the obstacle avoidance algorithm were discussed in detail as well as the performance test performed in laboratory.

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