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HUMAN FOLLOWING ROBOT

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***ABSTRACT* – In this modern age, due to its abundant applications in everyday life and manufacturing, Human Following robots have been researched and actively developed over the decades. Different techniques such as robot control algorithm, human target detection, and obstacle avoidance are necessary for the human robot to execute. Several human-following robotic procedures have been suggested, such as the use of ultrasonic sensors, infrared sensors, laser range sensor, voice recognition sensor camera charging-coupled devices (CCD) and so on. These technologies can detect the particular location between a mobile robot and a human. In this paper, we present a new approach to detecting the location of a human robot using an ultrasonic & infrared camera, which is the fundamental technique in the robot's human follow-up. In our project, the robot is equipped with an ultrasonic sensor which captures and detects an individual. A simple application implemented in real time using a PI controller shows some advantages of the proposed method.**

Keywords- LRF, Microcontroller, Acoustic Signal, Arduino UNO, Accelerometer [8]

I. INTRODUCTION

A Human Following robot is simply a robot which follows a human and gives assistance. The motive of the project is to make a robot that can follow and work together with humans, as running companions or carrier or travel guides. In a way the robots will have evolved from workers into our friends. Interaction between robots and people is a significant of human following capability.

The robot is follow a person within a certain range, robots and autonomous vehicles use human following techniques. The most significant factor in this case is interaction between the human and robot where different sensors and programs which ensure its functioning. In paper we will we discuss a robot system that utilizes ultrasonic and IR sensors for human following [1]. Ultrasonic sensors is generally used due to its large detection area, smaller in size, less in weight, not much light dependency, the prowess to detect shining wall and glass, uses a very low memory, low cost than laser detection gadget or camera and has low power consumption. The Ultrasonic, IR and other components are mounted on a four wheel robot platform [2].

Fig.1- A robot following a human [2]

In fig. 1 we explain daily motion of human and object and is Based on their specific purpose, mostly human following robots are equipped with many different combination of sensors like Ultrasonic and IR, light detection and ranging sensors, camera, radio frequency identification module (RFID), thermal imaging sensors, wireless transmitter/receiver, laser range finder (LFR) etc. for recognition and locating the target. Program used in the robot ensures all the sensors and modules to work simultaneously to detect and follow any target (human or vehicle).

The capability of a robot to track and follow a moving object can be used for various purposes:

- To create ease for people.
- To help humans.
- Can be used for defense purpose.

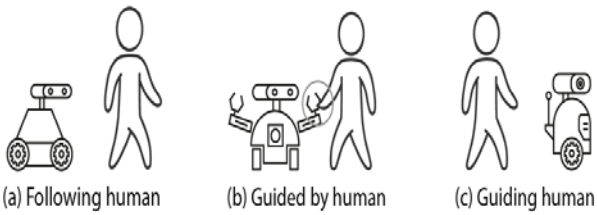


Fig.2 - A picture representing different applications of Human following robot. [6]

In this fig 2, we present a method of Human following Robot based on detection and identification of human by using Ultrasonic and IR sensors. Different sensors and modules are used to carry out intelligent tracking of specified target i.e. Design and development of Human Following Robot, Ultrasonic and IR Sensor, Network, Motor Drive and

Artmega. Robot control unit on the basis of information obtained from sensors and modules makes intelligent decision for tracking and finding specific object by avoiding hurdles and obstacles without colliding with the target. We have also discussed the problems in vision based human tracking and proposed solutions on how to fix or counter them.

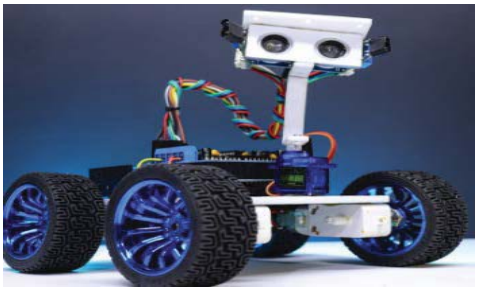


Fig.3- Prototype model of a Human Following Robot [10]

In Fig 3. Shows basic physical model of our robot Practically, Remote control have several possibilities. Frequently, Robots are controlled using control panel that requires certain skill but even skilled operator may need to keep one eye at panel and other at the process and this is a problem. Unfortunately this type of operation is slow and can risk in quick reactions and for this we need an intelligent robot system that can work fast on its own during human following.

II. RELATED WORK

Human Following Robot falls under the category of 'Assisting Robots' and lot of research have by done so far .Diverse logic and algorithms are implemented by people. The main focus of all these people has been entirely on to design a robot that follows the target/human [3].

For the detection process, Researchers have developed various algorithms and used different sensors. In some research, laser was used to detect the movement of legs and camera was used to detect a particular person or object [4]. In other case, a very simple technique of using distance sensor on person and robot was used. Radio waves were emitted by the sensor and were detected by the sensors on the person to be followed and by this way required target is followed by the robot [5].

A researcher, Burgard in his tour guide used laser sensor for human tracking. D. Schulz incorporated LRF to perform the, following'' [6]. Information linking for the detection was performed by using above mentioned process. By using LRF, a technique for pointing out different styles is used by 'Nicola', 'Husing'. Songmin Jia used Depth imagining to carry out the detection. The depth imagining is used to determine the model of a person [7]. ''Mehrez Kristou' used particular style of clothing and using a multi-directional camera. 'Wilhelm' conducted a research with the focus on the color of particular person's skin. In this research information from different sensors is also used [8].

Two stereo cameras for image capturing is used by researchers in the journal (Z. Chen). Using stereo based Lucas-Kanade approach, analysis is done on the two captured images. For vision based-capture, the human following robot uses 'Binocular Sparse Feature Segmentation (BSFS)[9]. The BSFS algorithm detect and track the feature points in the images and calculate the sparse disparity map and then remove the disparity from the images by using Lucas-Kanade approach. Random sample consensus approach is a technique that calculates the motion of the target in a static background using the match point of the two images [10]. The stereo and motion information that obtained from the approaches are fused, then the BSFS algorithm separates the moving target from the static background [11]. This entire system does not use color-based approach, it uses only gray level information and the targeted person does not necessary have to wear different color clothes to differ from the background. Face detection algorithm is also included into the robot to increase the accuracy of tracking, although the target person does not necessary facing the human following robot [11].

As for the research (J. Satake, 2012), the researchers built a human following robot which uses motion stereo camera that tracking the targeted person using depth templates. In this system, the researchers uses three types of template which is in different direction to the body[12]. The depth templates use the depth image which captures by the camera where the targeted person is 2m away. Extended Kalman filter (EKF) tracker is being used for tracking a target person by providing predicted scene positions. This tracker will check continuously whether there is new objects appear in the image. Besides that, support vector machine (SVM) based is being used to remove the false detection from other object with similar characteristic to the target person [13]. The color detection is included, but when the human following robot is in a low light & surroundings, the robot cannot detect and differentiate between two or more person with similar color clothes. To overcome this problem, scale invariant feature transform (SIFT) is being introduced. SIFT feature is an image feature that is powerful in scaling and rotation in the image plane and also resistant to lighting condition. The error point from the SIFT in the image is being filtered by the Random Sample Consensus. The SIFT feature decreases when the distance of the target person with the camera increases. To solve this problem, the distance of the camera and the target person is being set to limit the decrease of SIFT features [14].

III. COMPONENTS USED

Our Human Following Robot system consists of a four-wheel robotic vehicle mounted with a separate microprocessor and control unit along with various sensors and modules i.e. infrared & ultrasonic sensor, magnetometer which is shown in fig 4.

For efficient use' the hardware chosen for the system include:

Microcontroller: The hardware platform used is an Arduino microcontroller. It is base where all components is attached like (Accelerometers, Motors, and Bluetooth etc.) and also controlling. Two more microcontrollers is used in project, where Arduino Mega is used for Voice control and Arduino Uno is used for the gesture control. All these microcontrollers is also attached to one another for proper functioning.

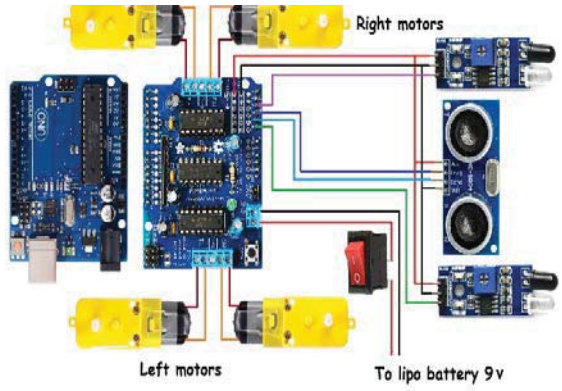


Fig .4- A picture showing components of human following robot and their connections. [17]

Bluetooth Module: The chosen Core module was a Bluetooth 2.0 HC-05 module. Bluetooth functionality can be easily applied to Arduino projects with the use of this Bluetooth module. Slave mode is the default setting, but it can be set to master mode to allow other Bluetooth devices to be attached. The simple Bluetooth 2.0 module, which is not cooperative with iPhone or iPod, receives and sends instraction from the application to the controller on the mobile device.

Accelerometer: The ADXL345 accelerometer used in the project is a lightweight, thin, low-power, high-resolution (13-bit) 3-axis accelerometer measuring up to ±16 g. For mobile device applications, the accelerometer is well suited. ADXL345 tests the static acceleration of gravity in tilt-sensing systems, as well as the dynamic acceleration resulting from movement or shock. Because of its high resolution (4 mg/LSB), it makes the calculation of inclination shifts of less than 1.0°.[15]

Motor Driver: Brian Schmaltz engineered the Easy Driver and it is based around the A3967 IC. This IC can drive bipolar stepper motors with 4, 6 or 8-wire configurations. With either 3.3V or 5V systems, the board can work, making it incredibly flexible. Two mounting holes are on-board for the user to stabilize the Easy Driver mechanically.

Stepper Motors: A stepper motor is a brushless DC electric motor that divides a complete rotation into a number of equal stages, also known as a phase motor or stepping motor. We used two different types of stepper motors.

Ultrasonic Sensors**:** US sensors are used to detect the human and its movements.

Infrared Sensors: IR Sensors are used to detect obstacles and void them while following the human.

Servo Motors: A servomotor is a rotary actuator or linear actuator that allows the angular or linear position, velocity and acceleration to be precisely controlled. It consists of an appropriate motor coupled to the sensor for position feedback. Servo Motors are used so that sensors can rotate in both directions.

Platform: The base on which the Robot was fitted was simply the platform. The device was equipped with Stepper Motors and its function is provided by the user's gesture command, thus moving the whole robot from different position.

Aims and Objectives

The main objective of this project is as following:

- To design and build a human following robot.
- To assist and tracking a specific human in a safe distance.
- To make sure that the human following robot follow the right person.

IV. METHODOLOGY

A robot for those who can identify / see a person called a person by following a robot. The next human robot needs a link between itself and the person to provide help / assistance for example the best freight robot helps to carry cargo to the airport. Development of a robot that cleans cell phones to recognize and track sound source with microphones without the private request of the next robot to be able to carry goods, as well as supermarkets, home, office or golf.[15]

Avoiding human carrier obstruction maintains a certain distance from the body and building the transmission connections between the microprocessor and the controller are the key elements of the project. In fig 5 we have shown basic algorithm of human following robot.

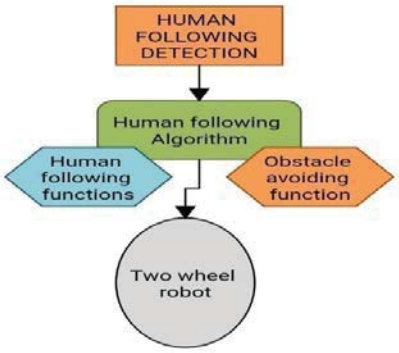


Fig.5- Block Diagram of working of human following robot. [14]

*ALGORITHM

NOVEL VISION BASED ALGORITHM FOR HUMAN FOLLOWING ROBOT

The tracking algorithm has features such as speeding up a powerful feature to find a person under a different difficult situation. For example, lighting variations, switching changes, partial blockage, and sudden / unexpected camera movements. The contribution of the novel to the tracking algorithm are1) A variable object / model that changes over time to deal with small changes, while maintaining stability goes on for a long time. 2) The KD online-based tree separator and kalman filter are used to distinguish the case for the change of exposure from the state of full proximity to the absolute proximity and 3) It is suggested how to detect the transition change due to flight rotation, which is an important obstacle leading to failure to track the next human robot. A reversible type of visual servo controller that uses feedback, line alignment to overcome the roar that exists in the use of a controller based on the forward mode. Satisfaction and real-life testing with a, unambiguous platform of a moving robot.

*Arduino Language Reference:

The language of Arduino is based on the language of C and C ++. C is known as the Arduino compiler in the accepted C; rather, a strong subset of standard C. There are not a few accepted features of C, but the lack of those features does not in any way disable it. Arduino C, it's worth doing almost any job you can throw at it. Lost features can be easily manipulated, or sometimes misplaced. Arduino systems can be divided into three main components: structure[16].

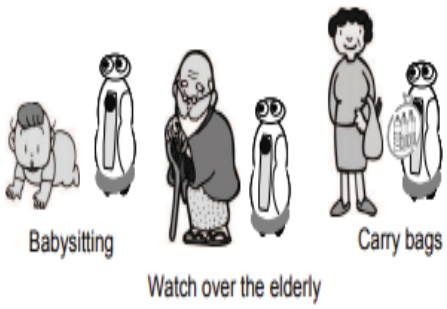


Fig.6- Work that can be made easy with the help of robots. [7]

In fig 6. Shows how robot can detect and response to see different type of people.

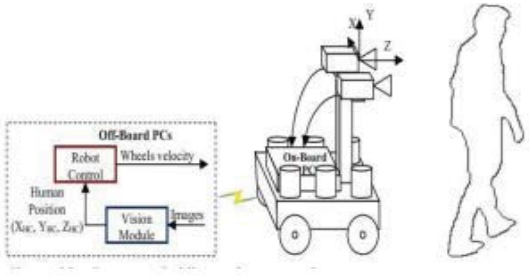
First Phase for working model

This robot has a mixture of benefits for human and it can also be used in different industrial applications. The robot, is not so advanced that it can take action without any instruction, so it requires a system to make decisions accordingly to take quick response so that the different work can be operate correctly. The installed function is a sensor that can sense restrictions or objects around the area itself. It is possible to mount a range of sensors such as lasers, radio frequencies, cameras and others that can monitor humans with the mobile robot itself at a constant distance. Waves in the sensor are used for detection by the robot. The sound wave moves at a certain frequency and returns when it detects a thing in real time to determine distance. It has its flaws, and detecting an object may be a challenge for the sensor since the sensor operates on a specular basis, which means that it is not a narrow scan angle. Therefore, in order to monitor an object, a precision and correct operation needs to be performed. The ultrasonic sensor is a very less amount device which capable of performing in any low visibility environment/atmosphere where interaction or laser range scanner is not effective. Using pulse, echo in real time, the ultrasonic sensor is design to calculate distance from itself to the particular object. Unlike other sensors, the ultrasonic sensor offers knowledge about the presence of objects in front of the sensor, but it is a very first-rate sensor that uses ultrasonic sensors to switch to various locations [17]. The ultrasonic sensor is used for leg recognition in robots. The position and several sensors were designed to simultaneously identify both human legs and follow the body. These sensors is for the detection of man legs and their interference is used to distinguish the different pair of legs so that it can operate smoothly. E.g.-Each sensor data is analyzed using likelihood and the algorithm to detect and recognize person legs is created. From here, the robot was able to follow both human legs as it could recall them. Then the working of the human following robot is examine.

Second Phase for working model

This paper helps us to describe the project and tell us how we should proceed with how we use the robot. The robot consists of ultrasonic & Infra-Red scanners at the top, at a distance of 108 cm above the ground to detect the target's waist. In accordance with this setting, a control system is developed as shown in Fig., divided into two parts: (1) The Acquisition Activity and (2) The Person Tracking Algorithm, which includes a Person Tracking Activity and a Prevention Work Obstacle, including Personal Tracking Activity and Activity Avoidance Barrier. Three parts of the ultrasonic sensor are used to track the tracking of both human leg. The theory is that at a certain distance, the nerves are arranged upwards, at which point this will be the average width of the legs of a person when a person walks normally [18]. The fundamental principle of the ultrasonic sensor arrangement in which the human legs are felt inside the grip region is shown in the figure. In sensory placement, there are two modes, the first is when there is a sensor signal between sensor 1 and sensor 2, the systems tell the robot what the human left leg means, while the system detects the right leg when there is a sensor signal between sensor 2 and sensor 3. The assembly of all the cut Perspex is then carried out according to the specification and attached using screws and nuts. In the center of the platform, one sensor is placed, while the other two are located on the right and left of the central sensor. By changing the angle, it is easy to improve the alignment of the algorithm.

The next human robotic system consists of independent processing and contract unit which is shown in fig 7. The main use of the camera is also integrated with the unit to control the sequence of visible information after the mass processing. The control unit is connected sequentially to the process and enables the use of several sensors and module eg ultra sonic sensor, magnetometer and infrared sensor. [18]The sensor and the camera above work in close proximity to each other and use the robot to operate and navigate its path by examining the barriers set in the concrete distance from the object. The decision is based on the construction of information from all of the above senses. Following the acquisition of the tag the next step is to establish a serial connection between the processor control unit. In this section of the tag link point section is passed sequentially to arduino for further reference. The next step is to integrate the required modules and sensors with the control unit. For this purpose we have used an ultrasonic sensor to protect the barriers and maintain the concrete distance of the object. The ultrasonic sensor operates accurately for four meters. Ultrasonic sensor works by calculating time difference. The final stage consists of mixing all the information received by the sensors and modules in the control unit which is why, the control unit makes a wise decision to transfer the direction of the robot and return to its path.[19]



Human Following Robotic System.

Fig.7 Human following robotic system [19]

FeatureExtraction A variety of techniques, such as shape or location, orientation and kineticism of the body, may reflect human gesture. This work focuses on the kineticism of the upper limbs, which is crucial for gesture apperception, particularly the left arm kineticism called good features.

Data Pre-processing In the training phase data processing begins with two steps, the percentage division the figure separation to separate the training data from the raw data.

Hidden Markov ***Models*** Low-frequency human mobility modeling (HMMs) acts as a representation of many simple movements so that certain simple movements are observable in a space narrowed by the trajectories of the movement parameters. HMM is a type of a mathematical model.

Recognition Phase In the recognition phase, we tested HMMs trained with two separate test subjects, a participatory study in the training phase, and one that did not follow the robot operating system (ROS) frame work for real-time operation. One of the advantages of the ROS frame work is that the system, built using ROS, contains several processors that can be present in different congregations. The performance of the system can be increased by this same processing framework.

Processing **Image** correction begins with image acquisition, hand splitting, morphological filtering, palm direction and feature removal by creating a binding box around the arm with parts, after taking the picture, the hand is separated from the rest of the image by using the limit value calculated in the Otsu method. In this process a binary image is obtained.[20]

Obstacle Avoidance Control In the case of movements, by image processing and the CRF sensing device, the robot detects a target individual and detects any barrier in its path with the help of ultrasonic sensor . When any barrier detected by an ultrasonic sensor in the path of a robot the robot change its path and then attempts to proceed to pursue the individual through the sensor, so that the robot preserves its visible and detects a particular person the avoidance control mechanism to the degree of freedom of its head.

V. VISION-BASEDTTRACKINGTALGORITHM

A. *Feature Parameters for Target Person Detection*

The most challenging thing for the robot is to follow the desired person and to follow a target person, to install a feature which identifies the target person. It be comes a disadvantage or may create a problem for robot to detect a target person because to detect a moving person becomes difficult for the robot both are moving. The color detected by robot may change in lightening

Dynamic Switching of Feature Parameters for Ta rget Person Detection

In case the most appropriate feature parameter to get the one person motionless. To follow a moving object/person we have introduced a way to drastically change the parameter of feature. New method introduced selects and change the appropriate character parameter to find the most targeted person depending upon the input image and achieves a strong target acquisition.

*Vision-based tracking problem

The two important parameter frame rate and image processing play a major role in determining the kinematic efficiency of movement of robot when robotics is handled by feedback using the image processing effect where situation occur of low frame rate is the same as that in which the sample rate of sensor is low. It becomes difficult to reach the individual after the output of the fast moving object when the response is magnified to a minimum.[20]

The effect of processing image data has a big influence on subsequent success in visual tracking. Second, this is one of the most significant variables in deciding if a monitoring object is correctly identified Even if he fails to get anything right, however. Other things can affect the person who follows the process..

Countering the vision-based problems

Sometimes in a vision-based algorithm, the sensor used to detect a person or object may malfunction and the robot may eventually follow a different object or even stop working, for this reason we suggest using variety of features that can be used as another way to give command to a robot.

Methods used for countering vision based problem.

- Voice Control
- Gesture Control

VI. VOICETCONTROL

The operation of translating an noisy signal, transmitted through a sound transmitter or telephone, into a series of term is speech recognition. A set of sounds are heard by two essential parts of speech recognition and classify the term in those sounds. These inputs can be categorized as continuous single identification and translated recognition: written, regulated, and a combination of both. Interrupted recognition is simply a recording of a signal. Since trying to grasp what is in the form of waves is not involved it, there is no need to watch. For this project, voice commands is taken with the mobile app for interrupted visibility [21]. The Arduino Uno and Bluetooth module are used to integrate the control unit with the Bluetooth system. The Bluetooth module is used to detect and read sound commands. The robot's arm will then act according to the order you have got. The control device can be any smart phone with android/OS transferrator has used the android system required to transfer data. Only the recipient can read and interpret these instructions and verify that the commands were received. The simulation commands give you the power to control the robot arm to move certain functions in various directions and performance. The number was allocated to each action along with three predefined terms, as the number in noisy circumstances will be simpler to pronounce and easier to identify.[22]

VII. GESTURETCONTROL

A touch control is a robot that can be manage using signalling not the former way of using buttons. Gesture requires motions of the hands, face, or other parts of the human. In this project, gestures were used to guide the robot.

This was a simple and easy to use way for a small transmission unit containing a sensor in this accelerometer to communicate with a robotic system and robots. When moving with different X, T, Y, and Z indicators, it produced analog values. At various positions, accelerometer meter values were determined and these positions were used to shift the motors in different directions. Each touch condition gave various analog values used in arduino to set different high-resolution pins. In some cases, when a high, the code was written to drive the motors. The motion of raising the arm up and pushing the base left and right is used in this project [23].

Working

Ultrasonic and infrared sensor is used in human following robot for avoiding obstacle and make sure that there is no noise or obstacle in front of them and keep traversing a pre-programmed work. However, there is a challenge for focusing a single object and calculating its distance and location that why ultrasonic sensor is situated in front of robot.

To get rid of this problem we will attach a transmitter do the object and receiver at the follow.

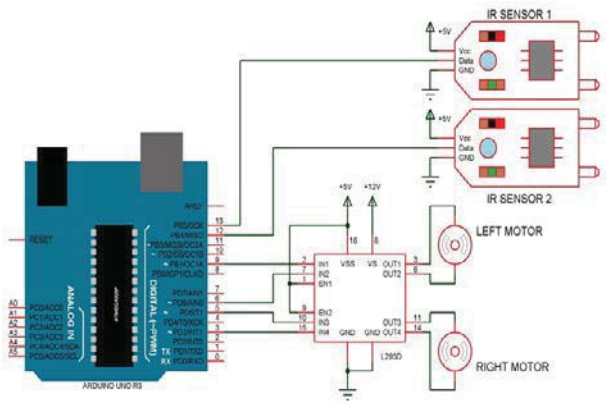


Fig.8- Pin diagram connections and working of the robot. [14]

In fig .8 we connect different pin of Arduino to different sensor we use ultrasonic sensor for avoiding obstacle and find noise free path for robot. Servo motor is placed at thirty degree arc. Assuming we are following an object with a flat back side, by comparing these values against one another; we will tell whether an object is turning left or right.

Fig.9-The object of interest (gray) turning right while the ultrasonic sensor (blue) measures edge distance.[10]

In fig. 9 we shows the object moving at some distance while the ultrasonic sensor measure the edge of the distance .With the aid of such data, robots can be instructed and operate accordingly to avoid losing the target object.

In our project, the main component is four wheeled robot with appropriate motor driver, Arduino Uno board , a servo motor and ultrasonic sensor.The most important is to make some appropriate programming for this robot and installed in Arduino Uno. This Arduino taken some instruction for different sensor and execute programming. We make these robots for different purpose for changing its programming.

VIII. CONCLUSION

Human following robot can help us in many way it provide benefit to the society. In the future, it can do even the smallest work of human; it is capable of doing human work quickly and is an easy manner. Human following robot will be one of the robots that will take over simple task, such as being a following assistant, maid, goods carrier or guider. Some application that can be useful to the hospital where the human following robot can be attached to the nurse cart and to the airport where it can become a luggage cart which brings the passenger luggage and follows the passenger. It is necessary for human to explore the knowledge of the robotics as it knows as no boundaries.

IX. FUTURE WORK

There are many consuming applications of this research in different fields whether military or medical. We can make changes like this by putting camera on the top of the robots and recognize or track far object or person according to algorithms. in future we can make many modification and design another type according to your convenience. We make many algorithms for human following robots in future for different purpose like lifting luggage in a shopping complex, helping people in station or public place, and also use for security purposes . In future we also change its design for different purposes it is also beneficial in medical sector for caring guiding of patients.

X. REFERENCES

[1] D. F. Glas, T. Kanda. Simultaneous People Tracking and Localization for Social Robots Using External Laser Range Finder, IEEE/RSJ Int. Conf. on Intelligent Robotics and Systems, p.846-853, 2009.

[2] Harshad Done, Pratik Chopra, Department of Electrical Engineering, 'VOICE Operated ROBOT,' K. J. Somaiya College of Engineering, 2006-2007.

[3] JavedAquib Khan, January 2015, "Wireless Gesture-Controlled Robot".

[4] Michael Moran, "Robotic Arm Evolution." March 2013 International Journal of Advanced Electronics and Communication Engineering Research

[5] 'Detection of hand movements using multiple sensors' by Peter Bajku, Martin Urban, and Jean Chistophen. Lementec2004 IEEE Conference on Intelligent Transportation Systems Washington, D.C., USA, October 4, 2004

[6] Gregory Jokin and Dudek Gregory Michael. Robotics' Computational Concepts. First edition, 2000, of The Press Syndicate of Cambridge University, Cambridge, UK.

[7] To M. Cristou, and A. And Ohya, and S. Yunta, "Person verification detected and based on omni directional variation" in RO-MAN, 2011 IEEE, 2011, pp. 419–424.

[8] J. Cai and T. Matsunaru, "Robot Human-following Limited Speed Control," The 22nd IEEE Int. Symposium Human Interactive Communication (Ro-Man2013), pp. 81-86, 2013.

[9] L. Ching, "Design and Implementation of Robot Interactive Demonstration System Based On Kinect," Chinese Control and Decision Conf., pp. 971-975, 2012.

[10] M. Cao, H. Hashimuto and E. Nachida, "Motion sensor Robot with Kinetic 3D Sensor," SICE Annual Conf., pp. 2207-2211, 2012.

[11] T. S. Jung, J. M. Lee, and H. Hashinoto, "Gesture Robot in Space program with Distributed Sensors," Int. J. of Control, Automation, and Systems, Vol.4, No.2, pp. 204-216, 2006.

[12] H. Noguchi, R. Jang, M. Shimonuaka, and T. Sato, "Person detection and Laser Range Scanner in Indoor Environments," J. of Robotics and Mechatronics, Vol.22, No.2, pp. 221-229, 2010.

[13] S. Kurazuge, and T. Hasegawau, O. M. Mozous " Object Detection by Using 2D Range Data," Int. J. of Social Robotics, Vol.2 , Issue 1, pp. 31-40, 2010.

[14] T. Hasegawa Y. Nohara , , and K. Murakami, "Floor detecting System for Public for Daily Life Environment," Japan Robot Conf., Vol.28, No.9, pp. 1144-1147, 2010.

[15] M. Eisenbuch, R. Kolarow , K. Debes, and H. M. Gross, " Robot of a placed network of laser range finder by matching movement trajectories," 2012 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS), pp. 431-437, 2012.

[16] K. O. Arras, B. Lau, S. Grzonka, M. Luber, O. M. Mozos, D. Meyer-Delius, and W. Burgard, "Short range People Tracking and detection for Socially Enabled Service Robots" in Towards Service Robots for Everyday Environments Springer Tracts in Advanced Robotics, Vol.76, pp. 235-280, 2012.

[17] Ahn, J, M, Kim, S, et al. formation based tracking method for human following robot (2018) 15th International Conference on ubiquitous robot(UR), Honolulu, HI, USA,26-30 June 2018,

[18] Alvarez-Santos, V, Pardo, XM, Iglesia, R,et al.(2012) feature analysis for human recognition and discrimination: Application to a person-following behavior in a mobile robot. Robotics and autonomous system

[19] Azarbayejani, A,, Pentland, A International Journal of Engineering Research & Technology (IJERT) Student Research Paper Conference Vol-2, No-15, July

[20] Babaians, E, Korghond, NK, A hmadi, A et al.(2015) visual tracking fusion for human following task of service robot. In: RSI international conference on robotics and mechatronics (ICROM), Tehran, Iran N0. 9 718-734

[21] Basso, F, Munaro, M, Michieletto, S, et al. (2013) Fast and robust multi-people tracking from RGB-D data for a mobile robot. Intelligent autonomous system NO .2 pp 221-229 2013

[22] Cai, J, Matsumaru, T. (2014) human detecting and following mobile robot using laser range sensor journal of robotics and mechatronics pp 2207-211 2014

[23] Chi, W, Wang, J, Meng, MQH (2018) A gait recognition method for human following in service robots. IEEE transactions on system, man, and Cybernetics.: system 48(9): 1429-1440