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End -User Personalization of a Smart Home and Companion Robot

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Abstract: Care issues and costs associated with an increasing elderly population are becoming a major concern for many countries. The use of assistive robots in "smart-home" environments has been suggested as a possible partial solution to these concerns. A challenge is the personalization of the robot to meet the changing needs of the elderly person over time. My project proposes efficient human movement detection based on background subtraction using dynamic threshold approach. To evaluate these issues, a commercially available autonomous robot has been deployed to detect moving objects using Background Subtraction algorithm and to identify it as a human using PIR sensor and track his movement using Kalman filter algorithm and assist the elderly person at home.

Keywords: CYBORG, Home Assisting Robot, Kalman Filter.

I. INTRODUCTION

A. Background

There is a growing need in society to enable older adults to remain in an independent living environment. Many older adults fear losing their independence and being required to move to an assisted living environment. Difficulty in efficiently managing medications is one of the main problem faced by elderly people. So some assistive technologies are implemented to support seniors to stay independent and active for as long as possible in their preferred home environment. A robot named CYBORG have been used to improve the quality of life of the elderly people.

Robot that would serve humans as assistants to enhance independent living.

- Aims at developing aids to improve the quality of human lives with disabilities.
- Grow in constant interaction and co-operation with humans.

B. Features

The proposed system will be able to assist the elderly person at home who wants to live an independent life in different ways. The system will allow the person to live an easy life with the help of a robot named CYBORG, who will assist the elderly person by controlling different activities like locking and unlocking the door, switch on or switch off the power supply unit based on the position of the person in the room.

In the second phase of the project, kalman filter technique is implemented to track the detected person. It predicts the next position of the person based on a number of past observations. Then a medication reminder was also implemented that helps the person to have medicines on time.

C. Motivation

In today's world we find a number of aged citizens leading a lonely life. Usually they are supported by a maid or a man servant in their daily activities such as giving medicines at the right time, and also their poor memory might result in many security issues. So the main motivation behind implementing this project was security and an independent life for the elderly person.

II. LITERATURE SURVEY

This discusses about the various literatures and publications that are conceptually or technically related to the various aspects of this project, which are studied and analyzed before the implementation of this project.

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A. Related Papers

- Joe Saunders, Dag Sverre Syrdal, Kheng Lee Koay, Nathan Burke, and Kerstin Dautenhahn in **" Teach Me–Show Me"—End-User Personalization of a Smart Home and Companion Robot " [1]** aimed at maintaining their physical functioning and emotional well-being of seniors residing in independent living facilities.

- Thirukural.R et al in **" Remote Access of Home Appliances Using Humanoid Robot" [2]** proposed to develop a Humanoid Robot to remotely access the home appliances.

- P. Bhuvaneswari, in **" Moving Object Tracking using Background Subtraction Technique and its Parametric Evaluation " [3]** provides an efficient motion detection based on background subtraction using frame difference with thresholding and mathematical morphology.

- Mahesh C. Pawaskar, N. S.Narkhede and Saurabh S. Athalye, in **" Detection Of Moving Object Based On Background Subtraction" [4]** analyses various ways where the complexity of calculation is avoided. Convolution operation is applied to the binary image. This paper provides methods to allow fast processing and removes noise.
- **Hitesh A Patel1, Darshak G Thakore, in "Moving Object Tracking Using Kalman Filter" [5]** proposed methods where object tracking of any single moving object has been successfully implemented using Kalman filter.

- Prasad Kalane and PREC Loni Pune ,in **"Target Tracking Using Kalman Filter" [6]** discuss the design of Kalman filter algorithm to track the target and shows the resulting improvement in tracking. This is of utmost importance for high-performance real-time applications.

TABLE I LITERATURE REVIEW

No	Paper	Authors	Publication And Year	Observations
1.	Teach Me–Show Me"—End-User Personalization of a Smart Home and Companion Robot	Joe Saunders, Dag Sverre Syrdal, Kheng Lee Koay, Nathan Burke, Kerstin Dautenhahn	IEEE transactions on human-machine systems, vol. 46, no. 1, February 2016	Aimed at maintaining their physical functioning and emotional well-being of seniors residing in independent living facilities.
2.	Remote Access of Home Appliances Using Humanoid Robot	Thirukural.R et al	International Conference on Recent Trends in Information Technology (ICRTIT), 2013	Humanoid Robot, Nao was developed to remotely access the home appliances
3.	Moving Object Tracking using Background Subtraction Technique and its Parametric Evaluation	P. Bhuvaneswari, T. Siva Kumar	International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) September 2014	Provides an efficient motion detection based on background subtraction using frame difference with thresholding and mathematical morphology.
4.	Detection Of Moving Object Based On Background Subtraction	Mahesh C Pawaskar, N. S.Narkhede and Saurabh S. Athalye	International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) Volume 3, Issue 3, May-June 2014	Complexity of calculation is avoided. Convolution operation is applied to the binary image, Fast processing and Removes noise

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III. OBSERVATION AND CONCLUSION

While conducting the literature survey, most of the papers, I went through, were discussing about a robot assisting a person at home with the help of various sensors. Different types of techniques were used to assist a human.

Above discussed papers suggested various methods and technologies to detect a moving object , tracking the moving object and how a robot can be used to assist an older person using many high cost and technically complicated methods. This high cost and technical complexity makes it difficult for using the robot by common man.

So, the aim was to develop a cost effective robot who can detect a moving object, track the moving object and identify the moving object as human without using any sensors that will decrease the technical complexity.

Papers[3] and [4] discussed about using Background Subtraction Algorithm to detect a moving object by frame differencing method. It also discussed about morphological operations like erosion and dilation which helps to remove noise .

Papers[5] and [6] discussed the importance and advantages of using Kalman Filter for tracking the moving object.

Hence in this project, the Background Subtraction algorithm is used for detecting human and Kalman Filter was used for tracking that identified human which helped to reduce the cost and technical complexity.

IV. ALGORITHMS AND IMPLEMENTATION

The algorithms used to detect a moving object using Background Subtraction Algorithm in the first phase. In the second phase, Kalman Filter Algorithm was used to track the moving object and the hardware part that was used.

In this system the main aim is to build robust moving object detection algorithm that can detect and Track object in video.

1. The first step is to take input video from static cameras. For processing the video file, convert the video into frames and from frame to images.
2. Next step is to consider first frame as a background frame and next is current frame and apply subtraction operation, and then background frame is subtracted from current frame.
3. Then thresholding is applied and foreground object is detected.
4. After object detected last step is track the object in video.

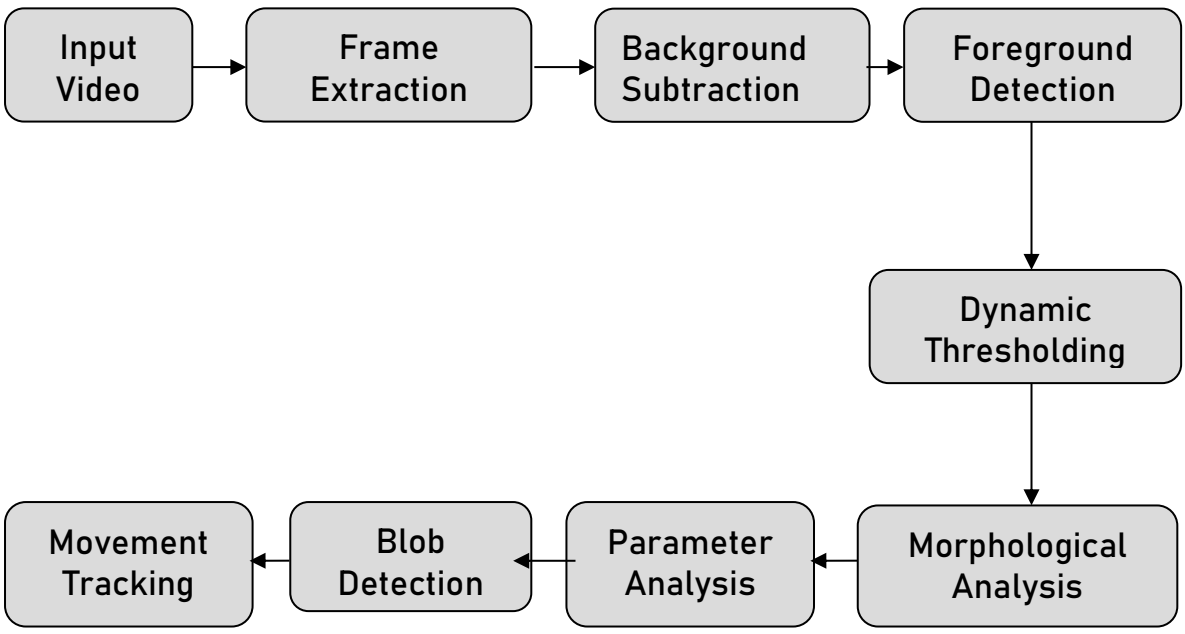

Fig. 1 Proposed Schematic Diagram

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The general approach for detecting moving object is either by considering a single frame or analyze the information from a sequence of frames . For real time applications we are choosing background subtraction because of its effectiveness and simplicity. Finding moving objects is one of the challenging task in the case of human or object detection and tracking for human computer interaction. In such cases Background subtraction is the common approach used for identifying moving objects.

The most important requirement of a background subtraction algorithm is that it should be robustness for detecting moving objects under high speed, having low implementation complexity and should be fast adaptation to changes in environment. Comparing with other moving object detection methods background subtraction method segments the foreground objects more accurately.

The background subtraction method is used for moving object detection. In background subtraction we use the difference of the current image and the background image to detect the motion region . The background image is subtracted from the current video frame. And if the pixel difference is larger than the set threshold value T, then it determines that the pixels of the moving object, or as background pixels. The Dynamic Threshold method is used to dynamically change the threshold value with respect to the lightning changes of the two images obtained that can reduce the impact of light changes. We consider initial frame as the background frame and then that frame is subtracted from current frame to detect moving object.

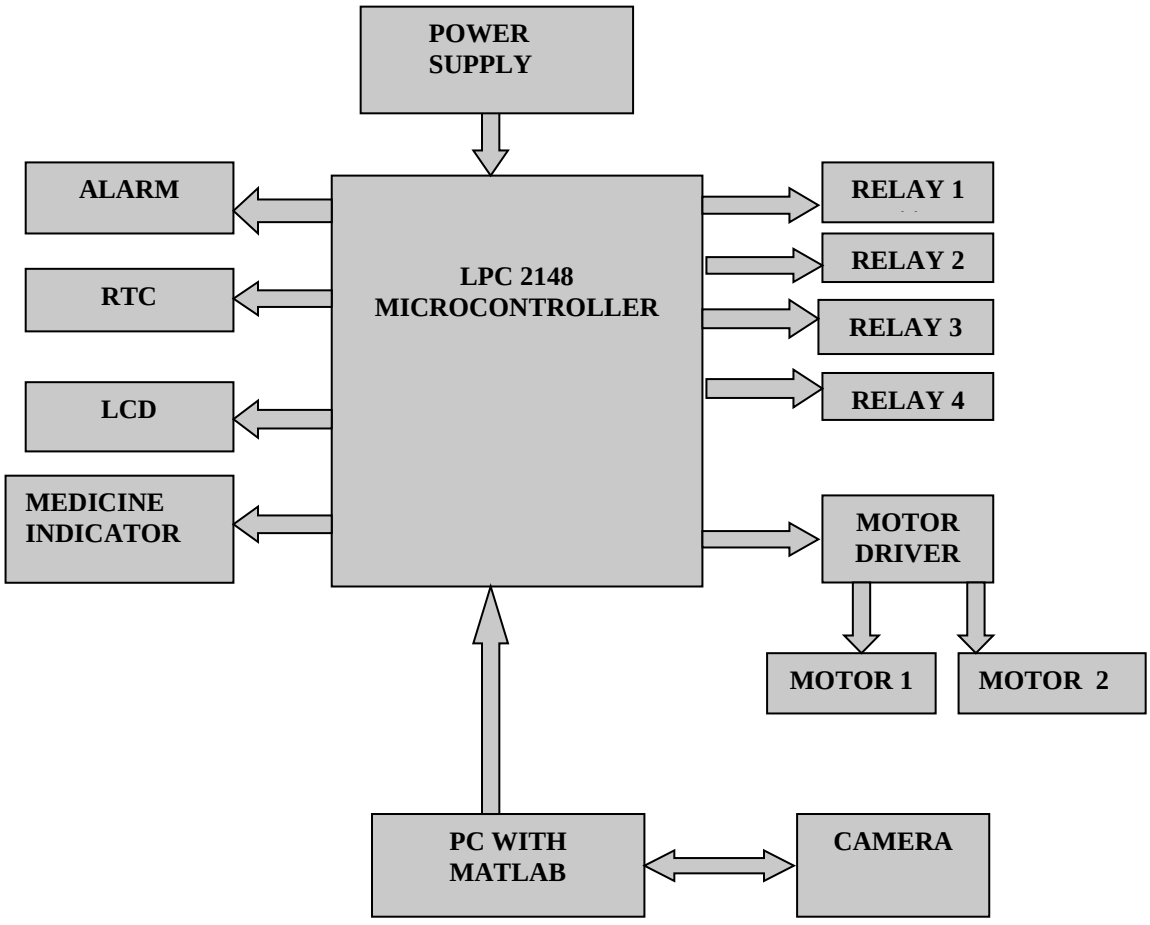

Fig. 2 Architecture Diagram

V. THE WORKING SCENARIO

It starts with the person entering the room which is the region of interest or the target region and ends with the robot performing some functions based on the position of the person in the room.

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A. Video Capturing

- A static camera was used for capturing the video of a particular room where there is an elderly person who is being assisted by a home assistive robot.
- The captured video is converted to still images frame by frame.
- The initial frame with no moving object is taken as the reference frame and the frame where the moving object appears is taken as the current frame for further processing
- The reference frame and current frame are given to a background subtractor to separate foreground from the background.

B. Moving object detection

- Background subtraction is the process of separating out foreground objects from the background in a sequence of video frames.
- It is a widely used approach for detecting moving objects from static cameras.
- For motion detection two images of the same size are taken from video – one is the background image in which moving object is not present and the other one is the current image in which the moving object appears .
- Frame Difference method was used for detecting moving objects from the difference between the current frame and a reference frame.
- The subtraction of the image is done pixel-by pixel. So the background of the current image and the reference image will have the same pixel value.
- A threshold value is selected such that it is not too low or too high for accuracy.
- The threshold value is applied to this difference to get the foreground mask.
- If the difference between the pixels is greater than the threshold value, then it is a foreground pixel. Otherwise it is a background pixel.

$$D(x,y\ ) = 1 \quad if\ F(x,y) - B(x,y) > T$$

$$= 0 \quad otherwise$$

C. Human Identification

- Blob detection method was used to detect regions in a digital image that differ in many properties such as brightness or colour compared to surrounding regions. All the points in a blob will be similar to each other.
- Blob detection was used to obtain regions of interest for further processing.
- These regions show the presence of moving object in the image and can be applied for object tracking
- The aspect ratio (width/height ratio) is calculated for each blob to identify the detected moving object as human.
- Finally a PIR sensor was used to confirm if the identified moving object is a human.

D. Tracking using Kalman filter

- A tracking algorithm using Kalman filter was used to locate the human at any point in time.
- For this only a limited region of the image is searched to improve efficiency.
- Kalman filter is used for tracking objects and focuses on two important features:
  - Prediction of object's future location
  - Reduction of noise introduced
- Kalman filter is composed of two stages – PREDICTION and CORRECTION
- Kalman filter track the system in discrete interval of time.
- After morphological operations are done to remove noise and fill in holes, predict new locations of existing track.
- Use the Kalman filter to predict the centroid of each track in the current frame, and update its bounding box accordingly.
- Shift the bounding box so that its center is at the predicted location.
- It also deletes the tracks that have been invisible for too many consecutive frames.
- Finally it draws a bounding box and label ID for each track on the video frame and the foreground mask.
- It then displays the frame and the mask in their respective video players.

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VI. CONCLUSION

In the first phase of the project a static camera was used to capture the video of a room where the person was supposed to be. Then background subtraction algorithm was used to differentiate foreground image from background. Morphological operations were done to remove noise so that we can get a clear image of the foreground where further processing will be done. by calculating the aspect ratio and using a PIR sensor we identify the detected moving object as human.

In the second phase Kalman filter was used for tracking the human and based on the position of the human in the room hardware part was successfully implemented.

The system is designed in such a way that any common man can easily use it without any ambiguity or confusion.

REFERENCES

[1]. Joe Saunders, Dag Sverre Syrdal, Kheng Lee Koay, Nathan Burke, and Kerstin Dautenhahn in " Teach Me–Show Me"—End-User Personalization of a Smart Home and Companion Robot " IEEE transactions on human-machine systems, vol. 46, no. 1, February 2016.

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[6]. Prasad Kalane and PREC Loni Pune ,in "Target Tracking Using Kalman Filter", International Journal of Science & Technology, April 2013