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Raspberry Pi based Real Time People Detection, Trackingand Counting System

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Abstract:

In present days, people detection, tracking and counting is an important aspect in the video investigation and subjectin demand in Computer Vision systems. For many applications it is necessary to identify people and then accurately count the number of people in the real time. To perform the people counting, a robust system for people Detection and Tracking is needed.

This paper mainly discusses the detection, tracking and counting of people in real time with images captured from a stationary camera.This method uses a Background Subtraction technique for people detection and Kalman Filtering Algorithm for tracking. The present work describes a standalone people counting gadget designed using Raspberry Pi2, asingle Board visiting card size computer. MATLAB Simulink computer vision system and Simulink support package for raspberry pi hardware toolboxes are used in rapid prototyping the design.

Keywords — **Motion detection, Tracking and Counting, Raspberry Pi2, SimulinkComputer vision, Raspberry pi toolbox, Rapid prototyping.**

1.Introduction:

Automatic human detection and tracking is an important and challenging field of research and is having many applications in it.Increasing use of computer vision in surveillance, replacing computers in place of human beings has initiated the research in the field of object counting and face detection. Early research mostly concentrated on Human recognition rather than Tracking. Monitoring movements are of high interest in determining the activities of a person and knowing the intentions of the subject. Monitoring the movements of human being has raised the need for tracking. Real-time people flow estimation can be very useful information for several applications like security or people management such as pedestrian traffic management or tourists flow estimation.The use of video cameras to track and count people increase considerably in the past few years due to the advancement of image processing algorithms and computers technology. New creative innovation rotates around how much an item is fit for executing alongside its cost.

Many motion detection techniques are extensively investigated in the literature. However, background subtraction technics are mostly used when dealing with fixed cameras. Each application that benefit from smart video processing has different needs, thus requires different treatment. However, they have something in common: moving objects.

a)Literature Survey:

Geoffrey Gordon [1] presented a paper on “Better Motion prediction for people tracking”. In this paper, he proposed a movement demonstrate for individuals following that is roused by the objective arranged nature of individuals' development. This movement show includes a learning segment that enables it to utilize data about individuals' normal directions in a particular domain to learn objective areas.

The objective areas are upgraded so ways delivered by an organizer concur well with the preparation directions. Ways arranged from the area of a man being followed to these objectives are utilized by the movement refresh to extend the speculations forward in time. He looked at the execution of the movement model to a basic Brownian movement display inside the system of a molecule channel based individual's tracker. Exploratory outcomes checked that the movement demonstrate performed better, making a more practical dissemination over positions.

BadhanHemangi [3] presented a paper on "PEOPLE COUNTING SYSTEM USING RASPBERRY PI WITH OPENCV". In this approach the framework checks the number of individualspassing through a virtual door by using a Picamera mounting vertically on the raspberry Pi board with Python programming device connected to the application but the framework needs a ton of upgrades to be truly dependable.

Mingxiu Zhang [6] presented the paper on "Real time tracking passing people using a single camera" In this approach he examined about the location and following of passing individuals by utilizing the bi-directional projection histogram of histogram and furthermore utilized two casing contrasting techniques for different individual's division.

M.Manikandan,R.Balamurali[5]presented a paper on "Real time People Tracking and counting system using Fuzzy Logic" which shows efficient and reliable approach to automatic people segmentation, tracking and counting, used in surveillance
systems using an improved mode algorithm to obtain the regions of static background and novel fuzzy background subtraction approach regions for background subtraction.

NiteshSanklecha [8] presented the paper on "Motion Detection and Tracking of a Leopard in a Video".In this paper, it represents two different scenarios for tracking of an object in a video sequence. Using the Horn-Schunck algorithm for motion estimation gave fair results, but it cannot eliminate in noise.But using Lucas – Kanade algorithm gave the best results compared to earlier algorithm with noise removal. The disadvantage of this method is there are some discontinuities observed while determining the Optical Flow pattern.

K.Shiva Prasad and M.Shirisha[4] presented the paper on "Human Face Detection and Tracking Using Raspberry PI Processor" which explains the techniques for human face detection and tracking in real time using a modified version of algorithm suggested by Paul viola and Michael Jones. It is based on object detection by extracting some specific features from the image.

2.Proposed Method:

Though many authors have implemented related work using raspberry pi and camera modules, we concentrated on developing a rapid prototyping model using powerful Simulink toolboxes available in MATLAB. MATLAB supports Rapid Prototyping for Embedded which provides early proof of our porotype designs that will work in the field. We can test our design in real time on hardware, and can quickly adjust design until satisfied results are obtained. This work is an attempt to designRealtimeimplementation of rapid prototyping model using MATLAB Simulink.

a)Hardware & software used

In our work, real time people detection, tracking and counting is implemented usingtwo hardware components

1.Credit card size single board computer Raspberry Pi 2 board

2.Raspberry Pi NoIR Camera Board which is Infrared-sensitive.

Raspberry pi 2 works as main element which executes the design model in standalone mode and NoIR Camera board is used to capture the real-time images.For software development, we used MATLAB Simulink toolboxes. Raspberry pi toolbox is used for image for capturing and result display and computer vision toolbox block sets are used for implementing the algorithm.

The proposed system consists of three stages:

1.People Detection

2. People Counting
3. People Tracking

The input images are taken from the NOIR Camera which is connected throughthe Raspberry Pi Board. The images are converted into gray scale by using the RGB to gray scale conversion. Then the images in binary format are applied to the Background subtraction method from which moving peoples are detected. For counting Blob analysis is used in which rectangular boxes are placed on the detected objects and counts the number of blobs is present. Then by using Kalman Filtering algorithm people tracking is done. Finally the output frames are displayed in SDL display which is seen through Laptop screen and the number of people detected i.e., the count is heard through speakers which are connected through 3.5 mm audio jack of Raspberry Pi Board. The Block diagram for the proposed method is shown below in fig. 1

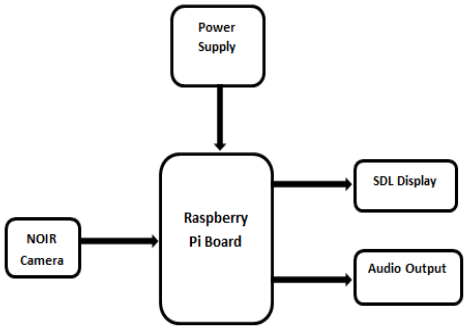

Fig. 1: Block Diagram of proposed method

3.Hardware Requirements

A).Raspberry Pi 2 Model B+ Board:

A Raspberry Pi is a small credit card sized computer board which when plugged with an LCD and attachment of a keyboard and a mouse it is able to function as a regular PC can. Like a PC, it has RAM, SD Card slot, Audio and Video ports, USB ports, HDMI port, and Ethernet port and 40 digital GPIO pins. With this board, users can create spread sheets, word-processing, browse the internet, play high definition video and much more [10]. The power to the board will be via a regular 5V micro USB port.

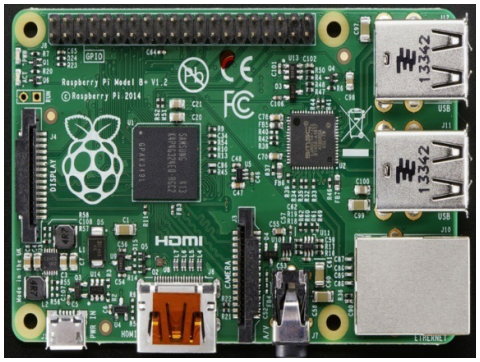

Fig.2:Raspberry Pi 2 Model B+ Board
(Image courtesy of www.raspberrypi.org)

B). NOIR camera Board:

The Raspberry Pi camera module includes an image sensor and a CSI interface. The CSI bus has high data rates and is exclusively carries pixel data. The image sensor converts an optical image to a digital image using a two-dimensional array of photo detectors. The array of photo detectors measures the intensities of specific colours (e.g. red, green, blue) throughout the optical image and the measurements, quantized over an interval (i.e. [0-255]), form the digital image. The interface delivers the digital image to the Raspberry Pi. The picture of NOIR Camera board and how it is placed on the Raspberry Pi board is as shown in fig:3

Fig.3: NOIR Camera
(Image courtesy of www.raspberrypi.org)

C). Speakers:

A set of USB speakers are connected to the 3.5 mm audio jack of the Raspberry Pi board to get the audio output of the count of number of people being detected.

4).Simulink model for Real time people Detection, Tracking& Counting System

The Robust system for People detection, tracking and counting is built usingComputer Vision Toolbox and Raspberry Pi Support packages in Matlab software. [7]. The detailed explanation of each subsystem is given below:

Segmentation: In Segmentation subsystem the image captured from the camera is substracted from the background image using Auto Threshold block. The Auto Threshold block calculates the differences in pixel values between the normalized input image and the background imageto know which pixels represents the object(people) in the image. The Simulink model for Segmentation Subsystem is shown below in Fig.4

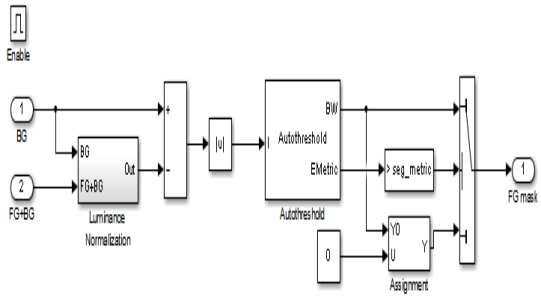

Fig.4: Simulink Model for Segmentation

Detection:The input for the Detection subsystem is foreground image (object image). For detection, Background Substraction method is used which divides the image into selective &Non-selective partsand it also improves sensitivity and provide accurate detection [11]. In the Simulink model for detection the close block merges the pixels which corresponds to the objects(people) in the image to form blobs and the blob analysis block will calculate the bounding boxes to those blobs [7]. Finally, each person detected in the image will be enclosed by a single bounding box. The Blob analysis block also gives the number of objects in the image.The Simulink model for the detection subsystem is as shown below in fig:5

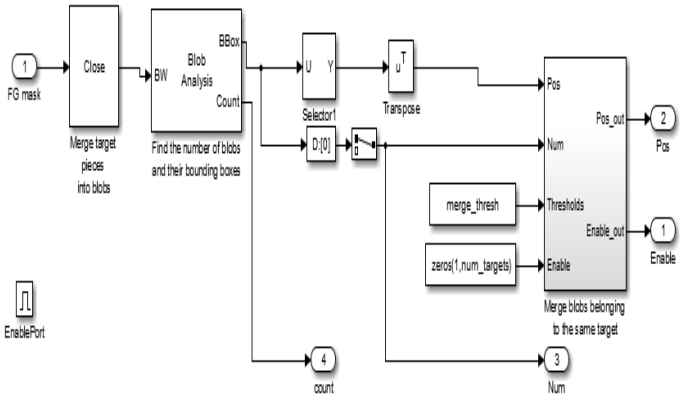

Fig. 5: Simulink model for Detection

Tracking:Kalman Filtering Algorithm has been used to track the objects(people) being detected. Kalman Filtering Algorithm provides an efficient estimation of past, present and future states even when the nature of the modeled system is unknown[9]. The Tracking subsystem, has a Kalman Filter block which uses the location of the bounding box detected in the previous frames to predict the location of the bounding box in the current frame. To find the location of some people it will compare the predicted location and the detected location. Kalman filter block also reduces the noise effect in the detection of bounding boxes[7].The Simulink model for tracking mechanism is as shown below in fig:6

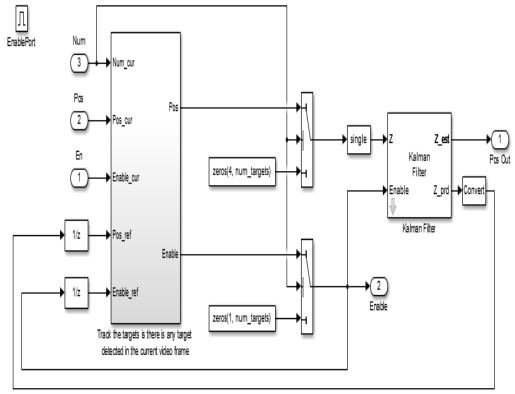

Fig.6: Simulink model for Tracking

Counting subsystem:Generating the audio output of the count is done using a matlab function which accepts the data from the detection subsystem and converts to character type data and will compare with constant character of same size. A free running counter is used to put gaps between each sound [2]. The output is given to Raspberry Pi Text to speech converter which will speak out the count through speakers. The Simulink model for Counting Subsystem is shown below in fig:7

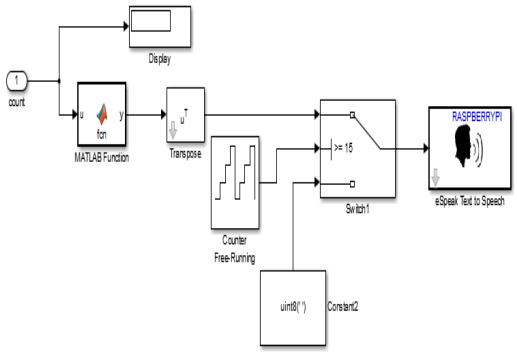

Fig.7: Counting system

Finally the Simulink model for the proposed method is obtained by combining all the 4 Subsystems and combinedmodels shown below in fig:8

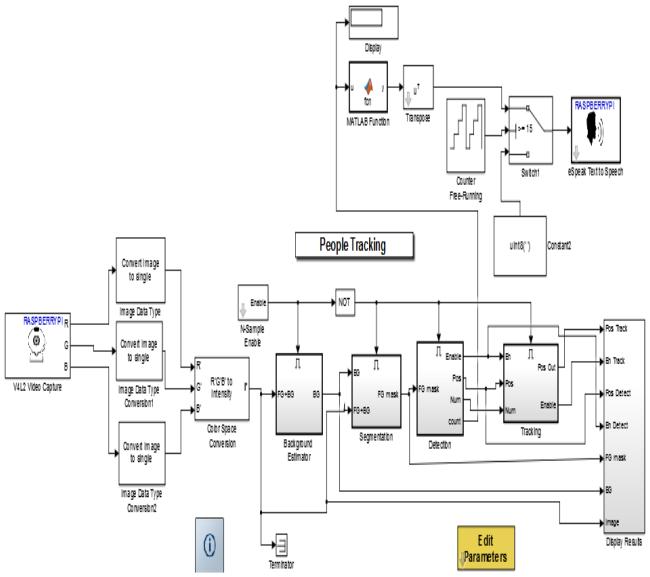

Fig. 8: Simulink model for Real time People Detection, Tracking and Counting

5. Flow Chart

The generic algorithm for the proposed method will start with capturing the images then followed by RGB to Grey conversion. Then it will go through all the subsystems first to detect the people and produce a count of them and then they will be tracked to find their locations. The detailed Flowchart is shown below in fig.9

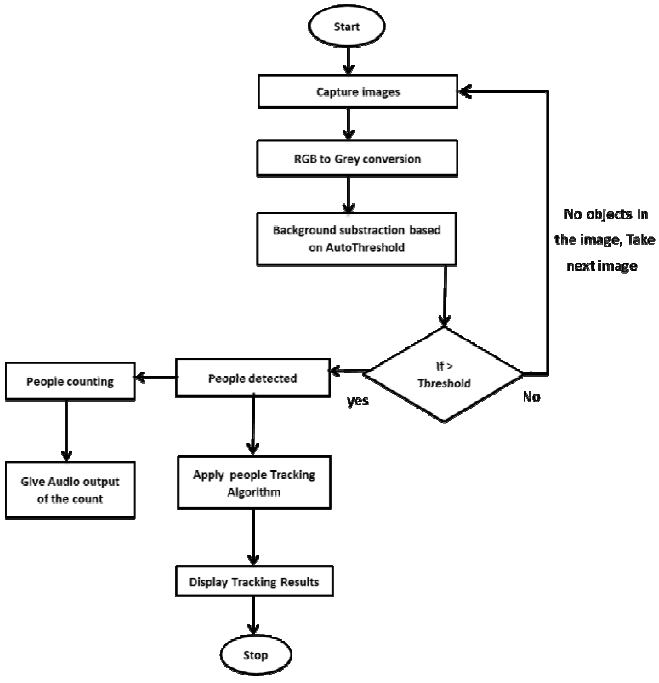

Fig.9: Flowchart showing Detection, Tracking and Counting process

6.Results & Description

Input Image:

The input image along with background information is as shown in fig:10

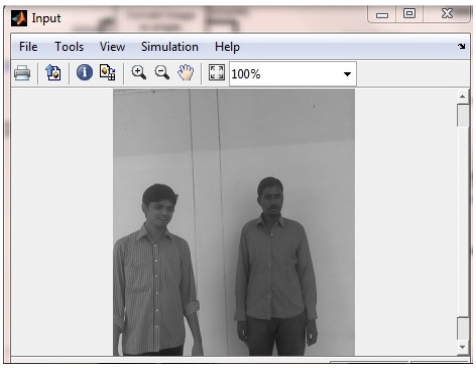

Fig.10: Input image

Background Image:

The background image after segmentation is as shown below in fig:11

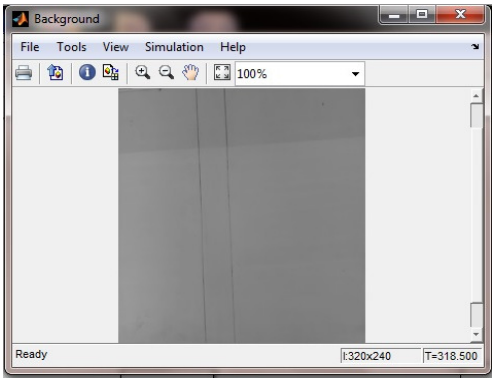

Fig.11: Background image

Detection Image:

After the detection subsystem we will get the people detected with blobs as shown below in fig:12

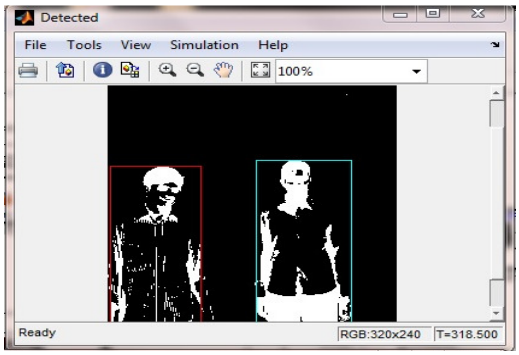

Fig.12: Detection Image

Tracking Frame output:

The Tracked output after comparing with reference target is shown below in fig:13

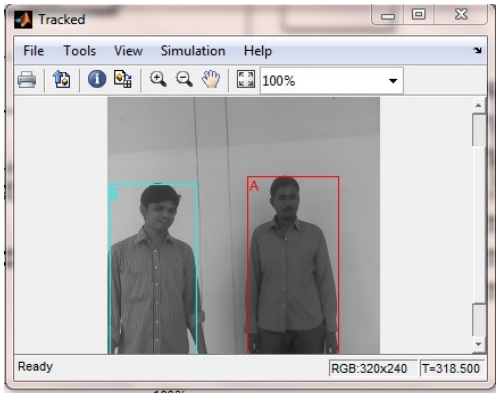

Fig.13:Tracking frame

An Experimental Trail with different images with different number of people is done and is checked individually. The following table will give the comparison between the actual count and the count obtained at the speaker and corresponding accuracy is listed after that. The above Table will give the information about the number of people counted in the current image in real time and compares with the different images.

Table I: Accuracy of People Counting

Scenario	Real number	Counting number	Accuracy
Image 1	2	2	100%
Image 2	10	9	90%
Image 3	20	17	85%

7.Conclusion

The objective of this project to track and count the number of people passing in front of a stationary camera using Raspberry Pi is implemented with accurate results. Perhaps the proposed system is an easy and cost effective method for providing Security in many application areas.Further this project can be extended by enhancing the detection and Tracking mechanism by using a database and face detection mechanism can also be added to the above system to enhance the security system.

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