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Automatic Human Following Trolley Using Raspberry Pi

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Abstract - Today robotics is being increasingly used to ease our lives. This paper is about the automatic human following trolley which follows the human user based on his/her shirt color. This can be used in the shopping malls for enhanced shopping experience. The trolley follows only a specific user based on HSV values of his shirt color. The model implements object detection and tracking technique to follow the user. There is no need of any manual effort to push the trolley and hence it makes shopping experience more user-friendly. There could be future uses based on modifications as well; which are discussed in the future scope. The proposed system uses RPi and computer vision techniques for human tracking and following.

Key Words: Human Following Trolley, Raspberry Pi, MobileNet SSD, Object Detection, Color Tracking, Color Tuning.

1. INTRODUCTION

The trolley plays crucial role while doing a shopping in big malls and other shops. The ergonomic design of these trollers is very important for better customer experience. Current trolleys require manual effort for movement and sometimes it leads to inconvenience. Also; it is difficult for elderly people to move heavy shopping trolleys.

This project proposes Human Following Trolley that employs object detection algorithms to detect and track humans. The tracking is done based on shirt color of user. This gives unique and customized mapping of user to the trolley. The color detection is done using image processing. Finally, servo motors are used with RPi based systems for the movement of the trolley. This automatic human following trolley reduces the efforts of pushing the trolley making shopping experience more user friendly.

1.1 Objectives

- To design and perform the algorithm for trolley user detection.
- Compare recognized object with existing database.
- Implementation of a hardware system to track the trolley user.
- Devising a system for tracking and following the user by keeping certain distance.

1.2 Scope of Discussion

Section 1 of the paper contains introduction to the proposed work. Section 2 has overview of related work done presented in a tabular format. Section 3 contains the methodology used for the project. Results are mentioned in the Section 4. Conclusions and Future Scope are in Section 5 and Section 6 respectively.

2. LITERATURE REVIEW

Title	Author	Proposed Work	Methods Used	Features
Design and developmen-t of human trolley	Sayali N Joshi, Vaishnavi Patki, Priyanka Dixit, Hussain Bhaldar	It discusses human following trolley using RPi. It avoids obstacles.	RPi, small camera, ultrasonic sensor, motor drivers.	Unique ID tag which is attached to a person. Sensors to avoid obstacle-s.
Modelling of Future Automatic Trolley System based on Sensors and Image Processing Guidance for Supermark-et	Divya T M, Aneeshya Soman, Abiraj K R	It discusses human following trolley with QR product reader and RFID payment.	RPi, ultrasonic sensor, motor drivers, QR Reader, RFID Reader and payment.	Ultrasoni-c sensors - distance calculatio ns. Automat-ic merchan-dise value using QR and RFID Payment
Automatic Human Guided Shopping Trolley With Smart Shopping System	Yen Leng Ng, Cheng Slong Lim, Kumerses-an A, Chee Wei Tan	Line following bot is used. Mall map is also present in the trolley.	Arduino, RFID reader to read the products in the cart.	Mall map can be used in future.
Human-Robot Interaction with Smart Shopping Trolley Using Sign	D. Ryunmin ,Denis Ivanko, M. Zelenzy	Gesture and voice comman-ds based	Kinet 2.0 based software and hardware for data collection	It can be very importa-nt add-on feature to the

Language: Data Collection		humanfo l-lowing trolley.	of sign and speech inputs.	trolley to make it specially-abled friendly.
Design of Human followers trolley robot based on object tracking (color detection method)	Denny Irawan, Misbah, Jefry R Baihaqi	To transfer the goods from one place to another by detectin g color of cloth (human) and to follow them.	Camera and ultrason i- c sensor is used. Arduino is used for the processi -ng.	Color detection method and distance measure-ment using ultrasoni c sensor.

Table-1: Literature Review

3. METHODOLOGY

Basically; there are three major processes which trolley performs serially.

- To identify the shirt color of the user. This color values are stored as HSV values and used to detect the particular user. This is also called color tuning.
- To identify the user(human) based on his shirt color.
- To follow the user by maintaining constant distance with him.

Let us understand these processes one by one and the algorithms used for the same.

3.1 Color Tuning:

This is done to identify the HSV values of the shirt color of the user. The range of HSV values is identified as High and Low. The system will track the color which falls within that particular range. Quantum USB camera QHM459LM which is interfaced with Raspberry Pi model B+ (RPi) and laptop is used to capture the image of the user. OpenCV is used for image processing.

Some of the results of color tuning are as given below:

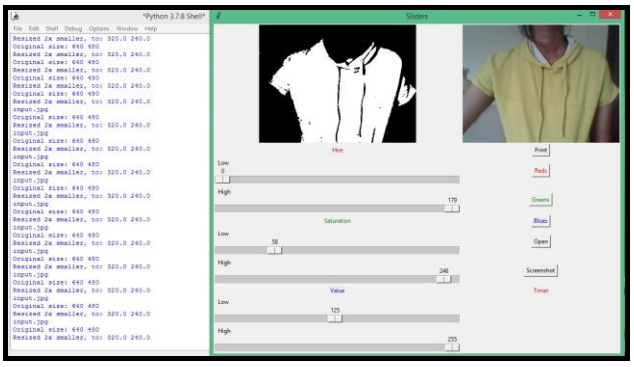

Fig -1: Color Tuning for Yellow Shirt

HSV high = (179,246,255)
HSV low = (0,58,125)

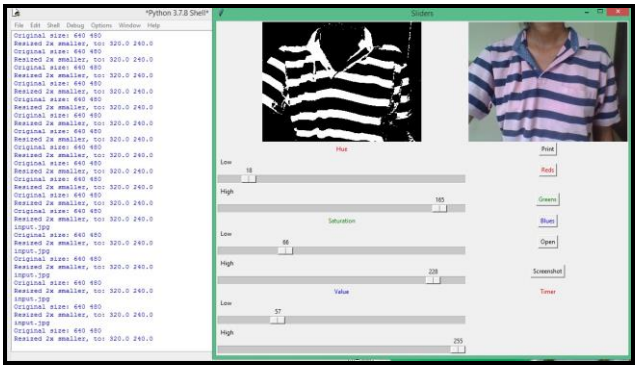

Fig -2: Color Tuning for Checked Shirt

HSV high = (165,228,255)
HSV low = (18,66,57)
Once we have these HSV values we can input them so as trolley follows a person with this particular shirt color only. Now next step is object detection or human detection**.**

3.2 Object Detection:

Object detection basically involves localizing one or more objects in an image and then identifying the classes of these objects. The algorithms are pre-trained to identify different classes of objects like human, dog, bottle etc.

Object detection has four consecutive occurring steps as follows:

1) Region proposal
2) Feature extraction and network predictions
3) Non-maximum suppression
4) Evaluation metrics

We are employing MobileNet SSD algorithm for object detection. It is integration of MobileNet into SSD framework. MobileNet divides a standard convolution into a depth wise convolution and 1*1 point wise convolution. This has a drastic effect on reducing computation and model size.
SSD then takes one single shot to detect multiple objects within the image. It produces fixed size collection of bounding boxes and the scores for presence of each object class in those boxes.

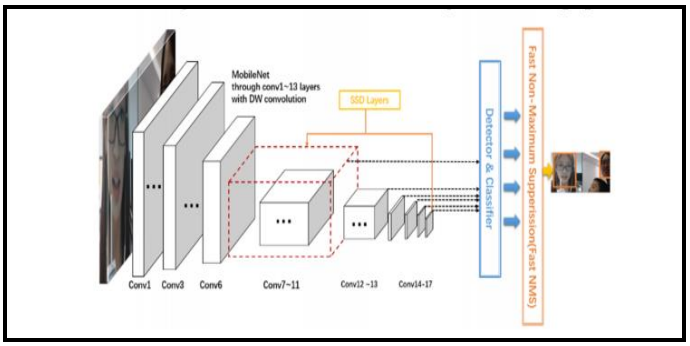

Fig -3: MobileNew SSD Architecture

3.3 Object Tracking:

After detecting the human, his shirt color is matched with the stored range of HSV values. If the colors match; then trolley follows the user by maintaining constant distance from him.

Following diagram explains the flow of user tracking.

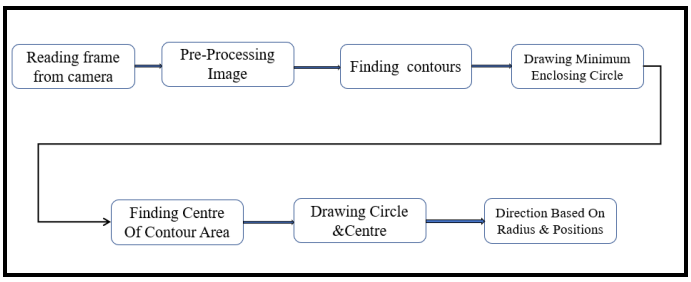

Fig -4: Object Tracking Flow

The radius and centre of minimum enclosing circle are used to measure the distance of a person from the camera(trolley) and the direction in which person is moving. When a person moves forward the radius of this circle decreases, and this gives an instruction to trolley to move forward. The trolley moves in a direction of user until pre-defined distance is achieved.

If person moves to the right, then the centre of circle shifts to the right and this gives indication to the trolley to move to the right. Same way if person moves to the left the trolley moves to the left and try to maintain the centre in predefined position.

The Euclidian distance between camera and the person is used for the distance prediction. It is nothing but the length of line joining centre of circle created on person's shirt and the camera. This distance will be maintained constant to avoid any collision of trolley with the person.

Four DC motors are used for the locomotion which are powered by two 9 V batteries. An ultrasonic sensor HCSR04 is used to avoid the collision of trolley with any other obstacles in the path.

Following figure summarizes the complete process flow.

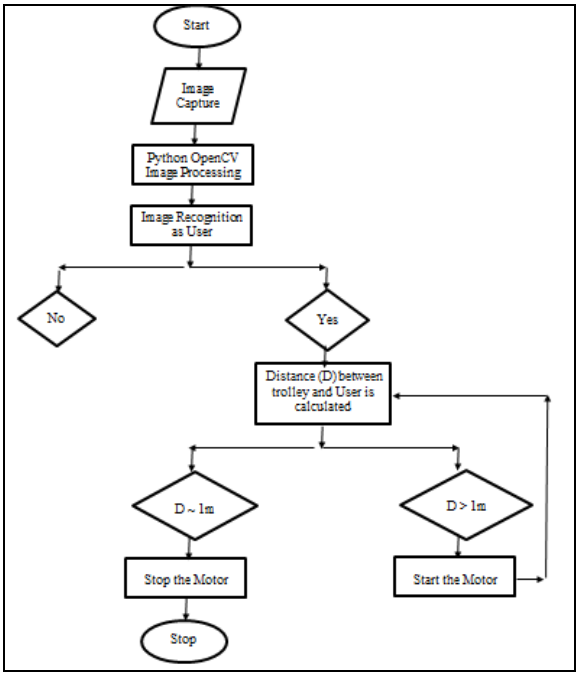

Fig -5: Process Flow

4. RESULTS

The trolley; designed to identify and track the particular human was able to follow the user. The complete assembled bot with some of the results are shown below.

Assembles Bot:

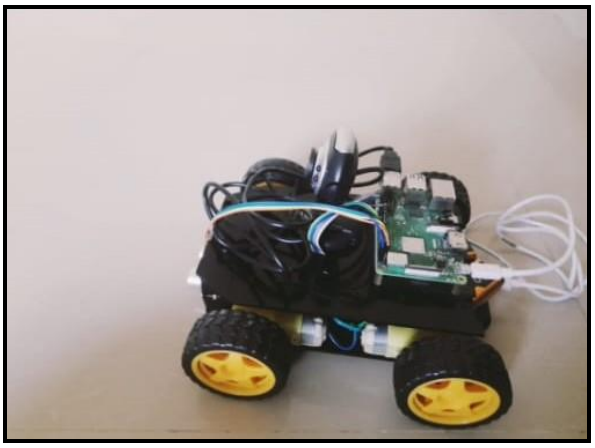

Fig -6: Human Following Trolley Bot

Object Detection:

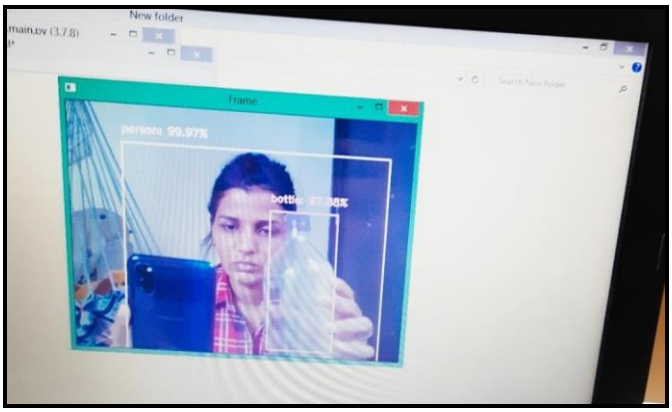

Fig -7: Object Detection 1

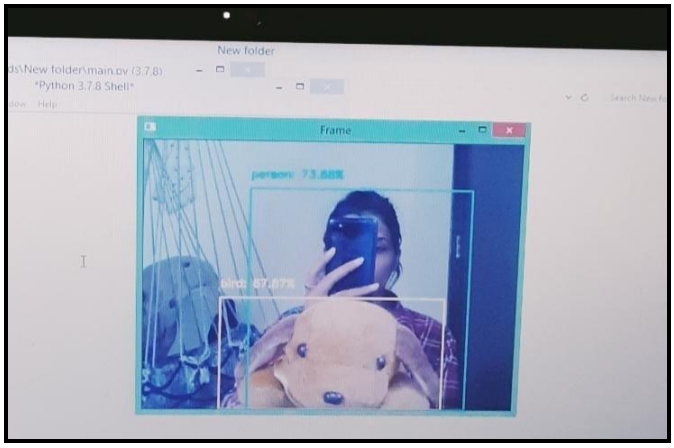

Fig -8: Object Detection 2

Color Detection:

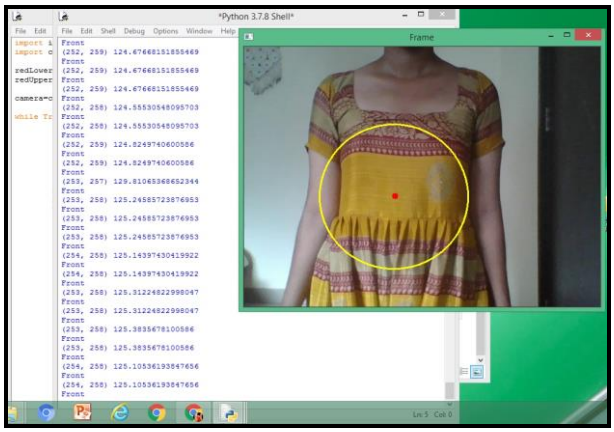

Fig -9: Color Detection 1

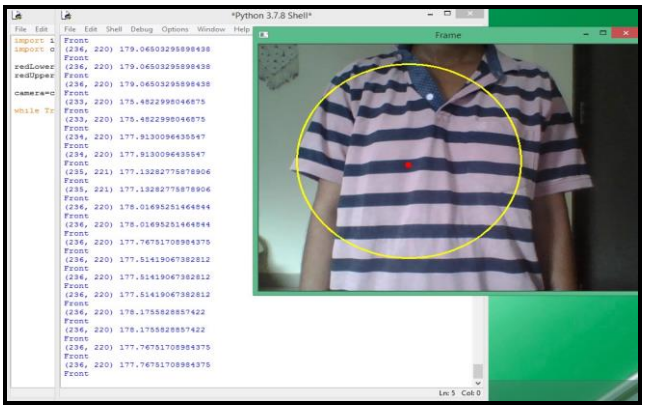

Fig -10: Color Detection 2

Person Detection and Tracking:

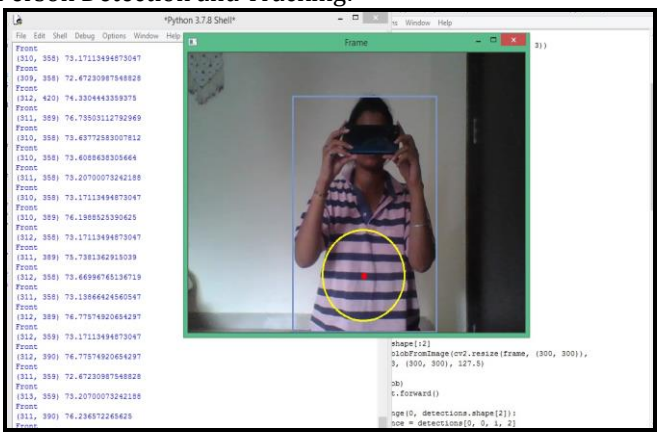

Fig -11: Person Tracking 1

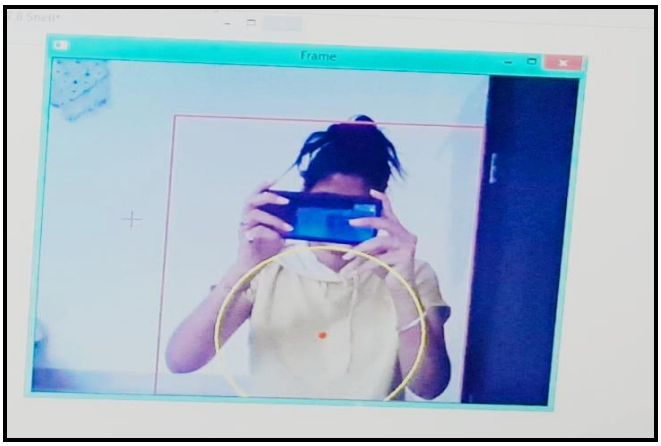

Fig -12: Person Tracking 2

The results are summarized in the table below.

Description	Expected Result	Actual Result	Status of Execution
Working of camera	To capture images continuously.	Captured images continuously.	Pass
Detection and tracking	Detect a person and track the shirt color.	Detected a person and tracked the	Pass

		shirt color.	
Detection in clumsy environment	Only one color to be detected ignoring others.	Only one person with a particular shirt color is detected.	Pass
Person moving forward	Trolley to follow person.	Trolley is following the person.	Pass
Direction Left	To turn left with person.	Trolley turned left if person turns left.	Pass
Direction Right	To turn right with person.	Trolley turned right if person turns right.	Pass
User Tracking	Trolley should stop if user stops.	If user stops then trolley first moves to the constant distance with person and then stops.	Pass
Obstacle Avoiding	Trolley should stop if any obstacles/different person comes in front of it.	Trolley stopped in case of any obstacles in its line.	Pass
To work in different lighting conditions	It should work efficiently during day and night.	It worked during day light as well as night light.	Pass
Two persons with same parameters	Trolley should track original user even if two persons of exact same color come.	If the color shades and patterns are exactly same, then difficult to differentiate.	Rare scenario and can be treated as exception

Table-2: Results

5. CONCLUSIONS

The MobileNet SSD system was efficient in terms of the computational work. The bot was able to identify the different objects successfully and was able to generate bounding boxes around them successfully. It can be seen in the results.

The algorithm was able to differentiate between different colors of the user's shirt. It was able to track the human with that particular shirt color.

The system works fine in most of the conditions except for some conditions that is – if multiple persons with same shirt color and same pattern come then bot might get confused and during night if the entire background is white and the shirt color is also white then there could be some issues. But both these conditions can be treated as exceptions as they are rare scenarios.

The model trolley built using this prototype will definitely be useful for shopping customers in malls. These automatic trolleys can follow them and there is no need of any manual effort

6. FUTURE SCOPE

There is lot of scope in adding multiple features in current human following trolleys. They are as follows:

- Locating:

By adding GPS feature we can locate them in bigger malls. Also; a small map can be provided on their screen (like google map but the map of the mall) so as customers can find and locate products easily.

- Payment:

We can integrate mobile based payment systems, RFID based payment systems with such trolleys. Also; the product QR codes can be scanned and the merchandise value of all the products in the cart could be displayed on the cart. This will prove helpful for customers to plan their shopping accordingly. The automatic payment system will reduce long queues during rush hours at malls.

- Auto Billing by adding weights in them and pricing accordingly especially for grains purchase.
- If we make it controllable from longer distances then it can also be used in military with some modifications.

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