

# MATLAB BASED REAL TIME TARGET DETECTION AND TRACKING USING ARDUINO

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**Abstract:** Face tracking in real-time is required for activity recognition, automotive safety, and for surveillance systems. For this Arduino is used along with the packages available in MATLAB using Kanade–Lucas–Tomasi (KLT) algorithm. However, due to more complex motion in real time, a better algorithm is required. In this paper, the entire process is divided into two steps: the face is detected by Viola-Jones detection algorithm and then the KLT algorithm is used to track the feature points in the video frame. Human faces are detected and tracked with the help of webcam and servo motors. The perfect intention of this paper is to progress a faster algorithm in detecting, tracking and recognizing a face, which serves as a useful process in several Real time applications like security systems, video surveillance, video coding and Advanced Robotics etc. Thus, an efficient, low cost, light weight programmable robot has been built.

**IndexTerms** - KLT algorithm, Viola-Jones algorithm, Face tracking, Arduino, MATLAB, Face Recognition.

## I. INTRODUCTION

In so many computer vision applications, the detection and tracking of object are very important and also including recognition of activity, surveillance and motorized safety. A face tracking system is very simple and mostly used system and which is established by separating the tracking problem into three distinct problems: Face detection in the frame, Initial facial features, which is used for tracking and Face Tracking. Face detection in MATLAB can be through using various dissimilar existing algorithms. These algorithms use different mechanisms to identify the facial features. Some use edge detection methods while some use contrast separation. One of the widely used algorithms is Viola-Jones algorithm. Generally, it is used in object detection applications but, due to its capability of detecting facial features using Haar based feature filters, is extremely easy to use for the face detection applications. The main reason overdue using MATLAB for image processing is due to its features with inbuilt tools and provision for good choice of hardware parts like that Arduino and Raspberry Pi. In this project, Arduino Uno was used due to its simplicity and compatibility with the MATLAB. Arduino hardware support package can be added to MATLAB via Add-Ons. The main purpose of this paper is to accentuate the use of Viola Jones object detection frame work on human faces in real-time.

The concept of face tracking emerges when there is a need for the tracking of a face when it is moving. The security surveillance systems is the main real-time application used for monitoring a crime action, robbery or any activity like that happening on roads or houses. This hence helps to find out the culprits and is a revolution in this field. It is implemented using CCTV cameras and their recording systems. It is used widely in the search for missing people by tracking their faces from the database.

Face tracking can be done in live video acquisition. Fundamentally, the whole process is divided up into three stages. The initialization of the process is face detection grounded on the Viola-Jones detection algorithm by using the Cascade object detector. The main important of Kanade-Lucas-Tomasi (KLT) algorithm is that to track the face; however, it is not very inexpensive. The combination of feature points is tracked using the KLT algorithm across the video frames of feature points. This is followed by the identification of necessary features and completion of tracking procedure. Hence the whole process of face tracking is a combination of detection followed by finding out some specific and unique points on the face using well-defined algorithm called the feature points. These points are then compared with the points of the image decided in the first frame. The set of matched feature points are then held by the tracking algorithm in such a way that they are tracked wherever they go. This whole procedure is called tracking. The main application comes in the CCTV cameras to track the missing faces. One of the interesting areas where this is used is in the driver drowsiness detection using the blink of eye. Note that the system tracks the face of the driver constantly, thereby notifying if the driver is drowsy while driving and hence decreasing the probability of accidents. This is achieved by a small monochrome camera and image processing.

Another major application is the Control of Wheelchair Dummy for Differently Able Patients via Iris movement using Image Processing in MATLAB. This is done by capturing frames of eyeball movement with a webcam. Viola-Jones algorithm in MATLAB is synchronized with Arduino to detect the eyeball and move the wheelchair independently. This is one way in which this concept can be implemented for social cause.

## II. METHODOLOGY

The proposed algorithm used for detection of human face is designated below. It contains of four major significant stages, they are given below:

**A. HAAR Features:** Images are categorized primarily on feature constructed systems because in feature constructed systems the calculations essential is fewer. For face detection generally two rectangular dimensional features, three rectangular dimensional features and four rectangular dimensional features are used. These features/structures are named as HAAR structures and are shown in below figure. The features are intended by simple adding and deduction operation. The features are calculated as the

modification of amount of pixels in the dark portion to the amount of pixels in the white portion. For any type of rectangular HAAR feature the features are intended in the above mentioned process. This process is frequent for dissimilar types of HAAR rectangular masks and also by fluctuating the dimension of the mask.

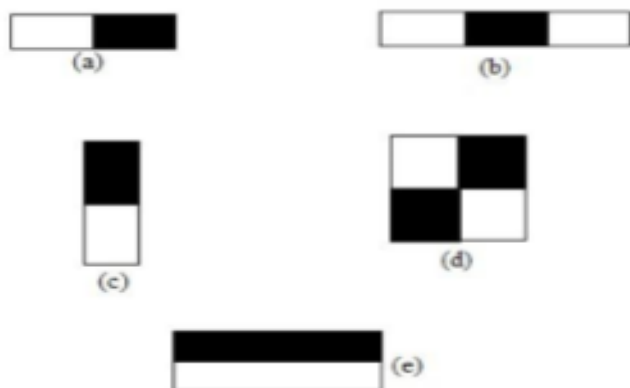


Fig 1: HAAR Features

**B. Integral Image:** Rectangular structures of an image are greatest designated by its middle form which we request it as an integral image. The equation for computing the integral form of an image is given by mathematically below and this can be described by capturing the below image

$$qq(a, b) = \sum_{a' \le a, b' \le b} q(a', b')$$

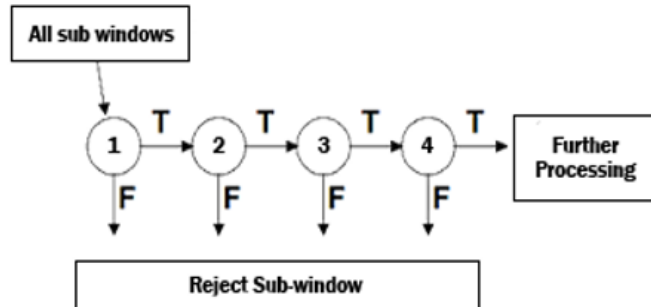
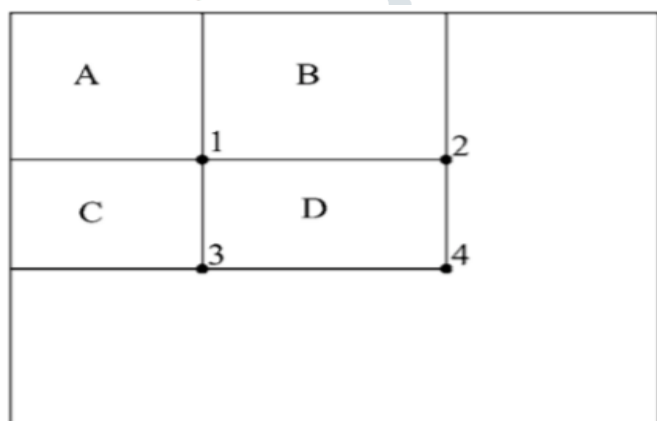


Fig 2: Integral image Fig 3: cascading

In the integral diagram, first point designates the whole sum of pixels which are existing in area A. For second point, gives the sum of pixels of the areas A and B. Similarly, for third and fourth points sum of pixels in the area (A, C) and (A, B, C, D). Where  $q(a,b)$  is an integral image and  $q(a', b')$  is the original image. Using the following formula,

$$P(a, b) = p(a, b - 1) + q(a, b)$$

$$qq(a, b) = qq(a - 1, b) + p(a, b)$$

Where  $p(a,b)$  is the cumulative row sum  $p(a,-1) = 0$  and  $qq(-1,b)=0$ .

**C. AdaBoost Training (Adaptive Boost):** The integral image calculates a value at every pixel (A, B) that is the sum of the pixel values above and to the left of (A, B) comprehensive. AdaBoost is adaptive by iteratively decreasing mis-classifications. The weights of mis-classified descriptors are attuned for the assistance of making a joint (weighted) application of the given  $w$  weak classifiers. The exercise set covers face and non-face examples with identical weight. For every round of boosting, it assesses every rectangular filter on every example and chooses the best threshold for every filter and then sets best threshold. After this, the weights are set again.

**D. Cascading Classifiers:** After the exercise is completed, the integral images are coordinated with the filters and cascaded using the MATLAB objects. The positive and negative portions of an image are separates using the classifier i.e., simple classifier. Weak classifiers are nothing but simple classifiers. Complex classifiers are sturdy classifiers in which it will yield the output from the preceding classifier and it will take as current input in which it may discard or accept that exact window. To attain the correct output for the detection this process goes on. Using AdaBoost method, stages in the cascade using training classifiers are created. To get the minimum false negatives evasion AdaBoost threshold values are intended and to yield low error rates. But at inferior threshold it becomes sophisticated detection as well a complex false positive amounts. The correctness in classifiers reductions if we reduce the calculation time. So there is a trade-off amid accuracy and speed. To boundary this one a two-feature robust classifier is built which is known as first stage classifier. In this we can detect 100% of the faces with a false positive amount of 40% by regulating the threshold. The second classifier drives through additional problematic task then the first. The whole

impression is to eliminate the needless areas and to growth the probability of face detection in the preliminary stages only. So that there will be a regular growth in the probability in further stages. The cascading is shown below in the below figure.

#### Cascade Objects in MATLAB:

Cascading of the integral images is completed using the inherent cascade structures of MATLAB. vision.CascadeObjectDetector(); detects the distinct object from the video input.

imaq.VideoDevice: This object allows MATLAB to interface camera to the system.

vision.ShapeInserter: This object places the distinct outline at the position if recognized HAAR features.

vision.VideoPlayer: This object shows the processing video with the recognized features.

vision.HistogramBasedTracker: This object paths the actions in the HAAR features using the histogram information.

### III. PROPOSED TECHNIQUE

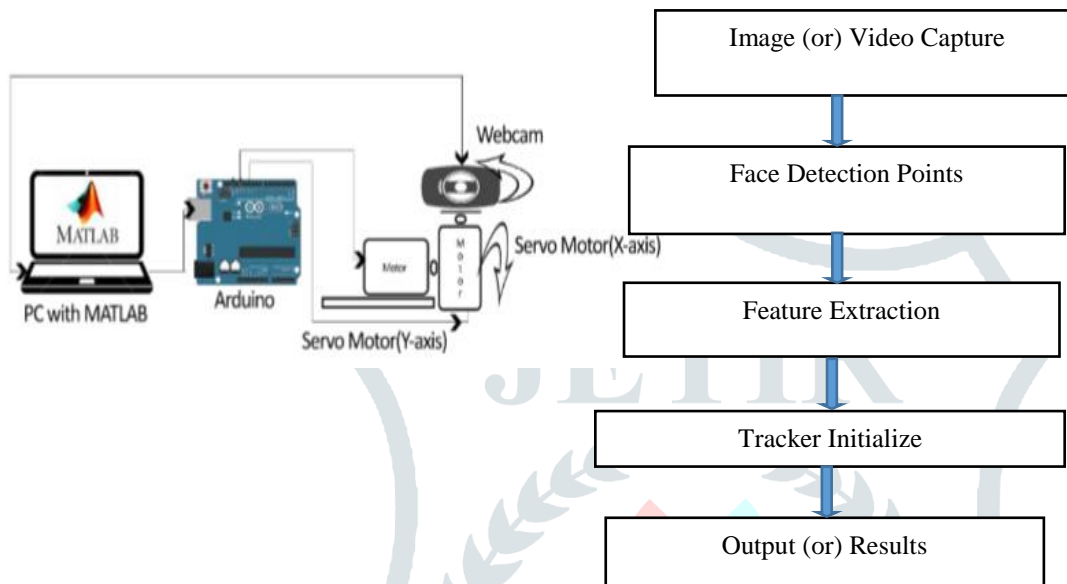


Fig 4: Proposed Model

Fig 5: Block diagram

The main purpose of the project work is to detect a human face in every frame of the video coming from a web camera and the captured image is processed using viola-jones algorithm using MATLAB and to detect the faces and send signals to the Arduino board to control the movement of the camera using two servo motors. One of the servo motor is for horizontal variation and another servo motor is for vertical variation, face shall be tracked actively and maintained in the frame. The MATLAB code may also include some of the built in functions for the effective face recognition and seamless tracking in real time environment. Applications of this concept are wide spread from video coding to advanced robotics.

The main impartial of this project work is to achieve detection and tracking of faces from real time input video. The block diagram of proposed system model as shown below.

#### a. MATLAB Software

In this proposed method, MATLAB uses the built in vision objects to detect the faces from a live video feed. For the first stage, a serial assembly to the Arduino hardware opens. Concurrently, the program recites the video feed from the webcam or external camera. For good efficiency, step is used for extracting frames from the continuous video feed. Using the Viola-Jones detection frame work, the frames extracted gets coordinated with the Haar features and faces are identified. Nose features gets matched after the faces. Then the boundary boxes will be placed at the identified face locations. Additional into the code, it computes the centroid of the boundary box and forms the portion of the frame it decreases in. As the frame of the video will be alienated into four quadrant, it computes the coldness from the center to the location of centroid of the bouncing box on both axes. These are fed to the Arduino serial input. MATLAB does this procedure constantly until the predetermined time after there is no face in the frame.

#### b. Arduino IDE

In this paper, Arduino Uno is used which switch the tracking gesture for the camera on two servo motors (pan-motion & tilt-motion). We used Arduino platform for this model because of its simple interfacing and working with the MATLAB. Adding the hardware support package to the MATLAB through the add-ons is extremely convenient. As the procedure of face detection occurs, serial input at the Arduino obtains the detachments from the midpoint to that of the bounding box. With this input from the serial port, Arduino code is printed such that it associates the input co-ordinates to the conditions in the program and operates the servo motors accordingly. This continuously runs to put the center of the bounding box on the center of the video frame.

#### c. Physical Connections

Components obligatory for this work comprises a web camera, Arduino Uno, a Computer with MATLAB (as well as Arduino hardware support packages) and Arduino IDE.

*d. Detection*

The input video stream is obtained using a webcam or any other live video acquisition device. The video is processed by dividing them into frames. Every frame is inspected for a face. Once the face is spotted, a bounding box is drawn around it. The coordinates of the box is obtained.

The first stage is performed on MATLAB software. MATLAB is a multi-archetype numerical computing programming language that uses Viola Jones algorithm for face detection. The coordinates achieved afterward detecting the face in a frame is written onto the Arduino Uno. Viola Jones algorithm is an object detection technique focusing on the faces in an image or video. It is operative only on frontal faces.

*e. Tracking*

The tracking of the face is done with the help of an Arduino microcontroller. Arduino is an open source platform with both hardware and software applications.



Fig 6: Hardware Setup

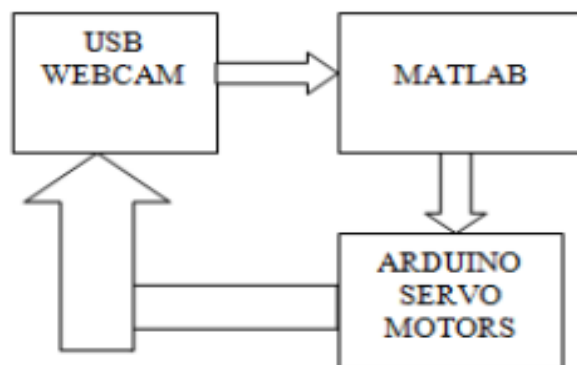


Fig 7: Relationship between software and hardware

The microcontroller is connected to two servo motors. The servos are centered before tracking begins. The coordinates obtained from the bounding box is used to track the face in the subsequent frames. The motors control panning and tilting the webcam mounted on it. The webcam's position changes according to the movement of the object or person. The servo motor varies its position from 0 degree to 180 degrees. Since Viola Jones algorithm restricts the operation to frontal faces, KLT algorithm is used for continuously tracking human faces in the live video stream. This is done by finding parameters that allows in reducing dissimilarity between feature points.

The above setup can be placed on any surface depending on the application. For example, the system can be mounted on walls for security surveillance systems similar to a CCTV camera.

**IV. SIMULATION AND RESULT**



Fig 8: Output for single face detection using Mat lab.

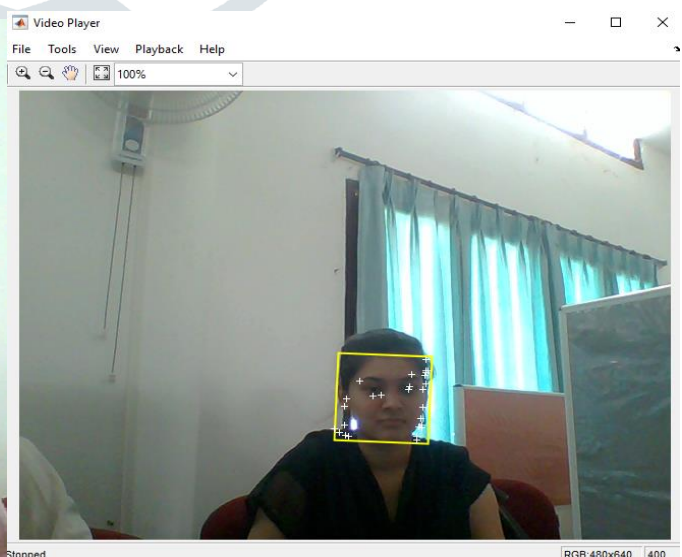


Fig 9: Output for single face detection using Mat lab.

The below figures shows the detection, tracking and recognition of the face using MATLAB and Arduino.

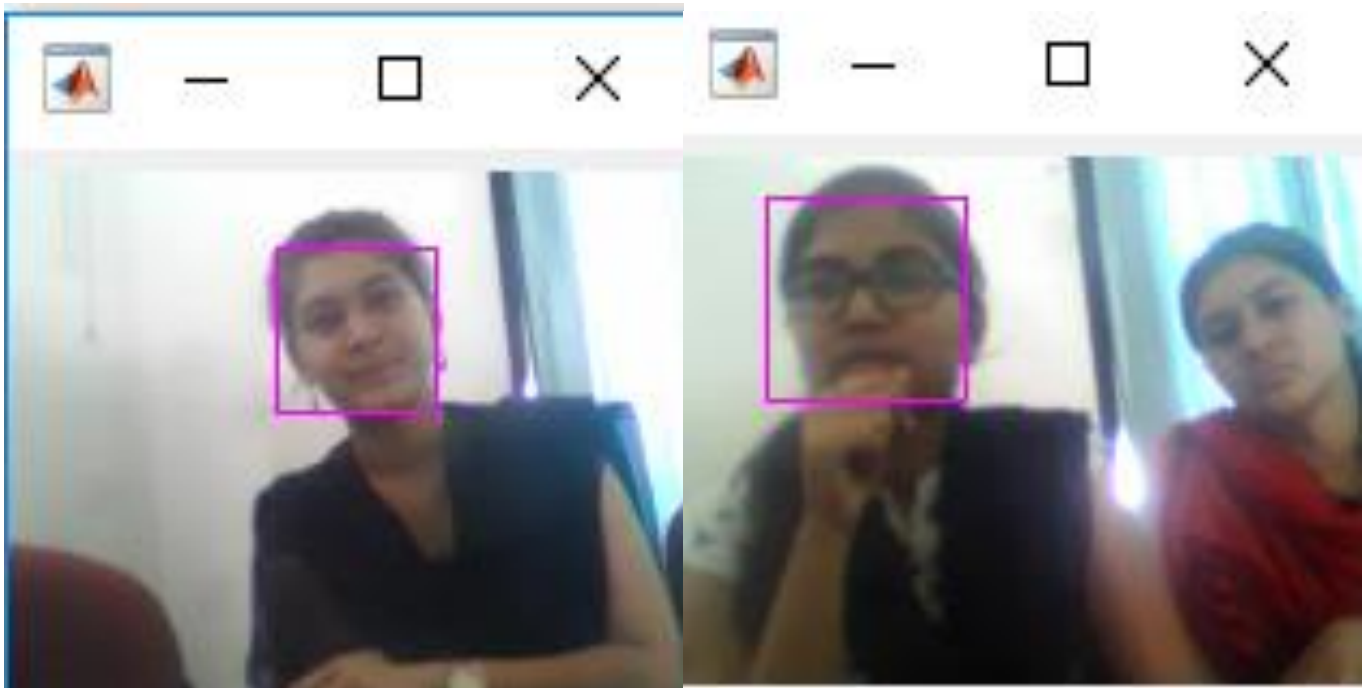


Fig 10: Output for single face detection Tracking Using MATLAB and Arduino.

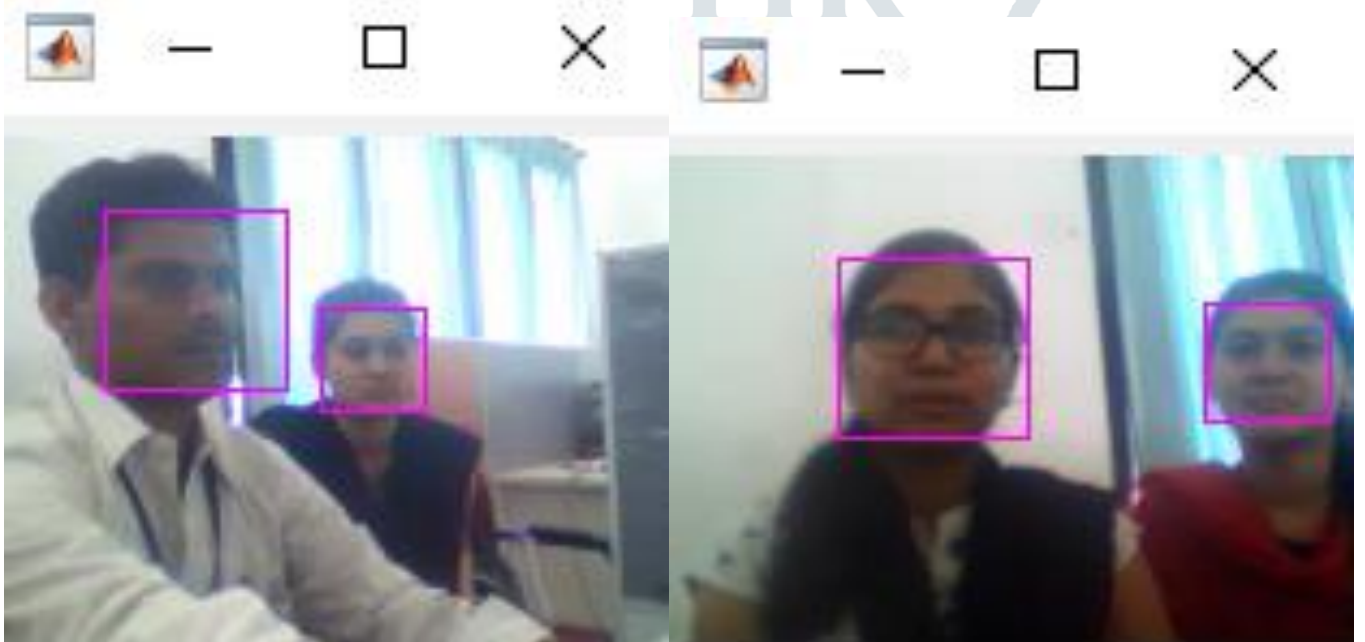


Fig 11: Output for Multiple Face Detection

```

Command Window
bbbox =
    63    18    38    38

c1 =
    82

c2 =
   -1

Command Window
wait =
    1
wait =
    2
wait =
    3
wait =
    4
wait =
    5

wait =
   101
wait =
   102
wait =
   103
wait =
   104
wait =
   105

bbbox =
    34    30    27    27

c1 =
  47.5000

c2 =
  16.5000

wait =
   106

wait =
   107
    
```

#### IV. CONCLUSION

The planned system for tracking faces using Viola-Jones algorithm in MATLAB is better than the present methods. Usage of adaptive boosting for the algorithm helps in increasing the precision and efficiency of the proposed method. This kind of tracking can be used effectively in the surveillance field. Also, Computer Vision is the major field which holds a vast scope for robotics. In our work, the face detection and tracking is mainly based on the facial features. The algorithm used for face detection and tracking are Viola Jones algorithm. It is an efficient and fast algorithm when compared to other algorithms. It is done by using MATLAB code, where Camera detects the face and tracking is done through the movement of camera using a Microcontroller called ARDUINO. We can implement this method in various places where security and video surveillance is highly essential. In this paper we are restricted with basic laboratory conditions where the application part can be done with high costs.

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