Human Gait Silhouettes Extraction Using Haar Cascade Classifier on OpenCV

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Abstract – Human Silhouette Extraction is one of the vital task in human abnormality gait detection. Hence in this study, extraction of human gait silhouette using Haar Cascade classifier is developed. This is done by detecting the region of interests (ROI) and by cropping the selected areas followed by background subtraction to eliminate unwanted background and further convert the images to silhouettes form based on human gait sequences acquired. Next, human abnormality gait detection is conducted based on front view markerless model. Classification results attained showed that the developed Haar cascade classifier is indeed suitable and robust in extracting front view gait features for abnormality gait detection with detection time of KNN surpass the SVM classifier.

Keywords - Haar Cascade Classifier, Detection Time, Human Silhouette, Gait, Python and OpenCV

I. INTRODUCTION

Haar Cascade is one of the effective detection classifier based on results attained by previous researches as mentioned in [1],[2],[3],[4],[5],[6]&[7]. For instance as reported in [1], enhancement of face detection achieved using Haar Cascade Classifiers that was based on skin color segmentation and reduction in execution time too. Further, Shujuan et al [2] developed a real time vehicle detection method using both Haar cascade classifier along with AdaBoost classifier and the algorithms are well validated using large database of both vehicles and non vehicles for training and testing. On the other hand, Goel & Agarwal [4] developed a robust gender classification technique using facial feature images based on Haar classifier and classification rate was over 98% and again reduction in computational time as well as suitability to be used in real time environment. Also, as mentioned in [8], Haar cascade was a rapid processing classifier in their research related to vehicle detection with good detection rates and proven suitable for computer vision based system. Consequently, an extension of Haar cascaded approach was also introduced by [10] specifically rotated Haar-like features for face detectors and boosting algorithms in related of performances and complex computational task.

Human detection are crucial factors in visual based surveillance system which discussed by many researchers as reported in [20], [21] and [22]. For instance, M. Paul et.al [22] discussed the steps for human detection of gait motion in surveillance monitoring that involved background subtraction, optical flow and spatial-temporal filtering as human being classifier. Additionally, as mentioned by R. Poppe [21] that discussed characterizing of image sequences as human action label, is explored in visual surveillance, video retrieval and human computer interaction tasks. On the other hand, an example of gender recognition survey study in [20], robustness of face and whole body parts contributed to good features extraction with high classification rate in controlled environment.

Consequently, K-Nearest Neighbour (KNN) is one of the simplest classification methods as compared with other machine learning methods as mentioned by Z.Changjun and C.Yuzong in [23], and generally, it is an accurate classifier in most of situations. Other than that, KNN model is a well-known supervised learning algorithm which firstly introduced by [24] for pattern recognition task. On the other hand, Support Vector Machine (SVM) was utilized for multi-classification in [25] and SVM with radial Kernel function for abnormal gait classifications as elaborated in [26].

Additionally, tracking algorithms using Haar cascade has improved the performance among machine learning approach for visual object detection and recognition as reported in [12] and the proposed method capable to handle large database of images. Moreover, Haar classifier as reported in [13] was broadly used in celebrities related queries using images database that automatically provide information on the query person with facial image of the celebrity as inputs. Other than that, as described by Kumar et al. [14], AdaBoost with Haar cascade was utilised as biometrics based on the face detection along with Principal Component Analysis (PCA) and Latent Dirichlet Allocation (LDA) for the real time biometric system. Hierarchical face and eye detection based on Haar Cascade as classifier was explored by [15] too and reported promising findins. Therefore, in this study we deemed further to evaluate and validate the effectiveness of Haar Cascade classifier as human gait silhouette extraction and further for classification of normal and abnormal human gait.
II. METHODOLOGY

This section will detail and elaborate the proposed method in this study. As we are aware, extracting human gait silhouette from video sequences using image processing technique is a complex task. The two main challenges are robustness of the background subtraction algorithm and attaining perfection for foreground extraction. Figure 1 depicted the general overview of this study with the main focus is to investigate the effectiveness of Haar Cascade classifier for human gait silhouette extraction.

As depicted in Figure 1, human silhouette will be extracted from the video sequences captured by either digital camera or Raspberry Pi. Firstly, object tracking via Haar Cascade classifier is performed followed by locating the x and y coordinates of the region of interest [ROI] and cropping of silhouette image sequences prior to feature extraction and classification for anomalous gait detection.

Here, the Haar Cascade classifier is to be trained with positive and negative images. For this study, positive images are the human gait images irrelevant of different types of lighting or illuminance whilst negative images are images that without the presence of the positive image that is the human gait. In this study negative images are the background scene. Figure 2 depicted some samples of database for positive images as well as negative images used in this study. Next, the Haar classifier needs to be trained with suitable number of training images specifically the human gaits. Based on previous researches by [9], [11], [12] & [16] and using trial and error approach, it was found that for this study, 1500 images are suitable to train the Haar classifier.

The negative images acted as background subtraction samples to remove the arbitrary background within the positive images. This is to ensure that the classifier can detect the human gait accurately, thus reducing imperfect silhouette extraction. This is repeated for all other positive images to ensure that the object of interest namely the human gait is detected. Then, the gathered features or vector values are converted into a single vector file to train the Haar classifier since Haar recognised the vector values instead of images. This is because Haar classifier needs to be trained with the (extracted) feature or vector values instead of bitmap images. All the features or vector values from each single frame of the positive image are computed via the edge, line and centre features [7]. This is done by focusing those features in each image.

Conversely, the steps involved in the Python program are as listed below:
- Define Haar Cascaded classifier file that contain the feature vectors of the human gait;
- Develop python file for detection of the human movement points remark on rectangular ROI;
- Setting of an Open-CV environment and Python core program for feature extraction stage and classification using Support Vector Machine (SVM) and K-Nearest Neighbour (KNN);

Figure 1. General Overview of the proposed Human Gait Silhouette Extraction.
Fig 2. Samples of Set of Positive Images (Top) and Set of Negative Images (Bottom) for training the Haar Cascade Classifier.
Note that the Python file developed is for detection of human movement, to locate the coordinate of ROI and to crop the human gait silhouette image in rectangular form based on the size of ROI as depicted in Figure 3. The Haar Cascade algorithm developed is able to identify mismatch area of ROI or if multiple ROI area detected. This is done via differential distance analysed computed for every multiple ROI generated prior to selection of the most optimum ROI. The next stage after image cropped is the front view based feature extraction and classification stages.

Based on Figure 3, \( w \) and \( h \) are the expansion units of the coordinates to create the region of interest. This is automatically generated for each human gait located during identifying the ROI and cropping.

Upon completion of silhouette gait extraction via Haar classifier, the silhouette will undergo feature extraction stage as described in [17] & [18]. Here six features of anatomical human body are evaluated to extract the gait features for modelling human walking gait. Based on front view markerless model as discussed in [19], four joint angles namely left thigh, left knee, right thigh and right knee are the feature inputs to the classifiers.

III. EXPERIMENTAL ANALYSIS AND DISCUSSION

This section discussed the experimental results attained based on the proposed method. Firstly, setting up for training and testing the Haar Cascade classifier need to be done as outlined below:

- Define vector file to store feature vectors generated;
- Define set of positive images – In this study 1500 sets of images of human gait;
- Define set of negative images that is 1500 sets of images without the image of human gait that is the background scene;
- Number of stages – The total number of Haar-training stages to be used.

Usually higher number of stages will reduce error but it may also lead to decrease the sensitivity of Haar classifier in detecting the human gait. Next, upon completion of training the Haar Cascade Classifier, the features vectors of human gait is generated in a specific file. Further, the Haar classifier will be tested with both positive and negative database totalling of 1500 for each case. Recall that appropriate detection of a human gait is vital in ensuring the ROI region coordinates are identified correctly.

Figure 4 depicted an example of ROI detection of a front view human gait as highlighted in the red box. As mentioned earlier, if more than one ROI are detected, the proposed shortest distance based Haar Cascade algorithm will select the most suitable ROI amongst them and identify the \( x \) and \( y \) coordinates of the ROI as well. Overall the Haar Cascade algorithm is able to identify the ROI of human gait followed by correct cropping of the human gait image. Next, the background subtraction is implemented to eliminate unnecessary background and as a result human gait silhouette is attained. Examples of human gait silhouettes extraction results are as depicted in Figure 5. On the contrary, to evaluate the effectiveness of the Haar Classifier, several more human gaits are also used as inputs. As shown, Figure 5 represented examples of normal and abnormal gait silhouette that are successfully extracted using the developed method.

Upon completion of silhouette extraction and feature extraction process, next is the detection stage using both KNN and SVM. Table 1 tabulated the accuracy rate for both classifiers along with the detection time.

![Fig 3. Human body area as region of interest](image)

**TABLE 1: OVERALL CLASSIFIER PERFORMANCE WITH HAAR CASCADE AS HUMAN GAIT SILHOUETTE EXTRACTION**

<table>
<thead>
<tr>
<th>Category</th>
<th>Gait Type</th>
<th>Accuracy (%)</th>
<th>Detection Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SVM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>84.2</td>
<td>89.5</td>
</tr>
<tr>
<td></td>
<td>Walking</td>
<td>84.2</td>
<td>89.5</td>
</tr>
<tr>
<td>Abnormal</td>
<td>Tiptoe</td>
<td>84.2</td>
<td>89.5</td>
</tr>
<tr>
<td></td>
<td>Drunken</td>
<td>84.2</td>
<td>89.5</td>
</tr>
</tbody>
</table>

Results attained showed that accuracy rate for KNN and SVM classifiers are similar for both normal and abnormal gait namely 89.5% for KNN and 84.2% for SVM respectively. In addition, KNN demonstrated higher recognition rate for both normal and abnormal gait. On the other hand, the detection time taken for detection of normal gait is shorter as compared to abnormal gait for both classifiers. Again, results attained showed that KNN required less detection time in identifying normal gait and abnormal gait as required by SVM.

IV. CONCLUSION

In conclusion, a more robust human silhouette extraction method using Haar Cascade classifier is developed. This is done via ROI identified and further cropped upon locating the ROI coordinates. The robustness of the Haar Cascade algorithm is the ability to identify variance in the ROI area or if multiple ROI detected and further capable to identify the most optimum ROI. Additionally, detection time during classification using KNN and SVM is reduced too. Future
work is to use the Haar Cascade classifier in real time environment.

Fig 4. Samples of ROI detection using Haar Cascade Classifier - Two ROI (Top); Three ROI (Middle) and single ROI (Bottom).

Fig 5. Example of human gait silhouette extraction based on ROI and further cropped: Top for normal gait and Bottom for abnormal gait
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