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Human Gait Recognition

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***Abstract*:** *To Compare Various Appearance-Based Approaches In The Terms Of The Recognition Rate, For A Walking Gait Of A Human, Is Proposed In This Paper. The First Step Comprises Of Obtaining Binary Silhouettes From A Video Sequence Of A Human Using Various Morphological Image Processing Techniques And A Relevant Gait Energy Image (GEI) Is Captured. Utilizing The Fact That The Frequency-Domain Information Of Gait Is Unique To Each Human, Discrete Cosine Transform (DCT) Is Used For Feature Extraction. Further, Features Obtained From DCT Are Mapped Onto Vector Space By Applying Linear Discriminant Analysis (LDA) And Principal Component Analysis (PCA) Independently For Feature Reduction. To Identify A Human Corresponding To His/Her Gait, Euclidean Distance Is Measured In Each Case. Results Obtained After Applying LDA And PCA Are Compared. Alternatively, Another Approach Consists Of An Object (Human) Detection From Frontal Angle Using The You Only Look Once (YOLO) Algorithm. The Bounding Box That Detects A Human Is Considered And Histogram For Every Such Frame In The Video Sequence Is Considered. An Average Flow Histogram (AFH) Is Calculated Which Is The Unique Gait Pattern For A Particular Human. Consecutively, PCA And LDA Are Used Independently Onto The Gait Pattern To Find The Best Features. Similar To Other Approach, Identifying A Human With Respect To One's Gait Pattern, Euclidean Distance Is Measured.*

Keywords– *Gait Recognition; Model Free Gait Recognition; Discrete Cosine Transform; You Only Look Once; Principal Component Analysis; Linear Discriminant Analysis; Gait Energy Image; Average Flow Histogram*

I. Introduction

Humans Can Walk, Jog, Skip, Run And Sprint. Human Gait Refers To The Various Locomotion Of A Human Using Their Limbs. Thus, Human Gait Is One Of The Main Activities Of Our Daily Life. Every Human Has A Unique Gait Pattern And It Is Formed By Utilizing 26 Muscles Of The Legs. A Gait Pattern For Any Human Being Depends On Various Parameters. Stride Length, Step Length, Foot Angle, Speed, Presence Of Clothing Or Footwear, Are Some Of The Parameters. The Fact That An Individual Has A Unique Gait Pattern Has Led To The Study Involving Human Gait Recognition. Human Gait Recognition Is A Way To Identify A Particular Person Through Their Gait Pattern. Using Such Knowledge Can Lead To A Successful Application In Human Surveillance, Medical Diagnostics, Analyzing An Athlete's Performance And Optimizing It. Another Application Is Concerning Biometric Identification Using Gait. Human Biometric Identification May Include Techniques Like Fingerprint Identification, Facial Recognition, Gait Pattern Recognition, Voice Analysis, Iris Scan. Facial Recognition And Iris Scan Requires High-Quality Images, Fingerprint Identification Requires Subject's Cooperation. By Contrast, Gait Recognition Has Many Unique Advantages, Such As Unobtrusiveness, Recognition At A Distance, And Operation Using Low-Resolution Images

Gait Recognition Can Be Categorized Into Two Types - Model-Based Approach And Appearance-Based Approach. A Model-Based Approach Utilizes Modeling Of Body Movement During Walking At Every Frame Of The Gait Sequences. In This Approach, Identification Is Done Using An Underlying Mathematical Construct Or A Set Of Constructs Representing The Discriminatory Gait Characteristics (Can Be Static Or Dynamic), With A Set Of Parameters And A Set Of Logical And Quantitative Relationships Between Them. These Models Are Often Simplified Based On Justifiable Assumptions Such As The System Only Accounts For Pathologically Normal Gait. Normally System Like That, Consists Of Gait Capture, A Model(S), A Feature Extraction Scheme, A Gait Signature And A Classifier (Like Support Vector Machine, K-Nearest Neighbour). The Model Can Be A 2 Or 3-Dimensional Structural (Or Shape) Model And Motion Model That Lays The Foundation For Extraction And Tracking Of A Moving Person. An Appearance-Based Approach Or Model-Free Approach On The Other Hand, Utilizes Binary Gait Silhouette Sequences Of Humans To Recognize An Individual. It Involves Estimation Of The Gait Cycle And Subsequent Operations To Find A Gait Energy Image Through Several Image Processing Techniques. Then, Various Subspace Learning Algorithms Like Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Discriminant Common Vector (DCV) Are Applied To Reduce Dimensionality Of Feature Vectors And/Or To Learn Features For Classification.

Human Gait Recognition Is An Ongoing Research That Has Been Around Since Past Decade. Various Methods Have Been Proposed To Improve On The Recognition Results. To Contribute To The Research Over The Approach Best Suited For Unique Gait Recognition, This Abstract Compares Various Techniques That Have Been Best Suggested And Suitable For Gait Recognition. The Approach In This Paper Is Appearance-Based And Uses The Fore-Mentioned Algorithms And Compares Them In Context Of Accuracy, Precision And Response Time. Although Some Research Has Been Performed Over These Approaches Independently, But They Have Never Been Compared Over These Parameters. The Algorithms Are To Be Compared And Carry Forward Through Different Methodologies To Get Various Results In Distinct Parameters. This Paper Is To Bring The Human Gait Recognition Concept A Step Forward In This Division. The Gait Patterns Are Studied And Analysed By The Algorithms Mentioned Ahead.

Here, The Attention Is On Appearance-Based Approach And Will Be Proceeded With It. Previously, DCT-LDA And DCT-PCA Had Been A Must For Human Gait Recognition, But This Paper Brings About Another Approach Using YOLO Which Is An Object Detection Algorithm. This Paper, Hence, Compares The Four Methods (Viz. DCT-LDA, DCT-PCA, YOLO-LDA, YOLO-PCA) In Which The Human Gait Recognition May Be Implemented.

II. Literature Review

An Appearance-Based Approach Utilizes Binary Gait Silhouette Sequences Of Humans To Recognize An Individual. This Needs Lesser Computational Resources As Well As Lower Cost Than The Model-Based Approach. This Involves Estimation Of The Gait Cycle And Subsequent Operations To Find A Gait Energy Image Through Several Image Processing Techniques. Han And Bhanu [1] Proposed A Spatio-Temporal Compact Representation Of Gait Called GEI (Gait Energy Image) Which Has Been Demonstrated To Be Effective For Representing Gaits In The Human Identification Problem. For This, Binary Silhouettes Of A Human Are Needed, Which Can Be Obtained Easily Even From Low-Quality CCTV Footage. Nurul Illiani Yaacob, Nooritawati Md Tahir [2] Implemented Human Gait Recognition Using Appearance-Based Technique - Which Uses Side Silhouettes Of Human Body, Wherein Feature Extraction Is Performed Using Discrete Cosine Transform (DCT) And Then Applies Principal Component Analysis (PCA) To Reduce Dimensionality. Here, DCT Can Extract Unique Features Since Gait Of A Human Is Unique And Unaffected. This Research Exploits The Fact That Frequency Domain Information Is Unique And Insensitive Of Human Appearance.

A Paper By Zheyi Fan, Jiao Jiang, Shuqin Weng, Zhonghong He, Zhiwen Liu [3], Improves On This Subject By Substituting Linear Discriminant Analysis (LDA) In Place Of PCA, Succeeding DCT. Another Approach By Shajiina T And P. Bagavathi Sivakumar [4], Extracts Gait Features Like Swing Distance, Joint Angle By Skeletonization On The Binarized Silhouette Image. The Features Are Then Represented As A Time-Series Data, To Obtain Shaplets That Are Found For This Data. These Shaplets Are Subsequences Of Time-Series Data, A Decision Tree Is Used To Classify This Data.

A Proposal Of Applying YOLO As A Regression Problem By Joseph Redmon, Santosh Divvala, Ross Girshick, Ali Farhadi [5] Inspires Us To Adopt YOLO For Human Detection On A Video Sequence. This Paper Outruns Many Object Detection Algorithms Like R-CNN And DPM. YOLO Can Be Implemented For Better Accuracy And Faster Processing. It Is A Simplified And Preferable Approach For Object Detection. YOLO Divides And Image In Bounding Boxes And Work On Them. The Paper Describes YOLO As Windowing On Bounding Boxes Of An Image, Detects And Predicts The Objects In Bounding Boxes Through Confidence Prediction And Probability, Which Results In Recognizing And Analyzing Most Objects Accurately In An Image.

III. Algorithms And Their Usage

GEI:

A GEI (Gait Energy Image) Is The Average Of All The Silhouettes In The Gait Cycle, Which Is Used For Further Processing In Gait Recognition. Silhouettes For GEI Can Be Obtained From Object Detection And Background Removal Of An Image, Which Only Focuses On The Human Gait. GEI Is Proven To Represent Velocity Significantly And Is Quite Robust.

DCT:

DCT Extracts Frequency-Domain Information Of An Image Signal, And Here, Focus Is On Interpreting And Differentiating Between The Low And High Frequency Information Obtained From The GEI. From The Obtained GEI, It Is Easy To Verify That There Isn't Much Movement On The Upper Half Of The Human, And Thus, It Is Slower Moving Part Having Low Frequency. As Analysing The Pattern Of The Limbs Is The Main Agenda, DCT Coordinates In Separating The High Frequency Components (Limbs) From Low Frequency Components. DCT Extracts The High Frequency Features And Thus Acts As An Feature Extraction Method.

YOLO:

You Only Look Once (YOLO) Is An Algorithm Wherein Object Detection Is Practiced Through Bounding Boxes And Confidence Prediction Mechanism. YOLO Adopts Windowing Through The Bounding Boxes Of The Image, Which Helps In Eliminating The Background And Focus Only On The Object In The Image. This Benefits In Faster And More Accurate Results. It Processes Object Detection Based On 5 Parameters - X,Y (Coordinates Of The Object's Center In A Bounding Box), Height And Width Based On The Prediction Of Bounding Box And A Confidence Factor Which Predicts The Surrounding Bounding Boxes. The Algorithm Assists In Eliminating The Added Attire On Human While Detecting One's Gait Pattern. This In Turn, Can Be Used To Produce A GEI.

PCA:

Principal Component Analysis Is Used To Reduce The Dimensionality Of A Data Set Consisting Of Many Variables Correlated With Each Other, Either Heavily Or Lightly, While Retaining The Variation Present In The Dataset, Up To The Maximum Extent. PCA Unlike LDA, Does Not Take Into Account Any Difference In Class. Visualization Becomes Easier With Fewer Variables. PCA Is Preferred When Data Is Of 3 Or Higher Dimension.

LDA:

Linear Discriminant Analysis Is A Generalized Version Of Fisher's Linear Discriminant, Which Is Used In Statistics, Pattern Recognition And Machine Learning To Find A Linear Combination Of Features That Characterizes Or Separates Two Or More Classes Of Objects Or Events. LDA Tries To Model The Difference Between The Classes Of Data. Linear Discriminant Analysis Is Primarily Used To Reduce The Number Of Features To A More Manageable Number Before Classification.

Data Sets:

Casia (Institute Of Automation, Chinese Academy Of Sciences) Data-Set Will Be Used For This Practice Which Comprise Of Two Types Of Data Sets Will Be Used- Training Data Set And Testing Data Set. Their Division Contributes As 40% Training Data Set And 60% Testing Data Set.

IV. INDENTATION AND EQUATIONS

1) Extracting GEI Requires Binary Silhouettes Of Captured Frames Of The Entire Gait Cycle. The Binary Silhouettes Should Be Preprocessed So As To Make Them Noise-Free And Focus On The Subject. The Subsequent GEI Is Can Be Obtained As –

Suppose There Are 'N' Frames In A Gait Cycle, And After A T-Th Frame, Gait Cycle Is Repeated. Then GEI G(X,Y), Where X And Y Are Integers, Is Given As -

$$G(x,y) = \frac{1}{n}\sum_{t=1}^{n} B(x,y)$$

Where, G(X,Y) Is A Gray Image, (X,Y) Is The Value Of Pixel,
B(X,Y) Is The Function Of The Location

2) After Extracting GEI, DCT Is Applied To The Image For Feature Extraction. It Removes Frequency Components Which Have Little Contribution To Energy. To Extract Frequency-Domain, We Need A *N X N* Image, And Two-Dimensional DCT Equation Is –

$$F(u,v) = a(u).a(v)\sum_{x=0}^{N-1}\sum_{x=0}^{N-1} f(x,y)\frac{\cos\ (2x+1)u\Pi}{2N}\frac{\cos\ (2x+1)v\Pi}{2N}$$

Where $a(u).a(v) = \sqrt{\frac{1}{N}}$ U,V = 0

$\sqrt{\frac{2}{N}}$ U,V = 1, 2, … , N-1,

And F(X,Y) Denotes Gray Value Of A Pixel In GEI,
And U,V Are Transformation Rates Of Horizontal And Vertical Direction Respectively,
And F(U, V) Denotes Frequency Coefficient After DCT

3) YOLO Divides The Image In Bounding Boxes And Hence These Bounding Boxes Need To Be Rectified Using A Linear Activation Function-

$\Phi(X) = \{\ X,$ If $X>0$

Φ(X)= 0.1x, Otherwise

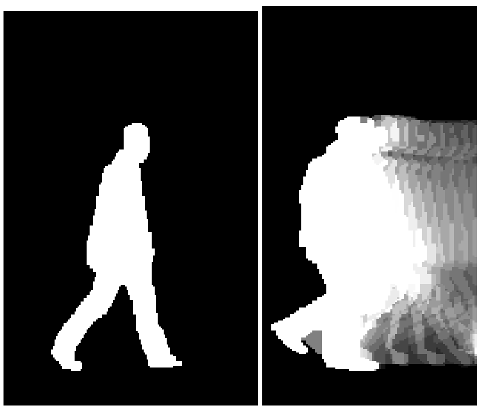
Where, X= X-Axis Dimension Of The Bounding Box That Is To Be Analysed.

However, This Equation Alone Cannot Eliminate All The Errors. Errors Are Bound To Take Place, Since Many Bounding Boxes Might Be Without Any Object. To Eliminate This Error, We Apply The Following Equation Of Loss Function-

$$\lambda_{\text{coord}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left[(x_i - \hat{x}_i)^2 + (y_i - \hat{y}_i)^2 \right]$$
$$+ \lambda_{\text{coord}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left[\left(\sqrt{w_i} - \sqrt{\hat{w}_i}\right)^2 + \left(\sqrt{h_i} - \sqrt{\hat{h}_i}\right)^2 \right]$$
$$+ \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left(C_i - \hat{C}_i\right)^2$$
$$+ \lambda_{\text{noobj}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{noobj}} \left(C_i - \hat{C}_i\right)^2$$
$$+ \sum_{i=0}^{S^2} \mathbb{1}_{i}^{\text{obj}} \sum_{c \in \text{classes}} (p_i(c) - \hat{p}_i(c))^2$$

Where, $\Lambda_{\text{coord}} = 5$,
$\Lambda_{\text{noobj}}=0.5$
$1^{obj}{}_{i}$ Denotes The Appearance Of Object In Cell 'I',
$1^{obji}{}_{j}$ Denotes J^{th} Bounding Box Cell Predictor In Cell 'I' Credited For That Cell's Prediction

FIGURES



A Gait Silhouette GEI For A Gait Cycle

A Gait Silhouette Of A Human Is The Cycle Of The Walking Pattern, Which Repeats Itself. An Entire Gait Cycle Consists Of The Gait Pattern Recorded For Gait Recognition.

V. CONCLUSION

This Paper Provides An Insight To Identify The Gait Pattern Of A Human. The Gait Pattern Of The Human Can Be Utilised To Provide An Identification Of A Particular Human. The Earlier Progress In Human Gait Research Testify That The Implementation Of Human Gait Identification Should Be Given More Importance To Further Develop It In Parameters Such As Response Time, Efficiency, User-Friendliness And Easily Available Data To Put Into Various Applications As Forementioned. Human Gait Analysis, Although Has Not Developed Much, But Can Simplify Most Crucial And Demanding Job And Result In Better Outputs. For Example Theft/Crime Can Be Detected Even If One Covers The Face. The Future Deployment Of Human Gait Is A Wide Spread, Open Field With Much To Progress In.

We Belief That This Paper Takes A Step Forward In The Research Of Human Gait And Inspires More Companions To Simulate Engagement In This Field In The Near Future.

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