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Review Article

FEEDBACK-BASED GAIT IDENTIFICATION USING DEEP NEURAL NETWORK CLASSIFICATION

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Abstract:
Identification of gait plays a major role in the healthcare industry, recognition of a gait having different angles, identification of abnormalities is a challenging task, to detect the abnormal person identification contains improper pattern style, human limbs, walking pattern, etc... A normal person has a correct pattern, an abnormal person has an irregular pattern. This paper provides the identification of the lean angle and ramp angle [19] of irregular patterns on three abnormalities such as Parkinson gait, Hemiplegic gait, and Neuropathic gait [18] by using deep neural network (DNN) without clinical observation by using DNN classification with feedback-based verification of trained features with query features of abnormal identification of trained features with query features. This paper concludes the gait abnormalities based on lean angle and ramp angle.

Keywords: Human Gait, Deep Learning, Deep Neural Networks, Feedback-based etc..

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INTRODUCTION:

Gait plays a major role in health care applications to identify the walking style of the person and movements of the human, the normal gait refers to the correct walking style stance (pattern) [1], swing phases and sequence of the person, the abnormal gait refers to irregular pattern of a person walking style stance, swing phases and sequence of the person, in different situations. Several research has been done on human gait analysis, while human walking spending some energy conserved from the different parts of the body, some energy distributed from the body that depends on different parts of the body [2, 18]. The analysation of the body can be identified by the walking movements of the lean angle and ramp angle [18]. The purpose of the lean angle and ramp angle is to keep the balance of the person to provide the observation health condition as follows[3, 19].

- Lean Angle: While person walking lean angle is the leg position boot that forces to keep away from actual position, the boot ranges between the 13-17 ° [4], the walking position boot feels unbalanced, one leg position is behind the next step of leg position, the forcing of walking legs to bend from one position to another position [5].
- Ramp Angle: While person walking the height difference between the toes and heels inside the boot ranges between 4-7 ° [6], the forward lean of the left leg to right leg, the general body position unbalanced to adjust walking position [7].

The lean and ramp angle is most required to observe the walking position and identify the abnormality of a human [5, 6, 7, 8], it depends on the "actual position of walking" the observation towards the foot, and also depends on the strength of the person stability to walk [8]. The difference of angle between the two legs with a heel wedge under the liner, the people with excessive range of motion while walking with a boot of lower ramp angle is standing more upright [9]. Based on the human walking style, and pattern of leg movements derived from the kinematics, we observed the video sequence, abnormal person, it identifies the abnormal person by using gait cycles. The mainly gait cycles can be characterised as two groups i) Normal Gait ii) Abnormal Gait [10, 11].

Normal Gait Identification [2]

The pattern occurs natural in gait cycles and it allows proper cycles while walking at least one foot can touch with the ground at one cycle of rotations, the recognition of human gait in healthcare industry plays a major role to identify normal or abnormal gait by identifying the walking style of the person movements which consist of the correct sequence of the stance and swing phases [4,19].

Abnormal Gait Identification [3]

Abnormal gait is the improper pattern sequence, it identifies the visualizing the video sequence with sluggish observation, once it plays the video sluggish and improper stance of swing phases [5, 19].

This paper proposed the novel approach to identify the abnormal person by identifying the neurological disorders. The observation of video head, hip, heal and toe bidirectional analysis provides three major types of gaits as shown in figure 1.

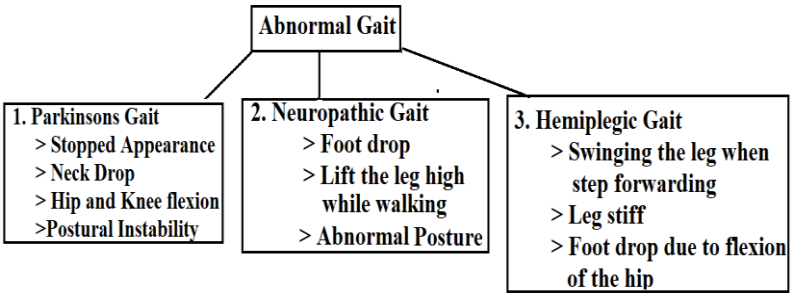

Figure 1: Types of Abnormal Gaits [18, 19].

The major three types of disorders are shown in the Figure 1 [18, 19]

- Parkinson gait: The persons with Parkinson's disease (PD) is called as Parkinson gait often called as abnormal gait [2], the classic stooped occurrence while walking, neck drop between trunk and limbs while walking, with flexion of the hips and knees while walking, and a huge gap between rounding of the shoulders while walking [9].
- Neuropathic Gait: The abnormality of neuropathic deformity seen with foot drop, swinging the leg when step forwarding, this is also due to the weakness of the person with leg stiff and foot drop due to flexion of the hip [10].
- Hemiplegic Gait: This abnormality detects that while walking each step is rotated away from the walking pattern, swinging the leg position, leg position is not proper position between the knee and foot, each walking step is semicircle [11].

This paper provides the novel vision approach to recognize the gait abnormalities by using the supervised DNN based classification. Section 2 deals with the related work, section 3 proposed gait abnormal detection, section 4 drawn the results and discussion and this paper concludes with the section 5.

RELATED WORK

Several studies have been carried out to detecting the abnormal gait, in health care applications detecting abnormal gait from video streaming is one of the challenging tasks. Zhang Anqin et. al., [1] abnormal gait detection used Fourier transform technique (FT), that computes the standard deviation to detect the abnormal detection but it needs large data sets of images. The support vector machine (SVM), machine learning (ML), KNN classifier used for abnormal detection requires a large scale of training data. The future enhancement of this work requires DNN training data is used to an effective way of abnormal detection. Paul et. al., [2] proposed surveillance videos sequences to detect the abnormality and applications used to solve machine-learning algorithm is a time-consuming process to detect Parkinson gait, DNN is most required to solve the abnormal detection. Kyoungchul Kong et.al [3] detecting the abnormal gait cycle by considering the foot, feedback enhancement is failed to explain the abnormal detection, it identified different abnormalities.

Jie Yin et.al [4] proposed a support vector machine (SVM) classification for detecting the gait based activities, it is the problem of anomalies detection in training data, sensors are attached to the human body that identified the abnormal detection, the feedback-based mechanism is not encompassed the proposed model [5].

The feedback-based mechanism is most required to solve for the gait. Ahmed et.al [6, 7] proposed for abnormal gait detection technique the joining the human body parts by suing Fourier transformation method. Faezeh et.al [8] proposed a different approach for a model-based approach for analysing the leg and arm movements and shoulders in human gait recognition, this problem is not solve the neuropathic gait [9, 18]. A model is constructed using active contour models (ACM) this model is incorporated with a feedback-based approach [10,18].

K-nearest neighbour problem and classification problem is quite similar to the feedback-based approach [11]. From the previous works, feedback-based approach is quite suitable to the machine learning algorithms, SVM, FFT, MSE, DFT, KNN[12]. All machine learning problems arises due to dataset of training video sequences that provides the comparison between the normal gait and abnormal gait, but feedback-based approach is appropriate [13]. Parkinson gait have high false rate detection occurs [10].

The comparison of Parkinson gait, hemiplegic gait and neuropathic gait, by using video sequences to ensure feedback-based approach [12]. The lean angle and ramp angle are two angles to useful to find the abnormal gait detection [13]. Extract the features of video sequence has been considered to check training features with query features [9]. The lean and ramp angle calculates the abnormal walking position of human [10], DNN based classification algorithms applied in lean angle and ramp angle dataset [11]. This work lies lean and ramp on three major gaits such as Parkinson gait, Hemiplegic gait and Neuropathic gait [18].

Parkinson Gait

It is also called Parkinson's disease (PD), it focuses on the way a person walks, the person changes walk from one position to another position is to identify the Parkinson's gait or Parkinson gait. Gait movements can be highly disruptive to the observation of every movement with PD and may interfere with the ability to actions, work, figure 2 shows the side view and front view of a person walking observation of PD [8].

Figure 2: Parkinson Gait [8,18]

Hemiplegic Gait

This gait legs swing outwards and a semicircle from the hip, the person while walking poor control of the flexor muscles during swing phase foot is moved beyond the initial point, pertic arm is fixed and leg is hyperextended [7]. The following Figure 3 shows the extensor muscles acting arm is fixed during the transporting body due to the swing phase the leg is increased during the swing phase.

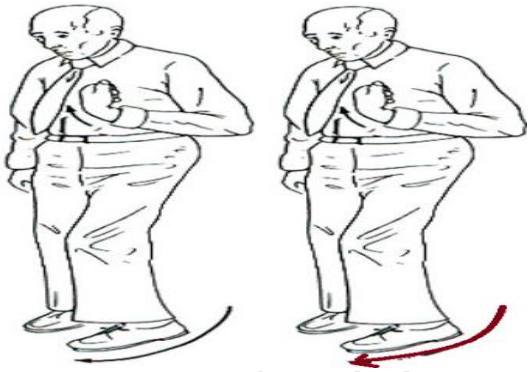

Figure 3: Hemiplegic Gait [7,18]

Neuropathic Gait

This type of gait occurs due to the high stepping, it is characterised as foot drop, hip flexion, and knee extension. The following Figure 4 shows the foot hangs with the swinging the leg when step forwarding and foot drop due to flexion of the hip [8].

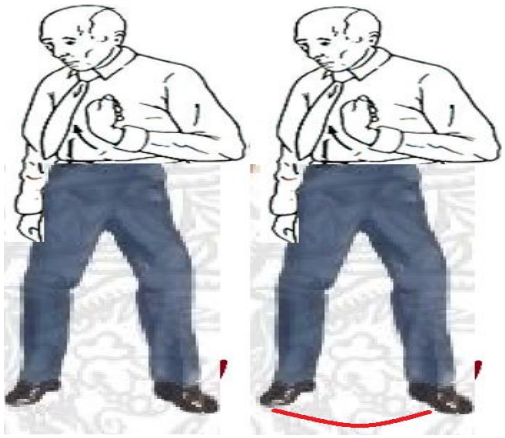

Figure 4: Neuropathic Gait [10,18]

Many researchers worked on the Chinese Academy of Sciences (CASIA) dataset gait recognition. The Institute of Automation, it provides the gait recognition based on video sequence, most of the work has supported due to the feedback-based assistance by using extracted training features with query features. This paper used the CASIA gait database used dataset-B (multiview dataset), the data set available on [http://www.cbsr.ia.ac.cn/users/szheng/?page_id=71].

GAIT ABNORMALITY DETECTION

In this section the proposed approach consists of three major phases, namely pre-processing, feature extraction of training data, check the feature extraction with the query features [15,19]. To start with, human silhouettes by using the video streaming are obtained through the image classification extracting the features of video sequence of each gait sequence obtain the extracted training features of lean angle and ramp angle of query features has been calculated using an instability of heel to toe behaviour [16,17]. Lean angle measured between the head and hip and ramp angle measured between the heal and toe measured between the walking style of the human of video sequences of the data set extracted feature data set to trained data set, the query features are user given data set then checked to the training features to query features to detect the abnormality as shown in Figure 5.

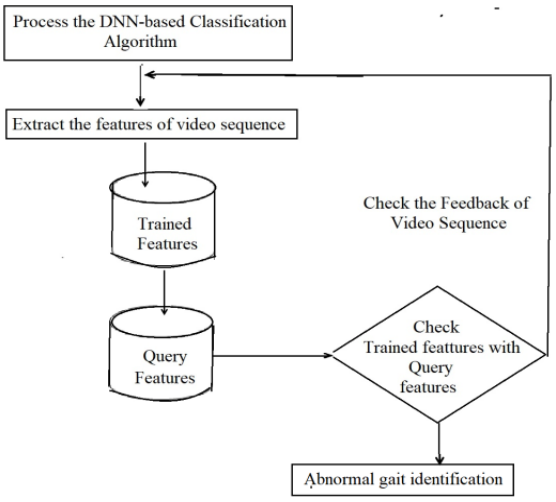

Figure 5: Proposed Architecture of Abnormal Gait Identification [16,17]

DNN-based Classification

DNN-based classification is observed based on walking style of person by observing the video sequences and surveillance of walking pattern of human. The extracted training features of video sequence of data set from a set of images based on the video sequence of their lean angle and ramp angle categororical features [16,17]. The extracted query features are used to classify the methods that involve the trained features of data set to check the features of a video sequence by using feedback-based approach. The proposed architecture is a supervised learning to maintain the two database training features and query features. The feedback-based approach comparison of the normality and abnormality with the back propagation approach. In the training phase, the extracted feature sequence of a normal walking and abnormal walking, the three classes A, B, C, D - normal, Parkinson gait, Hemiplegic gait, Neuropathic gait data sets compared with the normal data set.

The deep neural network classifieds the actual data sets of lean angle and the ramp angle are considered as classification parameters.

Algorithm: Feedback-based DNN classification
Input: Data sets of Lean and Ramp angle.
Output: Detection of Abnormality comparison with Normal data set

Step 1: Consider Extracted Set S, Training set T and Query Set Q
Step 2: Update the data set by using Lean angle and Ramp angle [19].
Step 2.1 Identification of Lean angle and Ramp angle

- Moving data sets considered as walking style (left to right (l->R) or right to left (R->l))
- Maximum Lean Angle [MaxLA], Average Lean Angle [AvgLA], Minimum Lean Angle [MinLA] [18]
- MaxRA: Maximum ramp angle of left leg (R_l)
  MinRA: Minimum ramp angle right leg (Rr) are observed by the gait cycles [18]

Step 3: Training Phase: The N training video streams of the gait cycle from the extracted training data set vector. The n persons gait cycles as follows ($G_1, G_2, G_3, \ldots, G_k$)
Step 4: Feedback-based identification [16,17]
The C is the query features considered as classification of Feedback as follows

Xc – *Lean Angle in x axis*
Yc – *Exemplar point of average Lean Angle in y axis*
Zc – *Exemplar point of minimum Lean Angle in z axis*
k – *Total Number of gait cycle in ith video of jth person*
xl – *Maximum Lean Angle of lthgait cycle in ith video of jth person*
yl – *Average Lean Angle of lthgait cycle in ith video of jth person*
zl – *Minimum Lean Angle of lthgait cycle in ith video of jth person*

Where $l \in (1,2,3, \ldots, k)$, $i \in (1,2,3, \ldots, n)$ *and* $j \in (1,2,3, \ldots, m)$,

Parkinson gait $X_C = \frac{1}{k}\sum_{l=1}^{k} x_l$ (1) [18]

Hemiplegic gait $Y_C = \frac{1}{k}\sum_{l=1}^{k} y_l$ (2) [18]

Neuropathic gait $Z_C = \frac{1}{k}\sum_{l=1}^{k} z_l$ (3) [18]

$$X_c, Y_c, Z_c = \left\{ \frac{1}{k}\sum_{l=1}^{k} x_l, \frac{1}{k}\sum_{l=1}^{k} y_l, \frac{1}{k}\sum_{l=1}^{k} z_l \right\} \quad (4)\ [18]$$

Step 5: Add training features T with the query features Q to the model.
Step 6: Check the trained features with query features.
Step 7: Apply the process of feedback-based approach to check the trained features with query features [16].
Step 8: Identify the abnormal gait by using the feedback-based approach as follows.
The query λ is establish between the training set T and query set Q
λ_A(LeanAngle ,RampAngle) [19]
λ_B(LeanAngle ,RampAngle) [19]
λ_C (LeanAngle ,RampAngle) [19]
λ_D(LeanAngle ,RampAngle) [19]
Step 9: The resultant query provides the identification of abnormal gait detection, the equation (4) is used to calculate the lean and ramp angle of abnormal gait detection using DNN-based classification of particular video sequences. The feature extraction is to be calculated for every video streaming in the CASIA multi view dataset [18].

Abnormal Gait Recognition

Abnormal Gait identification observed the particular person data set maximum lean angle represented as (MaxLA), Average lean angle represented as (AvgLA), Minimum lean angle represented as (MinLA) by measuring lean angle and ramp angle as shown in Table 1 [18].

Table 1: Lean and Ramp of Gait Disorders [18].

Lean Angle			
Type of Gait	**MaxLA**	**AvgLA**	**MinLA**
Parkinson Gait	3120’	2700’	60’
Hemiplegic Gait	2700’	1440’	180’
Neuropathic Gait	1800’	1320’	360’
Ramp Angle			
Ramp Angle	**Parkinson Gait**	**Hemiplegic Gait**	**Neuropathic Gait**
MaxRA(Ll)	1200’	1320’	1500’
MinRA(Ll)	180’	360’	120’
MaxRA(Rl)	1140’	1200’	-300’
MinRA(Rl)	1200’	360’	-1320’
MaxRA(Ll)	1500’	2040’	1560’
MinRA(Ll)	300’	180’	1800’
MaxRA(Ll)	1200’	180’	1800’

As per the feedback-based DNN classification compared with the training data set, to fix the query data set of Parkinson gait maximum lean angle (MaxLA=3120°), the hemiplegic gait average lean angle (AvgLa=1200’) and the neuropathic gait minimum lean angle (MinLA=360’). The extracted feature data set of gait cycle, the walking pattern style provides the training dataset, the major disorders observed by the older adults, the whole body weight forced to walking pattern sequence. The significance of this phase includes when foot and leg bearing the whole body weight. The sense of Parkinson, hemiplegic and neuropathic gait disorders as shown in Figure 6, 7 and 8 [18].

In Parkinson gait beyond the extracted position and sequence of walking position, difficult to long walking position and complex moving sequences while walking as shown in Figure 6.

Figure 6: Parkinson Gait Abnormality of Video Sequence [CASIA dataset[19]]

Hemiplegic gait as shown in Figure 7, the leg movements are semicircle while walking, the walking steps are too long position, hemiplegic gait is more disorder then the Parkinson gait.

Figure 7: Hemiplegic Gait Abnormality of Video Sequence [CASIA dataset [19]]

The neuropathic gait as shown in Figure 8, it is more disorder compared then Parkinson and Hemiplegic gait disorders, it is a very slow walking pattern, there are no knee extension movements while walking sequence.

Figure 8: Neuropathic Gait Abnormality of Video Sequence [CASIA data set [19]]

RESULTS AND DISCUSSIONS

The results are carried out by the existing dataset, in order to identify the gait [18] dataset available on CASIA [http://www.cbsr.ia.ac.cn/english/Gait%20Databases.asp] [19] is compared with lean angle, first half gait cycle of ramp angle and second half gait cycle [18] of ramp angle, the abnormal walking pattern observed from the knee to toe (lowest bottom of the foot) while walking. The observation identified from the 125 images sequences of three different persons. The different image sequences from the normal database and abnormal database are shown in Figures 6, 7 and 8 [18,19]. The classification of abnormal gait lean angle more than 100 and ramp angle more than 60. The abnormal gait has been observed using the video sequences as shown in Figure 9

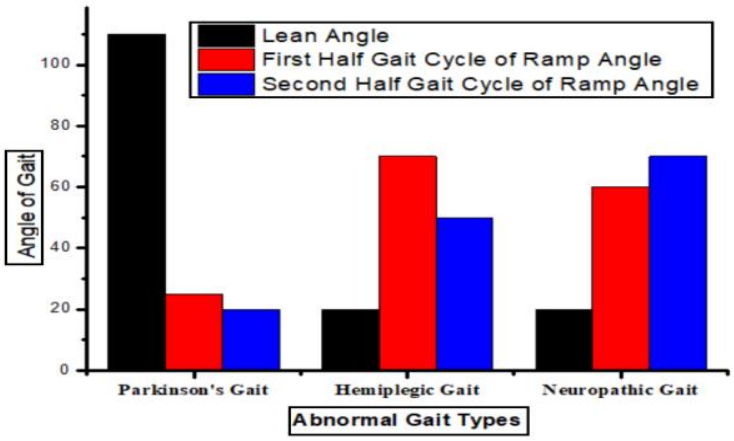

Figure 9: Abnormal Gait Identification [18].

The standard deviation compared with the normal and abnormal gait as shown in Figure 10, the major disorders have been observed in Parkinson, Neuropathic and Hemiplegic gaits.

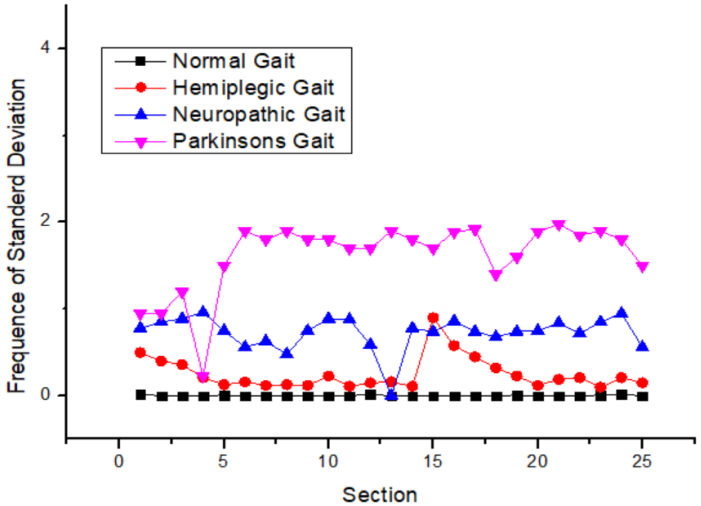

Figure 10: Standard Deviation of Normal and Abnormal Gait [18].

Table 2 and Table 3 describes the specifications of the database, the ramp angle is the maximum angle while a person walking at low speed over a ramp or obstacle without the underbody touching the edge of the ramp Leaning, the leg as

far one position to another position can, while leaving a small amount in reserve. The angle of the foot touches to the earth of the angle lean until a part of the foot touches down. Normal gait data set is compared with abnormal gait data set, the experimental results can be formed by three persons by measuring the angle in terms of minutes as shown in Table 2 & 3, the minimum lean angle lies between the 60 to 180 seconds, the maximum lean angle lies between the 360 to 420 seconds and the average lean angle lies between the 180 to 240 seconds as shown in the Table 2.

Table 2: Lean Angle Normal Gait data set Fixed for Training Dataset [19].

Person	MaxLA	AvgLA	MinLA
Person 1	360'	240'	120'
Person 2	300'	180'	60'
Person 3	420 '	240'	180'

Table 3: Ramp Angle Normal Gait data set Fixed for Training Dataset [19].

Person	MaxRA	AvgRA	MinRA
Person 1	1320'	900'	480'
Person 2	1200'	720'	240'
Person 3	1440,	900'	360'

CONCLUSIONS

In this paper, the proposed algorithm has been tested over CASIA dataset [19], the three (Parkinson, hemiplegic, and neuropathic) abnormality of gait detection has discussed and tested with the experimental results, the feedback-based DNN classification approach architecture has been derived to identify the abnormal gait disorders [18]. The neuropathic gait disorder has more diagnosed when compared Parkinson and hemiplegic gait disorders [18]. The feedback-based DNN classification approach provide most accurate results when tested with the training dataset.

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