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Gait Analysis in Humans Using Neural Network

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Abstract:- Gait analysis is the study of locomotion by an animal, animals including human beings. Gait analysis can be used that detects the motion of a human using cameras and markers with inclusion of machine learning into the mix, systems that can learn various defects and can classify them just by looking at the subject or can help identify persons through a security footage working as a biometric. Deep learning techniques, with the help of camera and image processing are presented in this paper that help in development of a design of gait analysis system. A similar system was developed and tested on various individuals..

Keywords:- *Gait Analysis, Machine learning, image processing, Neural Networks.*

I. INTRODUCTION

Gait analysis is the study of locomotion by an animal, animals including human beings. Understanding how a person walks or moves can help in a great way for security as well as medical science. There have been many advancements in biology and IoT, also combining these two in the form of wearable sensors have been a growing trend in recent times, a trend that is evident in the boom of Fit bit and smartwatches that track body movement for health purpose and otherwise. Similarly, wearable sensors or even cameras can help track and record motion by a human and help in clinical diagnoses and security. Machine learning, another pioneer in computer science that defines various methods for a computer to learn and classify and behave more human-like, and it doesn't even miss minor details that humans most often do. Using a mix of all these latest technologies a Gait analysis can be used that detects the motion of a human using cameras and markers with inclusion of machine learning into the mix, systems that can learn various defects and can classify them just by looking at the subject or can help identify persons through a security footage working as a biometric.

The model presented in this paper uses various image processing and machine learning techniques to classify gait patterns of different persons and give the most likely classification.

Artificial neural networks (ANN) are biologically inspired models similar to weighted graphs that try to imitate an animal's brain and learn like an animal does, that is through experience. When a human first comes in contact with an object, the brain images the object and classifies it. Similarly an ANN reads different aspects about an object and learns it then, using its "memory" it classifies the object if it comes in contact with the same object in future.

Image segmentation is dividing images into smaller segments such that a segment has the same data that may or may not be same to its neighboring segments. This segmentation has a contour (boundary) and a size. In this project we use contour detections to detect makers placed on the subject's body. Hue, saturation and value of different color varies and it also depends upon the lighting conditions, this help in developing a contrast from the background and contour detection is possible.

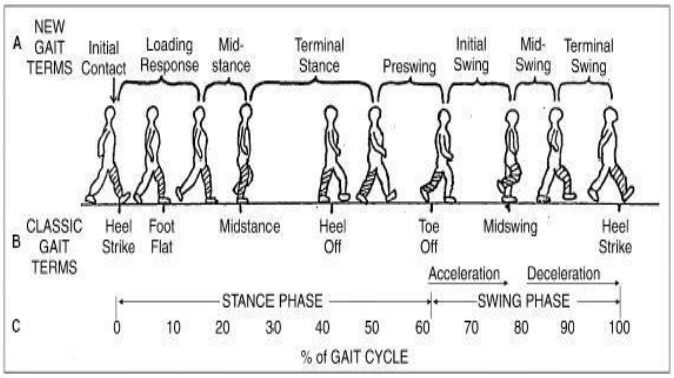

Fig1. Gait cycle of humans

II. PROPOSED METHOD

A. General overview

The system uses a machine-learning concept to analyze movement of the person and then compare it to the existing data to identify different individuals as done using other biometrics.

Several user inputs from the keyboard such as height and name of the subject are required when training the data so that the system can accurately guess the person. The system takes video input from the camera and uses image segmentation to find out different joints on a human leg, such as hip, knee and ankles. This information is passed to a neural network to process and save the training data set for future use.

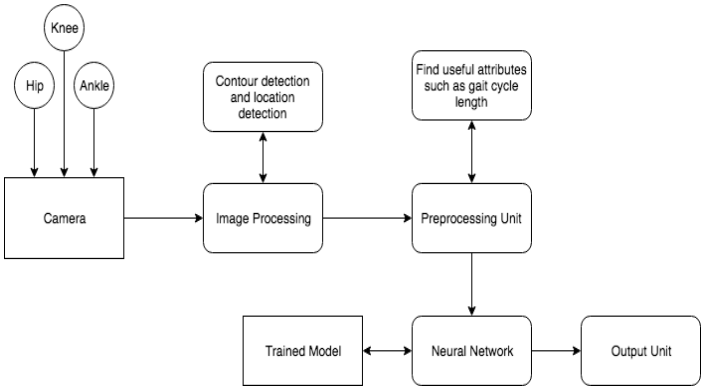

Fig2. Model of the system

B. Image Segment

The Image processing module (IPM) takes a video file from the camera as input, the system is already calibrated using the calibration module that returns high and low HSV of red, green and blue markers placed on the subject's body. Using the RGB image from the camera it is converted into a HSV image and filters for the value of HSV (from calibration) are applied to every frame of the system. Then using these boundary values, the module creates a mask over the image to extract the contour. To further enhance the contour and remove background noise these masked images are eroded and dilated, a process called opening. Then the contour size and location is estimated in pixel value. The system stores all the data into files as x, y coordinates of the hip, knee and ankle marker.

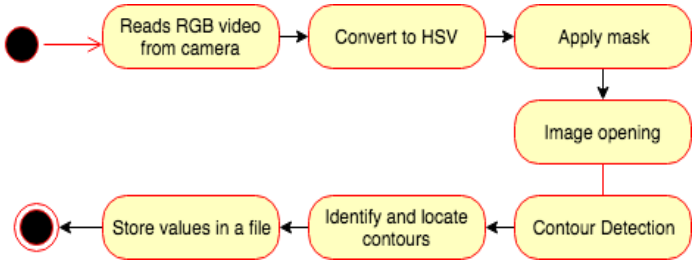

Fig 3 Image Segmentation

C. Calculations

Calculate the distance between different joints using the Cartesian plane and adjust the joints with hip as a reference.

$$Dist(A,B) \quad \sqrt{(A.y \quad B.y)^2 + (A.x \quad B.x)^2}$$

$$C \quad \frac{a^2 + b^2 \quad c^2}{2ac}$$

D. Neural Network

The neural network used is a simple feed forward network. The input for the machine learning module depends if it is being trained or tested for the user during training, output class has to be classified. several optimization techniques can be used to make the system more accurate such as learning rate, optimizer, number of epochs and size of the network. Shuffling data so that the network does not drift towards one class is also necessary. As said, there are several factors that affect optimization and hence various were compared for this application.

III. EXPERIMENT AND RESULT

To evaluate the proposed approach, a gait dataset from 100 individuals was collected and the system was tested using the dataset. The data set was split into a 70-30 training and test data set. Different neural networking models, each having slight variations in epochs, optimizer was used to find the best model for the network. Finally, a feed forward network with two hidden layers and five hundred nodes for each hidden layer was chosen with Adam's Optimizer used as an optimization function as it had the best accuracy in determining the test subjects.

Subject	Result	Output
31	31	1
51	51	1
87	87	1
31	31	1
1	1	1
9	9	1
4	5	0
31	31	1
87	31	0
1	1	1
9	5	0
5	5	1
51	51	1
1	1	1
5	5	1
2	2	1
87	87	1
31	31	1
31	51	0

Table 1. Sample data set and output

Accuracy = 15/19 = 78.9%

IV. LIMITATIONS

The system uses a marker system to detect and analyze the subject, which although is very cheap and accurate, might to always be fit for security purposes as people can not be forced to place markers on them all the time. Another limitation is due to lack of resources, not enough data could be provided for the neural network and tested only three subjects. To implement a full scale neural network large dataset and computational power is needed which was obtained using free tier of Google cloud but once the software has enough funding it can be moved to more power systems to perform faster and better. The proposed system can not identify if a subject has been previously encountered and will also classify new subjects to someone from data which ever has the highest confidence.

V. FUTURE WORK

As pointed out, in future systems markers can be removed and object detection to detect joint and subject and then perform gait recognition over it as a biometric.

As time passes and more users use the system, its scope and efficiency will improve as the data it uses will vastly increase, helping people from across the globe and making the system able to detect more abnormalities. With future development in artificial intelligence and image processing technique, two-core part of this project the gait analysis system can be improvised.

VI. CONCLUSION

The experiments show that the GAIT system can recognise and differentiate between people with up to 78.9% accuracy, which is not a lot, but there are several key areas where the accuracy can be improved. e.g., we can use mediapipe from Google and save on not only the speed of detection of the joints (knees) but better identify their locations as well. Further improvement in the neural network, such as using long-term memory networks (LTSM), which remember the previous state of the network so as to remember the context, which is very important in GAIT recognition and biometrics. Even GRUs, which aid in resolving the vanishing gradient problem in LSTM, In conclusion, the neural network can also be replaced by statistical models to get a quick picture of the subject without much training. This will lead to faster results. The best thing about this model is that it is flexible enough to work with a camera, or the camera can be replaced by sensors without much code change.

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