Real-Time Human Posture Recognition

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Abstract : The spinal cord of the human body serves as the integral part to sustaining our body's posture. An incorrect posture may lead to back and spinal injuries. To avoid this, we have come up with an application that uses Computer vision and Neural networks to analyze the human postures and immediately notify the users to recheck their postures through an Android app and a Desktop app. The data provided as input to the network is divided into two sub-classes and each posture is then recognized and analyzed. For primary training and testing purposes we have used Convolutional Neural Networks as it provides this intuitive way of looking at images, analyzing adjacent pixels in small areas and input those readings in a pooling layer. For final training and testing purposes we have used GANs, Generative Adversarial Networks, as it uses a generator network for generating the correct and incorrect data and dynamically classifying them. We tested the entire working model using a real-time video feed of various environments, the model proves to be highly accurate.

IndexTerms **- Posture Recognition; Neural Network; Feature Extraction; Image Processing; Python; Computer Vision; CNN; GANs; Android Application.**

I. INTRODUCTION

Image processing and computer vision has attracted a lot of researchers. Many researches are being conducted in these fields and are gaining a lot of recognition . Because of their highly valuable and useful applications, spectacular research work has been reported in this field. Generally, first the human motion is detected by the analysis of the pre-recorded videos, and then extraction of human silhouettes takes place using background subtraction techniques and foreground analysis . Then posture profiling is conducted after the other pre-processing algorithms are performed on the images and the frames that are extracted from the videos. The posture profiling also depends on the posture classification algorithms which are performed frame by frame. One of the most evident difficulties faced by the people while experimenting and applying different approaches towards the machine learning algorithms, is the effect of fluctuating or altering illumination and lighting, different dress appearances, disordered backgrounds and the varying motion of the human beings. To evade the impediments, the camera configurations adaptiveness to the varying illumination should be managed, and the coding standards should be followed, and sophisticated algorithms for analyzing should be applied, strong background designing models is necessary and extraction of the subjects and analyzation of the posture should be accurate. The long and tiresome computations of the algorithms become a hindrance for the overall processing speed, and might cause the algorithm to be not suitable for the real-time applications.

In this research project we have tried to use various computer vision and image processing techniques to successfully recognize the various human postures including sitting, standing, bending and many more, to apprise the user about their incorrect postures that could harm their spine and how to correct them. The application aids in posture recognition as well as correction using image processing and deep learning to help people of all age groups with their posture. There are various perils correlated with the incorrect postures. Poor posture is also a main risk factor in many injuries for all men and women and can be found everywhere. Lungs can get expanded due to the poor postures. Incorrect posture sometimes results in miscarriages and spondylitis. Long term maintenance of poor posture leads to spinal curvature disorders. Many aerial athletic or gymnastics injuries are due to the result of poor posture. As mentioned in the medical dictionary of Segen's, overhead term with regard to the athletes, refers to novice or elite athletes who participate and practice in aerial/aloft sports and hence they are at a risk of traumatic or retrogressive injuries that can happen to the spine and shoulders [32]. Poor posture may also weaken the digestive system. This affects working people, children, athletes, elderly people etc. as well and can be attributed to slouching and poor sitting habits. A Good Posture is very important for one to stay fit and healthy. Through a good posture each one of us can try and reduce the chances of postural injuries. It Keeps all the bones(which are necessary to keep our body in shape) and the joints(meeting point of two bones) in the correct order so that the muscles which are necessary for the movement are being put to their proper use. The aberrant exhaustion of joint surfaces and the stress on the ligaments (membrenous fold that supports an organ and keeps it in position) holding the joints/bends of the spine together can be decreased by correct posture maintenance. It helps the person to remain active and prevents lethargy because muscles start being utilized more frequently and efficiently, letting the body to use very limited energy and to work at optimum capacity. It Prevents backaches, rounded shoulders, bent knees and muscular pains and also contributes to a good appearance.
This project has applications in various case studies, we mainly focus on the following:
In Home Activities, maintenance of good posture results in prevention of a lot of posture related injuries , which are caused while watching TV, cooking, cleaning , washing etc and also reduces the risk of miscarriages during pregnancy. Also while playing indoor games like chess, carom-board poses a lot of stress on the shoulders and the back which can be prevented by maintaining correct body postures.

In Workout and sports, Long Term cartilage and spinal injuries can be prevented which are caused by doing heavy weight exercises. For example, doing dead-lift while maintaining an incorrect posture which leads to spinal curvature injuries, etc. Outdoor sports like canoeing, kayaking, golf, archery,etc require upkeep of a firm back.
In Workplace, this can be a Smart campus Initiative, by monitoring IT personnel sitting posture while using Systems, also, while giving presentations,team meetings and official management, people tend to have the incorrect stance.

Maintaining a good Posture, doing exercises regularly, preventing injuries, educating oneself about body alignments,etc should be important areas of concern for people to stay healthy. To find the significance of this project, we conducted a survey, where 65 people have responded till now. The survey was initiated to get a clear
idea of the knowledge and opinions that people carry regarding the need of a correct posture. Through the means of this project,we wish to highlight the importance of correct postures in ones' life and help them improve their health. The survey was run to include children/adolescents, parents , corporate executives, office workers, athletes, academics researchers, retirees and health/medical professionals. A few highlights of the survey report are presented in the below figures. A diverse age group(i.e. 14-50 years) from young children(28%) to adults (71%) was observed. The majority of the respondents who face posture issues have weight higher than the required body weight according to their BMI(Body Mass Index). People were asked to rate their daily posture, where 7 was obtained as an average and a lot of people were found confused since when they were asked whether they face problems with their posture, the responses were almost tied. As indicated on the survey, 52.2% spend 5-10 hours sitting while 43.5 people were recorded to spend more than 10 hours, siting on the systems or slouching or mobile phones. People also indicated that they have sometimes experienced pain from sitting for prolonged hours while 8.7% people convey that they always experience shoulder or back pains due to their incorrect postures. When asked about good posture's affect on appearances, everyone claimed that they feel that a person with a good posture looks healthier than a person with a bad posture. Balance/agility skills, muscular strength and endurance can also predominantly be gained by attaining correct postures. When asked about having an application that informs that about their correct postures , 66.2% say they would like to have such an application.

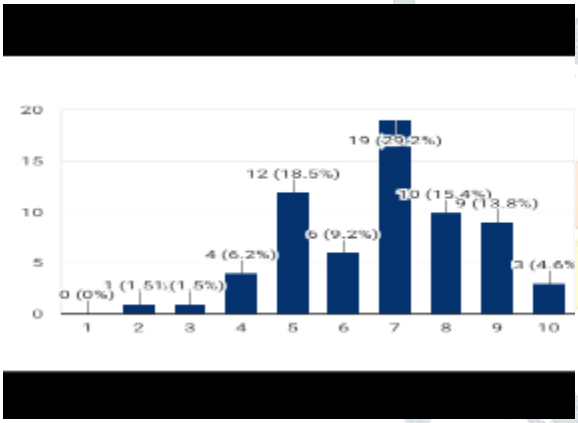

Fig. 1. People who think their posture is good.

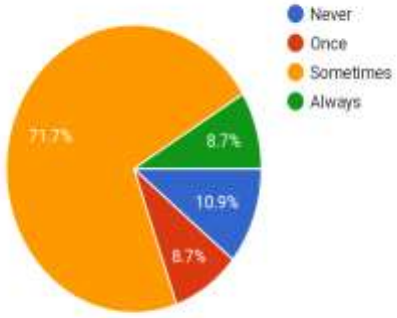

Fig. 2. Percentage of people experience pain from sitting at a desks.

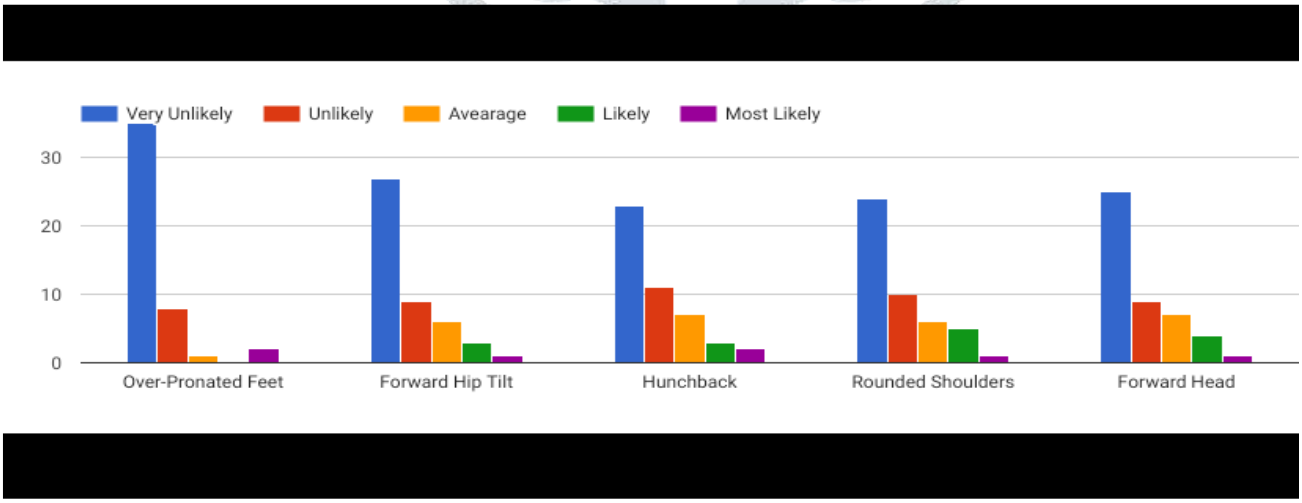

Fig. 3. Various kinds of posture disorders people are suffering from.

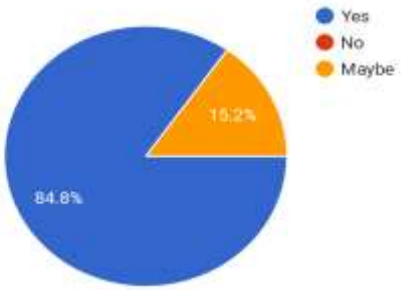

Fig. 4. Percentage of people feel that a person with a good posture looks healthier

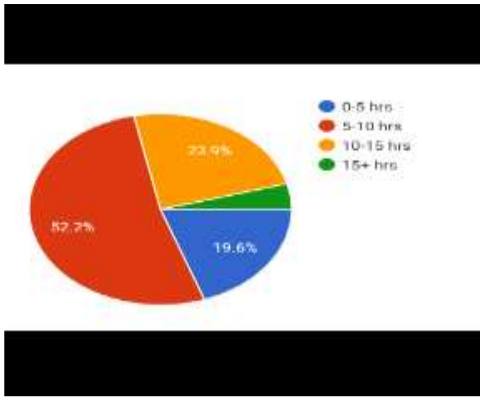

Fig. 5. Amount of hours a day people spend sitting

II. BACKGROUND AND LITERATURE SURVEY

In the past years, many researches have been done in the field of human postures. Firstly, the human body needs to be detected which can be achieved via hog algorithm[19] that is used in the field of computer vision and image processing. Hog algorithms are also used for detection faces and facial parts. Detecting Pedestrians can also be achieved using Patterns of Motion and Appearance[18] and deep learning semantic tasks[25]. In a system[4], Different silhouette images and colored markers can be used on people in order to detect various feature points on their body parts. Even strain sensors used on the prototypes of garments, were developed to recognize the upper body postures[1]. However, wearing coloured markers and sensor devices can be very uncomfortable and inconvenient. Hence, the practice of detection using such methods was not continued for a long time.

One more methodology used for classification of human body postures was based on a neural fuzzy network which was proposed in [2]. In this paper, Standing, sitting, bending and lying, were the four main body postures which were used for classification of human postures. In another project[6], the human body was first identified from the image. Then the body segmentation took place.Then the next step that took place was to apply classification on the features that were withdrawed from the silhouette which is represented on a light background. The different features that were used were, magnitudes of remarkable Fourier transform coefficients which were used together with the length-width ratio of the silhouette. Earlier, we have discussed that different coloured markers were used for posture detection purposes, while later on various Markerless approaches were also identified as mentioned in [7]. From a data of huge volume, the 3-D human poses were identified by recognizing the body joints and different parameter sequences of the poses. Numerous features of the joints that join the different bones, the points that will be useful for parts identification and various movement features such as the position of points, the way these points are oriented, the height of the person, the varied length of different bones,etc. were obtained from the 3-d models of the human body. Then the movement features were modeled and then the configuration features were modeled, these models were obtained from a Hidden Markov Model (HMM) and an exemplar-based HMM.

Another algorithm which used depth images, in fact they used monocular depth images, for tracking human poses, was a very efficient filtering algorithm that was also proposed in [8]. A highly productive model was combined with a discriminative model.This then formed model,provided evidence to identify the location of the different body parts. This evidence was obtained using the datasets. After each and every iteration, attained kinematic chain was applied by enhancing the model based searches locally. Human body posture recognition has also been achieved on the MPEG-7 dataset.They used different techniques and methodologies to obtain different shapes and poses, for shape matching by keeping in mind the standards of MPEG-7. They used advanced projections in the project[10] . Various image processing methodologies have been applied to the 3-D depth images captured by a depth Camera sensor or a Kinect sensor to first detect the human body and then to identify distinct human postures[9].

Support Vector Machine (SVM) is used for categorizing the data. SVM uses supervised learning algorithms for data analysis purposes which helps in classification of the data.Using SVM we can classify human postures from images or videos captured by the cameras. Various studies state that the posture recognition can be analyzed by applied by using inputs obtained from fuzzy logics. The varied inputs for fuzzy logics are horizontal and vertical projections, height and width ratios,myriad identified points. SVM optimization , theoretical confluence, multiple class classification, probability estimation and parameter selection issues were discussed[11]. A multi-scale morphological used adopted for human posture recognition[24]. It uses the different-areas-based shape similarity in morphological scale space, which contributes a lot to the robustness and reliability in identifying the pose. In [21] Human body posture estimation methods are proposed which make use of static images. This estimation is done using Artificial Neural Networks. Artificial Neural Network (ANN) deals with the functionalities and structural information obtained from the actual neural networks. First the image is analyzed using it's silhouette image, this acts as the input for the network and then human body's symbolic parts, which include the head, face, shoulders, hands, elbows, knees, arms , legs and feet,etc epitomize the output of the Neural network. All these parts indicate the 2D coordinates on the body.

Then by using the kalman filtration process the obtained results are enhanced and optimized. The above proposed method can be run on a personal computer, a laptop, etc and it can also be run in for real time estimations. The experimental results which are obtained by the above procedures present that it is more feasible and effective for human body posture estimations rather than the estimations done using the heretofore
mentioned methods.

Human motion analysis undergoing huge development[20] and is gaining more popularity than the static inputs. It is perturbed, with the human body detection, and then the recognition of people, and then most importantly, analyzing the people according to the requirements. The understanding of human behaviors is a difficult task for the computer system to grasp, from images or frames of images that includes human beings. Human postures were also recognized using video surveillance system[12]. The two most important modules that were to be implemented were, first,human detection and second,posture classification. In the first module, background subtraction technique
that is a pre-processing algorithm applied on images, was used to extract human blobs. While doing the background subtraction, all kinds of complexities were taken care of. For example, gaussian mixtures, varied colours, outdoor backgrounds,etc. To devise the divergence of human postures, such as sitting,standing, bending,lying,running,etc ,
hidden Markov model wastaken into consideration. Human Activities recognition using Non-linear SVM Decision Tree was implemented in [16] and By using image skeletonization the motion analysis of humans in real time has been proposed in [23]. However, these techniques are not very efficient and unable to handle the lags properly. In [28] After applying background subtraction there is another methodology that is applied to detect moving objects. This can be useful in detecting the motion of humans as well. The system focuses on efficiently detecting the motion in varied backgrounds and on different environmental conditions.So that the system can maintain stability in all kinds of situations. Hence, whatever be the background long term, or short term, it can deal with temporal stability issues and the negligent effects of rapid changes.

The human poses have not only been recognized on static data,but also dynamic data. Various Neural Network Techniques have been applied on Real time to recognize Human Gesture[15]. [17] proposes recognition of human body postures,dynamically, in real-time from monocular thermal images. An image is captured from the infrared
camera.The image is taken disregarding the background,environmental conditions and the lighting conditions. After acquiring the image, transformation processes are applied onto the parts of human body which are extracted from the thermal image. Later on the center of gravity, the moment of inertia and significant points such as the top of
the head, the tips of the hands,the backbone and foot,etc are calculated. Trinocular images have been used for detection[22]. The proposed method overcomes the occlusion problems like dynamic compensation using the Kalman filter and then the track of all feature points is kept. Static as well as dynamic recognition [26]. Pose estimation was tried using a model free,direct and indirect model approaches.Yet, we haven't achieved the perfect solution to the detection and recognition of humans, we are far away from a general solution to the human detection issues, but the researches still continue in this field.

III. IMPLEMENTATION

Machine learning has various methodologies such as image processing, computer vision, neural network,etc .They are planned in such a way to understand the working and behaviour of the human brain, and they also try to resemble it. The computer systems are trained and enlightened to notice the emerging patterns of the optical elements present within an image or frames of images, and also by noticing the varied designs through the databases, the computers are smart enough to get the sense of the pictures and then the system tries to develop applicable tag lines,categories and can perform various classifications based on the data interpretations. Image detection,recognition and classification is a very difficult task to accomplish. By utilizing the field of neural networks, it is possible to solve such confusing problems related to this field.

3.1 Data preprocessing

Since the raw data , unprocessed data is easily corrupted by noise and hardware issues. This step helps to clean the images and find smooth images by removing the unwanted noise, blurred images and the other background or shadowing effects. There are many pre- processing techniques available. Then we need to do background subtractions, and use various other pre-processing methods such as, edge detections, and other spatial and gaussian filters. Our project basically uses Artificial Neural networks to classify and recognize the various postures using logistic regression. In principle, we use a Deep Convolutional Neural Network to classify the various postures into classes and using regression, we analyze the pixel matrix of the images, as ConvNets generally specialize in Image analysis and processing by zooming in and out of the images and applying various image processing techniques like threshold, linear filtering, gray-scale and many more.

3.2 Convolutional Neural Network

A CNN requires inputs and parameters in large numbers, which also gets enlarged to very huge levels as the data and the required processing increases. A neural network is basically built on a a system of related and interconnected neurons. The artificial neurons interchange messages amongst one another. These neurons are accumulated and then tuned and turned for training purposes. The neural connections have high numeric weights which are also utilized while training process. The highly efficient

training results in system to correctly respond to the input images or videos or set of varied patterns that are supposed to be recognized logically, like a human brain might do. The neural network also contains multiple layers of feature-detecting neurons. Each and every layer has many different neurons that respond to different permutations and combinations of inputs from the previous layers. The first layer should detect a set of primitive patterns in the input then the second layer should detect the pattern of patterns,then the third layer should detect patterns of those patterns that were developed previously, this cycle keeps on repeating ,till the required accuracy is obtained. Keeping in mind about all these, the layers are built. Generally, CNNs use 5 to 25 distinct layers for pattern analysis and recognition.

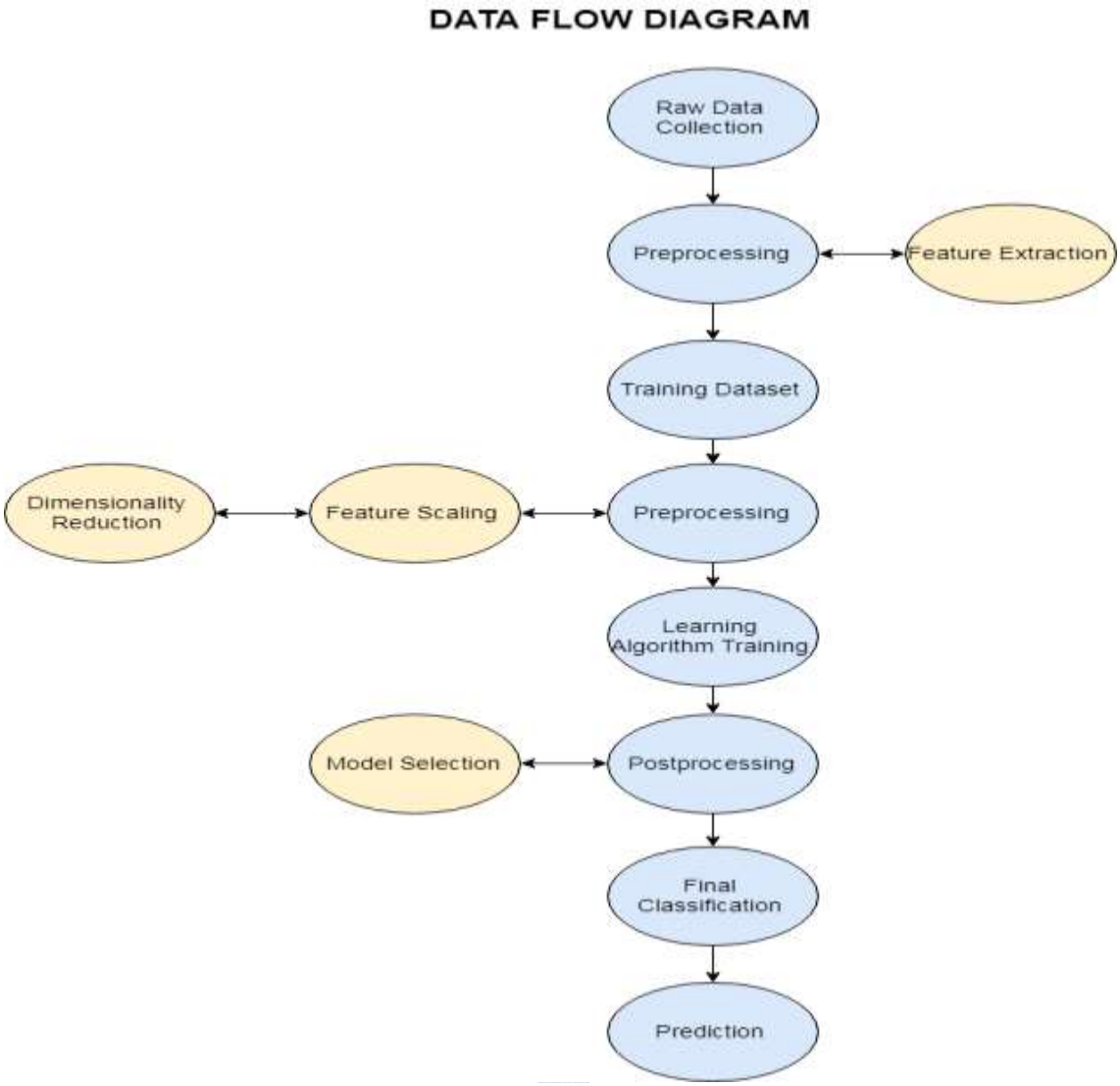

Fig. 6. Data Flow Diagram

3.3 Feature extraction and recognition

The Data is collected using our specialized data generator code, that instantly splits videos into frames of images and saves it locally on our drive. These images comprise of a total of eight classes among which each class is divided into two sub-classes correct and incorrect. These basically allow us to use a Random Forest Classifier to classify
the images according to their labels and limiting complications such as over fitting and under fitting. We use ConvNet for our primary training as its best neural network for image classification and processing. For further enhancing our project and for attaining the optimal solution we did a trial on by using a tensorflow based YOLO model (You Only Look Once), which basically works as its name suggests. It is basically an R-CNN network for detecting objects and proposing bounding boxes on them. It has a lot of variations and configurations. The reason we did not go about this approach was because it was majorly used for Object detection and hence has a lot issues when using for human posture detection. Thus, we resorted to enhancing the quality of our data-set by using a Generative Adversarial network along with our Convolutional Network. This Generative Adversarial network or GANs, was used since it consists of two neural network models which try to compete with one another. One has noise(incorrect data) as it's input and then it generates samples (generator). On the next step, Both the generator and the training data is fed into an another model (discriminator), and it is able to distinguish between the two sources. These two networks

continuously work together to achieve optimal output, where the generator learns to produce more realistic and practical samples, while the discriminator learns to get better at discriminating and distinguishing between the generated data and the real data. Both of these networks are further more trained contiguously. The training is done in order to get more accurate results about the data, and so that it difficult for the system to distinguish between the real and the generated samples. The Requirements for our project have been elaborated below.

3.4 Classification

Our Convolutional neural network uses a six layer network architecture, with four hidden layers and one input and one output layer. The hidden layer consists of a plethora of 32 filters, and as we want the the input images to optimized, so we used 64x64 input shape along with 3 strides. We used relu and soft-max activation for this, as we want the processed output to be in a range of 0 and 1,and -1 and 1 respectively. For the initial phase, we basically classified the images into four to ten different classes, and then analyzing them using our truth matrix of correct dataset. The dataset in between did result in a high variance, i.e Overfitting, which was resolved by increasing the test data as well as using a random forest classifier. After successfully training the neural network model, we now run the code on a Raspberry Pi, that's connected to a PiCam. The data of individual users gets logged in by RFID, which gets detected on entering the room. Now, the rasPi will be able to identify the individuals on a singular basis. The data gets stored on Google Cloud. We now bind the keras based model to our android application to fetch from the server or cloud. We use a .pB or Protocol Buffer normally known as protobuff, to bind the keras model, this model fetches the data from code ported in the CCTV and trains itself using the protobuff file with our model and then generates a graphical summary of the data and informs the user on his/her posture throughout the day.

3.5 TensorFlow

Various neural network models such as Conv-2D, Local response normalization, Max pool 2d, Dropout, Fully Connected and regression were used. It is an open source library. It is highly useful for fast computations and high performances. It helps to deploy various computations on different platforms such as CPUs , GPUs and also TPUs. It has a very flexible architecture which can work on a single computer or multiple systems, or multiple sets of servers of mobile devices as well as laptops. It supports innumerous machine learning and deep learning algorithms and it is well known for it's high computational speeds. There are a lot of companies which work on tensorFlow, such as, Uber, SAP, Intel , Dropbox, Snapchat, and many more. Tensorflow provides various toolkits which are helpful in building required machine learning models. Different mathematical operations can be performed by models which are built using low-level APIs.For using other neural network or regression architectures, high level APIs are used.

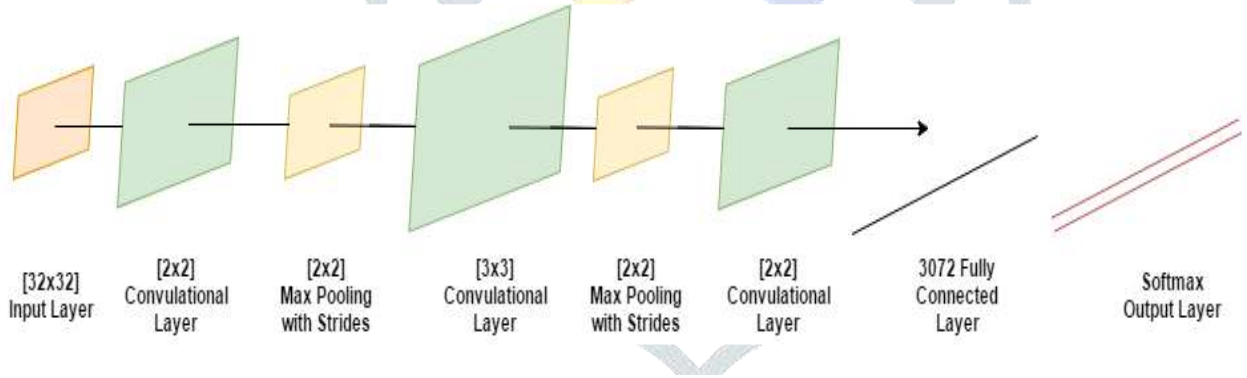

Fig. 7. Neural Network Models

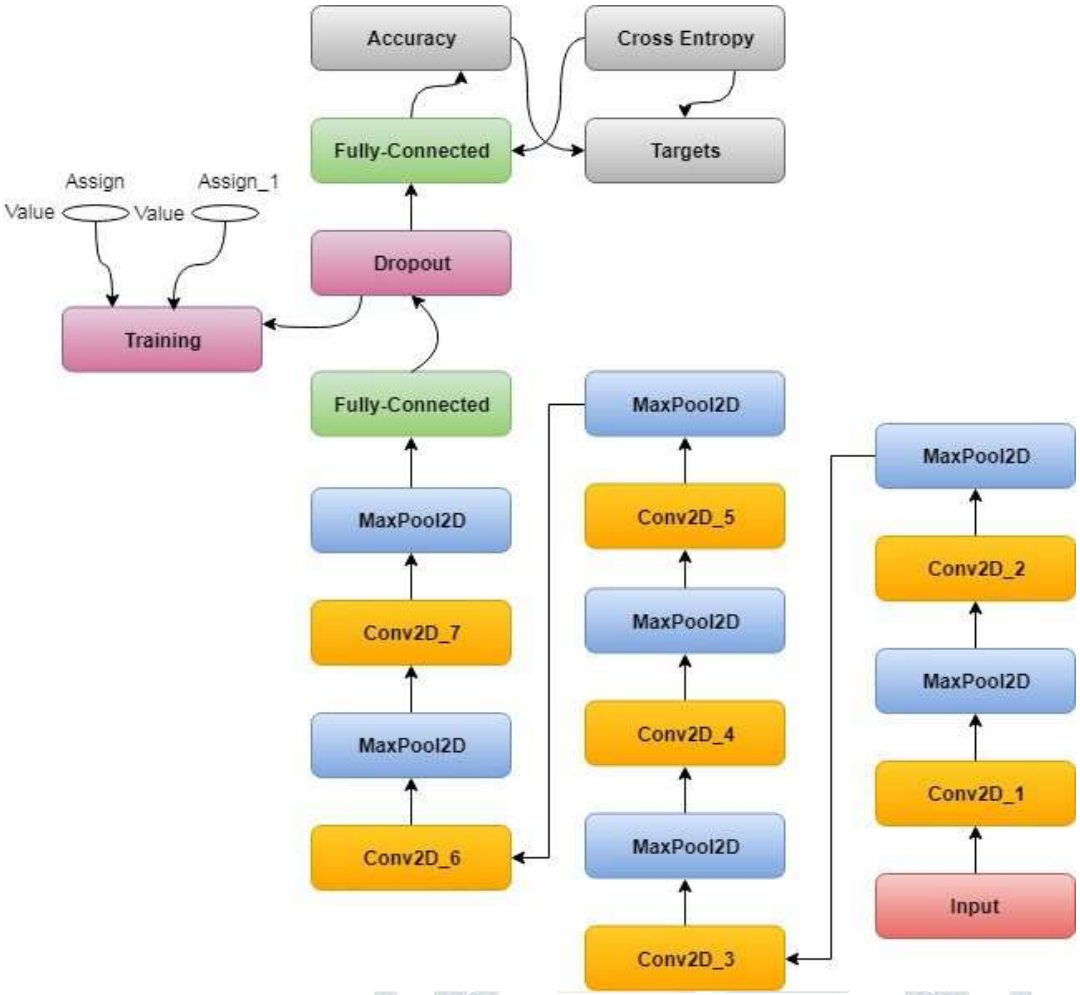

Fig. 8. Neural Network Architecture

3.6 Keras

Keras, is written in python. It is a python library for deep learning. It runs on top of tensorFlow or Theano or cntk and was developed for improvising the code and for faster computations. It also enables fast experimentations since it gives out the result with the least delays and also results in good researches. Keras is highly beneficial and can be used whenever there is a requirement of fast prototyping. It has high Extensibility and modularity and assists convolutional neural networks, recurrent neural networks and even the hybrid of the two networks. It runs smoothly on CPUs as well as on GPUs. It is highly user-friendly as it is not designed for the machines, instead it is designed for the human beings. It is very clear and keeps the interest of the user as the foremost priority. It works with python which is easier to code on, easier to debug, is also tremendously extensible and favourable over the other languages.

IV. CONCLUSION AND FUTURE WORK

This project suggests that CNN can be very useful in solving image processing and visual recognition tasks. With high efficiency, easy implementation and processing time, CNNs have an advantage over the earlier used posture recognition techniques. Our project not only recognizes the posture of the people using deep learning algorithms but
also informs them whether they are maintaining a correct posture or not. The people are apprised about their posture using an android application. They can view their user details along with the graphical description of their weekly posture report. By keeping track of their posture, the user can correct his faulty postures and can henceforth improve his body and health. The project results display an accuracy of about 97.75 percentage with minimal loss on real-time environment situations.

In future, we plan to improve and overcome the challenges. One of the common problems faced in the application of neural networks, that is associates with image recognition is the problem of overfiting. Overfitting or high variance has chances of occurance when the model finds itself to be very closely related to the data it has been trained on. We should always have different sets of data for training and testing purposes. Mostly, this overfitting problem leads to increase in the computational costs and energy cost, since the model is unable to perform well with the new dataset and models restricted exposure to the new data, causes loss in the general performance of the system. Improving the result and processing speed further, and fully automatic model initialization are the other challenges that need to be fixed. We also plan to inform the users about their incorrect postures using alert beeps and will further improvise it by using Google speech API. Google has developed the Google speech API that

can be used for converting text to speech and vice versa. By utilizing it we will notify the users. We further plan to enhance the performance of the
system and the user acceptance. In future, we also plan to use optimal Computer Vision technologies like face recognition, for identifying the individuals by using computer vision directly and removing the RFIDs, such that the use is free to move about the room without any hassle.

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