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Algorithm for Analysis of Emotion Using Body Language

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***Abstract*— This paper proposes a system which will detect emotion and mental state of a person by detecting the pose of a person, detection of emotion will be based on body parts not on facial expressions. Work done on emotion detection is basically done on facial expression, according to the psychological study it is found that every body part shows an expression. This whole detection is based on gestures of human body, we already have frameworks for facial expression detection but for body gestures we don't have any framework. Here we study different posture of human body and their movement during an interaction. Our proposed work includes studying the pose of a person, we study the normal body pose first and then estimate a threshold according to which we can find the difference between a person who is calm and the person who is showing deviation from calm attitude. Along with the shoulder movement, we studied the hand gestures so that we can get much more promising and sound results. By combining both the results for hand and shoulder together we will get the approximate picture of the person's state of mind. In the past, there has been similar project but their implementation and results were based on facial expression. But our approach is based on bodily gestures, and we are trying to detect emotions from them. Thus, to detect bodily expressions we have written an algorithm which will help us to predict the behavior of a person. The experimental result shows that by using algorithm we can infer emotions and state of mind from human pose, in terms of body gesture including shoulder and hand.**

***Index Terms*— Gestures, Emotions, human poses, Affective Computing**

I. INTRODUCTION

Communication plays a vital role in our daily life; it makes us capable to connect and express ourselves with others as individuals or as group. Without communication it would be really hard to exist, we communicate to others verbally and non-verbally. It is the basic need for building and developing our relationships, education and work. In human communication we extensively use body language, which includes: verbal and nonverbal. "Verbal Communication" can be referred to the spoken language for conveying messages or ideas in our day today life. Whereas, nonverbal communication includes communicating through gestures i.e. through facial expression, eye contact, body movement and posture, gesture, touch, and etc. The study of emotion has moved from psychology to computing, remarked by the book of Picard [15], which created a new field called Affective Computing. This book provides us with standards and ideology to create smart and intelligent emotion detecting system. The influence of emotion detection covered a wide range including medicine, education, health and at a grater extent in Human Computer Interaction [4]. Usually emotion detection system takes input either in the form of audio, image or visual and then provides appropriate results produced according to the input given. Visual emotion detection was established by the classical study of Darwin. Using the visual detection, Darwin gave us an idea of how emotions can be recognized from face and body; it created two broad fields for detecting emotions: facial and bodily emotions. Scientists and researchers have shown a keen interest to work on facial expression. Detection using facial expression has a successful history due to the work done by Ekman and Friesen who introduced us to Facial Action Coding System (FACS) [7]. This system has provided us with the standard and outlines for facial emotion detection, and using this system a lot of face recognition and facial emotion detection system have been evolved. As compared to the facial expressions bodily expression were not addressed by the researchers.

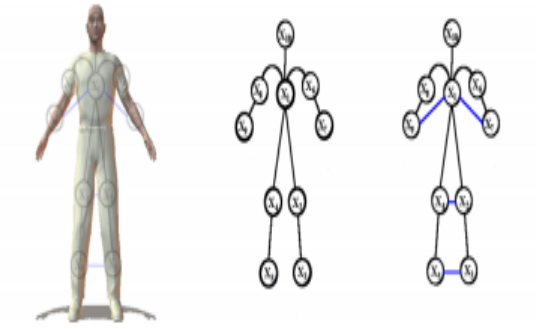

Fig. 1 Structural Model

Whereas psychology support the bodily expressions by providing evidences [19] and nonverbal communication gestures[6]. Bodily expressions are important as inferred from the evidences and they are as important as facial expressions. The evidences provided but the psychology made scientist and researchers to ponder over it again and work in this area of emotion detection. Body gestures include hand movements, shoulder position, torso alignment, head position and leg movements. Working alone on the body posture (hiding hand and face) we can predict the emotions of a person accurately, the results found are accurate as we get it form the analysis of facial expression as stated by Walter and Walk[19].

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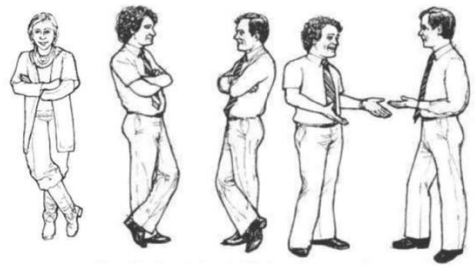

Fig.2 (a) Defensive position; (b) Closed attitude; (c) Open attitude

TABLE 1
Expressive Elements of Posture.

Emotion	Body Posture
Anger	Head backward, no abdominal twist, arms raised forwards and upwards, shoulders lifted.
Joy	Head backward, no chest forward, arms raised above shoulder and straight at the elbow, shoulders lifted.
Sadness	Head forward, chest forward, no abdominal twist, arms at the side of the trunk, collapsed posture.
Surprise	Head backward, chest backward, abdominal twist, arms raised with straight forearms.
Pride	Head backward or lightly tilt, expanded posture, hands on the hips or raised above the head.
Fear	Head backward, no abdominal twist, arms are raised forwards, shoulders forwards.
Disgust	Shoulders forwards, head downwards.
Boredom	Collapsed posture, head backwards not facing the interlocutor.

Our major interest is on reading the upper part of the human body and correlating the pose with emotion so as to get the emotional state of a person. We study the body posture but there are factors that makes the task problematic and challenging, because there are different traditions different attires worn by people, background clutter, and occlusion. There are efforts made my researchers to estimate body pose by removing the errors [3], [16], [15]. Although these methods perform well on certain body parts, e.g., head, their performance on localizing parts corresponding to lower arms, i.e., elbows and wrists, is poor in general. When we read the pose, we combine it with the information provided in Table-1 to find the emotions of a person.

II. RELATED WORK

Here is a general overview of the existing methods for Body Language Analysis. Like facial expression, bodily language also expresses their emotion, mood, attitude, and attention. A person's body language also provides other information that includes identity, gender, age, attractiveness, and personality. One of the most active and current fields in computer vision is the analysis of bodily expression in image sequences, including body posture analysis and body gesture (including gait) analysis. Most of the existing work can be classified as model-based or appearance-based. Much progress has been made in visual human motion analysis in the last two decades [18].

Darwin C. (1872) et al. he studied how we express our thoughts and feelings through emotions. According to Darwin's our expressions of emotion express our thoughts more than words. He stated that our emotions are intricately intertwined with our whole body. Our emotions, mind, and body work as one to send signals to other people. Ekman (1969) et al. identified five characteristics of how our bodies communicate through movement stated below [8], [9]. Barclay (1978) et al. carried out further study by examining temporal and spatial factors. They suggested that successful gender recognition requires exposure to approximately two walking cycles, and the rendering speed has a strong influence over recognition [2]. Zuckerman (1981) et al. stated that a single behaviour will not tell about or give any evidence of lies, deception while threatening cause increase in tension in an individual leading to certain nervous behaviours. Ekman (1982) et al. stated that one of the key areas in honest communication is focusing on a person's face and maintaining eye contact. There six expressions most displayed which are fear, anger, disgust, sadness, happiness and surprise [10]. Moghaddam (2002) investigated nonlinear SVMs for gender classification with low-resolution thumbnail faces, and demonstrated the superior performance of SVMs to other classifiers [14]. Navarro (2007) et al. stated that hands can be moved out of sight to the lower half of the speaker's body to show deception, a rubbing of one's hands together can display closed characteristics, nervousness.

There are Hierarchical models which allow us to combine the benefits of part-based approaches and the multiple parts approach. These methods read the whole person at the root and individual body part at the leaves. Wang et al. [20] stated that inference is performed according to hierarchical Poselets. It is performed using the basics of the Pictorial Structure model. It lead to increase in the performance and was made more cost efficient than the earlier models. Fischler and Elschlager [11], Felzenszwalb and Huttenlocher [12], [13] et at. Proposed to use the Pictorial Structure Model (PSM) respectively, it provides us a framework for the deformable object detection and poses estimation. Sapp et al. [17] stated that when a model is represented using a convex combination of the tree-structured graphs which is linked with the dual variables, and the solution is done with dual decomposition algorithm. Zuffi et al. [21] stated that in a situation where poses in two different frames are coupled using optical flow. Even-though the method provided sound results but it had a drawback of frame-to-frame refinements.

III. PROPOSED WORK

Our work relies on the pose estimation [1]; we study the body pose of the targeted person to know the body postures at different instances. After studying the pose of a person we use the following algorithm to estimate the emotion of a person. Using this algorithm we got approximate idea about the mental state of a person.

The algorithm consists of six steps: first, divide a given video into frames so that we can study the body posture in different frames. Second, pose estimation [1] we get the stick pose of upper part of the body namely shoulders left and right hands and mid torso using,

$$C(I; p) := \sum_{u \in V} \varphi_u(I; p^u) + \sum_{(u;v) \in E} \psi_{u;v}(p^u - p^v) \quad (1)$$

Where, cost C(I; p) for a pose p and an image I where φu(I; pu) is an appearance term for the body part u at the position p^u in I, and $\psi_{u;v}(p^u - p^v)$ is a deformation cost for body parts (u; v). A video sequence I = (I_1; I_2.....; I_T); it is common to introduce temporal links between frames, impose temporal consistency in the estimation of the pose positions p_1; p_2;..... ; p_T . This is achieved by adding a temporal edge between every pair of nodes p^u_t and p^u_{t+1},

$$C(I_t; p_t) + \sum_{t=1}^{T-1} C(It; pt) + \lambda_1 \theta (p_t; p_{t+1}; I_t; I_{t+1}) \quad (2)$$

where θ is a consistency term between the poses in two consecutive frames and λ_1 is a regularization parameter. We measure the consistency between p_t and p_{t+1} by comparing p_{t+1} with pt adjusted with optical flow as follows:

$$\theta (p_t; p_{t+1}; I_t; I_{t+1}) = \sum_{u \in V} \|p^u_{t+1} - p^u_t - f_t(p^u_t)\| \quad (3)$$

Where $f_t(p^u_t)$ is the optical flow between frames I_t and I_{t+1} evaluated at the position put . Indeed, this approach is quite natural and similar formulations have been proposed [28]. Third, we remove the world details to get the stick pose that we need for further steps. Next, we study the shoulder, firstly we study the shoulder of a person standing or sitting in normal pose by calculating their slopes,

$$\alpha_i = (b_n - b_m) / (a_n - a_m) \quad (4)$$

where α denotes the slope of the lines representing shoulder and 'a' and 'b' are the coordinates of the lines representing x and y axis respectively. Now we calculate θ using the mathematical formula,

$$\theta = \tan^{-1} |(\alpha_1 - \alpha_2) / (1 + \alpha_1 \alpha_2)|. \quad (5)$$

When we calculate value of θ for the shoulders if the calculated value is grater then θ then the person is amazed or confused and if the value is less then θ then the person is lazy or not interested in the conversation. Similarly, in the next step we study the hand movement if value of θ is more then the desired threshold the hand movement is considered as not harmful. If the value of θ is less then the desired threshold, we check if the hand is accompanied with a fist or a flat hand, if fist or flat hand is found then the person could cause some harm. Finally we conclude that using the results of both hand and shoulder we can predict the emotional state of person.

I. RESULTS

The system is proposed to detect the emotion from the body parts i.e. shoulder and hand gestures. We analyzed the shoulder in the normal pose and tried to find out the slopes of the shoulder lines and using slope we evaluated the angel between them. The angle found is used as the threshold to determine the mood and state of mind of the person.

Fig 3 a) Shows a person in normal and calm posture. b) Shows a person in confused or amazed state . c) Shows a person in leaning and is depressed or not interested pose.

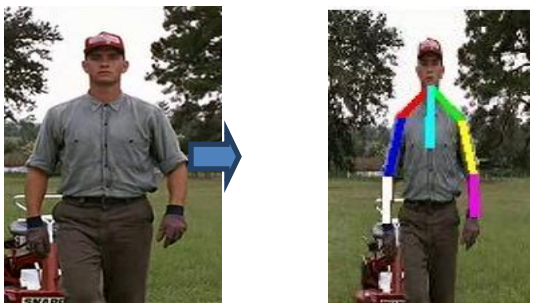

Fig 4 Shows a rgb image used as input and we get a stick pose of the person [28].

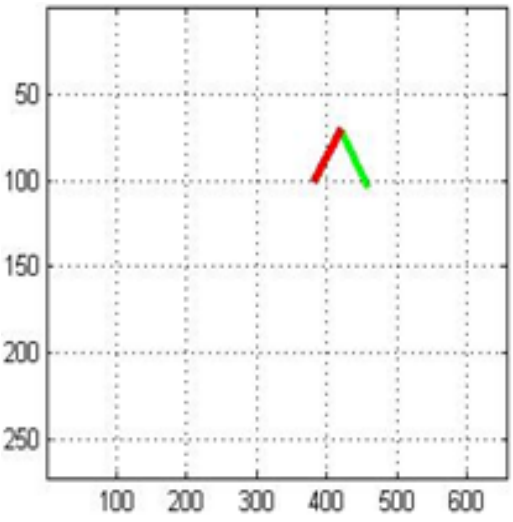

Fig 5 Removing the background and study the stick pose of shoulder.

In figure 4 we show the stick pose of the shoulder which is extracted from the fig 5. Firstly we removed the background and the unwanted sticks used for depicting various parts of upper body. Then we find the coordinates of the left and right shoulder respectively.

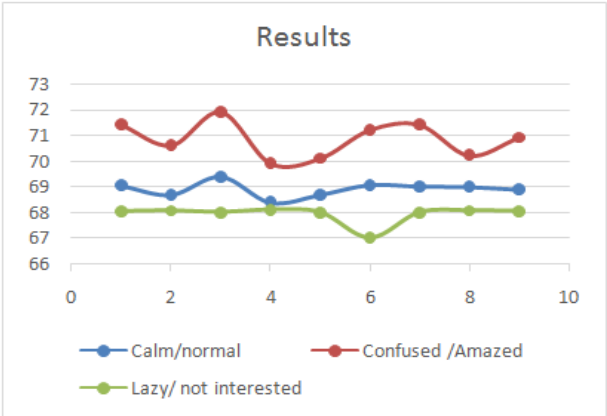

Fig 6 Graph shows the comparison between calm, confused and lazy pose.

Graph shows the comparison between the three poses. When a person is confused and amazed the value is grated then threshold i.e. greater than normal pose, and when a person is depressed or lazy the values is less than the threshold. Using these results we can infer the approximate state of mind and mood of a person. X axis shows the number of results and Y axis shows the angle between the lines.

The results found were based on fig 5, we have studied different images and marked a threshold based on normal human pose. For better results we can study the subject at that instant and find out the emotional state of a person.

Table2
Results according to Algorithm

Hand Shoulder	Confusion and Doubt	Calm Normal	Lazy Not-interested
Anger/Fight	X	Yes	X
Hitting/Tapping	X	Yes	X
Normal Gesture	Yes	Yes	Yes

The above table we can infer different emotions gestures that can be found using hand (H) and shoulders (S). If the hand is accompanied with the fist he will be standing in a normal pose and this shows sign of anger. A person standing in anger is neither confuse or lazy. If the person's hand is accompanied with a flat hand he could be hitting or tapping another person. If a person doesn't have fist or flat hand and he is standing in normal position i.e. hands are aligned with the torso, then the person could be calm, confused or may be lazy. The results shows the approximate results for emotions that are been detected by body gesture. Along with the facial expressions if we study and use body gestures to seek emotional state of mind we can get the correct, precise and sound results.

IV. CONCLUSION AND FUTURE WORK

We presented a novel algorithm for predicting and estimating the emotional mind set of person based on bodily movements. This algorithm uses body pose estimation module to get the stick pose of human posture. Our approach is divided into two parts: 1) we study the Shoulders movements for different gestures and 2) we study the upper and lower part of hand gestures along with fist. Using the human posture we analyze and predict the human nature using the proposed algorithm. According to the results generated we found that without facial expression it's hard to get the exact state of mind of a person, using the results we are predicting the approximate mood and emotional behavior of the person. We already have frameworks studying facial expressions but not for body gestures, according to psychological study every part of the body shows emotion and we are working on just facial features. In the near future we can develop and prepare a framework for studying the body gestures so that we can read different behavior and emotional states using bodily gestures. Secondly, we can study different hand gestures so that it can be used in robotics and medical fields. Along with the facial expressions if we study and use body gestures to seek emotional state of mind we can get the correct, precise and sound results.

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