

# Affective Computing For Empathic Behaviour Change

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**Abstract**—Humans strive to build machines that can interact with humans in a humanoid way. This is why it is crucial for a computer to be able to understand in which emotional state the user is in. To achieve such a feat there are different approaches. Within the research area of affective computing, a large part of the studies focusses on facial expressions and changes in speech. These expressions are good to recognize the emotional state of a human during social interaction, however they may not be suitable in other situations for example recognizing emotions from a greater distance [1]. In this paper I give an overview over the body language recognition approaches done today and propose a model which analyses emotions based on the way a human subject walks.

## I. INTRODUCTION

For a long time people were convinced that human behaviour is "all nurture and no nature" [2]. However already Darwin [3] suggested that along with the facial expression, the human body movements and the gestures also represent the state of mind and the corresponding emotions of humans. We know today that body language plays a very important contribution to understand the affective state of a person [4], [5]. Surprisingly only 7% of human communication are made of words and 55% are made up of non-verbal communication [2], [6], [7]. The idea of this paper was to focus on micro expressions in body language. However there are no bodily micro expressions as in facial micro expressions. A micro expression is a "very fast facial movement lasting less than one-fifth of a second" [2]. Body language in comparison can be subconscious however it can be consciously changed more easily, than a facial micro expression. This is the reason that I focus on the emotion detection via body language in this paper.

There are various uses for emotion detection by body language. Some of those are detecting the *affective state* of a person, *lie detection*, the degree of *accessibility* towards another person etc. Different indicators for interpreting body language can be *body position and distance* [5], [7], *body movement* [1], [6] and *hand form* [8], [9]. This list is not necessarily concluding, but those are the parts that I focussed on in this work.

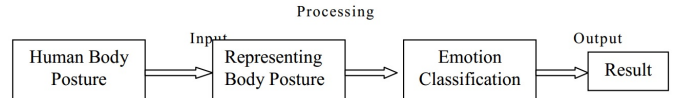


Fig. 1. The phases of a bodily emotion detection system [6]

In the field of affective computing however, it is not only a challenge to interpret the body language, but also to detect the position of the human posture and get useful data out of it. This leads to the two main challenges: 1. *Detection of the posture* and 2. *How to interpret the posture representation* (see Figure 1 [6]). However those two steps are done in one with certain machine learning approaches that consist of neural networks [10]–[12].

In the following work I will first give an overview over the psychology behind emotion detection through body language. After that I present papers that provide approaches for both, the detection of the human posture as well as for interpreting the found results. Finally I propose a theoretical model of how to recognize human emotion by gait in real-time.

## II. EMOTIONS THROUGH BODY LANGUAGE

As already stated, 55% of our communication consists of non-verbal cues, like body language. The expression of emotions has been studied extensively [13]–[16]. According to Eckman [2] there are 6 basic categories of emotions:

- Anger
- Disgust
- Fear
- Happiness
- Sadness
- Surprise

Those emotions seem to be universal and the same across different cultures [14]. The motivation for those 6 categories goes back to the theory, that the same facial muscles are used for the same emotions across different cultures [10]. This categorical notion of emotions allows systems to more easily categorize new samples to one of those existing categories, instead of having to create new categories from scratch [10]. We can find clear signs of all those emotions in our faces (see Figure 2<sup>1</sup>), because those signs are mostly shown involuntary

<sup>1</sup><https://hubpages.com/health/Facial-Expressions-Emotions-and-Feelings>

### The Seven Universal Facial Expressions of Emotion



Fig. 2. Facial expression of the six basic emotions ( and contempt)



Fig. 3. Bodily signs of the six basic emotions [10]

micro expressions. Recently more research has been done in the field of detecting emotions through body language, like body movement and body pose [17]–[19]. In Figure 3 we can see a representation of the body pose for the 6 basic emotions.

In Figure 4 we can see a possible way on how to interpret certain bodily signs based on the body position and body movement. The distance between two people can also show the attitude between them. If the distance is less than the local social norms permit, we can infer a negative attitude [7]. However this has to be treated carefully, because the context is important. For example, if two people that are in a romantic relationship with each other, then less distance is not a negative

Emotion	Body Posture
Anger	Head backward, no chest 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.

Fig. 4. A table of bodily signs for different emotions [6]

sign. It has also been found, that the meaning of distance depends on the expectancies of the subjects. If the subjects expect a positive interaction, then a close distance is a positive thing, and if they expect a negative interaction, then a close distance is negative [7]. Examples of approaches in section III

In addition larger body movements like the gait of a person, can also tell us something about the emotional state of a person. For example are angry movements larger, faster and seem jerky, compared to normal movements [6]. Whereas fearful and sad movements tend to be less energetic, smaller and slower [6]. Examples of approaches in section VI.

The form of the hand can also give information about the emotional state of a person. For example open palms could mean pleasure/ openness, closed hands towards the chest could mean a sense of pride and clenched fists could mean anger [20], [21]. Kipp and Martin (2009) et al. [22] even stated, that for right-handed people, the right hand was more used when experiencing anger and the left hand more, when their feelings were relaxed and positive. Examples of approaches in section V.

In the following sections I summarize a few approaches that extract and/or interpret body language in different ways.

### III. EMOTION DETECTION THROUGH BODY POSITION

#### A. Lie Detection based on Facial Micro Expression, body Language and Speech Analysis

A very interesting approach was done by Barathi [23].

1) *Body pose extraction*: To extract the body poses from videos the Limb Action Model Converter [24] has been used. This converter uses Microsoft Kinect as a base. The Limb Action Model extracts 10 limbs from a body posture: "Spine to center shoulder, center shoulder to head, left/right shoulder to left/right elbow, left/right elbow to left/right wrist, left/right hip to left/right knee and left/right knee to left/right ankle" [24]. In Figure 5 we can see how the posture is represented after the extraction.

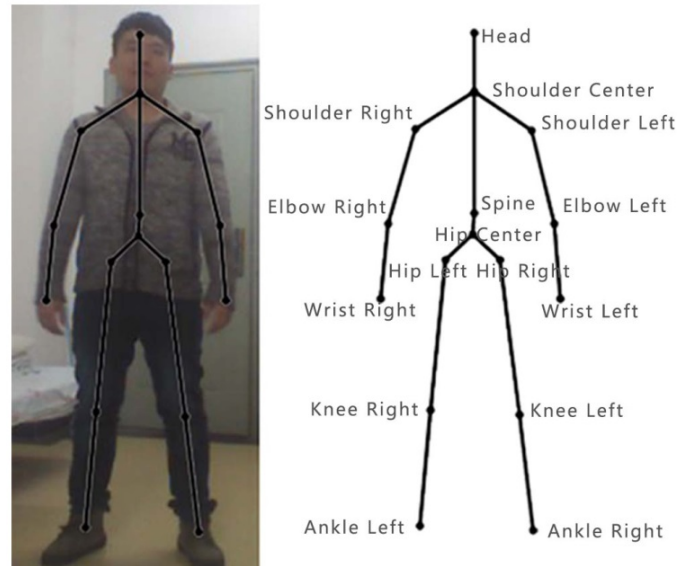


Fig. 5. Skeleton joints extracted with the Limb Angle Model [24]

2) *Interpretation*: As the paper focusses on lie detection, they defined the following signs for lying [23], [25], [26]:

- Increasing hand to face/mouth gestures
- Nose touching: Because of an adrenaline rush, the capillaries open up, which causes the nose to itch
- Place the hand close to or over the mouth
- Small gestures like lip biting, hands rubbing, fidgeting
- Clenched fist, crossed arms

According to those specifications they trained their system with images of liars that were exhibiting those typical body language cues for lying and pictures of people who were not lying. All the images are subjected to the Limb Action Model Converter. Finally they clustered the converted pictures with k-means. Sadly they did not provide an evaluation for the body language part of their method.

#### B. EDBL - Algorithm for Detection and Analysis of Emotion Using Body Language

1) *Body pose extraction*: EDBL relies on a pose estimation which is using postelets for human parsing [27]. Different postelets are extracted from images. A linear SVM classifier is trained for detecting the presence of each postelet. In the end we get a complete model of the human. See Figure 6 for a graphical representation of the process.

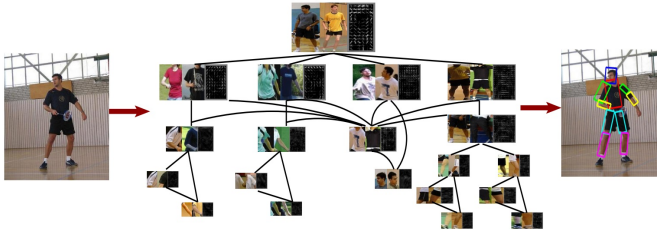


Fig. 6. Graphical illustration of the postelet model [27]

Based on the postelet representation a line graph (see Figure 7 of the extracted pose is created and used for the interpretation of the body posture.

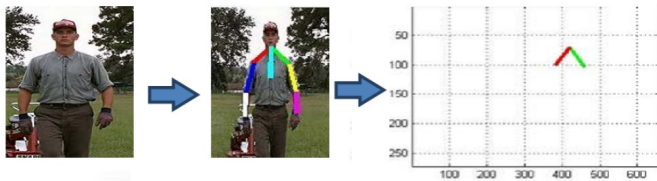


Fig. 7. EDBL stick pose representation [21]

2) *Interpretation*: To figure out the emotional state of a person, the position of the shoulders is interpreted. There is differentiated between three different types of poses: 1. normal/ calm, 2. confused, amazed or in doubt and 3. depressed/ not interested. Figure 8 shows the three different types. First the slope of the normal shoulder position  $\theta$  is calculated. An initialisation pose is needed. Then it is compared to other images of the same person and if the slope is bigger than

the slope of  $\theta$  then it is a sign of doubt, confusion or being amazed. If the slope is smaller than the slope of  $\theta$  then it is a sign of a depressed, not-interested or lazy emotional state.



Fig. 8. Meaning of shoulder positions. (a) shows a person in normal or calm position, (b) shows a person in confused or amazed state and (c) shows a person in a depressed or not interested pose. [21]

#### IV. AFFECT DETECTION FROM BODY LANGUAGE DURING SOCIAL HRI

1) *Body pose extraction*: This approach of McColl et al [5] also uses Microsoft Kinect as a base to extract the body pose. It creates an ellipsoid model as seen in Figure 9. To do this, the Kinect sensor first performs a human body extraction. Then the extracted body poses are observed to see if a static pose is displayed. Once a static pose is identified the segmented body parts are fitted with ellipsoids [5]. The static body poses are further explained in subsubsection IV-2.



Fig. 9. An ellipsoid model of the human body built on the basis of Microsoft Kinect. [21]

2) *Interpretation*: To figure out the emotional state of the subject, static body poses are used. The poses are based on the Nonverbal Interaction States Analysis of the Davis Nonverbal States Scale [28]. Body angle, trunk lean and arm position are evaluated. The resulting metrics are the following:

- **Three different body angles:** *Toward(T)*: 0-3 angle from the robot, *Neutral(N)*: 3-15 angle from the robot, *Away(A)*:  $\geq 15$  from the robot
- **Trunk lean:** *Upright*: The shoulders are over the hips, *Forward/backward lean*: The shoulders are closer/ farther away than the hips in relation to the robot, *Right/left lean*: The right/ left shoulder is tilted past the right/ left hip.



- **Arm positions:** *T*: The arms are closer to the robot than the upper trunk, *A*: The arms are farther from the robot than the trunk, *N*: else

According to those metrics 4 accessibility levels [5] have been defined (see Figure 10). Level I-IV, where I is least accessible and IV is the most accessible state. The arm orientation is used for a finer scaling of the accessibility levels.

Trunk Orientation	Accessibility Level	Arm Orientation	Finer-Scaling
Upper/Lower trunk: T/N or N/T combined with upright or forward leans, T/T with all possible leans	IV	T	12
		N	11
		A	10
Upper/Lower trunk: T/N or N/T except positions that involve upright or forward leans	III	T	9
		N	8
		A	7
Upper/Lower trunk: N/N, A/N, N/A, T/A, A/T with all possible leans	II	T	6
		N	5
		A	4
Upper/Lower trunk: A/A with all possible leans	I	T	3
		N	2
		A	1

Fig. 10. Different accessibility levels defined to determine the level of accessibility of the person against the system [5]

This approach classified accessibility with an accuracy of 88% [5].

#### A. Recognizing Emotions Expressed by Body Pose: a Biologically Inspired Neural Model

This approach by Schindler et al. [10] aims to categorize images into the 6 basic emotions [2] *angry*, *disgusted*, *fearful*, *happy*, *sad*, *surprised* and *neutral*. The Idea is to model the visual pathway of recognition of a human. This means the process in which the visual cortex extracts cues from the visual input to determine an emotion [10]. The model is inspired by [29], [30]. The model consists of a hierarchy of neural feature detectors [10]. The visual cortex contains various areas: *Primary visual cortex (V1)*, *secondary visual cortex or prestriate cortex (V2)*, *visual area (V3)*, *visual area (V4)* and *middle temporal visual area (V5)*<sup>2</sup>. The model is built according to those areas (see Figure 11).

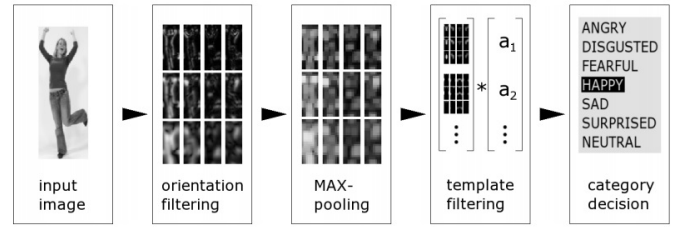


Fig. 11. "Illustration of the neural model. From the raw image on the retina, local orientation is extracted (area V1), pooled over spatial neighborhoods (V2/V4), and filtered with learned complex features (V4/I).T The filter response serves as input into a discriminative classifier (IT). Parameters were chosen for illustration purposes and are different from the actual implementation." [10]

The recall of the system achieved 82% whereas the recall for human testers was 87%. This means that on average the model only miss-classified 5% more than the human testers. Interesting to see is the direct comparison against the human for the single emotions that were classified (see Figure 12).

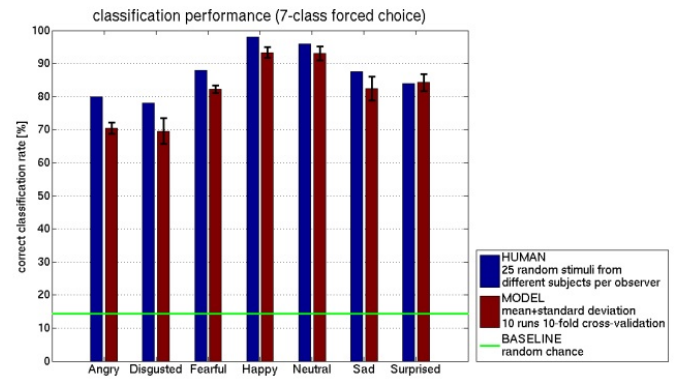


Fig. 12. The classification performance of the model in comparison to the human testers [10]

#### B. Real Time Multi-Person 2D Pose Estimation using Part Affinity Fields

The approach of Cao et al. [31] inputs a given image into a two-branch convolutional neural network. First a feed forward network simultaneously predicts a set of confidence maps of the body part locations (see Figure 13 (b)) and a set of vector fields of part affinities, which encode the degree of association between the different parts (see Figure 13 (c)) [31]. After that the confidence maps and the affinity fields are parsed by greedy inference (see Figure 13) and they output the 2D key points for all the people in the image [31]. Like this we could also analyse the shoulder position like it was done in [23] and other movement based emotion detection. However it would not be possible to angle-based evaluations like in McCol et al's approach [5].

<sup>2</sup>[https://en.wikipedia.org/wiki/Visual\\_cortex](https://en.wikipedia.org/wiki/Visual_cortex)

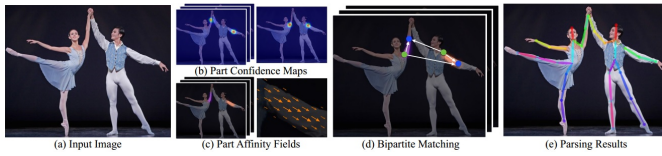


Fig. 13. OpenPose process visualized [31]

## V. EMOTION DETECTION THROUGH HAND FORM

### A. A system for person-independent hand posture recognition against complex backgrounds

1) *Hand pose extraction:* Most approaches in this field, require the hand to be in front of a static background or the hand to be the only skin coloured item in the picture, in order for it to be recognized [32]–[35]. The approach of Triesch and Malsburg [9], proposes a solution using elastic graph matching (EGM) with multiple feature types. EGM is "a neurally inspired object recognition architecture" [36]. In EGM the views of objects are visualized as a labeled 2-d graph. [9]. The nodes of the graph contain a local image description and the edges are labelled with a distance vector which represents the distance between the nodes.

2) *Interpretation:* Various graphs are created from training images and then images of new hands are matched to the most similar existing image. In ?? we can see an example of a graph, which is matched to a new hand.

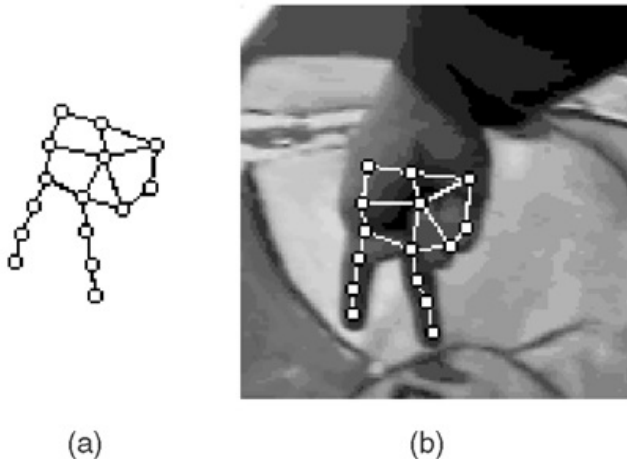


Fig. 14. Picture of an elastic graph of a hand, and a new hand that matches it [9]

Like this we can easily recognize if a hand is clenched to a fist ( e.g. anger).

The reported accuracy of this approach is 92.9% accuracy on simple backgrounds and 85.8% accuracy on complex background.

## VI. EMOTION DETECTION THROUGH GAIT

## VII. PROPOSED MODEL

## VIII. CONCLUSION

IncrementalAndInteraction paper, tell that i've learned that some emotions are grouped close together and share some

similar features, e.g. happy and surprise.

## IX. FUTURE WORK

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