Collection and characterization of emotional body behaviors

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ABSTRACT
This paper addressees two issues in modeling bodily expression of emotions; emotional behaviors collection and expressive movement characterization. In this paper, we describe our body movement coding schema intended to the characterization of bodily emotional expression in different movement tasks. We describe as well the database that we use for the characterization of emotion expression in different movement tasks through the proposed body movement coding schema.

Categories and Subject Descriptors
J.4 [**SOCIAL AND BEHAVIORAL SCIENCES**]: Psychology; H.5.1 [**Multimedia Information Systems**]: Evaluation/methodology

General Terms
Expressive body movement

Keywords
Body movement, Emotional behavior, Movement characteristics

1. INTRODUCTION
Humans, whether in individual or interactive setting, display a rich mosaic of actions, gestures, and postures with their bodies [17]. Body movement has been studied for several objectives such as trying to understand or to reproduce complex behaviors. Recently, several researches have been conducted to study the expression of emotion through body movement and body posture. Several studies in neuroscience and psychology have shown the importance of body movements in the display of emotions [30, 9, 2].

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The principal aim of our work is to characterize bodily emotional behavior based on body movement features describing the quality of movement. We aim to characterize the expression of different emotions in different types of movement tasks (like walking, knocking at the door). The characterization of bodily emotional behavior requires two fundamental steps: the definition of body cues that will be used to describe the expression of emotions and a human body movement database. In this paper, we discuss body movement coding systems and body movement cues used in previous studies to characterize emotional behaviors. Few existing coding systems based on movement type were used for the characterization of emotional behaviors in a fine-grained fashion [10, 9]. However, previous coding systems based on movement quality were mainly dedicated to the characterization of artistic expression of body movement (dancing) [1, 6] or communicative emotional behaviors [29]. In our work, we propose a coding system based on the representation of movement quality and body form through several description levels. Considering the combination of different description levels allows an accurate and detailed description of movement quality and body form. This coding systems is mainly intended for the characterization of emotional expressions in different movement tasks. We discuss also the collection of previous dataset and we describe the collection of a new database of bodily emotional behaviors. The collection of our database was motivated by the lack of dataset that refer to the expression of several emotional states in different movement tasks. In the remaining of this document, we describe the related work on body movement coding scheme and the collection of dataset for the studies of emotional and expressive body behavior. Then we describe our body movement coding system approach and the collection of our new database.

2. RELATED WORK
While advancing researches have been conducted for developing coding system on facial behavior (such as the Facial Action Coding system (FACS) [12] which is used as a general framework to describe nonverbal facial behavior), there is a lack of consensus on a common coding schema for the description of body movement. This is due to the complexity of body structure and the variety of domains in which the body movement coding systems occurs (nonverbal emotional communication, dance, social interaction, co-verbal behavior ...). Coding systems for emotional body movement

description can be split into two categories: coding systems based on the type of movement and coding systems based on the quality of movement. Coding systems based on movement type tend to decompose the body movement into a set of body actions and/or postures units [10]. The type of movement can be then defined as the function of the action (like manipulators or adaptors which refer to actions in which one body part touches another body part [11]), or as the form of the movement with respect to the anatomical and directional level (like Left arm action upward). Coding systems based on the quality of movement focus on the manner the body movements are performed [20] [6].

2.1 Movement type based approaches

Coding systems based on the type of movements describe the body movement in a fine-grained fashion according to the anatomical and directional description level as well as the nature of movement; action or position.

Several coding systems exist to describe the actions and positions of the body. Birdwhistell [4] developed a notation system of movement behavior based on the anatomical level with respect to the three spatial dimensions. The Bernese system is another system based on the anatomical and directional levels to describe body movement [13]. The system is able to describe the spontaneous movements that occur when the person communicate with another person. The system provides a detailed description of body parts movement of head, shoulders, trunk, arms, hands, legs and feet. Dael et al. [10] have recently proposed a new Body Action and Posture coding system called BAP. They focused their attention on the distinction between postures (or positions) and actions. Postures are basic units defined as the alignment of one or a set of articulations. Action units are local excursion composed of three steps (starting point, duration, and end point). The BAP coding system provides a detailed description of body postures and actions considering the anatomical level (body parts/articulation involved in the movement) and directional level (the spatial direction of the movement in sagittal, vertical and lateral axis). Action and postures units described in BAP coding system were used to characterize the expression of emotions in body action and posture [9].

In the specific field of bodily expression of emotions, coding systems based on movement type are mainly used to associate distinct patterns of movement and postural behaviors with some emotions using body action/posture units and/or gestures (such as arms crossed in front of chest for Pride and self-manipulators for Shame [29]). Bodily expression of emotions can also be signaled and described by the way a person is doing an action, usually defined as non-emblematic movement [14] or non-stylised body motion. The latter approach of studying bodily expression of emotions uses body movement coding system based on movement qualities (or movement characteristics).

Coding schema used in movement type based approaches are not well adapted to describe the quality of movement. While anatomical and directional description levels used in movement type coding system provide an accurate and objective description of posture units, considering additional description levels may be required to describe more accurately the characteristics of movements (in particular the form of body movement).

An action unit in movement type based coding systems is mostly coded independently from the spatial direction of movement since the action refers to the movement itself [10]. The definition of movement characteristics should be based on further description levels to incorporate the quality of movement dynamics and postural changes during the movement.

2.2 Movement quality based approaches

Coding systems based on the movement quality focus on the way in which body movement are performed. This can be perceived from the quality of the movement dynamic or the shape of the body during movement. Coding systems based on movement quality provide the description of body movement while abstracting the communicative role of the posture/action units involved in the movement. Thus, the use of movement quality based approaches is more appropriate for the characterization of emotional behaviors in different movement tasks (such as walking).

The Laban Movement Analysis (LMA) is one of the most known coding systems based on the quality of movement. It appeared initially to describe the movements of dancers, but it has been argued that its use may have important implications in other fields such as the study of body expression of emotion [14]. Four major concepts were defined to describe movement in the basis of this system; Body, Shape, Effort and Space. Effort and Shape components were often the only factors used to describe body movement in order to study the bodily expression of emotion. The analysis of body movement based on these two components is known as Effort-Shape analysis, derived from Laban Movement Analysis [14]. However, the use of Effort-Shape analysis has been limited due to the lack of documentation in coding reliability and the subjective connotations in the definition of some factors.

Camurri et al [6] proposed a collection of computational models called EyesWeb expressive gesture processing library for real-time expressive body movement analysis. Similarly to the LMA system, the EyesWeb library was designed firstly to describe dance movements as dance can be viewed as the main artistic expression of human movement [6]. The EyesWeb library includes three main sub-libraries: The motion analysis library, the space analysis library and the trajectory analysis library. Alaoui et al. [1] proposed a computational model for the modeling and the recognition of three movement qualities that describe dancing movements: Breathing, Expanding and Reducing. Since these approaches are mainly used to describe dancing movement, the proposed coding systems focus on the description of the whole body movement while ignoring the description of some articulations that may convey important information of emotional behaviors (such as head upward/downward movement [29]). Hence, introducing "local" body cues related to some particular articulations can be helpful to better describe the expression of emotions in body movements.

In the specific field of characterizing emotional and expressive body movements, scholars tend to use different coding

systems to define movement characteristics. The use of the appropriate coding system has been widely depending on the method used to describe emotion-related movement characteristics: qualitative or kinematic analysis [14]. The qualitative description of body movements refers to the description of (High-Level) emotion-related movement characteristics. The kinematic (Low-Level) description is required to build computational models for emotional and expressive movement behavior. In both qualitative and kinematic analysis, the proposed set of movement characteristics has been also widely depending on the movement task being studied. Pollick et al. [24] used some movement kinematics (such as the velocity and the acceleration of wrist movement) to describe the expression of affects in arms movement during knocking on the door. Hicheur et al. [16] investigate the kinematic aspect of emotional locomotion through features of gait patterns.

In our work, we propose a movement quality coding system based on the descriptions levels that allow describing the body posture (e.g. body straightness), the postural changes (e.g. the quantity of movement) and movement qualities (e.g. the speed of movement). Considering different levels altogether provides an accurate illustration of the form and the dynamic of body movement and allows the description of different movement tasks in both qualitative and kinematic analysis.

2.3 Body movements dataset for studying emotional and expressive body behavior

Databases of bodily, vocal or facial expressions are used in order to analyze or synthesize human-like channels of communication. The development of databases for emotion-oriented systems is, in particular, a challenging task at the level of recording practicalities and at conceptual issues in psychology [8]. Thus, the design of emotion-related database needs to consider the main principles proposed in previous works including database functions (the future use of the database), structure and scope (database size and balance between classes), and related psychological theories [8].

Several important points must be considered in the collection of a reliable emotional behavior database. There is a large consensus on the multimodality of emotion expression like vocal expression from the voice, facial expression from the face, bodily expression from body postures and gestures) [27]. However gathering accurate data from all modalities (face, gaze, voice, body...) requires very sophisticated recording equipment. A discrete emotion model is usually used in emotional body behaviors collection [9, 16, 21] .Wallbott et al. [30] have shown that the construction of emotional database in the study of bodily expression of emotion based only on one actor cannot be considered as efficient.

We can distinguish mainly two types of recording equipment; audio-visual recording and 3D motion capture recording. Audio-visual recording provide 2D information about the real video of the subject and/or audio information. 3D motion capture of body movement provides accurate information about the posture and movement of some specific body joints of the subject. As examples of audio-visual based databases we can cite; 1)GEMEP-GEneva Multimodal Emotion Portrayals: A corpus for the study of multimodal emotional expressions[3], 2) A Bimodal Face and Body Gesture Database for Automatic Analysis of Human Nonverbal Affective Behavior [15]. For existing 3D motion capture database we can refer to; 1)A motion capture library for the study of identity, gender, and emotion perception from biological motion [21], 2) IEMOCAP: Interactive Emotional dyadic Motion Capture database [5], 3) A motion captured database for postural expressions of emotion [19], and 4)The Mockey Database for stylistic walk analysis and synthesis [28].

3D motion capture databases are more appropriate for low-level analysis of expressive body movements since they provide accurate information about the 3D information (3D rotation, position or both) related to body movement. However existing databases based on 3D body movement recording so far are limited to a small range of emotional states [21] or movement tasks [28].

3. EXPRESSIVE BODY MOVEMENTS CHARACTERIZATION

Our aim is to characterize emotional body expression in daily actions using a large set of body features. We propose a movement quality based coding system that allows to define body movement characteristics in different movement tasks. Three global description levels are proposed to describe the characteristics of body movement: anatomical level, directional level and posture/movement level (See Fig. 1).

Anatomical description level describes the body segments involved in the definition of one movement feature. We distinguish three different sublevels to describe the anatomical level: global (which involves the whole body to refer for example to the bounding box or the convex hull surrounding body shape [6]), semi-global (which involves some specific body segments to refer for example to the relationship and the synchronization between them or the relative body segment position regarding another one) and local (which involves one body joint). **The directional description level** defines the spatial direction in which movement is possible. Movement direction has been traditionally defined with respect to three directions, which refers to the orthogonal axes of the body: the sagittal, vertical, and transverse axis [10], where vertical direction refers to left/right rotation around the vertical axis. In LMA system, shape change in movement according to the vertical direction is manifested in upward and downward directions [7]. In our coding schema, we consider both the length and rotation dimensions in vertical direction. In addition to those directions, we consider also the three-dimensional direction which may be useful to describe the overall extension of body shape through the 3D distance between the end effectors and the body center. The directional description level is then defined through five possible directions (sagittal direction, lateral direction, vertical direction defining vertical length of body shape, vertical direction defining left or right rotation and finally 3D information). **The posture/movement description level** aims to distinguish three categories of movement characteristics; features describing the postural information (body shape), features describing the postural change and variation, and finally features describing the dynamics of movement. All

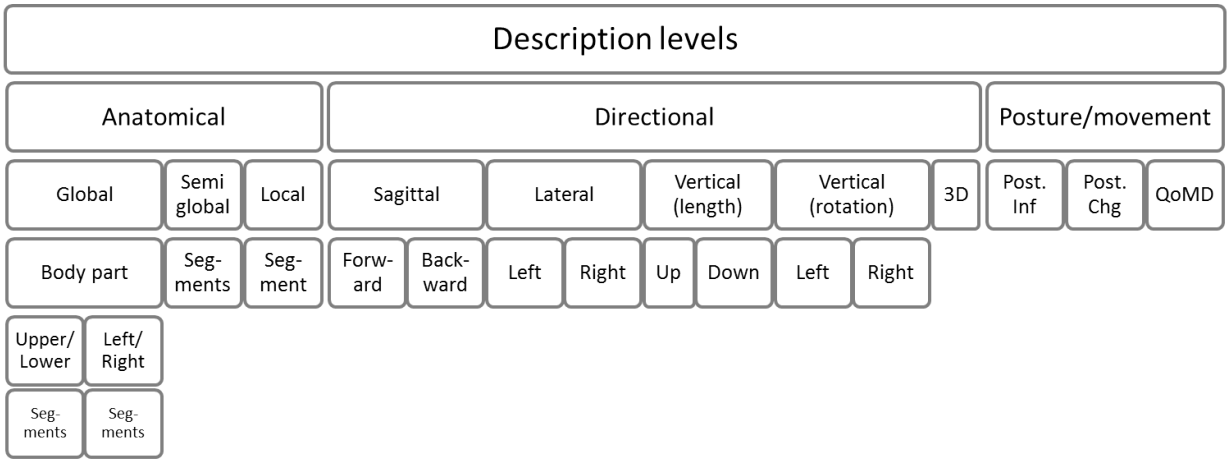

Figure 1: Body movement features description levels (Post. Inf stands for Postural Information, Post. Chg stands for Postural Changes and QoMD stands for Quality of Movement Dynamics)

proposed description levels and sublevels aim to give a more comprehensive definition of body movement features.

The description levels that we consider in our body movement coding schema are illustrated in Figure 1. The proposed coding schema can be used for both qualitative and kinematic methods. Considering for example body straightness feature, which refer to a postural information (in posture/movement level). This body cue can be defined in qualitative analysis according to the length of body shape in upward and downward directions (in directional level) while considering the global shape of the body (in anatomical level). The straightness of the body shape involves mainly the trunk, the head and the knees posture [22]. Hence, if 3D rotation data is provided for each body joint, this body cue can be defined in kinematic analysis by the mean of upward/downward rotation of head, trunk and knees (three "local" body segments in anatomical dimension). Moreover, the same description sublevel can be used to define several body cues. For instance, the quality of movement dynamics can refer to the speed, the power or the fluidity of movement.

4. EMOTIONAL BODY BEHAVIOR DATABASE

The main goal of our work is to study the body features that describe the way by which an emotional or expressive body action is performed. Few databases were devoted to this purpose [28] [21], while they tend to focus on a very limited set of discrete emotional states mainly selected from the six basic emotions [21]. Similarly only a limited range of actions, mostly reduced to one action, is studied [28, 16] while the study of emotion expression through body movement requires exploring of a large set of emotional states and body actions type to better understand body features used to express different affects. Hence we proposed to create a new acted emotional body behavior database that can be used to study various bodily emotional behaviors through a large set of movement tasks which are relatively simple bio-mechanically and can be performed expressively.

4.1 Database recording

Actors: The actors were eleven (6 females and 5 males) graduate students. The mean age was 26 ranging from 23 to 28. They were motivated to participate to the construction of our database and they gave informed consent that their motion capture data as well as their video could be used and published for research purpose. A professional acting director gave them 7 training sessions regarding the use of body movements to express emotional states. A principal purpose of those sessions was to show the actor the ability of body movements to express affect through actions we perform in our daily live.

Actions: We captured a wide range of daily actions that involve the whole body as well as upper body and arms in particular as it has been shown that the upper body parts receive generally more attention than lower body parts in the study of emotional bodily expression [18]. The actions are Walking, Sitting down, Knocking at the door, Moving objects (books) on a table with two hands, Lifting and Throwing objects (a piece of paper) with one hand. In order to capture two types of arms behavior during walking action, walking was divided into a simple walk and a walk with an object in hand. Some of the proposed movement tasks were already used in past studies and considered as relevant to discriminate between different styles of the same movement type [14, 25]. We asked the actors to perform each action with four repetitions to capture a large set of data. A continuous sequence consisting of the series of all the actions with one trial per action was also recorded.

Emotions: The emotions used in our study are Joy, Anger, Panic Fear, Anxiety, Sadness, Shame, Pride and Neutral. Those emotions were used to cover a significant difference along the arousal and valence dimensions. Following the induction approach described in [3], a scenario-based approach was adopted to describe the context of emotions. Three different scenarios were proposed to instantiate each affective state (except for Neutral which was described through two scenarios).

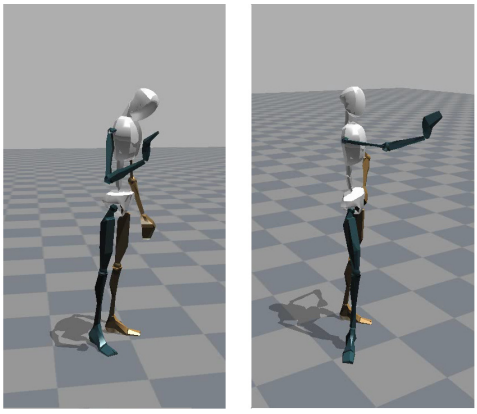

Figure 2: Two postures related to the movement task "Knocking at the door" when the hand is touching the door. The first posture (on the left) refers to the actor's expression of Sadness while the second posture (on the right) refers to the same actor's expression of Pride

Most of the scenarios that we used were adapted from those used in the study of Bänziger et al. [3] and Scherer et al. [26]. The other scenarios were validated through an informal experimental study where 10 participants had to attribute an emotion chosen from a closed list to each scenario. Figure 2 depicts the expression of Pride and Sadness related to one actor while Knocking at the door.

Technical description: The motion capture took place in a professional audio-visual recording studio in our institute, Telecom ParisTech in France. For each sequence of body movements, we recorded 3D motion capture file as well as video file (see Fig. 3). We used the inertial motion capture system Xsens [31] to record the 3D motion data of the whole body (see Fig. 2). The 3D orientation and position data are obtained for each body joint. We recorded as well the visual content of the emotional behaviors through four XF105 CANON Camera to capture different viewpoints. Unlike the software-based synchronization solution used in previous databases [23], a hardware-based solution was used in our work to synchronize video and motion capture files as this solution provides more accurate results. The hardware used for this solution were the Rosendahl nanosyncs HD (a professional video and audio sync reference generator) and the Alpermann card PLC PCIe, used in addition to the MVN time Code and Remote Control Plug-in of the motion capture system software.

In total, we obtained around 176 continuous motion capture sequences (11 actors * 8 emotions * 2 scenarios). After the post-processing of data, we obtained around 1771 motion capture sequences of one movement task repeated 4 times and around 7084 motion capture sequences of one movement task trial (11 actors * 23 motion sequences * 7 actions * 4 repetitions). The number of videos file is equal to the number of motion capture files multiplied by the number of cameras for which the viewpoint is relevant to visualize the entire movement task.

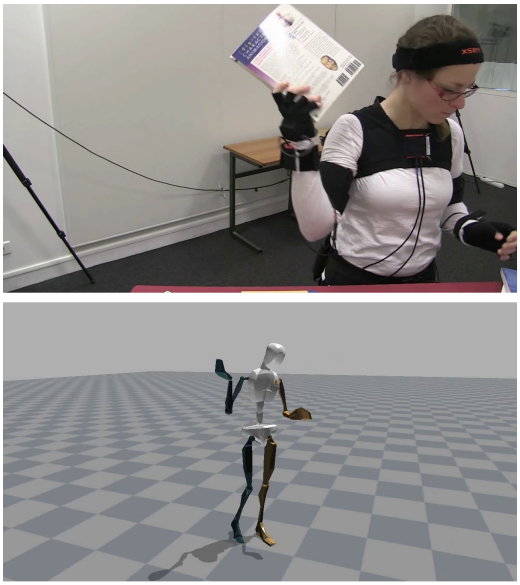

Figure 3: Example of emotional behavior showing the synchronized visual content with motion capture result. The actor is moving books from one side to another while expressing Anger

4.2 Database validation: Matching between expressed and perceived emotional behaviors

Since our principal goal to collect a new dataset is to characterize emotional body behavior, it is interesting to investigate the matching between the emotions that the actors were asked to express and the emotion perceived from other subjects. As the main goal of our study is based on the analysis of 3D motion capture data, we have designed a perceptual study using movies where the emotional behavior is reproduced on an avatar instead of the real video of the actors. The popular crowd-sourcing website Amazon Mechanical Turk was used to collect the results of emotion perception. Participants were asked to evaluate which emotions are displayed (using a Likert-Scale) as well as to characterize some body cues (using a Semantic Differential Scale). The analysis of the results collected from this evaluation study is part of our current work. So far we have collected data from more than 1000 participants.

5. CONCLUSIONS AND FUTURE WORK

In this paper, we discussed previous works related to the elaboration of body movement coding systems and the collection of body movement dataset for the study of emotional and expressive body behavior. We described as well our work conducted on the characterization of body movements and the collection of a new dataset of body emotional behaviors. The validation of the new database through a perceptual study is part of our current work. Our future work is mainly about the characterization of body emotional behaviors based on our dataset and our proposed body movement coding schema. Our goal is to characterize emotional behaviors in different movement tasks (as walking, lifting and throwing an object).

6. ACKNOWLEDGMENTS

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