Emotion specific body movements
Studying humans to augment robots’ bodily expressions

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ABSTRACT
Robots are starting to share our social space and will continue to do so in the future. These interactive devices have the capability of facilitating various interaction modalities which could go beyond voice and screen based interactions. When developing interaction technologies, theories such as psychobiological and media compensation suggest to replicate natural ways of human interactions such as face to face. As a result, it is vital to study how people interpret robot’s physical appearance and actions. According to previous studies, designing acceptable humanoid robots is far more challenging than designing robots with less human qualities. This paper emphasizes the importance of human non-verbal communication in emotional interactions and analyzes how people use full body expression to communicate basic emotions, in particular happiness, surprise, and anger. Furthermore, this paper presents a list of emotion specific movement behaviors that can be used and applied to better design forms and movements for both humanoid or non-humanoid robots.

CCS CONCEPTS
• Human-centered computing • HCI design and evaluation methods • Laboratory experiments • Interaction devices

KEYWORDS
Non-verbal communication, Emotional expressions, body movements, body language, human robot interaction, Robots’ emotional expressions

1 INTRODUCTION
1.1 Robots are starting to share our social space
Due to the advancement of interactive technologies, the way people interact with devices has changed dramatically. People interact with devices in an emotional level [1] while some products mediates people’s emotional experiences. Social robots can be identified as a new genre of interactive devices that will rapidly share our everyday living spaces. Most of these social robots are physically manifested, thus, are having greater potentials to offer multimodal interaction capabilities which go beyond commonly used speech and screen based interactions. According to psychobiological model [2] and media compensation theory [3] as humans, we evolved to interact face to face. Thus, it is vital to develop interaction methods for social robotics which are closer to human natural interaction modes where non-verbal communication plays a crucial role.

1.2 Human non-verbal communication to HCI and HRI
“Nonverbal communication is an elaborate secret code that is written nowhere, known by none, and understood by all” [3, p.556]. Affective information such as feelings and attitudes are mainly communicated by non-verbal communication such as body movements and less by words [5]. The majority of research on non-verbal interactions in HCI has focused on gestural inputs form the user and automatic recognitions of user’s movements by the computer, while limited number of research focus on gestural or non-verbal output for computer systems or robots. Moreover, as robots begin to share the social space with us, it is important for robot designers to understand how robot physical actions are interpreted by people around them [6]. Thus, this paper seeks to...
understand human non-verbal communications particularly in the area of bodily expressions of emotion in order to improve emotion specific movements for social robots.

1.3 Why movement is special
Humans have great sensitivity to biological motions. Prior studies show that people are capable of identifying expression such as attitudes and emotions by only looking at point light displays where it shows only the locations of human joints in space when they move [6, 7, 8]. Further, people assign expressions for abstract shapes in motion [10]. For instance, one of the earliest animation films "The dot and the line" uses a dot and a simple line to exhibit various complex expressions [11].

1.4 Studying human non-verbal emotional expressions
In order to make human robot interaction (HRI) more natural, it is vital to study how humans use non-verbal communications in emotional expressions. This is a widely explored area in psychology. However, the majority of those research has focused on human facial expressions, while comparatively less on body movements [11, 12]. Additionally, focus of these studies was mainly to explore the 'human nature' in general and less focused on applying them to HCI. Moreover, most of the existing work mainly pay attention to automatic recognition which is the side of input for computer systems. Therefore, research described in this paper mainly focuses on identifying emotion specific full body movement features which can be used to develop expressive movements for robots/computer systems as outputs.

2 RELATED WORK
2.1 Expressive body movement research
Studies on expressive body movements started with the seminal work of, “The expression of the emotions in man and animals” by Darwin [14]. Since then, human emotion expression has attracted much research across a variety of fields. Researches have been able to identify that some emotions can be recognized through facial expressions [14, 15]. Ekman, Friesen, & Ellsworth [17] strengthened the idea of basic emotion introducing nine characteristics which aid to discriminate basic emotions [18].

Emotion recognition research can be divided into two areas, namely facial expressions and body movements. Research on body movements is well behind studies on facial expressions [12, 18]. Further, in the recent review Witkower & Tracy [19] highlight the importance of considering body movements in emotion recognition research over facial expressions. Emotions can be recognized even at distance [11, 19, 20], even from behind the encoder [22], recognition rate for some emotions go beyond facial expressions [23], can be interpreted even without facial expressions [7], and sometime they override facial expressions [24].

2.2 Available body movement coding systems
Literature shows several coding systems which have been developed to study body movements. These coding systems can be divide into subjective measurers and objective measurers. Laban movement analysis (LMA) is a widely used movement annotation system which falls into the subjective category. LMA use a notation system called Labanotation to code qualitative aspects of movements [25]. The next category objectively measures movement qualities. Birdwhistell [26] developed a spatiotemporal coding system which gives anatomically categorized list of possible body movements. This coding system was not feasible to use due to the exhaustive list of movement behaviors. Bernese coding system is another coding system which annotates movement objectively [26, 27]. Facial action coding system (FACS) is one of the well-recognized coding systems which has been developed to analyze face muscle movements [29]. Due to the success of FACS, similar attempts were made to develop coding systems to code body movements: Body Action Coding system [30] and Body Action and Posture (BAP) Coding system [31]. However, these coding schemes have not been able to attract the popularity as FACS due to the long list of movement behaviors and time consuming coding process. Auto BAP coding system was developed as an automatic version of BAP coding system [32] although there is no space for semantic meaning coding [33].

After considering pros and cons of the above mentioned coding systems, we developed a new spatiotemporal coding system which can analyze body movements objectively. Further, this new coding system consists of a reduced behavior list and facilitate multilevel iterative analysis of movements. It allows both objective observations and subjective interpretations of movements. Moreover, the coding system is developed to identify suitable human body movements which can be applied to robotics and/or computer systems.

2.3 Expressive form and movement designs for social robots
Overall form and expressive movement capabilities are vital in a robot to make them accepted in social interactions. The morphology of social robots has been attracted by many researchers while less attention has been given to their expressive movements. Thus, the study presented in this paper focuses on observing human expressive movements in order to help develop expressive movement for social robots.

Social robots come in various forms and movement capabilities. Duffy [34] maps these forms in the three different ends of a triangle including human, iconic, and abstract. In a recent study, Balit, Vaufreydaz, & Reignier [35] arrange a collection of social robots in a continuum form non-humanoid forms to human or animal like forms. In a similar vein, Parlitz, Häggele, Klein, Seifert, & Dautenhahn [36] discuss that once the robot take human like appearance people tend to expect it to behave like a human. If the robot fails to reach the expected behavior people tend to dislike...
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the interaction. Evidently, Mori’s [37] ‘uncanny valley effect’ can be used to demonstrate the relationship between level of likeness towards a robot’s appearance and its form factor.

From a practical point of view, these theoretical notions help designers to develop acceptable designs for robots. In fact, most accepted practice of designing expressive movements for these robots is getting the involvement of professionals such as animators and choreographers. For instance, movement designs for Greeting machine robot and Travis robot were done by a professional choreographer and an animator [38, 6]. To ease the process of movement design, Hoffman & Ju [6] presents a framework which consists of a detailed design process. Further, Balit and the team [35] advanced Hoffman & Ju’s framework by developing a pipeline which uses the Blender animation software. Conversely, it is vital that robot designers need to work closely with experts from other fields such as animation, acting, dancing, choreography or obtain additional skills in order to design believable expressive movements for robots. This research attempts to fill this identified gap by identifying a list of emotion specific human non-verbal behaviors which can be mapped in designing movements for social robots.

3 THE CURRENT STUDY

3.1 Study overview

The study began by video recording bodily expressions for three different emotions: Happiness, Surprise, and Anger. Subsequently, they were analyzed and a final list of emotion specific movement behaviors were developed. The list has been presented at the end of the paper along with intended future steps where we embed these movements to physical prototypes of non-humanoid social robots.

3.2 Participants

The current study uses data corresponding to five participants. All the participants were students of Queensland University of Technology (QUT), Australia. Participants’ ages were ranging from 18 to 45 years old. The participant sample consists of three female and two male participants.

3.3 Study procedure and data collection

This study was conducted in a laboratory at QUT. Even though, natural settings could provoke genuine emotions, participants performed the activity in a laboratory setting due to the ethical considerations and also to ensure internal validity. No one was allowed to stay inside the laboratory while doing the performance except the participant. Participants were asked to perform bodily expressions for three different emotions: Happiness, Surprise, and Anger in two intensities: low and high. Performances for high intensities were taken to the analysis. Participants did their performance to a camera located in front of them. The list of emotions were displayed behind the camera. A keyboard which can operate the emotion list was placed near the participant (See Figure 1). Participant could use arrow keys to navigate the list in order to select relevant emotion for the performance. The time spent for each performance was decided by participates themselves.

3.4 Data analysis

Data analysis was conducted in four steps.

In the first step, Elan software was used to analyze video data (Figure 2). A full body movement behavior list of total 63 behaviors was developed through an iterative process. In this iterative process, each participant’s performance for each emotion were observed multiple times in order to identify possible movements which could insert into the list of behaviors.

In the second step, each performance were coded using the behaviors list developed in step one. Elan video analysis software was used.

In the third step, data of all the five participants were compared in order to identify commonly visible behaviors for each emotions.

In the fourth step, each participant’s expressions were re observed in order to identify any additional features and also to compose an emotion specific behavior list.

Figure 1: Arrangement of the laboratory to capture participants’ performances

Figure 2: Interface of the Elan video analysis software
4 FINDINGS AND DISCUSSION

Emotions specific full body movement behaviors were identified as the main finding of the study (See Table 1). The study differs from non-verbal communication research in psychology due to the fact that the search for movements is mainly done with the goal of applying them to non-humanoid robots. Thus, robot designers will be able to directly apply these findings when designing both form and movement for robots.

However, identified movement behaviors comply with previous literature to a greater extent in addition to new findings (See, [19] for a latest comprehensive review of previous research on emotion specific body movements). In addition to previous findings, the results show some interesting new patterns of body movement behaviors.

For instance, happiness shows repetitive up and down hand movements. Further, people fold and unfold fingers when expressing happiness. Moreover, people keep lips as opened and looks at the subject almost during the full expression time.

**Table 1: Emotion specific body movement behaviors for Happiness, Surprise, Anger**
