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The Influences of Emotional Intensity for Happiness and Sadness on Walking

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Abstract— **Walking is one of the most common activities that we perform every day. Even if the main goal of walking is to move from one place to another place, walking can also convey emotional clues in social context. Those clues can be used to improve interactions or any messages we want to express. However, there are not many studies on the effects of the intensity of the emotions on the walking. In this paper, the authors propose to assess the differences between the expression of emotion regarding the expressed intensity (low, middle, high and exaggerated). We observed two professional actors perform emotive walking, with different intensities and we analyzed the recorded data. For each emotion, we analyzed characteristic features which can be used in the future to model gait patterns and to recognize emotions from the gait parameters. Additionally, we found characteristics which can be used to create new emotion expression for our biped robot Kobian, improving the human-robot interaction.**

I. Introduction

Emotions are an important component of our daily life and they play an essential role in social interactions. The emotions can be expressed with different modalities: body movement with gestures and pose, facial expression, the contents of the speech and its tone. It had been shown that one of the most effective ways to transmit emotions is through facial emotions [1]. Ekman et al. found out that humans understand six basic emotions (anger, disgust, fear, happiness, sadness and disgust), regardless of their culture. Since Ekman, extensive research has been carried out on emotive facial expressions [1-4] and the research on emotions expression in the body movements received little attention until a few years ago [5, 6]. Indeed the way the body moves is an important source of information [7] for daily interaction among human beings. It had been demonstrated that body expressions affect face-based emotion recognition [8, 9] and can help to discriminate ambiguous facial expression [10]. Also, when people try to be deceitful, they have a better control on their facial expressions than their body movements [1].

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Emotions expressed with body movements can be demonstrated with specific emotional gestures such as the facepalm showing frustration or embarrassment or the French bras d'honneur ("arm of honor"), which can represent among others, a sign of anger similar to giving the finger. If the recognition of the emotion in motion was demonstrated sufficient [11], a study by Hadjikhani et al. [12] went further in this direction. They indicated that the perception of face-blurred fearful bodies activates areas in the brain known to be activated especially by fearful facial expression. Emotions can also simply affect and make vary simple movements such as walking. In [5], Michalak et al. found out that gait patterns associated with sadness and depression are characterized by reduced walking speed, arm swing and vertical head movements.

However, almost no studies to date have investigated the influence of the intensity in the emotion expression in the walking. We suppose that there are invariants for each emotion expressed in the walking. Different intensities – low, middle and high – should affect in the same way the gait parameters. First, the question is to measure how emotions are affecting the gait parameters. Second, we want to understand how the emotions evolve according to the intensity and what are the parameters affected. Unlike Montpare et al. [13] which used verbal cues or Crane et al. [14] which used only shoulder and hip kinematics to discriminate emotions, we decided to measure the gait parameters. The main advantage is that those parameters can be easily transferred to our biped robot through our pattern generator software. The results of this study will be used to create emotive patterns for our robots and will improve human robot interaction.

II. Method

A. Experiment

To observe the difference in the movements, particularly the walking during emotive states, we asked two Japanese professional actors (one male, one female, both 22 years old) to perform several types of emotive walking. We chose continuous emotions from the Ekman set of emotions [1] (happiness, sadness, anger and fear) while instantaneous emotions, like surprise, were discarded. We recorded four intensities of emotions: low, regular, high, and exaggerated. Normal walking was also recorded as a neutral condition. We asked the first three intensities to have a natural feeling similar to emotive walks that could be seen in society. The exaggerated intensity is characterized by an extravagant theatricality, broad gestures and overplayed expression. This way of expressing emotions is often seen in plays or theatre. First we met the actors a few days ahead the experiment to explain them the protocol and we asked them to accordingly prepare a small scenario for each emotion and intensity but they were free in their interpretation of the emotions. Similarly to Ma et al. [15], the order of emotions was randomized for each actor. We used the Cortex ® motion capture system to obtain 425 data records at 120 Hz (normal walking: 100 repetitions, 4 (emotions) x 3 (low, middle, high) x 10 repetitions + 100 (exaggerated) = 320 repetitions) for the Japanese actress. We used VICON ® motion capture system to obtain 105 data records at 100 Hz (normal walking: 25 repetitions, 4 (emotions) x 4 (low, middle, high, exaggerated) x 5 repetitions = 80 repetitions) for the Japanese actor. Helen Hayes markers set (Fig. 1) and VICON markers set (Fig. 2) were used. For the purpose of our research, using different markers sets is not detrimental since both are used in gait analysis. All the processing was done with Matlab® scripts we developed ourselves and the data were smoothed with a Butterworth filter. The axis x, y, and z are defined as the following: the x-axis describes the lateral displacement, the y-axis the longitudinal displacement and z-axis the height.

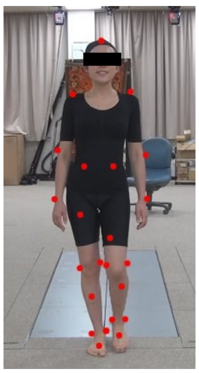

Figure 1. Helen Hayes marker set

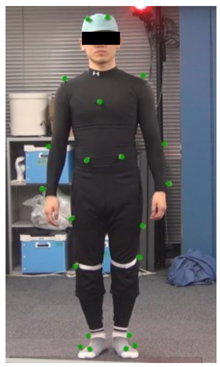

Figure 2. Vicon GAIT markers set

Walking features can be divided into two groups: the locomotor units and the passenger units. The locomotor unit is formed by both legs and the pelvis. We studied the change of step length (mm), stride length (mm), step height (mm), velocity (s/step) and the stance/swing ratio for the normal walking, happy walking and sad walking. The passenger unit is formed by the head, the neck, arms, the trunk and the pelvis. The characteristics studied are the trunk and the head inclination.

B. Parameters measured

We chose to analyze the following parameters for two reasons. First, the characteristics of the gait are analyzed extensively for more than thirty years and literature can provide many sources for comparison [16-18].

Step height (mm) The height is measured from the ankle. For each step, we measure the difference of z-axis on ground and at maximum height and the local maxima found are the maximum heights for the steps. We calculate the mean of the right and the left foot respectively. The first and last steps for each foot since the features are different at the start and end of the gait.

Step length (mm) The step length is measured by from right heel to left heel. The Euclidean distance along the x and y axis is computed between the right heel and left heel. The local maxima found are the events at which we measure the length of one step. For each trial, we remove the first and last step length and calculate the mean.

Stride length (mm) The stride length is measure from the right (left resp.) heel to right (left resp.) heel. For each step, we determine the points of highest variation along the y-axis. We measure between the founded consecutive points. The mean of the right and the left foot respectively is calculated, and then the general mean. We don't process the first and last step for each foot since the features are different at the start and the end of the gait.

Swing phase (s) The swing phase is the period in seconds during which the foot is off the ground. We decided to use as starting point the toe off event and as stopping point the heel strike event.

Stance phase (s) The stance phase is the period in seconds during which the foot is on the ground. We choose to use as starting point the heel strike event and as stopping point the toe off event.

Cadence (steps per minute) The cadence is defined by the number of steps per minute. We identify the second step and the step before the last. The time interval between those two steps is called the step time. We then divide the number of steps by the step time to obtain the cadence.

Velocity (s/step) The velocity is simply defined by the time interval between the second step and the step before the last divided by the number of steps in this time interval.

III. Results

By analyzing the movements, we observed two behaviors: an evolution from the low emotive intensity to the high emotive intensity or a stagnation of the characteristics. Those behaviors are different for each emotion. Unexpectedly, the melodramatic intensity does not necessarily follow the linear progression from low to high intensity. We compare the percentage value obtained for each parameters and different intensities with the corresponding value for the neutral condition which is the percentage Value for the Normal Walking (VNW). Figure 3 and 4 show the comparison between different intensities for sadness and happiness.

A. Sadness

1) Step height

For the actress, there is a constant decrease from low to exaggerated intensity (111.1% to 61.7% of the normal walking value). For the actor, the step height varies between 80.1% and 91.2% of the normal walking value.

2) Step length

There is a steady decrease from low intensity (90% of normal step length) to high intensity (67.5% of normal step length). The exaggerated intensity is at 72.5% of normal step length.

3) Stride length, Cadence and Velocity

The stride length, cadence and velocity stride length decrease regularly over time. They decrease by a value comprised between 12% and 14% for each intensity.

4) Stance

It increases over time from low, from a level 7% to 16% higher than normal walking to finish for the exaggerated intensity at 44% to 70% percent more than the normal condition.

5) Swing

For the actress, there is a slow increase over time from low (same level as normal) and arrives at a level 26% higher than the normal walking. For the actor, there is a slow decreases over time from low (same level as normal) and arrives at a level 27% lower than the normal walking.

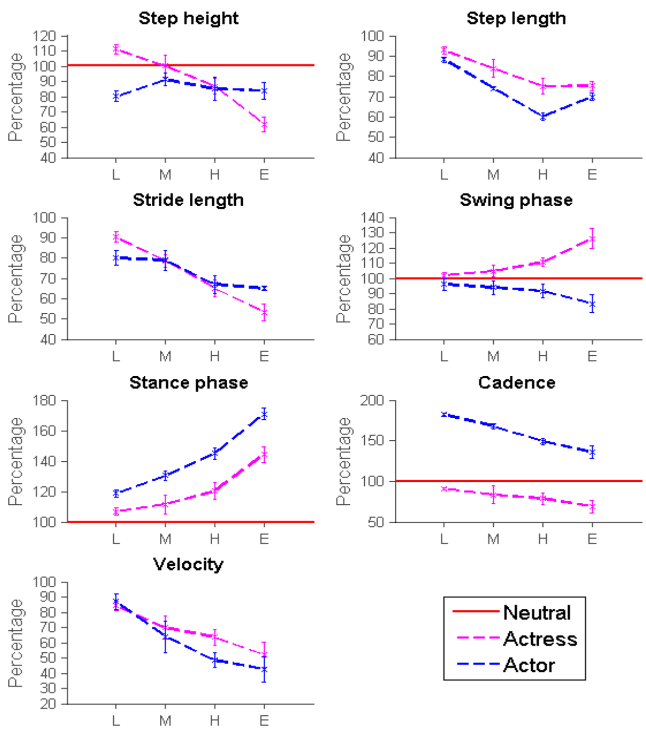

Figure 3. Comparison of the different intensities (L: low, M: middle, H: high, E: exaggerated) for Sadness

Besides the swing phase, the values of the locomotor and passenger parameters and their evolution are constant and similar in both actors.

B. Happiness

1) Step height

The step height stays constant over time for the low, middle and high intensity. The exaggerated intensity is 12.8% to 25.8% percent higher than the normal walking.

2) Step length

The step height stays constant over time for the low, middle and high intensity. The exaggerated intensity is 13.6% to 17.9% percent higher than the normal walking.

3) Stride length

For the actress the stride length decreases from low to high intensity (from 88.4% to 69.9% of the normal walking). For the exaggerated intensity, the value is 14.4% higher than the normal walking value. For the actor, the stride length is similar between low and exaggerated intensity (4.2%~6.7% higher than the normal walking) and also between middle and high intensity (20.2~20.7% higher than the normal walking).

4) Cadence

For the actress, the cadence is constant over time for all the intensity (84% of the normal walking value) except for the high intensity which is much lower (67.8% of the normal walking value). For the actor, the cadence increases over the time: from 234% of the normal walking value for low intensity to 294% at the exaggerated intensity.

5) Velocity

For the actress, the velocity is constant over the time for low and middle intensity (78.7% of the normal walking value). The high intensity which is much lower (58.8% of the normal walking value). The exaggerated intensity value is similar to normal walking (4.4% higher than the normal walking value). For the actor, the cadence increases over the time: from 234% of the normal walking value for low intensity to 294% at the exaggerated intensity.

6) Stance

For the actress, low intensity is similar to neutral. From middle to exaggerated intensity the value decreases by a value 19.1% higher than the normal walking to 8% lower than the normal walking. For the actor there is a constant decrease from low to exaggerated (92.5% to 74.0% of the normal walking value).

7) Swing

For the actress, low and exaggerated intensity are similar (20% higher than the normal walking value). From the middle to high intensity, there is an increase of 43.9% (from 116% to 159.9% of the normal walking value). For the actor there is a constant decrease from low to exaggerated (90.7% to 79.8% of the normal walking value).

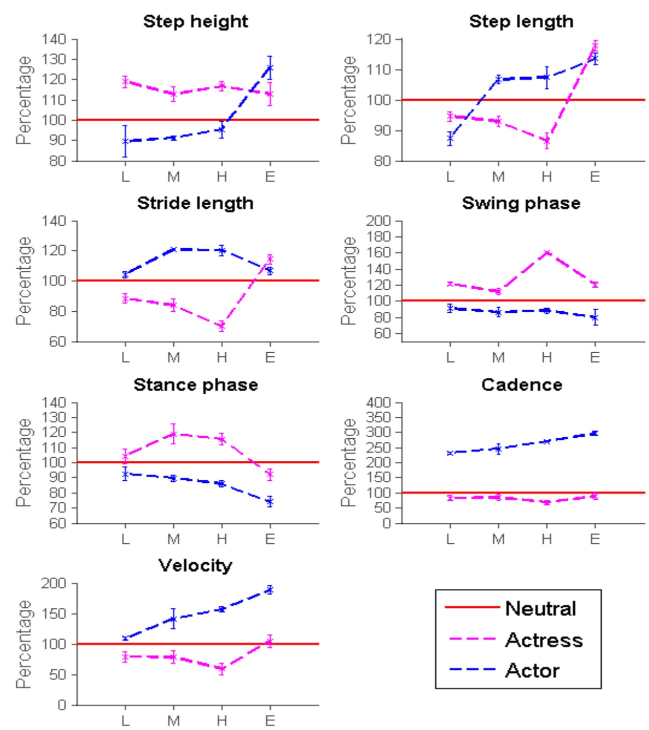

Figure 4. Comparison of the different intensities (L: low, M: middle, H: high, E: exaggerated) for Happiness

The main noticeable difference we found regarding the actors is about the velocity and the parameters associated such as cadence. This difference can be explained by two reasons. First, even if the emotion portrayed by both of the actors is happiness, the emotion is difficult to determine exactly. It can vary from contentment to intense joy. The actress expressed a peaceful happiness and then her movements became slightly slower than the normal condition. The actor expressed more actively this emotion through his high and vigorous pace. Second, the way of acting is different for both of the actors. The actress had a long experience in cinema and television and then she is used to play the emotions in a natural looking way, which can be difficult to discriminate just only the motion cues and without context or facial expression. The actor is a theater actor and theatre acting is usually defined as bigger-than-life, with broad gestures and exaggerated expressions since the actors on the scene might be far from the spectators.

IV. Discussions

According to the results, the sadness can be described as the following. As the emotion intensity increases, the step length, velocity, cadence and the stance phase increases. The main difference between the actress and the actor is the swing phase. As the emotional intensity increases, the actress' swing phase increases and the actor's swing phase decreases. The happiness is harder to define. The actors might have represented the happy walking in different ways: a content walk (actress) and a joyful walk (actor). To avoid this kind of problems in the future, we need specifically define in advance the context to the actors (or naïve subjects). For a content walk, the step height is constant over time and higher than the normal walking value. The velocity and cadence are lower than the normal walking value and constant over time. For the joyful walk, as the intensity increases, the step length the cadence and the velocity increase as well.

In a previous work [19], we did a preliminary assessment of the recognition rate of videos (real and stick figure from the captured data) of the actress performing sadness and happiness walking with different intensities and neutral walking. The overall recognition rate was 70.0% (±14.14), happiness 31.0% (±34.7) and sadness 95.8% (±7.7) for the real videos. For the stick figure videos, the overall recognition was 40.5% (±9.79), happiness 31.3% (±11.2), sadness 43.7% (±9.44) and neutral 58.3% (±35.35). The recognition rates are 4.2% (±9.44) for low, 12.5% (±18.16) for middle, 41.7% (±22.9) for high and 95.8% (±8.8) for exaggerated intensity. From the preliminary results we can conclude that the intensity affects the recognition rate. We can use those outcomes to focus on the most recognized emotive walk intensities and their parameters.

V. Conclusion

We analyzed the movements of two professional actors performing emotive walking with different intensities. For sadness and happiness, we analyzed the gait parameters and their change with different intensities. Those changes will be used in the future to model gait patterns. We plan to record more data with other actors and non-professional people in order to have a better comparison between different styles of emotional expressions. The data will be also assessed to keep the most recognized gaits. In addition, we will analyze other characteristics such as arm velocity and its angular positions, and the anger and fear emotions.

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