5 Emotion parameterization of gesture

Variations in human gestural movement can be explicitly characterized through the dimensions of physics such as time, space, acceleration, etc. These dimensions are useful because they are easy to describe and measure. But they may not psychologically reflect a person's intentions as they gesture. Gesture variations may be more appropriately parameterized by psychologically meaningful dimensions.

This chapter presents a framework for using dimensions of emotion to parameterize avatar gesture. We describe a different mapping from handwriting features to motion parameters required by the new parameterization. Finally, the framework changes the way sample gestures are selected and synthesized. Note that we have not implemented the idea described in this chapter.

5.1 Parameterization of movement by emotion

Among the signals that are sent through movement is emotional state. Darwin was one of the first scientists to describe the movements associated with emotion and to theorize on the relationship between emotions and their expression [29]. He suggested that expressions of emotion evolved from adaptive movements that turned out to be serviceable under certain states of mind. Later work by ethologists and psychologists found that these expressions became adaptive because of their communicative value [47][101]. The most studied form of expression of emotion is facial expression, however, it is understood that emotion has its expression in the body as well [39]. For instance, the fear response in humans is not only recognized as a particular facial expression, but is also accompanied by the adaptive movement of the tensing and slight raising of the shoulders [29]. A study by Montepare, Goldstein and Clausen describes the emotional cues that can be determined from the way someone walks—a heavy-footed gait and longer strides indicate anger while a faster pace indicates happiness [79]. A study by Allport and Vernon found that across a wide range of human motion, "emphasis" is a combination of increased pressure and constricted area [3]. Since writing is merely a particular mode (albeit stylized) of human movement, it follows that some expression of emotion should be expressed in it

The decodability of these signals suggests that motion variation can be classified by its emotional content. To be useful for our system, we need more than classifications of emotional expression; we need a continuous space in which these classifications can be located. Then we can use the dimensions of the space to parameterize expressive motion. That is, we can locate variations in motion within this emotional space.

Some psychologists conceptualize the communication and experience of emotion in terms of a two or three dimensional space [81][97]. The two dimensions that are agreed upon are "pleasantness" and "activity" [1][94]. Particular emotions can be described as qualitative combinations of these basic dimensions that are located within this space as shown in Figure 5-1. For instance, excitement is a combination of high activity and high pleasantness while depression is low in activity and pleasantness. In the communication of affect, a third dimension, sometimes referred to as "power," describes the sense of control over the emotion and

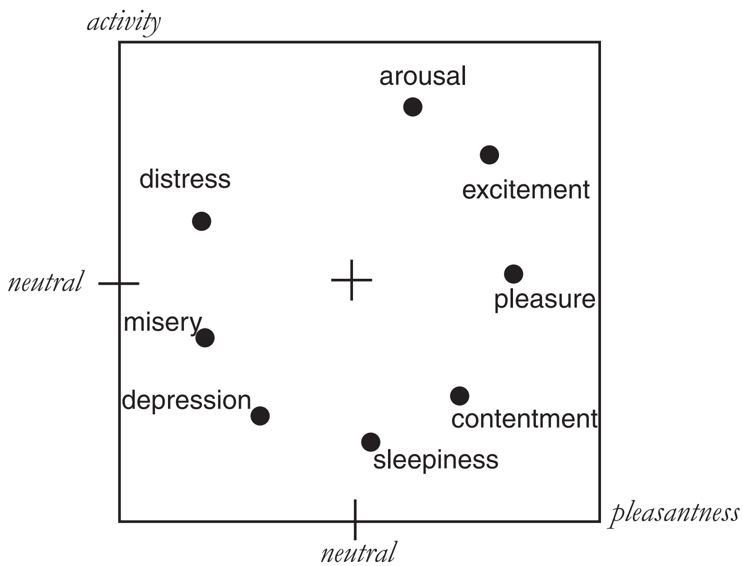

Figure 5-1. Emotion representation as a continuous dimensional space (after [17]).

distinguishes between emotions initiated by the individual from those elicited by the environment. For instance, contempt has high power while fear has low power.

Using a parameterization based on emotion dimensions may make it easier to obtain meaningful gesture variations. When using purely physical dimensions, the designers of the system must decide ahead of time which combinations and ranges of physical dimensions will result in psychologically meaningful variations. An arbitrary space may not adequately capture the ranges and combinations of physical features which communicate emotion. Using emotion dimensions allows us to sidestep this issue of finding the appropriate physical space. Instead, we can define a space based on the range of emotions we wish to make available.

5.2 Handwriting and nonverbal expression

Another reason that an emotion parameterization makes sense is because handwriting is known to reflect an individual's mood and emotional state and we intend to control gesture movement using handwriting. Elevated moods result in greater "total graphic movement" [35] an increase in writing size has been correlated with greater sense of confidence [114]. The question is how to choose handwriting style features and map these to affective expression.

One field that has studied the importance and meaning of handwriting features is graphology. Graphologists believe that handwriting can reveal and predict an individuals personality. Before continuing further with a description of graphology we should distinguish between this practice and other related fields of study. Graphology is distinct from similar sounding fields such as forensic handwriting analysis and graphonomics [80]. The former, also referred to as expert document analysis, analyses handwriting to determine the authenticity of a document's authorship. It makes no claims about the author's personality. Graphonomics is the interdisciplinary study of handwriting based in the scientific disciplines of psychology, physiology, education, bioengineering and computer science. Unlike these other fields, graphology is not based in the scientific method, though there have been some psychological studies seeking to validate (or invalidate) the field [3][57].

The term *graphology* was first used in 1871 by Michon [78]. The basic tenet of graphology is that long term personality traits are exhibited in a person's handwriting. Its results are deemed, by some, to be such a good indicator of character that many businesses, especially in Europe, use graphology to determine employee placements [92].

The earliest graphological systems looked for "signs" in a person's writing, the presence and absence of particular shapes, flourishes, marks and dots. However, modern graphologists place less emphasis on the particular shapes of letters. They look at features of the writing as a whole and use combinations of these features to detect particular traits[13][26].

The features that they use fall into the categories of size, slant, patterning and pressure. Size may refer to vertical size, width or size of particular regions of letters. Slant is the direction of slant of letters. Patterning relates to the movement of writing, its speed, spacing and general shape of connectors between letters. Pressure refers to both "point pressure" of the pen on the paper and the writer's grip on the pen.

Though he emphasizes that handwriting features are never judged in isolation, Wolff provides a summary of how the different features might affect an interpretation [114]. Size of the letter is related to the individual's sense of self-estimation, feelings ranging from inferiority and modesty to feelings of dominance. Slant is usually related to more "emotional" states[95]. Right leaning slants, depending on the degree of slant are associated with warmth, passion, irritability and vehemence. Left leaning slants are associated with restraint, denial, resistance and coldness. Speed of writing indicates temperament, and spacing of letters or words is a measure of emotional distance from others. Angular connectors are thought to express determination and will.

5.3 Handwriting style features

For our system, we seek a set of writing features whose variations correlate with the affective state or communicative intent of the writer. As of yet, there are no scientific studies that prove a valid mapping from handwriting features to emotion. Instead, we can select features from the graphological literature and find the map ourselves.

5.3.1 Graphological features

Graphologists use scores of features and combine them in many ways to make their interpretations. However there is broad agreement on the most important measurements—measurements related to writing speed, point pressure and area of writing. In addition, we are restricted to the kinds of features that we can easily compute from the digital ink. We suggest the list of features, shown in Table 5-1, taken from various sources [3][54][87][95][114].

Writing features	Definition
Speed	Average speed of point.
Pressure	Average point pressure.
Tension	Maximum pressure minus average pressure
Height	Vertical extent of ink
Width	Horizontal extent of ink
Bounding box size	Height times width
Slant	Angle of major axis of letter

Table 5-1. Suggested pen gesture features to extract.

5.3.2 Experimental method to find map

The next step is to find a relation that takes writing feature values and maps them to the dimensions of emotion. If we assume a linear relationship between these two spaces, then what we are looking for is the relation

$$\mathbf{A}\begin{bmatrix} f_1 \\ f_2 \\ \dots \\ f_n \end{bmatrix} = \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

where e_1 and e_2 are the coordinates for emotion in the emotion space and $f_1, f_2, \ldots, f_n$ are values for the pen gesture features and $\mathbf{A}$ is an $n \times 2$ coefficient matrix. Actually, since the relation will most likely differ from letter (i.e., pen gesture) to letter, we need to find a matrix $\mathbf{A}_i$ for each character, where i is the index of the *ith* character in the pen gesture set.

We can use linear regression to estimate the values for the coefficients in the relation. The first step is to choose a set of emotions E_j distributed within the emotion space (as shown in Figure 5-1), and assign coordinate values to these emotions. Then we will have a set of coordinates $E = \{(e_{11},e_{21}), (e_{12},e_{22}), \ldots, (e_{1m},e_{2m})\}$, where m is the number of emotions. Then for each of the letters that will be part of the pen gesture vocabulary, we ask the user to write the letter in the style of these various emotions. For each character i and each emotion j, we obtain a set of feature vectors. In fact, we will need to take several writing samples for each emotion to determine an approximation for the coefficient matrix using linear regression, so we end up with a set of feature vectors F_{ijk}, where k indexes into the sample number.

5.4 Synthesis

5.4.1 Avatar gesture samples

The avatar gesture motion samples are selected so that they are spaced around the origin of the emotion space. The origin is also the location of the neutral expression where we take one more sample. We assign to each of the avatar gesture locations the values of its coordinates in the space. One way to further personalize an individual's avatar gesture set is to ask the person to perform the gesture five different ways, and then have them place the gestures within the space themselves. The result would be a set of gesture samples labeled with their location in the emotion space as shown in Figure 5-2

5.4.2 Interpolation

Given a point p_0 in the emotion space, we want to find the motion trajectory associated with the this point. We can find this trajectory by interpolating among the three trajectories that form a triangle enclosing p_0. One point of this triangle will always be the neutral sample p_0. The other two points, will have vectors whose angles with the vector $\overline{s_0 p_0}$ will have opposite signs.

To find this triangle, we compare the vector from the origin to the point p_0 to the vectors defined by each of the samples as in Figure 5-3. The first step of the procedure is to find

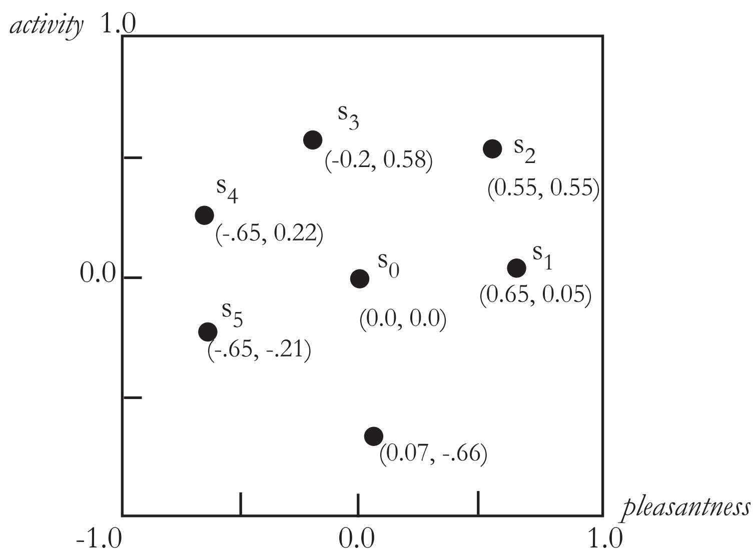

Figure 5-2. Personal avatar gesture samples in two-dimensional emotion space.

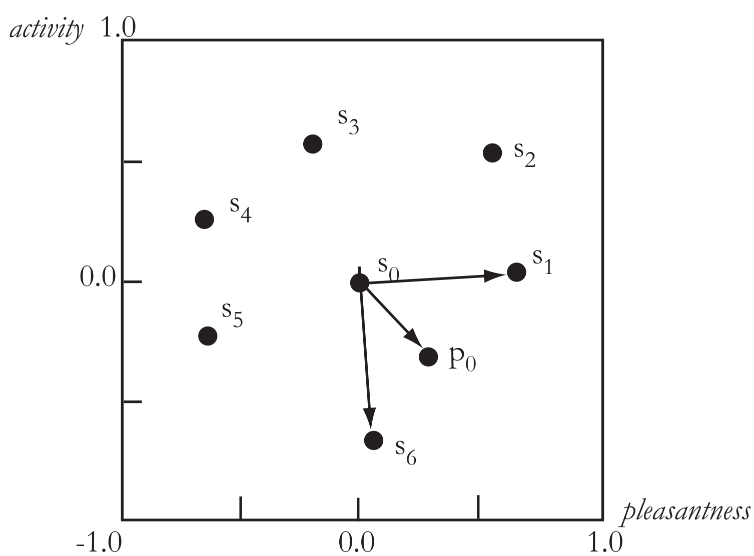

Figure 5-3. Finding the three closest neighbors of the new point p_0.

the point with the nearest vector. We can do this by taking the dot product of the new vector with each of the sample vectors, and the sample that results in the biggest dot product is the closest. Then, to find the third sample, look at the adjacent vectors on either side of the closest sample. Choose the vector whose angle with $\overline{s_0 p_0}$ has the opposite sign from the point with the nearest vector.

We use a multi-step interpolation, illustrated in Figure 5-4, to find the trajectory at p_0.

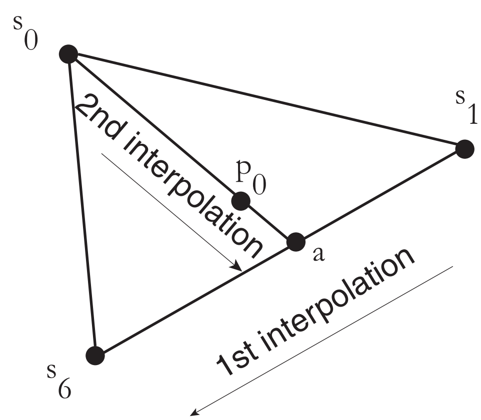

Figure 5-4. Multistep interpolation of gesture trajectory from enclosing triangle.

First we find the point a in the emotion space where a is just the point where $\overline{s_0 p_0}$ intersects with $\overline{s_1 s_6}$. Then we compute an intermediate trajectory at a by interpolating between s_1 and s_6 using spherical linear interpolation as described in Section 4.3.3. Finally, we can compute the trajectory at p_0 by interpolating between p_0 and a.

5.5 Towards affective input

In this chapter we presented a possible instantiation of our interaction technique using results from psychological research on the dimensions of emotion. Note that we have yet to implement the idea described in this chapter. People naturally communicate through their handwriting by varying the forms of the letters. Using a computer, we can capture affect not only in the script of the letter, but from the actual movement of the pen by the user. Pen interfaces can take advantage of handwriting skills, a skill which requires years of training but which most adults acquire prior to learning to use a computer. We believe that pen user interfaces are a uniquely promising technology for truly affective interfaces.