Design of Interactive Systems (DIS)

Lecture 12: Foundations of designing interactive systems– Affect

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Part IV Foundations of designing interactive systems

- **Chapter 21**: Memory and attention
- **Chapter 22**: Affect
- **Chapter 23**: Cognition and action
- **Chapter 24**: Social interaction
- **Chapter 25:** Perception and navigation

Introduction

- Role of emotions (affect in this context) in interactive system design
- Introduction to theories of human emotions
- Demonstration of their application in technologies that respond to emotion or can generate emotion.

Aims

- The physical and cognitive accounts (models) of emotion
- The potential for **affective computing** in interactive systems design
- Applications of affective computing
- Sensing and recognizing human affective/emotional signals and understanding affective behaviour
- Synthesizing emotional responses in interactive devices.

Introduction

- Affect is concerned with describing the whole range of **emotions**, **feelings, moods, sentiment** and other aspects of people that might be considered **non-cognitive** (not aiming to describe how we come to know and understand things) and **non-conative** (not aiming to describe intention).
- Basic emotions: fear, anger and surprise
- Longer-term emotions: love or jealousy
- Affect interacts with both cognitive and conative aspects of people. For example, if you are afraid of something it will affect the attention you pay to it.

Introduction

- Affective computing concerns how **computing devices** can deal with **emotions**.
- There are three basic aspects to consider:
  - getting interactive systems to recognize human emotions and adapt accordingly;
  - getting interactive systems to synthesize emotions and hence to appear more engaging or desirable;
  - designing systems that elicit an emotional response from people or that allow people to express emotions.

Introduction

- Example of getting computers to recognize human emotions and react accordingly: a sensor in a motor car to detect whether or not the driver is angry or stressed

Introduction

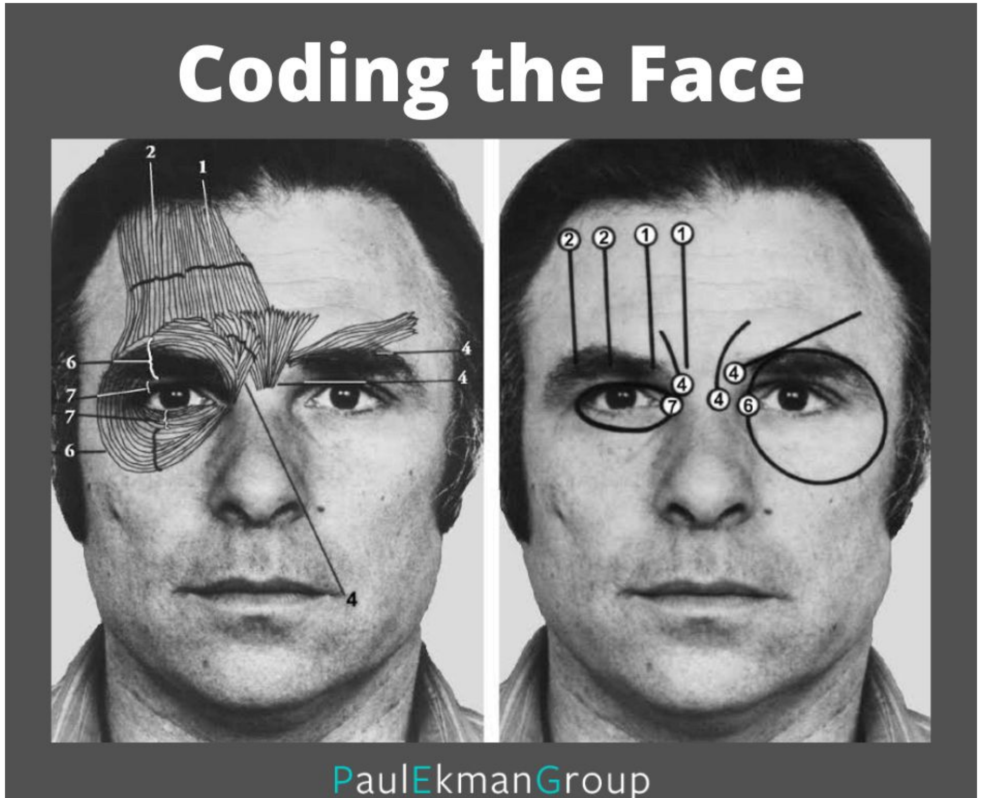
- Synthesizing emotion is concerned with giving the impression of computers **behaving** or **reacting** with **emotion**
- Here an example might be a machine showing signs of distress when a system crash has just destroyed several hours' work.

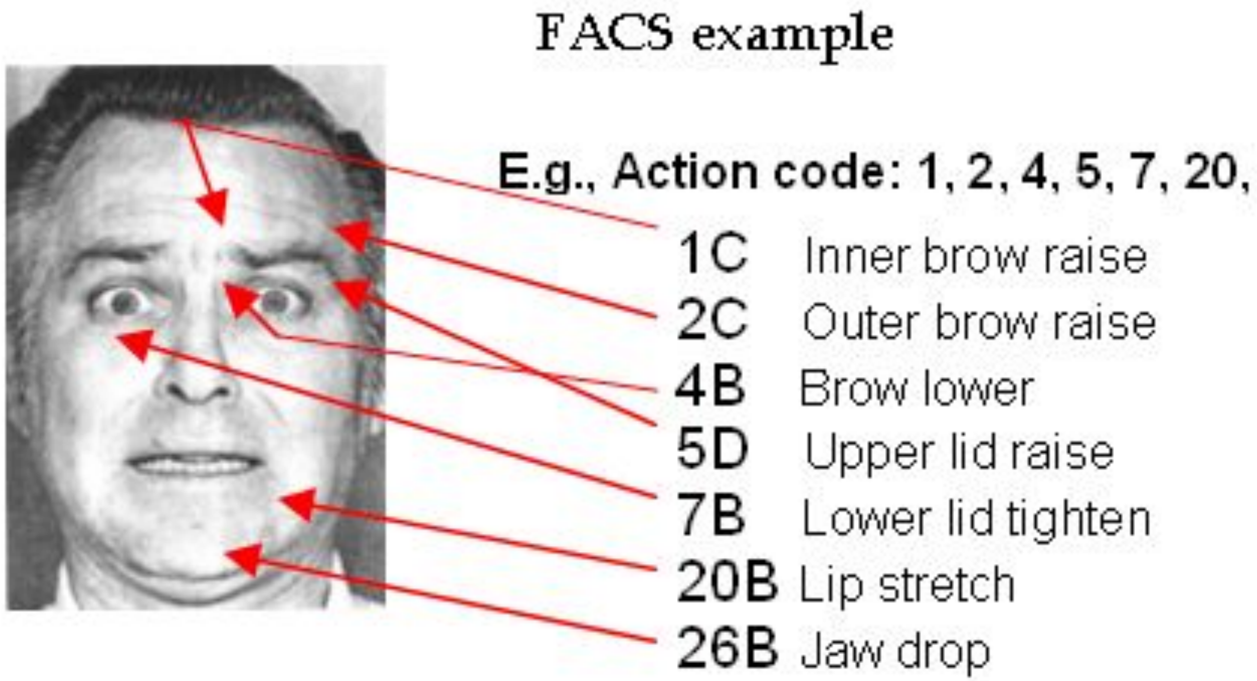
Introduction

- Designing interactive systems that **communicate** or **evoke human emotions** is another key aspect of affective computing.
- Emotion plays a significant part in decision making, social interaction and most aspects of cognition, such as problem solving, thinking and perception.
- Understanding how emotion works can help us design systems that recognize, synthesize or evoke emotions.

Psychological theories of emotion

- Six basic emotions: fear, surprise, disgust, anger, happiness and sadness
- Ekman and Friesen (1978) went on to develop the ‘facial action coding system’ (FACS) which uses facial muscle movements to quantify emotions;





Psychological theories of emotion

Similar work by Plutchik (1980), eight pairs of basic emotions that can be combined to produce secondary emotions.

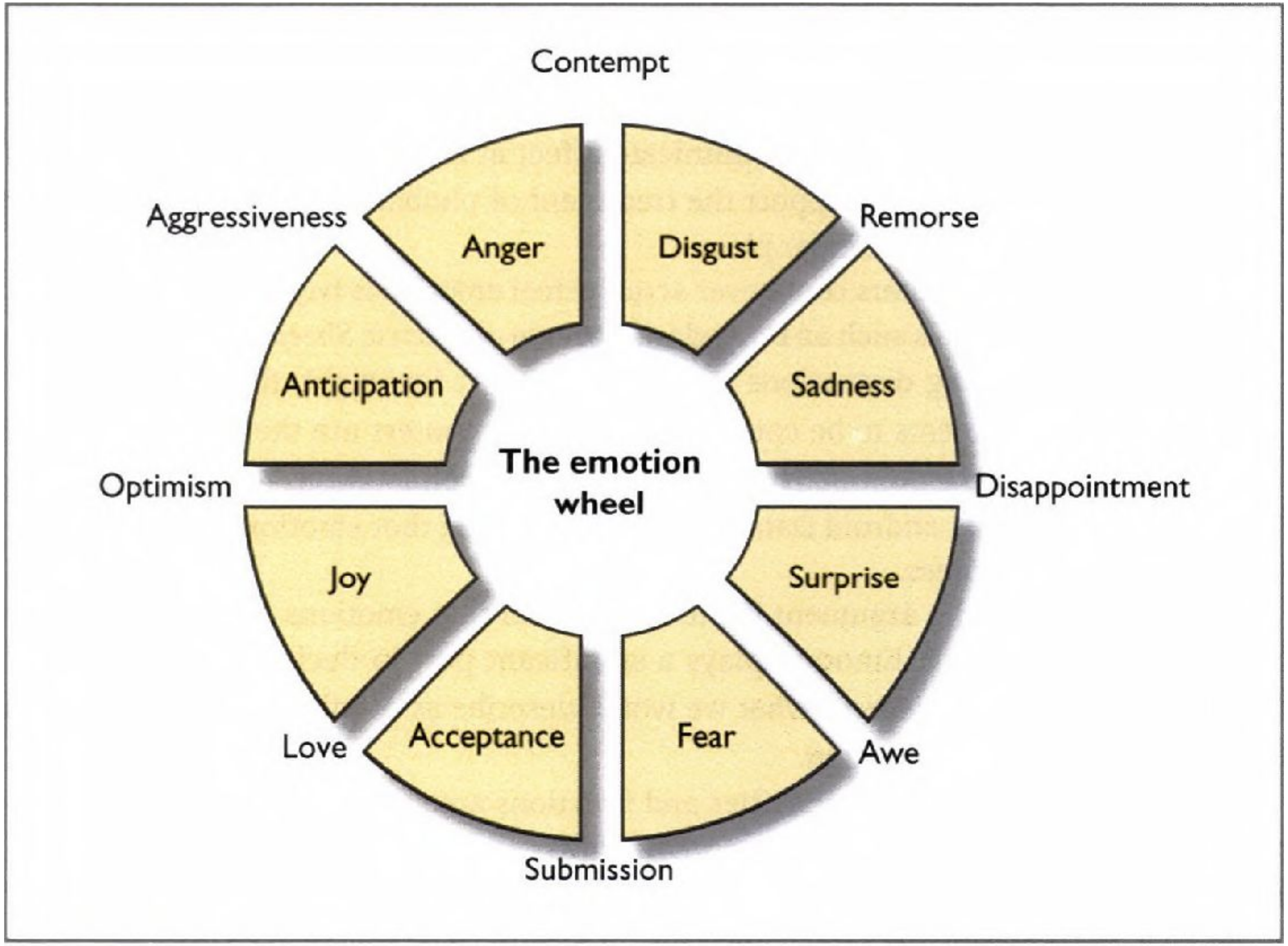


Figure 22.1 The 'emotion wheel'

Psychological theories of emotion

- **The James-Lange theory** This theory argues that action precedes emotions and the brain interprets the observed action as emotions. So, for example, we see an axe-wielding maniac walking towards us: in response our pulse rate rises, we begin to sweat and we quicken our step - we run for our lives
- **The Cannon-Bard theory** disagreed with the James- Lange theory and argued that when an emotion-arousing stimulus is first perceived, actions follow from cognitive appraisal.
- **Cognitive labelling and appraisal theories: Schachter-Singer and Lazarus** they favoured the idea that the experience of emotions arises from the **cognitive labelling** of physiological sensation. However, they also believed that this was not enough to explain the more subtle differences in emotion self-perception, i.e. the difference between anger and fear.

Detecting and recognizing emotions

- Human emotional states have physiological, cognitive and behavioural components.
- **Behavioural** and (some) **physiological changes** are, of course, most apparent to the outside world, unless we deliberately choose to disguise our feelings.
- while some of the **physiological changes** are **obscure** to other people, unless they are extremely **physically close** or have special **monitoring equipment**, they are virtually all accessible to a computer armed with the appropriate sensors.

Table 22.1 Forms of sentic modulation

Apparent to other people	Less apparent to other people
Facial expression	Respiration
Voice intonation	Heart rate, pulse
Gesture, movement	Temperature
Posture	Electrodermal response, perspiration
Pupillary dilation	Muscle action potentials
	Blood pressure

Basic capabilities for recognizing emotion

- Technologies that successfully recognize emotion need to draw upon techniques such as pattern recognition and are likely to need to be trained to individual people - as for voice input technologies.
- A computer requires the following capabilities to be able to discriminate emotions.
- **Input**
- **Pattern recognition**
- **Reasoning**
- **Learning**
- **Bias**
- **Output**

Basic capabilities for recognizing emotion

Input

- Receiving a variety of input signals, for example face, hand gestures, posture and gait, respiration, temperature, electrocardiogram, blood pressure, blood volume, and electromyogram (a test that measures the activity of the muscles).

Pattern recognition

- Performs feature extraction and classification on these signals. For example, analyzes video motion features to discriminate a frown from a smile.

Reasoning

- Predicts underlying emotion based on knowledge about how emotions are generated and expressed. This reasoning would require the system to reason about the context of the emotion and a wide knowledge of social psychology.

Basic capabilities for recognizing emotion

Learning

- As the computer ‘gets to know’ someone, it learns which of the above factors are most important for that individual, and gets quicker and better at recognizing his or her emotions.

Bias

- The emotional state of the computer, if it has emotions, influences its recognition of ambiguous emotions.

Output

- The computer names (or describes) the recognized expressions and the likely underlying emotion.

Basic capabilities for recognizing emotion

- **Sensors** and **software** that **detect physiological changes** such as heart rate, skin conductivity and so forth have long been available.
- However, there are **practical issues** with relying on this sort of data alone.
- The sensors themselves are too **intrusive** or **awkward** for most everyday uses, and the data requires **expert analysis** - or intelligent systems - to **interpret** the significance of changes.
- The same combinations of **physiological signs** can belong to **different emotions** - the signs of disgust and amusement are very similar,

Recognizing emotions in practice

- Pattern recognition was exploited in work by Picard which was designed to explore whether a wearable computer could recognize a person’s emotions over an extended period of time
- Over a period of ‘many weeks’, four sensors captured
  - an electromyogram (indicating muscle activity)
  - skin conductance
  - blood volume pulse (a measure of arousal)
  - respiration rate.

Recognizing emotions in practice

- In one experiment, for example, Ward *et al,* (2003) used a commercially available **facial tracking** package. The software works by tracking facial movements detected from a video of the face. The findings suggested the following:
  - Facial expressions change in response to even relatively minor interaction events.
  - These changes were detected by the tracking software.

Recognizing emotions in practice

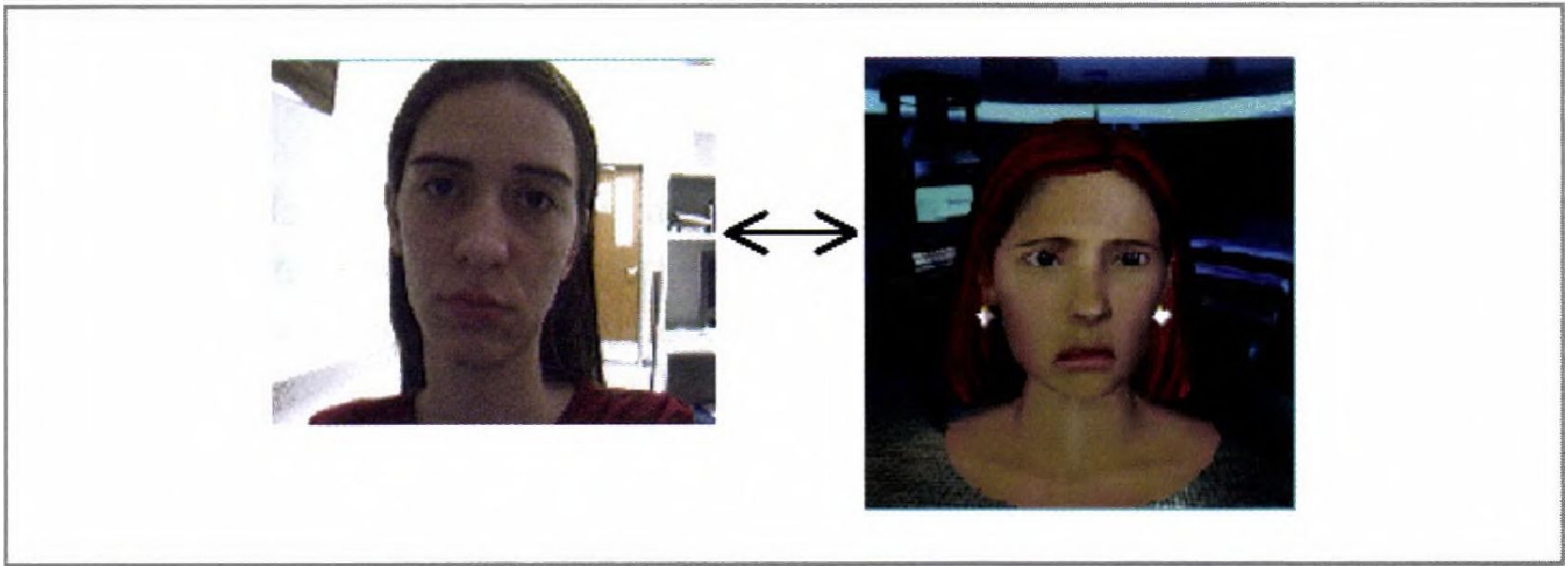


Figure 22.6 An avatar mirroring a user's sad state

Affective wearables

- An affective wearable is a wearable system equipped with sensors and tools that enables recognition of its wearer’s affective patterns
- Wearables can be used whether we are walking, standing or travelling. Wearables are also always on (in every sense).
- They can supply information on affect naturalistically.
- Currently, the most common examples of affective wearables are affective jewellery.

- The earring involves using an LED to sense the amount of blood flow in the earlobe. From this reading both the heart beat and constriction of the blood vessel can be determined
- Fig. 22.8, further example of a system that can sample and transmit biometric data to larger computers for analysis. The data is sent by way of an infra-red (IR) link.

Figure 22.7 The Blood Volume Pressure (BVP) earring

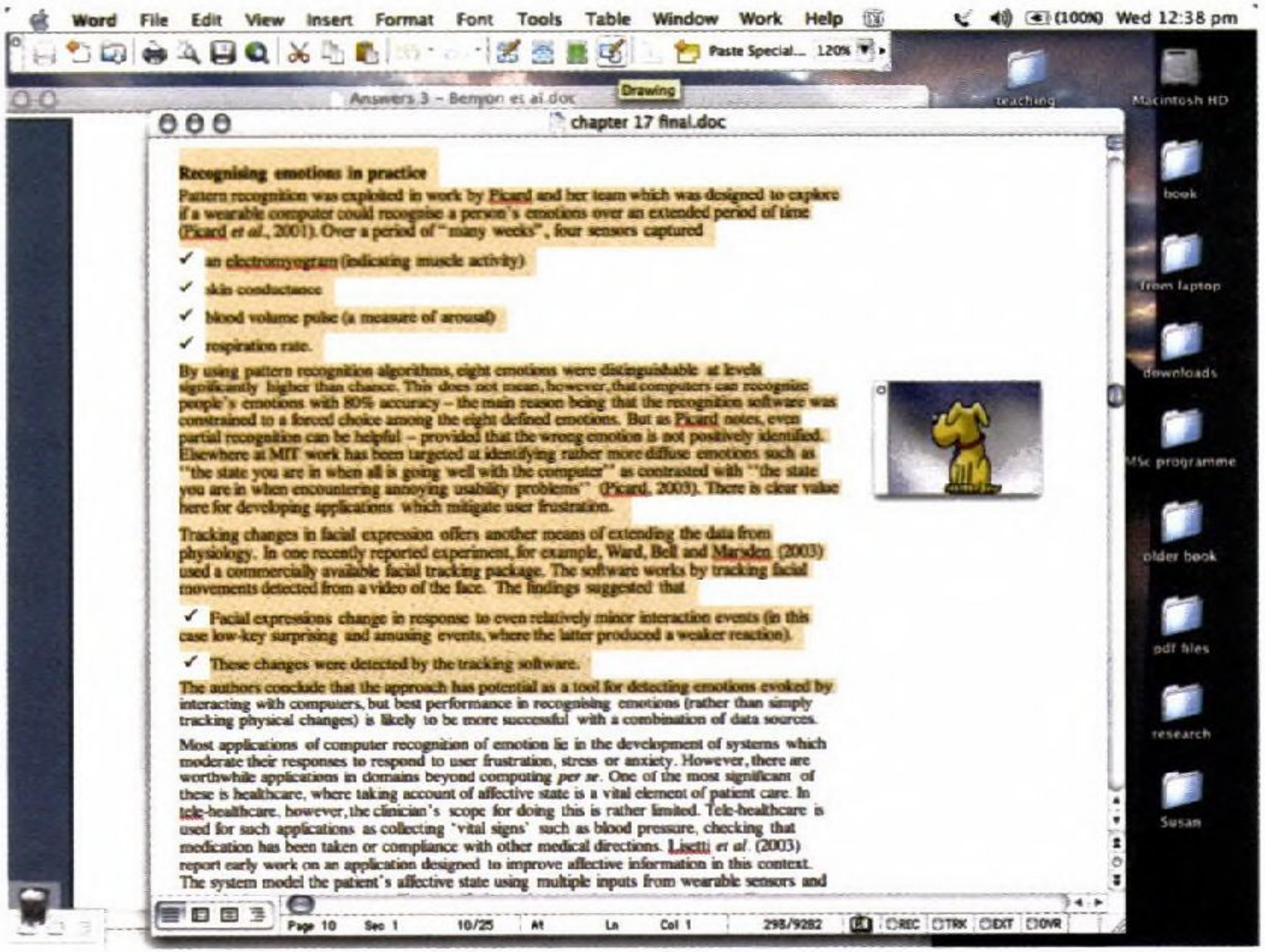
Figure 22.8 Sampling biometric data with a wearable device

Expressing emotion

- This is the other side of the affective computing equation.
- With interactive systems, there are several aspects to consider:
  - How computers that apparently express emotion can improve the quality and effectiveness of communication between people and technologies.
  - How people can communicate with computers in ways that express their emotions.
  - How technology can stimulate and support new modes of affective communication between people.

Can computers express emotion?

- Consider the expressions of the Microsoft Office Assistant - in Figure 22.9 he is ‘sulking’ when ignored by the author.



Recognising emotions in practice

Pattern recognition was exploited in work by Picard and her team which was designed to explore if a wearable computer could recognise a person's emotions over an extended period of time (Picard *et al.*, 2001). Over a period of "many weeks", four sensors captured

- ✓ an electromyogram (indicating muscle activity)
- ✓ skin conductance
- ✓ blood volume pulse (a measure of arousal)
- ✓ respiration rate.

By using pattern recognition algorithms, eight emotions were distinguishable at levels significantly higher than chance. This does not mean, however, that computers can recognise people's emotions with 80% accuracy – the main reason being that the recognition software was constrained to a forced choice among the eight defined emotions. But as Picard notes, even partial recognition can be helpful – provided that the wrong emotion is not positively identified. Elsewhere at MIT work has been targeted at identifying rather more diffuse emotions such as "the state you are in when all is going well with the computer" as contrasted with "the state you are in when encountering annoying usability problems" (Picard, 2003). There is clear value here for developing applications which mitigate user frustration.

Tracking changes in facial expression offers another means of extending the data from physiology. In one recently reported experiment, for example, Ward, Bell and Marsden (2003) used a commercially available facial tracking package. The software works by tracking facial movements detected from a video of the face. The findings suggested that

- ✓ Facial expressions change in response to even relatively minor interaction events (in this case low-key surprising and amusing events, where the latter produced a weaker reaction).
- ✓ These changes were detected by the tracking software.

The authors conclude that the approach has potential as a tool for detecting emotions evoked by interacting with computers, but best performance in recognising emotions (rather than simply tracking physical changes) is likely to be more successful with a combination of data sources.

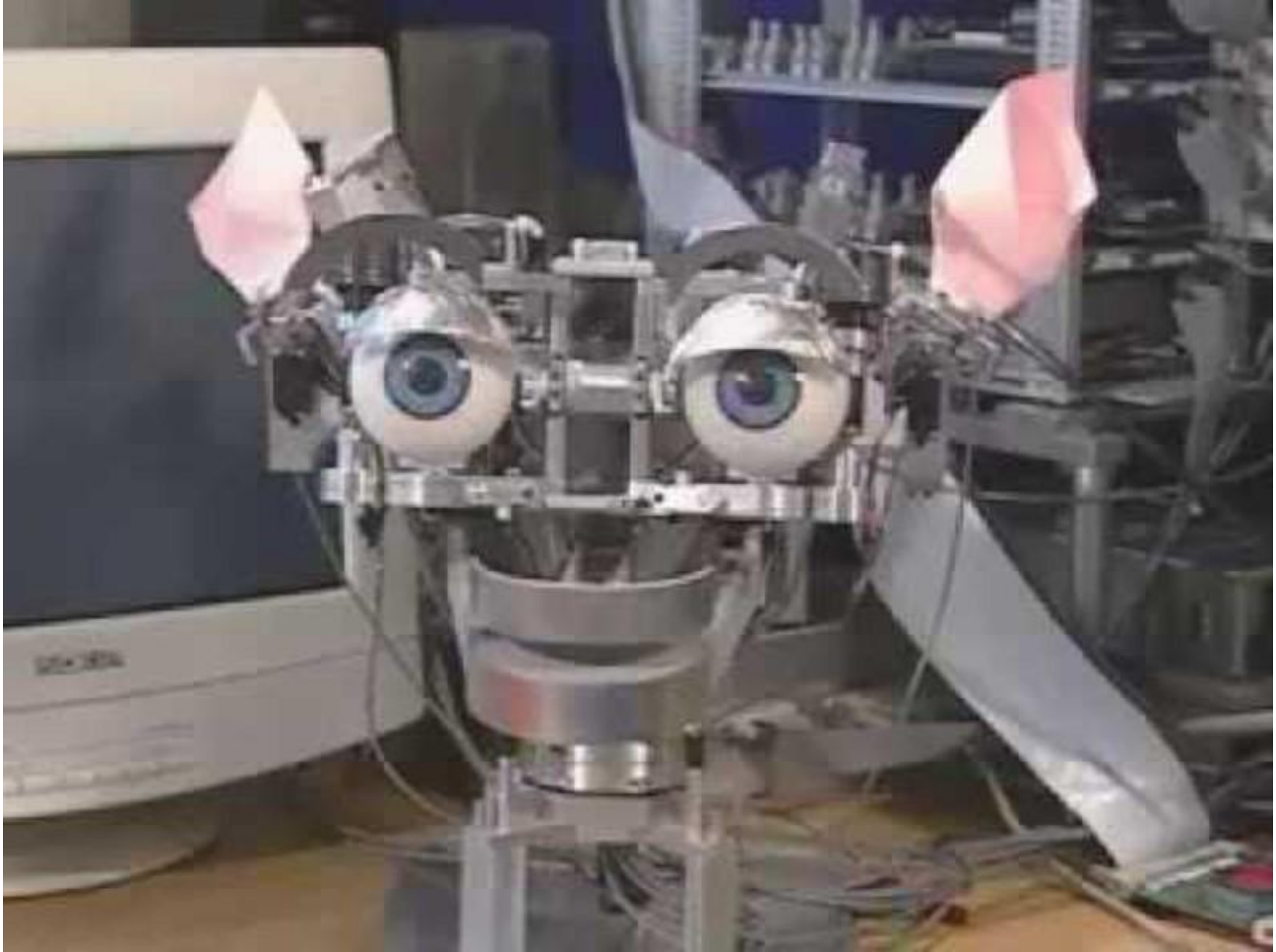
Most applications of computer recognition of emotion lie in the development of systems which moderate their responses to respond to user frustration, stress or anxiety. However, there are worthwhile applications in domains beyond computing *per se*. One of the most significant of these is healthcare, where taking account of affective state is a vital element of patient care. In tele-healthcare, however, the clinician's scope for doing this is rather limited. Tele-healthcare is used for such applications as collecting 'vital signs' such as blood pressure, checking that medication has been taken or compliance with other medical directions. Lisetti *et al.* (2003) report early work on an application designed to improve affective information in this context. The system model the patient's affective state using multiple inputs from wearable sensors and

Can computers express emotion?

- Schiano *etal,* 2000 conducted an experiment, which tested an early prototype of a simple robot with ‘a box-like face containing eyes with moveable lids, tilting eyebrows, and an upper and lower lip
- Most of the subtle changes in facial folds and lines that characterize human emotions were missing
- Despite these limitations, human observers were able to identify the emotions communicated successfully.

Can computers express emotion?

- ‘Kismet’ (Figure 22.10), an expressive robot developed at MIT, provides a much more complex physical implementation.
- It is equipped with visual, auditory and proprioceptive (touch) sensory inputs
- Kismet can express apparent emotion through vocalization, facial expression, and adjustment of gaze direction and head orientation.



Affective input to interactive systems

- computers can detect affective states.
- Interactive systems generally aim to monitor human affective signs unobtrusively so as to identify current emotions.
- But what if the human wants to communicate an emotion more actively, perhaps to influence the actions of her character in a game?
- The affective, tangible user interface developed in the SenToy project (Paiva *et al.*, 2003) affords an imaginative treatment of this type of input problem.

Affective input to interactive systems

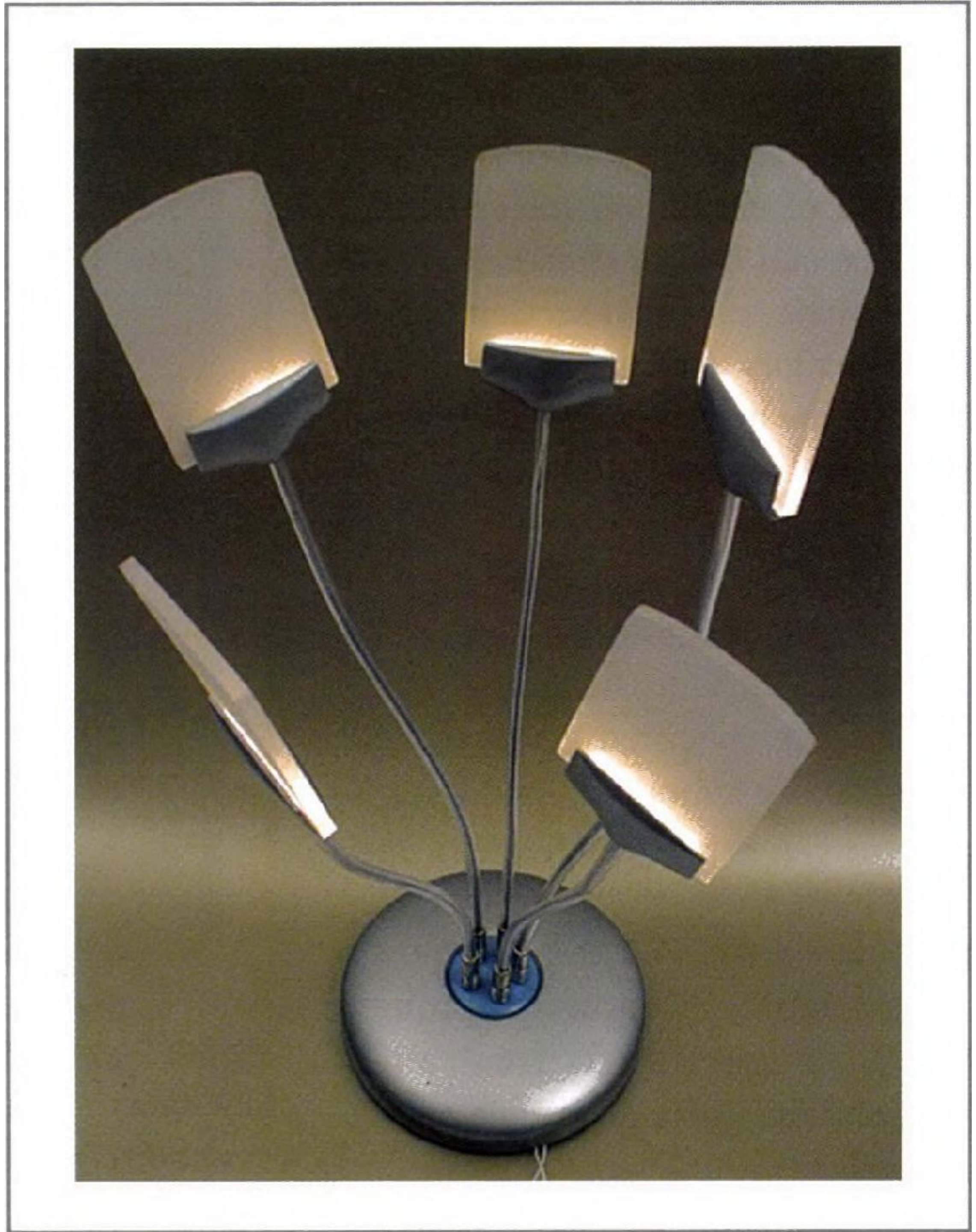
- People can express anger, fear, surprise, sadness, gloating and happiness through gestures which are picked up by the doll's internal sensors and transmitted to the game software.
- Sadness, for example, is expressed through bending the doll forwards, while shaking it with its arms raised denotes anger.

Figure 22.11 The SenToy affective interface

Enhancing human affective communication

- Idea is to convey a particular emotion - generally a positive one - but more often the aim is to foster emotional bonds through feelings of connection.
- A representative set of examples, designed for ‘telematic emotional communication’, is described by Tollmar and Persson (2002).
- Rather unusually in this domain, the inspiration behind the ideas comes from ethnographic studies of households and their use of artefacts to support emotional closeness.
- They include ‘6th sense’ (Figure 22.12), a light sculpture which senses body movement in the vicinity.

Fig. 22.12
6^{th} sense



Potential applications and key issues for further research

Table 22.2 Potential 'areas of impact' for affective computing

	Human-human mediation	Human-computer interaction
Foreground	Conversation • Recognizing emotional states Wireless-mobile devices • Representing–displaying emotional states Telephones • Speech-synthetic affect and voice Video teleconferences • Affective iconics	Graphical user interface • Adaptive response based on physiological detection Wearable computers • Remote sensing of physiological states Virtual environments • Emotional capture and display Decision support • Affective elements of decision-making
Background	Portholes (video/audio links between offices or other spaces) • Affective interchanges – adaptive monitoring Electronic badges • Affective alert and display systems Avatars • Creation of personality via synthetic emotional content	Smart house technology • Sensors and affective architectures Ubiquitous computing • Affective learning Speech recognition • Monitoring voice stress Gaze systems • Movements and emotion detection Intelligent agents • Social and emotional intelligence

Potential applications and key issues for further research

- There are fundamental issues which remain to be clarified.
  - In which domains does affective capability make a positive difference to human- computer interaction, and where is it irrelevant or even obstructive?
  - How precise do we need to be in identifying human emotions - perhaps it is enough to identify a generally positive or negative feeling? What techniques best detect emotional states for this purpose?
  - How do we evaluate the contribution of affect to the overall success of a design?

Class exercise

We have established that affect stems partly from physiological sensations such as increases in pulse rate, perspiration and so on. Given that sensors exist to detect these changes, how could these phenomena be exploited in the design of interactive games? You should consider acceptability to gamers alongside technical feasibility.