University of Essex

School of Computer Science and Electronic Engineering

# CE803 – Human-Machine Interaction

## Part II – Lecture 4

- **Galvanic Skin Response (GSR)**
- **Blood Volumetric Pressure (BVP)**
- **Affective Computing**

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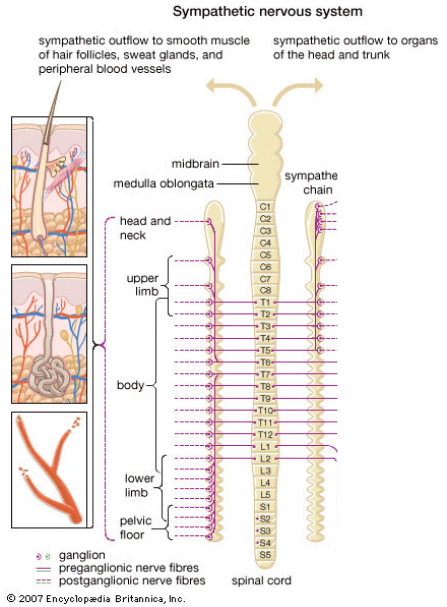
# Affective Computing

- Supplementary reading:
  - E. Leon (2007). 'Towards Affective Pervasive Computing: Emotion Detection in Intelligent Inhabited Environments'. PhD thesis, University of Essex. (available from the CE803 web page)



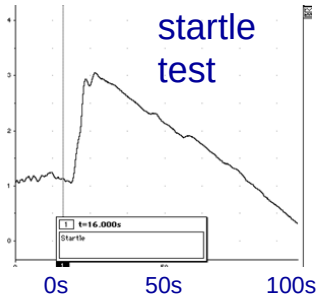
# Galvanic Skin Response

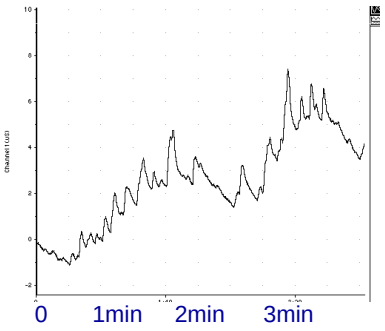
- Skin electrical conductance:
  - changes according to
    - sweat gland activity
    - pore size
  - determined (mostly) by neural signals
    - autonomic nervous system
      - – sympathetic
      - – parasympathetic
  - depends on emotions, stress level, etc.






# GSR



# GSR

- Measurement:
  - no gel to be used (distorts conductance readings)
  - skin should be dry
  - hands should be relaxed but stable
  - participant should relax a few minutes with electrodes on skin before measurement
- Very low DC voltage (<100mV)
- Typical values 5-100μS
- Sampling at 5 samples/s usually enough
- Most of the energy is below 3Hz



# GSR

- Example: 'Normal' vs. 'Abnormal'

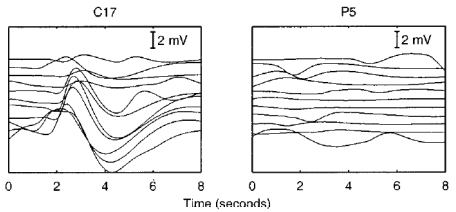
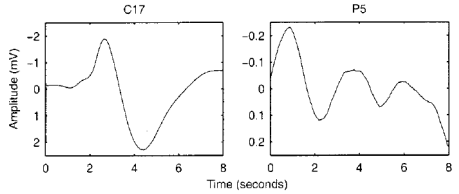



Fig. 2. Measured responses for (a) healthy control (C17) and (b) psychotic patient (P5) as a waterfall plot.






# GSR

- Spontaneous fluctuations are at <0.5Hz
- Antialiasing at 5Hz, Lowpass at ~3Hz, Highpass at 0.5Hz
- Latency:
  - delay after stimulus
  - about 2-3s
- Rise time:
  - from baseline to peak
  - 2-4 seconds
- Half-recovery time:
  - drop to half peak value
  - 3-10s or longer



# GSR

- Common important features:
  - latency
  - rise time
  - rise amplitude
  - half recovery time
  - final baseline convergence level
- Relative measures
  - absolute values are not very meaningful
- Measurements done against neutral state
  - relaxation state
  - neutral question for calibration

# GSR and HMIs

- Advantages:
  - very inexpensive
  - simple instrumentation
  - easy neutral vs. non-neutral classification
    - 'if-then' and fuzzy rule sets may work
- Disadvantages:
  - signals are very sensitive to motion
  - difficult to interpret beyond neutral vs. non-neutral
    - e.g., is participant startled or just alert?
  - equipment moves and falls easily
    - problem for many mobile situations, e.g., driving



# GSR Applications in HMIs

- Lie detector
- Assessing engagement in game scenario
- Monitoring level of stress, e.g.:
  - while performing brain surgery
  - using dangerous machinery
  - car racers
  - pilots
- Assessment a user's interaction with environment:
  - environment changes (temperature, ambient music, etc.) (see suggested reading)

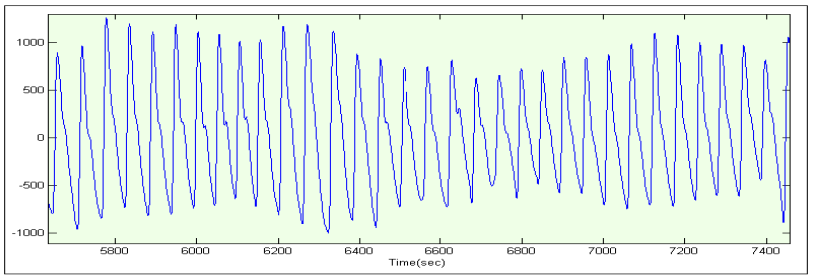


# Blood Volumetric Pressure

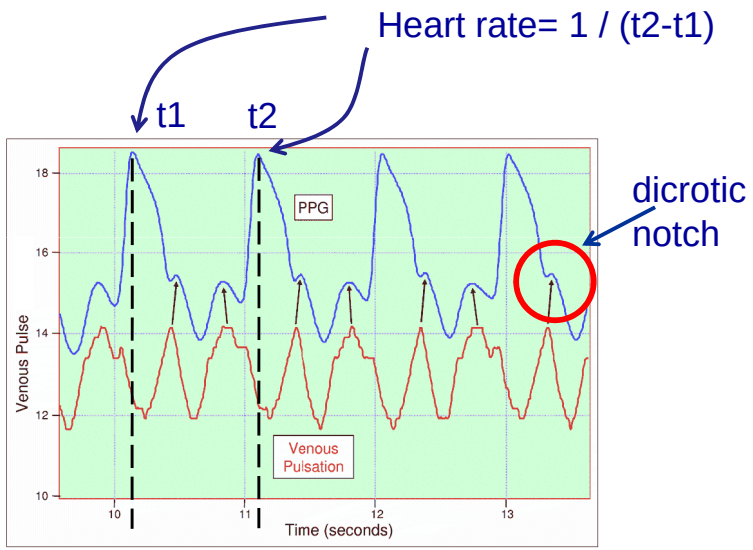
- BVP, or photoplethysmography (PPG):
  - plethysmography: measuring volume
  - light emitted through tissue
  - volume depends on light absorption in tissue
  - red and infrared are often used
  - absorption depends on hemoglobin dynamics
- Common measuring sites:
  - ear lobe
  - finger tips



# BVP



# BVP and Heart Rate






# BVP

- Too tight:
  - blood flow restriction
  - discomfort
- Too loose:
  - will fall off
  - noisy, jumpy readings
- Low-pass at <10Hz
- High-pass at ~0.5Hz
- Detrending:
  - only peak-to-peak values are used



# BVP and HMIs

- Advantages:
  - portable
  - inexpensive
  - non-invasive blood oxygenation estimate
- Disadvantages:
  - Very sensitive to motion
  - Sensor falls very easily in mobile situations
  - Dicrotic notch can confuse algorithm
  - Absolute pressure values are meaningless:
    - other devices needed is mmHg are required
  - Noisy data leads to abrupt HR changes

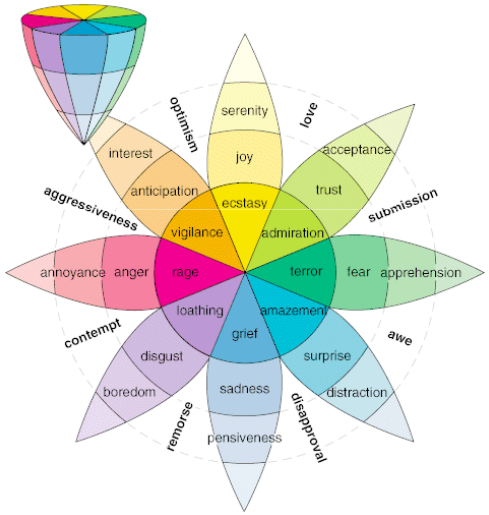


# Affective Computing

- A plausible definition:
  - R. Picard: computer methods that are related to, derived from, or influence emotions (Leon, 2007)
- Two sides:
  - Emotion simulation through devices or agents
  - Automated emotion recognition
- Approaches:
  - observation of behaviour and speech
    - both conscious and unconscious
    - purposeful or spontaneous
  - facial gestures
  - physiological signals

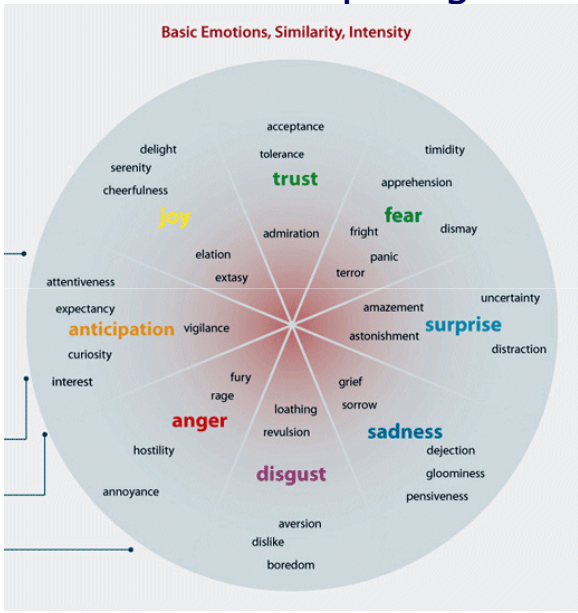
# Affective Computing

- Emotion Dimensions:






# Affective Computing






# Affective Computing

- Involves psychology, large uncertainties
  - on both simulation and recognition side
- Aimed at creating a more comfortable HMI
- Ethical issues:
  - Do we want machines that can 'read' our emotions?
  - Do we want machine to 'act human'?
- Cultural issues:
  - the expression of emotions is done differently in different cultures
  - physiological signals remain the same
- Additional confusing factors:.
  - physical exertion, rain, noise, surprises, etc.



# Affective Computing

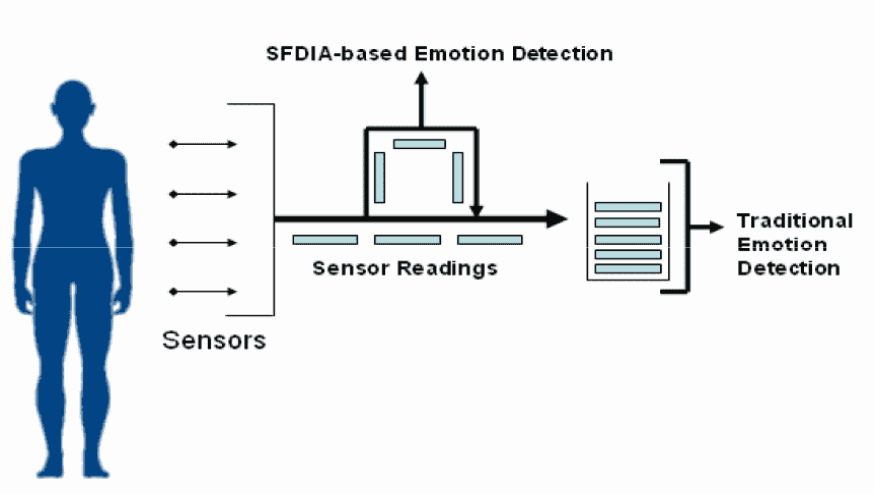
- Examples:
  - Interacting with computer avatars
  - Changing environment settings (light, temperature, colours, music, etc.)
  - Changing a toy robot's behaviour to please a child
  - Assessing the emotions in someone who is unable to express them, for therapeutic purposes
- **Important**:
  - This will be a powerful technology
  - Power carries dangers of mis-use.
  - Can only 'positive' applications be guaranteed?

# Affective Computing

- What if sensors fail?
  - Robustness is necessary
  - SFDIA: Sensor Failure Detection, Isolation, and Accommodation
  - Redundancy is needed
- How to ensure reliability?
  - Intensive calibration and testing
  - Adaptive algorithms are a must
  - 'No action' state better than wrong action
  - Incorporate more psychology and biology



# Affective Computing

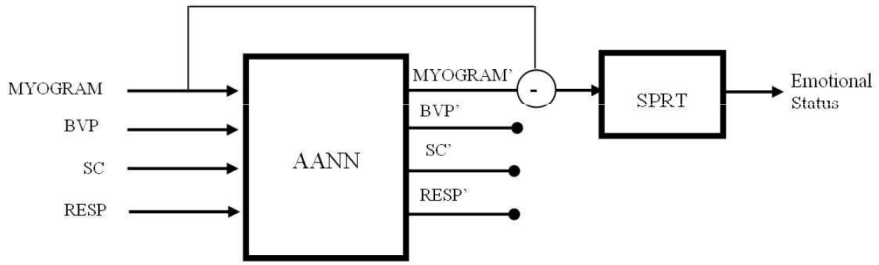



(E. Leon, 2007)



# Affective Computing

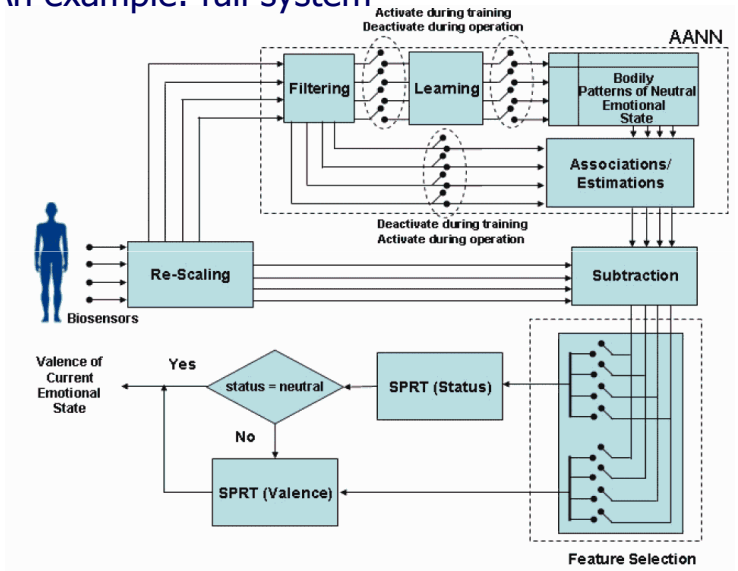
- An example using autoassociative NNs:






# Affective Computing

- An example: full system

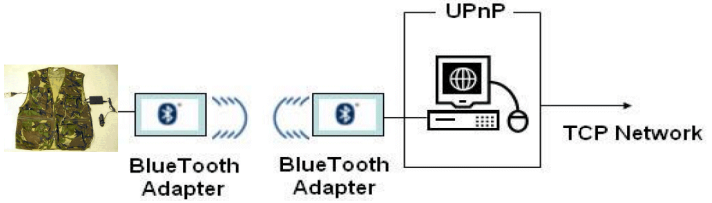


# Affective Computing and HMIs

- Mutual link will grow stronger
- Always aiming at better, more humane, but not necessarily more human, machines
- Issues for the future:
  - intrusiveness
  - reliability
  - beyond portability:
    - **wearability**
    - **pervasiveness**
  - un-natural aspect of technology
  - cost
  - ethics, ethics, ethics, ...



# Affective Computing




The X-Vest



# PII – Lecture 4
# Study Guide

From this week's material, you should:

- Know what **GSR** is, how it is measured, and how it is used in HMI
- Know what **BVP** is, how it is measured, and how it is used in HMI
- Know about the advantages and limitations of using GSR a BVP in HMI
- Know what **affective computing** is, what technology it uses, and what its problems are

- Practice exercise: design a full HMI system using GSR and BVP to determine whether a pilot should take a mandatory rest.