Lecture 2 - Overview of Emotions and Affective Computing

Jesse Hoey
School of Computer Science
University of Waterloo

January 9, 2017

Readings:
- Picard *Affective Computing* Introduction and Chapter 1
- Damasio *Descartes’ Error* Chapters 1 and 3
- Kahneman *Thinking Fast and Slow* Chapters 1-3
Artificial Intelligence
The State of the Art

1970

2015
Are you going? Or should I go?

What if I point a lot and flail my arms around?

Wait, maybe you should go.

You go first.

This is confusing.

Let's just sit here and reflect.
Cognition and Affect (Dualism)

Plato 440BC
- reason: mind, purity, god
- emotions: body, sin, devil

Descartes 1600AD
The Dawn of A.I. (1940s-50s)

Turing 1950

von Neumann 1944

Simon 1967
Artificial Intelligence: Rationalistic

Current State → Agent Action → Post-Action State → Observation/Alter Action → Next State

TIME

REWARD/UTILITY
AI: Rationalistic Approach

1. Current State
2. Agent Action
3. Observation/Alter Action
4. Next State
5. Post-Action State
6. REWARD/UTILITY

Time Arrow
Enlightenment, Phenomenology and Social Behaviourism

Smith 1759
- “Nay, it is chiefly from this regard to the sentiments of mankind, that we pursue riches and avoid poverty.”

Mead 1934
- “Mind arises through communication [...] in a social process [...] not communication through mind.”

Heidegger 1927
Hume 1777

**AN ENQUIRY Concerning the Principles of Morals.**

By David Hume, Esq.

LONDON: Printed for A. Millar, over against Cadburys Head in the Strand, 1751.

Hume: Without sentiment, there can be no moral action
→ social-intuitionist rationality (Haidt 2001)

Kant 1785

**Grundlegung zur Metaphysik der Sitten**

von Immanuel Kant

Kant: Categorical Imperative
→ Super-rationality (Hofstadter 1983)
Phrenology 1980s
Limbic/Cortical Systems

Triune Brain

- Paul MacLean’s *Triune Brain* 1960s
- limbic ≈ hypothalamus, hippocampus, amygdala
- but these “systems” are really very mixed up in the brain
Phineas Gage

Antonio Damasio *Descartes’ Error*, 1994, Chapter 1

- Suffered brain damage (frontal lobe)
- Was perfectly good at reasoning and language
- Made disastrous decisions, or could not make decisions
- Lacked “somatic markers” - “gut feelings” about decisions
Antonio Damasio *Descartes’ Error*, 1994, Chapter 1

- Suffered brain damage (frontal lobe)
- Was perfectly good at reasoning and language
- Made disastrous decisions, or could not make decisions
- Lacked “somatic markers” – “gut feelings” about decisions
Elliott

Antonio Damasio *Descartes’ Error* Chapter 3

- Frontal damage (tumor) - like Phineas Gauge
- Again, could not make decisions in real life
- Especially with respect to personal or social matters
- Felt *emotionless*, but *knew* he used to feel emotions
Elliott

Antonio Damasio *Descartes’ Error* Chapter 3

- Elliott Passed a massive battery of intellectual capacity tests: perception, memory, learning, language, math all intact
- Including ethical and moral decisions: standard “personality tests”:
  - Generation of options for action
  - awareness of consequences
  - Means-ends problem solving for social goals
  - predict social consequences
  - standard issue moral judgment

- This caused problems for analysis as there seemed to be no standard tests to explain Elliott’s problems
Elliott’s condition: *to know but not to feel*

Lack of decision making ability was *not due to:*
- lack of social knowledge
- deficient access to knowledge
- impairment of reasoning
- defect in attention or working memory

Defect in decision making ability happened *late*

Elliott could generate choices, but could not choose one
Emotions as Somatic Markers

- Animals are faced with a vast space of possible decisions
- Resources are bounded
- Time is limited
- Must somehow only evaluate the “good” actions
- Somatic markers indicate which ones these are.
- Like an “oracle”, but a learned oracle (somehow)
Neurophysiologically...

Fig. 2. The amygdala: hub in the wheel of emotion (based on LeDoux, 1996, Chapters 6 and 9).

Neurophysiologically...

Fig. 3. Two separate pathways from sensory stimulus to emotional responses (adapted from LeDoux 1996, p. 164).

Kahneman - 2010

- **System I**: Operates automatically and quickly, without voluntary control
- **System II**: effortful mental activity, complex calculations
- When system I “runs into trouble”, it calls upon System II
## System I
- Orient to the source of a sound
- Complete the phrase “bread and ...”
- Detect hostility in a voice
- Answer $2+2=?$
- Determine if someone you see in a hospital is a doctor or a nurse

## System II
- Focus attention on one person at a party
- Maintain a faster walking speed than is natural
- Count the number of “a”s in a page
- Answer $178+341=?$
- Remember a new phone number
- Construct a logical proof
A bat and a ball cost $1.10
The bat costs one dollar more than the ball
How much does the ball cost?
System I biases

- System I makes “mistakes”
- Biases perceptions and actions that are fast, but sometimes wrong
- can these be overcome? Do we want to overcome them?
- System II too slow and inefficient to be practical everyday
- Tasks that require a lot of “System II” thinking are effortful, tiring, and people will avoid them if they can.
- This has a profound influence on humans’ ability to think “rationally”
- Kahneman and Behavioural Economists have noted that this also has a profound effect on economics.
## Cognitive Aspects of Emotions

<table>
<thead>
<tr>
<th>Damasio:</th>
<th>Kahneman:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary emotions: fast, pre-cognitive responses</td>
<td>System I: default, fast, heuristic reasoning</td>
</tr>
<tr>
<td>Secondary emotions: slower, cognitive responses</td>
<td>System II: rational, slow, thought</td>
</tr>
</tbody>
</table>

- There is not a 1-1 correspondence between these, and the lines are blurry
- Primary/System I is often “wrong” but airs on the side of caution
- Risk-aversion is a unifying element
- Evolutionarily makes sense -
  - risks lead to death,
  - the rewards (for the survival of the species) outweigh the benefits for the individual
<table>
<thead>
<tr>
<th>Who</th>
<th>When</th>
<th>Affective</th>
<th>Cognitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>William James</td>
<td>1890</td>
<td>associative reasoning</td>
<td>true reasoning</td>
</tr>
<tr>
<td>Heidegger</td>
<td>1927</td>
<td>ready-to-hand</td>
<td>present-at-hand</td>
</tr>
<tr>
<td>Dreyfus/Ryle</td>
<td>1950</td>
<td>knowing-how</td>
<td>knowing-that</td>
</tr>
<tr>
<td>Gene Rodenberry</td>
<td>1966</td>
<td>Spock</td>
<td>Captain Kirk</td>
</tr>
<tr>
<td>George Lucas</td>
<td>1977</td>
<td>C3P0</td>
<td>Han Solo</td>
</tr>
<tr>
<td>Joseph LeDoux</td>
<td>1998</td>
<td>Low Road</td>
<td>High Road</td>
</tr>
<tr>
<td>Stanovich/West (Kahneman)</td>
<td>2000</td>
<td>System I</td>
<td>System II</td>
</tr>
<tr>
<td>Jonathan Haidt</td>
<td>2001</td>
<td>intuitive</td>
<td>reasoning</td>
</tr>
<tr>
<td>Paul Thagard</td>
<td>2006</td>
<td>hot thought</td>
<td>cold thought</td>
</tr>
</tbody>
</table>
Behavioural Economists (e.g. Kahneman) are trying to
- explain human behaviour,
- help people make rational choices,
- guide social policy to be more effective (e.g. saving energy),
- or even guide people in exploiting irrational choices?

Artificial Intelligence researchers can use these ideas to
- build computer systems that work *with* people
- endow computer systems with a “system 1”
- build emotionally aligned computers
Breakdown/Negotiation

System I  \(\rightarrow\) \textit{alignment} \(\rightarrow\) \textit{tension}\(\rightarrow\) System II

\(\rightarrow\) \textit{negotiation} \(\rightarrow\) \textit{breakdown}
Why do we need a “low road”?

**The Social Cortex**

As brain size increases, so does group size. Human group size as predicted by Dunbar's model comes out to about 150.

- **Humans**
- **Monkeys**
- **Apes**

![Graph showing the relationship between the size of the neocortex relative to the rest of the brain and average social group size. The graph illustrates that as the size of the neocortex increases, so does the average social group size, with humans having the largest group size among primates.]
Why do we need a “low road”?

The Social Cortex

As brain size increases, so does group size. Human group size as predicted by Dunbar’s model comes out to about 150.

Monkeys = ●

Apes = ○

Size of neocortex relative to rest of brain

Average social group size

DATA: THE SOCIAL BRAIN HYPOTHESIS, DUNBAR 1996
○ Creativity

○ Creation of new meaning
○ Happens at the boundary between System I and System II
○ Happens when challenges just barely exceed skills
○ System I is “on”, but forced to resort to System II occasionally
○ Mihaly Czitzenmihaily “Flow”
Emotions: the new AI

- Artificial Intelligence: intelligence = rationality
- We now know that emotions are necessary for intelligence
- A low road gives “heuristic” social intelligence
- Encode a social order that allows us to work in a society

With infinite resources, are emotions necessary?
Experiments showed that people treat media (e.g. computers) like people.

- e.g. “dominant” vs “submissive” computers
- e.g. “specialist” vs “generalist” computers

More important: it was hard for people not to do this!
The Singularity (von Neumann/Ulam)
Herbert A. Simon *Motivational and emotional controls of cognition* 

Emotions as “interrupts” to cognitive processing

Increased complexity of interaction $\rightarrow$ increased “emotionality”

Increased “emotionality” $\rightarrow$ increased cognitive explanations and coping strategies

Increased cognitive burden $\rightarrow$ increased interrupts

Increased interrupts $\rightarrow$ increased complexity of interaction ...
Emotions and Intelligent Computers

1997: Rosalind Picard in *Affective Computing*

*This book proposes that we give computers the ability to recognize, express and in some case “have” emotions. Is this not absurd?*

Now:

- IEEE Transactions on Affective Computing
- International Conference on Affective Computing and Intelligent Interaction (ACII)
  → acii2017.org ... **deadline: May 2nd, 2017**
- Increasing awareness that emotions play a significant role in human intelligence
- but, still don’t have “emotional machines” - why not?
Does not:

- try to build a psychological *model* of human emotions
- try to perform surgical interventions on humans

Does:

- build systems that can reason about human emotions
- claim that emotions will allow us to build better AI
- use psycho-social models of emotion
We will not worry too much about these distinctions

- Physical/Cognitive
- Brain/Body

But these are more significant as the terms are “loaded” (significant to some communities, or have different meanings to different groups):

- Emotion/Emotional - has a specific meaning in affect control theory, much less clear in most other accounts
- Sentiment/Sentic - is the term used for “emotion” in affect control theory
- Affect/Affective - more generally anything to do with reasoning/intelligence
- Mood/Moody - longer-lasting emotional/affective/sentic state
Four Basic Problems in Affective Computing

- Recognize affective states
- Model affect, emotion, sentiment
- Generate and display/communicate affective states
- Build applications using affect
Recognition and Generation of Emotions

Emotion Signals “Sentic modulation” Picard, Table 1.1 **Physical Aspects**

<table>
<thead>
<tr>
<th>Apparent to others:</th>
<th>Less apparent to others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial expression</td>
<td>Respiration</td>
</tr>
<tr>
<td>Voice intonation</td>
<td>Heart rate, pulse</td>
</tr>
<tr>
<td>Gestures, Movement</td>
<td>Temperature</td>
</tr>
<tr>
<td>Posture, Proxemics</td>
<td>Electrodermal response, perspiration</td>
</tr>
<tr>
<td>Pupillary dilation</td>
<td>Muscle action potential</td>
</tr>
<tr>
<td></td>
<td>Blood pressures</td>
</tr>
<tr>
<td>A vast array of expressions - person,culture, context specific</td>
<td></td>
</tr>
<tr>
<td>e.g. context: heart rate increases while running <strong>or</strong> when angry</td>
<td></td>
</tr>
<tr>
<td>These differences <strong>are important!</strong>, and make recognition much harder (many more things to recognise)</td>
<td></td>
</tr>
<tr>
<td>psychology : focussed on finding <strong>universal</strong> emotional signals in the lab</td>
<td></td>
</tr>
</tbody>
</table>
Models of Affect

Theories of Affect
- Appraisal
- Dimensional
- Rational
- Neurophysiological
- Social-Psychological
  - Theory of Social commitments
  - Affect Control Theory
The Theory of Social Commitments

Instrumental/Transaction

Affective/Relational

non-separability of contributions

perceptions of shared responsibility

attribution of emotions to group

strengthening of ties (if +ve emotions)

longer-lasting group cohesion

Affect Control Theory


Osgood’s Semantic Differential

Affective “EPA” Space

E: Evaluation; P: Potency; A: Activity
Affective “EPA” Space

E: Evaluation; P: Potency; A: Activity
E: Evaluation; P: Potency; A: Activity
Affective “EPA” Space

Evaluation; P: Potency; A: Activity
Affect Control Theory

- Actor-Behaviour-Object
- fundamental sentiments: $\mathbf{F} \in [-4.3, 4.3]^9$
- transient impressions: $\mathbf{T} \in [-4.3, 4.3]^9$
- deflection $D = \sum_i w_i (f_i - \tau_i)^2$
- prediction $T_{t+1} = \mathcal{M}_G(F_t, T_t)$ measured empirically

Affect Control Principle: actors work to experience transient impressions that are consistent with their fundamental sentiments

- Emotion $\epsilon \propto f - \tau$

Bayesian Affect Control Theory

- identities and behaviours as probability distributions
- external goals and planning
Somatic Transform

Connotative-Affective Meaning
Dimensional Parsimony: EPA (Evaluation, Potency, Activity)
Motivation: Energizes Behavior
“Low Road”

PORTAL

Denotative-Cognitive Meaning
Dimensional Complexity:
Hyper-dimensional
Motivation: Directs Behavior
“High Road”

EVOKE

SOMATIC TRANSFORM
Artificial Intelligence: Affect Control Theoretic

CONNOTATIVE AFFECTIVE

Current State

Post-Action State

Next State

Agent Action

Observation/Alter Action

Agent Action

DENOTATIVE COGNITIVE

REWARD/UTILITY

TIME
Cognitive Assistive Technologies
Deflection:
Deflection: 0.6
Deflection: 0.6
Deflection: 7.9

irate
hurry up, I don't have all day!
nervous

boss around

strong

weak
ACT Examples

Deflection: 7.0
Deflection: 9.5
Applications of Affective Computing

- Tutoring/Education
- Caregiving/Healthcare
- Economics/Advising
- SmartHomes
- Emotional Manipulation “inducement”
  - Advertising
  - Movies
  - Music
- ...

...
The future of A.I.?