Emotional Machines
an overview

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Emotional Machines
OUTLINE

- Why it is important?
- What is an emotion?
- How can it be recognized?
- How can it be synthesized?
- What are the main usecases?
- How does the market look?

Emotional Machines
TRENDS

- **Ubiquitous computing** accessible via
- Smart mobile devices: phones, glasses, watches, t-shirts, implants, etc.
- Home automation: central intelligence controlling media, communication, environment
- Aging society gets supported by technological interfaces

- **Uses natural interface**: voice, gestures, wearables, …
- Gets much nearer to user, unobtrusive
- Will be **emotional because it‘s easier**: emotion expression is a channel of communication

What is an emotion?

Emotional machines
EMOTIONS AND INTELLIGENCE

- “For decades, biologists spurned **emotion and feeling** as uninteresting. But Antonio Damasio demonstrated that they are **central to the life-regulating processes** of almost all living creatures.”
- Brain injuries specific to emotional processing robbed people of their **capacity to make decisions**, see the bigger picture, exercise common sense
- In opposition to Descartes, body and mind are not separated

Emotional machines
CATEGORIES

- …everyone except a psychologist knows what an emotion is (Young 1973)
- Charles Darwin: The Expression of the Emotions in Man and Animals
- The big four:
  - **Anger**
  - **Sadness**
  - **Joy**
  - **Fear**
- Needed to survive and „culturally universal“
- Many more catgorical models exist, e.g. Ekman‘s six ot Plutchik‘s emotion weel

Emotions as characters in Pixar‘s „Inside Out“ (anger, fear, joy, envy, sadness)

Emotional machines
PANKSEPP‘S SEVEN PRIMAL EMOTIONS

- Jaak Panksepp was a neuro-scientist who suggested seven emotion categories in men an animals that can be localized in the brain.
- Search (anticipation, desire)
- Rage ((frustration, body surface irritation, restraint, indignation)
- Fear (pain, threat, foreboding)
- Panic/Loss ((separation distress, social loss, grief, loneliness)
- Play ((rough-and tumble carefree play, joy)
- Lust (copulation, mating)
- Care ((maternal nurturance)

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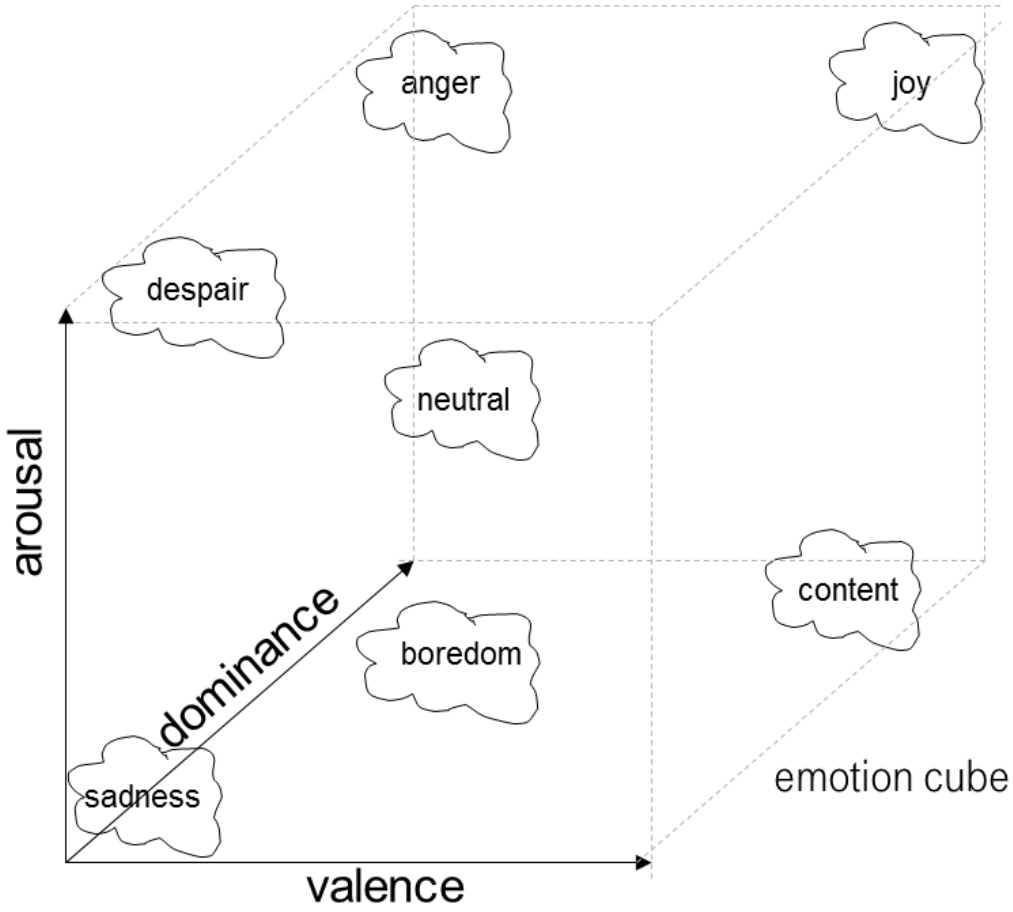
DIMENSIONAL MODELS

- Dimensions consider an emotion as a point in an n-dimensional emotion space.
- One of the most well-known spaces is the PAD-space:
  - **Pleasure (valence)**
  - **Arousal (activation)**
  - **Dominance**
- Specific dimensions are better recognized by different modalities, e.g. activation in the speech but valence in the mimics



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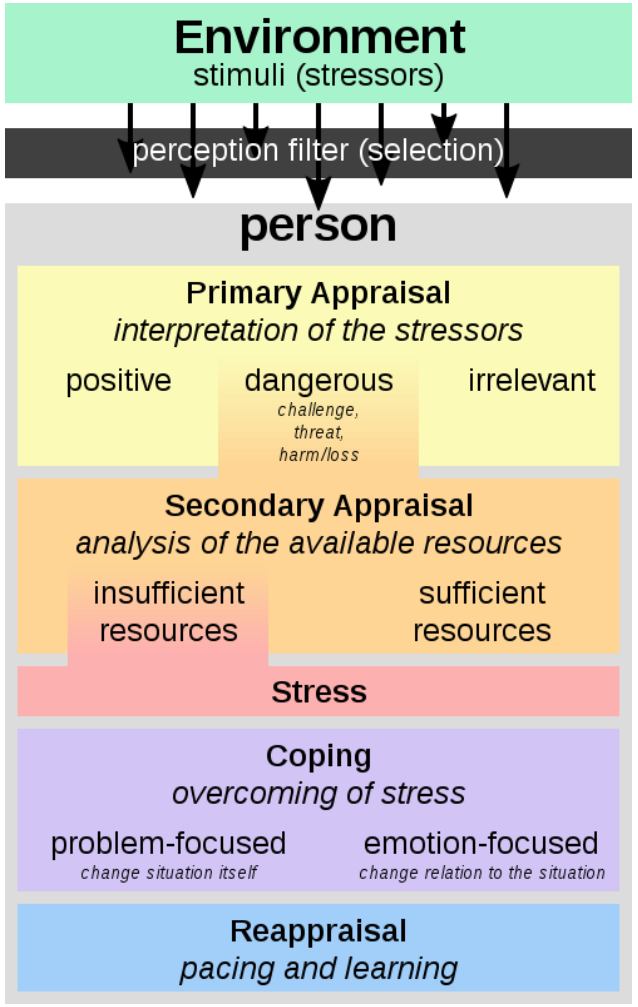
APPRAISAL THEORY

- Appraisal theory means that emotions are extracted from our evaluations (appraisals or estimates) of events that cause specific reactions in different people.
- E.g. Scherer's multi-level sequential check model
- Three levels of processing are: innate (sensory-motor), learned (schema-based), and deliberate (conceptual)

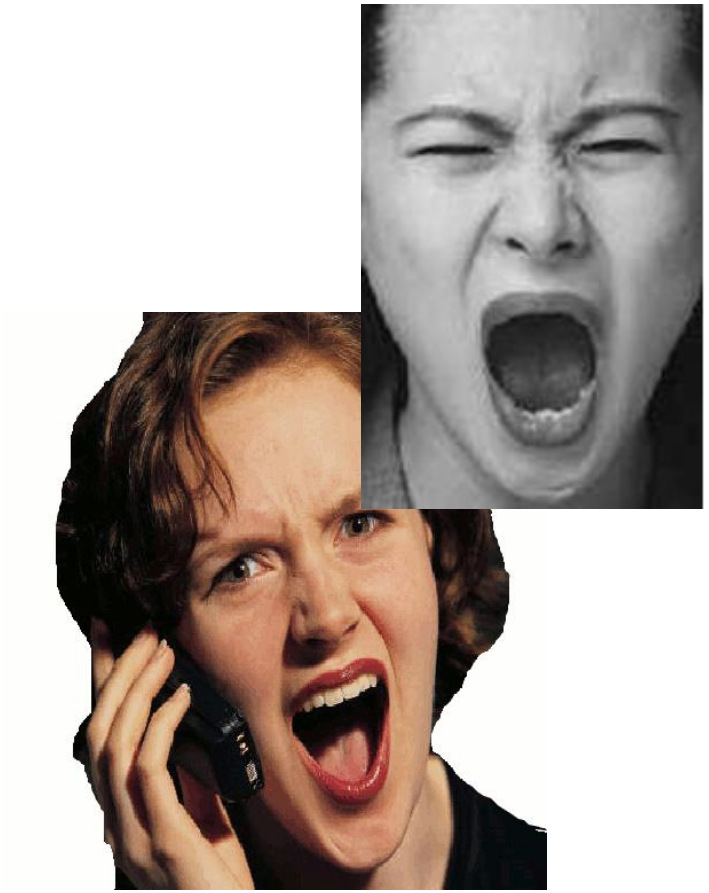


https://en.wikipedia.org/wiki/Appraisal_theory

http://emotionresearcher.com/the-component-process-model-of-emotion-and-the-power-of-coincidences/

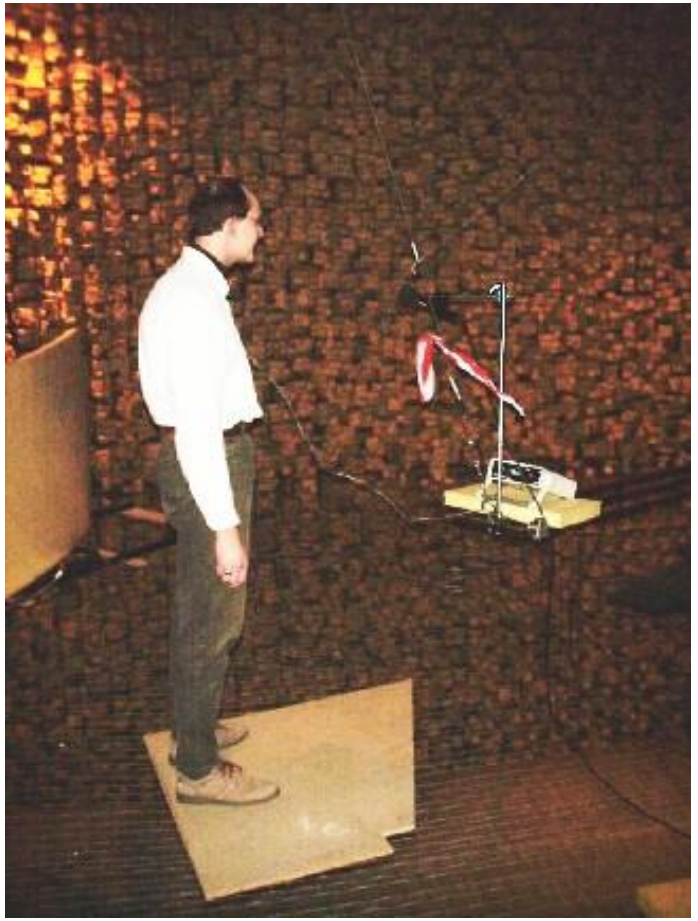
Emotional machines
MODALITIES

- User introspection: e.g. Emoticon, press button etc
- Text: sentiment analysis
- Audio: speech, extralinguistics
- Video: facial expression, gestures, posture
- Physiology: respiration rate, blood pressure, skin conductivity, neuronal activity, speech (held vowels)
- Behaviour, e.g. switched room often, typing speed
- Context: localization, weather, time of day, other people‘s moods etc.



Emotional Machines
WHERE DOES THE DATA COMES FROM?

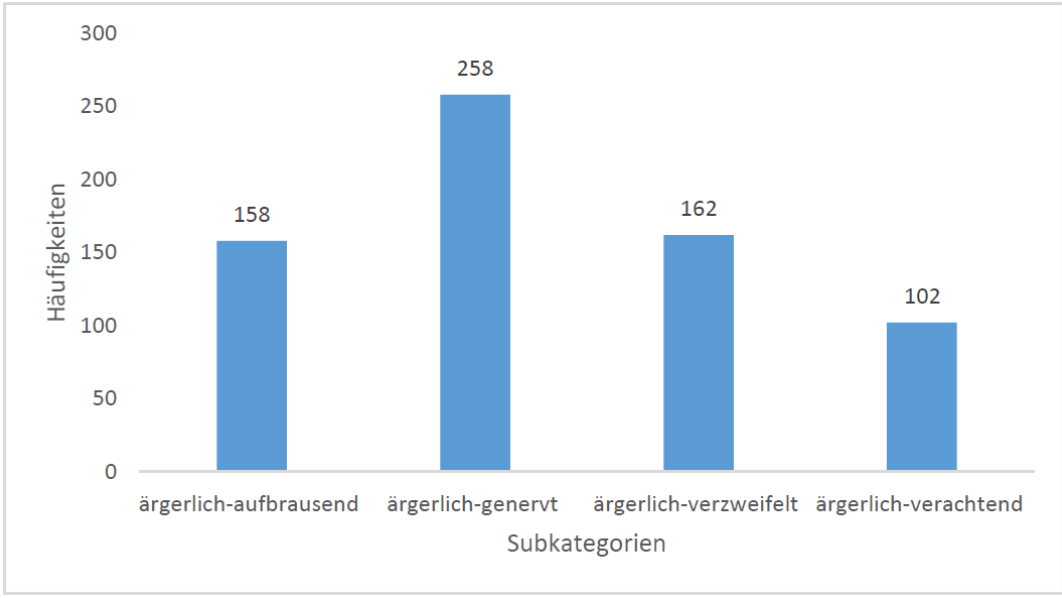
- Ideally from the application
- From an application similar to the target
- From Wizard of Oz scenario
- From field recordings („Vera am Mittag“)
- From induced emotions („Lost luggage“, „Aibo“)
- From actors



Felix Burkhardt, Astrid Paeschke, Miriam Rolfes, Walther F. Sendlmeier and Benjamin Weiss: A Database of German Emotional Speech, *Proc. Interspeech* 2005

Emotional Machines
WHICH EMOTION EXACTLY IS MEANT?

- 20 listeners judged the distribution of four anger sub-categories in a German customer voice portal data.
- The choice of subcategories was based on a listener experiment undertaken by Banse and Scherer (hot, cold anger, despair, contempt).
- All subcategories were attributed with a Kappa value of about 0.3 and they have distinct acoustic features.



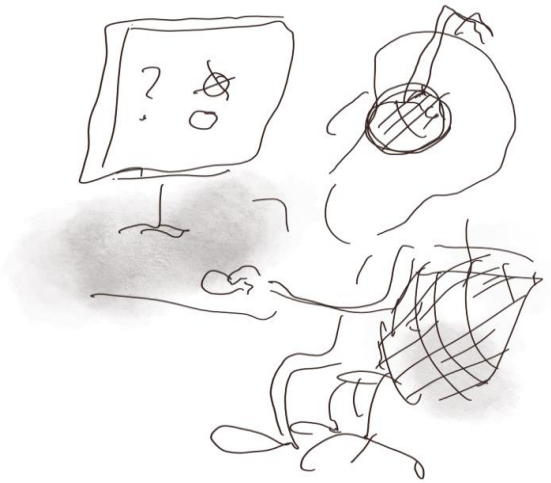
Maximilan Schmitt Masterthesis TU-Berlin 2018

Banse, Rainer; Scherer, Klaus (1996): Acoustic Profiles in Vocal Emotion Expression

Emotional machines
WHERE IS THE GROUND TRUTH?

- Five human labelers annotated the emotional content of textual data using four categories.
- A machine algorithm did the same classification.
- “majority” means the majority voting of the human labelers.
- The chart shows the Cohen’s kappa values for the so-called “inter rater agreement”, i.e. how much each rater agrees with all other raters.
- It is a statistical measure relating the agreement to the agreement with chance level, given the categories and their frequencies.

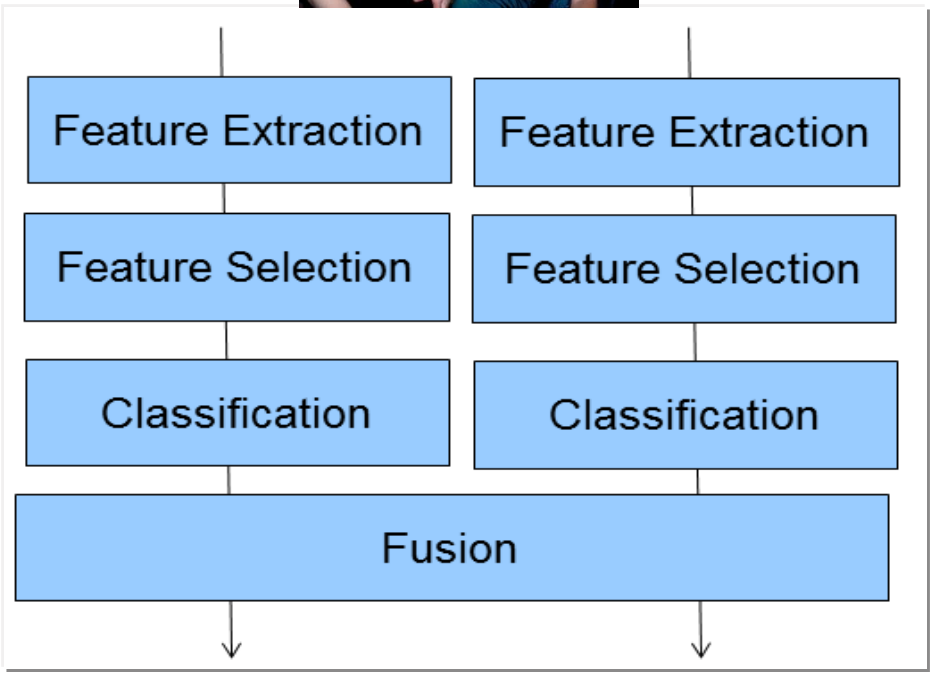
	labeler A	labeler B	labeler C	labeler D	labeler E	majority	machine
labeler A	1,00	0,20	0,19	0,10	0,24	0,27	0,15
labeler B		1,00	0,79	0,46	0,15	0,81	0,15
labeler C			1,00	0,47	0,19	0,83	0,14
labeler D				1,00	0,09	0,52	0,07
labeler E					1,00	0,29	0,10
majority						1,00	0,17
machine							1,00



How can it be recognized?

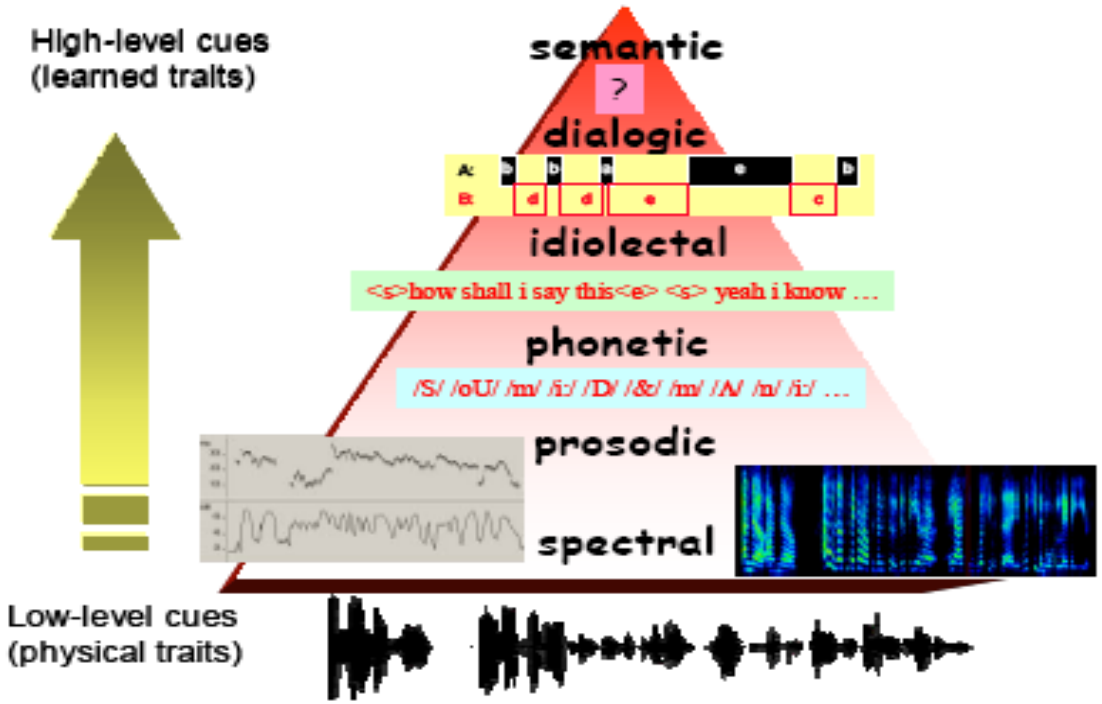
Emotional Machines
RECOGNITION BY STATISTICAL CLASSIFICATION

- Basic approach:
  - extract features,
  - select best ones,
  - classify features,
  - fuse classifier outputs
- Classifiers: **Gaussian Mixture Models**: model training data as Gaussian densities, **Artificial Neural Networks** (ANN), e.g. Multi Layer Perceptron, **Support Vector Machines** (SVM): use „kernel functions“ to separate non-linear decision boundaries, **Classification and Regression Trees** (CART), **Hidden Markov Models** (HMMs) used to model temporal structure
- Deep Neural Networks can operate directly on signal: end-to-end approach



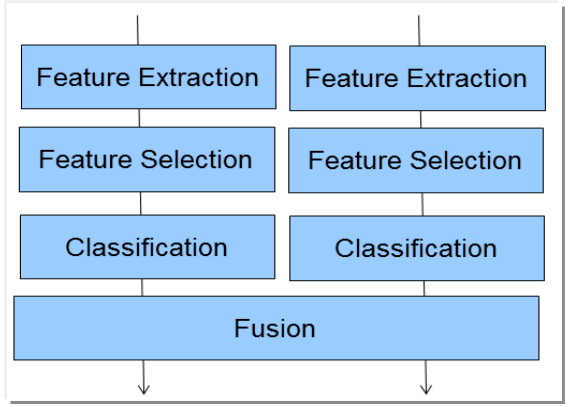
Emotional Machines
EXAMPLE: SPEECH FEATURES FOR CLASSIFICATION

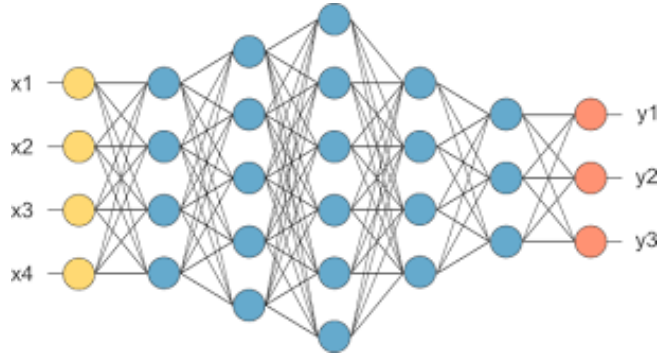
- Telephone speech: digital signal
- Base features, e.g. MFCCs
- Prosody
- Microprosody, e.g. jitter/shimmer
- Pitch durations and energy
- Functionals: Mean, max/min, deviation, regression, …,
- Text (as recognized by Automatic Speech Recognition)



Emotional Machines
EXAMPLE: IVR ANGER DATABASE

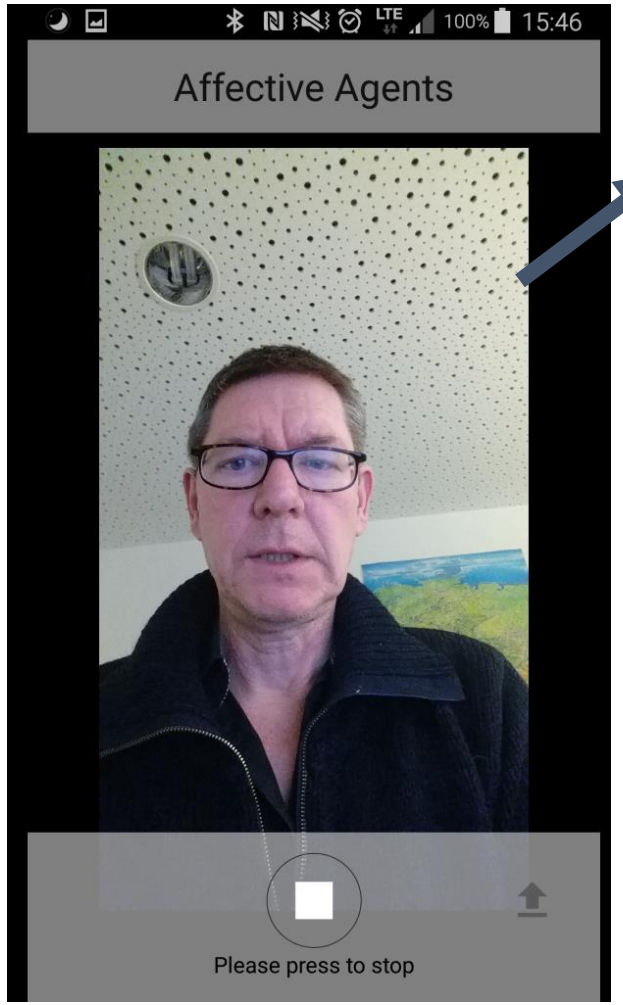
- A) Basic approach:
  - extract features, select best ones, classify features, fuse classifier outputs
  - Apply different classifiers like Gaussian Mixture Models (GMMs), Support Vector Machines (SVM)
- B) Deep Neural Networks
  - might operate directly on base features: end-to-end approach
- Results:
- Compared to 2009, the results improved 10% in average recall: 80.1 % with a bidirectional LSTM network (ComParE feature set) vs. 69.0 % with SVMs on a reduced feature set.

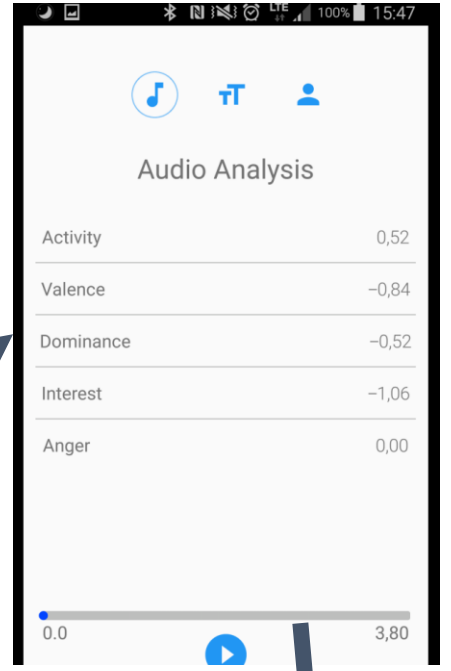


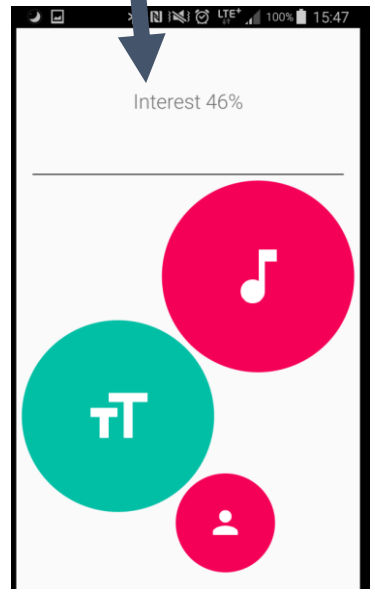


Emotional machines
DEMONSTRATOR

- Press the „record“ button at the bottom
- Look into the camera and say something of about three seconds length
- Try to smile while you speak
- Then press the stop bottom at the bottom



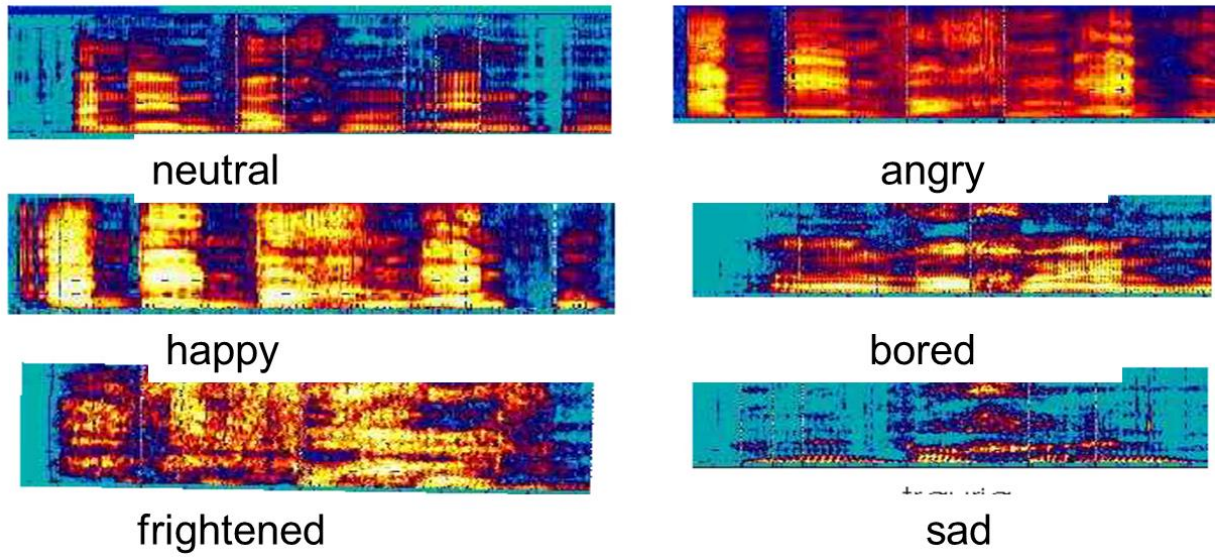




How can it be synthesized?

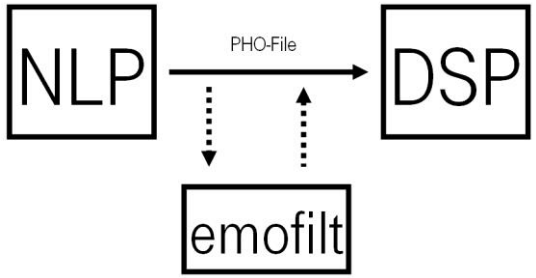
Emotional machines
EXAMPLE: SIMULATION OF AFFECTIVE BEHAVIOUR BY SPEECH SYNTHESIS

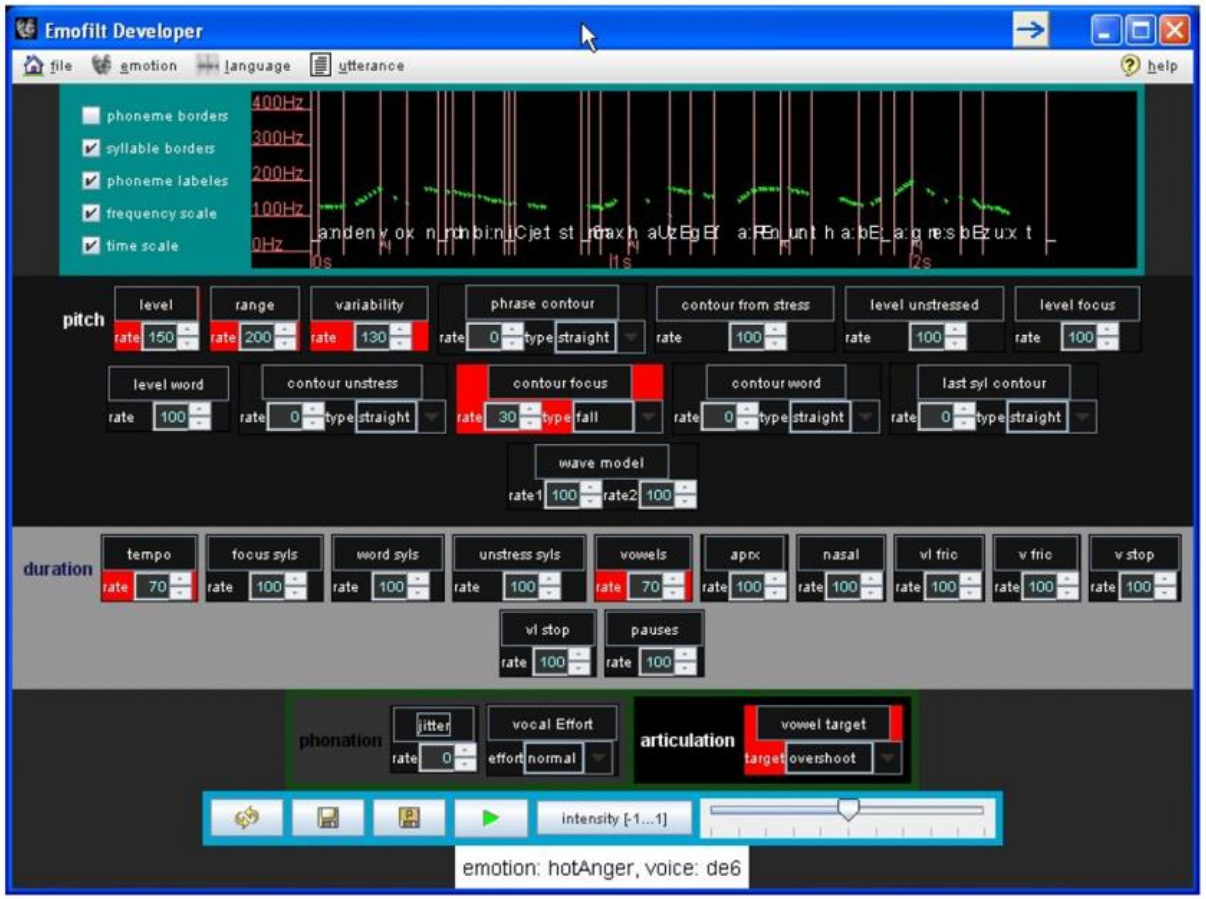
- DNN Synthesis: TTS with neural nets has been done since many decades. They replace the HMM approach to predict the best acoustic parameters for a given sequence of symbols representing text.
- HMM Synthesis: Synthesis based on Hidden Markov Models, a statistical approach to model the transition probabilities of the acoustic parameters based on the speech to be generated.
- Non-uniform unit-selection: Best chunks of speech get concatenated, minimizng a double cost-function: best fit to next unit and best fit to target prosody.
- Diphone-synthesis: Speech concatenated from diphone-units (two-phone combinations), prosody-fitting done by signal-manipulation
- Formant-synthesis: Speech synthesized by physical models (formants are resonance frequencies in vocal-tract).
- Articulatory synthesis models the human voice tract by mathematical models. Modeling dynamics is difficult.



Emotional machines
EXAMPLE EMOFILT

- Emofilt is a tool to transform the prosody of a given utterance in order to simulate emotional expression
- It is based on Mbrola for speech generation and an arbitrary phonemization generator like MARY or Txt2Pho
- Mbrola is a diphone synthesizer from the University of Mons with databases for 34 languages





What are the main usecases?

Emotional machines
FIVE TYPES OF APPLICATIONS

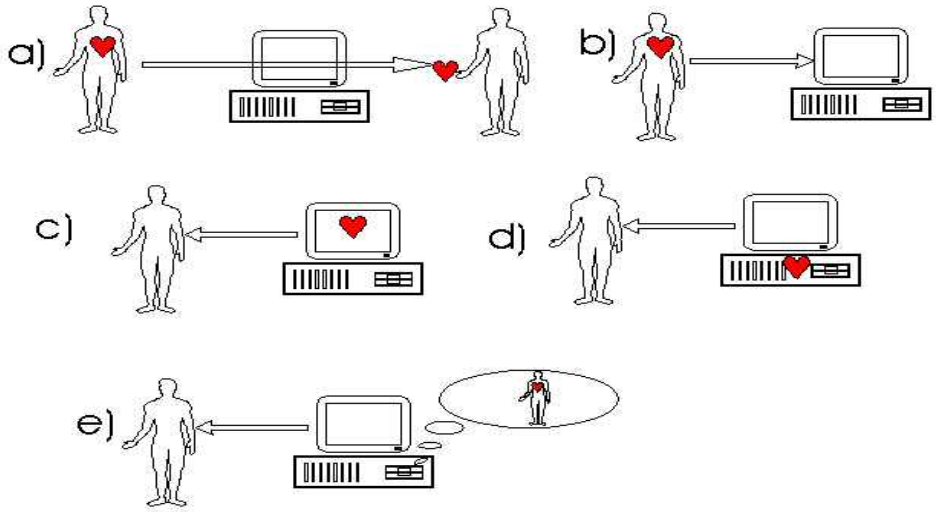
a)**Mediated emotion**

b)Affect **recognition**

c)Affect **simulation**

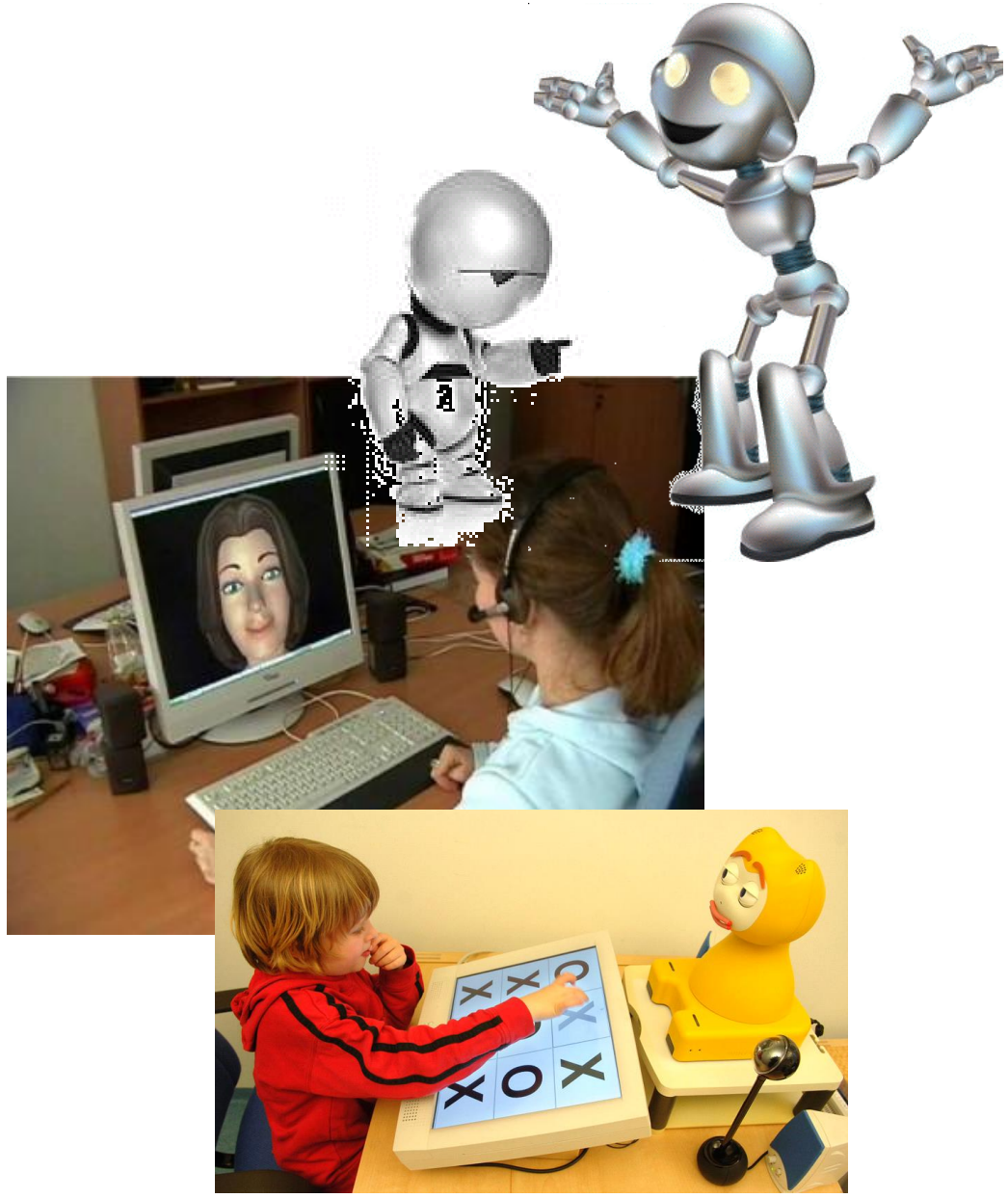
d)Modeling emotional **intelligence**

e)Modeling human emotional **behavior**



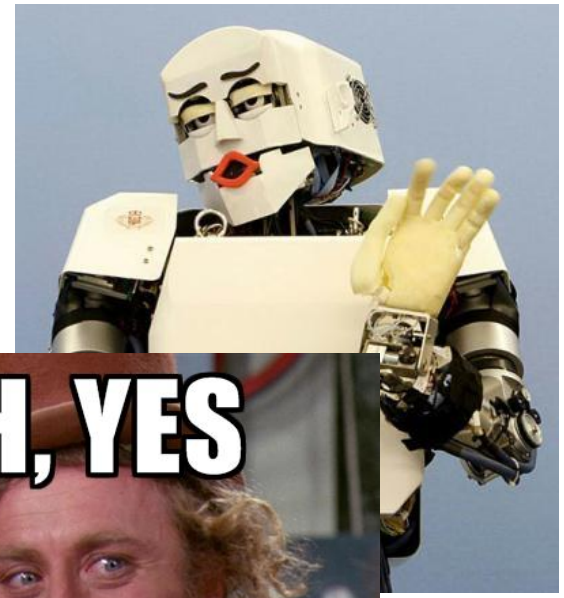
Emotional machines
SOME APPLICATIONS IN GENERAL

- Market research: analyze users response on new products
- Emotional Diary
- Comedy club charges per laugh, price advertising depending on how people respond to it
- Detect stress/interest in tutoring application
- Make artificial beings believable



Emotional machines
APPLICATIONS IN THE TELEKOM DOMAIN

- Irony / Sarcasm detection: To analyze user opinion this is still a big probl
- Call center support: distribute aggressive callers, support training.
- Automated dialog support: Anger detection can be used for churn prevention or for automatic quality monitoring.
- Emotional Chat: Facilitate emotional computer mediated communication.
- Emotion-aware Surrounding: Computer controlled environment that adapts automatically on the user's mood.
- Search–by-emotion, e.g. Entertain product.
- Believable Agent: The naturalness of an artificial 'being' and the appearance of intelligence is highly altered by emotional expressions.
- Artificial intelligence models, use emotions for motivation modeling



How does the market look?

Emotional machines
W3C STANDARD FOR EMOTION ANNOTATION

- As the Web is becoming ubiquitous, interactive, and multimodal, technology needs to deal increasingly with human factors, including emotions.
- The specification of Emotion Markup Language 1.0 aims to strike a balance between practical applicability and scientific well-foundedness.
- The language is conceived as a "plug-in" language suitable for use in three different areas:
- manual annotation of data
- automatic recognition of emotion-related states from user behavior
- generation of emotion-related system behavior

Emotion Markup Language (EmotionML) 1.0

W3C Recommendation 22 May 2014

Authors:

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(in alphabetic order)
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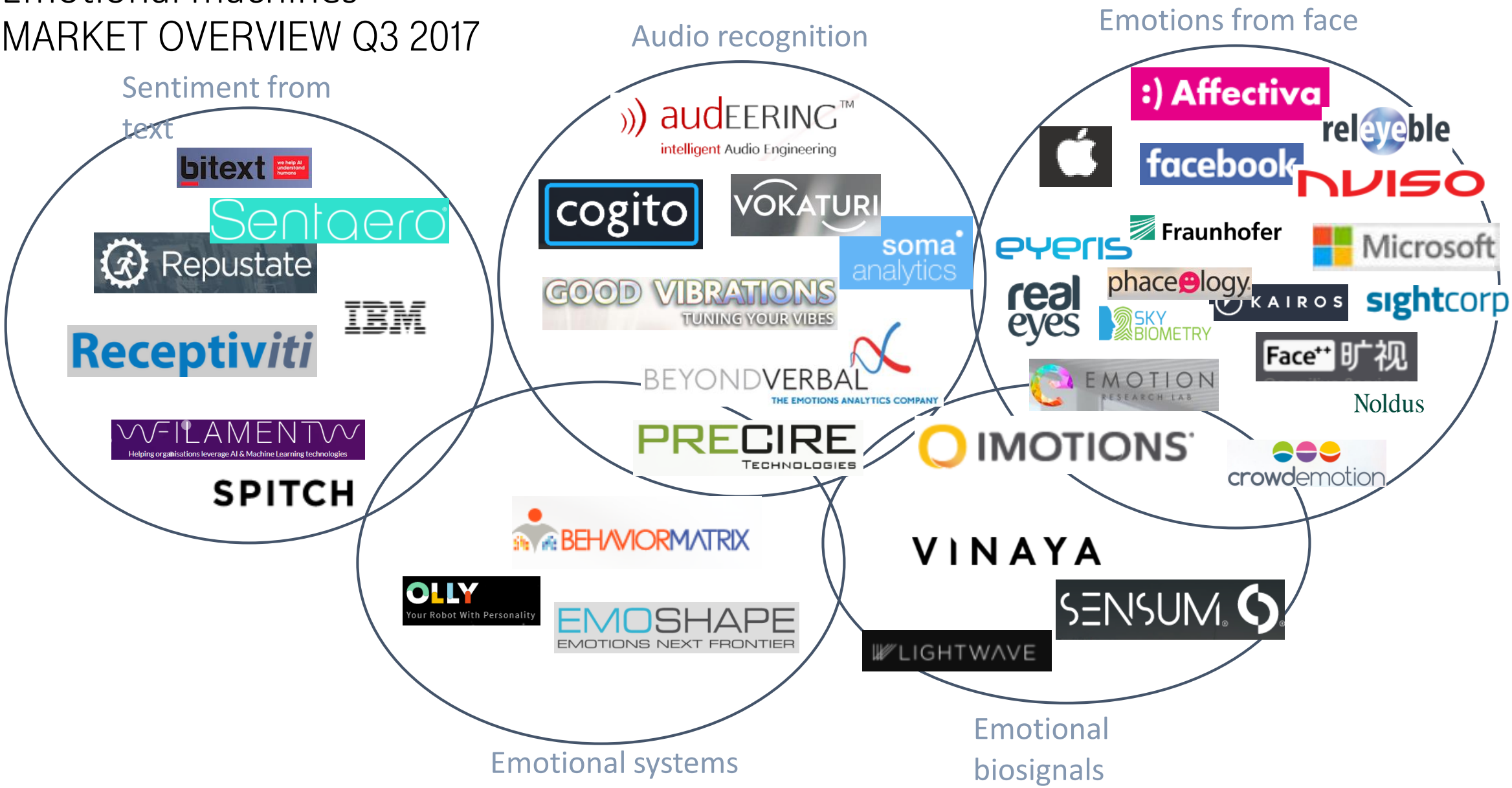
Catherine Pelachaud (Telecom ParisTech)
Christian Peter (Fraunhofer Gesellschaft)
Enrico Zovato (while at Loquendo, currently Nuance Communications)


```
<emotion action-tendency-set="http://www.example.com/custom/action/robot.xml#voc">
    <action-tendency name="charge-battery" value="0.9"/> <!-- need to charge battery soon -->
    <action-tendency name="pickup-boxes" value="0.3"/>   <!-- feeling tired, avoid work -->
</emotion>
```

https://www.w3.org/TR/emotionml/

Emotional machines
MARKET OVERVIEW Q3 2017



Emotional machines
WRAP UP

- Emotional processing comes with **pervasive computing**
- It can be used with intuitive interfaces, **more natural mediated communication and sophisticated AI models**
- Emotional categories contrast with more complex models
- The nature of **emotion is dictated by application**
- The market is growing, all the **big players are already there**
- **Facial detection comes first** because emotional expression is most easily detected in the mimics