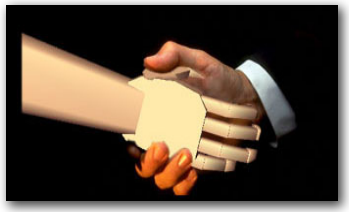
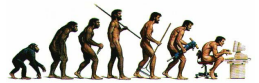
Human-Computer Interaction

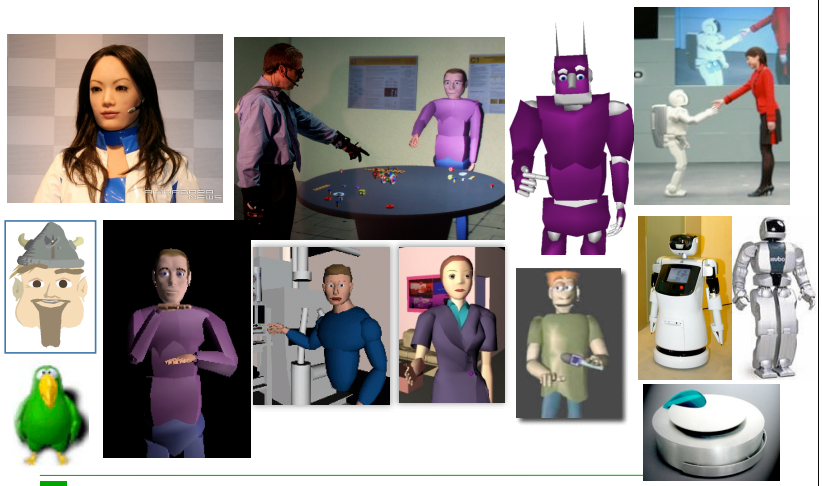
Session 12
Agent-based interaction



The evolution of user interfaces



Year	Paradigm	Implementation
1950s	None	Switches, punched cards
1970s	Typewriter	Command-line interface
1980s	Desktop	Graphical UI (GUI), direct manipulation
1980s+	Spoken Natural Language	Speech recognition/synthesis, Natural language processing, dialogue systems
1990s+	Natural interaction	Perceptual, multimodal, interactive, conversational, tangible, adaptive
2000s+	Social interaction	Agent-based, anthropomorphic,social, emotional, affective, collaborative



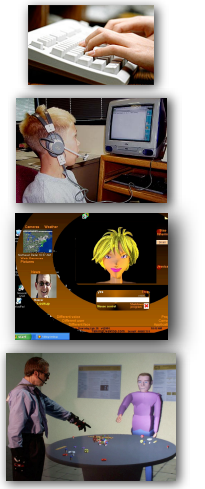
Evolution of interaction styles

tools ➜ operate

smart tools ➜ instruct

interactive interlocutors ➜ converse

companions ➜ collaborate



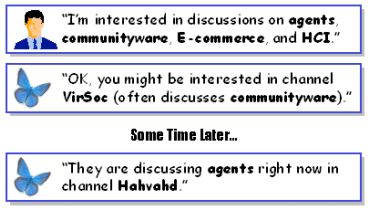
Agent-based interaction - ideas

- Build interactive software that...
  - can communicate with other agents
  - is autonomous, reactive, and proactive
  - is context-aware and situated
  - has specialized expert knowledge
  - is personalized and user-adaptive
- In practice, the term „agent" applies broadly
  - Search (e.g., *Letiza* broadens depth first browsing)
  - Desktop support (e.g. *Microsoft's Office Assistant* provides Bayesian-based task-sensitive help)
  - Collaborative filters (e.g. email), shopping recommenders, auction bots

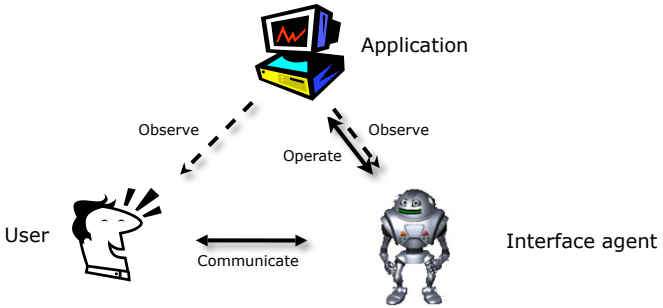
Terminology

Agent

- computer system that observes and initiates actions in its environment, and is able to communicate with other individuals
- has a specific expertise and carries out specific tasks



Agents as direct interfaces

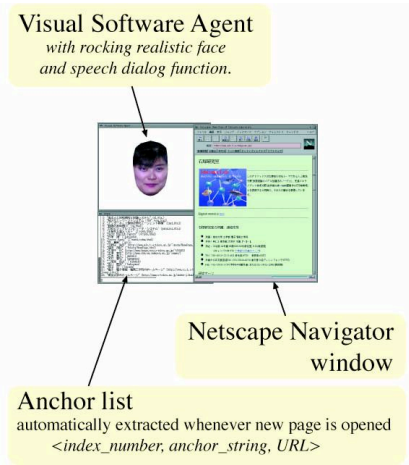


Agent mediates between the user and an application

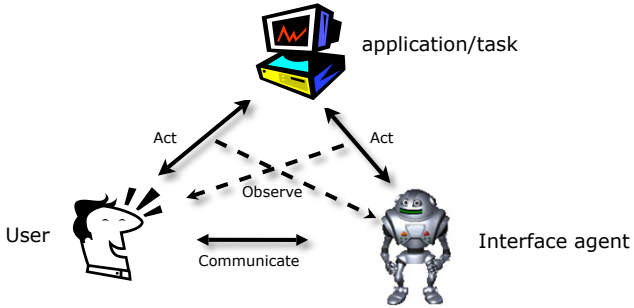
- accepts the operating of the system
- communicates with and supports the user

Web browser interface agent

(U.Tokyo)



Collaborative interface agents



User and agent collaborate on a shared task

- User and agent con both take actions
- User and agent observe each other's actions
- User and agent communicate abouth their task and collaboration

Collaborative interface agents

„A buddy is better than a slave“

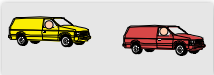
Agent1	We need to repair a connectivity problem between Mars and Saturn. Do a remote ping from Mars to Saturn.
Agent2	I can't. Saturn seems to be down. I'll take care of that first.
	<Agent2 taking action>
Agent2	Okay, Saturn's back up and the remote ping was successful.
Agent1	Good. Verify Mars' IP address for Saturn for me.
Agent2	The entry for Saturn was wrong, but I corrected it.
Agent1	Okay, good. We're done then.

Interaction

- working on someone or something, possibly according to common rules, in order to achieve a personal goal

Collaboration

- working with others in order to achieve shared goals
  ➜ focus on working jointly



Cooperation

- working together with „somebuddy" to the same end
  ➜ focus on working *and* togetherness

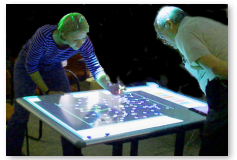
So, not only division of labor

One approach to involve users actively in problem-solving

- leverage their skills
- steer solving process based on preferences or experiences
- increase user's trust, understanding, justifiability of solution

HuGS - Human-guided Search (Klau et al. 2002)

- user can monitor, modify, or track back solutions
- user can apply, halt, or modify algorithms
- user can constrain and focus search
- improved performance, up to the best heuristic algorithms around



Collaboration

„Must design collaboration into systems from the start."

B. Grosz (1994)

Features of a multi-agent collaboration

- No master-slave relationship, but equality of partnership
- Agents have different beliefs, knowledge, and capabilities
- Agents share a goal and are committed to this goal
- Agents collaborate during *both* planning what to do and doing it
- Agents communicate to coordinate their collaboration

Collaboration - some theory

Agent's intentions are crucial (Bratman 1987)

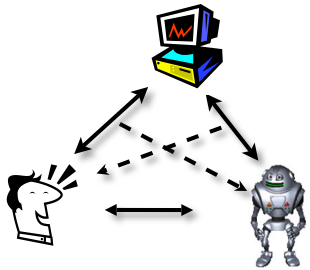
- commitment to action in order to achieve a goal
- constrain choices what else to intend
- provide context for re-planning upon failure
- guide means-ends-reasoning for plan refinement

M. Bratman

Plans are mental states (Pollack 1990; Bratman 1990)

- not just knowing *how* to do an action (recipe)
- also having the intentions to do the actions entailed

Collaborative interface agents



Bratman: **Shared collaborative activity** requires

1. mutual responsiveness
2. commitment to a joint activity
3. commitment to mutual support
4. meshing of subplans

SharedPlans formalism

(Grosz & Sidner 1990; Grosz & Kraus 1996, 1999)

Formalizes how agents move from individual goals and intentions into collaborative, coordinated activity based on representations of the minds of the other agents:

- what is mutually believed and intended
- what commitments have been taken by whom

Predominant model in multi-agent collaboration in A.I. and collaborative interfaces in HCI.

SharedPlans formalism

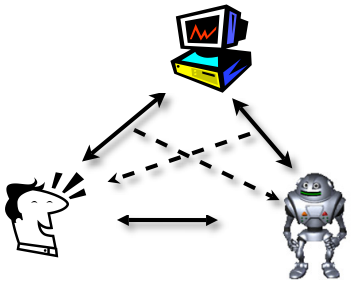
Collaboration starts by moving from one agent having a goal to a group having a SharedPlan to achieve it

- explicit communication and conversational default rules
- implicit plan recognition

An initially partial shared plan gets refined and augmented through reasoning, communicating, and group decision-making to become a full shared plan.

- each agent attributes to other(s) individual beliefs and intentions
- each agent establishes mutual beliefs and intentions based on this and the context

COLLAGEN



MERL: Charles Rich
Candace Sidner
Neal Lesh

Mixed-initiative problem solving assistant

- task-oriented spoken language dialogue
- employ SharedPlan formalism to manage collaborative discourse

Collaborative discourse

Successful collaboration requires:

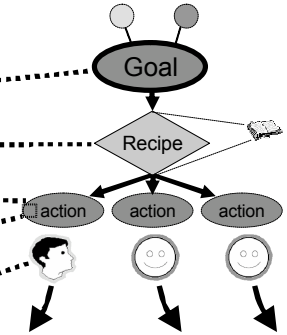
- common goal ? viable recipes
- shared recipe ? constituent actions
- agent assignment ? action plan
- agent commitment ? execution

SharedPlans recursive to level of primitive actions …

Collaborative discourse

Interactions identified by purpose:

- directly achieve current goal
- identify recipe to be used for goal
- achieve step in recipe for goal
- specify parameter of step/goal
- identify agent to perform step/goal



Hierarchy used to track content and context of discourse …

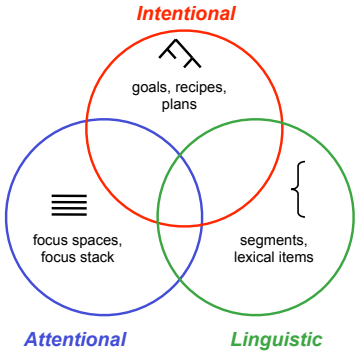
Collaborative discourse theory

(Grosz, Sidner, Kraus, Lochbaum 1974-1998)

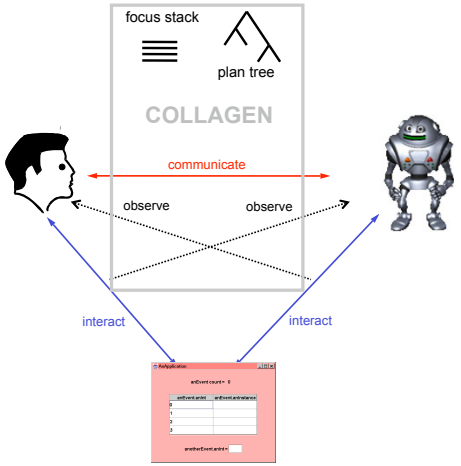
intentional structure
- hierarchy of individual or shared goals and sub-goals (partial SharedPlan)

linguistic structure
- hierarchy of segments, each serving a purpose in the intentional structure

attentional structure
- context represented as focus stack of discourse segments



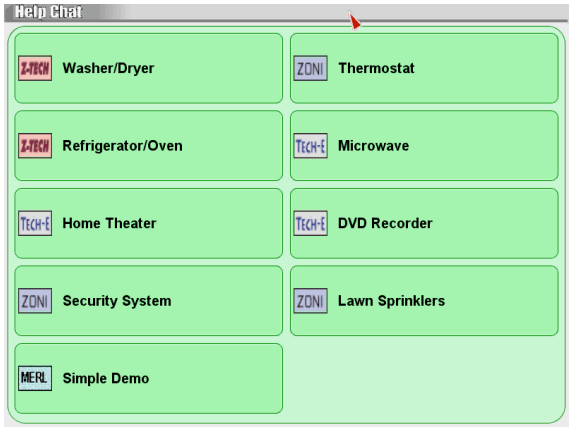
Collagen



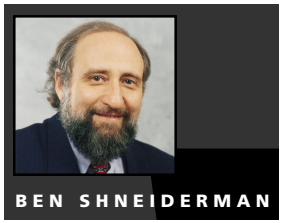
Collagen collaboration cycle

1. communication or observation event arrives at the discourse interpretation module
2. discourse interpretation module updates the discourse state
3. new agenda of expected communication and manipulation acts is computed by the discourse generation module
4. agent may decide to select an entry in the new agenda for immediate execution (according to its initiative strategy)
5. user menu update with all the communication actions in the agenda for which the actor is either unspecified or the user

Example: Daimond Help



Direct manipulation vs. interface agents



(U. Maryland)

(MIT Media Lab)

Ben Shneiderman and Pattie Maes debated these issues and more at both IUI 97 (Intelligent User Interfaces conference - January 6–9, 1997) and again at CHI 97 in Atlanta (March 22–27, 1997)

Ben Shneiderman

*„Goal: users **comprehend** the display, feel in **control**, can **predict** the system, take **responsibility** for their actions“*

*„**Responsibility** will be the central issue in this debate.“*

„Direct manipulation: rapid, reversible, incremental, point & click, immediate feedback, reduces error, encourages exploration“

*„Future is moving in the direction of information **visualization**“*

*„**Overview** is most important, giving users a sense of context.“*

*„Anthropomorphic or social interface is **not to be the future** of computing.“*

Pattie Maes:

*„Software agents are **personalized**, **proactive**, **long-lived**, **adaptive** to user, acts on user's behalf based on knowledge of user preferences"*

„Necessary because environment becomes complex, users become naive, number of tasks and issues increase"

*„Agents are **no alternatives to direct manipulation**, nor are they necessarily personified or deal with NL interaction. You still need a well-designed interface when incorporating agents in an application. However, some task I may just not do myself."*

*„Using an agent **doesn't imply giving up all control**, just over the details and that saves me a lot of time."*

*„The true **challenge** lies in designing the **right user-agent interface.**"*

Shneiderman:

*„Speech is important for niches but will **not** be a generally usable tool, and it **degrades** your problem solving performance."*

*„Anthropomorphic representation **misleads** designer, **deceives** users, increases **anxiety** about computer usage, **interferes** with predictability, **reduces** user control, **undermines** users' responsibility."*

„Users want to have the feeling that they did the job-not some magical agent."

*„I **don't think** that human-to-human interaction is a good model for the design of user interfaces."*

*„Get past the argumentation about a system being more friendly than yours or more natural or intuitive, focus on real user performance and real tasks. Do your **scientific evaluation**."*

Maes:

*„A good user-agent interface takes care of two issues: **understanding** (of the agent) and user's felt **control** over tasks but its possible delegation to the agent."*

*„Most successful interfaces are the ones where the agents are pretty much **invisible**."*

*„Ben focuses on professional users and well-structured task domains and well-organized information domains. We are dealing with **untrained** end users and **ill-structured** and **dynamic** information domain."*

*„Users **do not** always want to have **all of control**."*

Embodied conversational agents

Face-to-face encounter and interaction as user-agent interface

Terminology

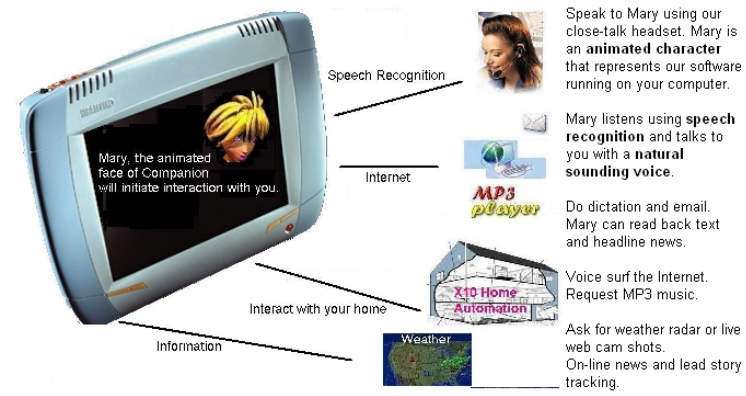
Agent

- computer system that observes and initiates actions in its environment, and is able to communicate with other individuals
- has a specific expertise and carries out specific tasks

Embodied Agent

- equipped with a human-like body
- employs body for action and communication
- aspires human-like use of modalities and communication protocols of face-to-face conversation

Example: the talking desktop



Embodied agent interfaces - motives

- Interaction is more natural & intuitive
  - familiar communication and interaction strategies apply
- Tasks appears less complex in a team
  - expertise and proactivity of the agent supports the user (e.g., expert critics, subtask completion, coordination)
- Metaphor of a mediator becomes tangible
  - „somebody" is there, with me, and helps me out (a persona)
- Motivational and social factors
  - interacting with „somebody" is more entertaining and motivating, entails socio-affective effects

Machines as proper interlocutors?

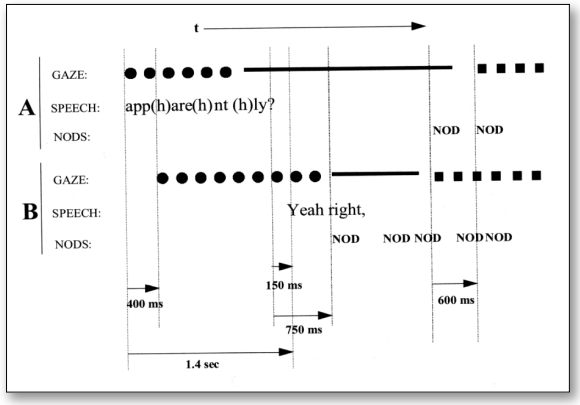
Embodied conversational agents (ECA)

„*Computer interfaces that hold up their end of conversational, have bodies and know how to use it for conversational behaviors as a function of the demands of dialogue and of emotion, personality, and social convention*" (Cassell 2000)

Envisioned features:

- Recognize and interpret verbal and nonverbal input behavior
- Generate verbal and nonverbal output behavior
- Process the multiple functions of conversational behavior
- Take an active role in dialogue (mixed-initiative)

Multimodal conversational behavior



Conversational behavior

Functions, Behaviors, Timing, Modalities

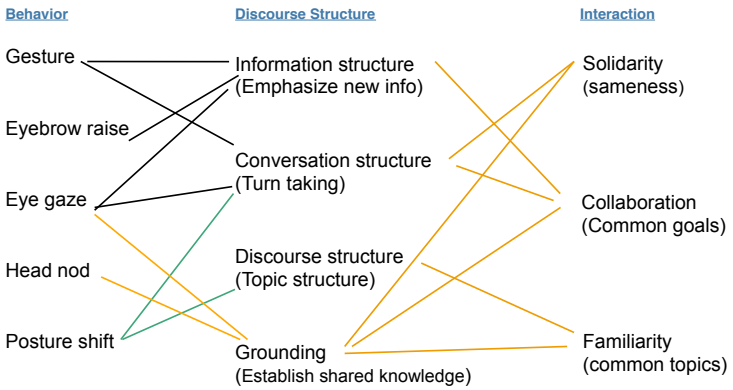
- use multiple, finely synchronized modalities to pursue interactional and propositional goals in parallel
- fulfill conversational **functions** (e.g., turn taking, turn keeping, feedback, emphasize) realized by communicative **behaviors**

A behavior may convey several function's; a function may be realized by different sets of behaviors

- Example: Turn-taking:

Conv. function	*Comm. behavior*
Give turn	Look, raise eyebrows
Want turn	Raise hands
Take turn	Glance away, start talking

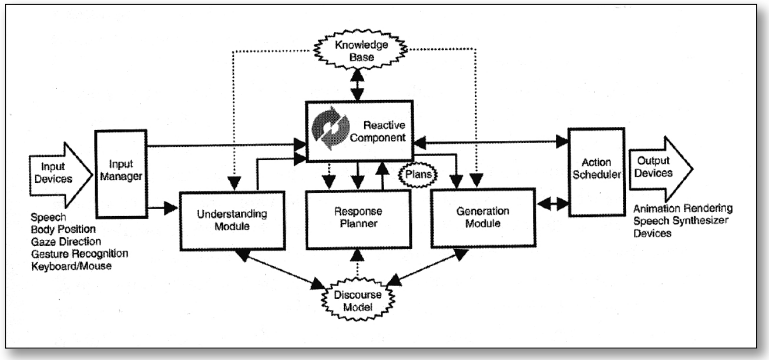
Functions of nonverbal behavior



Why is it so hard to build an ECA?

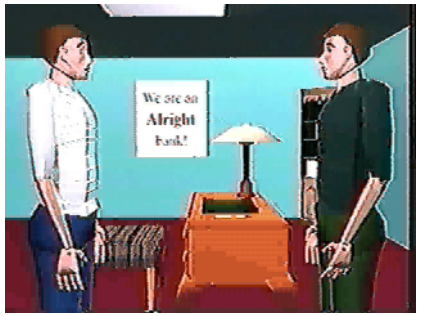
- Conversational behavior theory
  - Explicit representations of cf and cb's and their mappings needed for both input processing and output generation
- Propositional and interactional information
  - Handling both kinds of information at the same time requires rich dynamic models of user and discourse, as well as large domain and environment knowledge
- Multistep deliberation, parallelism, modularity
  - Input understanding, response/dialogue planning, and output generation must run fast, integrated, in parallel
- Timing & efficiency
  - Different threads of communication must be handled at different timescales
- Output synchrony

ECA architectures



The beginning...

- Animated Conversation (1994)



Example: REA (MIT, 2000)

- Scenario: Real estate agent
- Multimodal input/output & active dialogue management

(Cassell et al., 1999, 2000)

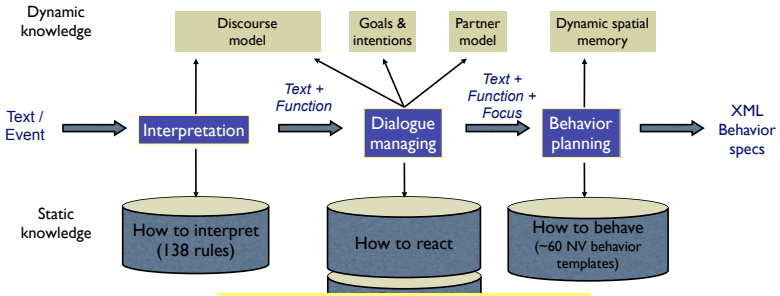
Example: Cultural training (ICT/ISI)

Example: Max (AG-WBS, Uni Bielefeld)

- As conversational museum guide in the HNF

Max in the M4 hallway/lab

Plan-based dialogue system



- 876 domain-independent „skeleton" plans
- >1.200 domain-dependent plans that implement rules of input interpretation and response selection

Runs completely in BDI interpreter, i.e., based upon principles of current beliefs, competing goals and structured, prioritized plans.

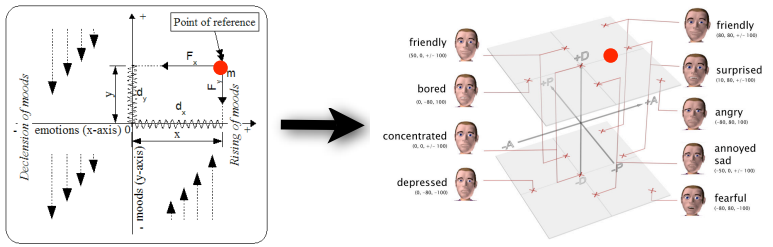
C. Becker

Modeling affect

Affective state = emotion (short-lived) + mood (more diffuse, lasting)

- emotions can fortify/alleviate mood
- mood affects experience of emotions

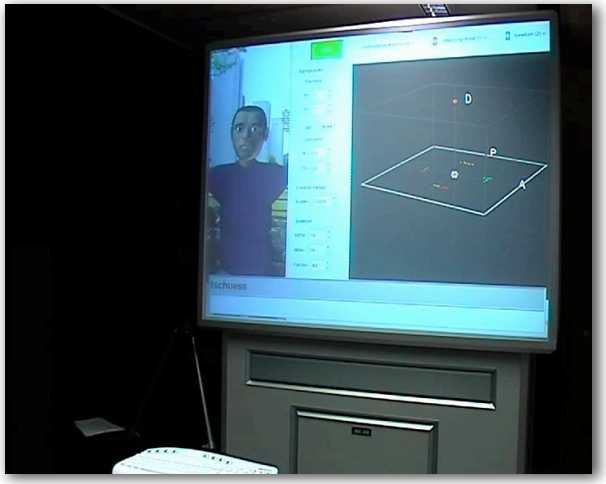
Affective state are mapped onto basic emotion categories in a PAD space



dynamical system

pleasure, arousal & dominance space

Emotions



Effects of embodied agents?

Virtual faces draw attention (Dehn & van Mulken, 2000)

Interaction tends to be more entertaining (Takeuchi & Naito, 1995; Koda & Maes, 1996; van Mulken et al., 1998, Krämer et al., 2002)

Acceptance is higher (Hubona & Blanton, 1996; Ahern, 1993)

Perceived intelligence, trustworthiness, believability of the system is increased (Sproull et al. 1996; Walker, Sproull & Subramani, 1994; Rickenberg & Reeves, 2000)

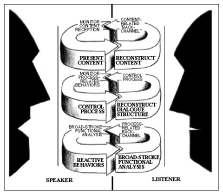
User are more inclined to delegate tasks to the system (Milewski & Lewis, 1997)

Natural language & reciprocal communication is triggered (Krämer, 2005)

The power of nonverbal feedback

Ymir/Gandalf (Thorisson, 1996):

- Different kinds of feedback
  - Content-related: question answering, command execution
  - „Envelope": gaze and head movement for turn-taking/-giving and as attentional cues, coverbal beat gestures
  - Emotional: happy, puzzled face
- Fewer user repetitions and hesitations, better ratings of language capability of the system in content + envelope FB condition

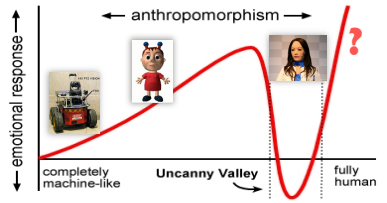


(Cassell & Thorisson, 1999)

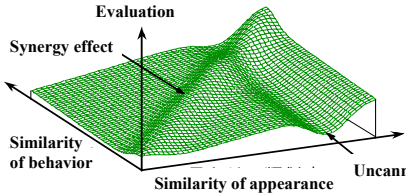
But, unknown effects lurking...

Human-like appearance

- impact on social evaluation
- similarity with self
- high realism may raise high expectations



Hypothetical „uncanny valley" (Mori 1970; Ishiguro (2005)



Embodied companions

Robotic partners

Robots today don‘t interact with people as people

- not aware of other‘s goals and intentions
- don‘t adjust their behavior to help us
- no joint attention, no spatial or mental perspective-taking
- don‘t know what‘s hard to access or important for the human
- don‘t communicate to establish shared beliefs, coordinate, and demonstrate commitment
- don‘t live up to the social models that humans use to understand and predict behavior

(Breazeal et al. 2004)

Max as a cooperation partner

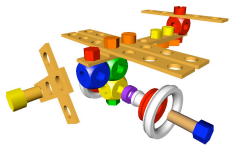
Face-to-face interaction with the embodied agent *Max* in an immersive Virtual Reality environment

Study communication in a cooperative construction task

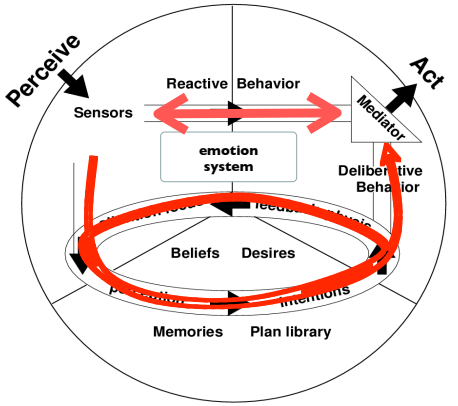
Situated Artificial Communicators

SFB 360

Nadine Pfeiffer-Leßman



General cognitive architecture



concurrent perceive, reason, and act processes

sensor-based perception

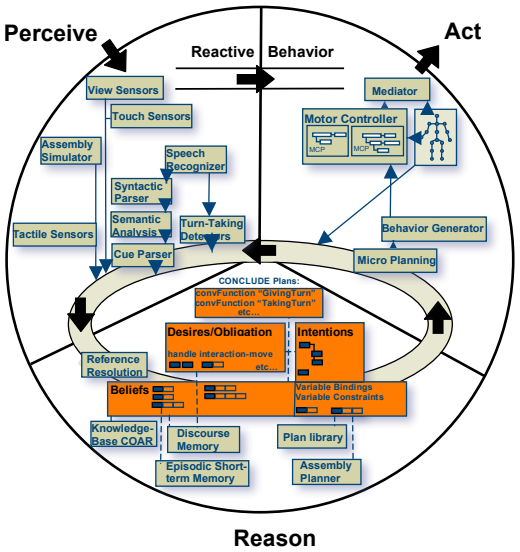
parallel processing of reactive and deliberative systems

recurrent information flow in central cognitive loop

BDI-deliberation, interpreter kernel based on JAM [Huber, 1999]

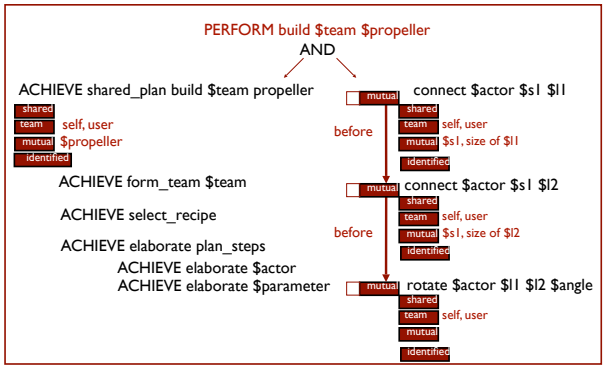
emotion system

Nadine Pfeiffer-Leßmann & Ipke Wachsmuth



Shared cooperative activity

Shared plans, mutual beliefs, intentions that the group succeeds



Example

Next (and last) session:
Social interaction as model for HCI