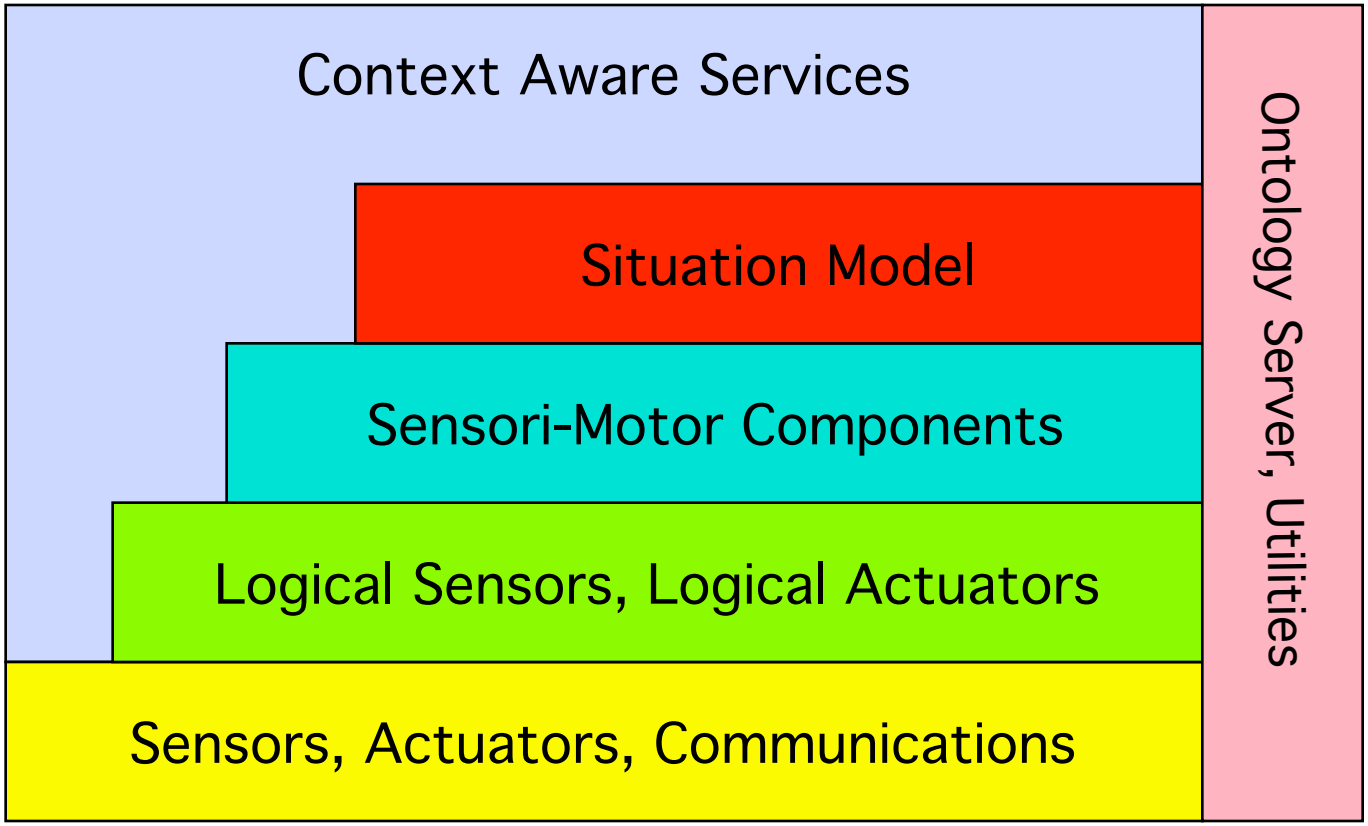
Situated Multimodal Interaction

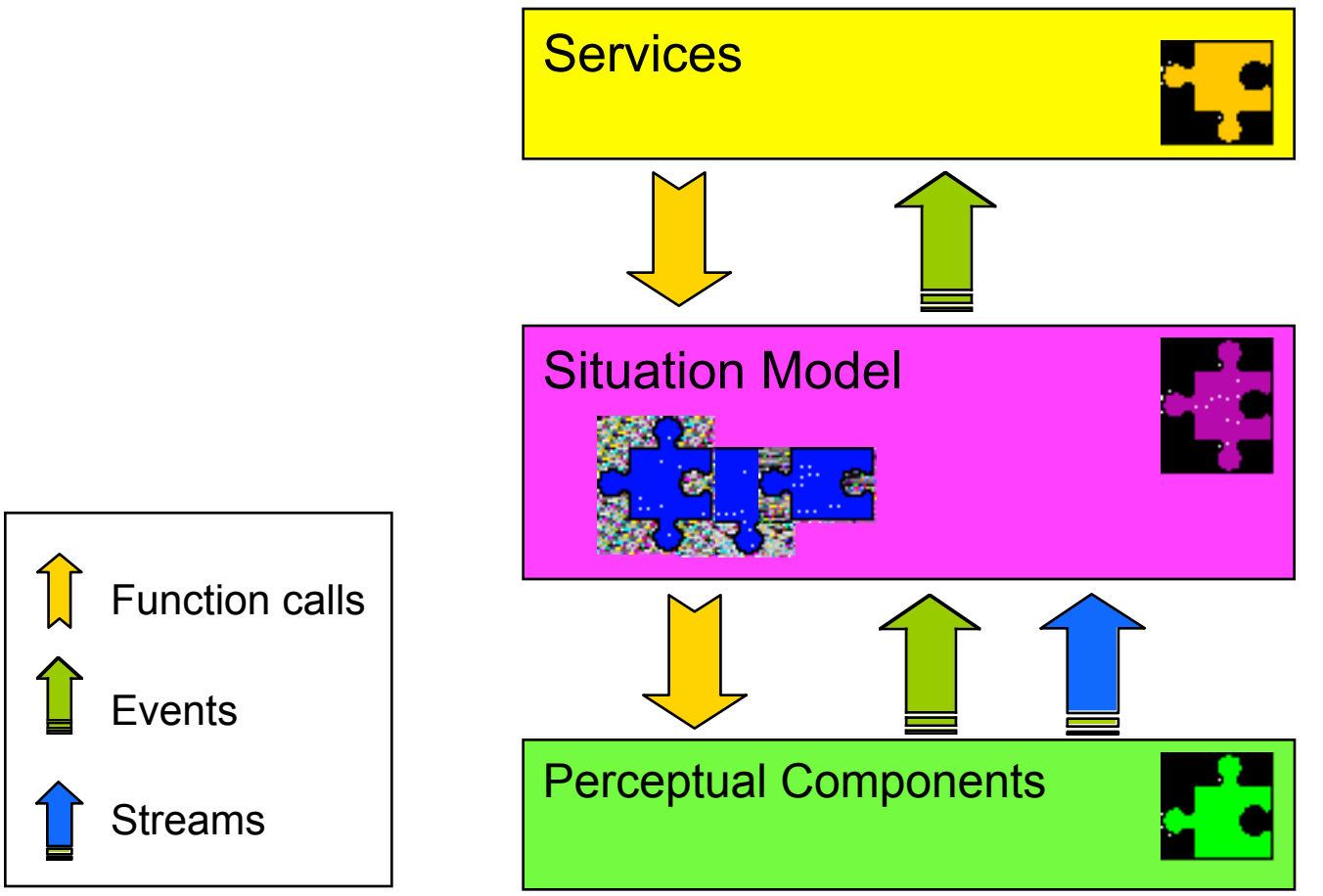
Situation Models - 10 years after CHIL

James L. Crowley
Professor, Grenoble INP
Université Grenoble Alpes
INRIA Grenoble Rhône-Alpes Research Center
Grenoble, France

IST CHIL Software Reference Model for multimodal services.



IST CHIL Core: Situation Model



Situated Multimodal Interaction

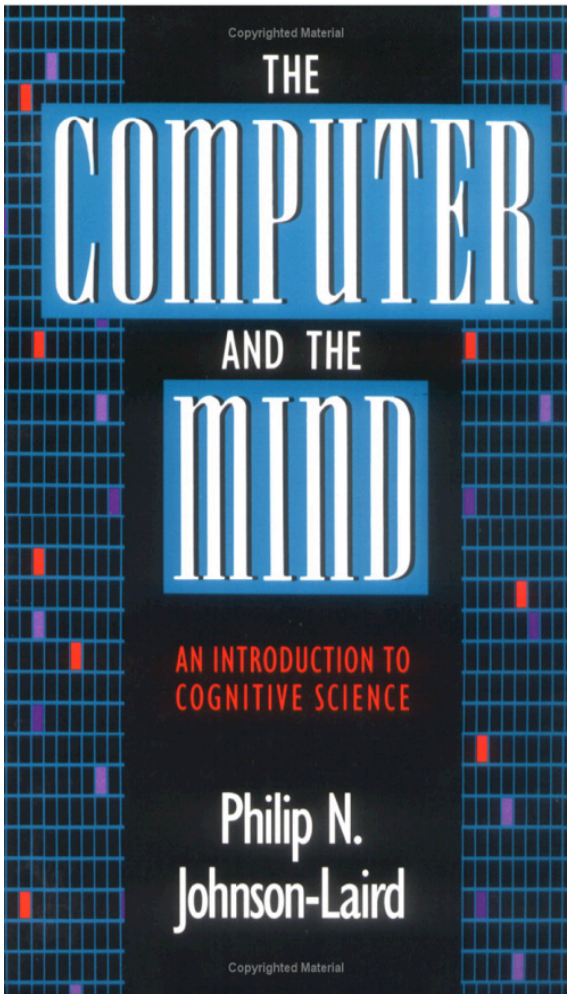
Outline

- Situation Models
- Software components
- Learning Situation Models
- Probabilistic Situated Reasoning
- Situated Interaction
- Conclusions

Situation Models: Philip Johnson-Laird

Philip N. Johnson-Laird

PhD Psychology, 1967, University College London
Stuart Professor of Psychology at Princeton Univ.
1971-1973: Inst. of Advanced Study, Princeton U.
1973-1989: Laboratory of Exp. Psychology, Univ of Sussex
1989- Applied Psychology Unit, Princeton Univ.



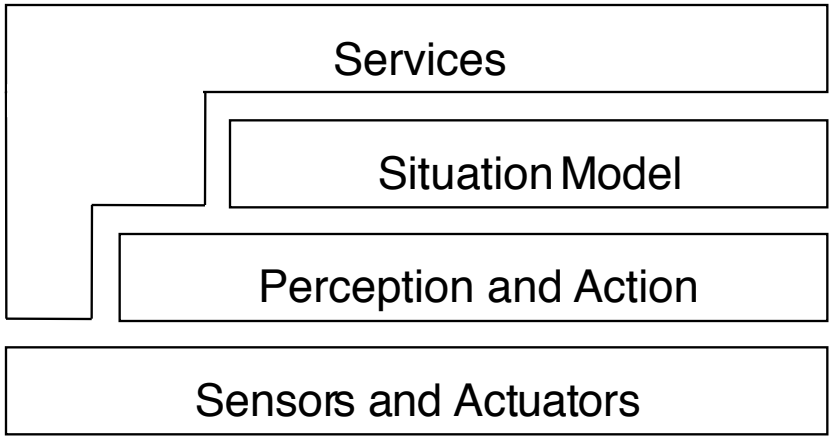
Situation Models:
a theory of mental models for natural language and inference.

Situation Models are widely used in Cognitive Psychology
to describe human abilities for

1) Providing context for story understanding
2) Interpreting ambiguous or misleading perceptions.
3) Reasoning with default information
4) Focusing attention for problem solving

Proposal: Use situation models as a software framework for systems and services that interact with humans

Situation Models:
as a theory for context aware services



Services: Communications and Information. Event driven. Non-disruptive

Situation: Describe relevant actors and objects for services, Filter events.

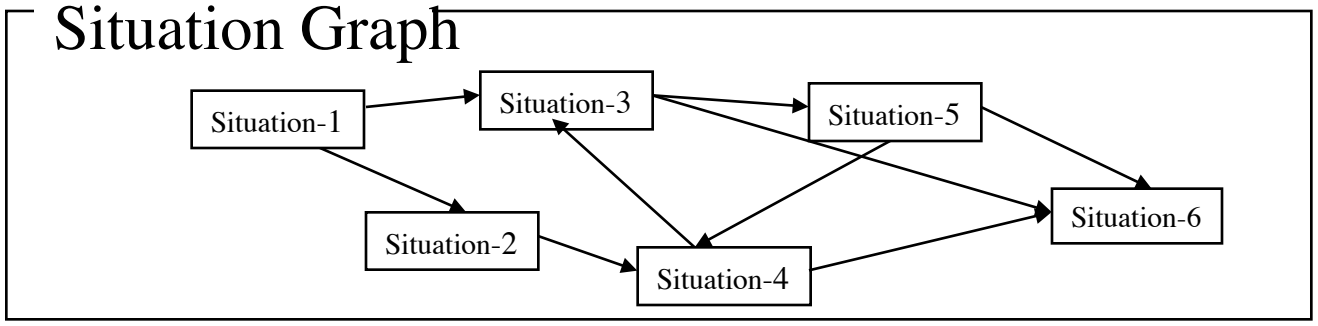
Perception and action: Recognize and model. Perform Tasks

Sensors and actuators: interact with the physical or virtual world.

Situation Models:
as a theory for context aware services

Situation:	a set of relations between entities. A State.
Entities:	Any relevant observable phenomena Ex: People, things, times, places, events
Properties:	Attributes that describe entities
Relations:	Truth Functions. Boolean or probabilistic predicates
Behaviors:	Event-Condition-Action rules Behaviors control perception, action, interaction, reasoning and system associated with each state.

Situation Models:
as a theory for context aware services



Situation Graph: A network of situations with transition conditions

- Each situation specifies: Entities to observe, actions to take,
- Behaviors for sensing, action, interaction, changes to state and context.

Context Model:

A specific set of entities, relations, behaviors, situations and transitions.

Early Examples of Situation Modeling

Examples of situation aware systems constructed at LIG

- Privacy filter for MediaSpace
- Lecture recording system (IST FAME)
- Activity monitoring for assisted living (ANR CASPER)
- Polite, social interaction with robots (Barraquand 08)

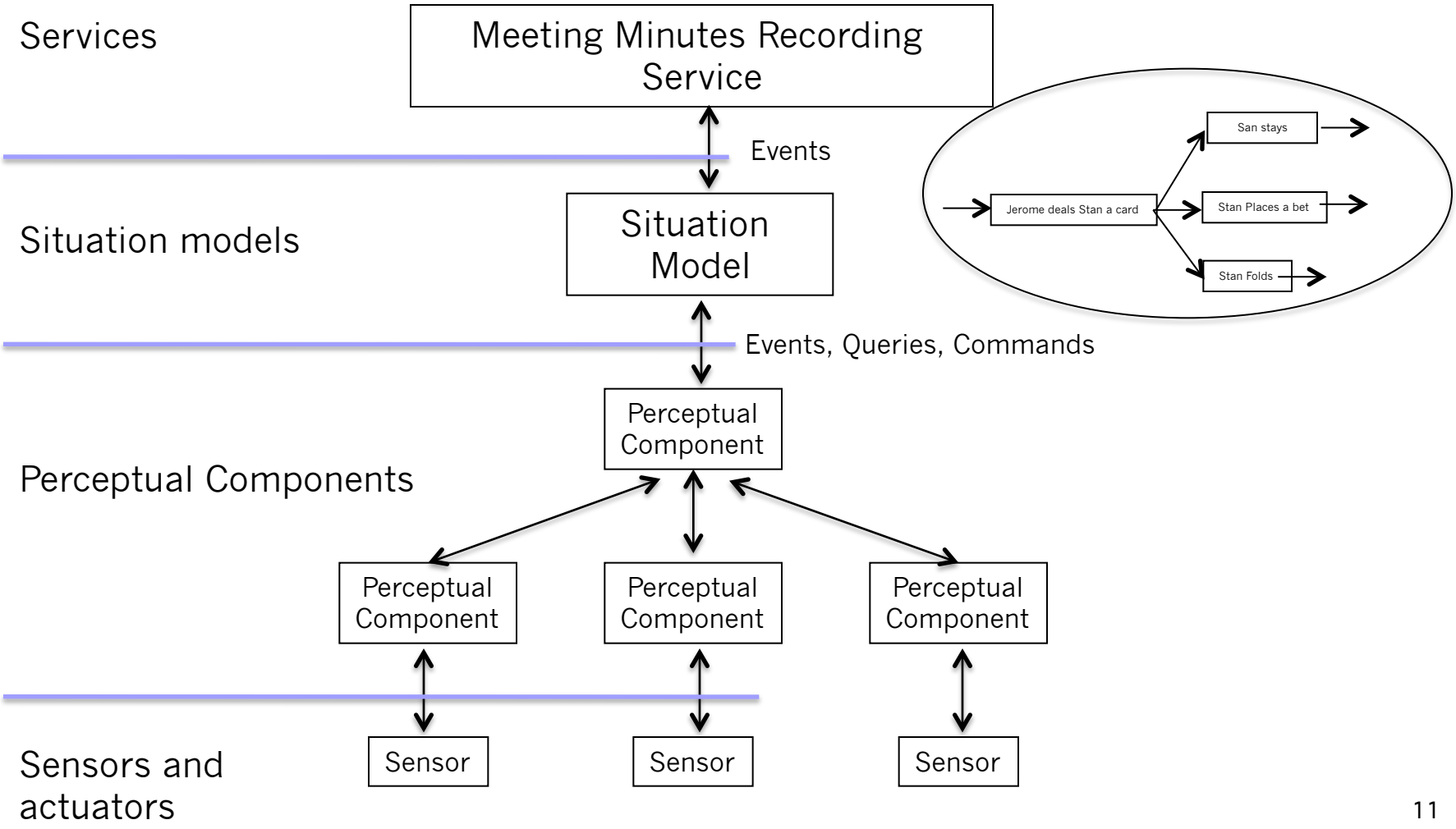
Examples constructed in IST CHIL (multi-modal services)

- Memory Jog (non-obtrusive memory prosthesis)
- Context aware Mobile Phone manager
- Meeting minute recording system

Examples in IST Perada ALLOW (Context as flow model)

- Logistics warehouse management System
- Hospital health-care activity monitoring and recording.

Example: Recording Events in a Meeting



Example: Recording Events in a Meeting

Entities:

- Patrick, Jerome, Sonia and Stan, agenda

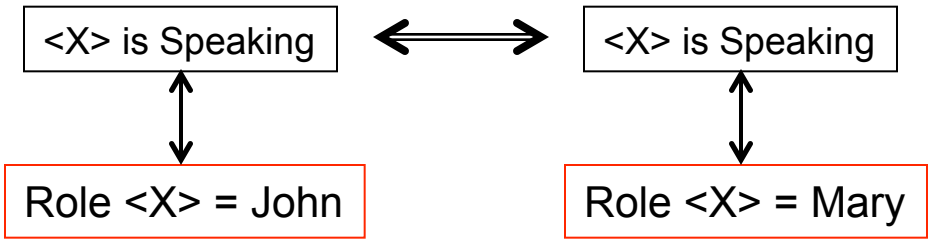
Roles:

- Moderator, Speaker, Participant, current-agenda-item, etc

Relations:

- Moderator(Patrick) speaks-to participants(…)
- Participant(Jerome) talks-to Participant(Stan)
- Participant(Sonia) looks-at Participant(Patrick)
- …

Roles



A role is a "variable" for entities. (similar to a Skolem Function in Logic)

Roles allow generalizations of situations.

Roles enable learning and reasoning by analogy

More Examples of Applications

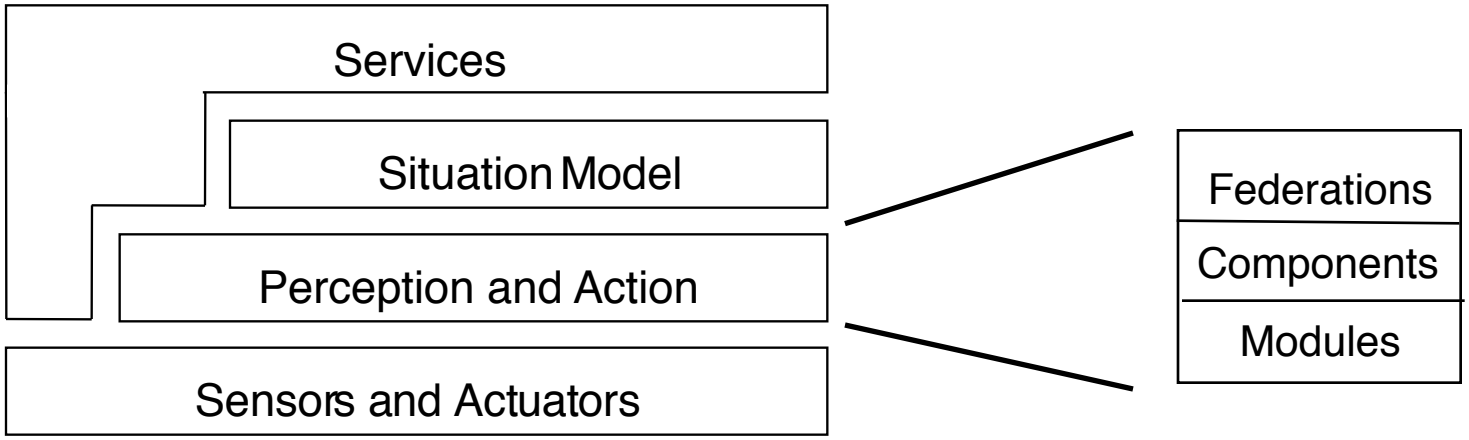
1) Event Recording (Startup MeanInFull - 2014)
2) Video Surveillance (Startup BlueEye Video – 2003)
3) Customer monitoring (Start up: HiLabs - 2008)
4) Actimetry and monitoring for Elderly and Handicapped
5) Socially-Aware Human-Computer Interaction
7) Context aware mobile applications (Start up: Situ8ed 2015)
8) Sociable Systems (Startup planned for 2017)

Situated Multimodal Interaction

Outline

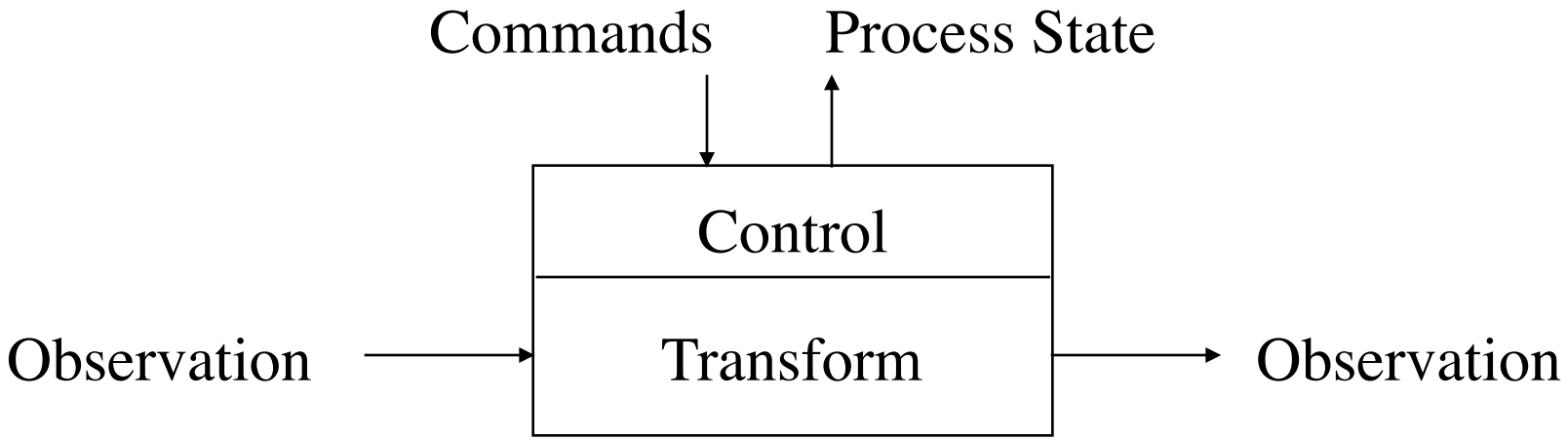
- Situation Models
- Software components
- Learning Situation Models
- Probabilistic Situated Reasoning
- Situated Interaction
- Conclusions

The Perception-Action Layer



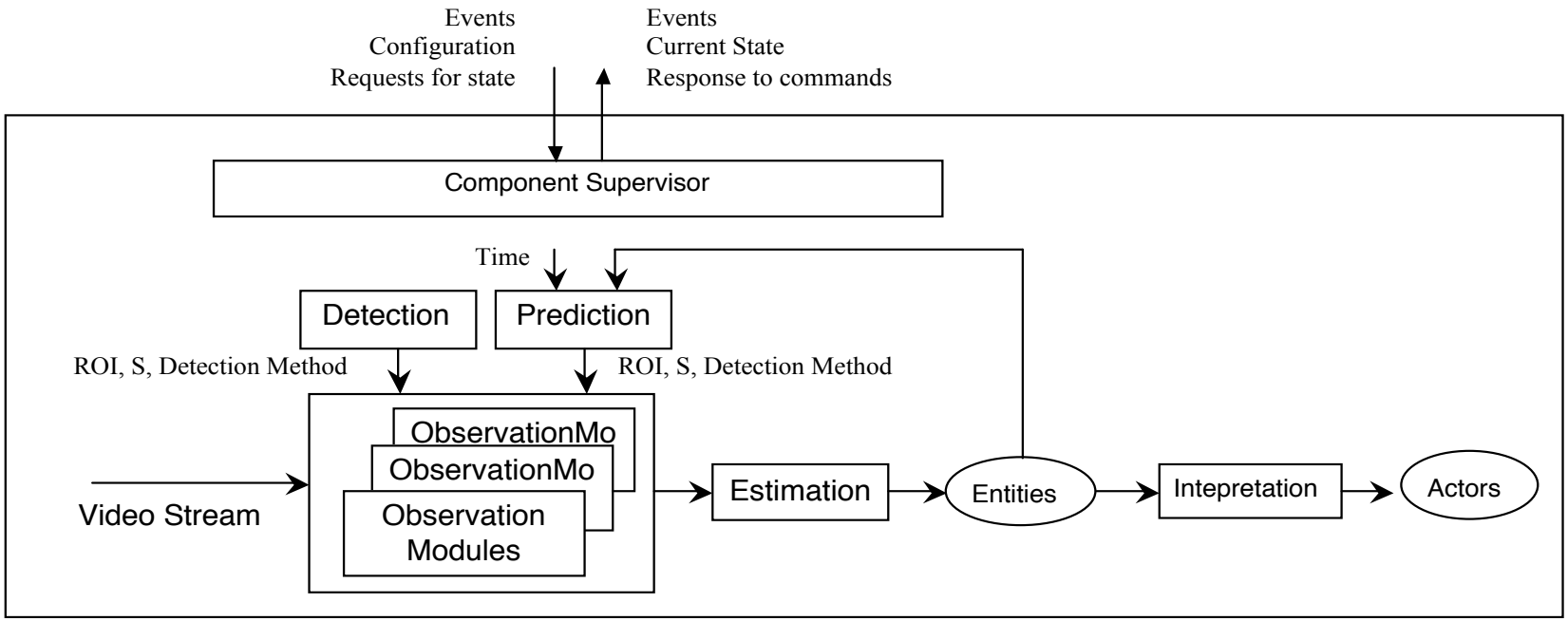
The perception action layer can be organized as federations of components for perception and action

Perceptual Components



Data flow Software Architecture (Shaw-Garlan 96)

Perceptual Components



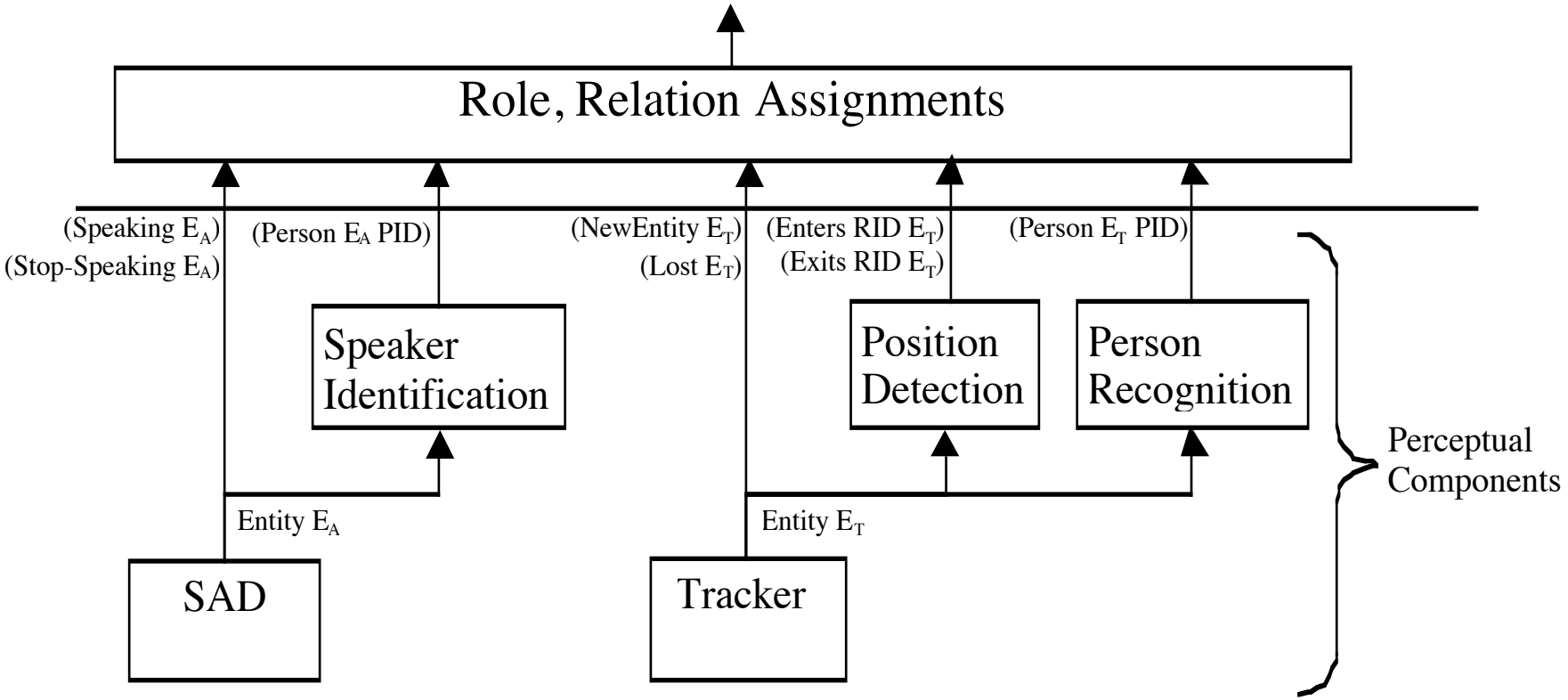
Supervisor Provides:

Execution Scheduler

Parameter Regulator

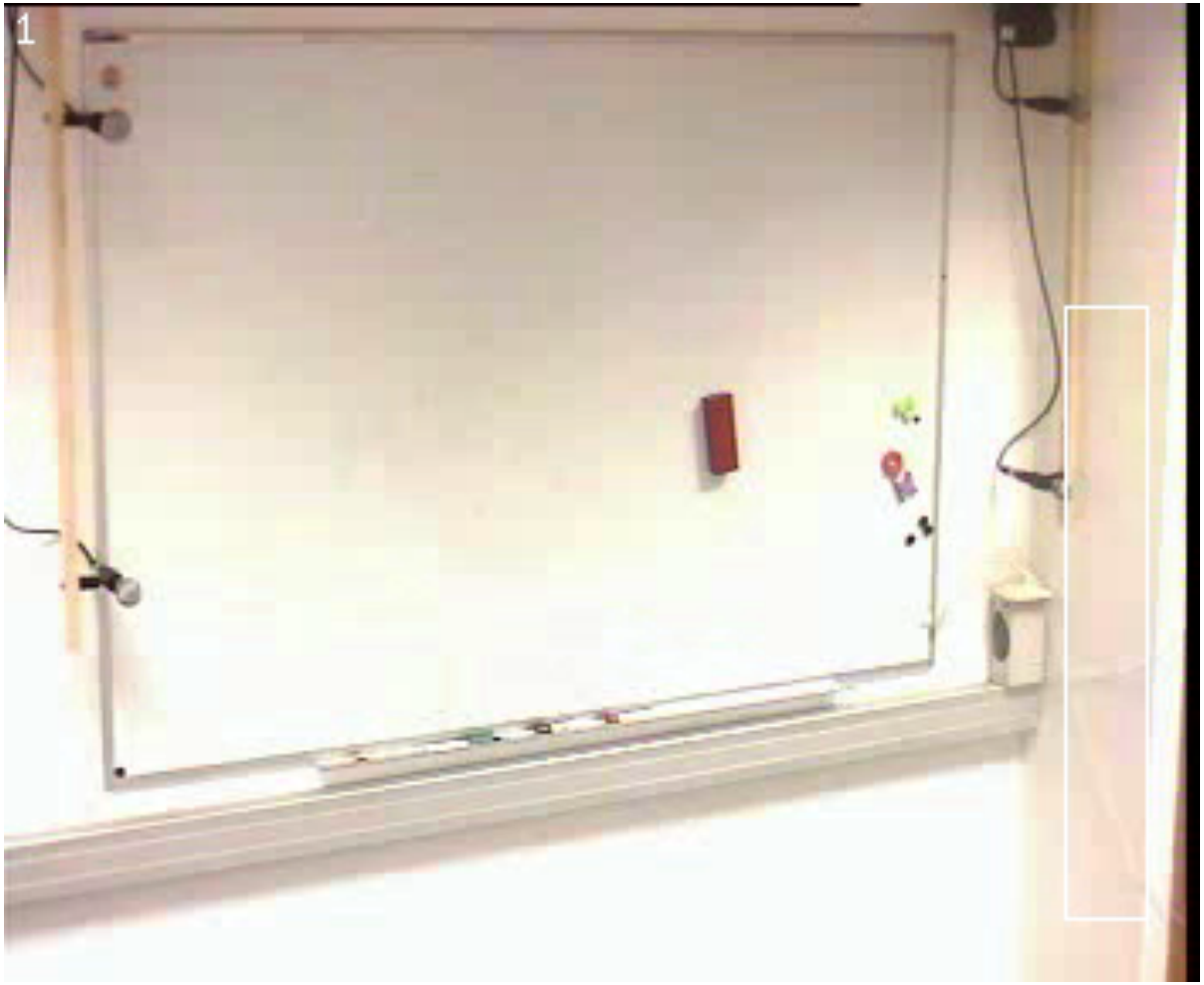
- Command Interpreter
- Description of State and Capabilities

Role Assignment



Roles are assigned to entities by “role assignment tests” directed by perceptual behaviors associated with a situation

Bayesian Track of Face and Hands



Situated Multimodal Interaction

Outline

- Situation Models
- Software components
- Learning Situation Models
- Probabilistic Situated Reasoning
- Situated Interaction
- Conclusions

Training Aibo to be polite

John is on the phone ⟷ John is facing Mary ⟷ John is talking to Aibo

AIBO Behaviours
- Be Quite (10)
- Play (-5)
- Talk to John (-10)
- Dance (-10)
- Sing (-20)

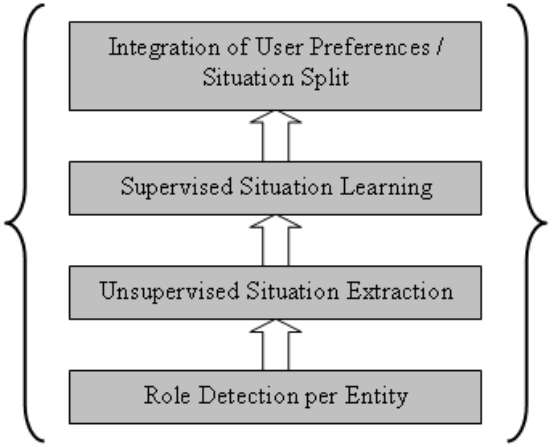
AIBO Behaviours
- Be Quite (5)
- Play (0)
- Talk to John (-5)
- Dance (-10)
- Sing (-20)

AIBO Behaviours
- Be Quite (-10)
- Play (5)
- Talk to John (10)
- Dance (5)
- Sing (-5)

Problems:

1) Learn to identify relevant entities and relations (Brdiczka et al 06)
2) Learn network of situations for a context (Zaidenberg et al 06)
3) Learn to appropriateness of behaviours for each situation (Barraquand 12)

Acquiring Situation Models*



Approach:

1) Acquire a simple model with supervised learning
2) Use feedback from users for online supervised learning.
   - Generate new situations as variations of existing situations with different user service actions.
   - Generate new roles and relations as needed to discriminate situations.
3) Use Failure of predictions as feedback for on-line learning

Developing Situation Models

3 Algorithms*:

Find-S: construct the most specific hypothesis for each action based on the role and relation configuration.

Candidate Elimination: constructs the most general hypotheses for each action based on the role and relation configuration.

ID-3: construct a decision tree that classifies the different actions based on roles and relations. The decision nodes provide the predicates that define situations.

*Thesis of Oliver Brdiczka 2008

Situated Multimodal Interaction

Outline

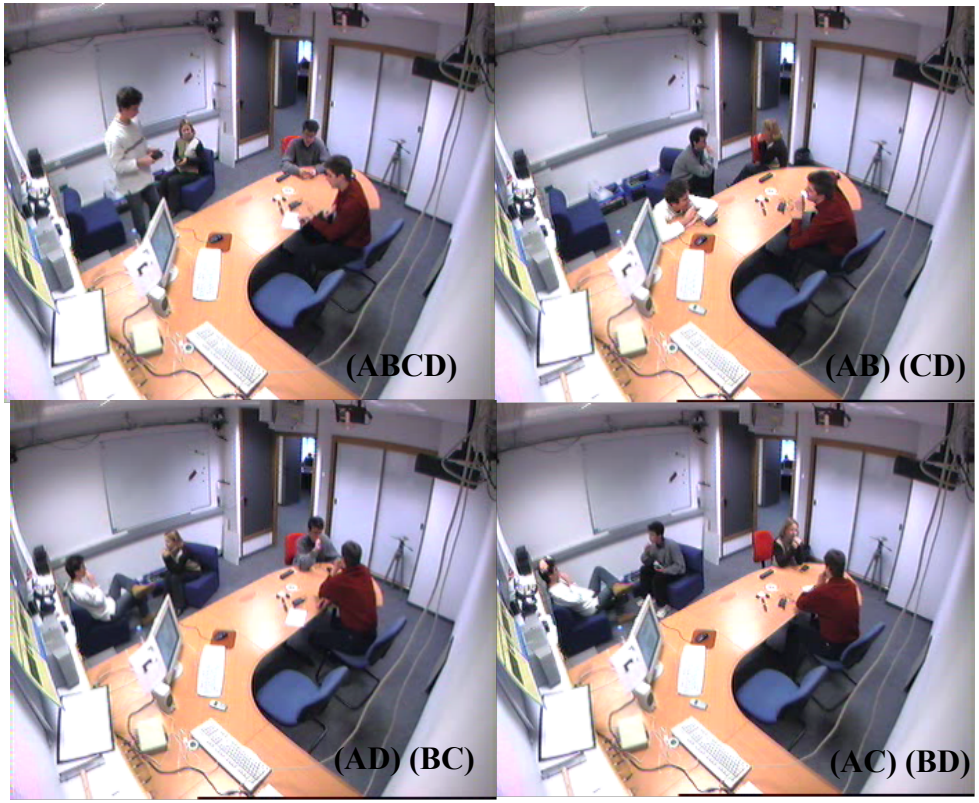
- Situation Models
- Software components
- Learning Situation Models
- Probabilistic Situated Reasoning
- Situated Interaction
- Conclusions

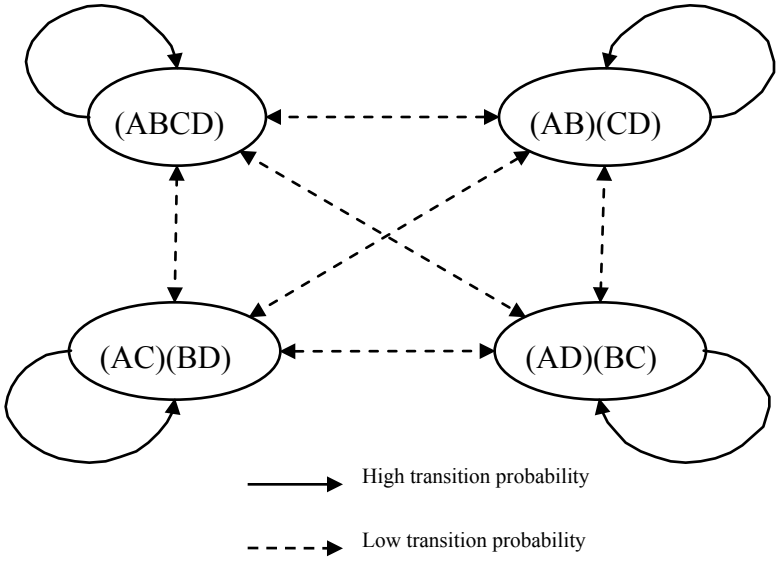
Situated Multimodal Interaction

Outline

- Situation Models
- Software components
- Learning Situation Models
- Probabilistic Situated Reasoning
- Situated Interaction
- Conclusions

Probabilistic situation models





O. Brdiczka, J. Maisonnasse, and P. Reignier. Automatic detection of interaction groups. In Proceedings of International Conference on Multimodal Interfaces (ICMI), October 2005.

Probabilistic Predicates

Predicate: Boolean valued truth function. $P: X \rightarrow$ {true, false}

example: at(Home, Joe)

Probabilistic Predicate: Probability valued truth function.

$P: X \rightarrow [0, 1]$.

Probabilistic Predicates allow us to reason with Probabilistic Graphical Models.

Probabilistic Predicates

A probabilistic predicate is any truth function *p(X)* that obeys the 3 axioms of probability .

Axioms: For some event, *E*, and disjoint Classes C_k from a space *S*

$$S = \bigcup_{k-1}^{K} C_k$$

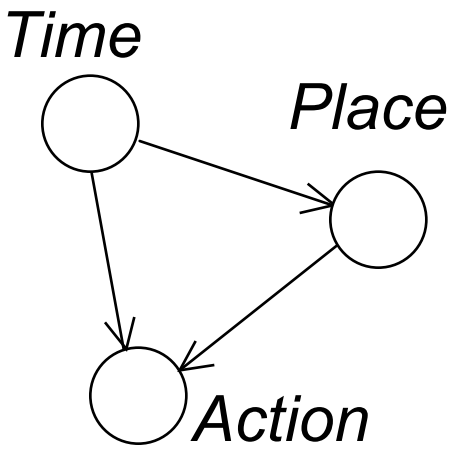
$$1)\ p(E = C_k) \geq 0$$

$$2)\ p(E \in \bigcup_{k-1}^{K} C_k) = 1$$

$$3)\ p(E \in \bigcup_{k=1}^{K} C_k) = \sum_{k=1}^{K} p(E \in C_k)$$

Probabilistic Predicates

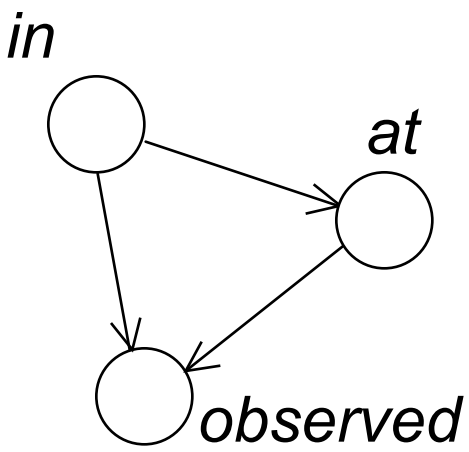
Graphical Models



$$doing(Action, Place, Time) = observed(Action \mid Place, Time)\ \text{in}(Place \mid Time)\ at(Time)$$

Probabilistic Predicates

Graphical Models



$$doing(Action,\ Place,\ Time)\ =\ observed(Action \mid Place,\ Time)\ \text{in}(Place \mid Time)\ at(Time)$$

Probabilistic Predicates

We can convert a set of likelihoods into probabilities by normalizing so that the sum of all likelihoods is 1.

$$P(E = C_k) = \frac{L(E = C_k)}{\sum_{k=1}^{K} L(E = C_k)}$$

Situated Multimodal Interaction

Outline

- Situation Models
- Software components
- Learning Situation Models
- Probabilistic Situated Reasoning
- Situated Interaction
- Conclusions

Situated Interaction Theory
(Suchman 87)

Study of the interaction between an agent and its environment.

Core Concept: Mediation:

- Emphasizes the emergent, contingent nature of activity.
- Includes the environment as part of the cognitive process.
- Asserts that plans are artifacts of reasoning about actions (after the fact explanations, rather than deliberate procedures).

Situated interaction requires awareness

Situated Interaction Requires Awareness

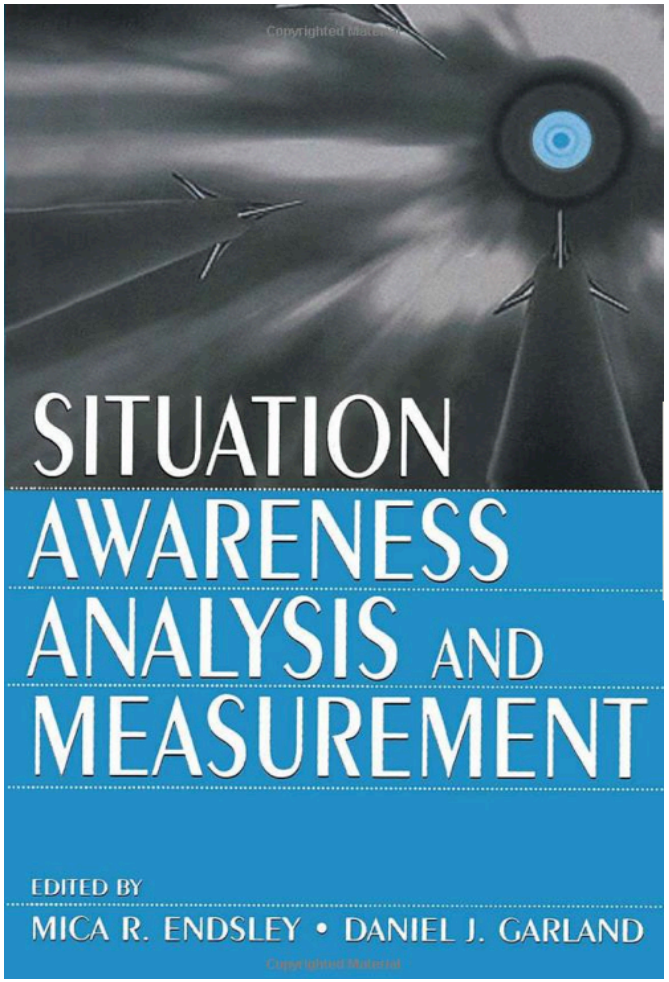
Awareness (Human Factors)

- Vigilance against danger or difficulty.
- Having knowledge of something.
- The ability to perceive, to feel, or to be conscious of events, objects or sensory patterns.
- Conscious of stimulation, arising from within or from outside the person

Models of awareness have been studied and applied for human factors in aviation since at least 1914.

Situated Interaction Requires Awareness

Mica Endsley, Ph.D., P.E.
PhD USC 1990
editor-in-chief of the Journal of Cognitive Engineering and Decision Making
President: SA Technologies
Specialty: Cognitive Engineering
Application Domain: Aviation and critical systems.



Situation Awareness

Situation Awareness : The Perception of [relevant] elements of the environment in a volume of space and time, the comprehension of their meaning and the projection of their status in the near future.

(M. Endsley, D. Garland , Situation Analysis and Awareness, Lawrence Erlbaum, 2000)

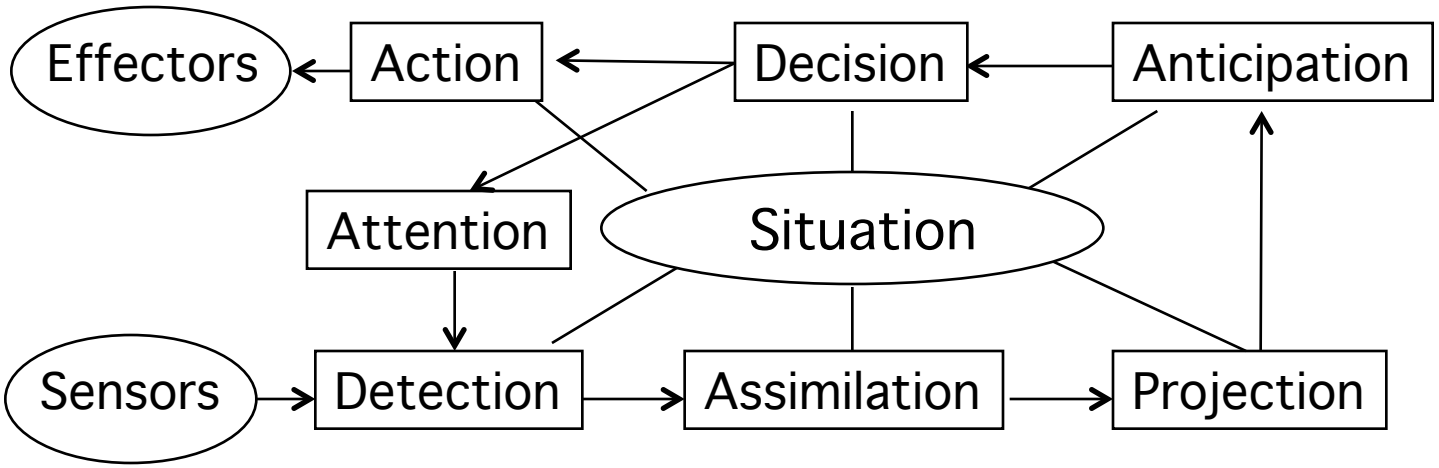
Levels in Situation Awareness (Endsley)

1: Detection: Sensing of entities relevant to task

2: Assimilation: association of percepts with models that predict and explain.

3: Projection: Forecast events and dynamics of entities

A Process Model for Situation Awareness



Attention: Tuning senses for directed sensing
Detection: Directed Sensing of relevant entities
Assimilation: Integrating sensed information into context model
Projection: Prediction of trends, events and situations
Anticipation: Inference of Consequences and possible reactions
Decision: Determination of course action

Situ8ed

The right information at the right time

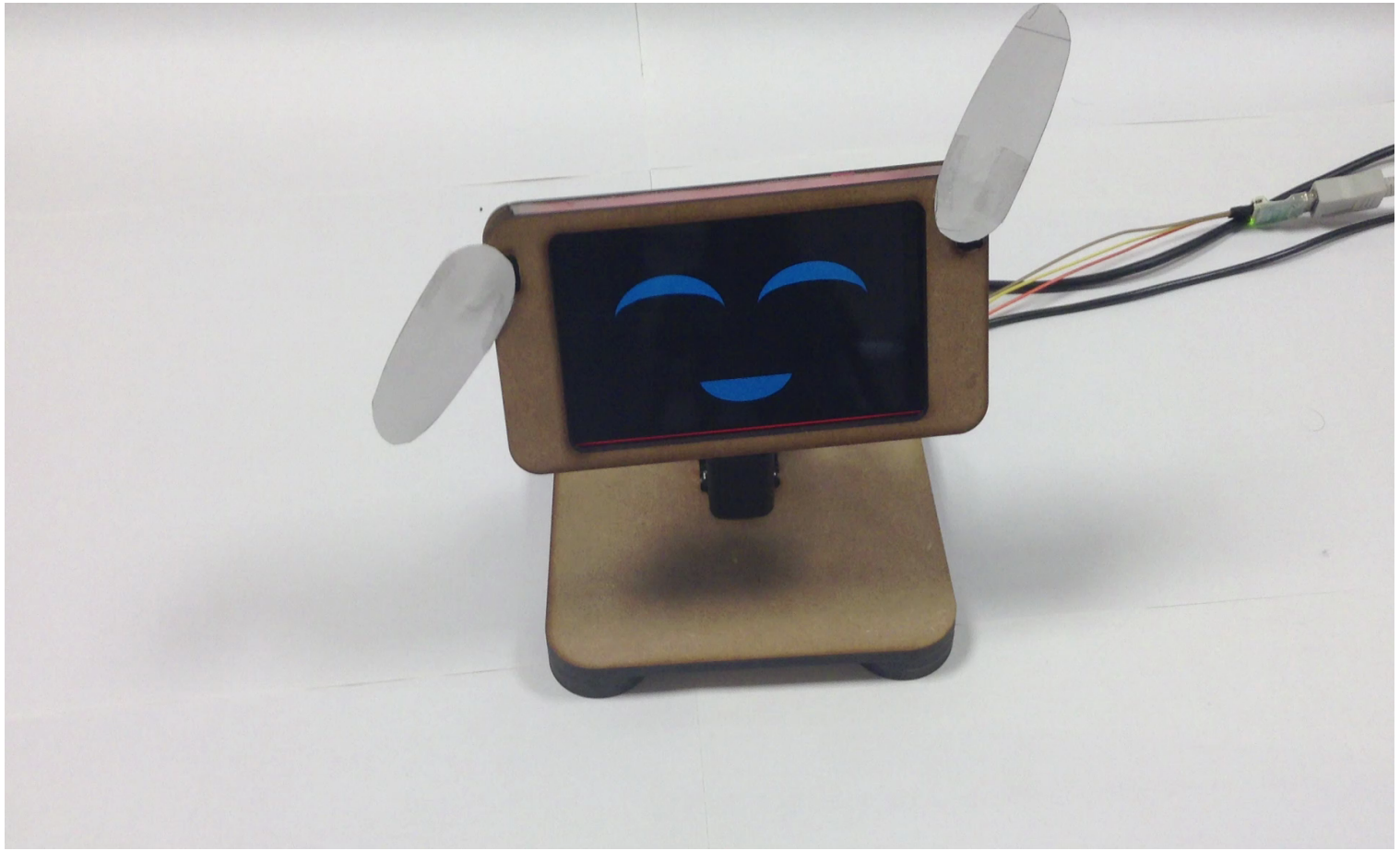
Mobile “component” for apps.

- Monitors Activity 24/7 (driven by initial model of human daily cycle)
- Associates activities with semantic locations and semantic time
- Learns routines (sequence of contexts and situations)
- Predict situations, anticipate needs, proposes information and services
- Learns to predict best situations for interaction.

Situated Services in the Home.

1) Sensors
2) Learning Routing Patterns of Activity
3) Predicting activities and anticipating needs
4) Examples of Situated Services:
    1) Home Logistics
    2) Travel Advisory
    3) Communications assistant
    4) Life logging

Sociable Interactive Agents



Situated Multimodal Interaction

Outline

- Situation Models
- Software components
- Learning Situation Models
- Situated Interaction
- Conclusions

Bibliography

Dey 2001	Dey, Anind K., et al. "Situated interaction and context-aware computing." *Personal and Ubiquitous Computing* 5.1 (2001): 1-3.
Johnson-Laird 83	P. N. Johnson-Laird, Mental Models: Toward a Cognitive Science of Language, Inference and Consciousness. Harvard University Press, 1983
Johnson-Laird 88	P. N. Johnson-Laird, Computer and the Mind: An Introduction to Cognitive Science. Harvard University Press. 1998
Shaw-Garlan 96	M. Shaw and D. Garlan, Software Architecture: Perspectives on an Emerging Disciplines, Prentice Hall, 1996
Brdiczka 05 et al	O. Brdiczka, J. Maisonnasse, and P. Reignier. Automatic detection of interaction groups. In Proceedings of International Conference on Multimodal Interfaces (ICMI), October 2005.
Barraquand 08	R. Barraquand and JL Crowley, “Learning Polite Behavior with Situation Models”, Human Robot Interaction (HRI ‘08), Amsterdam, Mar. 2008.
Suchman 87	L.A. Suchman, *Plans and situated actions: The problem of human-machine communication*. Cambridge university press, 1987.
Endsley 00	M. Endsley, D. Garland , Situation Analysis and Awareness, Lawrence Erlbaum, 2000
Barraquand 12	Rémi Barraquand, Design of Sociable Technlogies, Doctoral Thesis of the University of Grenoble. Feb 2012,
Brdiczka 07	Oliver Brdiczka, "Learning Situation Models for Context-Aware Services", Doctoral Thesis of the University of Grenoble, May 2007.

Situated Observation of Human Activity

Contribution from

Patrick Reignier,

Dominique Vaufreydaz,

Oliver Brdcizka,

Sonia Zaidenberg,

Jerome Maisonasse,

Remi Barraquand,