Overview

Intelligent User Interfaces

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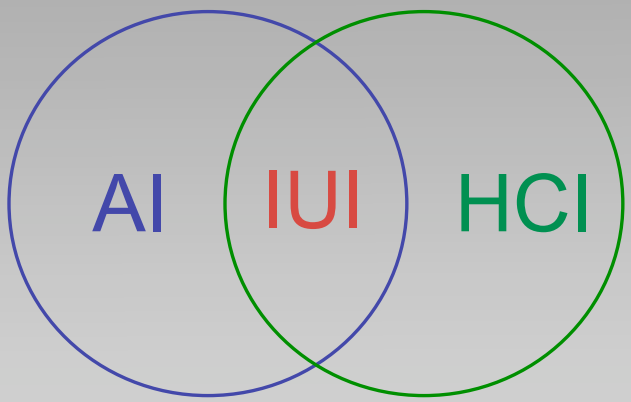
An Interdisciplinary Field



Four Underlying Propositions *

1) Serious interface problems are ultimately *semantic* problems
   - "ergonomics" of user interfaces fairly well understood (if not uniformly practiced)
   - e.g., selection from menu by mouse

* From: Introduction to Intelligent User Interfaces, Sullivan & Tyler, 1991.

Four Underlying Propositions *

2) Those semantic problems *cannot* be solved through good interface techniques *alone*
   - need a representation of the domain and tasks (offered by AI techniques)
   - e.g., a good menu system cannot make up for a poor task analysis

* From: Introduction to Intelligent User Interfaces, Sullivan & Tyler, 1991.

Four Underlying Propositions *

3) These problems *cannot* be solved by AI *alone*
   - need to take context of use (physical, cognitive, social, etc) into account
   - e.g., lack of acceptance of early medical expert systems

* From: Introduction to Intelligent User Interfaces, Sullivan & Tyler, 1991.

Four Underlying Propositions *

4) What is needed to address these problems is a *synthesis* of the two perspectives
   - creative tensions
   - e.g., augmenting rather than replacing human (even if replacement "possible")

* From: Introduction to Intelligent User Interfaces, Sullivan & Tyler, 1991.

11 "Sub-Areas" we are going to study

Basic Concepts , How Used , Readings

Goal/Task Based User Interfaces *	Intelligent Tutoring Systems	Automated GUI Design	Personal Assistants
Recommender Systems	Multimodal Dialogue	Collaborative Dialogue	Embodied Conversational Agents
Affective Computing	Human-Robot Interaction	Intelligent Environments	???

1. Goal/Task Based User Interfaces

- *Basic concepts:* goals/tasks, recipes, plans
- *How used:*
  - hierarchical task analysis (modeling)
  - planning
  - plan recognition

Goal/Task Based User Interfaces

- System contains and *uses* (partial) model of what a person is trying to accomplish and how to operate the system to contribute
- Just “contains” not enough, e.g., searchable user manual
- But similar knowledge as contained in a *good* user manual --- “active manual”
- A kind of “reflection” (often considered a hallmark of intelligence)

Goal/Task Based User Interfaces

- Kinds of knowledge system needs to represent and reason about:
  - objects (in the computer and/or real world) and their properties/relations
    - e.g., books, authors, ISBN numbers, etc.
    - e.g., window, scroll bar, text position, etc.
  - (primitive) actions/events and how they affect objects
    - e.g., lookup title in catalog, take book off shelf, etc.
    - e.g., open/close window, move cursor, etc.

Goal/Task Based User Interfaces

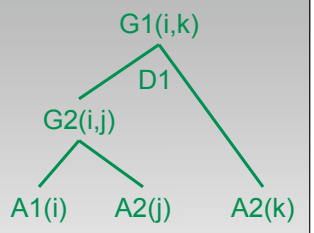
- Kinds of knowledge system needs to represent and reason about: [cont'd]
  - typical user goals
    - e.g., borrow a library book
    - e.g., write a letter
  - steps (decompositions) to achieve particular goals (under particular conditions)
    - e.g., find book; take book to checkout counter
    - e.g., start editor; write text; save file

Note "task" is used generically for primitive action or goal.

Goal/Task Based User Interfaces

- Somewhat more formally...
  - *Domain Model:* $\{ \mathcal{T}, \mathcal{A}, \mathcal{R} \}$
    - $\mathcal{T}$ object types
    - $\mathcal{A}$ (primitive) action types
    - $\mathcal{R}$ relations on $\mathcal{T}^*$
  - *Task Model:* $\{ \mathcal{G}, \mathcal{D} \}$
    - $\mathcal{G}$ goal types (built on $\mathcal{T}$ and $\mathcal{R}$)
    - $\mathcal{D}$ decomposition types (built on $\mathcal{G}$ and $\mathcal{A}$)
  - A particular interaction instance:
    - T1,T2 $\in \mathcal{T}$; A1,A2 $\in \mathcal{A}$; G1,G2 $\in \mathcal{G}$; D1 $\in \mathcal{D}$
    - i,j $\in$ T1 ; k $\in$ T2

    G1(i,k):D1:< G2(i,j):< A1(i), A1(j) >, A2(k) >



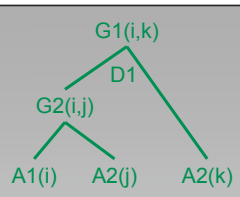
Goal/Task Based User Interfaces

- Task modeling (analysis)
  - Defining the domain and task models for a particular application
  - Somewhat of an art---we'll practice next week
    - finding right level of abstraction
    - what to ignore, what to make primitive
    - alternative groupings of lower-level actions/goals
  - "Achilles heel" of goal/task based user interfaces
    - special case of "knowledge acquisition bottleneck"
    - research towards automating using demonstration and/or learning techniques

Goal/Task Based User Interfaces

- Reasoning techniques
  - planning: finding a sequence of actions to achieve a desired state of the world
    - first principles
    - hierarchical task network
  - plan recognition: inferring plans or goals from observing actions
    - goal recognition
  - general inference: e.g., about domain relations
    - fast, incomplete (e.g., constraint propagation)
    - dependency-directed (e.g, TMS)

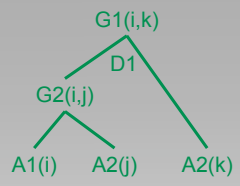
Goal/Task Based User Interfaces



- Planning tradeoffs
  - First principles ("classic")
    - requires *complete* domain model, i.e., the pre/postconditions of all actions accurately known
    - very flexible and general
    - many search algorithm variations: forward, backward, island, partial-order, hierarchical, etc.
    - task model not required, but can be used
  - Hierarchical task network
    - only the task model (predefined goals & decompositions)
    - task types can just be names (no pre/postconditions)
    - can use more domain model information if known

Research to synthesize the two approaches.

Goal/Task Based User Interfaces



- Plan recognition
  - reduces communication burden, e.g.,
    - observe A1(i) → infer G2, G1, D1 → suggest A2(j) next

    versus
    - tell G1(i,k), tell D1, observe A1(i) → suggest A2(j) next
  - goal recognition: just G1, G2 (not D1)
  - both kinds of recognition NP-complete in general
  - however, can often be done practically
    - incremental (in context of collaboration)
    - fall-back on communication

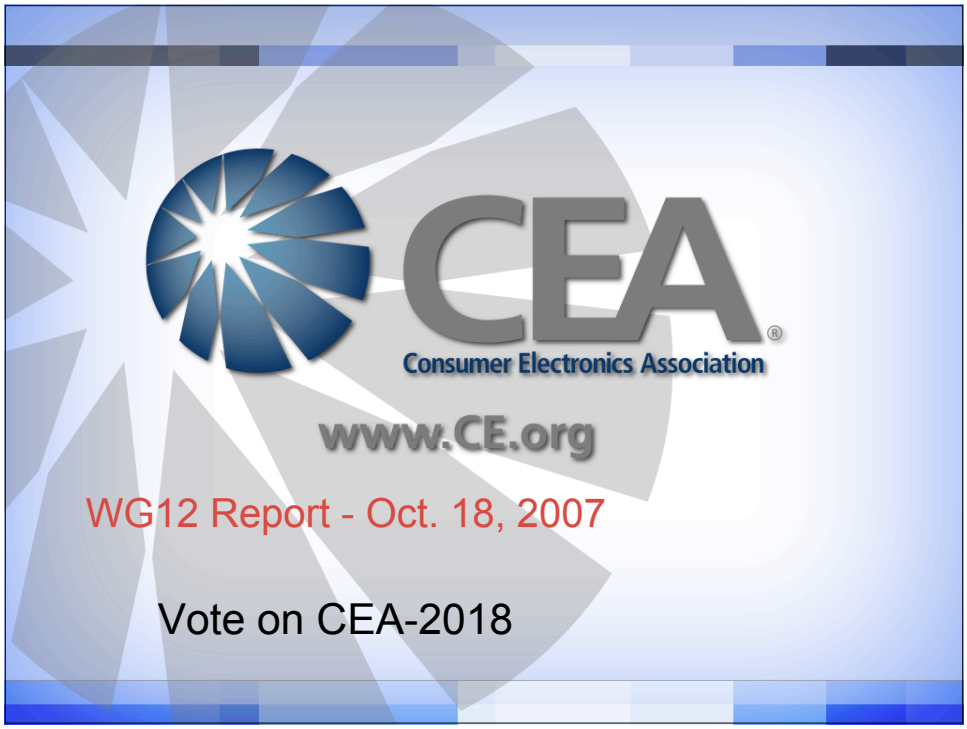
Goal/Task Based User Interfaces

- Interaction styles
  - pure advisor
    - user performs all actions (e.g., system does not have physical access to world)
    - system may not be able to directly observe actions (relies on user's reports)
    - system advises, critiques, etc. (fail soft)
  - purely automatic
    - system performs all actions
    - user provides toplevel goal (NB: difficulty of expression)
    - difficult to recover from undesired behavior
  - collaborative (mixed initiative)
    - best of both, but hardest to implement

Goal/Task Based User Interfaces

- *Readings:*
  - Rich & Sidner, DiamondHelp: A Generic Collaborative Task Guidance System, AI Magazine 2007
  - Lieberman & Espinosa, A Goal-Oriented Interface to Consumer Electronics using Planning and Commonsense Reasoning, IUI'06
  - ANSI/CEA-2018 Task Model Description (CE Task 1.0), 2007

    [Basis for semester project!]



CEA-2018 Task Model Description

Half of all "malfunctioning products" returned to stores by consumers are in full working order, but customers can't figure out how to operate the device…

-E. den Ouden, Technical University Eindhoven (Ph.D. thesis 2006)

This usability problem is particularly acute when devices are connected in home networks, because achieving a single goal often requires understanding how to operate multiple devices.

CEA-2018

Task Model Description

Produced by R7 Working Group 12 (created March, 2006)

Co-Chairs: Charles Rich, Mitsubishi Electric Research Labs
Alan Messer, Samsung Research

Editor: Gottfried Zimmerman, Consultant

CEA-2018 Task Model Description

WG12 Participants:

Motorola	JVC	HBO
NAB	TCS	4HomeMedia
LonMarks	AT&T	DirectTV
Hitachi	LOYTEC	EchoStar
Alpine	Panasonic	

CEA-2018 Task Model Description

1 SCOPE

A task model is a formal description of the activities involved in completing a task, including both activities carried out by humans and those performed by machines.

This standard defines the semantics and an XML notation for task models relevant to consumer electronics devices.

CEA-2018 Task Model Description

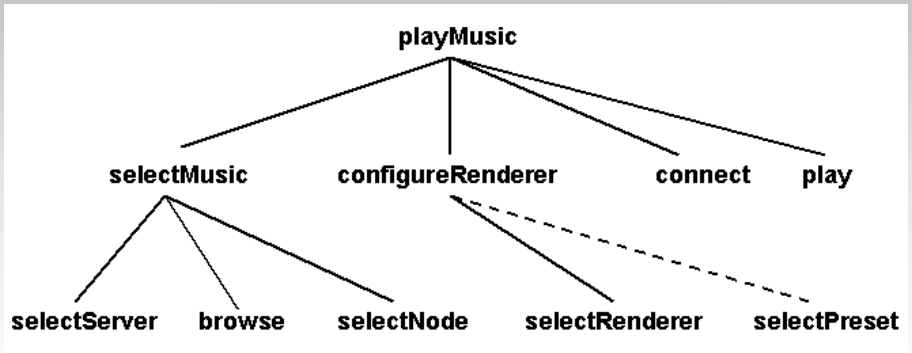
What we are not doing!

The standard does ***not*** define or restrict the actual appearance of a user interface or its detailed operation, and thus will not interfere with the preservation of brand identity via corporate logos or other means.

The standard does ***not*** depend on any specific home networking technology or infrastructure.

CEA-2018 Task Model Description

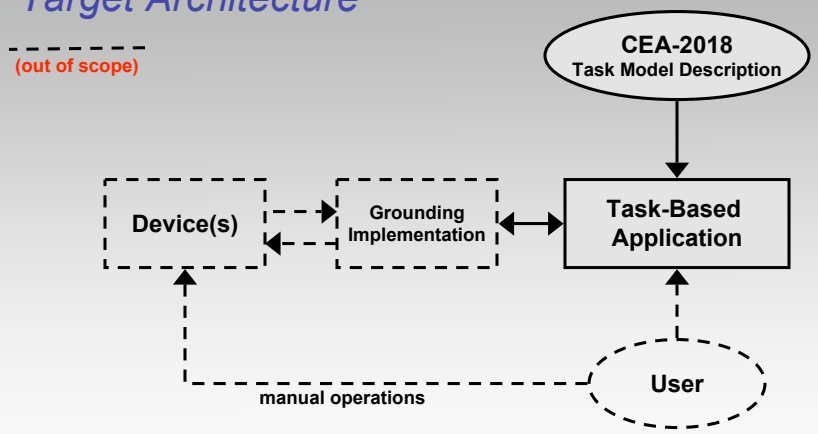
An Example Task Model




```
<taskModel
    about="http://ce.org/cea-2018/AnnexB"
    xmlns="http://ce.org/cea-2018"
    xmlns:dc="http://purl.org/dc/elements/1.1"
    xmlns:dcterms="http://purl.org/dc/terms">

  <dc:title xml:lang="en">Playing Music</dc:title>
  <dc:description xml:lang="en">CEA-2018 conformant sample task model description for
    playing music with UPnP AV devices and URC grounding.</dc:description>
  <dc:creator>Gottfried Zimmermann</dc:creator>
  <dc:contributor>Charles Rich</dc:contributor>
  <dcterms:issued>2007-08-25</dcterms:issued>
  <dcterms:modified>2007-09-10</dcterms:modified>

  <task id="playMusic">
    <subtasks id="playMusicSteps" ordered="false">
      <step name="select" task="selectMusic"/>
      <step name="configure" task="configureRenderer"/>
      <step name="connect" task="connect" requires="select configure"/>
      <step name="play" task="play" requires="connect"/>
      <binding slot="$connect.preferredConnectionProtocol" value=""*""/>
    </subtasks>
  </task>
  <task id="selectMusic">
    <subtasks id="selectMusicSteps">
      <step name="server" task="selectServer"/>
      <step name="browse" task="browse"/>
      <step name="node" task="selectNode"/>
      <binding slot="$browse.browseFilter" value="*"/>
      <binding slot="$browse.browseSortCriteria" value="+dc:title"/>
      <binding slot="$play.connectionId" value="$connect.newConnectionId"/>
    </subtasks>
  </task>
  <task id="configureRenderer">
    <subtasks id="configureRendererSteps">
      <step name="select" task="selectRenderer"/>
      <step name="preset" task="selectPreset" minOccurs="0" maxOccurs="1"/>
    </subtasks>
  </task>

  <script platform="URC">
    // ...
  </script>

  <script platform="URC" init="true">
    // ...
  </script>

  <task id="selectServer">
    <input name="selectedMediaServer" type="string"/>
  </task>
  <task id="browse">
    <input name="browseFilter" type="string"/>
    <input name="browseSortCriteria" type="string"/>
  </task>
  <task id="selectNode">
    <input name="selectedNodeId" type="string"/>
  </task>
  <task id="selectRenderer">
    <input name="selectedMediaRenderer" type="string"/>
  </task>
  <task id="selectPreset">
    <input name="presetName" type="string"/>
  </task>
  <task id="connect">
    <input name="preferredConnectionProtocol" type="string"/>
    <output name="newConnectionId" type="string"/>
    <output name="error" type="ErrorDescription"/>
  </task>
  <task id="play">
    <input name="connectionId" type="string"/>
    <input name="playCurrentPlayMode" type="PlayMode"/>
    <input name="playTransportPlaySpeed" type="PlaySpeed"/>
  </task>

  <!-- external events -->

  <task id="transportStatusError">
    <output name="error" type="ErrorDescription"/>
  </task>
  <task id="conNotifyContentFormatMismatch">
    <output name="error" type="ErrorDescription"/>
  </task>
  <task id="conNotifyInsufficientNetworkResources">
    <output name="error" type="ErrorDescription"/>
  </task>
  <task id="conNotifyUnreliableChannel">
    <output name="error" type="ErrorDescription"/>
  </task>
  <task id="conNotifyUnknownConnectionError">
    <output name="error" type="ErrorDescription"/>
  </task>
</taskModel>
```

CEA-2018 Task Model Description

Target Architecture



CEA-2018 Task Model Description

Examples of Task-Based Applications

CEA-2018 will facilitate CE manufacturers developing a wide range of new capabilities to improve usability and customer satisfaction, such as:

- Network Command Menu
- Natural Language Access to EPG *
- Intelligent Help Agent *
- Task Personalization
- Intelligent Home Network Troubleshooting
- etc.

* *Based on submissions to DLNA call for Far-Future Usage Scenarios*

CEA-2018 Task Model Description

(1) Network Command Menu

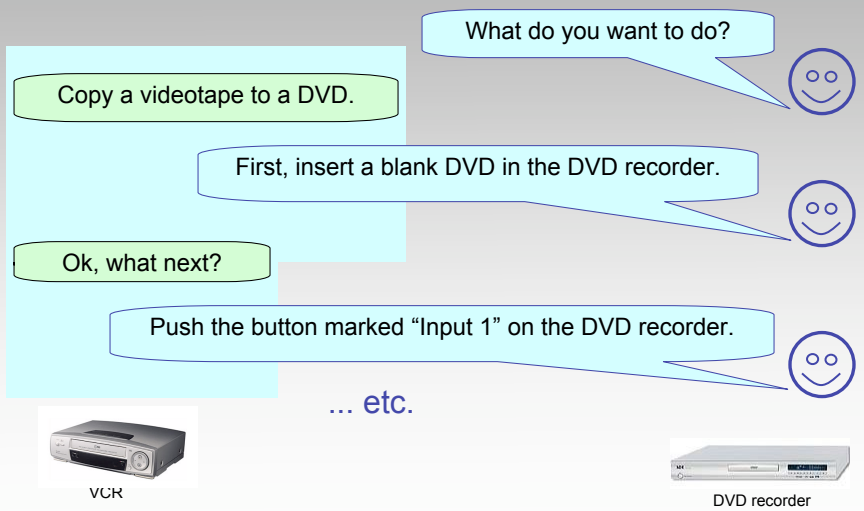
Copy	The Matrix		in the	living room
Play	**Star Wars**			**bedroom**
Record	Survivor			kitchen
Delete	CSI			study
Stop	Numbers			
	Top Gear			

CEA-2018 Task Model Description

(2) Natural language access to Electronic Program Guide


DVR

(3) Intelligent Help Agent



CEA-2018 Task Model Description

(4) Personalized Tasks

Task: “Wake me up”

6:00 am – set thermostat to 70 F.

6:45 am – start coffee pot

7:00 am – ring alarm clock

“Wake me up tomorrow morning.”

2. Intelligent Tutoring Systems

- *Basic concepts:* goals/tasks, student (cognitive) model, tutorial strategies, assessment
- *How used:*
  - tutorial presentation and dialogue
  - diagnosis
  - knowledge tracing
  - data mining
- *Readings:*
  - Conati et al, On-Line Student Modeling for Coached Problem Solving Using Bayesian Networks, UM'97
  - Rickel & Johnson, Integrating Pedagogical Capabilities in a Virtual Environment Agent, AA'97

3. Automated GUI Design

- *Basic concepts:* goals/tasks, usage pattern (trace)
- *How used:*
  - automated layout
  - automated adaptation to device characteristics
  - maximizing user performance
- *Readings:*
  - Gajos & Weld, SUPPLE: Automatically Generating User Interfaces, IUI'04
  - Bunt et al, Supporting Interface Customization using a Mixed-Initiative Approach, IUI'07

4. Personal Assistants

- *Basic concepts:* goals/tasks, (mixed) initiative, collaboration, utility
- *How used:*
  - delegation of tasks
  - adaptation to user (learning)
- *Readings:*
  - Segal & Kephart, MailCat: An Intelligent Assistant for Organizing E-Mail, AA'99
  - Berry et al, A Personalized Time Management Assistant: Research Directions, AAAI SS 2005

5. Recommender Systems

- *Basic concepts:* rating, user profile, “taste” space (neighbors)
- *How used:*
  - recommend item (with constraints)
  - predict rating for given item
  - collaborative or single-user
- *Readings:*
  - Schafer et al, Collaborative Filtering Recommender Systems, LNCS 2007
  - Pazzani & Billsus, Content-Based Recommendation Systems, LNCS 2007

6. Multimodal Dialogue

- *Basic concepts:* speech, gesture, gaze, vision, graphics (smell?, touch?)
- *How used:*
  - both as input to system (e.g., reference resolution)
  - and as output (e.g., presentation planning)
- *Readings:*
  - Chai et al, A Probabilistic Approach to Reference Resolution, IUI'04
  - Horchani et al, A Platform for Output Dialogic Strategies in Natural Multimodal Dialogue Systems, IUI'07

7. Collaborative Dialogue

- *Basic concepts:* goals/tasks, focus of attention, collaboration, (mixed) initiative
- *How used:*
  - conversation (natural or artificial language)
  - discourse interpretation and generation
- *Readings:*
  - Allen et al, Chester: Towards a Personal Medication Advisor, J. Biomedical Informatics 2006 [*long paper*]
  - Rich et al, COLLAGEN: Applying Collaborative Discourse Theory to Human-Computer Interaction, AI Magazine 2001

8. Embodied Conversational Agents

- *Basic concepts:* avatar (on-screen "body"--not robot)
- *How used:*
  - facial expression and body language
  - multimodal interaction
  - personal relationship
- *Readings:*
  - Pelachaud, Multimodal Expressive Embodied Conversational Agents, MM'05
  - Bickmore & Picard, Establishing and Maintaining Long-Term Human-Computer Relationships, ToCHI 2005 [*long paper*]

9. Affective Computing

- *Basic concepts:* emotion model
- *How used:*
  - relating emotion to goals/tasks and world state
  - displaying emotion
  - recognizing display of emotion in others
- *Readings:*
  - Gratch & Marsella, Lessons from Emotion Psychology for the Design of Lifelike Characters, AAI 2005
  - D'Mello et al, Towards an Affect-Sensitive AutoTutor, IEEE Intelligent Sys. 2007

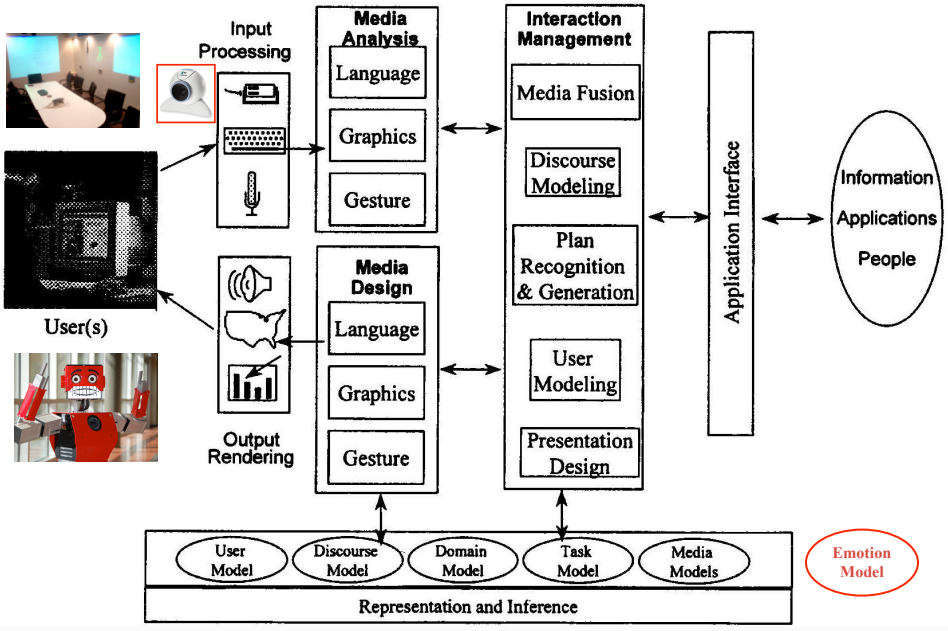
10. Human-Robot Interaction

- *Basic concepts:* tasks/goals, sensors, actuators, collaboration, engagement
- *How used:*
  - multimodal interaction
  - humanoid ("anthropomorphicizable") robots (and not)
  - teleoperation (esp. for multiple autonomous vehicles)
- *Readings:*
  - Morency et al, Head Gestures for Perceptual Interfaces: The Role of Context in Improving Recognition, AIJ 2007 [*long paper*]
  - Breazeal et al, Learning From and About Others: Towards Using Imitation to Bootstrap the Social Understanding of Others by Robots, Art. Life 2004 [*long paper*]

11. Intelligent Environments

- *Basic concepts:* pervasive sensors & actuators
- *How used:*
  - office environment (e.g,. meeting support)
  - home environment (e.g., heat, lights)
  - outdoor environments (e.g., mobile)
- *Readings:*
  - Hanssens et al, Building Agent-Based Intelligent Workspaces, ABA'02
  - Youngblood et al, A Learning Architecture for Automating the Intelligent Environment, IAAI'05

Goal/Task Based User Interfaces -*all* (except maybe recommender systems)	**Intelligent Tutoring Systems** -goal/task based UI -multimodal dialogue -collaborative dialogue -embodied conv. agent -affective computing	**Automated GUI Design** -goal/task based UI -personal assistants	**Personal Assistants** -goal/task based UI -recommender systems -embodied conv. agent
Recommender Systems -personal assistants	**Multimodal Dialogue** -goal/task based UI -multimodal dialogue -intelligent tutoring sys. -personal assistants	**Collaborative Dialogue** -goal/task based UI -multimodal dialogue -intelligent tutoring sys. -personal assistants	**Embodied Conversational Agents** -goal/task based UI -multimodal dialogue -intelligent tutoring sys. -personal assistants
Affective Computing -goal/task based UI -multimodal dialogue -intelligent tutoring sys. -human-robot interact.	**Human-Robot Interaction** -goal/task based UI -multimodal dialogue -collaborative dialogue -affective computing	**Intelligent Environments** -goal/task based UI -multimodal dialogue -personal assistants	



From: Introduction to Readings in Intelligent User Interfaces, Maybury & Wahlster, 1998.

Three important sub-areas not covered

1) Information Visualization
   - Closely related to automated GUI design
     - CS 525D - special topics course taught occasionally by Prof. Ward
     - S.K. Card, J.D. Mackinlay & B. Schneiderman, Readings in Information Visualization, Morgan-Kaufmann, 1999.

Three important sub-areas not covered

2) Example/Demonstration Based Systems
   - Use generalization techniques to replace manual programming
     - cover in this course next time?
     - H. Lieberman, Your Wish is My Command: Programming by Example, Morgan-Kaufmann, 2001.

Three important sub-areas not covered

3) Evaluation
   - Same issues as evaluating any interactive system
     - CS 546 - grad HCI course, taught alternate years
     - H. Sharp, Y. Rogers & J. Preece, Interaction Design: Beyond Human-Computer Interaction, 2nd ed., Wiley, 2007

Resources

• J.W. Sullivan & S.W. Tyler, Intelligent User Interfaces, ACM Press, 1991.

• M.T. Maybury & W. Wahlster, Readings in Intelligent User Interfaces, Morgan-Kaufmann, 1998.

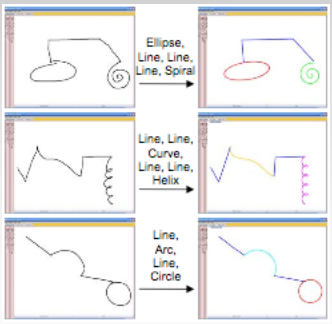
• ACM International Conference on Intelligent User Interfaces, 1993-2008 (www.iuiconf.org)

** Program Cochairs: Charles Rich and Nuno Nunes*

Highlights of the 2008 Conference

Sketch-Based Interfaces

- PaleoSketch: Accurate Primitive Sketch Recognition and Beautification
  - Brandon Paulson, Tracy Hammond, Texas A&M



Intelligent Fitting Room

- An Intelligent Fitting Room Using Multi-Camera Perception
  - Wei Zhang (Oregon State), Takashi Matsumoto (Keio), Juan Liu, Maurice Chu, Bo Begole (PARC)