

People, Sensors, Decisions: Customizable and Adaptive Technologies for Assistance in Healthcare.

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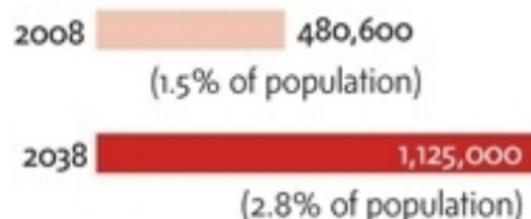
POMDP Practitioners Workshop, May 12th, 2010



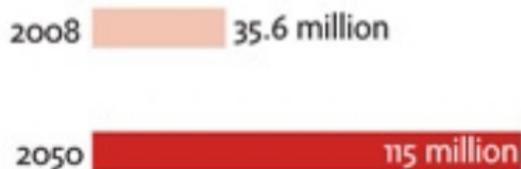
School of Computing
UNIVERSITY OF DUNDEE

Motivation

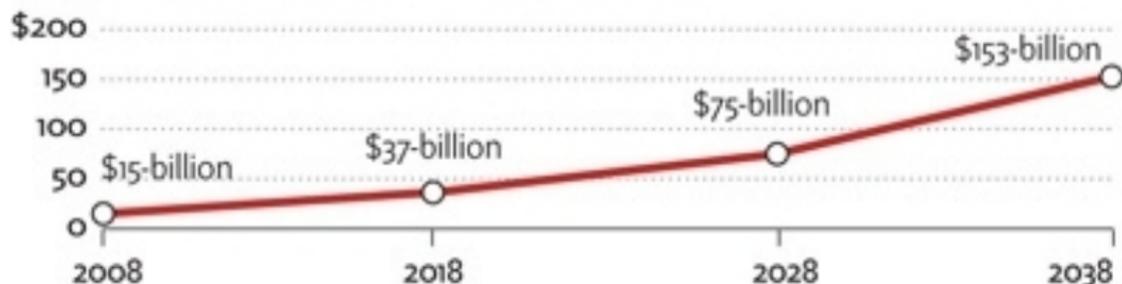
Prevalence of Alzheimer's and related dementias in Canada



Prevalence of Alzheimer's and related dementias worldwide



The economic burden of dementia in Canada



THE GLOBE AND MAIL » SOURCES: ALZHEIMER SOCIETY OF CANADA. WORLD ALZHEIMER REPORT

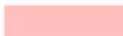
Motivation

*Excess demand for
LTC beds in Canada*

2008  15,392

2038  **157,461**

*Hours of informal care provided
for people with dementia in Canada*

2008  231 million hours

2038  **756 million hours**

source: Alzheimer's Society of Canada

Motivation

Care is shifting toward home/patient/community

Technology

- ▶ can connect providers with recipients,
- ▶ can increase range/scope of care provision,
- ▶ but currently developed for specific applications:
- ▶ difficult to modify to suit individual user needs.

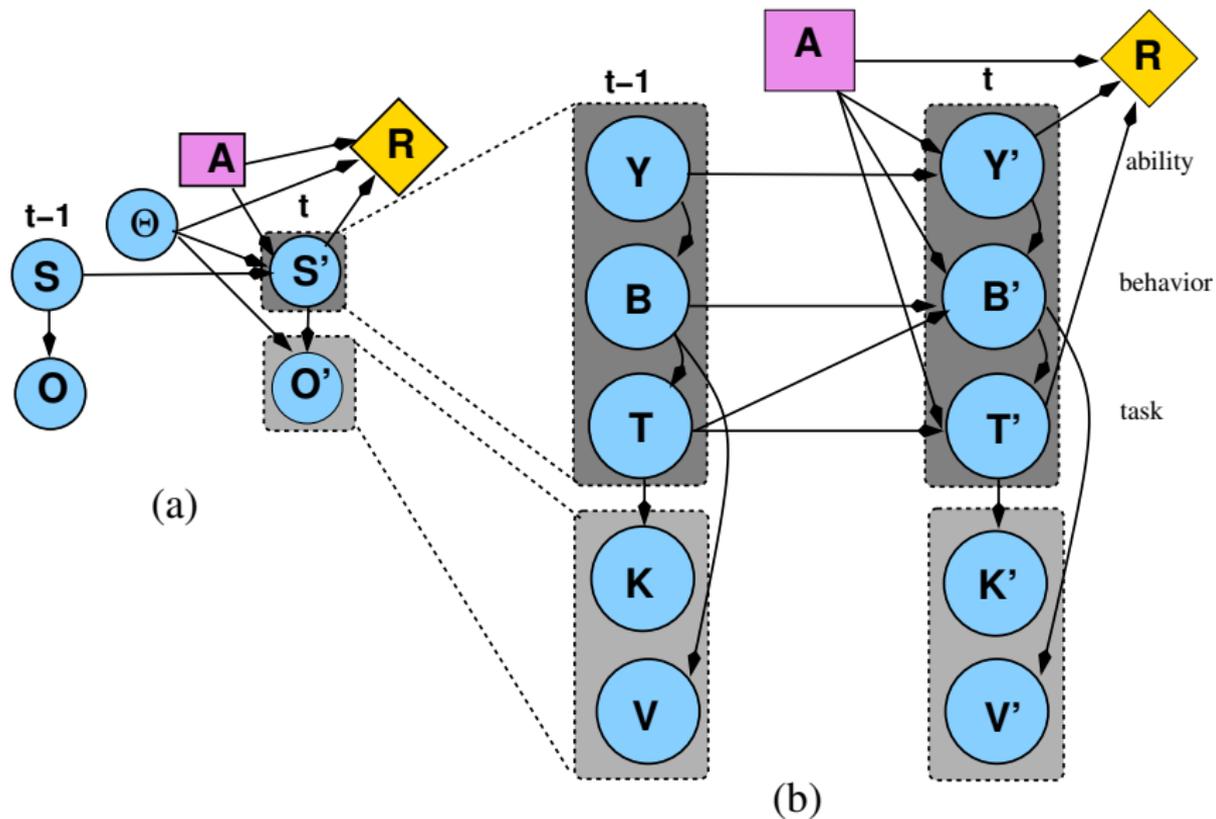
Economic and Social impact of Healthcare Informatics:

- ▶ Users/Customizability
- ▶ Sensors/Generalizability
- ▶ Decisions/Adaptivity

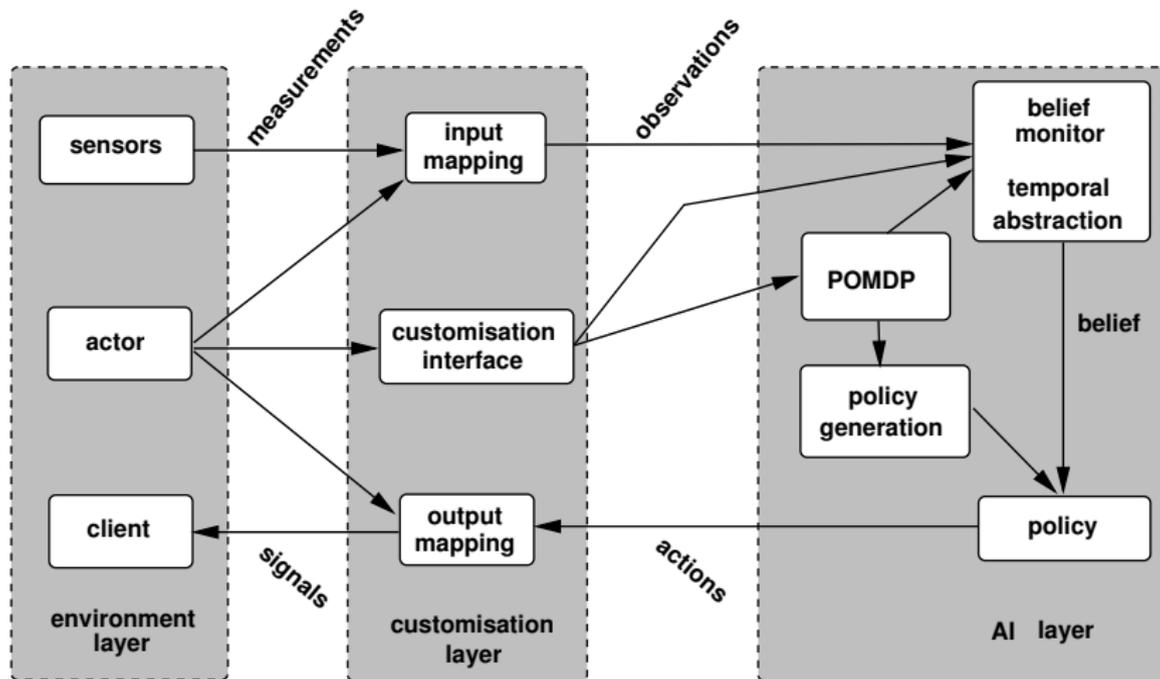
Talk Overview

- ▶ Assistance: what is involved?
 - ▶ User-centered design: what clients want
 - ▶ Computer vision: a general purpose virtual sensor
 - ▶ Generic, customizable task controllers
- ▶ Examples
 - ▶ COACH: Handwashing assistant (the “Talking Sink”)
 - ▶ ePAD: Art Therapy Tools
 - ▶ SNAP: Customizable situated prompting
- ▶ Future Work

Assistance Model



System Model



Solutions

- ▶ 200K states \times 198 observations \times 26 actions
- ▶ Optimal solution **intractable**
- ▶ **Approximations** used:
 - ▶ Point-based (**Perseus** - Vlassis & Spaan, 2005)
 - ▶ Structured solution (**SPUDD** - Hoey & St. Aubin, 1999)
 - ▶ Bound size of solution (Poupart, 2005)
 - ▶ Disregard observations (Hoey & Poupart, 2005)
 - ▶ State aggregation (St. Aubin & Hoey, 2000)
- ▶ 75 iterations on Intel Xeon 3GHz - 4GB RAM: 53 Hours

Example I: COACH Handwashing System

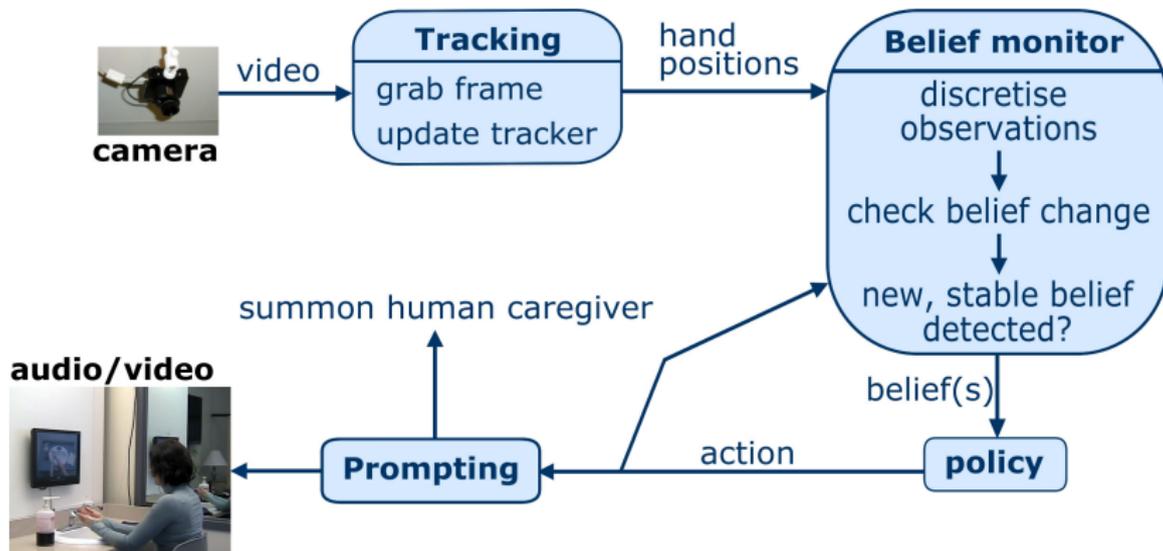


An intelligent cognitive device that tracks a user through handwashing, providing cues when necessary.

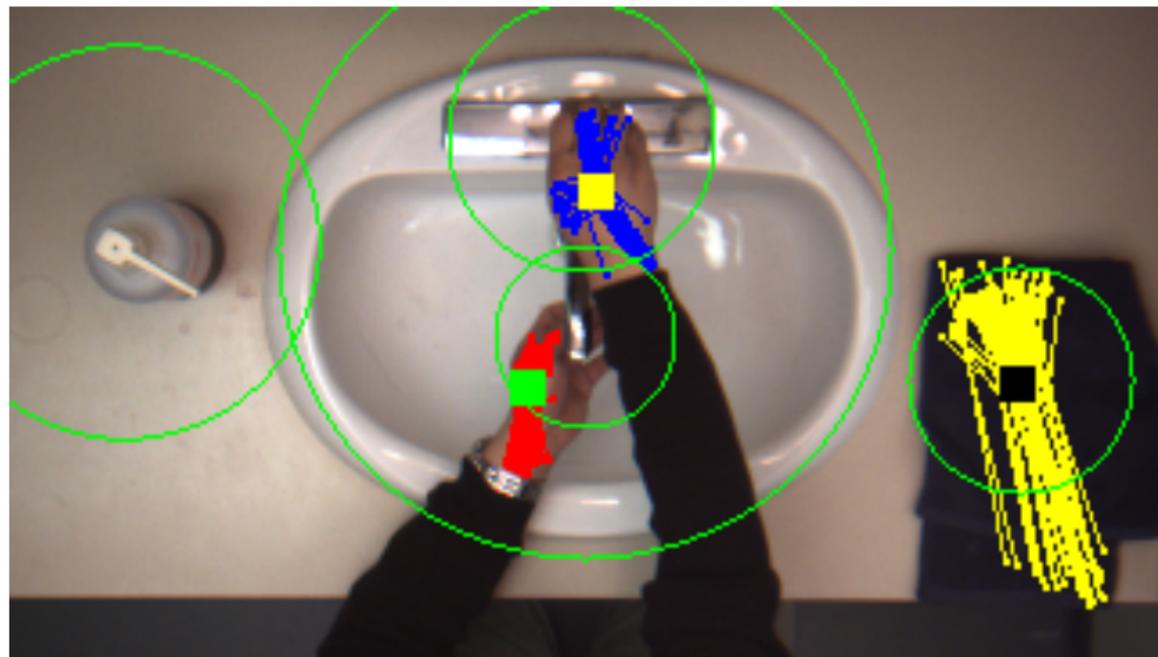


Cognitive Orthosis for Assisting Activities in the Home

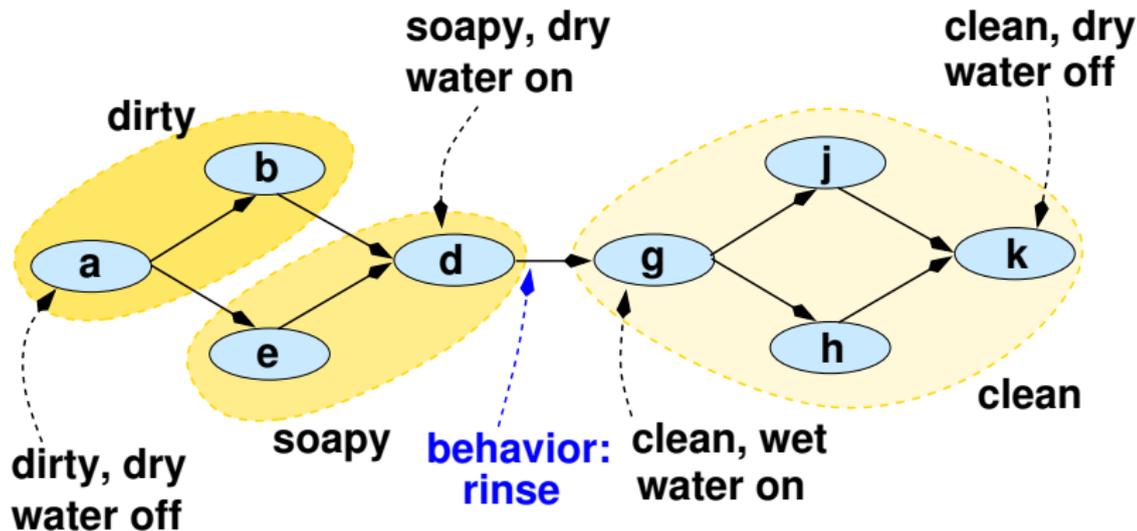
Handwashing: Integrated System



Handwashing Behaviors: Hand Locations



Handwashing Task: Plansteps



Handwashing: Abilities

Factor:	Models:	Dynamics:
Awareness	need for assistance	changes quickly
Responsiveness	response to assistance	changes from day to day
Dementia Level	likelihood user will be aware and responsive	does not change ...learn?

Handwashing: Rewards

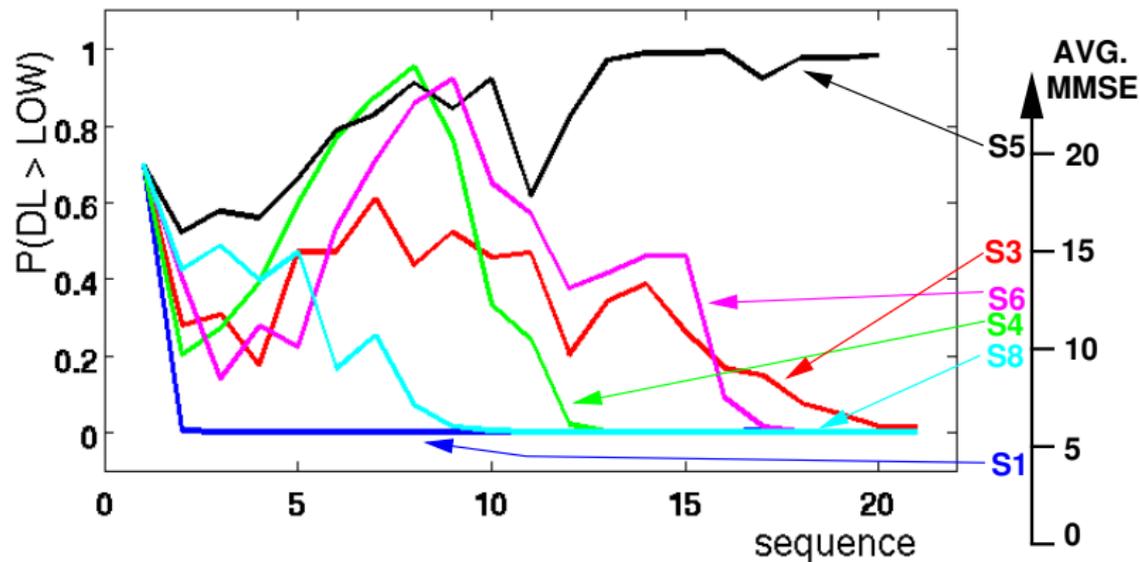
Tradeoff multiple, competing objectives



User Trial Example

Example: Subject 4, Trial 34

Learning Dementia Level



Example II: Art Therapy



Benefits:

- ▶ Leisure promotes well-being
- ▶ Leisure decreases Dementia Risk
- ▶ Cognitive activities slow down progress of AD
- ▶ Visual artwork has additional benefits

Engaging Platform for Art Development

User Centered Design

Four phases:

- ▶ Online survey (Jan 09)
- ▶ Focus group with creative arts therapists (May 09)
- ▶ One-on-one interviews, rapid prototyping (Nov 09)
- ▶ Efficacy trials with older adults (Spring 10)

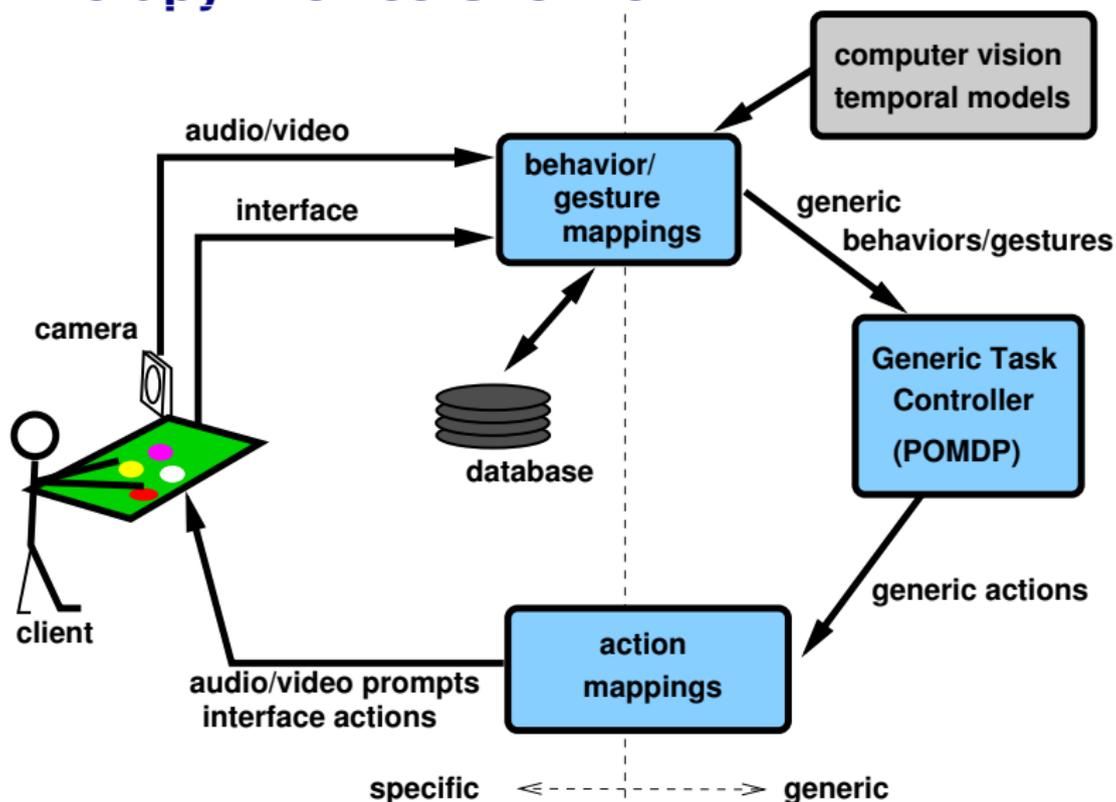
User Requirements Analysis

Major findings:

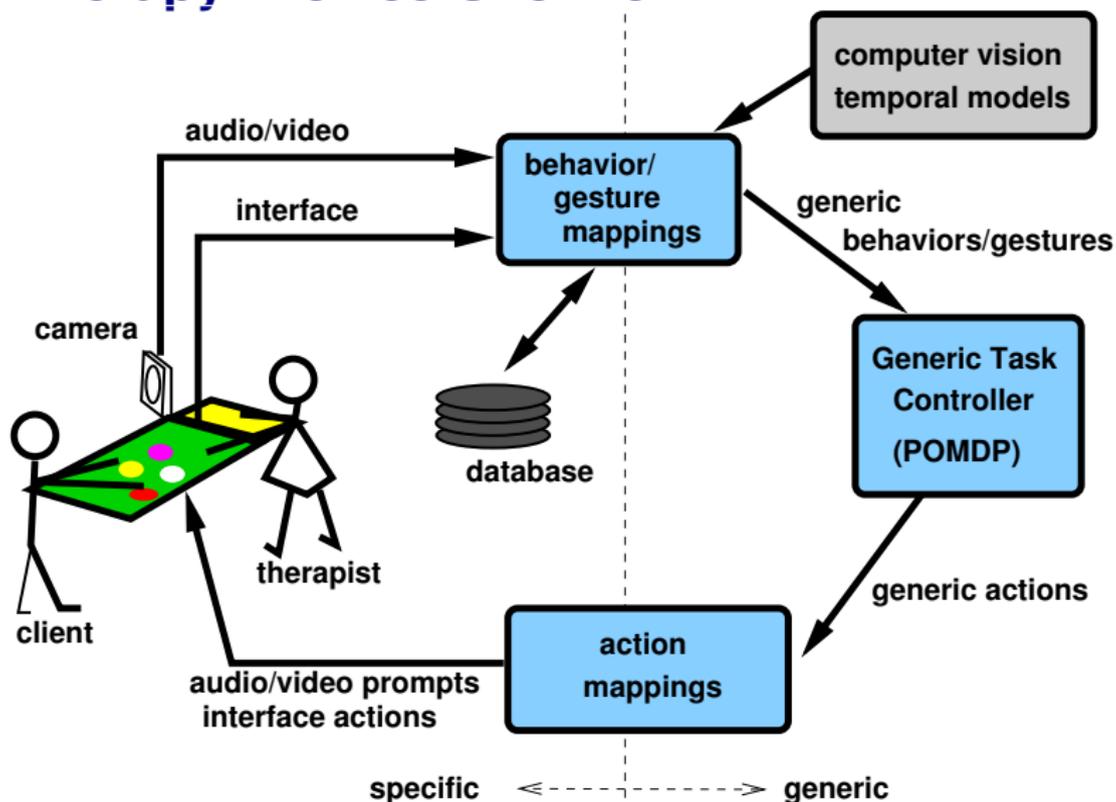
- ▶ **Enthusiasm** for idea
- ▶ **Limit** device to a therapist **inertial** tool
- ▶ **Adaptivity** to changing users
- ▶ **Multi-touch** better than single touch
- ▶ **Large** better than small
- ▶ **Customizability** by therapists



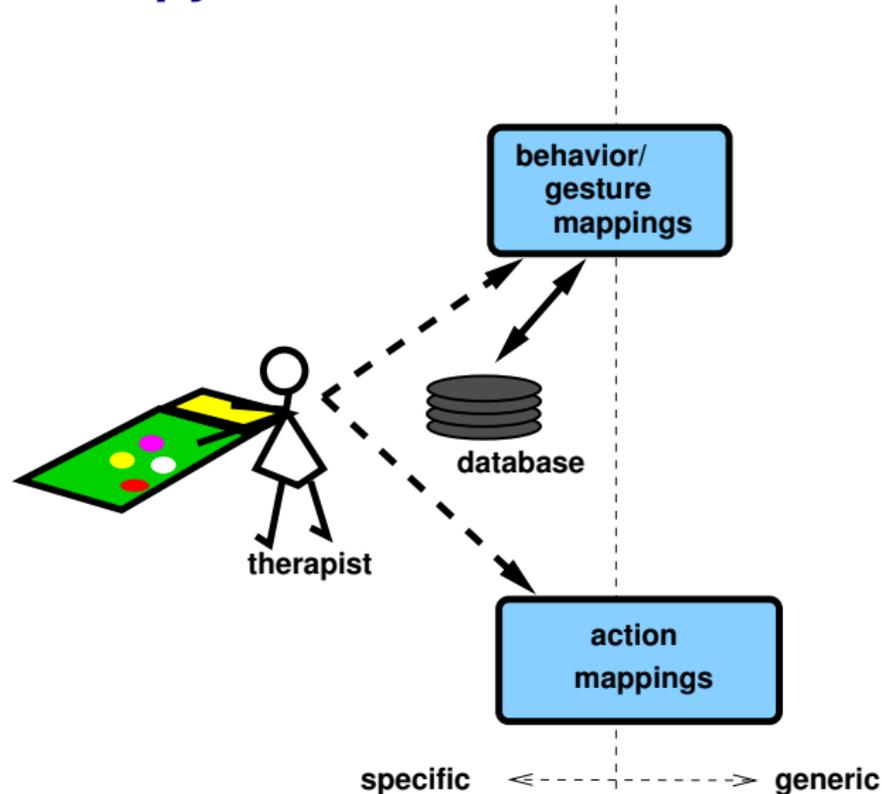
Art Therapy: Device Overview



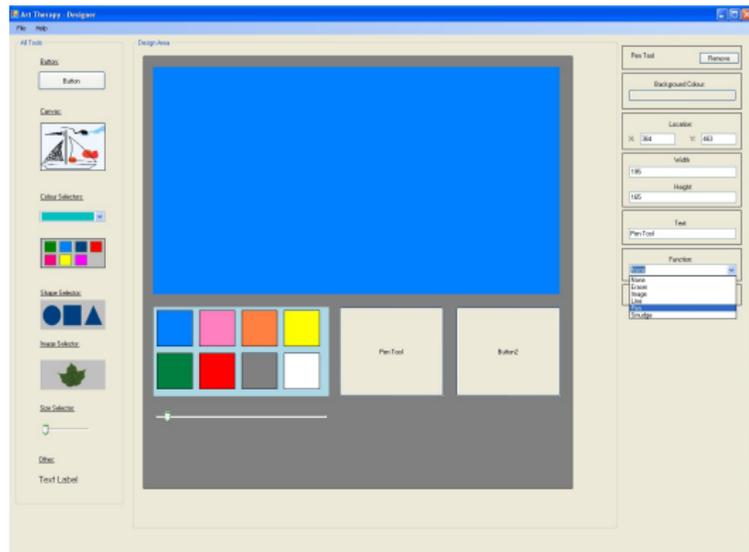
Art Therapy: Device Overview



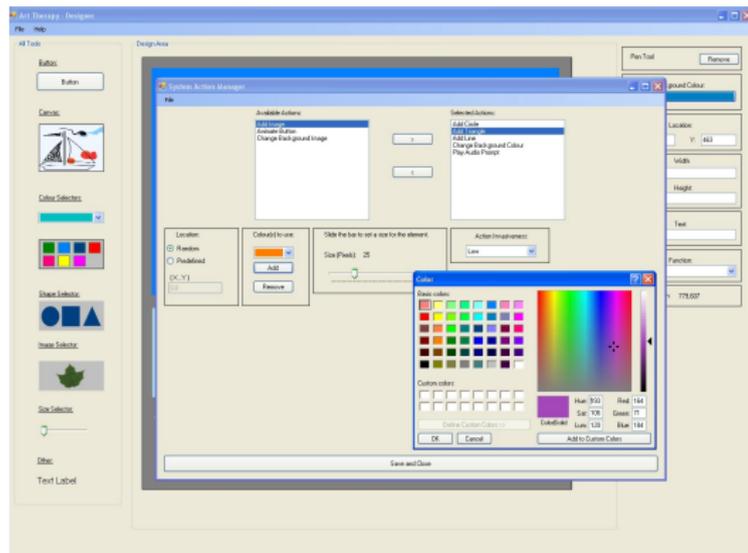
Art Therapy: Device Overview



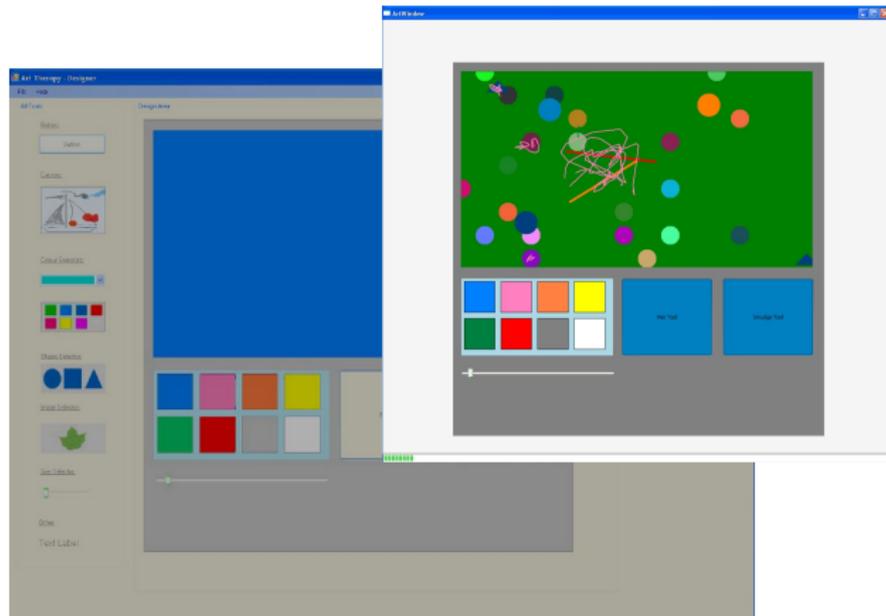
Art Therapist Interface



Art Therapist Interface

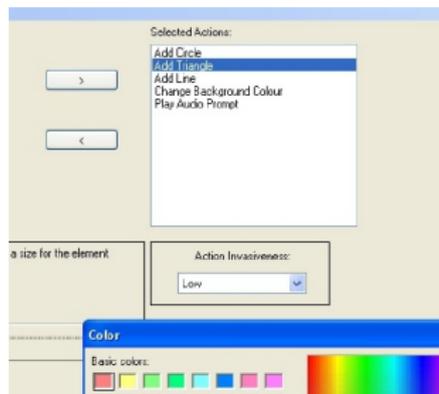


Client Application



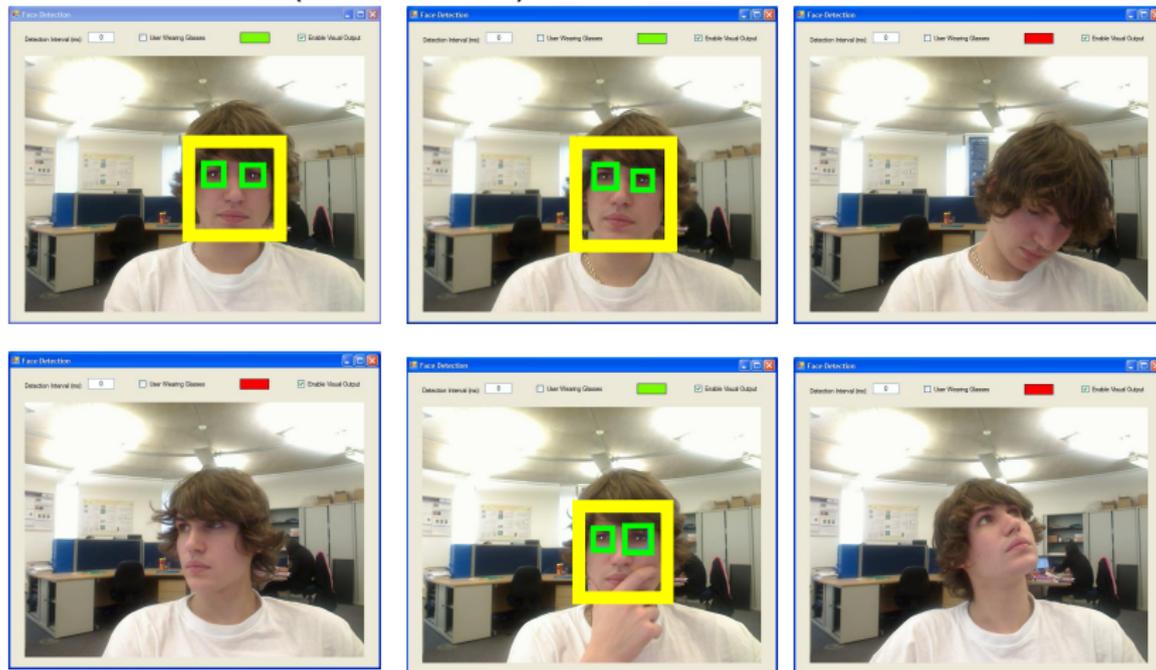
Art Therapy: Customization

- ▶ **Engagement (ability):** level of attention of a user in a task
 - ▶ face/head orientation
 - ▶ gaze direction
 - ▶ temporal on-screen actions
- ▶ **Involvement (behaviour):** categories defined by the level of engagement they demonstrate
 - ▶ interactive
 - ▶ active
 - ▶ intermittent
 - ▶ inactive
- ▶ **Interactivity (actions):** system actions place requirements on users
 - ▶ attention grabbing
 - ▶ high
 - ▶ medium
 - ▶ low

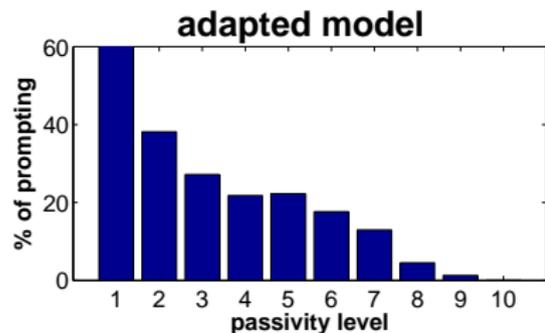


Art Therapy: Observations

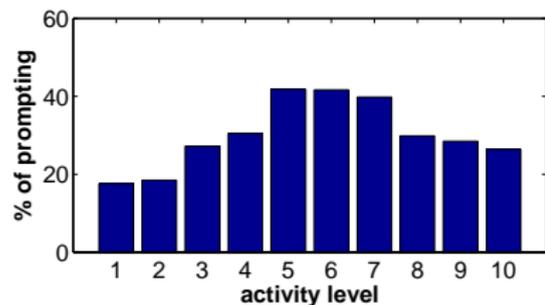
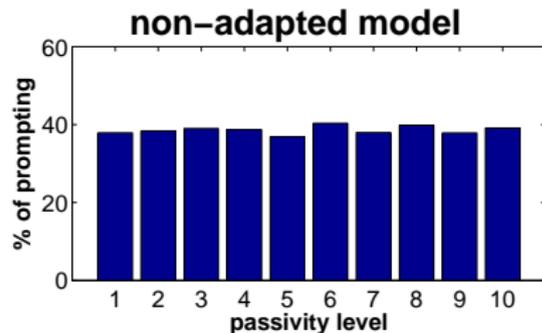
Face detection (Viola Jones)



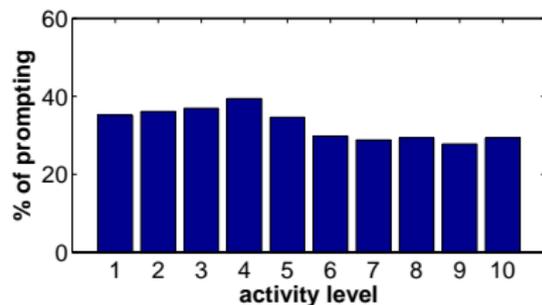
Art Therapy: POMDP Customisation



(a)



(b)



Example III: SyNdetic Assistance Processes (SNAP)

Syndetic Interaction Unit (IU) analysis
(Wherton and Monk, York)

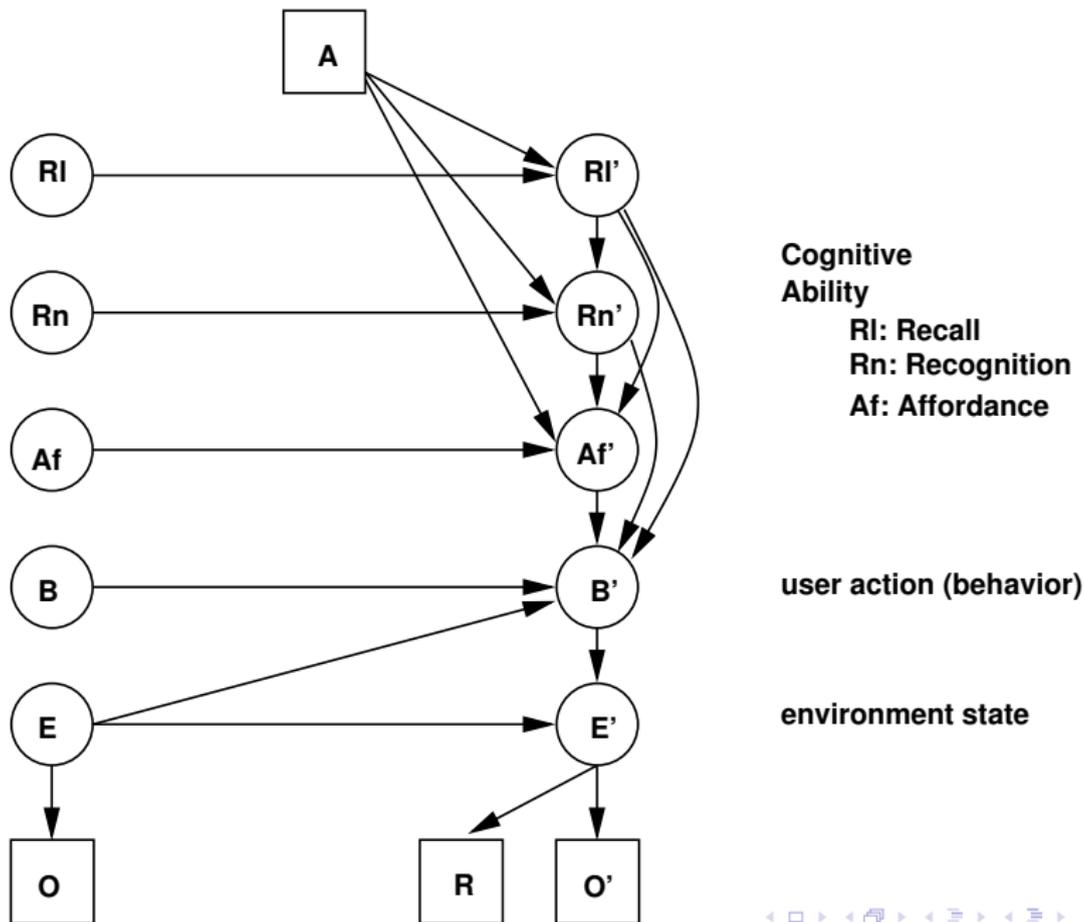


SyNdetic Assistance Processes (SNAP)

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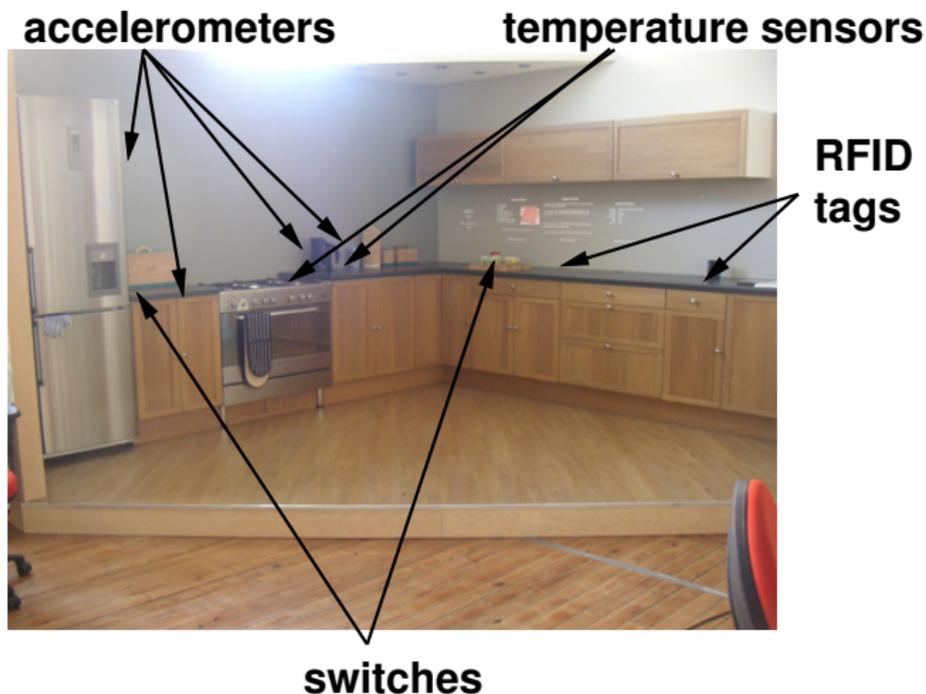
IU	Current Goals	Current Environment	Recognition/ Recall/ Affordance	Action
1	Final	cup empty on tray	Rn cup on tray Rl step	No Action
2	Final cup TB+water	cup empty on tray	Af cup tray WS	Move cup tray → WS
3	Final cup TB+water cup TB	cup empty on WS box closed	Rl box cont. TB Af box closed	Alter box to open
4	Final cup TB+water cup TB	cup empty on WS box open	Af TB in box cup	Move TB box → cup
5	Final	box open	Af box open	Alter box to closed
	Final cup TB+water			

SyNdetic Assistance Processes (SNAP)



SyNdetic Assistance Processes (SNAP)

Sensors (Ambient Kitchen, Culture Lab, Newcastle):



SNAP Demonstrative Example

Related Ongoing Work

- ▶ Stroke Rehabilitation
- ▶ Speech and Dialogue for Assistive Technology
- ▶ Wheelchair control
- ▶ Handwashing for Autistic Spectrum Disorder (ASD)
- ▶ Emergency Response and Health Monitoring
- ▶ Toothbrushing
- ▶ Music Therapy
- ▶ Decision theoretic information sharing in healthcare
- ▶ Customizable smart homes

Thanks to...

Support:

EPSRC

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Research Council

alzheimer's  association®



Partners:

