Understanding Nonverbal Behaviors

The Role of Context in Recognition

Louis-Philippe Morency | 09/24/2008

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Research Agenda

Nonverbal Behaviors for interactive interfaces

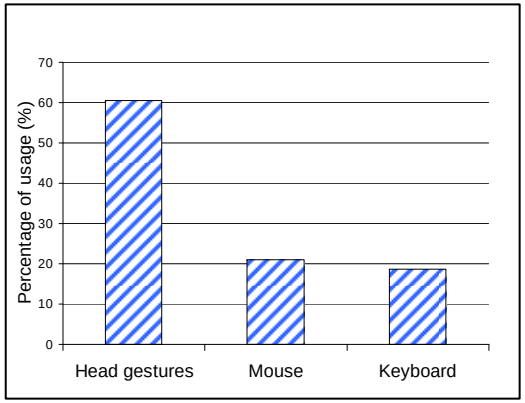
- Natural and useful feedback
- Recognition algorithms
- Contextual information

User Studies: Natural Behaviors

Mel, robotic penguin [HRI 2006]

GUI interface [IUI 2006]

Peter, virtual human [ICMI 2006]



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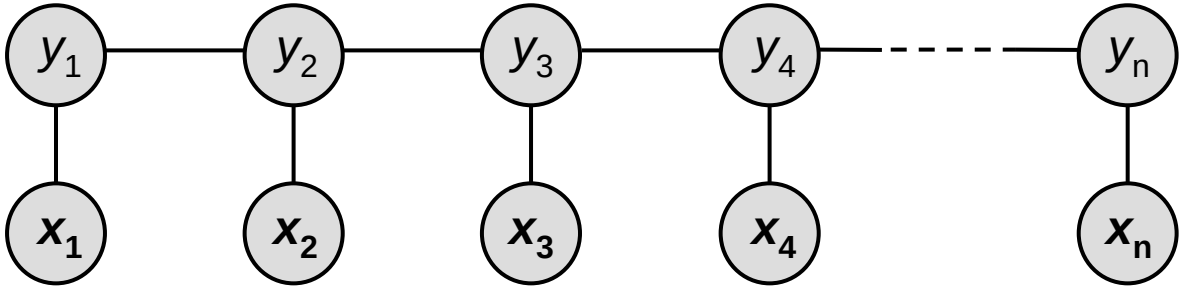
User Study Observations

- Natural gestures:
  - Head gestures: head nods and head shakes
  - Eye gestures: gaze aversion
- Internal sub-structure
- Dynamics between gestures

Conditional Random Field (CRF) [McCallum 2001]



$$P(\mathbf{y} \mid \mathbf{x}, \theta) = \frac{1}{Z(x, \theta)} \exp\left(\sum_k \theta_k \mathbf{F}_k(\mathbf{y}, \mathbf{x}) \right)$$

CRF outperforms HMM for activity recognition

[Sminchisescu05]

Problem: CRF does not model internal sub-structure

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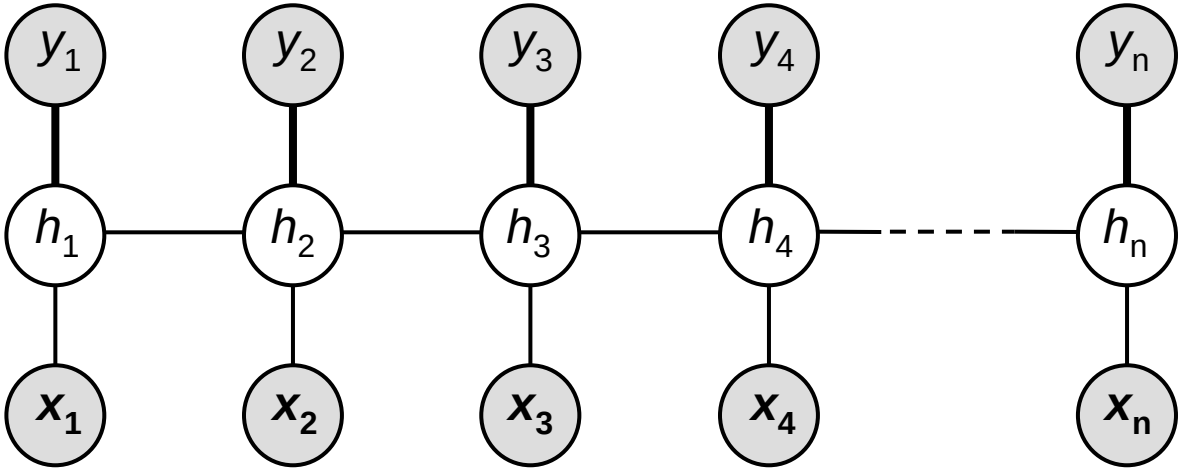
Latent-Dynamic CRF [CVPR 2007]



y_j : label

h_j : hidden state

$\boldsymbol{x}_j$: observations

$$P(\boldsymbol{y} \mid \boldsymbol{x}, \theta) = \sum_{\boldsymbol{h} \in \mathcal{H}^m} P(\boldsymbol{y} \mid \boldsymbol{h}, \theta)\, P(\boldsymbol{h} \mid \boldsymbol{x}, \theta)$$

where $\boldsymbol{h} = [h_1, h_2, h_3, \ldots, h_n]$

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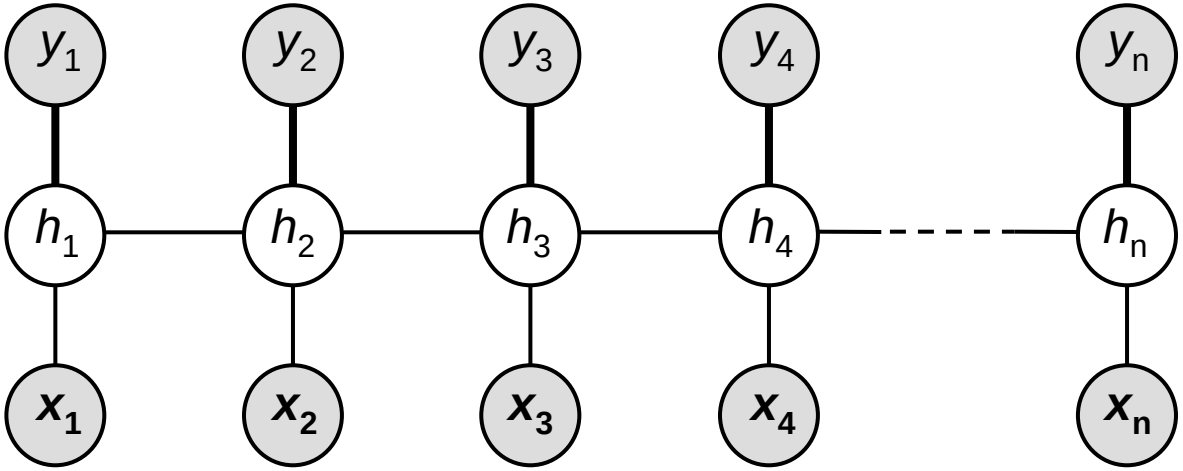
Latent-Dynamic CRF [CVPR 2007]



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Same as CRF

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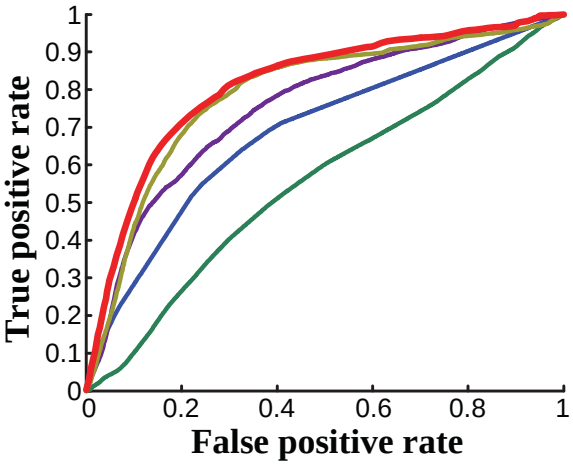
Head and Eye Gaze Estimation

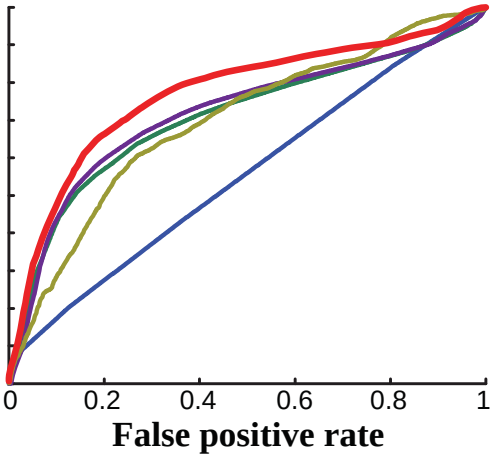
- Head gaze tracking
  [CVPR2003]
  - Adaptive View-based Appearance Model
- Eye gaze estimation
  [ICMI 2006]
  - View-based eigenspaces from 18 participants looking at 35 targets

Vision-based Recognition using LDCRF

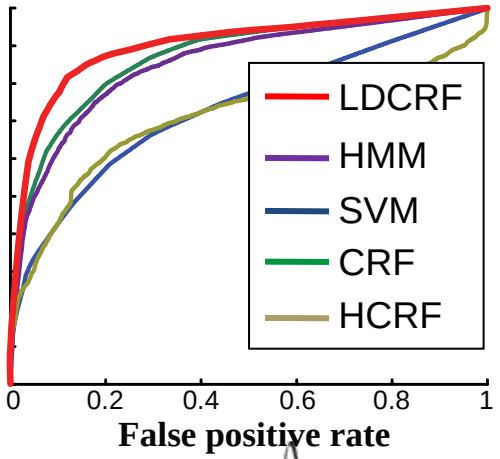
Head nods



Head nods



Gaze aversion



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Vision-based Recognition

Input Images

Head nod
or look down

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Visually Ambiguous Gestures

Head nod

Look down

Context-based Recognition

Input Images

Context

Head nod or look down

Head nod

Head nod or head shake?

"By the way, do you know Paul?"

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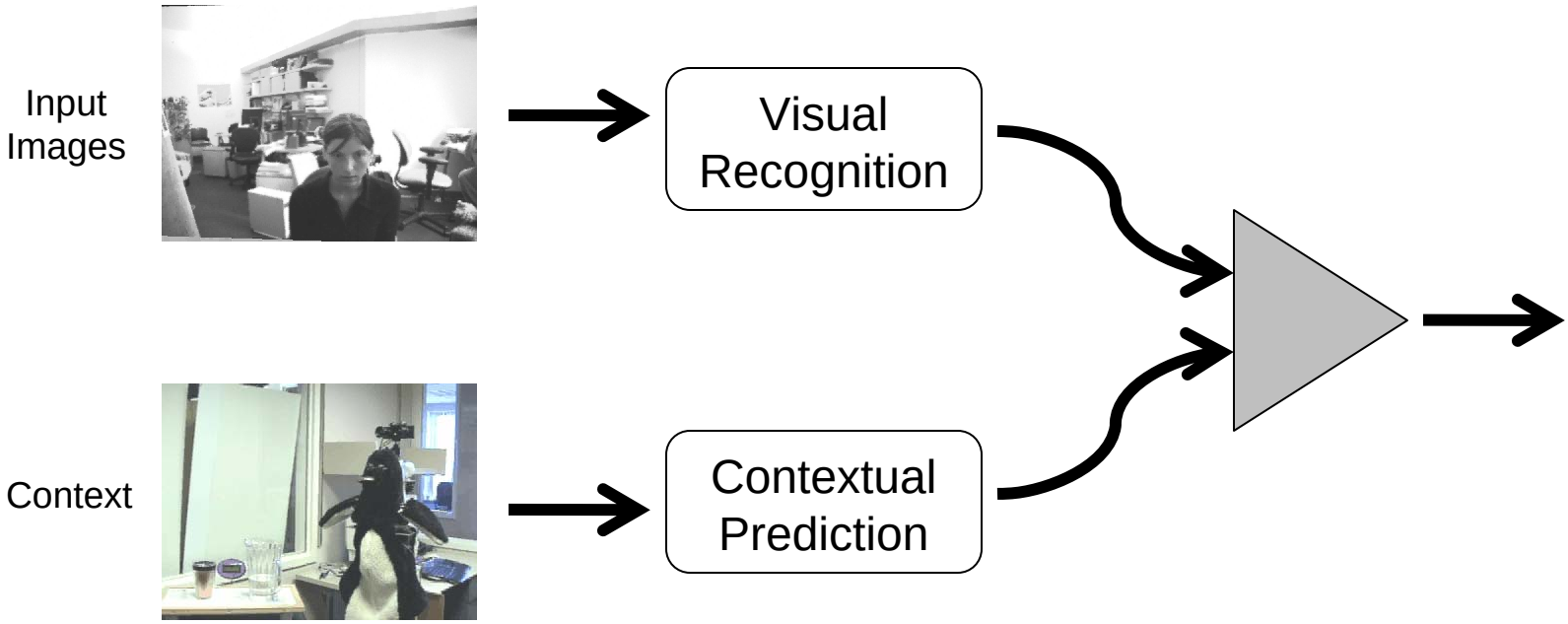
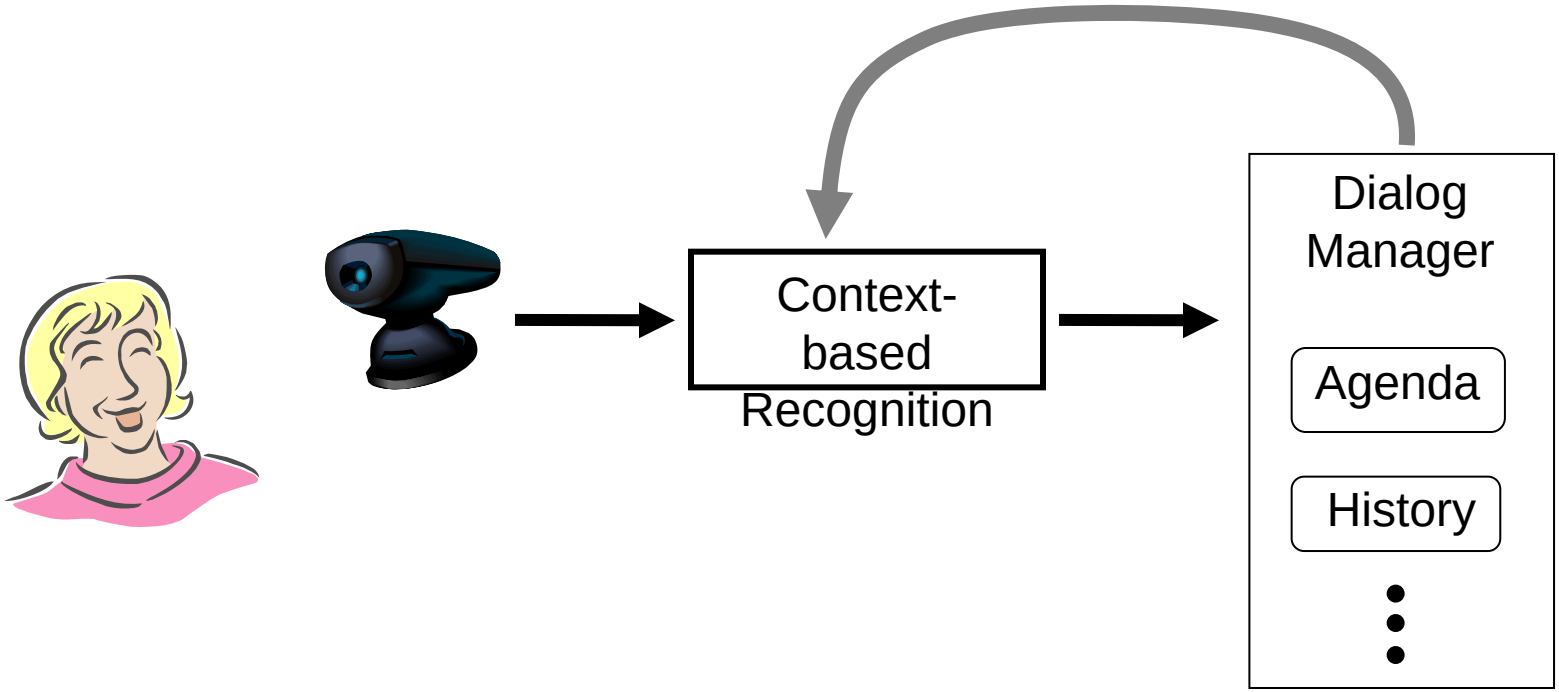
Understanding Nonverbal Behaviors

- **Use contextual knowledge from the interactive system to improve recognition of nonverbal behaviors**



Dialogue Context

- Next spoken utterance
- Prosody/punctuation
- Avatar gestures



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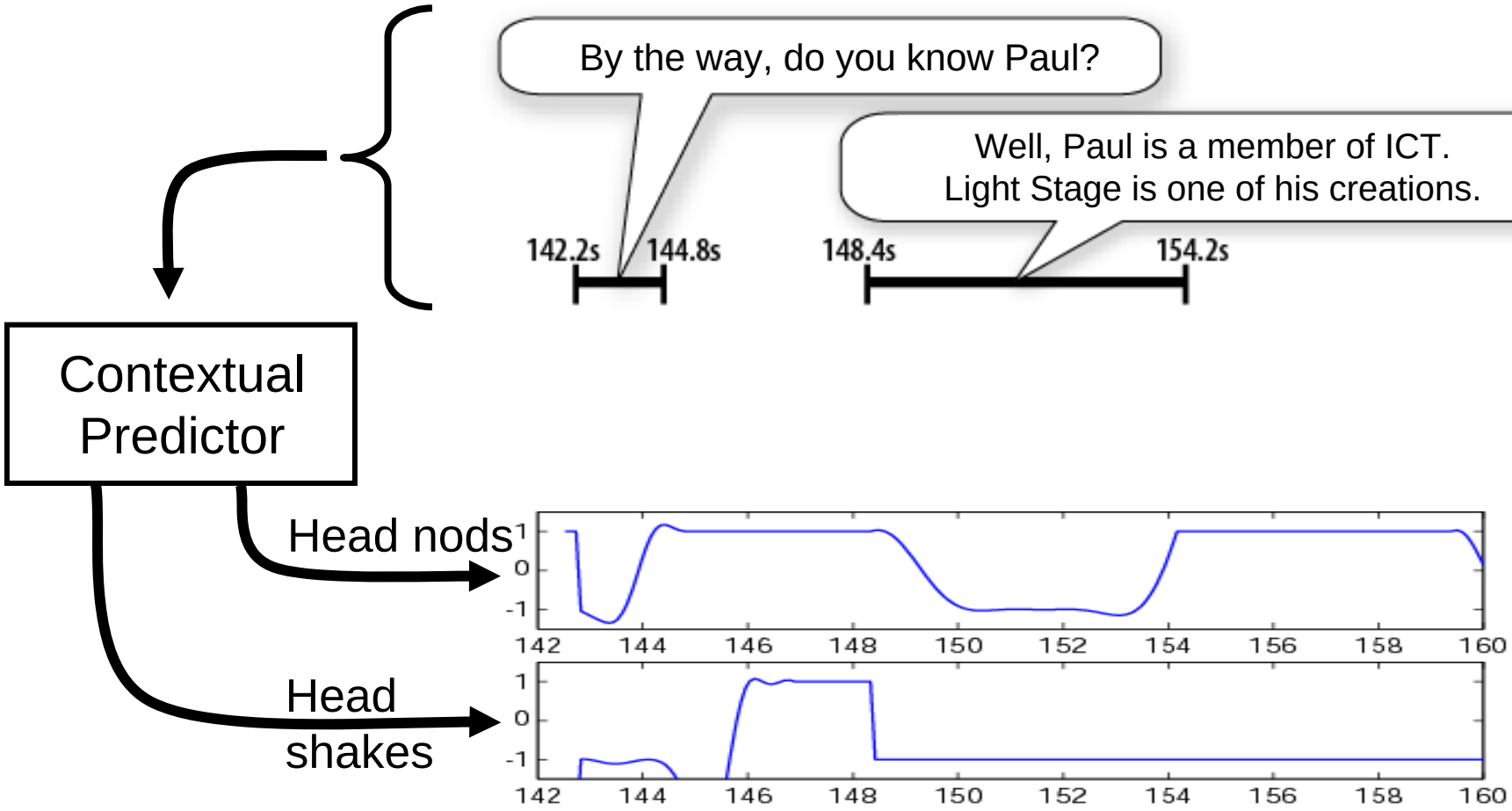
Learning Context



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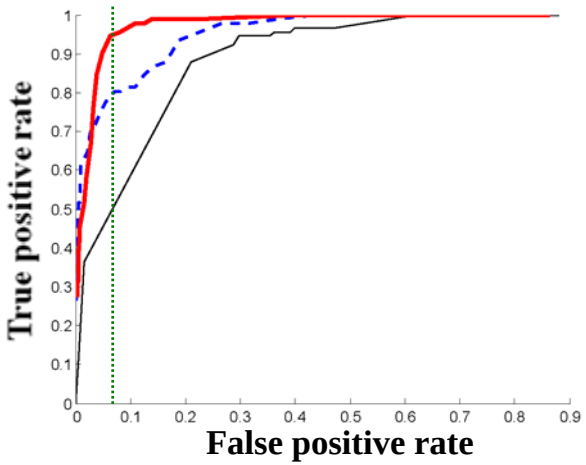
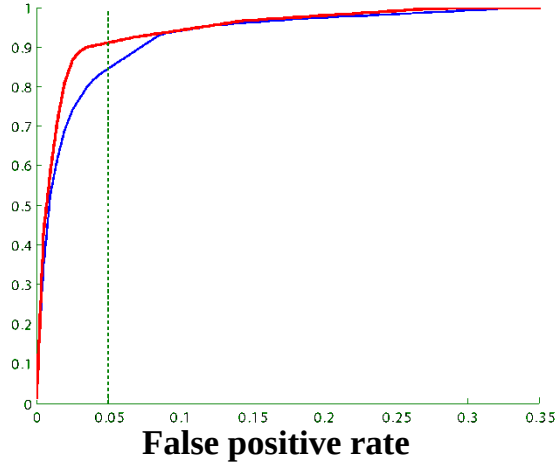
Context-based Recognition

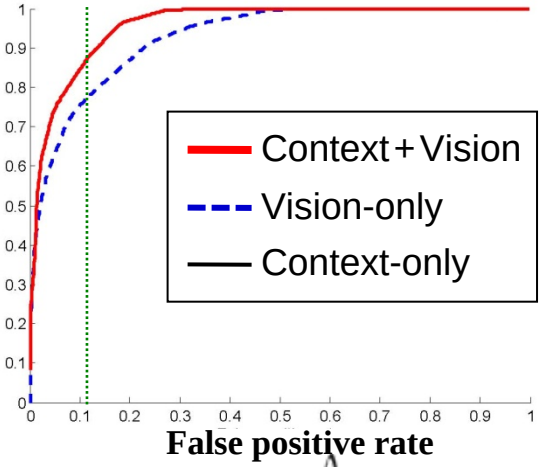
Head nods



Head nods



Gaze aversion



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Contributions

Nonverbal Behaviors for interactive interfaces

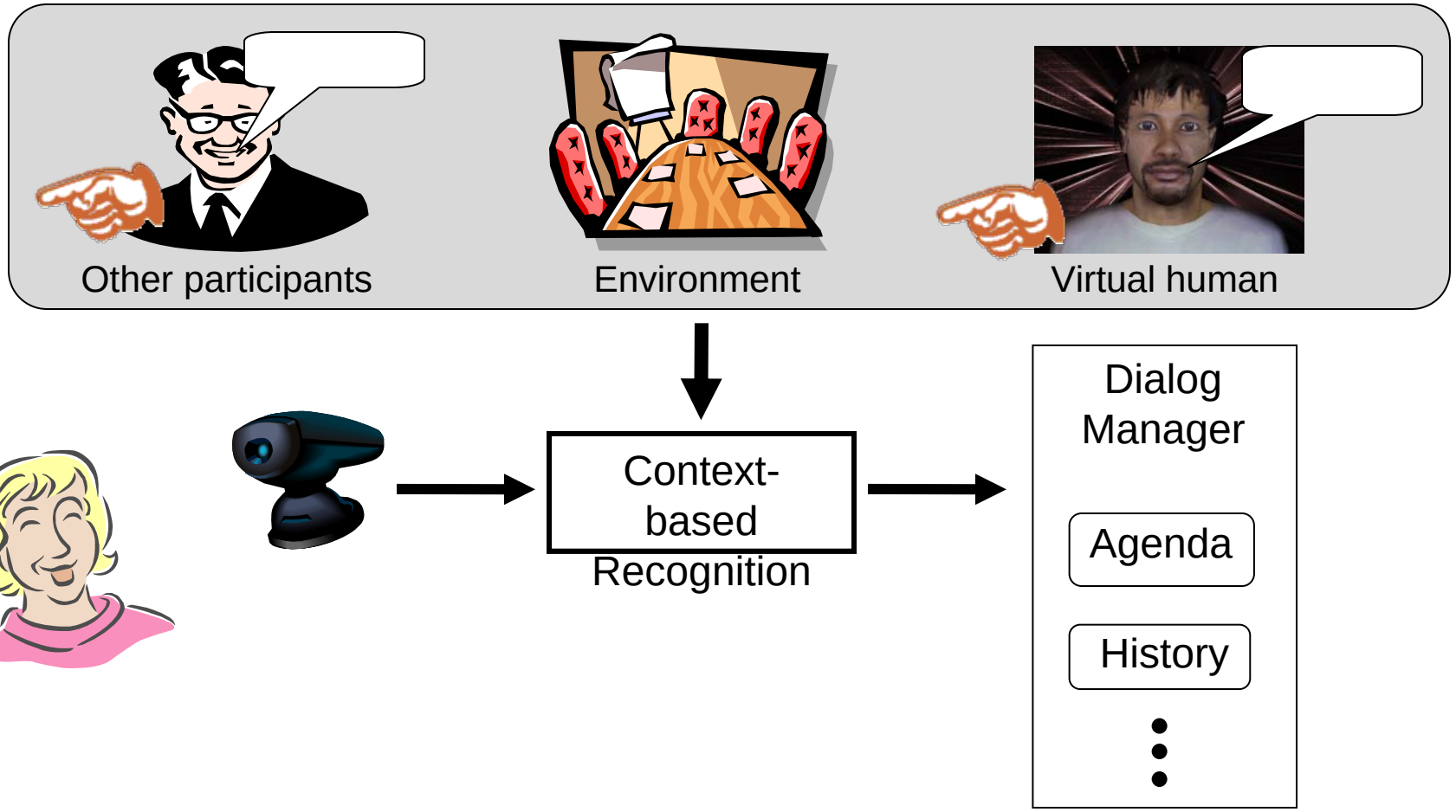
- Natural and useful feedback
  - User studies with head and eye gestures
- Recognition algorithms
  - New model for visual gesture recognition
- Contextual information
  - Context-based Visual Feedback Recognition

Future Directions

Nonverbal Behaviors for interactive interfaces

- Natural and useful feedback
  - Facial expressions, arm gestures and body posture
- Recognition algorithms
  - Shared latent-dynamic: multiple gestures and modalities
- Contextual information
  - Automatic of contextual features

Contextual Information



Collaborations

- **Watson, real-time nonverbal behavior recognition**
  - Head tracking, eye gaze estimation and gesture recognition
  - Downloaded by more than a hundred research groups
  - http://projects.ict.usc.edu/vision/watson/
- **hCRF library, discriminative dynamic models**
  - Matlab and C++ implementations of LDCRF, CRF and HCRF
  - More than 15 downloads every weeks
  - http://hcrf.sourceforge.net/

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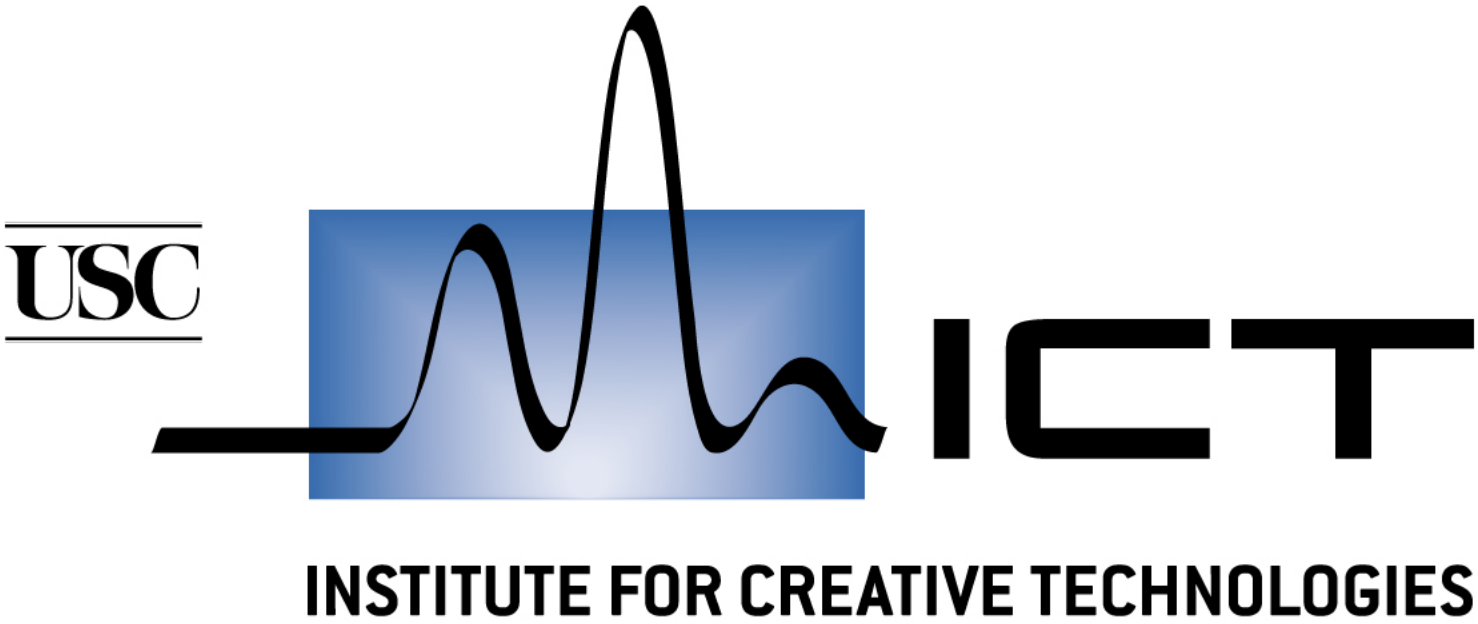
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