Learning complex visual concepts

detecting hands  direction of gaze

difficult to detect, appear early, important for subsequent learning of agents, goals, interactions
Hands are difficult to detect

multiple appearances

Van Gogh
Kirchner
small and inconspicuous

Selectivity to hands appears early in infancy

using a head camera to study visual experience

“overall... hands were in view and dynamically acting on an object in over 80% of the frames.”
Yoshida & Smith 2008

what makes hands learnable by humans?
Motion, hand as ‘mover’
(7 months old)

Saxe, Carey (2006) The perception of causality in infancy

Early sensitivity to special motion types

- high sensitivity to motion in general
  (detecting motion, motion segmentation, tracking)
- specific sub-classes of motion: self-motion, passive, and ‘mover’

A specific motion is highly indicative of hands
Detecting ‘mover’ events
Ullman, Harari, Dorfman (2012)

mover event = moving image region causing a stationary region to move or change after contact
simple and primitive, prior to objects or figure-ground segmentation
‘mover’ as an innate teaching signal for learning the concept of a hand

‘Mover’ events extracted from videos

detect high fraction of hand images
(90% recall, 65% precision)
internal supervision by movers and by tracking
Training videos

movies of scenes, people moving, manipulating objects, moving hands
‘mover’ events are detected in all movies and used for training

Hand detection in still images

detection mainly of hands in object manipulation scenes
Continued learning

Two detection algorithms:

- hands by their appearance

- hands by the body context

Hand by surrounding context

face ➔ shoulder ➔ upper-arm ➔ lower-arm ➔ hand

Amano, Kozuka, Yamamoto 2004
Slaughter Heron-Delaney 2010
Slaughter, Neary 2011
Co-training

appearance

pose

two supervised classifiers
internal co-supervision

appearance

context
Own hands

(A) [Image of own hands]

(B) [Graph showing precision and recall for manipulating and freely moving hands]

learned class, not the basis of hands in general caregiver’s hands
Gaze direction

- infants follow the gaze of others
- starts at 3-6 months and continues to develop
- head orientation first, eye cues later
- important in development of communication & language
- modeling mainly head direction

Wollaston 1824

W.H. Wollaston (1824) On the Apparent Direction of Eyes in a Portrait
Gaze cues are subtle and inconspicuous

mover supplies the teaching signal

Use hand ‘mover’ events to learn gaze direction

store: representation of image gradients
Gaze extraction

Training

Testing

model →

humans →

Gaze results, 700 test images