

Learning complex visual concepts



detecting hands

direction of gaze

Difficult to detect, appear early, important for subsequent learning of agents, goals, interactions

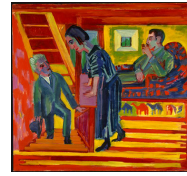
Why are hands difficult to detect?



multiple appearances



Van Gogh



Kirchner

small and inconspicuous

Selectivity to hands appears early in infancy

using a head camera to study
visual experience

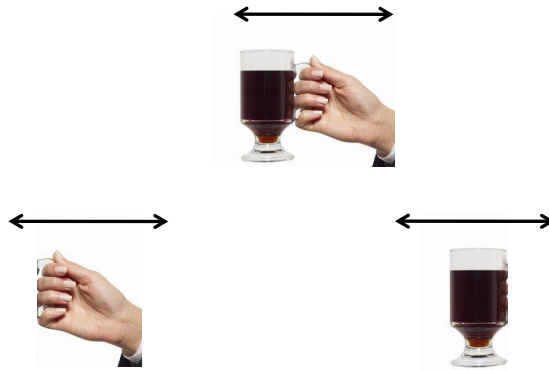


*“overall... hands were in view and dynamically acting
on an object in over 80% of the frames”*

Yoshida & Smith 2008

What makes hands learnable by humans?

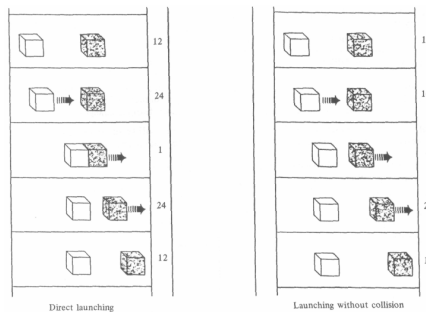
Motion, hand as 'mover' (7 months old)



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

Early sensitivity to special motion types

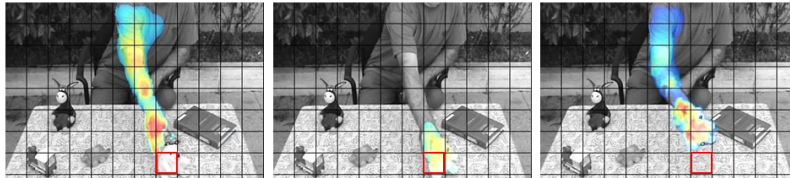
- high sensitivity to motion in general
(detecting motion, motion segmentation, tracking)
- specific sub-classes of motion: self-motion, passive, and 'mover'



A specific motion is highly indicative of hands

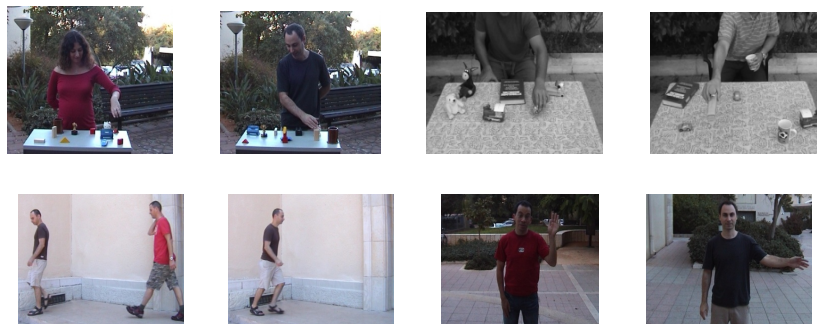
Detecting 'mover' events

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

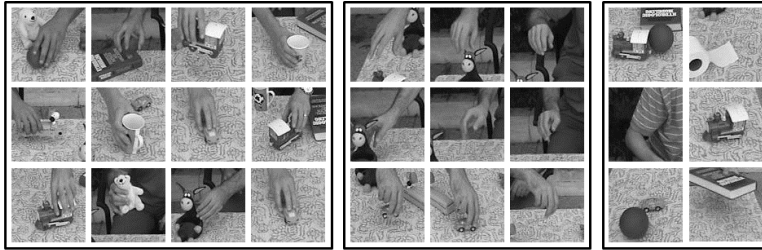
Training videos



Movies of scenes, people moving, manipulating objects, moving hands

'Mover' events are detected in all movies and used for training

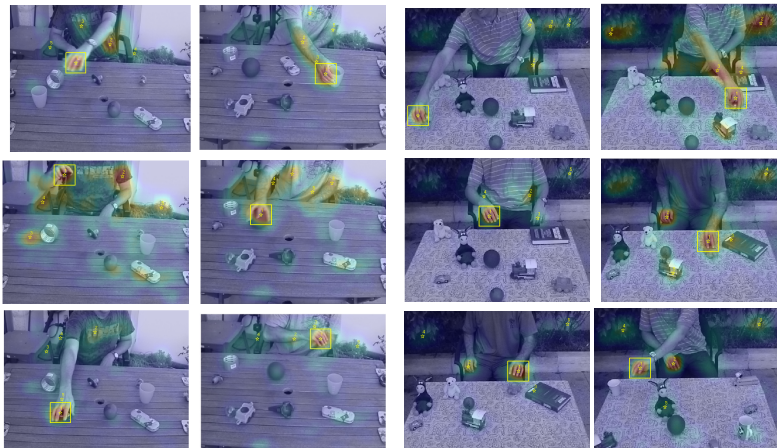
'Mover' events extracted from videos



High fraction of detected mover events involve hands
(90% recall, 65% precision)

Extract many images of objects entering cells of mover events
& use images to train a hand object classifier

Hand detection in still images



Trained classifier mainly detected hands in object manipulation scenes

Continued learning

Two detection algorithms:

- Detect hands with greater range of appearance by tracking



- Detect more hands by the body context

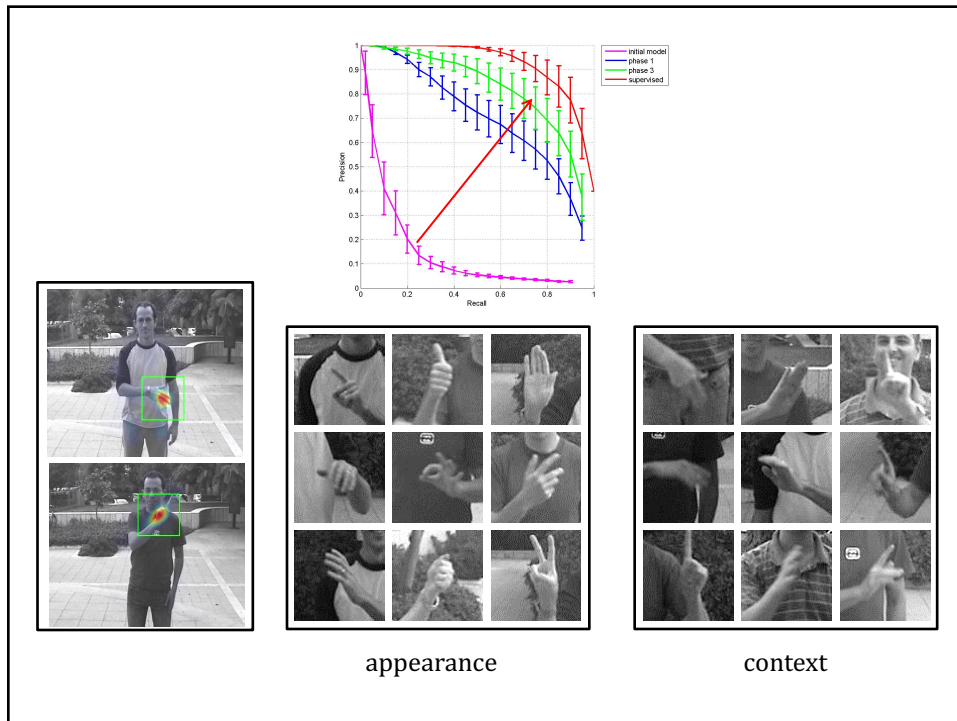


Hand by surrounding context



face → shoulder → upper-arm → lower-arm → hand

Amano, Kezuka, Yamamoto, 2004
Slaughter, Heron-Delaney, 2010
Slaughter, Neary, 2011



Gaze direction



W.H. Wollaston (1824)

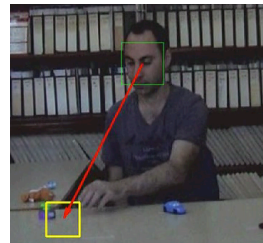
On the Apparent Direction of Eyes in a Portrait

- 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

Gaze cues are subtle and inconspicuous



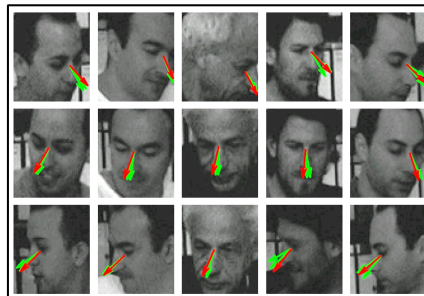
mover events supply the teaching signal



Gaze extraction



Training



Testing

model →
humans →

Use facial appearances and gaze directions derived from mover events as a training set to learn direction of gaze

