Group Behavior Analysis and Its Applications

CVPR 2015 Tutorial

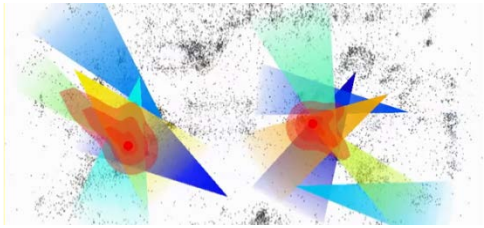
Lecturers:
Hyun Soo Park (University of Pennsylvania)
Wongun Choi (NEC America Laboratory)

Schedule

08:30am-08:50am Introduction

08:50am-09:50am **Social statics**

- Gaze/Head signals
- Body signals



09:50am-10:10am Invited talk

Action Localization

Ivan Laptev (INRIA)

10:10am-10:45am Coffee break

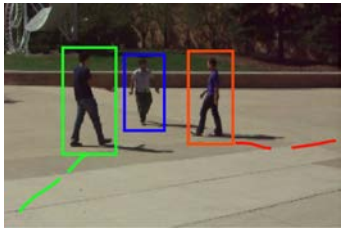
10:45am-11:15am Invited talk

Capturing Subtle Social Behaviors in the Panoptic Studio

Yaser Sheikh (CMU)

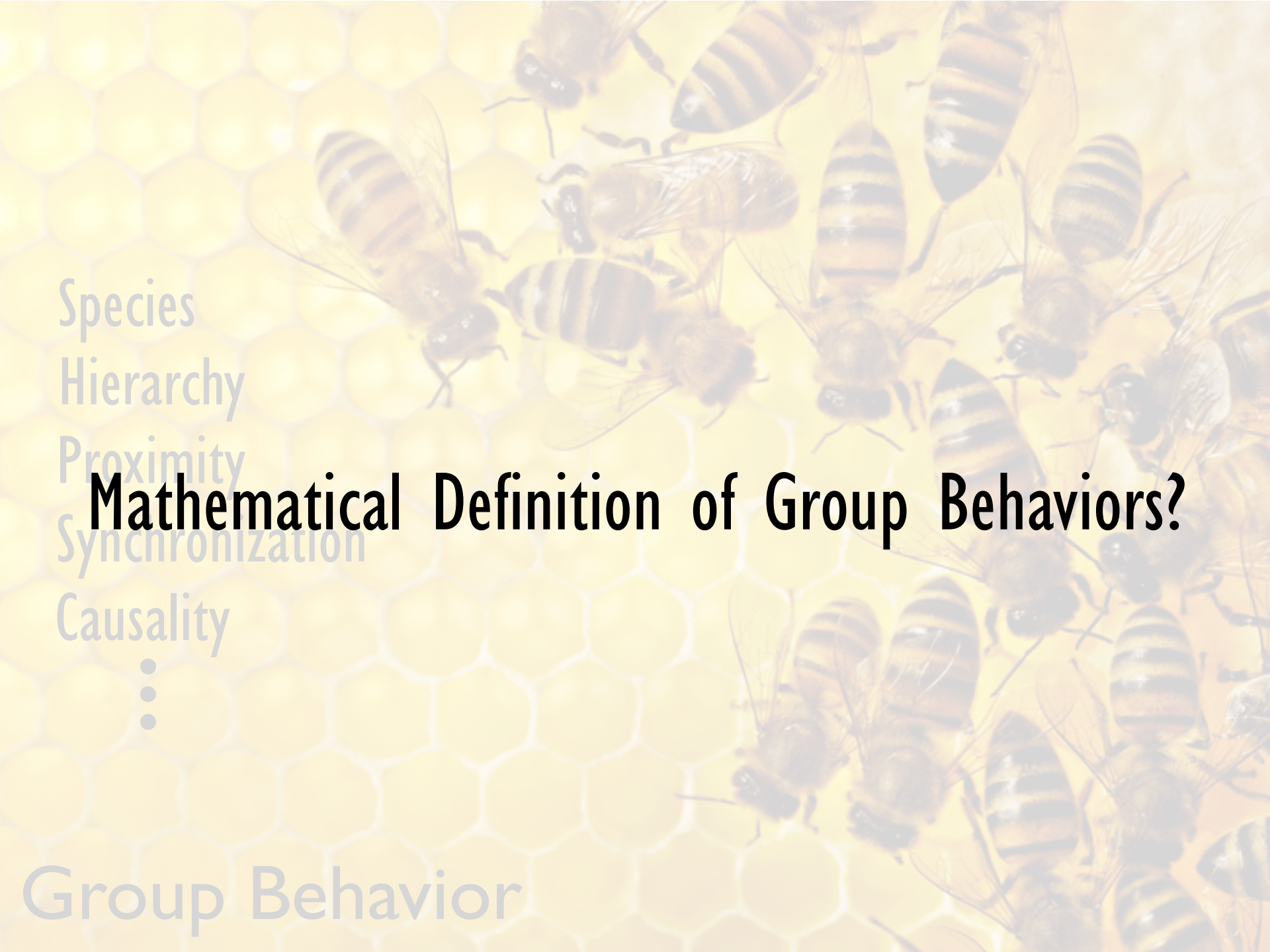
11:15am-12:20pm **Social dynamics**

- Model based approach
- Data driven approach



12:20pm-12:30pm Summary and open problems


Species
Hierarchy
Proximity
Synchronization
Reciprocity
⋮
Group Behavior

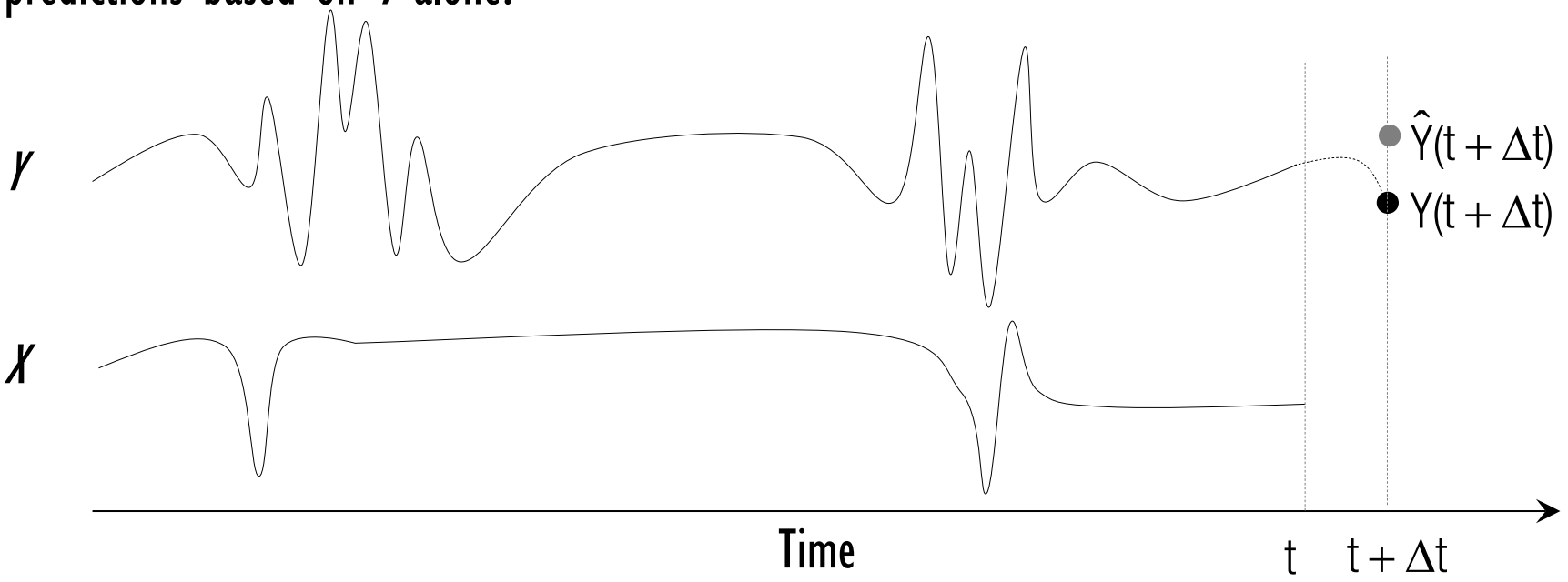


Mathematical Definition of Group Behaviors?

Granger Causality

[Granger Econometrica69]

A time series *X* could be considered to causally influence a time series *Y* if predictions of future values of *Y* based on the joint history of *X* and *Y* were more accurate than predictions based on *Y* alone.



Prediction based on history of Y

Prediction based on history of Y and X

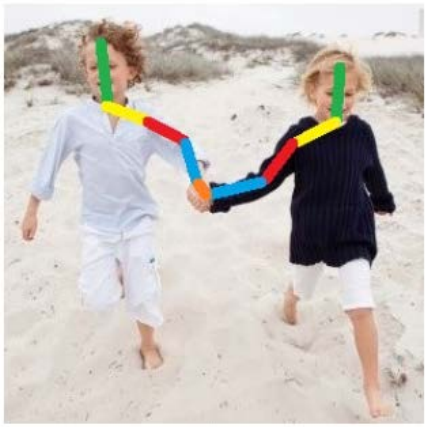
Mathematical Definition of Group Behaviors

Behaviors of *X* and *Y* are a **group behavior** if spatial/temporal predictions of *Y* based on *X* and *Y* jointly are more accurate than predictions based on *Y* alone.

$$\left\| Y(t+\Delta t) - \hat{Y}(t+\Delta t \mid Y(0), \cdots, Y(t)) \right\| \geq \left\| Y(t+\Delta t) - \hat{Y}(t+\Delta t \mid Y(0), \cdots, Y(t), X(0), \cdots, X(t)) \right\|$$

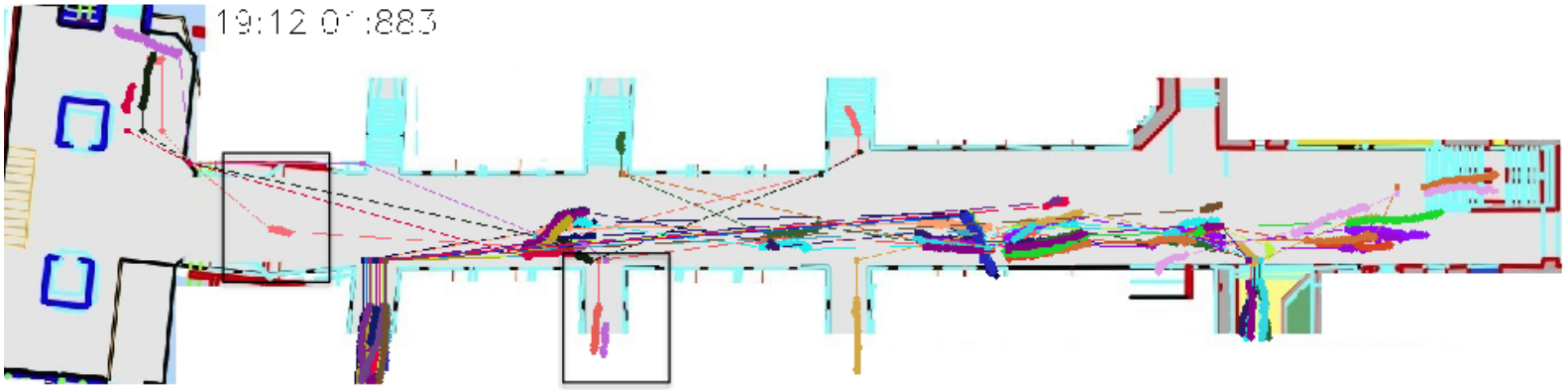
Mathematical Definition of Group Behaviors

Behaviors of X and Y are a **group behavior** if spatial/temporal predictions of Y based on X and Y jointly are more accurate than predictions based on Y alone.



[Yang CVPR12]

[Park ICCV13]



[Alahi CVPR14]

Mathematical Definition of Group Behaviors

Behaviors of X and Y are a **group behavior** if spatial/temporal predictions of Y based on X and Y jointly are more accurate than predictions based on Y alone.

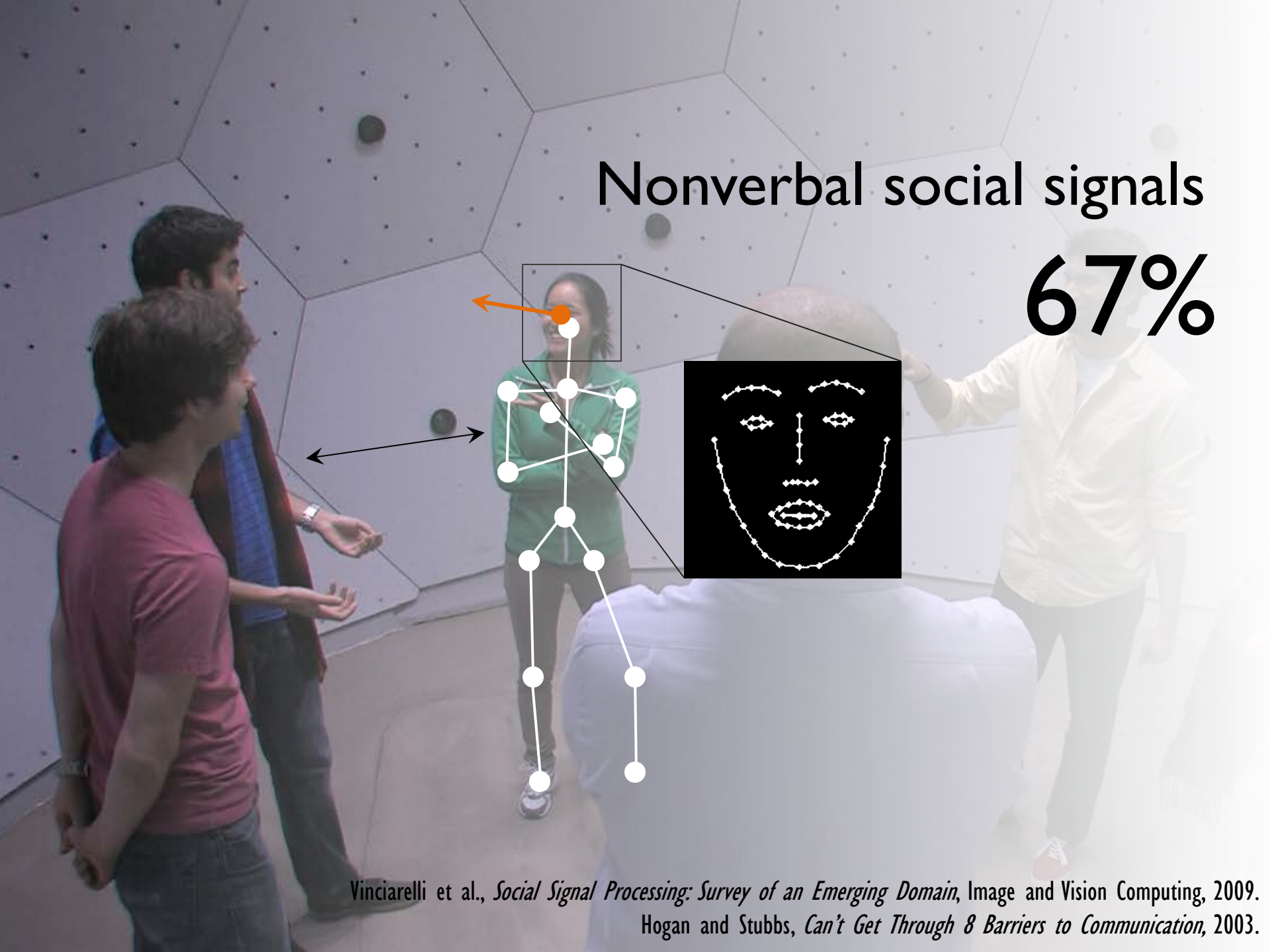
[Choi ECCV14]

Not group behavior

Social Signals:
A Realization of Group Behaviors

Nonverbal social signals

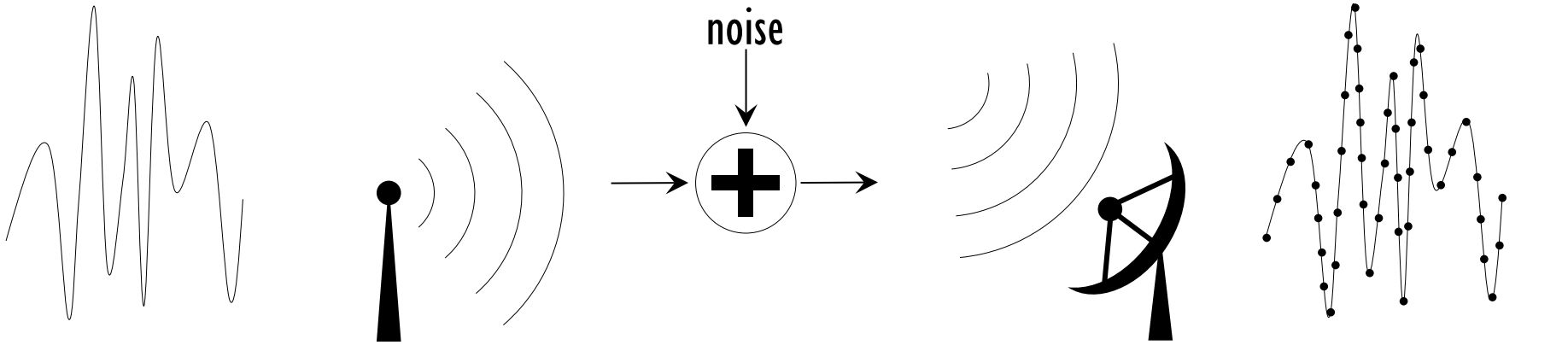
67%



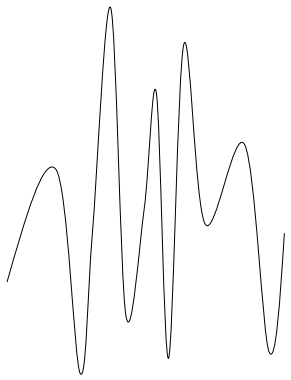
Vinciarelli et al., *Social Signal Processing: Survey of an Emerging Domain*, Image and Vision Computing, 2009.

Hogan and Stubbs, *Can't Get Through 8 Barriers to Communication,* 2003.

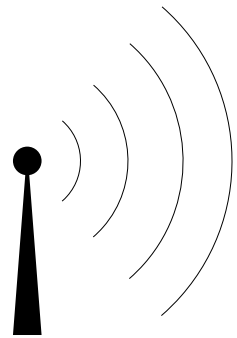
Signal Processing



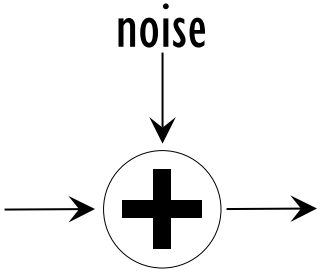
Social Signal Processing



Signals

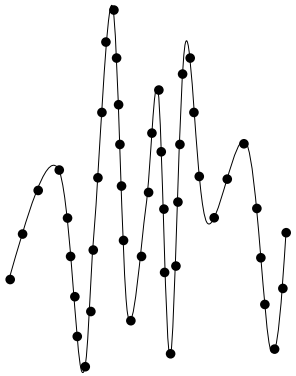


Transmitter



Channel

Receiver



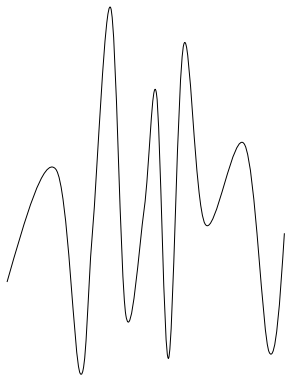
Signal reconstruction

Social signals

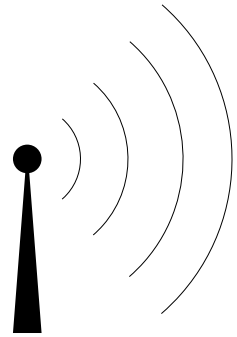
Visual observation

Understanding

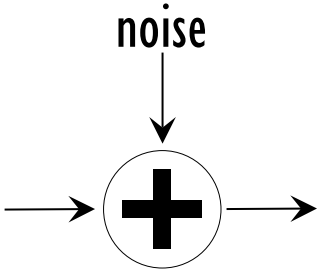
Social Signal Processing



Signals



Transmitter



Channel

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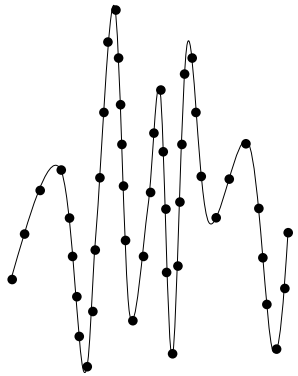
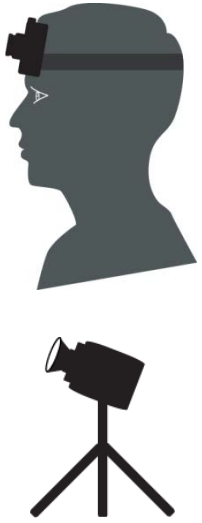
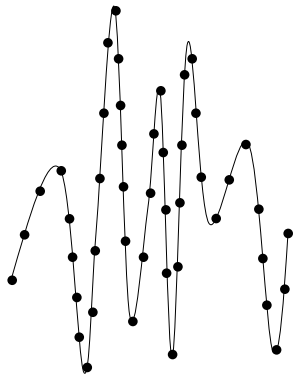


Signal reconstruction

Social signals



Cameras



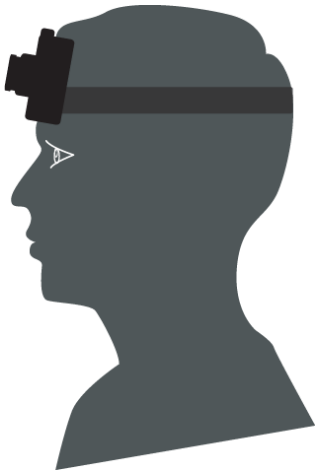
Computational rep.

Challenges In Social Signal Processing

Challenge 1: Micro Social Signals

Social signals are too *subtle* to be detected by computer vision solutions, e.g., activity recognition frameworks.

Challenge II: Signal Interdependency



Challenge III: Ambiguity

Challenge IV: Scene Variability

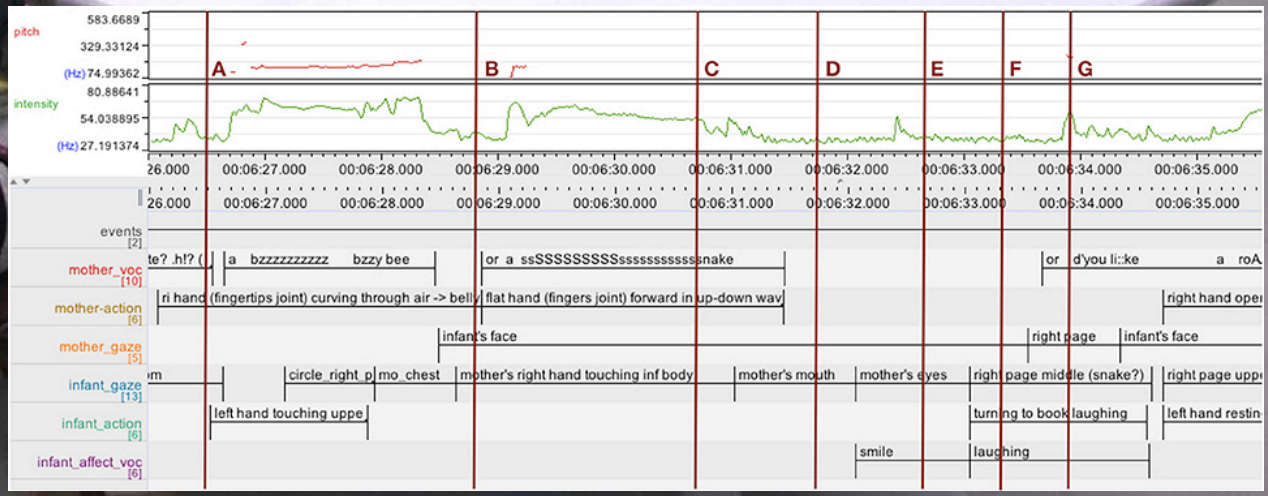
Broad Impact:
Why Social Interactions?

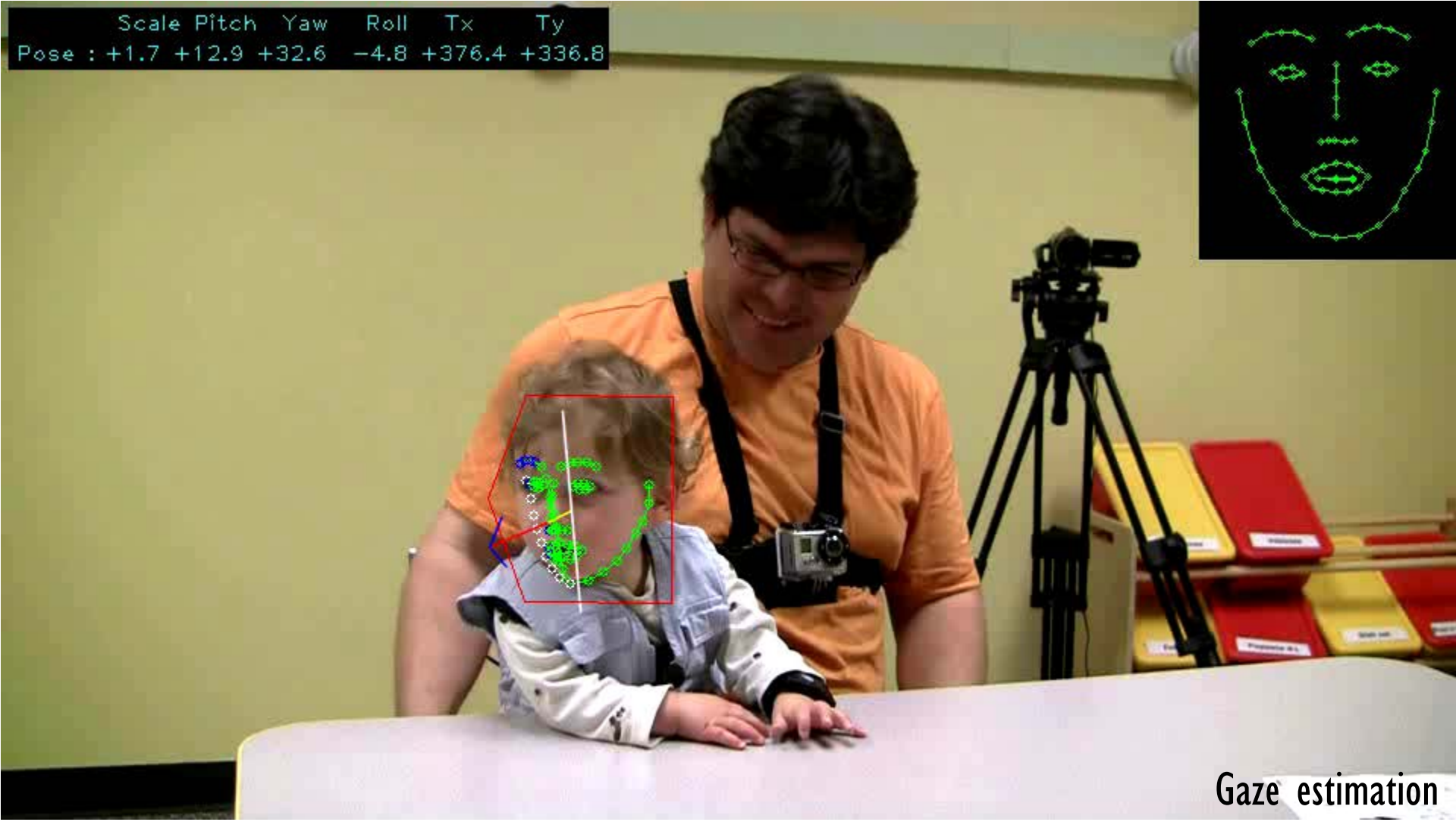
Computational Behavioral Science

Clinician

Subject

Autism Spectrum Disorder (ASD)



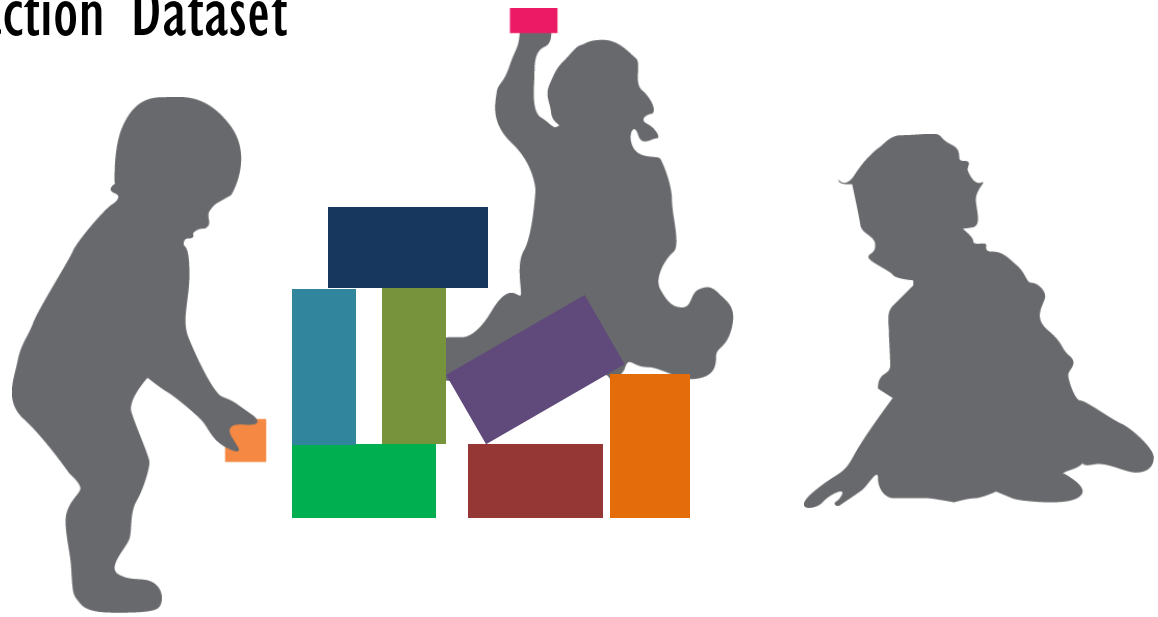


Multimodal Dyadic Behavior Dataset

http://www.cbi.gatech.edu/mmdb/

Collaborative Behavior Monitoring

First Person Interaction Dataset

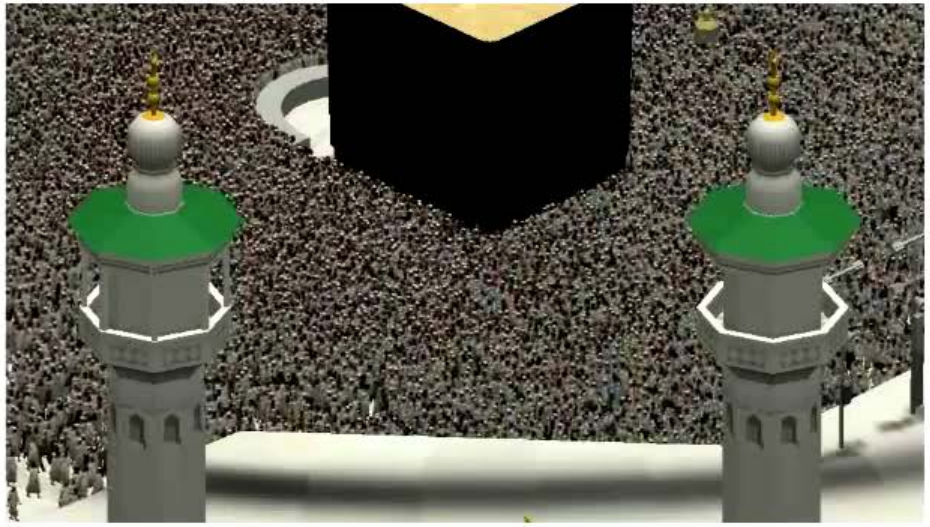


[Park CVPR15]

Crowd Behavior Analysis

Large Scale Simulation and Flow Analysis

Real footage

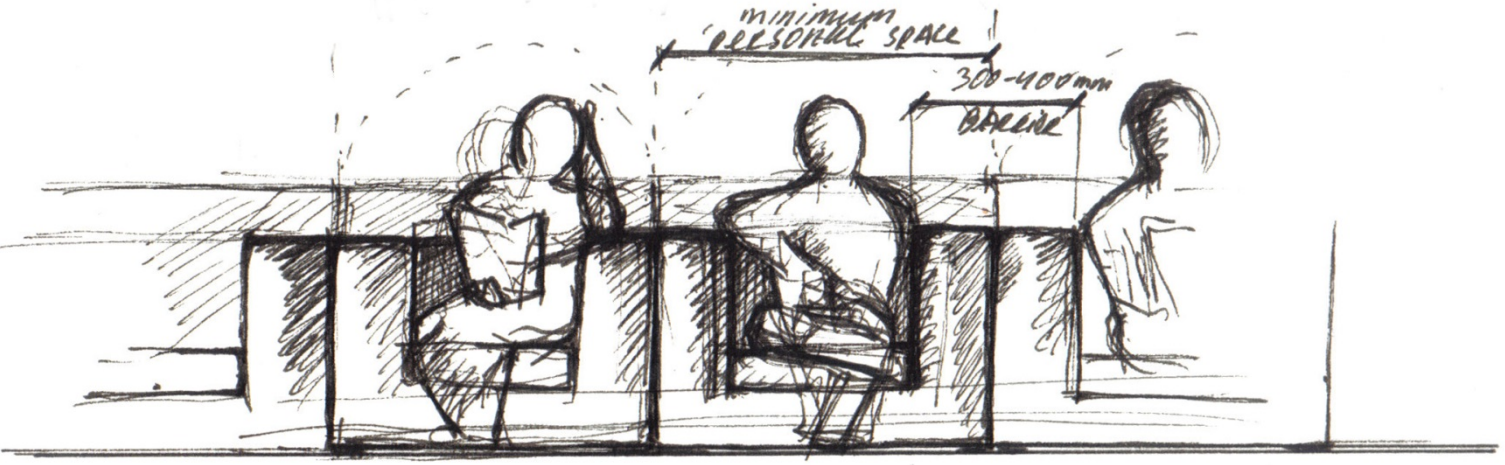


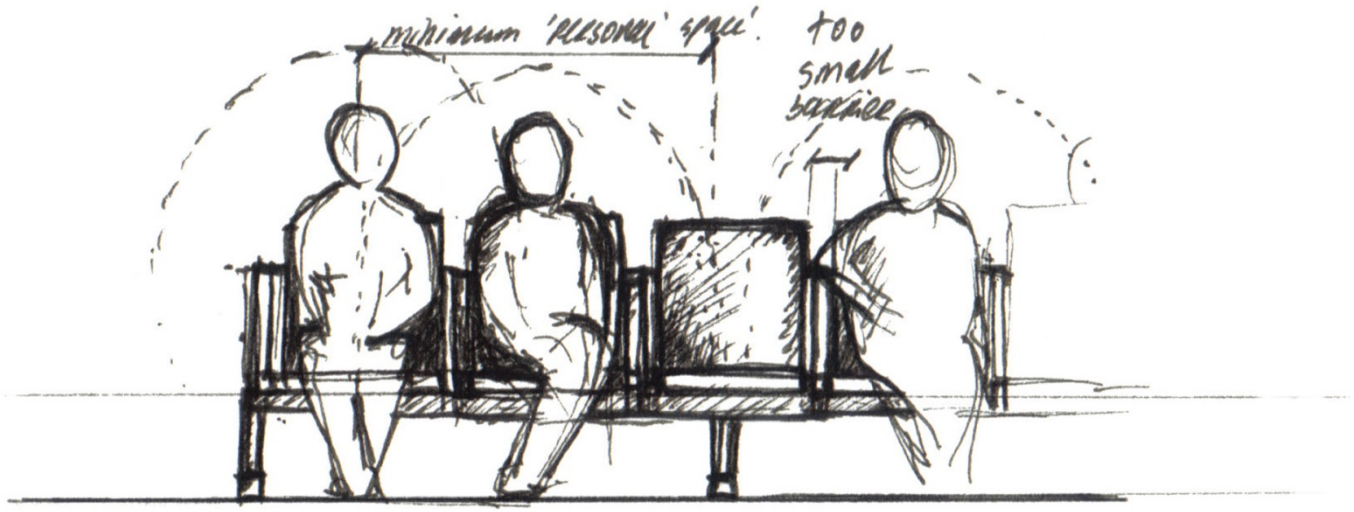
Our Simulation

Hajj, Mecca (Saudi Arabia)
Hundreds of thousands of pilgrims

http://gamma.cs.unc.edu/REACH/CrowdT/


• Education
• Assistance
• Collaboration
• Entertainment
http://humanoid.itu.edu.tr/
Social Robotics





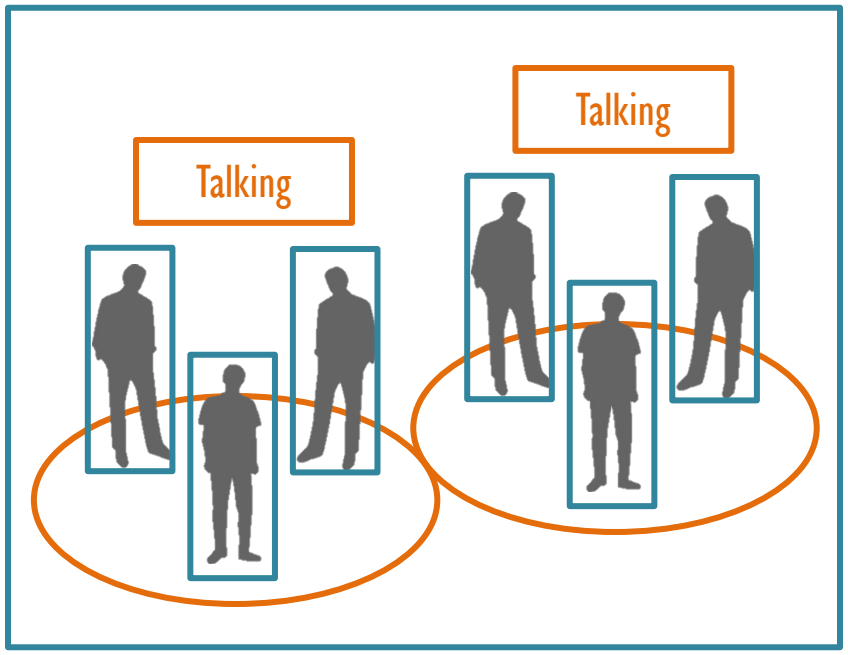
Social Space Design

Main Tasks

Social Interaction Detection / Joint Attention Localization

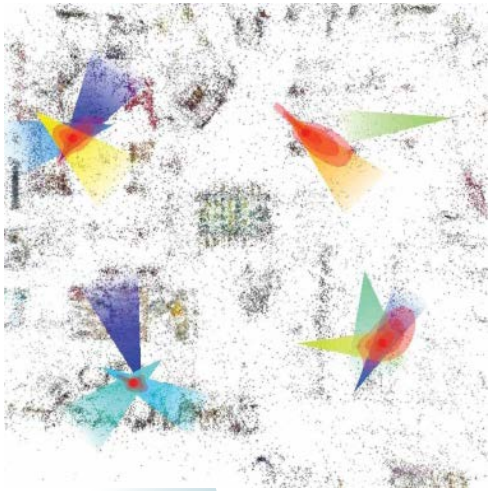
Input: image and bounding boxes

Output: groups with activity label



Input: images from first person cameras

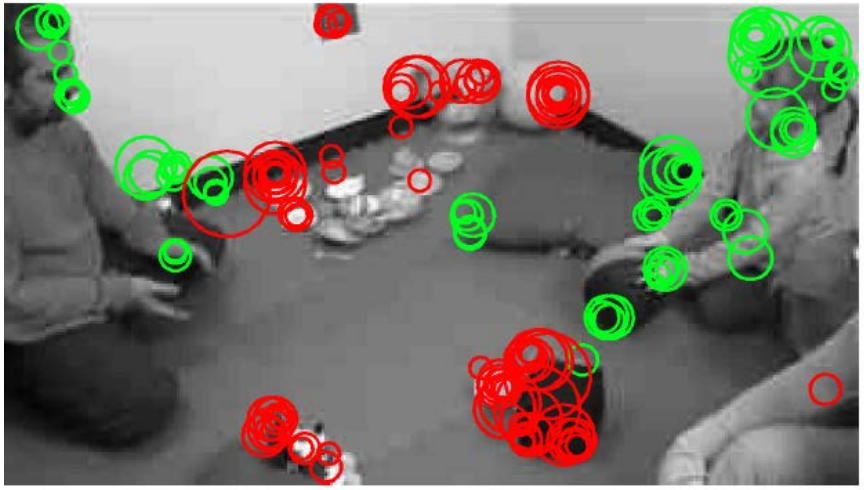
Output: to localize joint attention in 3D



Space / Time Relationship

Input: a video of social interactions

Output: to find a causal relationship



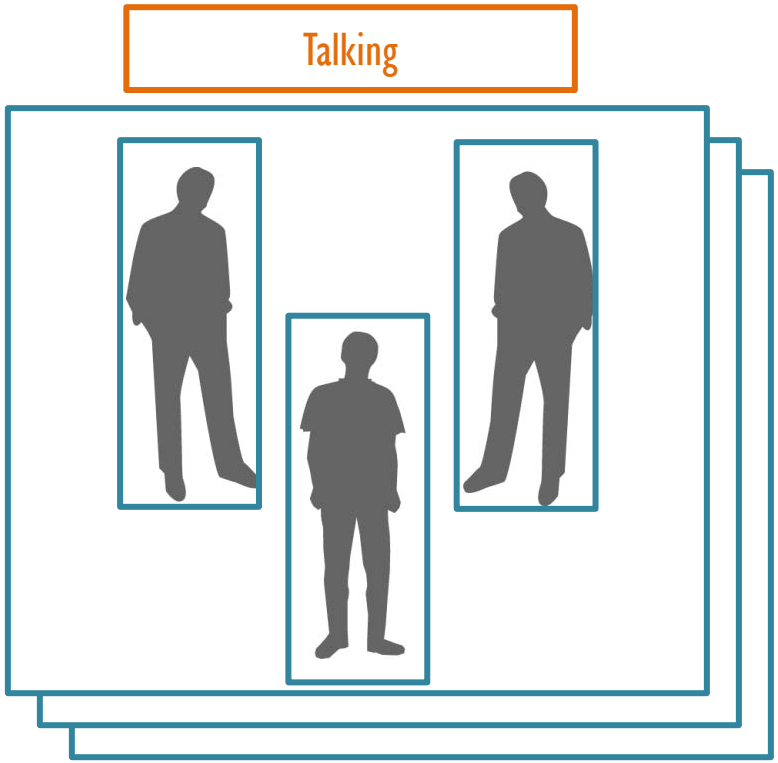
Input: image

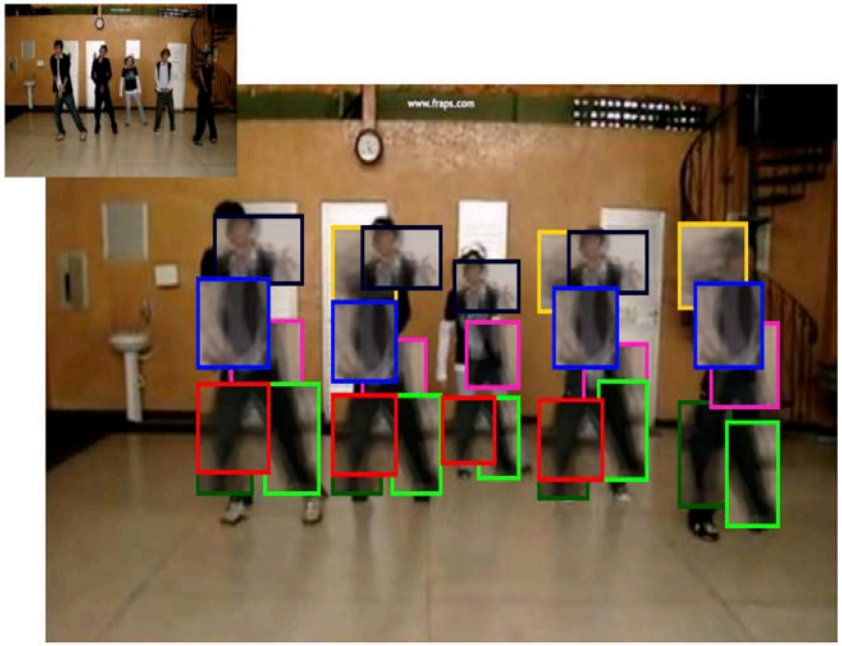
Output: proxemics label and skeletons

Group Activity Detection/Recognition

Input: video and box tracks

Output: group activity labels in time





Group Behavior Prediction / Anomaly Detection

Input: a crowd video

Output: individual tracking

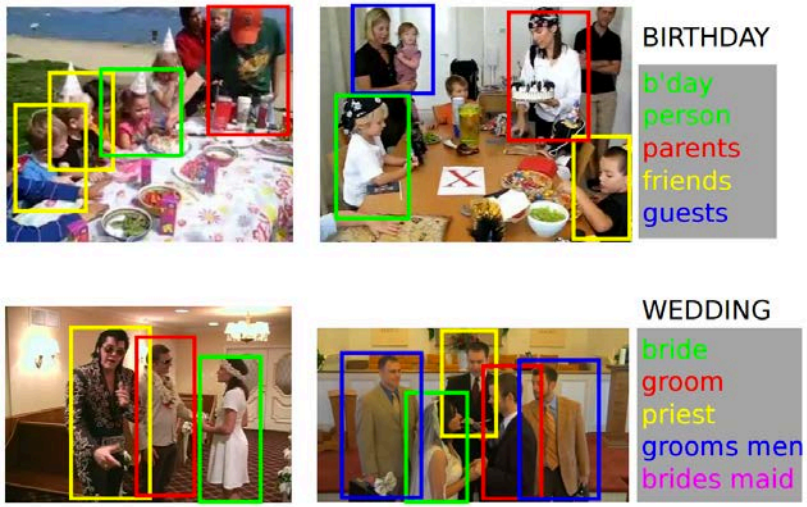
Input: pedestrian tracks

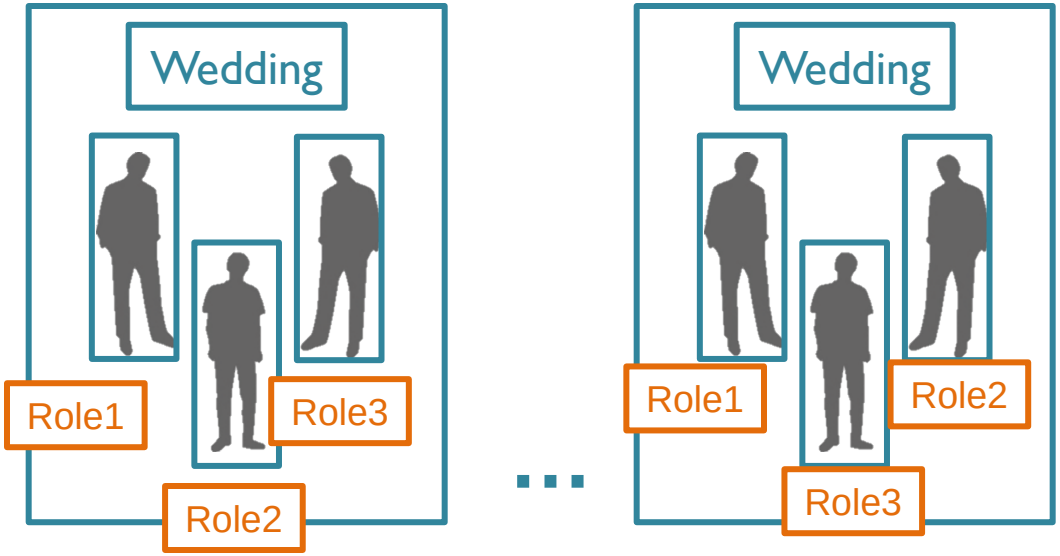
Output: to detect abnormal behaviors

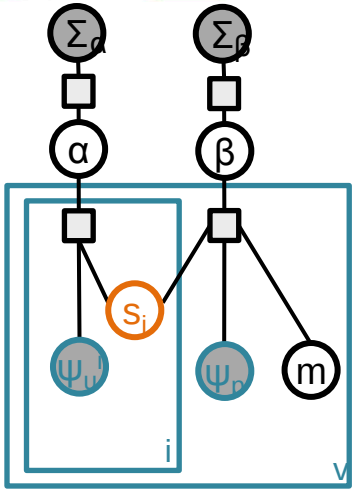
Social Role Discovery

Input: videos with event labels, box tracks

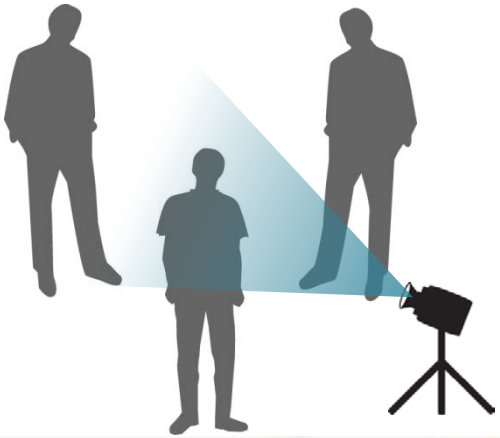
Output: groups with activity label

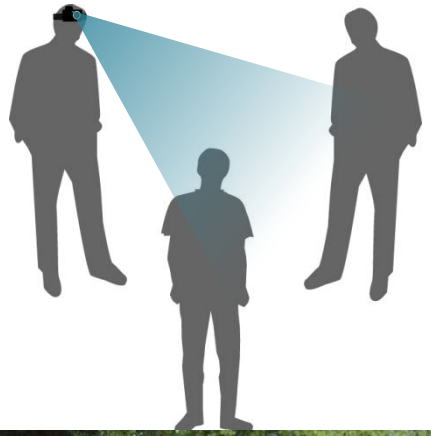


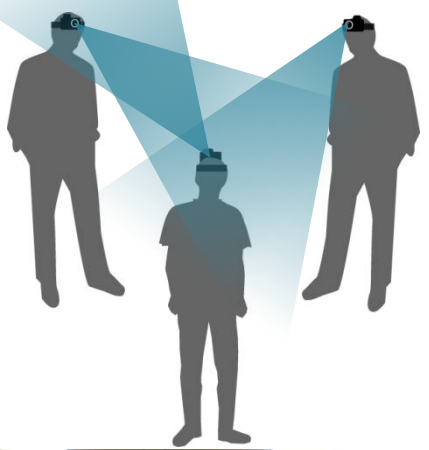




Measurement Tool







Rodriguez et al., ICCV 2011
Lan et al., PAMI 2012
Chakraborty et al., CVPR 2013
Yang et al., CVPR 2011
Alahi et al., CVPR 2014
Choi et al., ECCV 2014

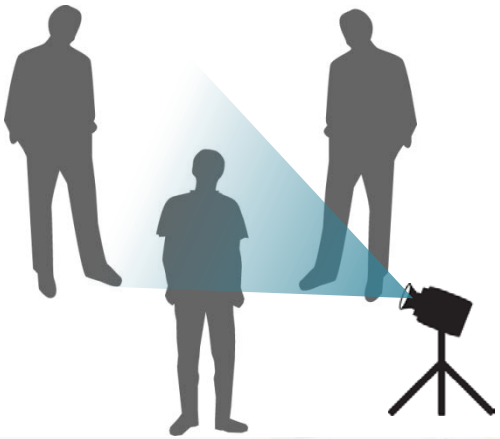
Li et al., ICCV 2013
Ryoo et al., CVPR 2013
Pusiol et al., CogSci 2014

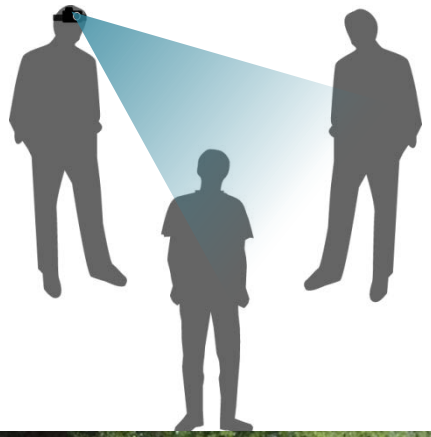
Arev et al., SIGGRAPH 2014

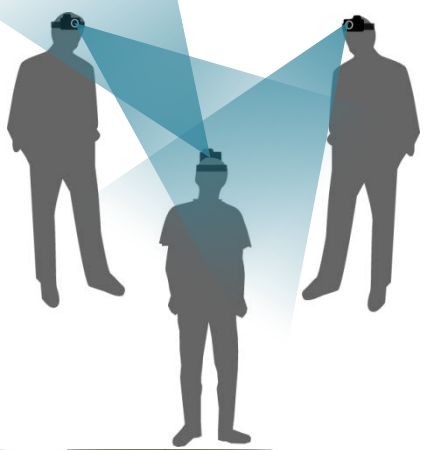
Third person view

Distance between eyes and camera

First person view







Noninvasiveness

Measurement accuracy

Third person view

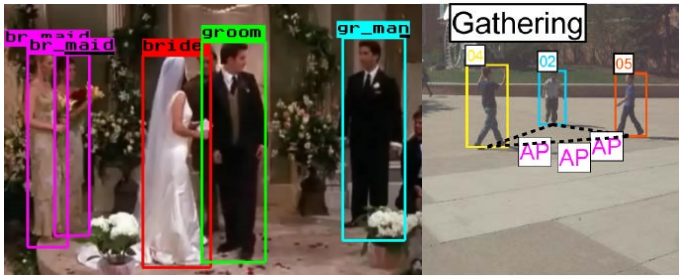
Distance between eyes and camera

First person view

Scene dynamism

Dynamic scene

Rehg, CVPR13
Prabhaker, ECCV12
Prabhakar, CVPR12
Patron-Perez, BMVC10

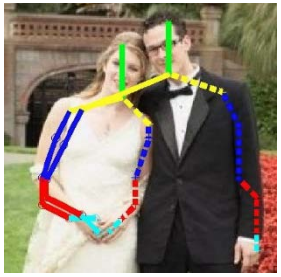


Lan, CVPR12
Ramanathan, CVPR13
Antic, ECCV14

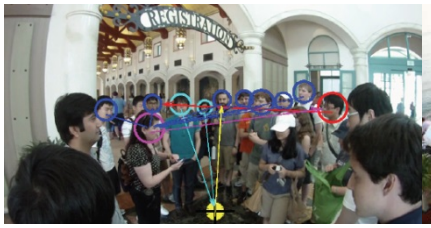
Ding, ECCV10
Choi, ECCV12, CVPR14
Direkoglu, ECCV12

Rodriguez, ICCV11a, ICCVb
Mehran, CVPR09
Alahi, CVPR14

Static scene



Yang, CVPR12
Hoai, CVPR14



Fathi, CVPR12
Choi, ECCV14
Park, NIPS12, ICCV13

Cristani, BMVC11
Park, CVPR15
Arev, SIGGRAPH14

Wang, ECCV10
Gallagher, CVPR09

Dyadic interaction

Crowd interaction

Number of group members