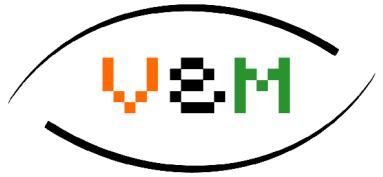



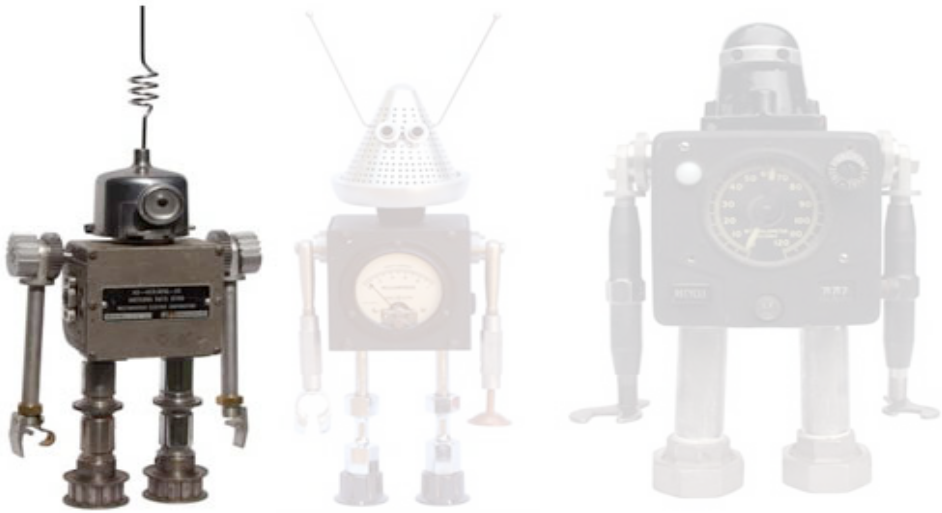

# Selecting and Commanding Individual Robots in a Multi-Robot System

Alex Couture-Beil, Richard Vaughan, Greg Mori

School of Computing Science
Simon Fraser University
Burnaby, BC, Canada

# Human-Robot Interaction

- human-robot interface:
  - Select an individual robot
  - Command the individually selected robot with a motion-based hand gesture



photos: Guyrobot.com

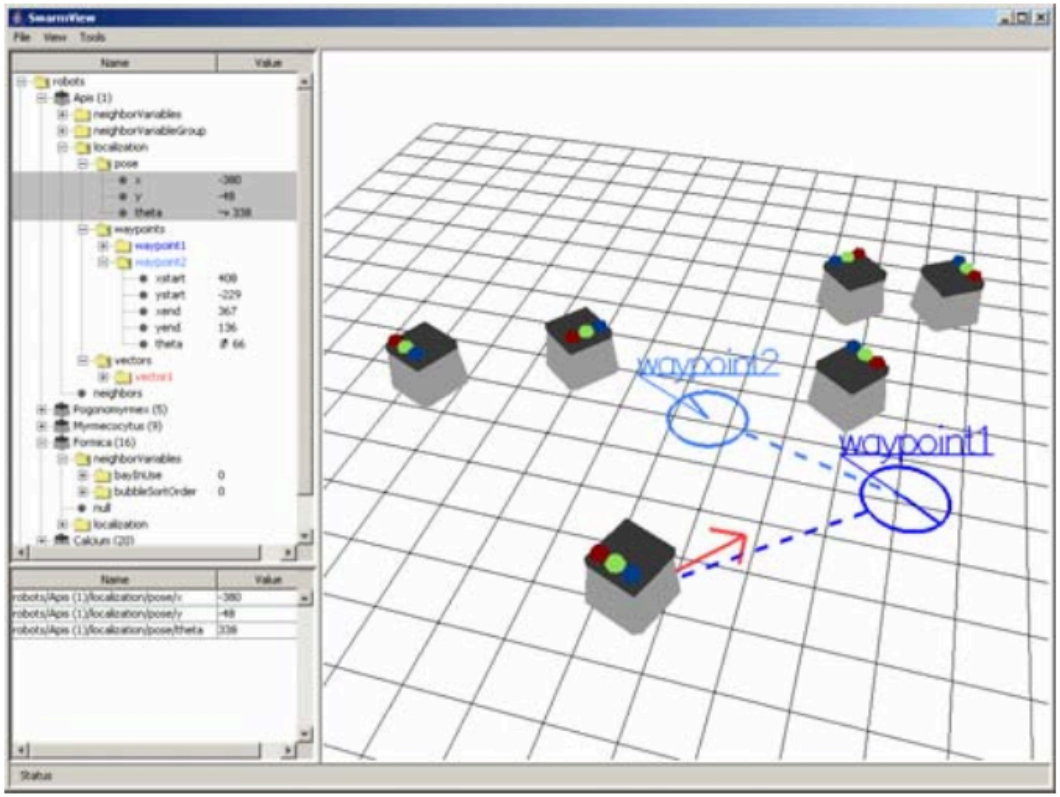
# Selecting and Commanding Individual Robots in a Vision-Based Multi-Robot System

Alex Couture-Beil
Richard T. Vaughan
Greg Mori

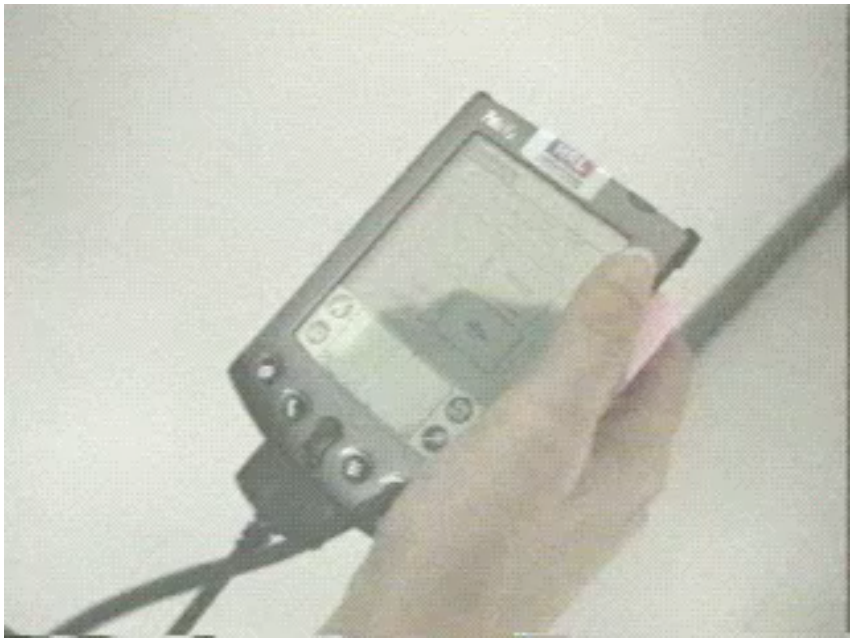
Autonomy Lab
Simon Fraser University

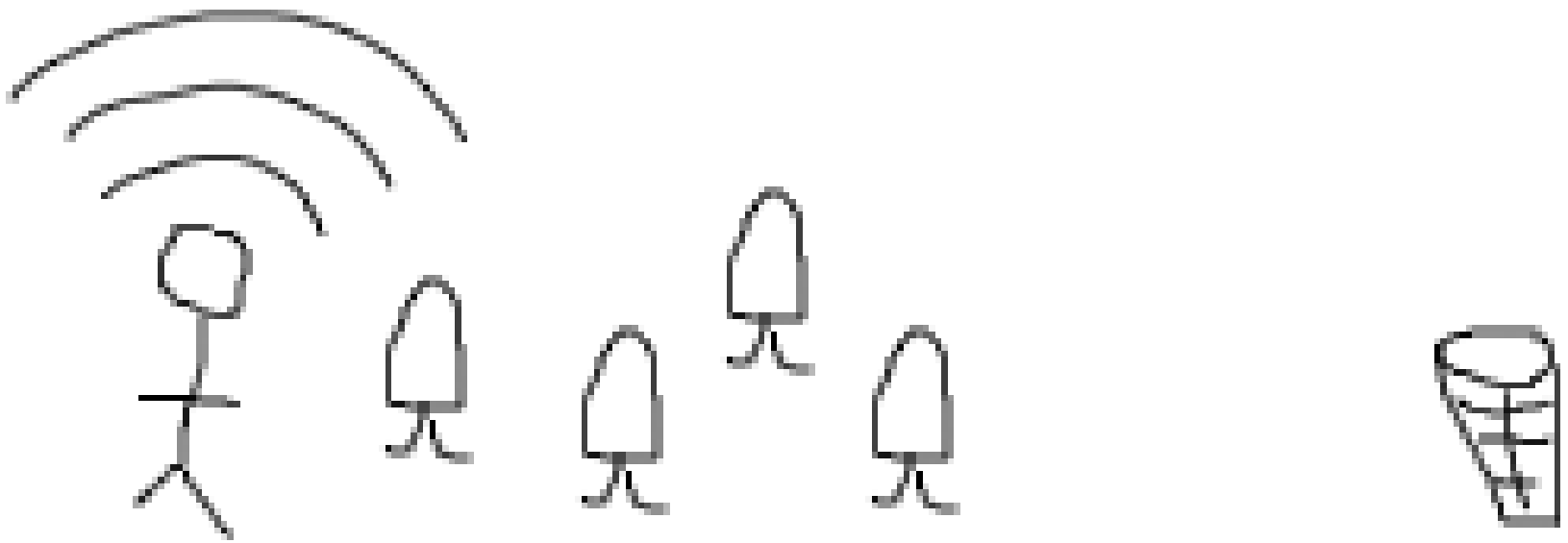
# Swarmcraft (McLurkin 2006)

- Conventional Human-Computer Interface

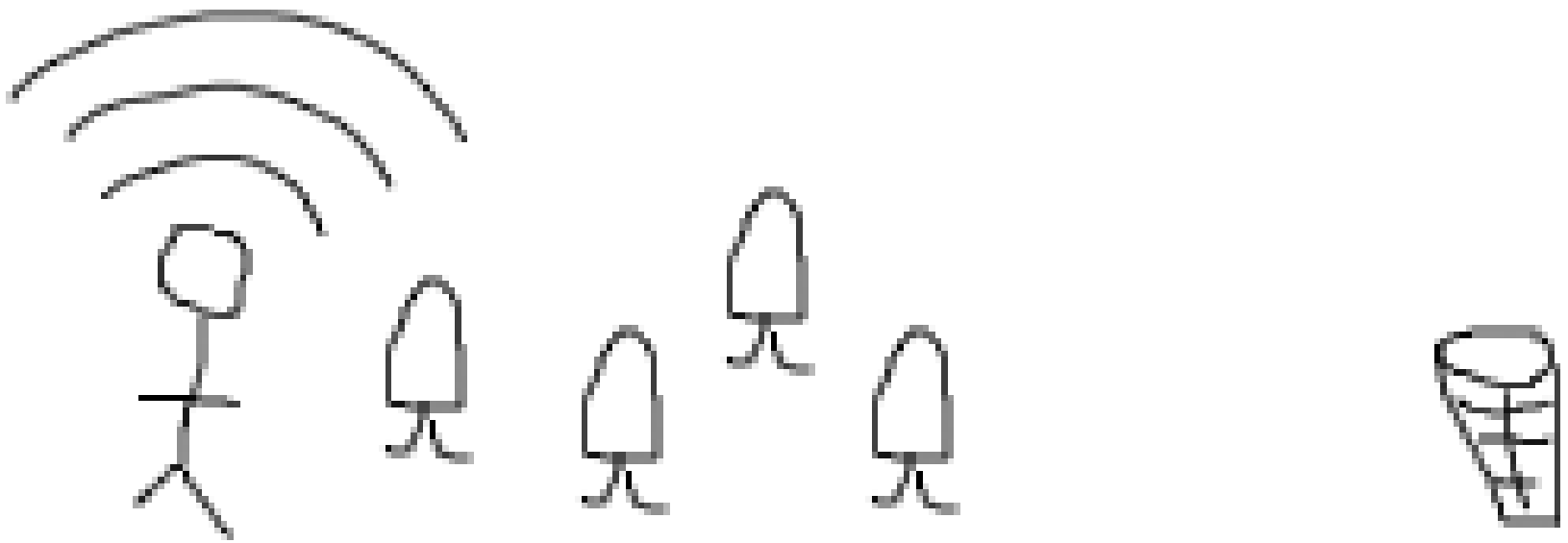


# Pheromone Robot Remote Control (Payton 2004)



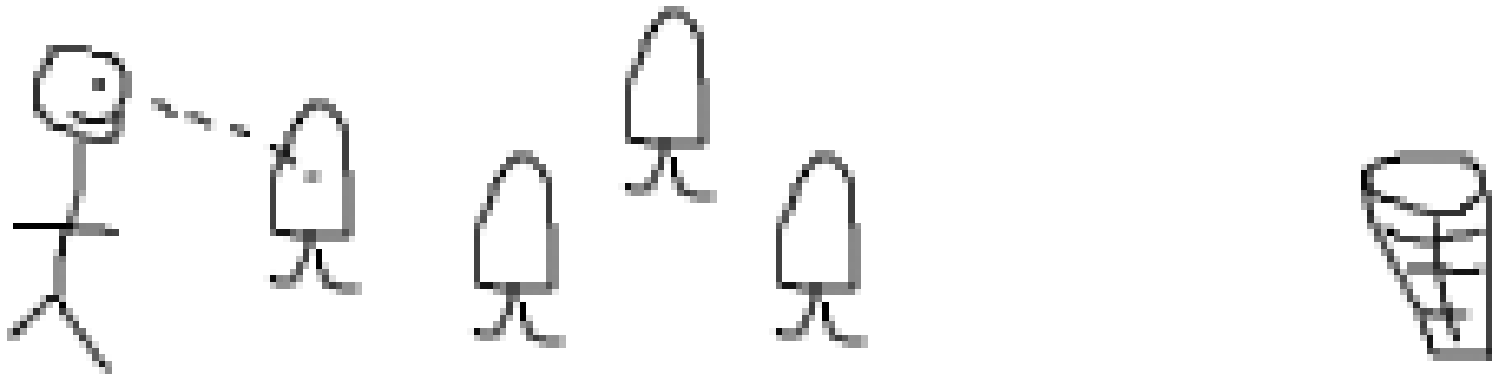


Hey Robot #472, take out garbage #532



Hey Coyote, take out the nearest garbage
(e.g. Perzanowski et al. 2002)

# Our Method: Face Engagement

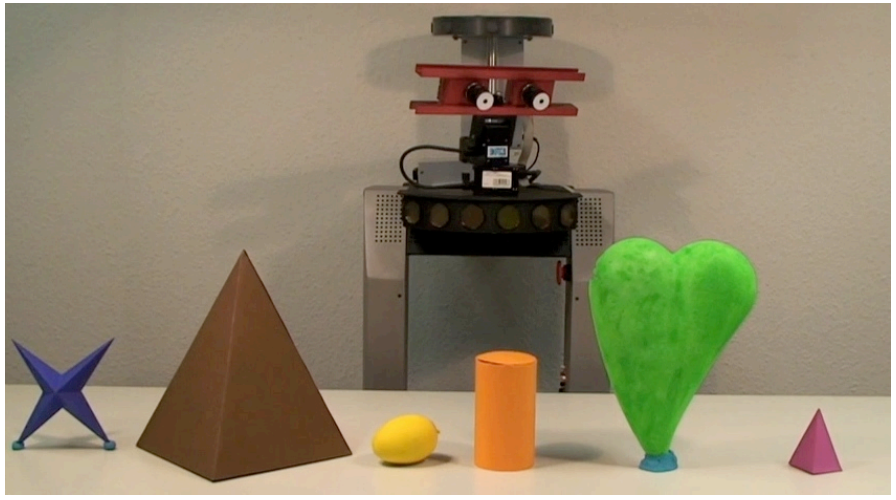


Hey you, take out the nearest garbage

# Robots and Face Engagement

- Goffman 1966 – face engagement:
  - the process in which people use eye contact and facial gestures to interact with people (and robots too?)

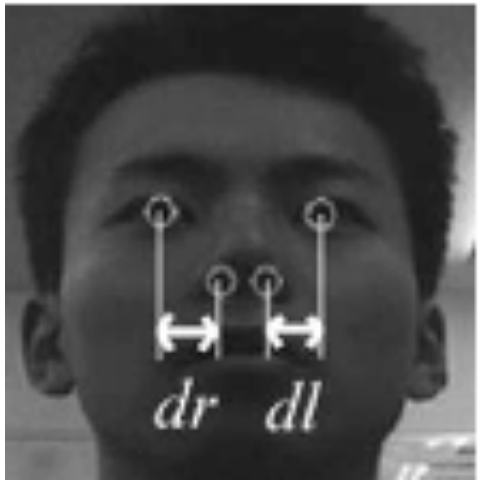

Credit: Mutlu et al. 2009;
developed at ATR by Ishiguro et al.



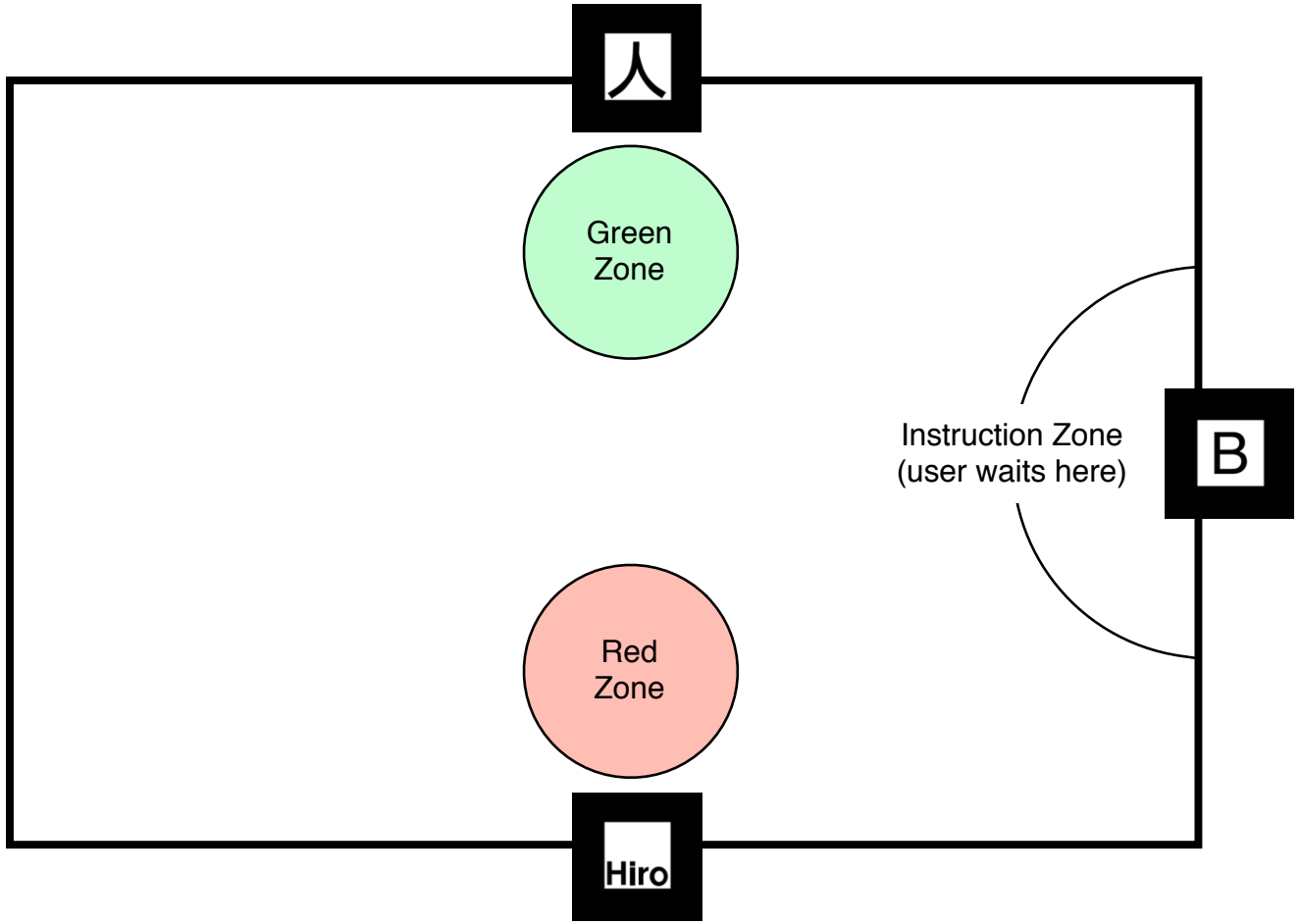
Credit: Staudte and Crocker 2009

# Activating a robot with Face Engagement

- Tour-guide robot by Kuno et al.
- Approaches a user when directly looked at




# Demonstration Task

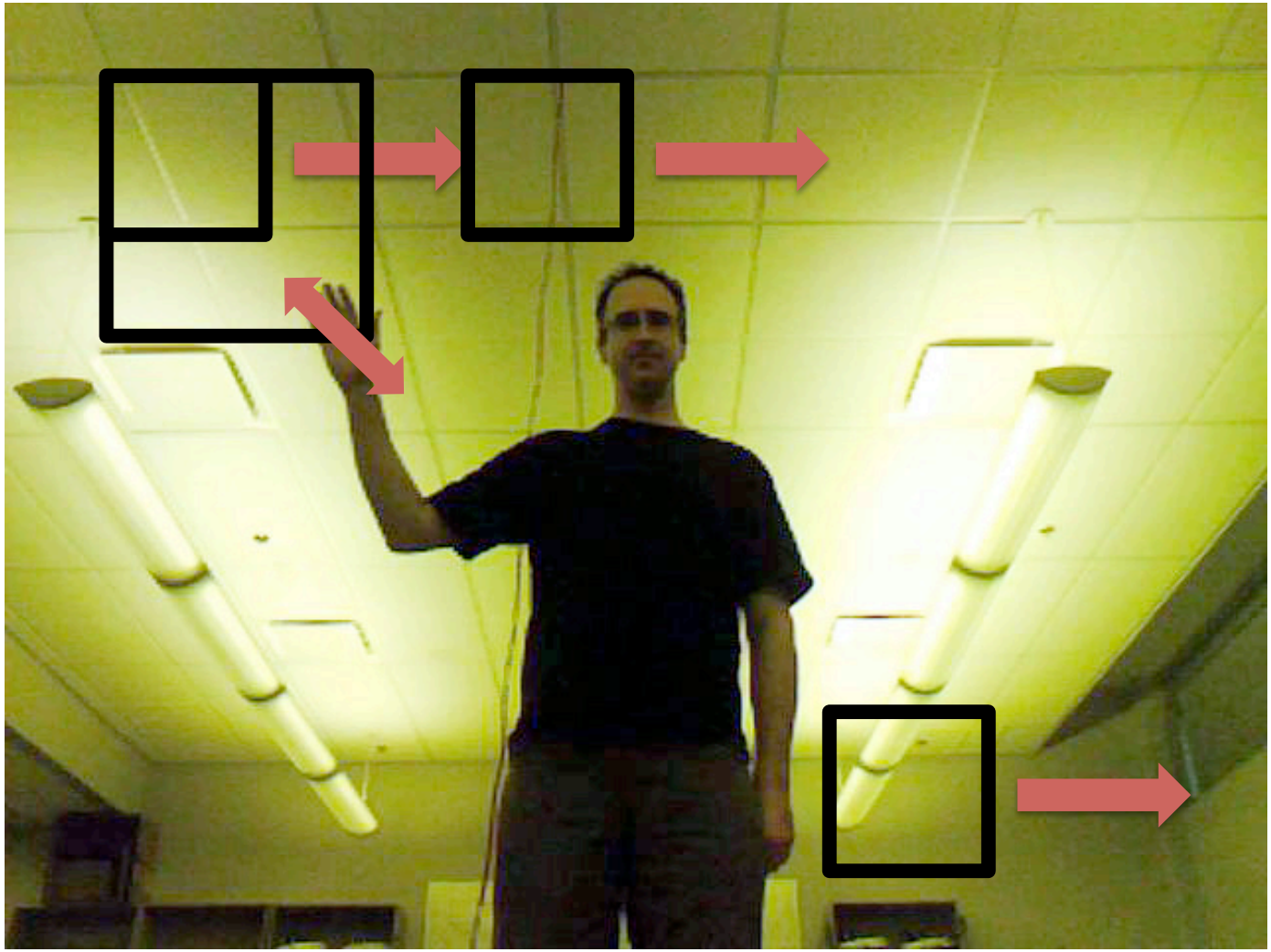



Wave-right

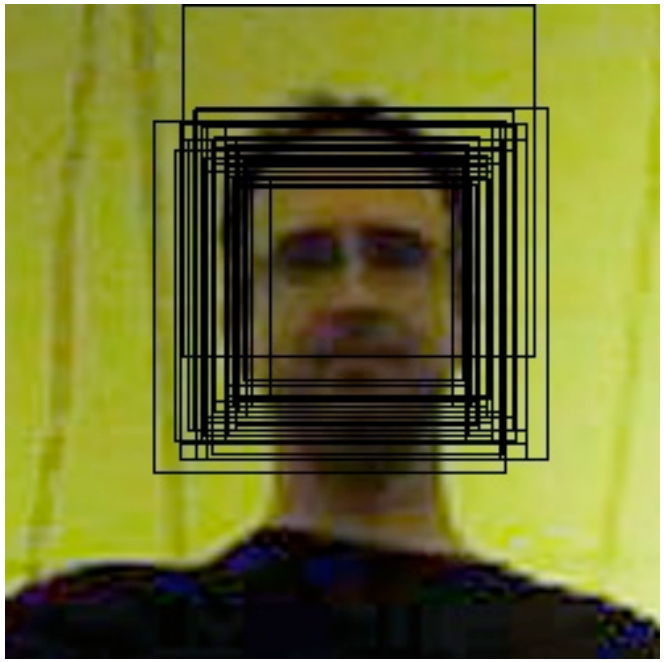
Wave-left

# The Algorithm

# Viola Jones Face Detection

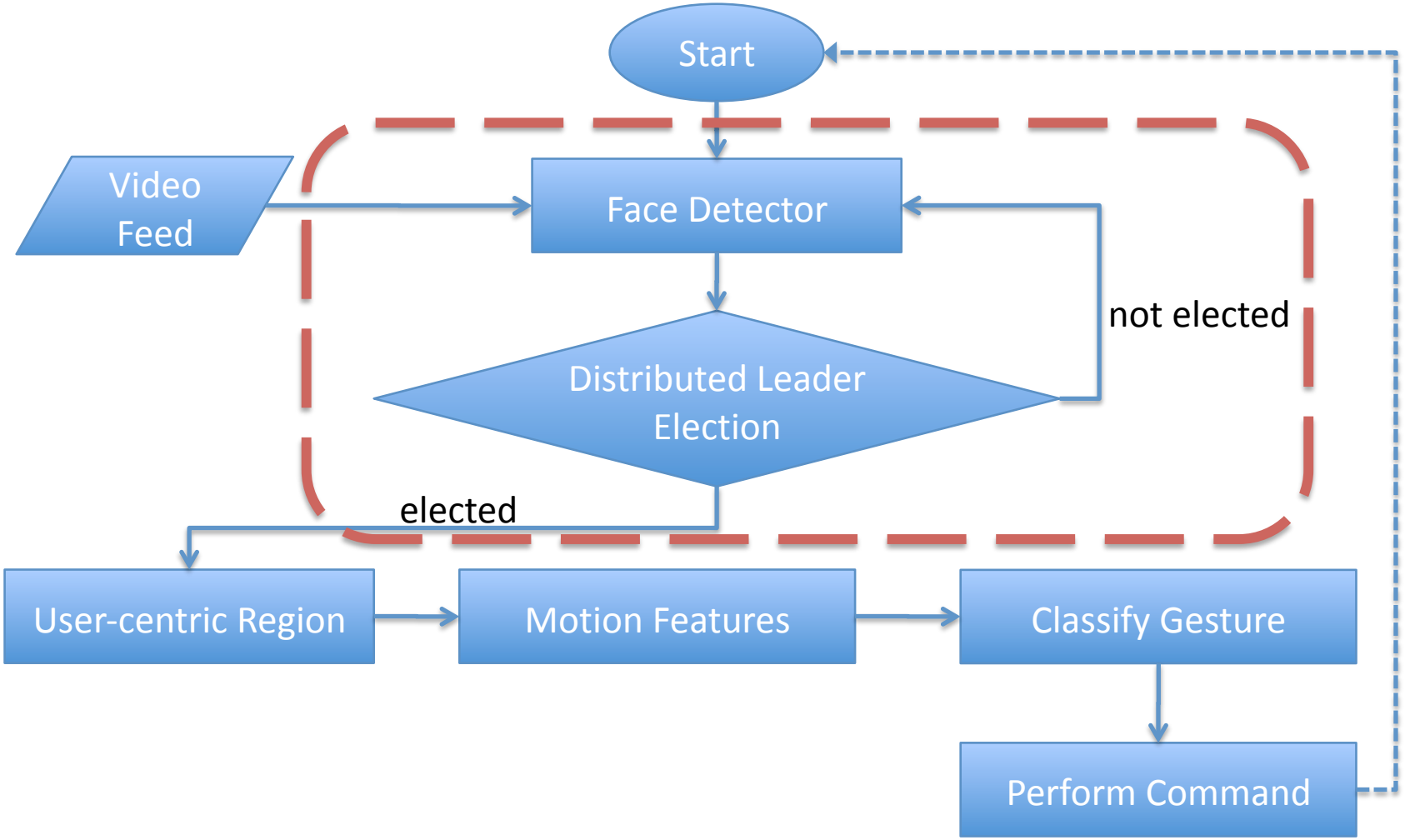


# Viola Jones Face Detection

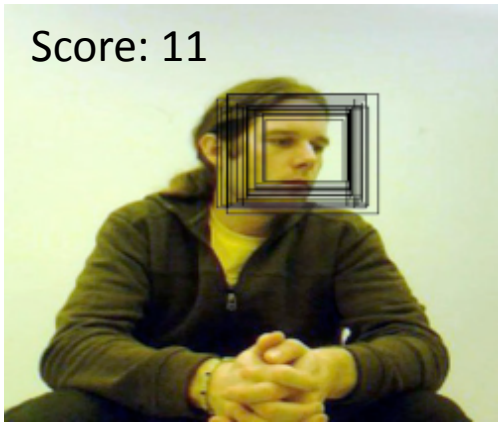


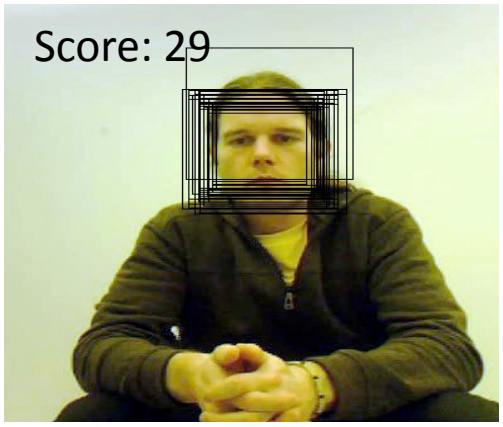
- Detector is insensitive to small changes
- Overlapping detected rectangles
- We use the number of overlapping rectangles as the detection score

# The Algorithm

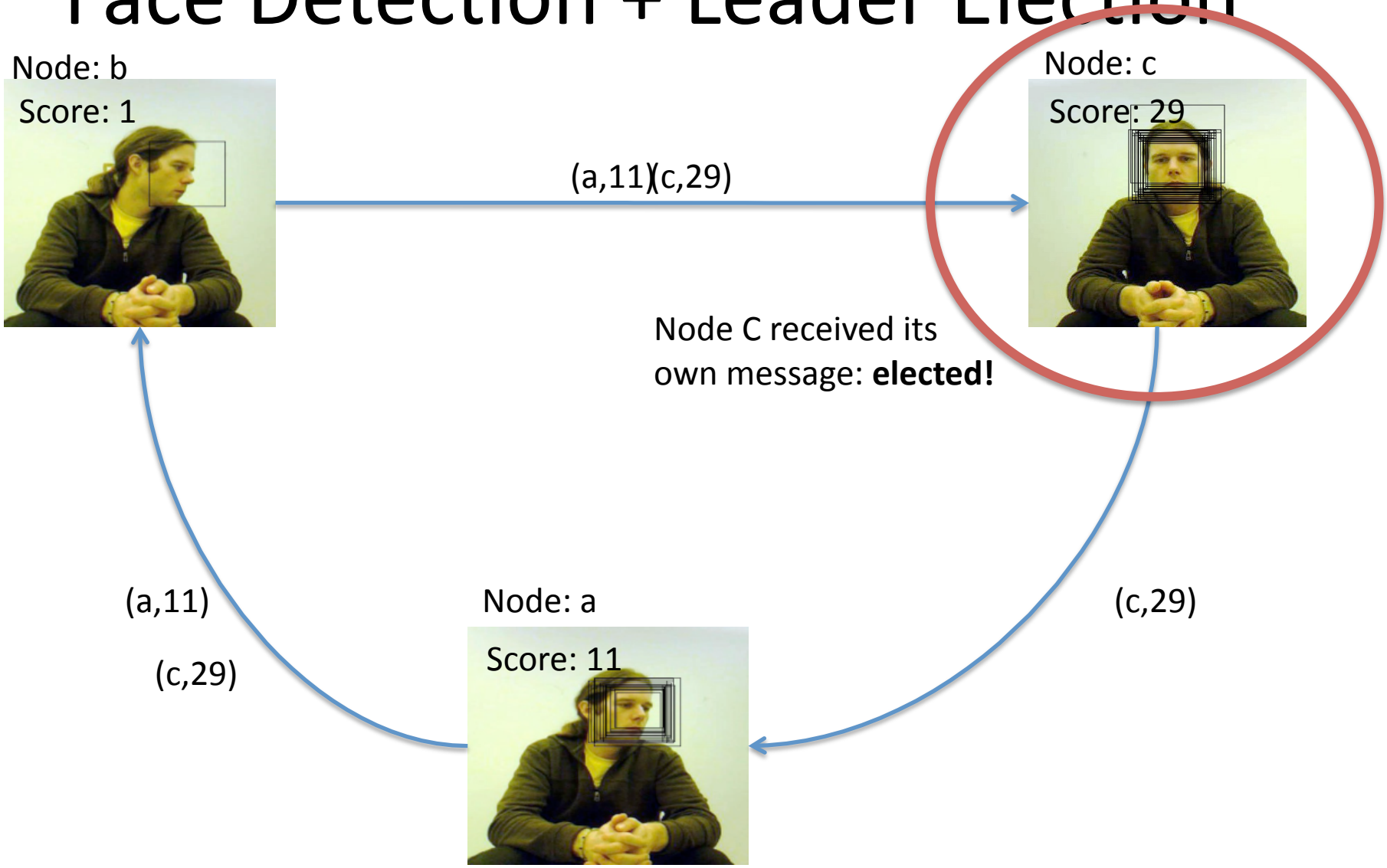


# Face Detection + Leader Election

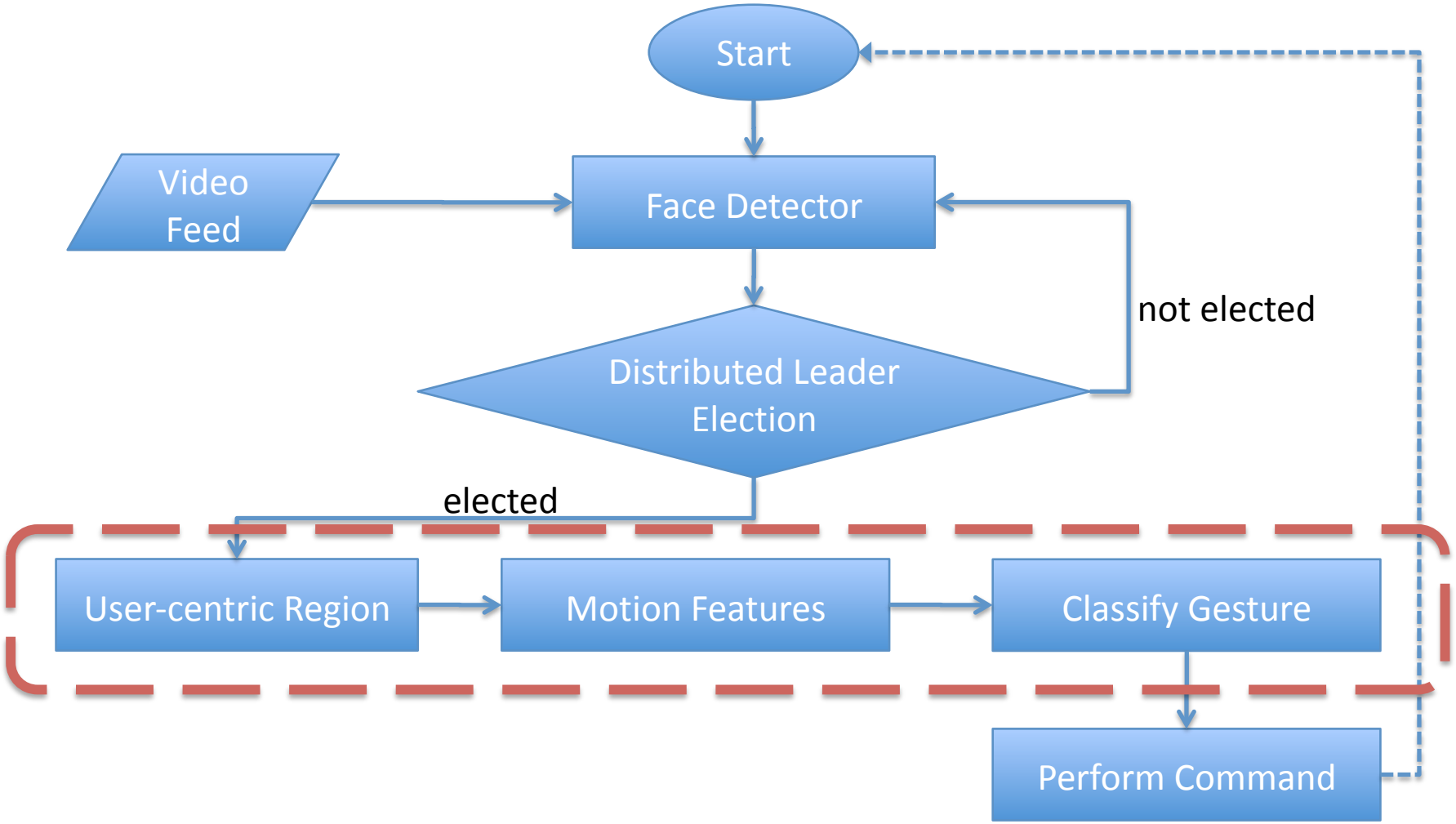




# Face Detection + Leader Election

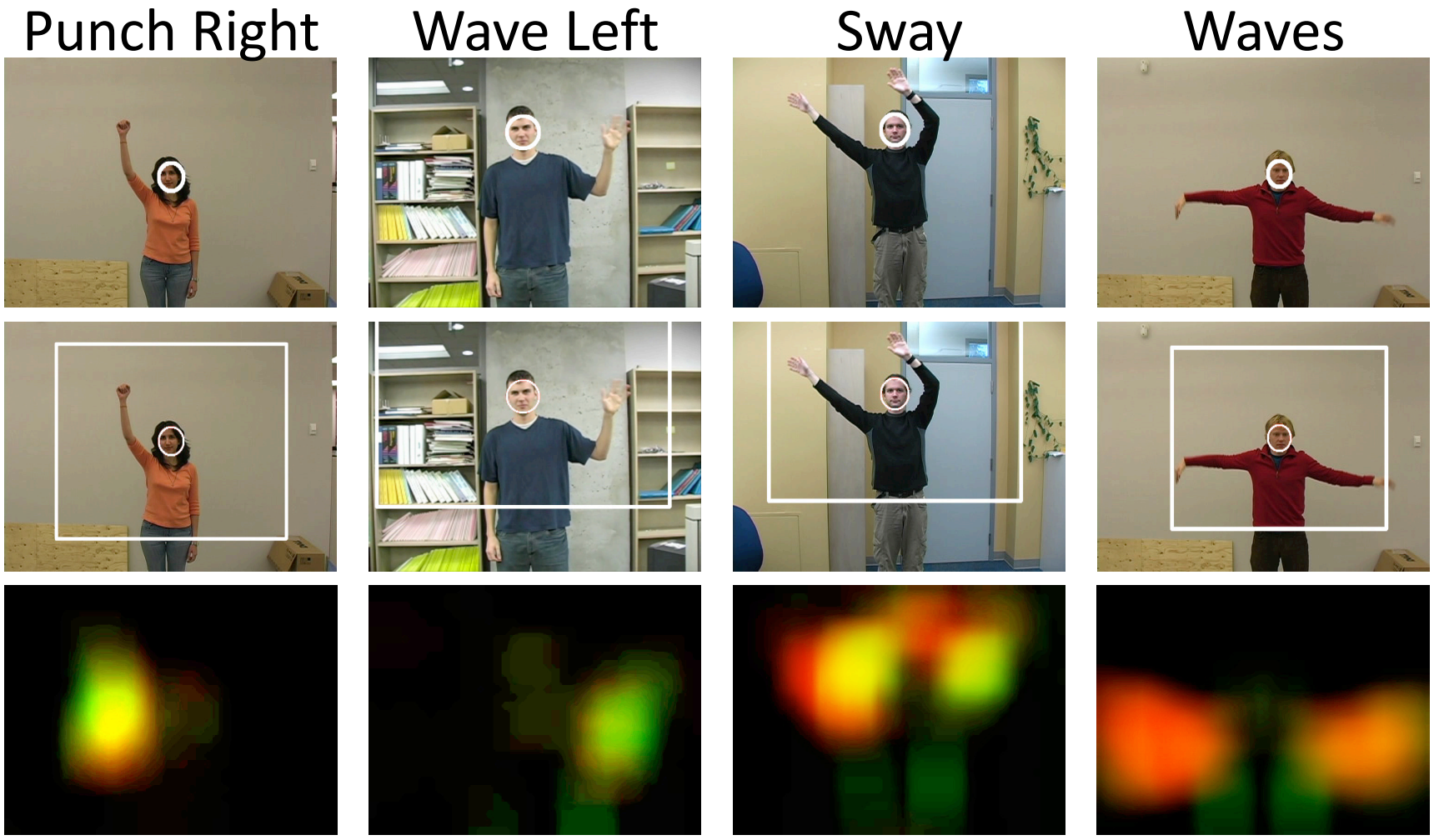


# The Algorithm



# Classifying Gestures

# Our Approach



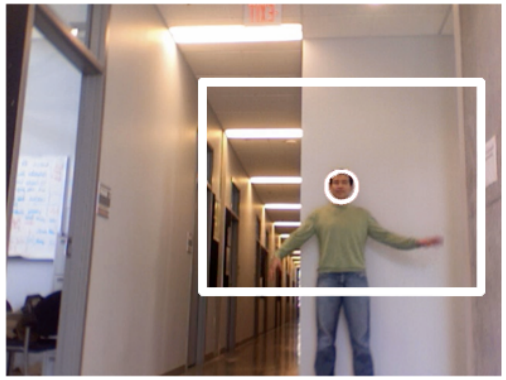
# Related Work

- Many other papers on motion-based gesture/ activity recognition
  - E.g. Bobick and Davis PAMI01; Yamamoto and Koshikawa CVPR97; Shechtman and Irani CVPR05; Freeman et al. FG96; Ike et al. MVA07; Jhuang et al. ICCV07
- Our focus is on a fast real-time method
  - Derived from Fathi and Mori CVPR 08
  - Using GPU programming

# User-centric Region

- Face detection (as detected for leader election)
  - user centric
  - scale invariant

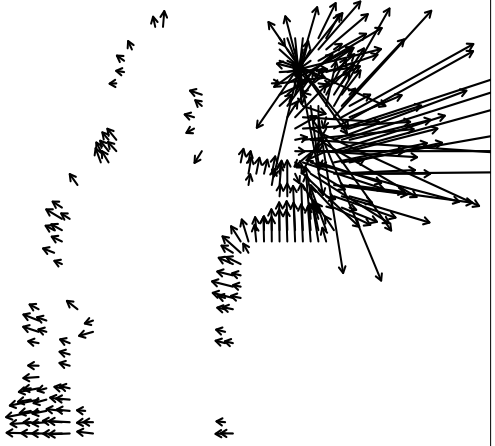




- Face detection in a separate thread
  - Updated every 5-10 frames

1) Calculate Optical Flow

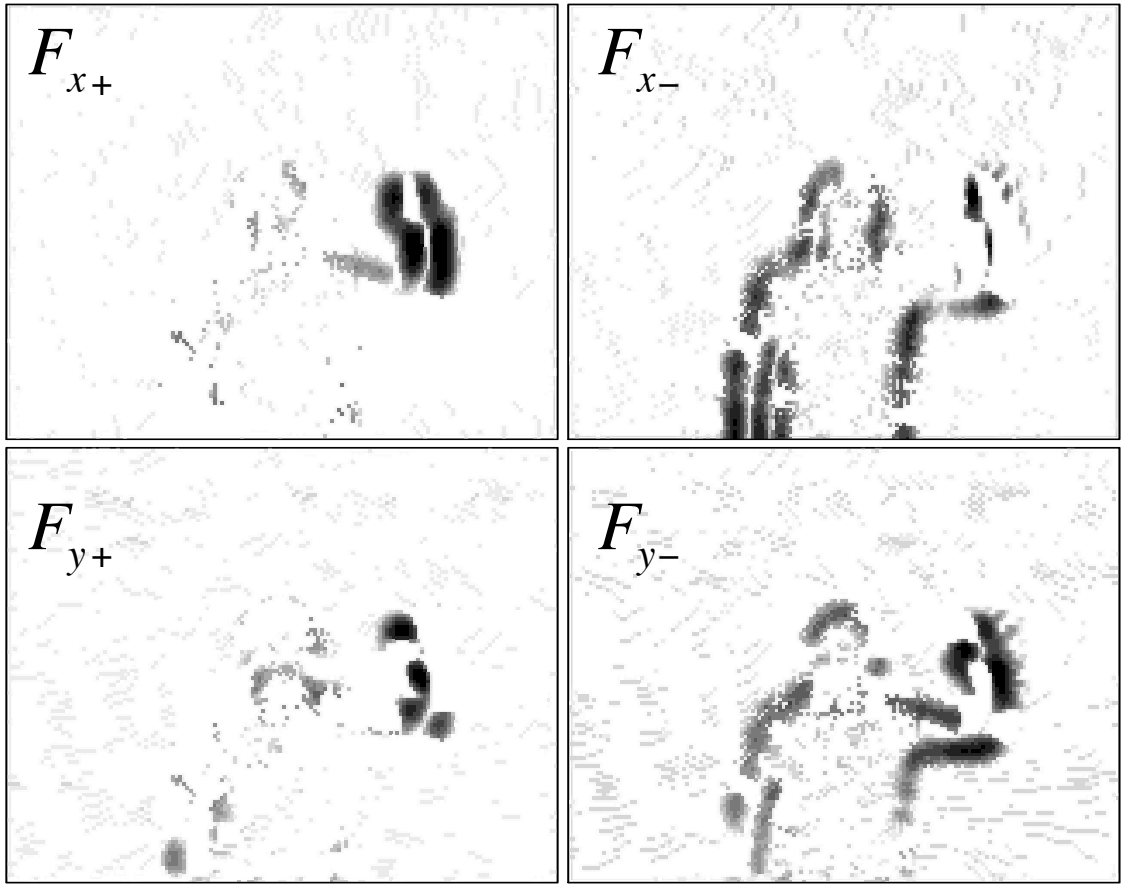
2) Normalize / remove noise



$$v'_{i,j} = \frac{v_{i,j}}{\|v\| + \varepsilon}, \quad \varepsilon = 0.5$$

3) Separate components

4) Blur components

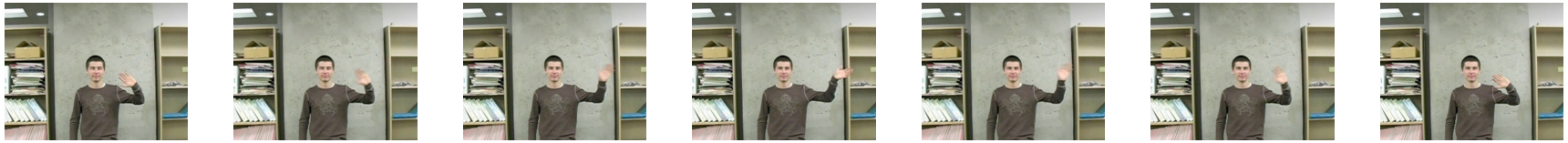



5) Compute zero component

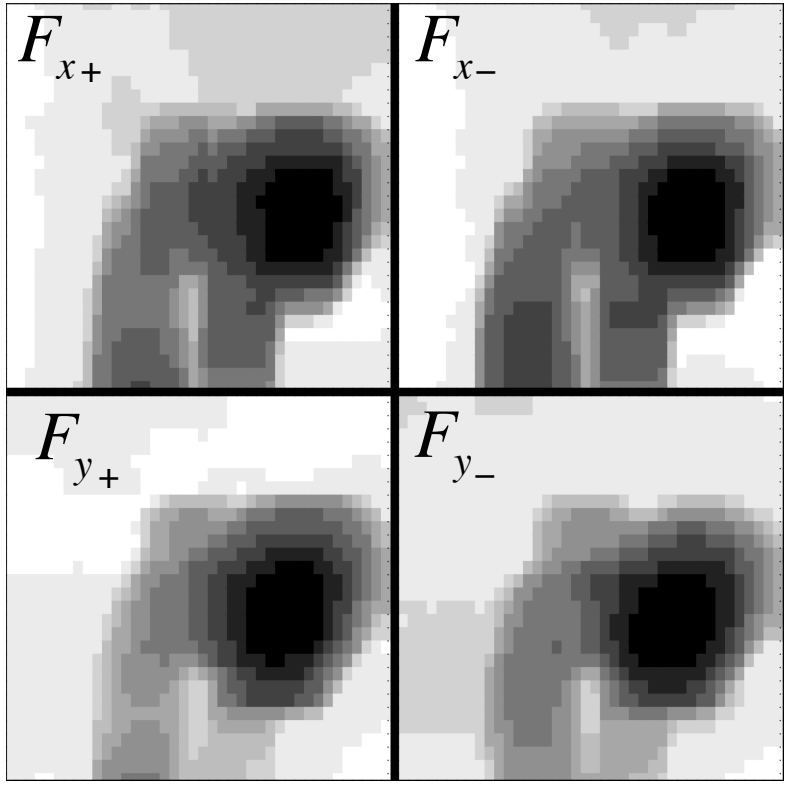
$$F_0 = F_{x+} + F_{x-} + F_{y+} + F_{y-}$$

Similar to Efros et al. ICCV03
Template matching too slow

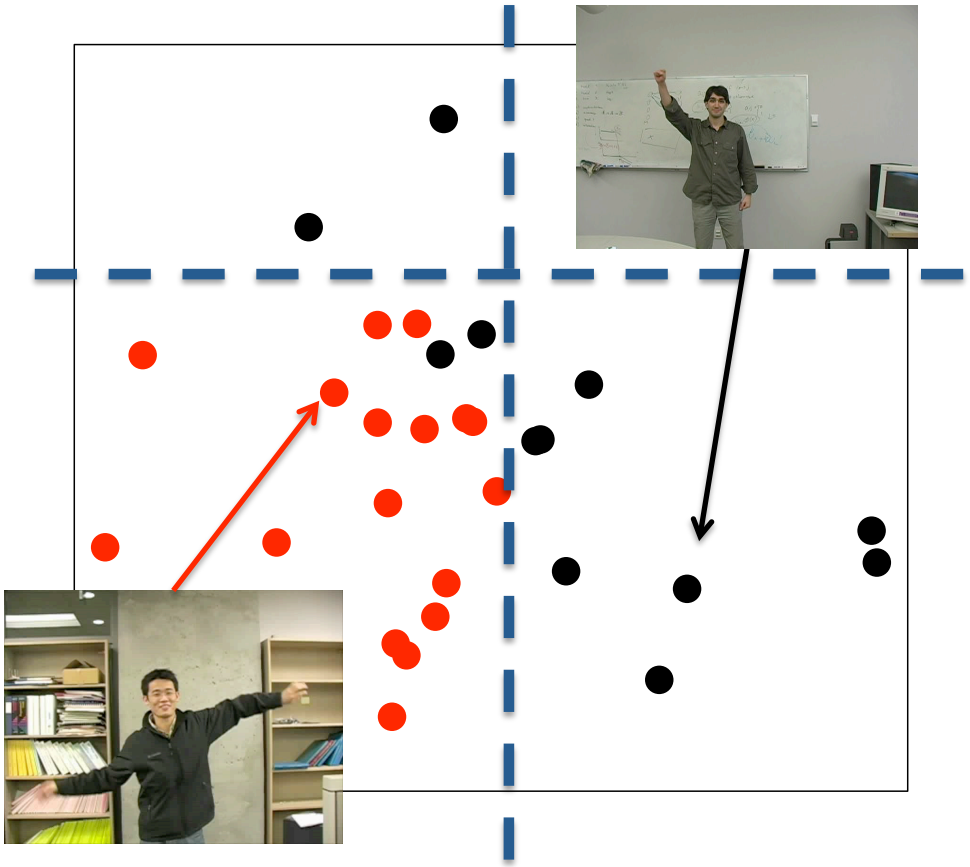
# Motion Features (cont.)

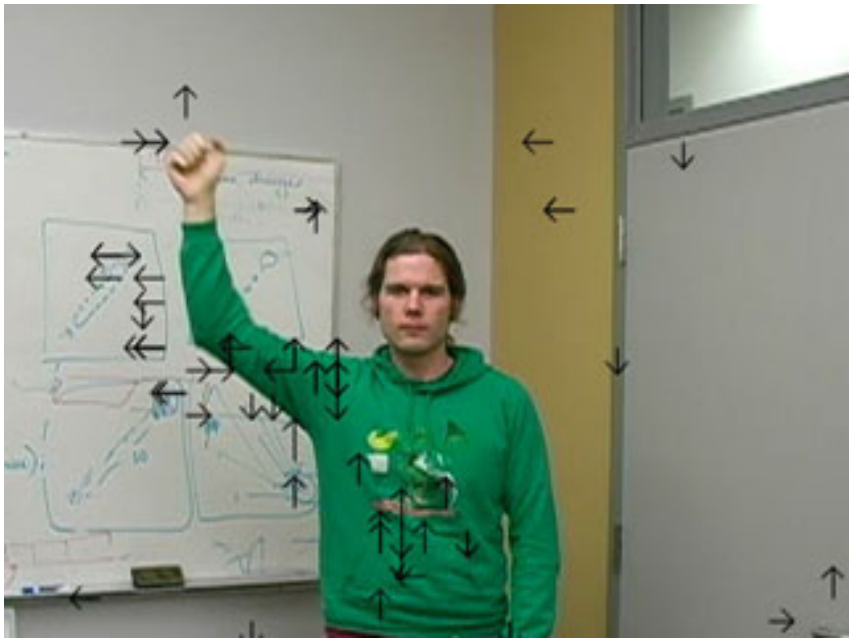


- Temporal Blur
  - Capture a single cycle of movements
  - Roughly 1 second
- Collapsed into a single vector $v \in \Re^{6000} \quad (5\times 40\times 30)$



# Adaboost Classifier



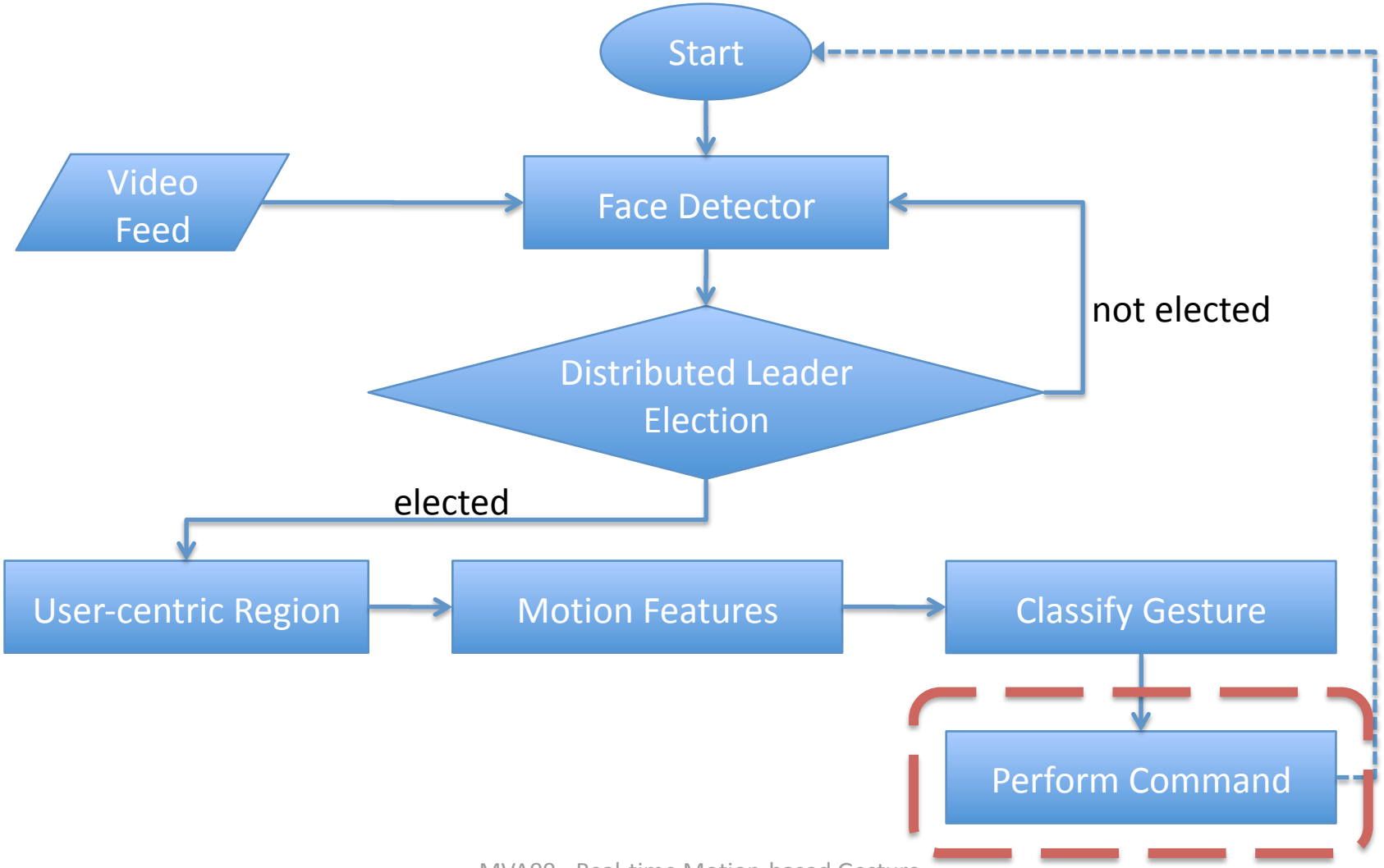


$$h_t(v,l) = \begin{cases} 1 & p_{t,l} v_{\tau(t)} > p_{t,l} \theta_t \\ 0 & otherwise \end{cases}$$

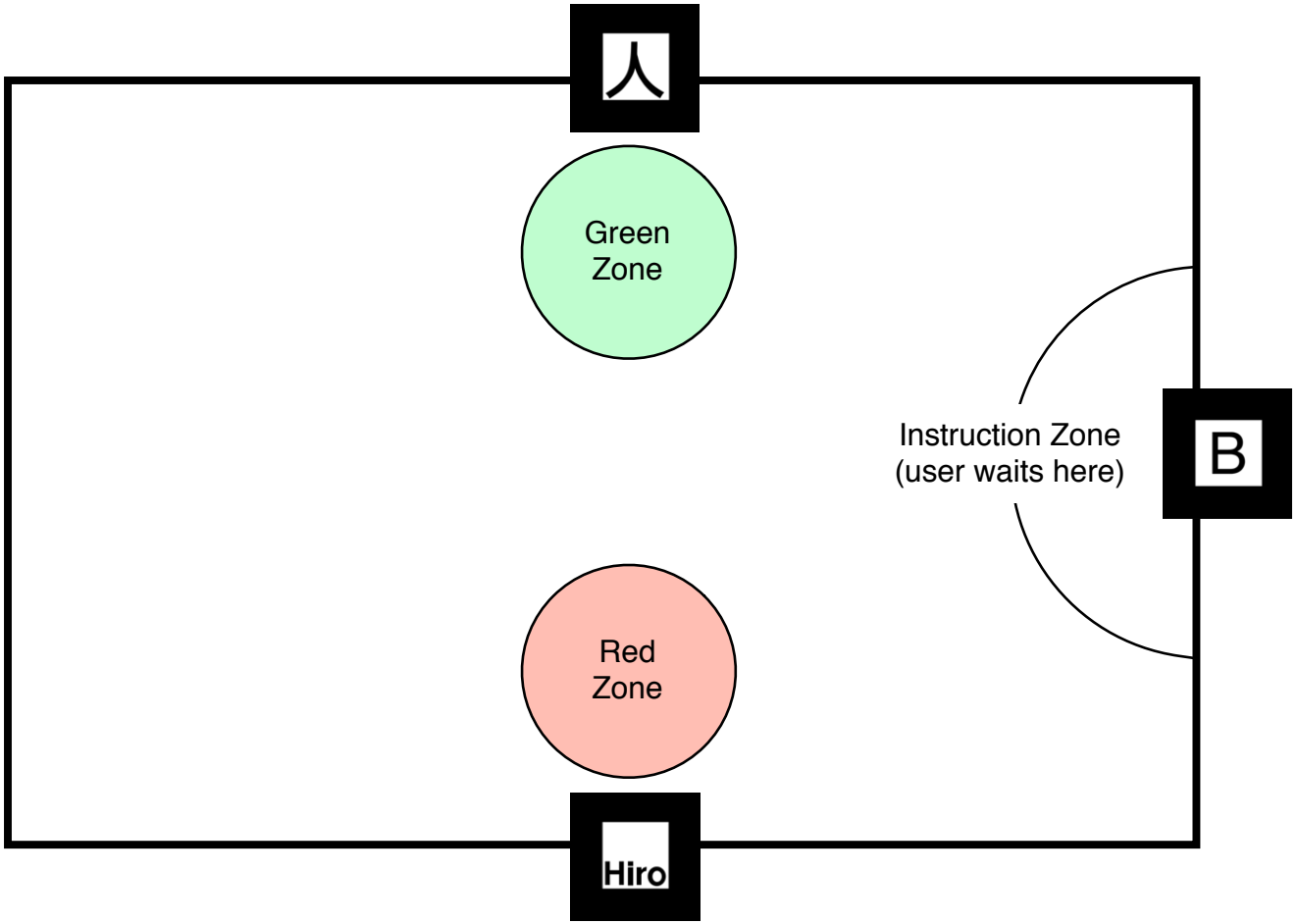
$$H(v,l) = \sum_{t=1}^{N} \alpha_t h_t(v,l)$$

N = 1500 weak classifiers

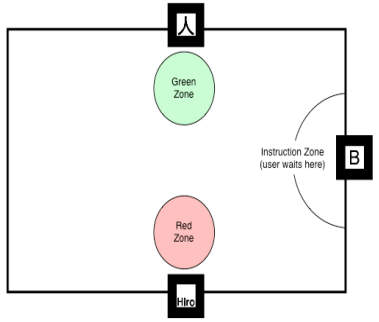
# The Algorithm



# Demonstration Task




Wave-right



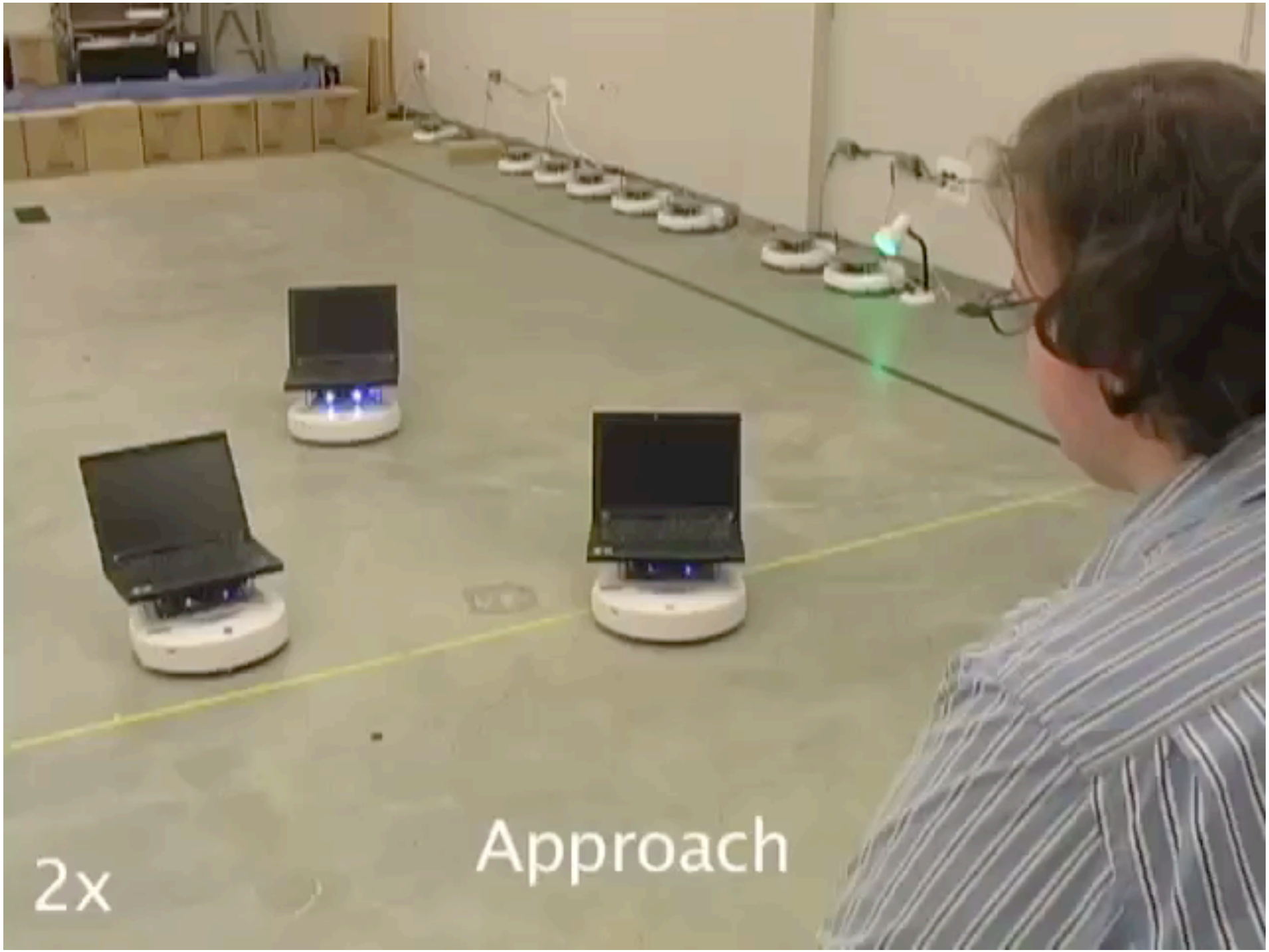

Wave-left

# Conclusion

- First system to use face-engagement to select individual robots in a multi-robot system
- Use of a standard frontal-face detector in a novel way – in a distributed leader election to estimate which robot is being looked at
- A real-time motion-based gesture recognition system for assigning tasks

# Future Work

- User study
  - With the current system
  - Would an anthropomorphized robot help?
- Directing a robot to any arbitrary point by means of pointing
- Selecting a subset of robots
- Integration with speech-based commands


Approach
2x