Assistive Technologies for Children with Autism Spectrum Disorders

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Autism Spectrum Disorders

- Autism Spectrum Disorder (ASD)
  - Autism
  - Asperger Syndrome
  - Pervasive Developmental Disorder Not Otherwise Specified
- Pervasive Developmental Disorder classification
  - Delays social or communication development [10]

ASD Characteristics

- Inability to relate to others [9]
- Difficulty with self-initiation of social behaviors [4]
- Social interaction, communication, imagination impairments [7]

ASD Diagnosis and Therapy

- **Diagnosis**
  - Cause unknown
  - No definitive test
  - Time consuming, expensive
  - Technology can make more accurate, cheaper
- **Therapy**
  - Teach social behaviors
  - Many ASD therapies
  - Select one or combination
  - Time consuming, expensive
  - Technology can make cheaper, provide therapy at home

Outline

ASD Diagnosis

- Observe child's behavior, interview with parents
- Behavior compared to set of behavioral norms
- Diagnostic and Statistical Model for Mental Disorders (DSM) Autism diagnosis: [11]
  - At least 2 symptoms of impairment in social interaction
  - At least 1 symptom of impairment in communication
  - At least 1 symptom of restrictive and repetitive behavior
- Childhood Autism Rating Scale (CARS)
  - Rates children from 1-4 for various social behaviors
  - Yields composite score

Robots and ASD Diagnosis

- Social interaction difficult to observe
- Children with ASDs not social, especially in new situations
- Children with ASDs respond positively with robots

Robots and ASD Diagnosis

- Feil-Seifer and Matarić hypothesized that interacting with a robot that responds to behavior will increase social interactions [6]
- Increase opportunities to observe

Robots Influence Social Behavior

- Robot blows bubbles
- Responds to button presses or acts randomly
- 3 children with ASDs interact with bubble blowing robot
- Sessions were video recorded, annotated by human observers

Figure : From [8].

Robots Influence Social Behavior

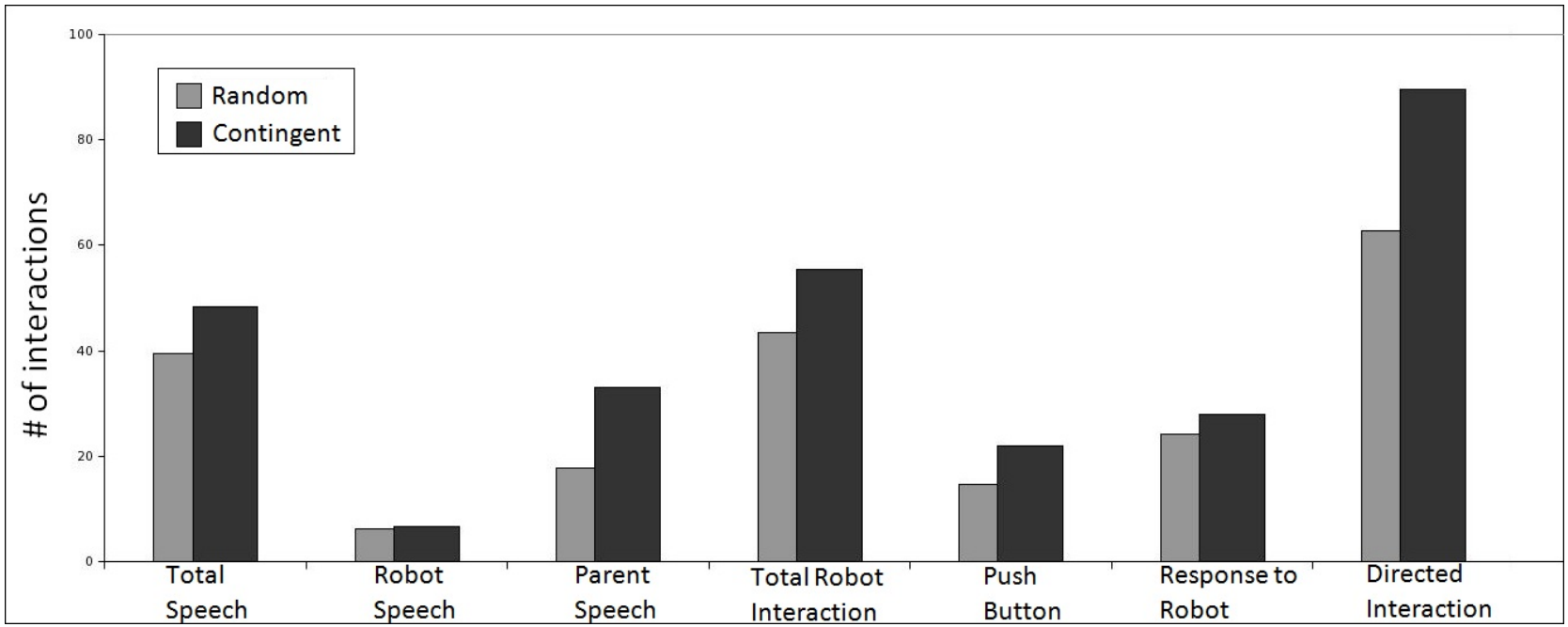


Figure : Results from Feil-Seifer and Matarić's bubble robot study (graph origionally from [6], text made larger).

Embedded Technology and ASD Diagnosis

- Help recognize different behaviors
- Monitor some behaviors for clinician
- More accurate diagnosis

Passive Sensing

Scassellati hypothesized passive sensors could record social information without engaging in interactions [9]

- Outfit evaluation rooms with cameras, microphones, interpreting software
- Use passive sensing to record gaze patterns
- Trained classifier to classify gaze patterns with 90-92% accuracy on the individual trained upon

Passive Sensing Results

Accuracy classifying gaze patterns:

- Trained on typically developing individual
  - Classify typically developing gaze patterns: 86%
  - Classify ASD gaze patterns: 72%
- Trained on person with ASD
  - Classify ASD gaze patterns: 73%

ASD Therapy

- Different kinds of therapy
  - Behavior therapy
  - Drug therapy
  - Communication assistance
- Stressful for family
- Time intensive
- 10 times higher medical bills [1]

Applied Behavioral Analysis (ABA)

- Most popular behavior therapy
- Manipulate environment stimuli to encourage social responses
- Teach proper social protocols
- Success closely monitored [2]
- Asking for something example

Robots and Therapy

- Social behaviors are encouraged by a robot's presence [7]
- Can help speed up learning social behaviors
- Child could have negative reaction, detrimental to therapy

Behavior Classifier

Feil-Seifer and Matarić studied the correlation between robot behavior and the reaction of children [5]

- Can child's reactions automatically be detected and classified?
- If so, robot could adjust behaviors

Behavior Classifier

Study involved 8 children with ASD, each with one of their parents, and autonomous robot

- Can move head, arms
- Can move around the room
- Camera on room's ceiling and infrared sensors for sight
- Background subtraction algorithm to detect child and parent

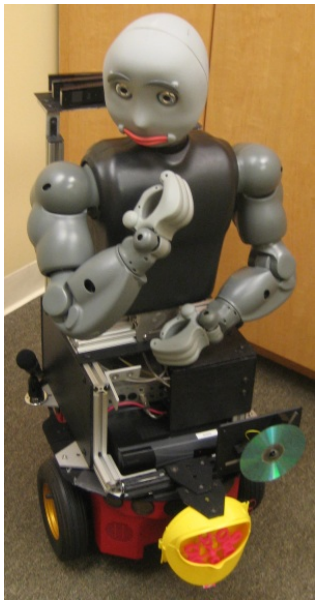


Figure : From [5].

Behavior Classifier

- 3, 5-minute sessions
  - Robot responded to actions of child
  - Robot would act randomly
  - Session with non-robotic toy for control

Behavior Classifier

Common behaviors of children

- Interacting with the robot or bubbles
- Staying still
- Near parent
- Against the wall
- Avoiding the robot
- None of the above

Classified each frame into a behavior category

- Positive reactions- 80% time interacting with robot
- Negative reactions- less than 20% time interacting

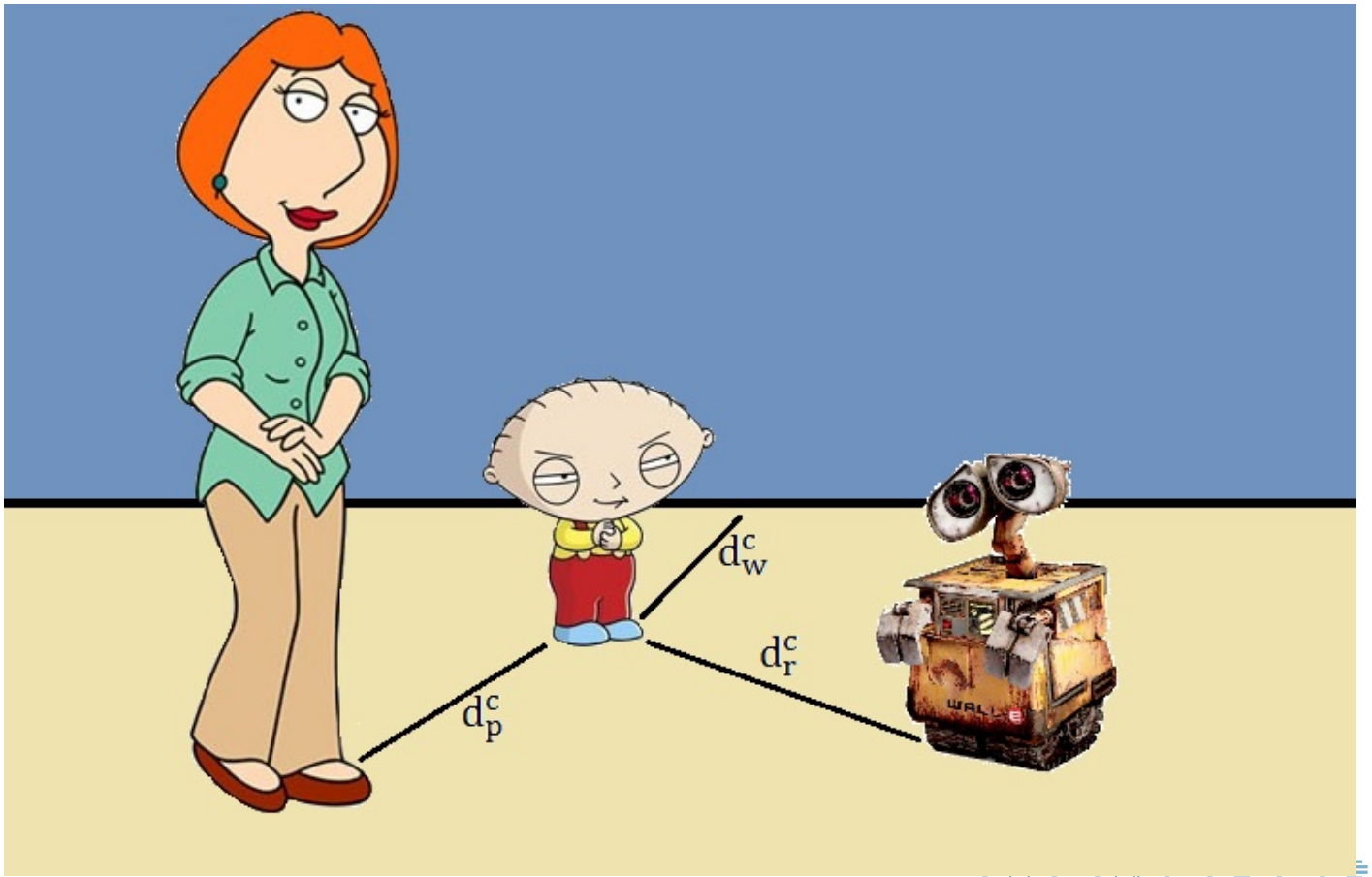
Behavior Classifier

- Grouped all recorded frames into 3216 "tiles" (30 consecutive frames, 2s of video)
- Fit data to a Gaussian Mixture Model: plane containing data points (tiles) grouped into clusters

Behavior Classifier

8-dimensional feature vector to track important distances:

$v =< d_r^c, d_p^c, d_w^c, \psi_r^c, v_c, v_r^c, v_w^c, v\psi_r^c >$



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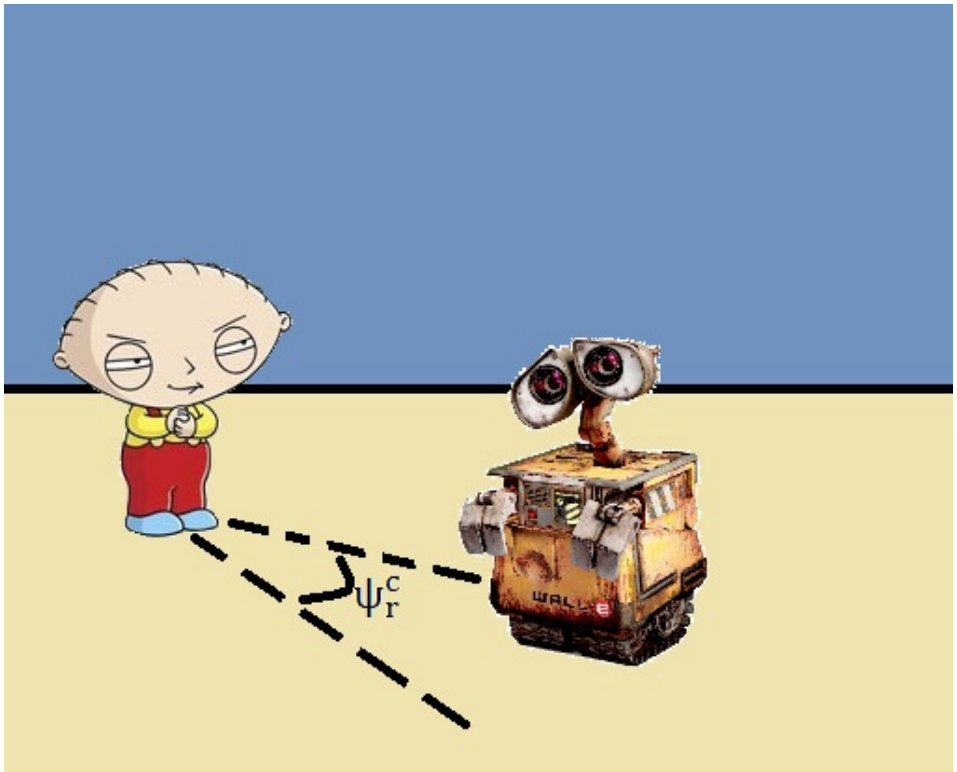

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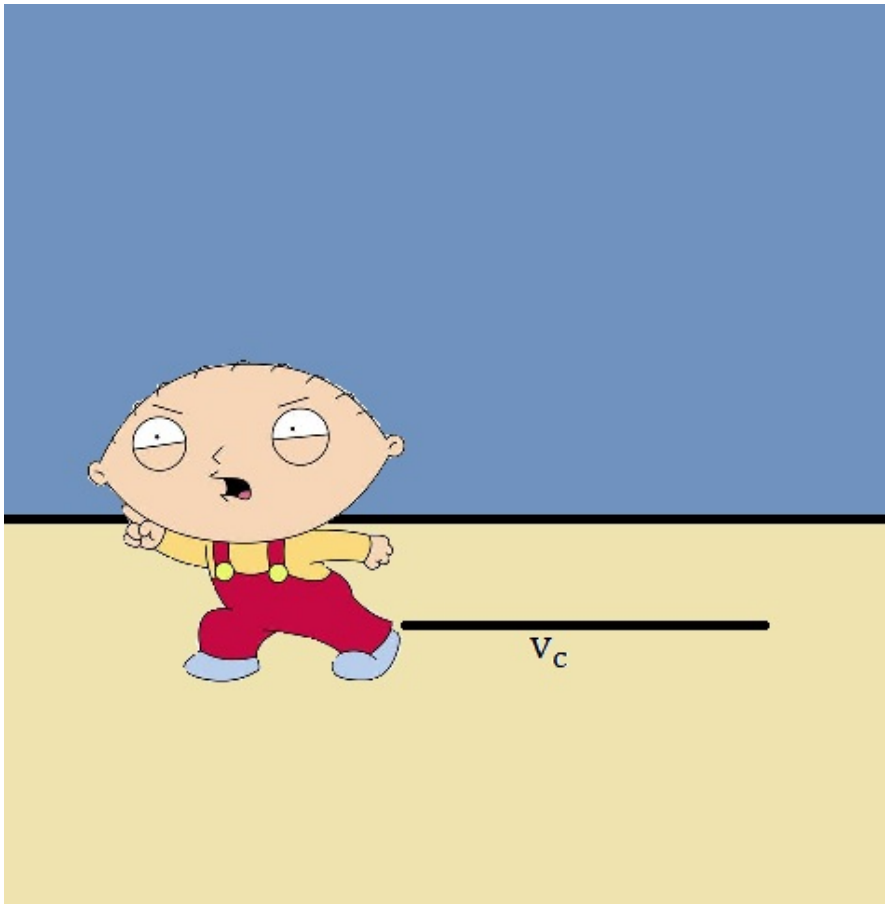

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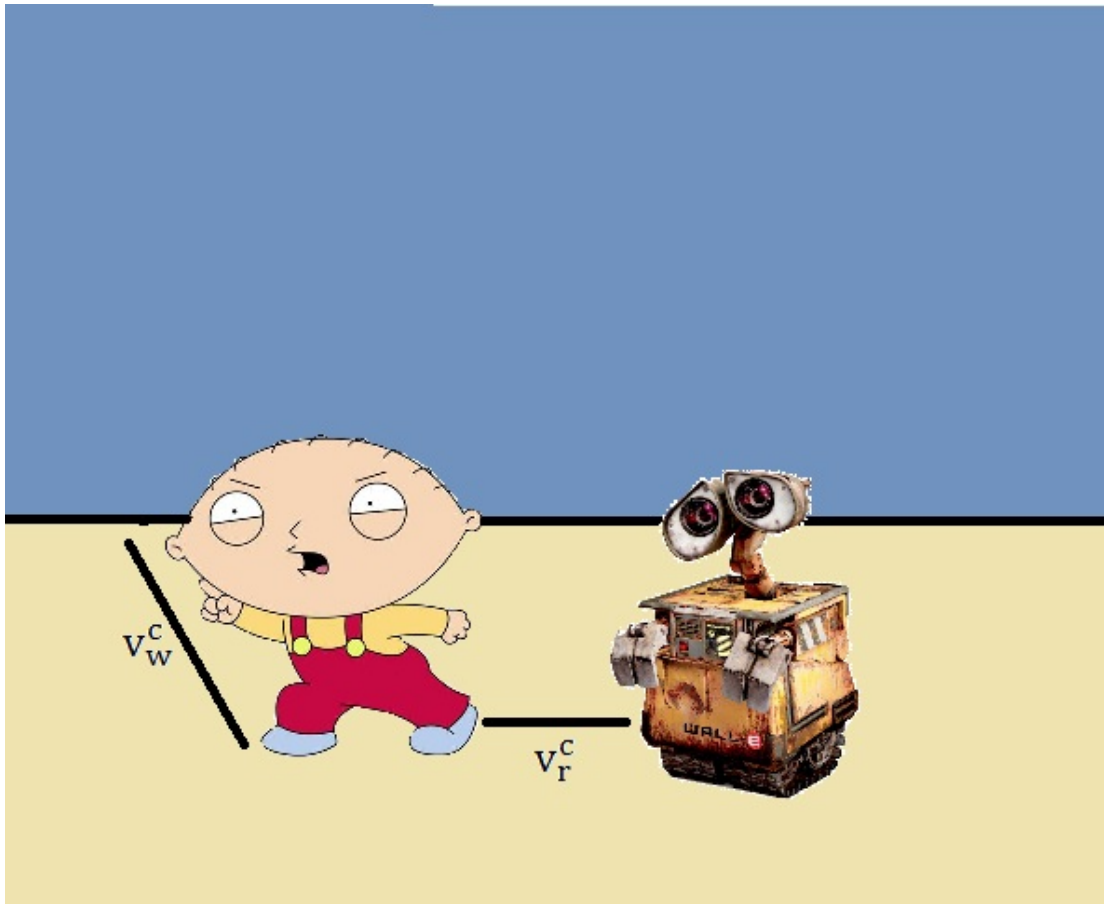

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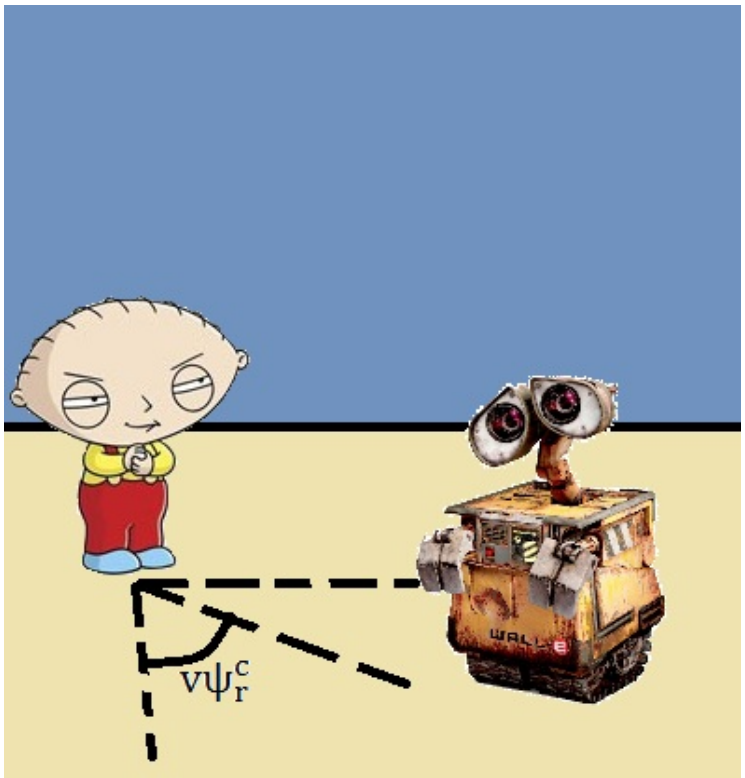
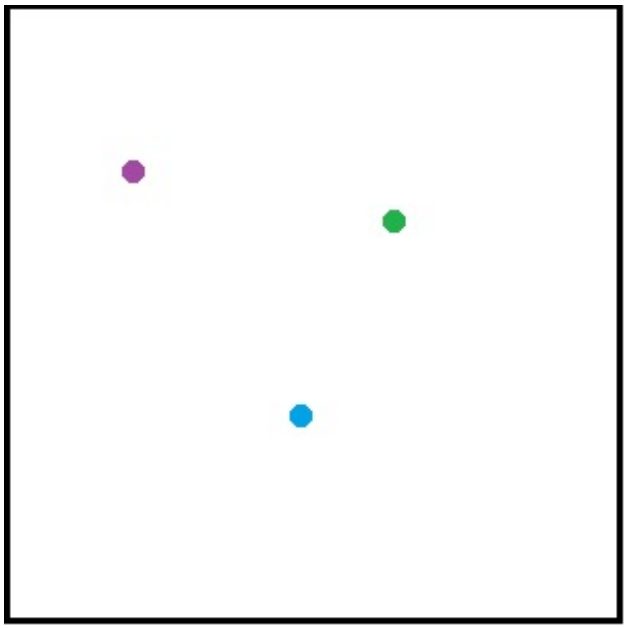


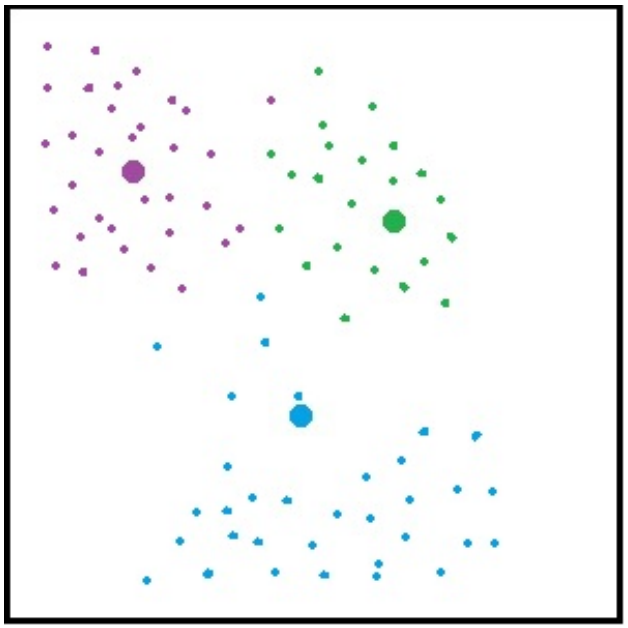
Behavior Classifier

- Optimal number clusters calculated(23-25 clusters)
- Center point for each cluster randomly selected on plane



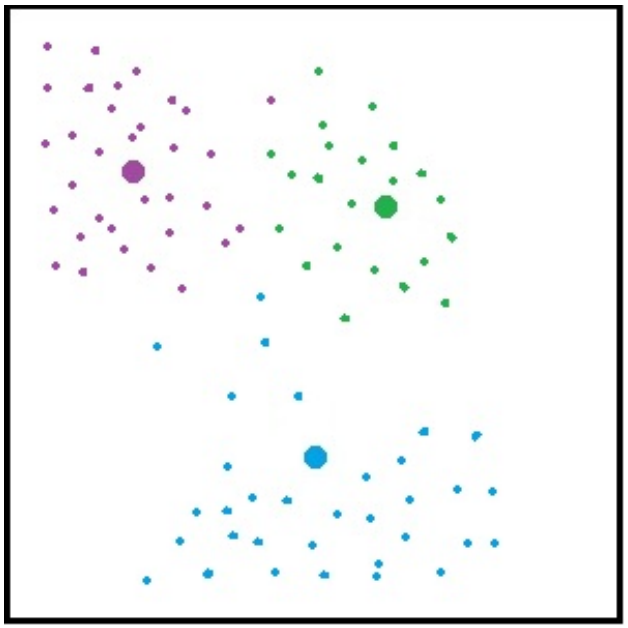
Behavior Classifier

All tiles added to the plane, closest cluster identified



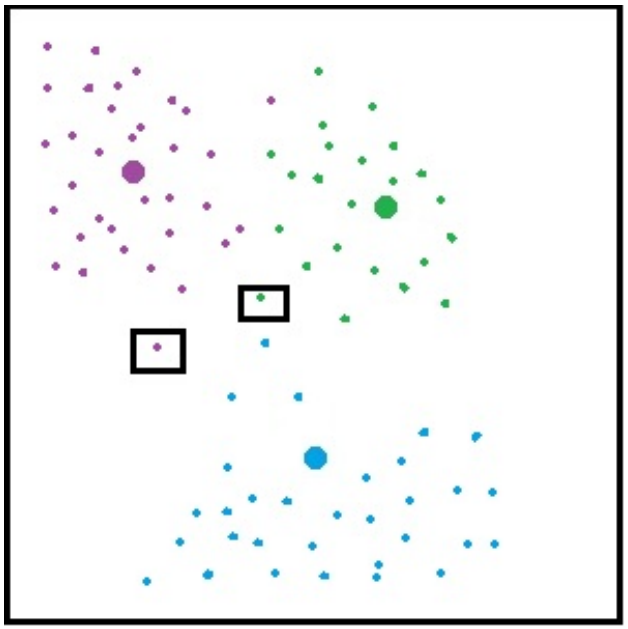
Behavior Classifier

Center point for each cluster reassigned to average of all tiles in the cluster



Behavior Classifier

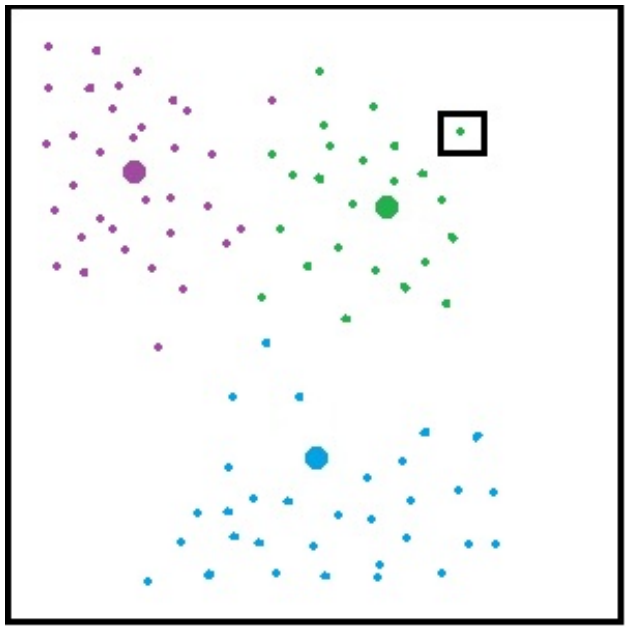
Cluster assignment and averaging repeated until assignments cease to change



Behavior Classifier

Classifying the clusters

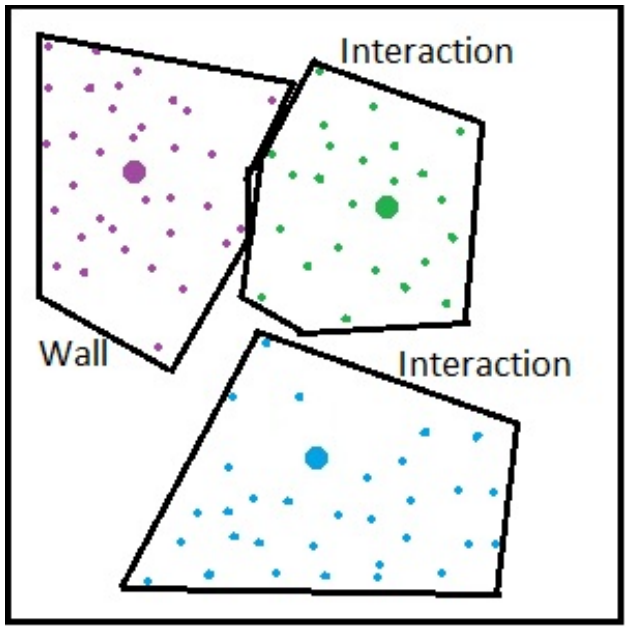
- Human-labeled observations added to GMM
- Closest cluster to that point is labeled with that observed behavior



Behavior Classifier

Classifying the clusters

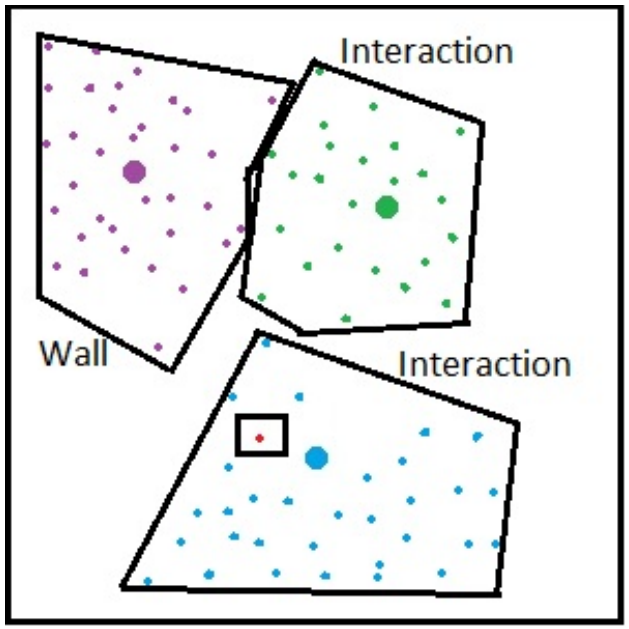
- Human-labeled observations added to GMM
- Closest cluster to that point is labeled with that observed behavior



Behavior Classifier

Classifying new observations

- New observation added to GMM
- Cluster it is most likely to belong to is the classified behavior



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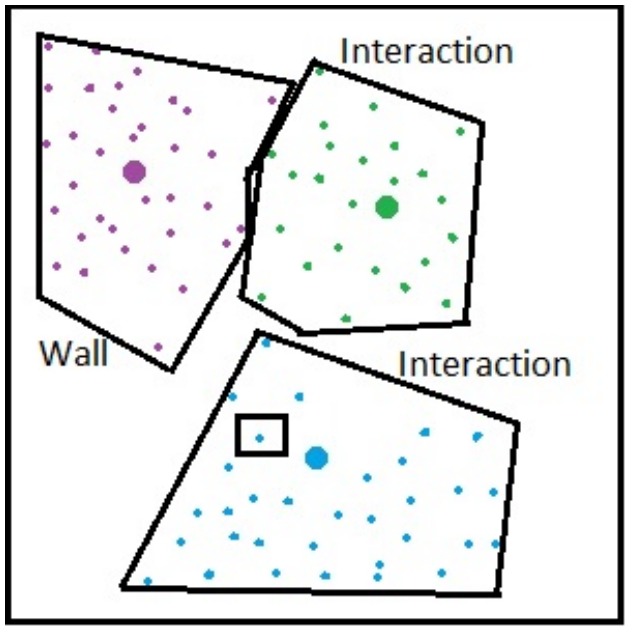

Behavior Classifier

Table : Confusion between behaviors (data from [5]).

Classifier	Human			
	avoidance	interaction	parent	wall
avoidance	**34.76%**	1.11%	3.87%	1.26%
interaction	55.83%	**97.70%**	25.60%	16.36%
parent	8.28%	1.03%	**70.53%**	3.22%
wall	1.25%	0.16%	0.00%	**79.16%**

Behavior Classifier

Table : Confusion between behaviors, after doubling number of clusters (data from [5]).

Classifier	Human			
	avoidance	interaction	parent	wall
avoidance	**52.76%**	0.80%	1.40%	2.59%
interaction	34.86%	**97.53%**	7.60%	11.56%
parent	9.90%	1.51%	**90.80%**	3.67%
wall	2.48%	0.16%	0.20%	**82.18%**

Behavior Classifier

- Classifier can accurately identify behaviors
- Can determine if child is having positive or negative reaction
- Robot can alter behavior

Mobile Technology and ASD Therapy

- Popularity of smartphones and tablets
- Cost effective over time

MOSOCO Phone Application

- Follows Social Compass ASD therapy curriculum
- Addresses eye contact, starting interaction, asking questions, sharing interests, finishing interaction
- Progress through curriculum outside of class
- Runs on Android smartphone
- Augment real-life social situation

MOSOCO Phone Application

Supports individual:

- Identifier for students using system
- Progress reports
- Self-report
- Social cues

Figure : From [3].

MOSOCO Phone Application

Supports group work:

- 6-step interaction schedule (Interaction Visual Schedule)
- Potential interaction partner
- Synchronizes interaction visual schedules of each partner
- Records missteps

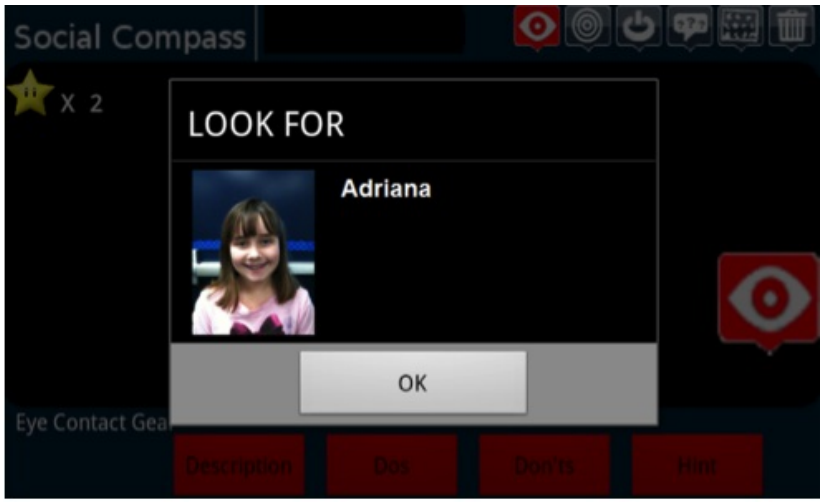

Figure : From [3].

MOSOCO Phone Application

- 12 children: 3 with ASDs, 9 typically developing
- 3 weeks using MOSOCO during recess and lunch breaks
- Results:
  - Children with ASDs improve in social interactions
  - Typically developing children have greater understanding for those with ASDs

Figure : From [3].

Conclusion

- ASDs are becoming more prevalent
- Technology can help make the diagnostic process more accurate
- Technology can help make therapy cheaper, more effective, and/or less time consuming

Questions?


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