Attending to Learn and Learning to Attend

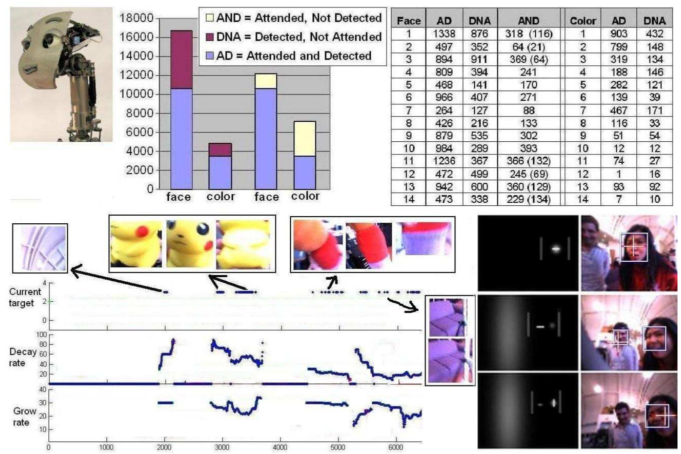
Lijin Aryananda
MIT Computer Science and Artificial Intelligence Laboratory
32 Vassar Street 32-380, Cambridge, MA 02139, USA, lijin@csail.mit.edu

Our motivation is to create a robotic creature, Mertz, that 'lives' among us daily and incrementally learns about people through long-term social interaction. These developmental and social robotic approaches have been widely explored (2, 1). The parallel task of interacting with while learning from the environment is in some ways conflicting, calling for a balance between reactivity and persistence. The robot must be reactive to find learning targets and also persistent to observe once a target is found. This dichotomy is reflected in the exogenous and endogenous control of our visual attention.

In this paper, we propose a developmental framework integrating an adaptive multi-modal attention and perceptual learning. Our approach is inspired by the coupling between the infant's attention and learning process. The attention system determines what infants can learn. Conversely, the infant's learning experience adapts attention to incorporate knowledge acquired from the environment. We implemented a multi-modal attention system that is coupled with a spatiotemporal perceptual learning mechanism, which adaptively controls the attention's saliency parameters for different stimuli (face, color, and sound). Many properties of the robot's attention system were inspired by the Sensory Ego-sphere (3). Incorporating learning for the top down control of attention has also been explored in (4).

We conducted 14 experiments with 10 people for 173 minutes. Figure 1 (top right) illustrates that faces and colors were attended about half the time whenever detected. When not detected, the robot attended to faces about 25% the time. Six sequences indicated that about 30% of these attention guesses were actually correct. During the last sequence, the robot succeeded in forming 4 face clusters for 3 people who it interacted with simultaneously.

Figure 1 (bottom right) shows an example of how saliency parameters for color segments automatically adapt based on past experience. The saliency growth and decay rate affects how well a stimuli catches and maintains attention respectively. Superimposed on the saliency graph are objects whose color clusters were formed. At time 2000, the robot found its first cluster and the saliency parameters for colors increased to allow learning of more color targets. After the robot found more clusters, the decay and



Face	AD	DNA	AND	Color	AD	DNA
1	1338	876	318 (116)	1	903	432
2	497	352	64 (21)	2	799	148
3	894	911	369 (64)	3	319	134
4	809	394	241	4	188	146
5	468	141	170	5	282	121
6	966	407	271	6	139	39
7	264	127	88	7	467	171
8	426	216	133	8	116	33
9	879	535	302	9	51	54
10	984	289	393	10	12	12
11	1236	367	366 (132)	11	74	27
12	472	499	245 (69)	12	1	16
13	942	600	360 (129)	13	93	92
14	473	338	229 (134)	14	7	10

Figure 1: The robot and various experimental results.

grow rate started to decrease. However, at around time 5300, the attention system adapted to maintain longer attention on the rattling caterpillar which was vigorously moving by increasing the color decay rate again. Figure 1 (bottom left) illustrates a sample sequence of the attention output when interacting with two people. The robot's egocentric attentional map allows the robot to form short-term memory about various stimuli to allow for continuity during interaction.

References

T. Fong, I. Nourbakhsh, K. Dautenhahn. (2003). A survey of socially interactive robots. *Robotics and Autonomous Systems 42:143-166.*

M. Lungarella, G. Metta, R. Pfeifer, G. Sandini. (2004). Developmental robotics: A survey. *Connection Science, vol.00 no.0:1-40.*

R. Peters, K. Hambuchen, K. Kawamura, D. Wilkes. (2001). The sensory egosphere as a short-term memory for humanoids. *Proc. International Conference on Humanoid Robots, pp 451-459.*

S. Frintrop, G. Backer, E. Rome. (2005). Selecting what is important: Training visual attention. *Proc. 28th German Conference on Artificial Intelligence.*