A Short Review on HMAX Model for Biological Object Recognition

Amir Reza Saffari Azar

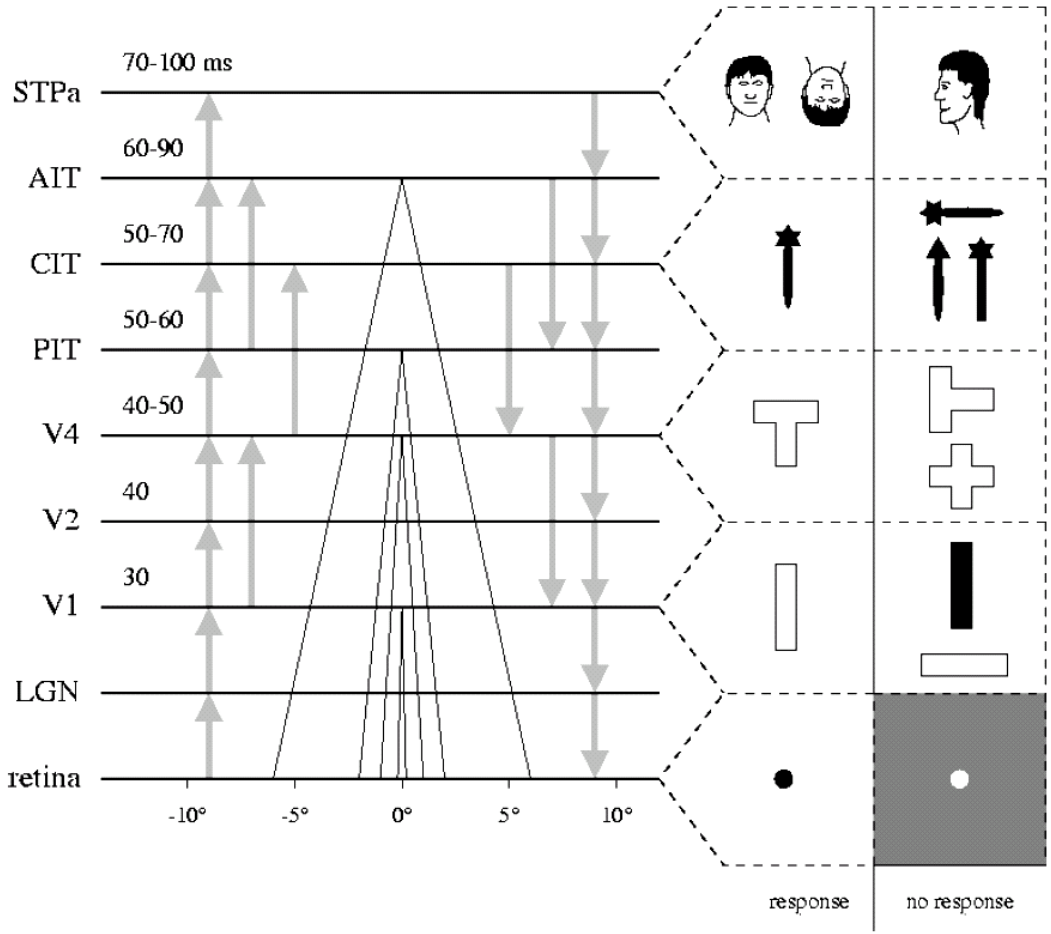
Institute for Theoretical Computer Science,
Graz University of Technology

amir@igi.tugraz.at

Outline

- Visual Cortex
- HMAX
- Modified HMAX
- New HMAX
- Experimental Results
- Discussion
- Our Motivation

Visual Cortex Structure: Ventral Pathway

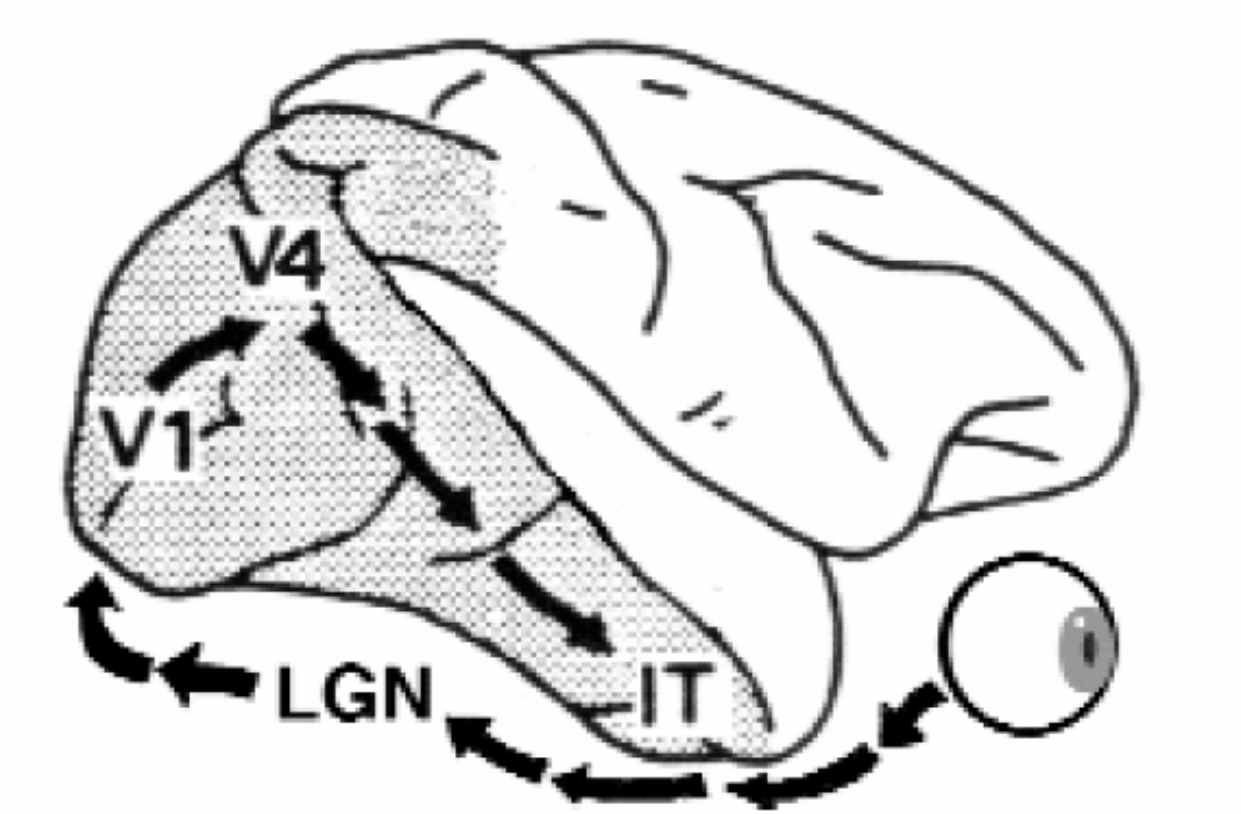


Wiskott, L. (2003)

Properties

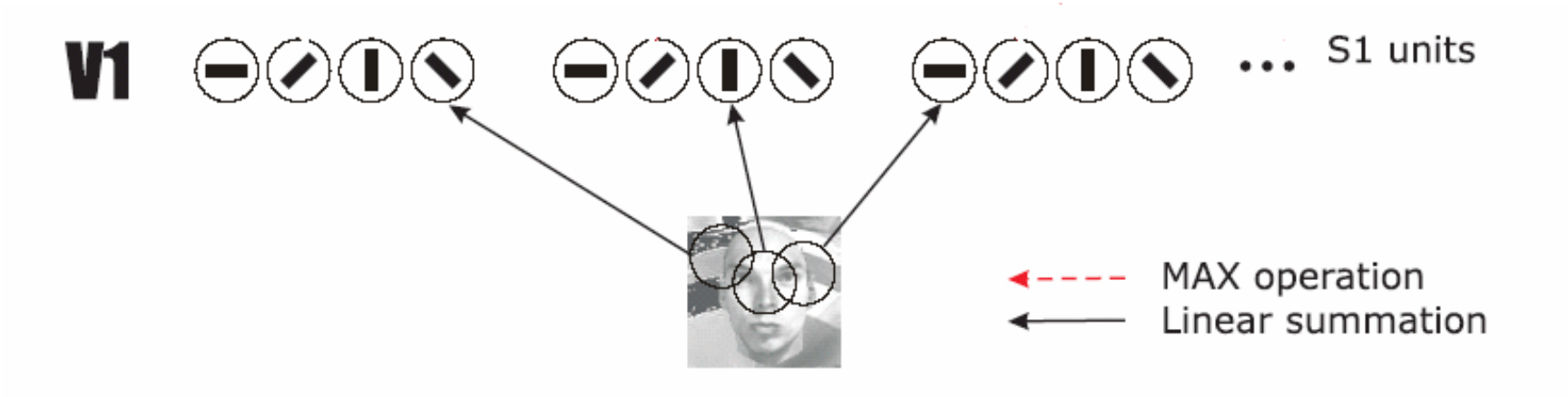
- Layered Structure
- Feedback Connections
- Feature Hierarchy
- Invariance Hierarchy
- Fast Recognition
- Attention
- Learning

Simplified Anatomy



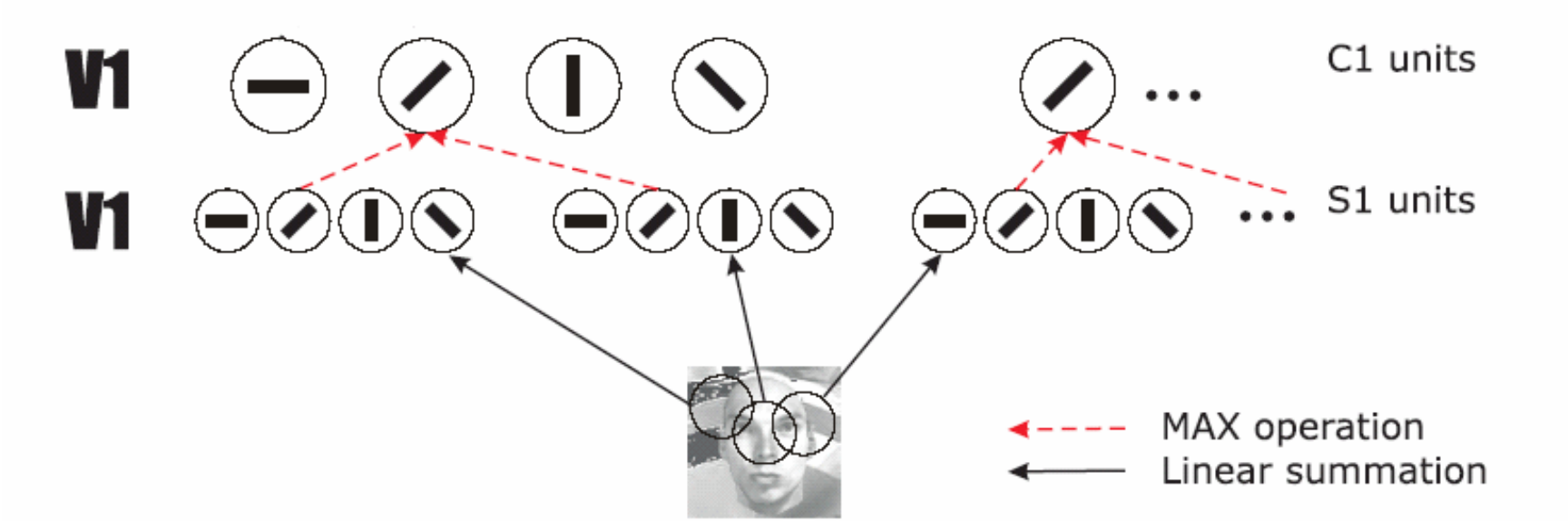
Riesenhuber, M., and Poggio, T. (2000)

HMAX



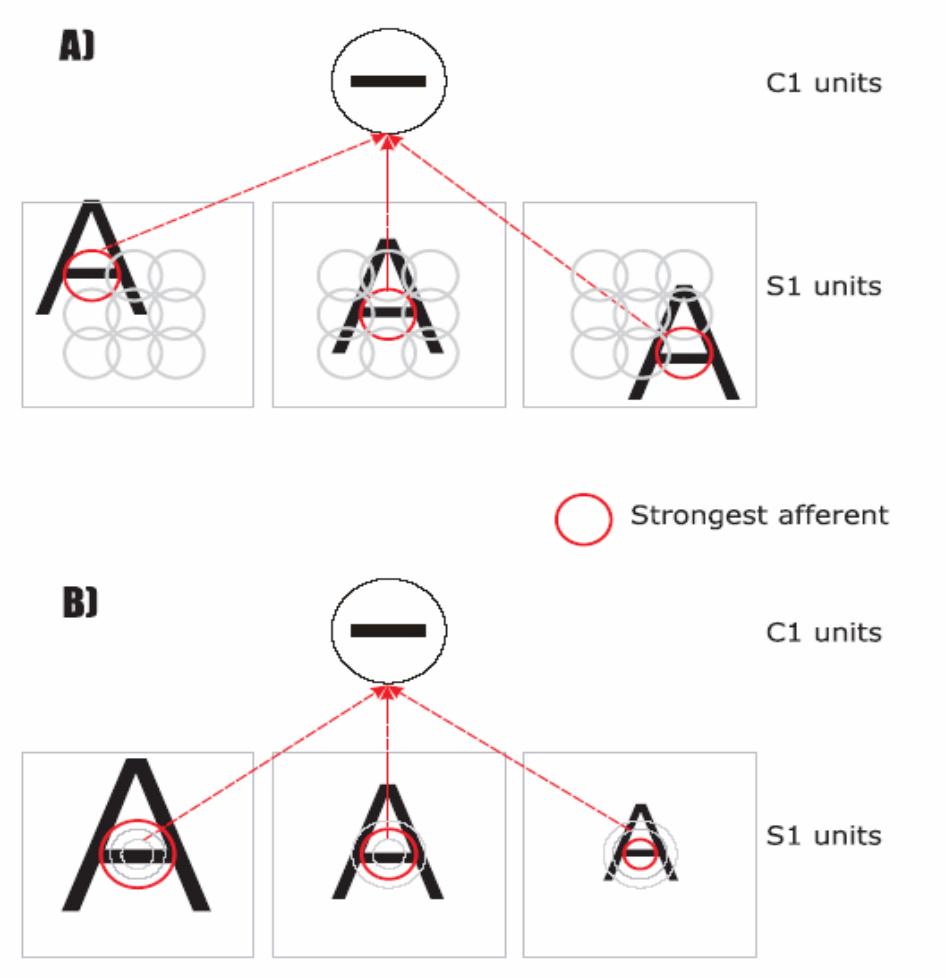
Serre, T., and Riesenhuber, M. (2004)

HMAX



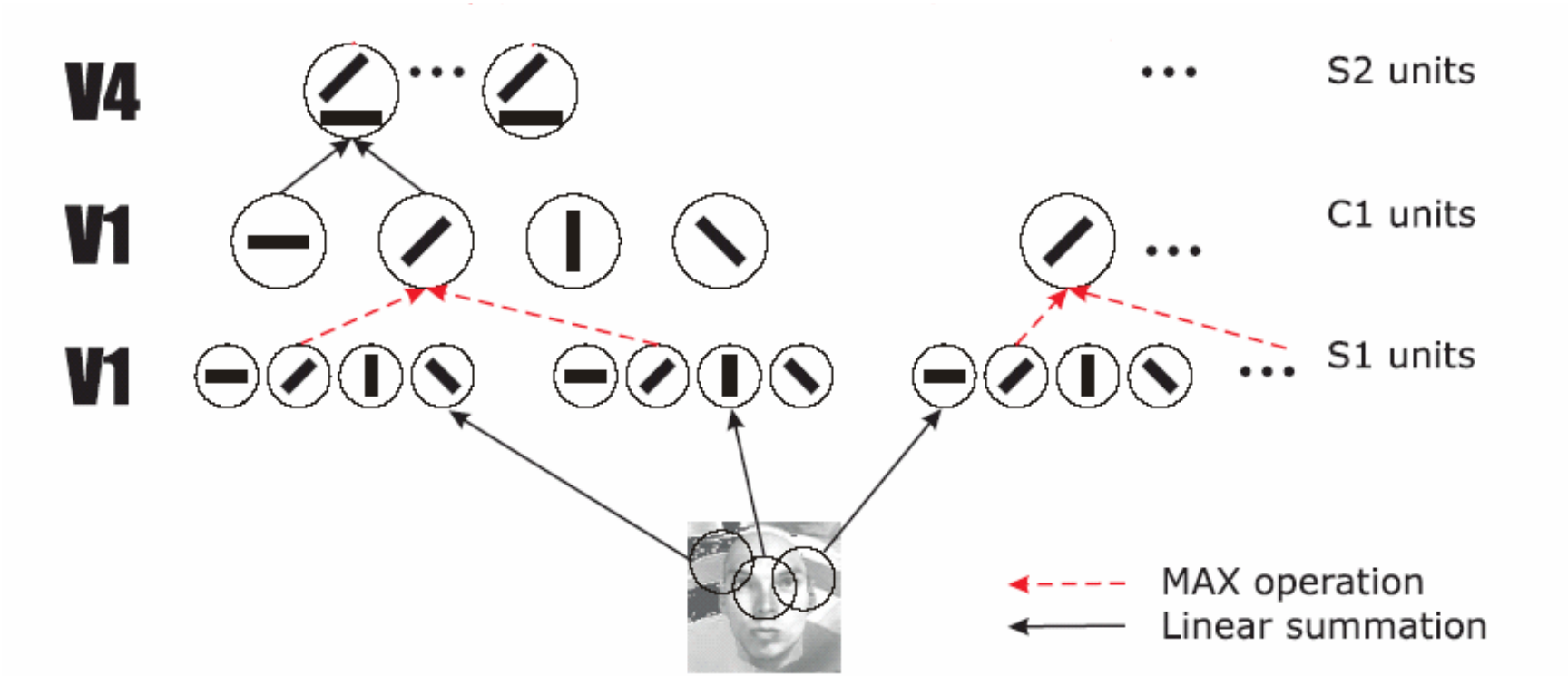
Serre, T., and Riesenhuber, M. (2004)

HMAX



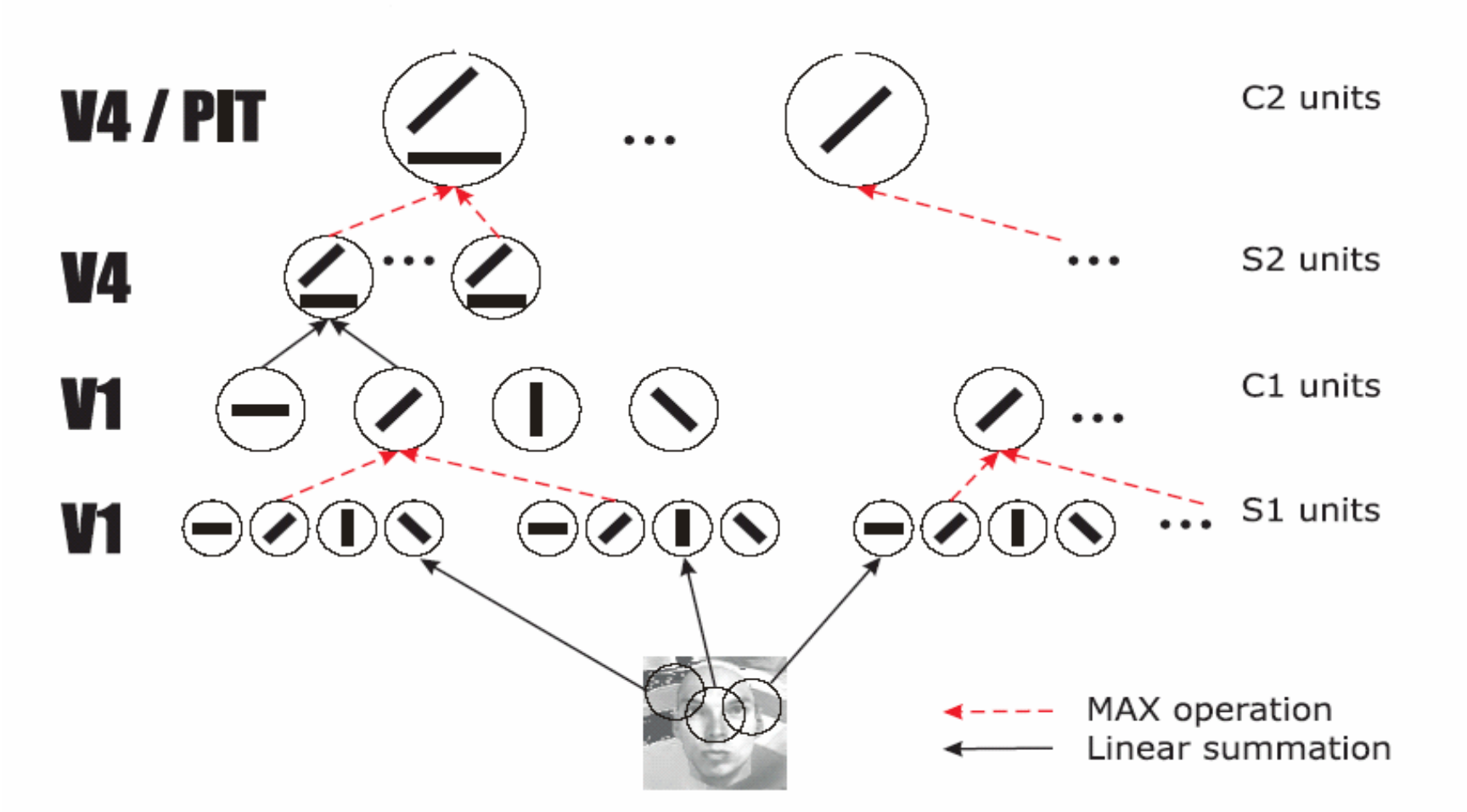
Serre, T., and Riesenhuber, M. (2004)

HMAX



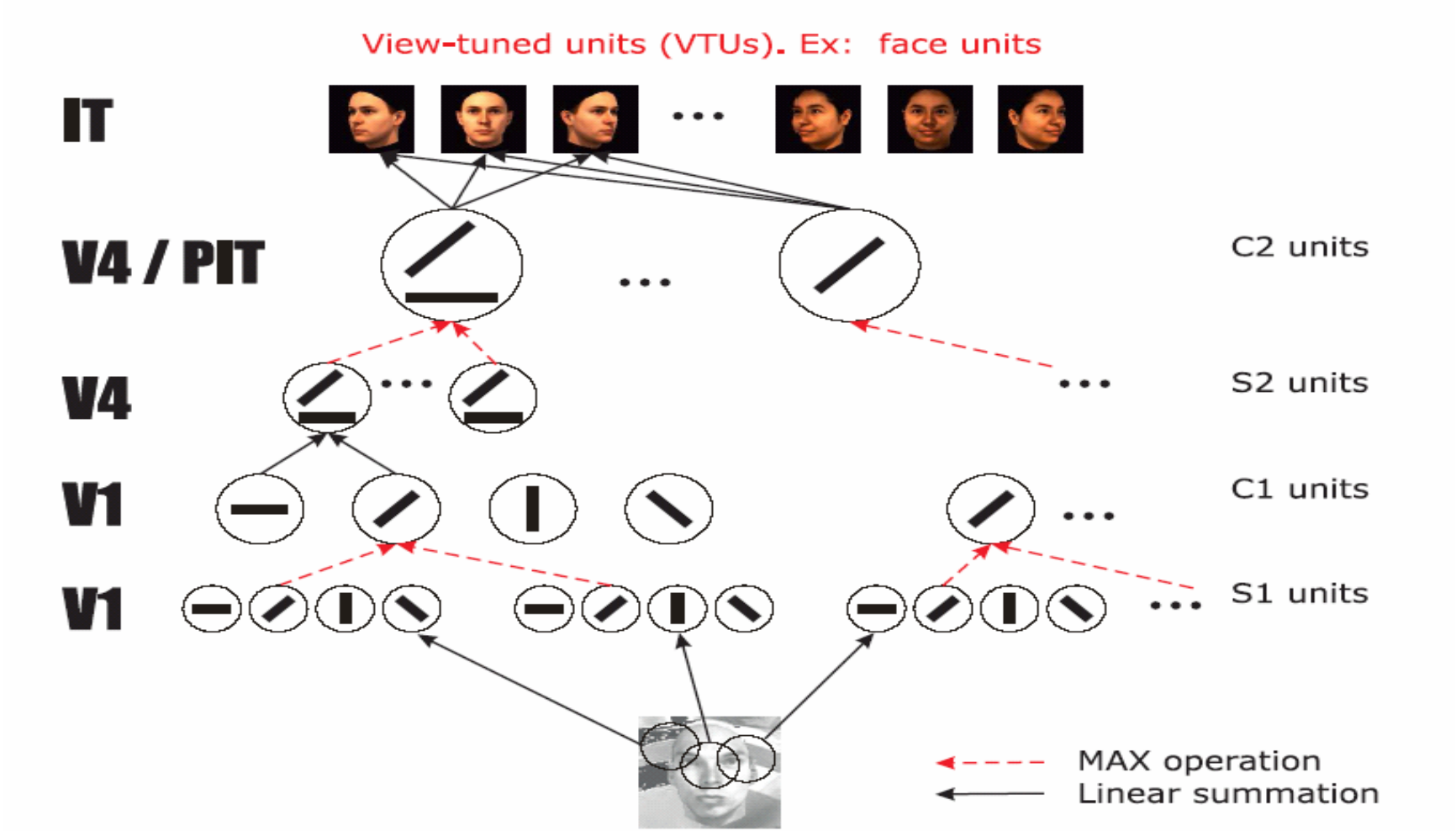
Serre, T., and Riesenhuber, M. (2004)

HMAX



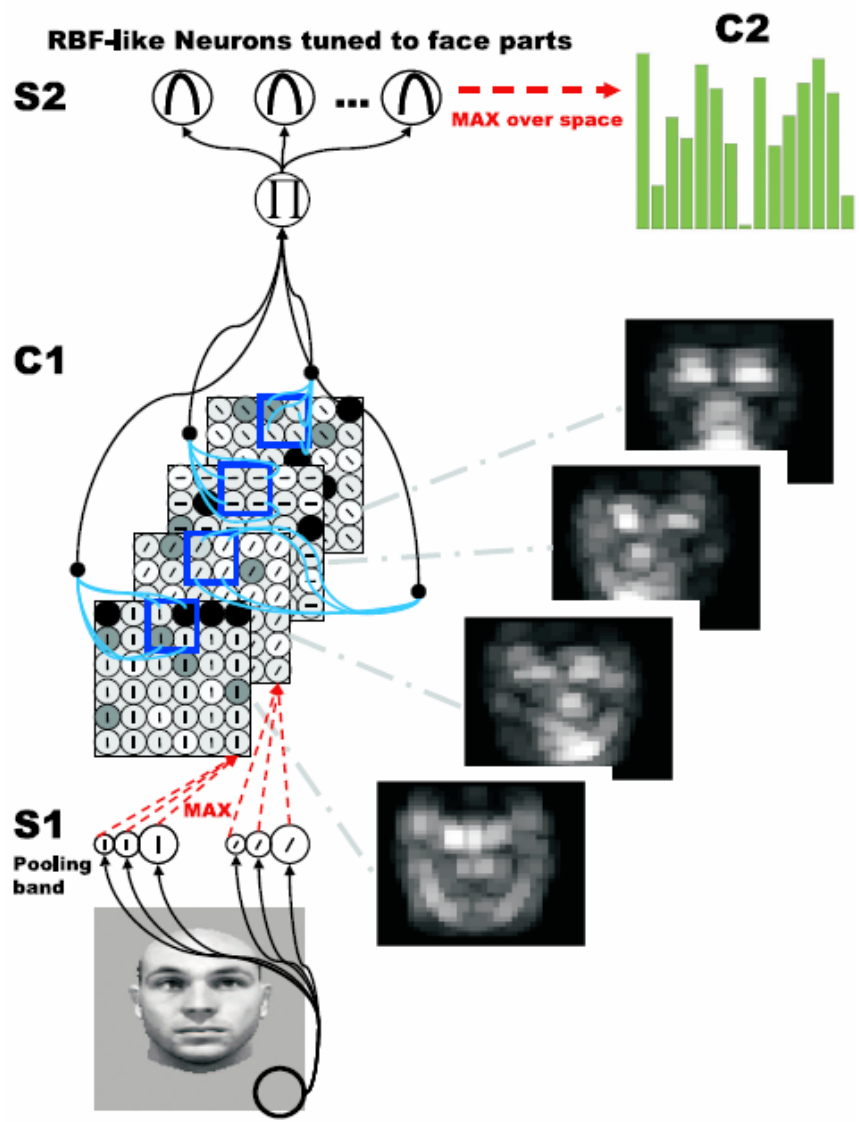
Serre, T., and Riesenhuber, M. (2004)

HMAX



Serre, T., and Riesenhuber, M. (2004)

Modified HMAX



Serre, T. et. al (2002)

New HMAX

Band Σ	1	2	3	4	5	6	7	8
filters sizes s	7 & 9	11 & 13	15 & 17	19 & 21	23 & 25	27 & 29	31 & 33	35 & 37
effective width σ	2.8 & 3.6	4.5 & 5.4	6.3 & 7.3	8.2 & 9.2	10.2 & 11.3	12.3 & 13.4	14.6 & 15.8	17.0 & 18.2
wavelength λ	3.5 & 4.6	5.6 & 6.8	7.9 & 9.1	10.3 & 11.5	12.7 & 14.1	15.4 & 16.8	18.2 & 19.7	21.2 & 22.8
grid size N^{Σ}	8	10	12	14	16	18	20	22
orientation θ	$0; \frac{\pi}{4}; \frac{\pi}{2}; \frac{3\pi}{4}$							
patch sizes n_i	$4 \times 4; 8 \times 8; 12 \times 12; 16 \times 16$ (×4 orientations)							

Serre, T. et. al (2005)

Experimental Results

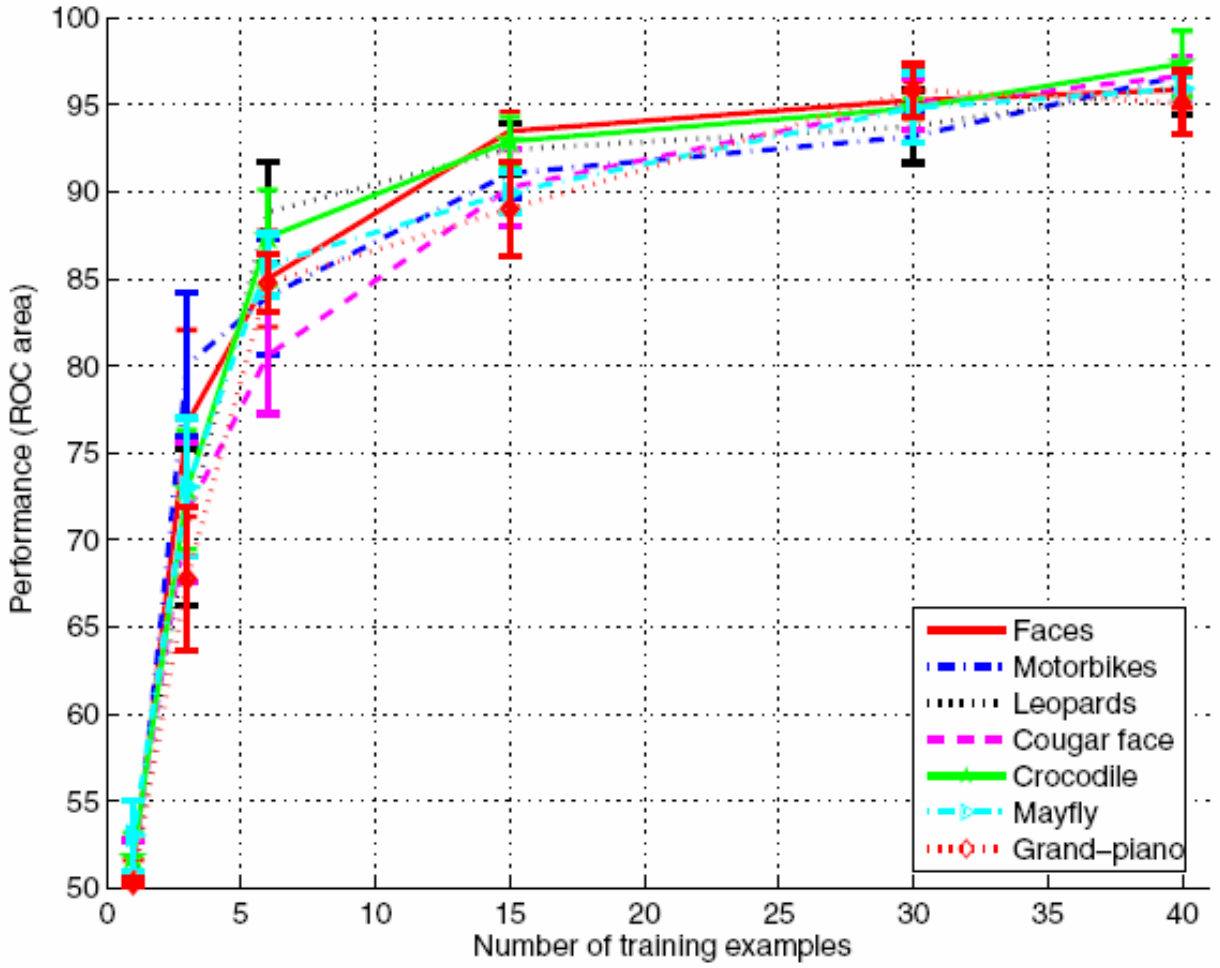
Serre, T. et. al (2005)

Experimental Results

Datasets		Bench.	C2 features	
			boost	SVM
Leaves (Calt.)	[24]	84.0	**97.0**	95.9
Cars (Calt.)	[4]	84.8	99.7	**99.8**
Faces (Calt.)	[4]	96.4	**98.2**	98.1
Airplanes (Calt.)	[4]	94.0	**96.7**	94.9
Moto. (Calt.)	[4]	95.0	**98.0**	97.4
Faces (MIT)	[7]	90.4	**95.9**	95.3
Cars (MIT)	[11]	75.4	**95.1**	93.3

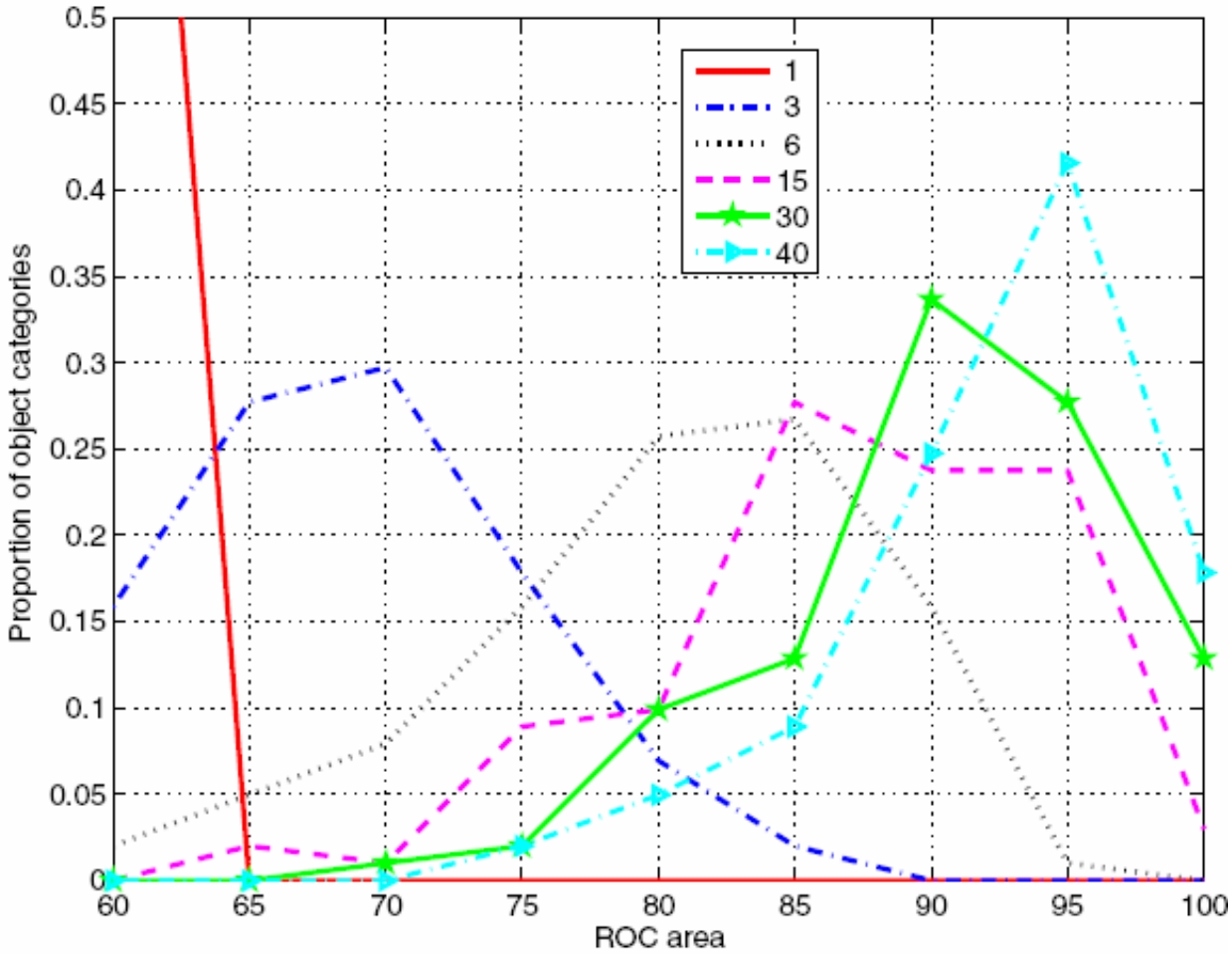
Serre, T. et. al (2005)

Experimental Results



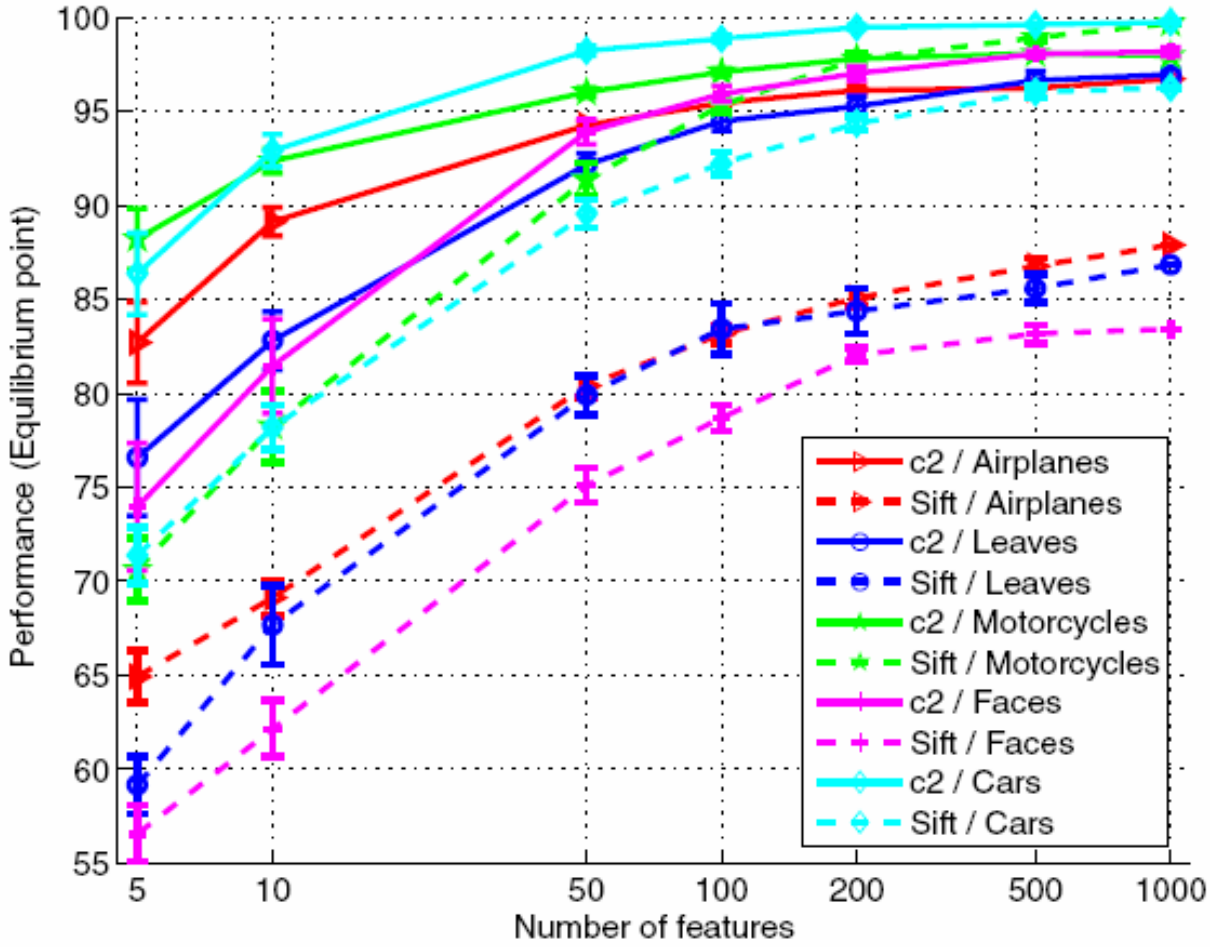
Serre, T. et. al (2005)

Experimental Results



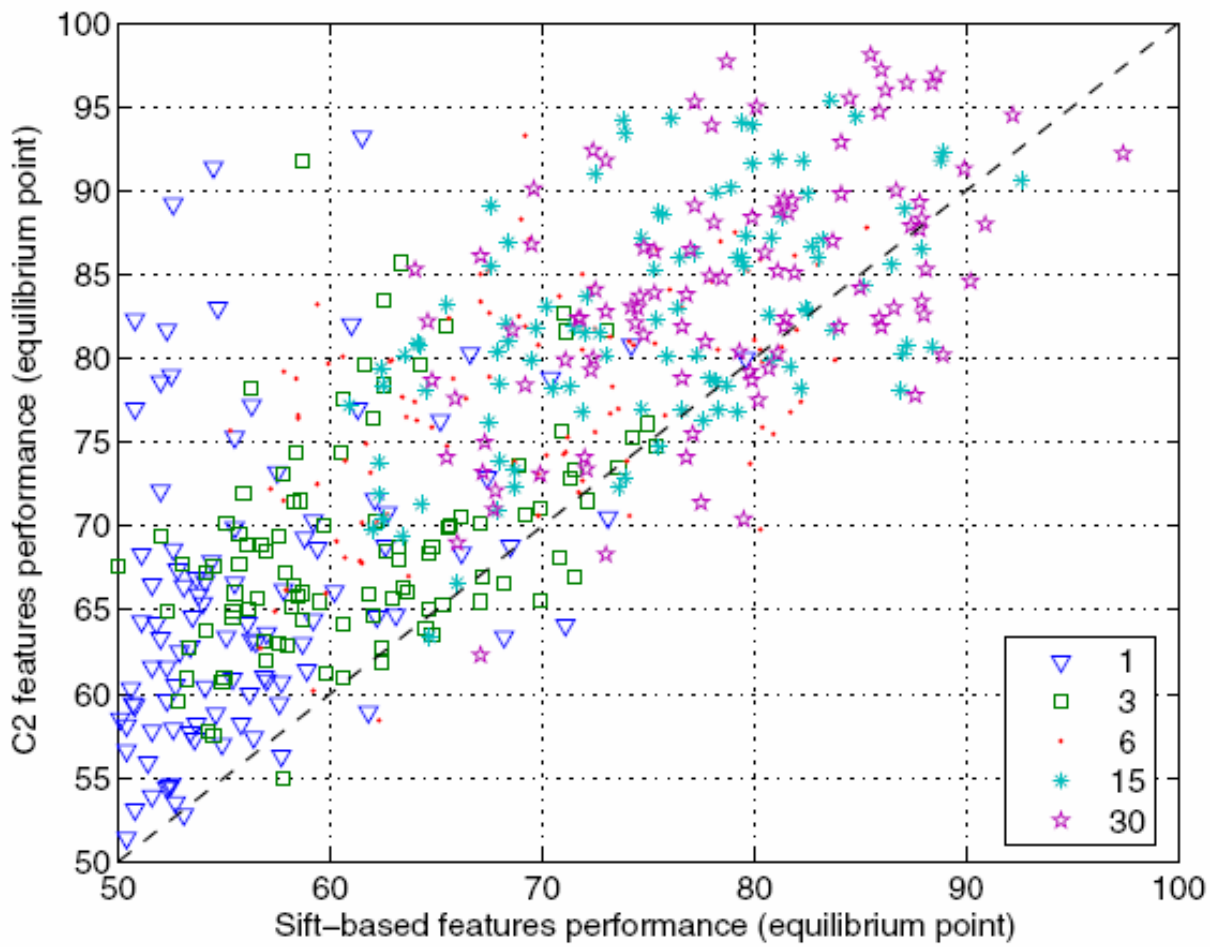
Serre, T. et. al (2005)

Experimental Results



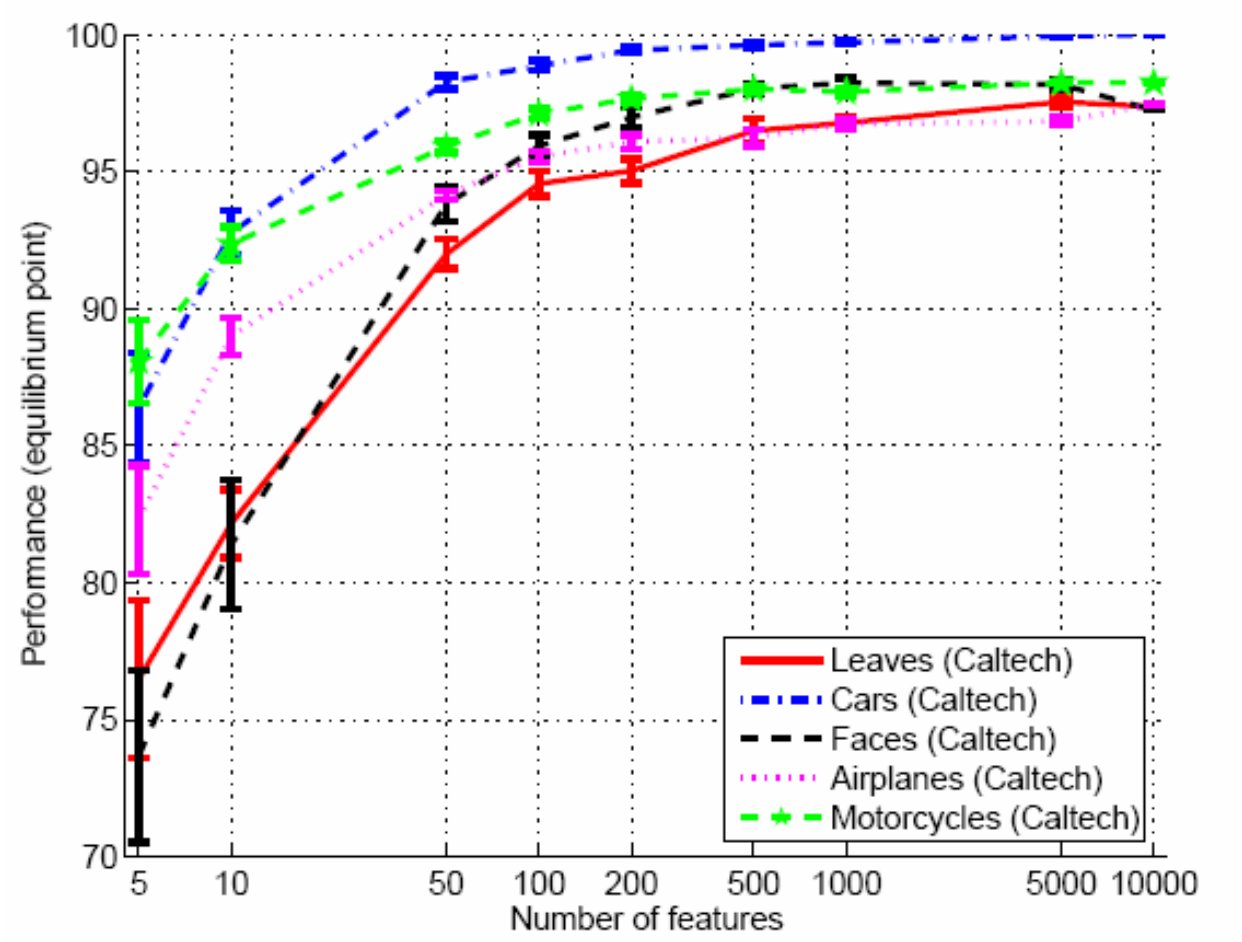
Serre, T. et. al (2005)

Experimental Results



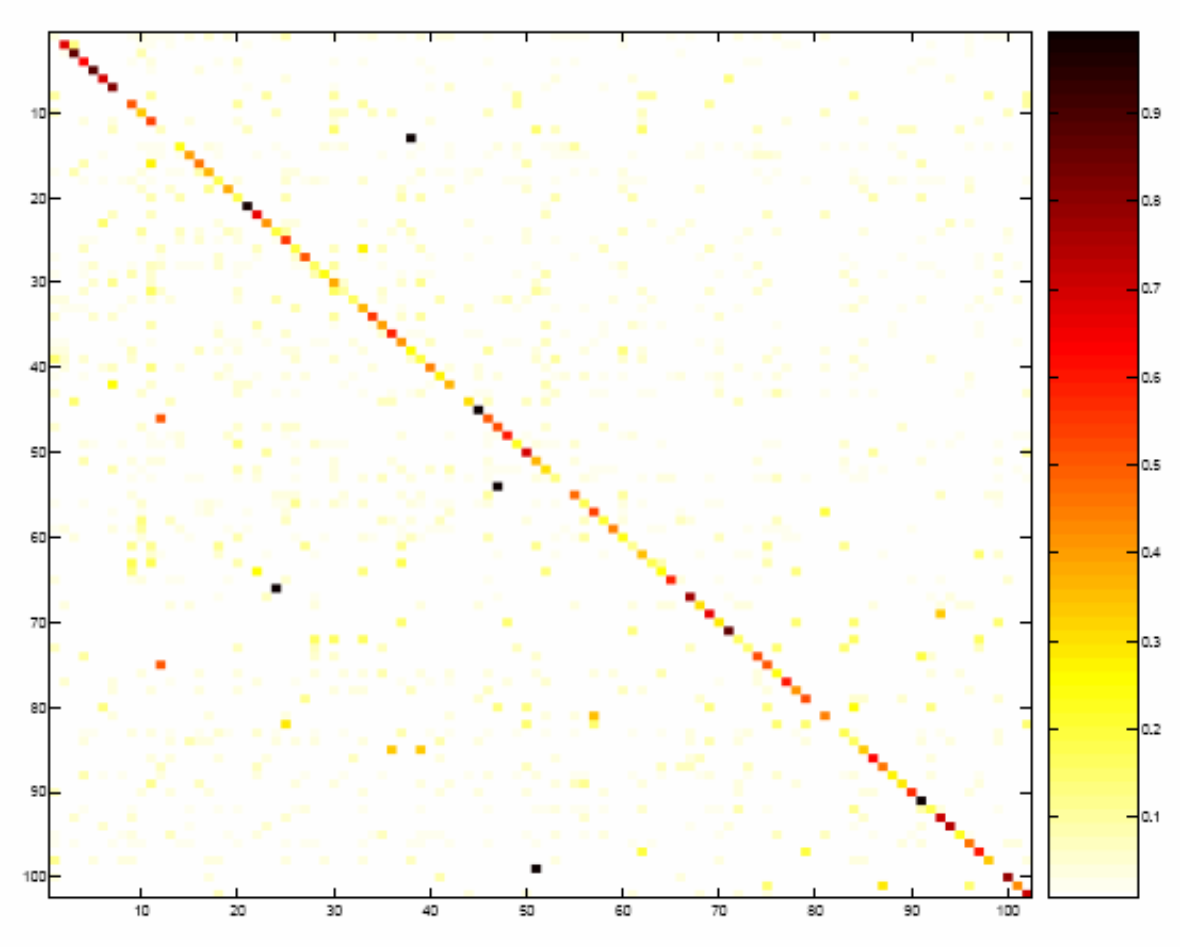
Serre, T. et. al (2005)

Experimental Results



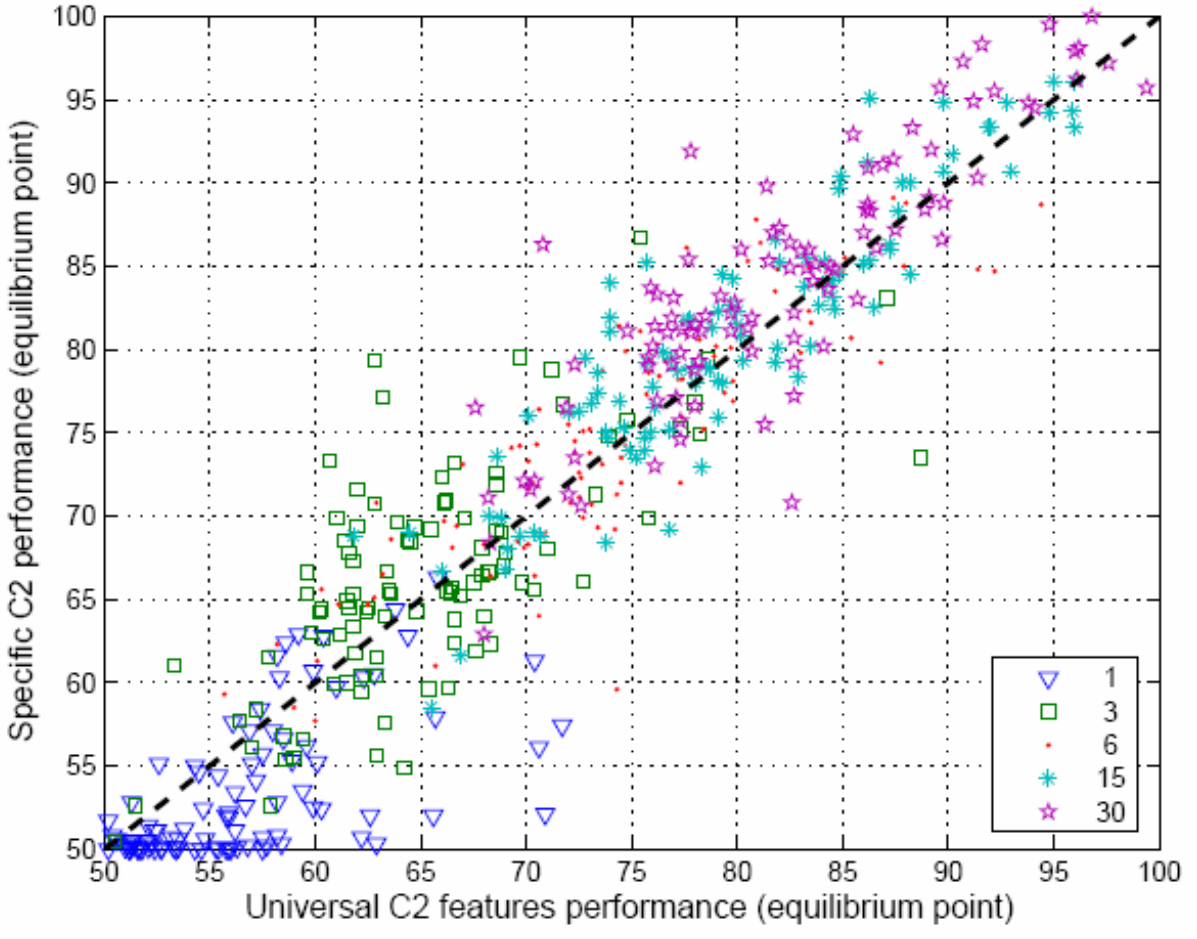
Serre, T. et. al (2004)

Experimental Results



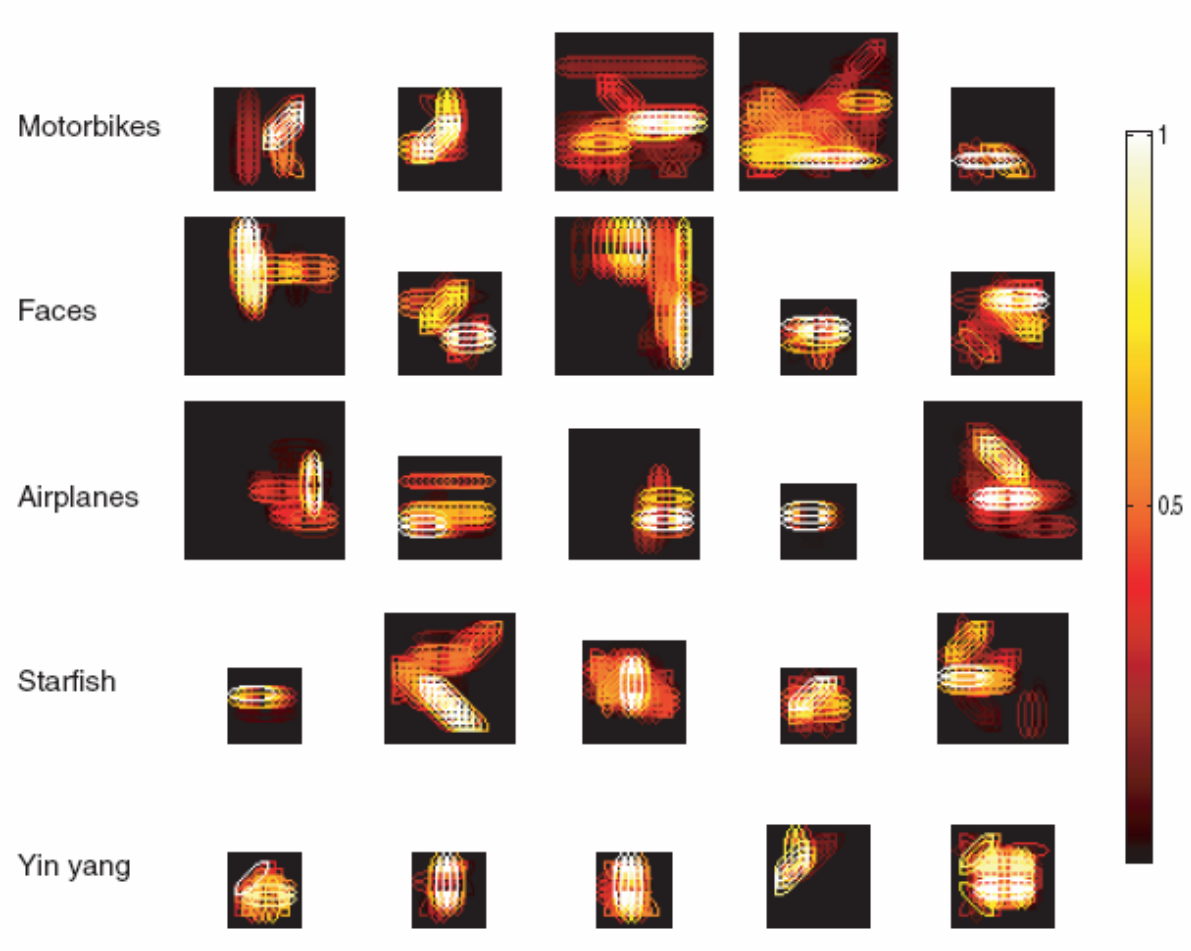
Serre, T. et. al (2004)

Experimental Results



Serre, T. et. al (2004)

Experimental Results



Serre, T. et. al (2005)

Discussion

- A promising biologically inspired model for object recognition.
- Simple features.
- Good performance with low number of training samples.
- Operates well on different object categories without extensive tunings.
- Universal dictionary of features.

Our Motivations

- Recurrent (feedback/lateral) connections.
- Sparse representation.
- Overcomplete representation.
- Online unsupervised learning.
- Image sequences: movies.

References

- Wiskott, L. (2003) **How Does Our Visual System Achieve Shift and Size Invariance?** Cognitive Sciences EPrint Archive (CogPrints) 3321, http://cogprints.org/3321/
- Riesenhuber, M., and Poggio, T. (2000) **Models of Object Recognition**. *Nature Neuroscience* **3** supp., 1199-1204.
- Serre, T., and Riesenhuber, M. (2004) **Realistic Modeling of Simple and Complex Cell Tuning in the HMAX Model, and Implications for Invariant Object Recognition in Cortex**, *CBCL Paper #239/AI Memo #2004-004*, Massachusetts Institute of Technology, Cambridge, MA.
- Serre, T., Riesenhuber, M., Louie, J., and Poggio, T. (2002) **On the Role of Object-Specific Features for Real World Object Recognition in Biological Vision**. In *Biologically Motivated Computer Vision,* Lee, S-W., H.H. Buelthoff and T. Poggio (eds.), Second IEEE International Workshop, BMCV 2002, Tuebingen, Germany, December 2002, 387-397.

References

- Serre, T., L. Wolf and T. Poggio. (2005) **Object Recognition with Features Inspired by Visual Cortex**. In: Proceedings of 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR), IEEE Computer Society Press, San Diego.
- Serre, T., L. Wolf and T. Poggio. (2004) **A New Biologically Motivated Framework for Robust Object Recognition**, *CBCL Paper #243/AI Memo #2004-026*, Massachusetts Institute of Technology, Cambridge, MA, November.