“Identifying Emotions Using Topographic Conditioning Maps”

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Introduction - Topic Overview

- **Introduction:** Introducing the field and motivating our research.
- **Background / Motivation:** Why our approach is interesting, what are its biological foundations
- **Method:** Presentation of our model's architecture
- **Experimentation:** Experiments on abstract and real emotional face stimuli
- **Conclusions and Future Work:** Evaluation of the status of this research and proposed approach for future work.

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Project domain: Computational modelling of biological mechanisms responsible for encoding and responding to visual threat.

Particularly: Utilise basic biologically plausible principles and properties found in structures participating in the mechanism of threat detection.

Computer Science Perspective:

Knowledge of brain functions has ignited a trend of exploring what can we learn from such in terms of systems' modelling:

- Ministry of Defence Grand Challenge (MoD, 2007)
- Foresight Cognitive Systems Project (Foresight, 2003)

Neuroscience Perspective:

Paraphrasing LeDoux (1996) if anatomy can illuminate psychology, then computational modelling can illuminate anatomy.

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Studying the Brain – Structures and Pathways

• The mechanism involves a **cortical** and a **sub-cortical** pathway leading to a structure called the **amygdala** that has the role of evaluating the emotional significance of a stimulus.

• How does the amygdala know what is fearful?

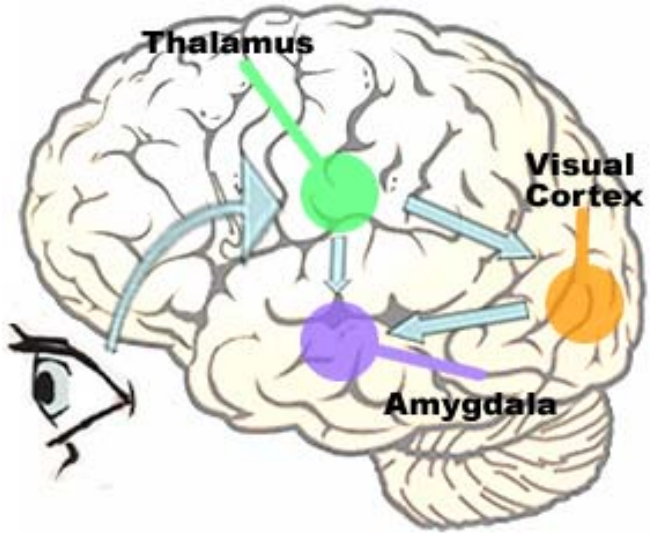
  • Fear can be learnt through Pavlovian or **classical conditioning**.

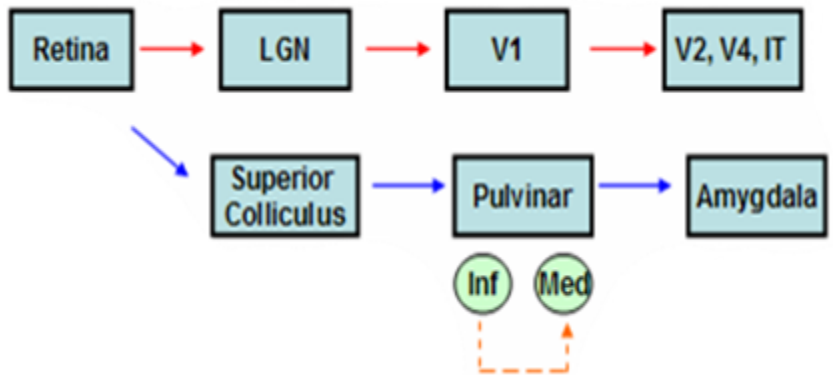
  • Experiments as early as 1920's from **Pavlov (1927)**.

  • Experiments that revealed anatomical structures from **LeDoux (1994)** for the auditory modality on rats modelled by **Armony et al (1999)**.

  • Still some debate on the matter (Pessoa, 2005).

  • Amygdala involvement in evaluation of **both positive and negative emotions** (Murrey, 2007).





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Model Architecture

• Extending Armony's(1999) model by incorporating topography → Introduction of winner areas.

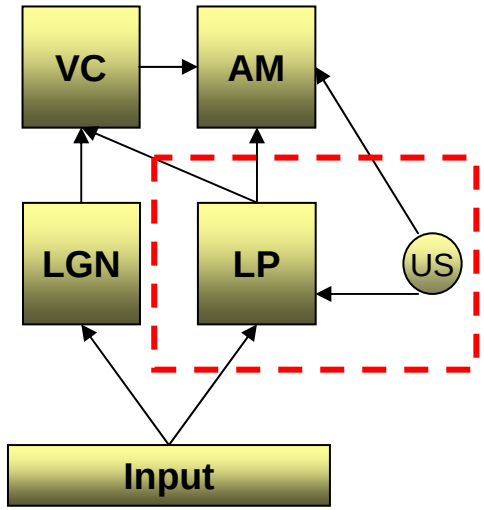
•Each module a 2D neuron grid. LGN, LP, VC → 10x10 and AM→ 5x5

• Connectivity: Feed forward fully connected hebbian learning network.

• Training: Weights updated per input presentation. One epoch is complete upon presentation of the whole training set.

• Gaussian Neighbourhood: In each epoch there is a winner area around the neuron with highest activation. This area is reduced over time starting from a maximum of 10.

• US: The unconditioned stimulus is a fixed weight. First the model trains for a number of epochs (700) with US turned off (pre-conditioning). Then the model trains again with the US turned on (post-conditioning).



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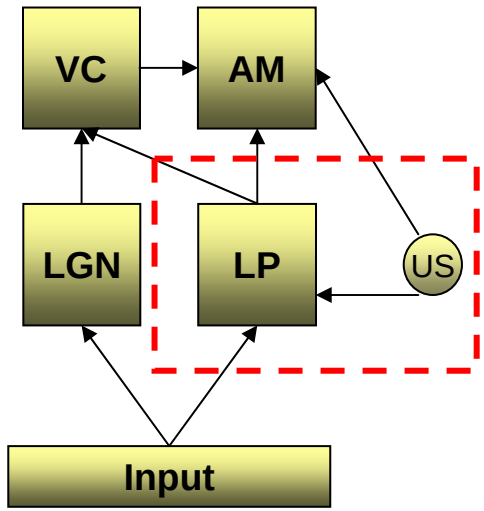
Net $u_{ij} = \sum_{k=1}^{m} x_k w_{kij}(t),$

Output $y_{ij} = \begin{cases} f(u_{ij}) & \text{if } \|c_{ij} - c_{win}\| < h(t) \\ f(u_{ij} - y_{win}) & \text{otherwise} \end{cases}$

Ramp $f(u) = \begin{cases} 1 & u \geq 1 \\ u & 0 < u < 1 \\ 0 & u \leq 0 \end{cases},$



Weight Update $w'_{kij}(t+1) = w_{kij}(t) + \epsilon(t) x_k y_{ij}$

Normalisation $w_{kij}(t+1) = \frac{w'_{kij}(t+1)}{\sum_{l=1}^{m} w'_{lij}(t+1)}$

Neighbourhood $h(t) = r_{min} + (r_{max} - r_{min}) e^{-\left(\frac{(t/t_e)^2}{2r_s^2}\right)}$

Learning Rate $\epsilon(t) = l_{min} + (l_{max} - l_{min}) e^{-\left(\frac{(t/t_e)}{2l_s^2}\right)}$

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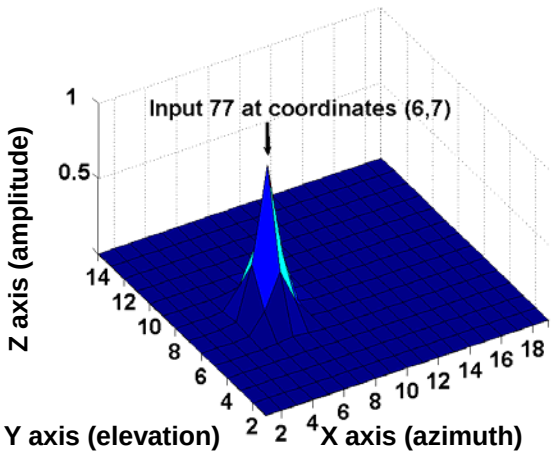
Experiment 1: Input

Abstract Input ⇨ $x_{pq} = \lambda e^{-(\frac{p^2-q^2}{\sigma^2})}$ **(Gaussian Activation Patterns)**



- Within a 2D space between azimuth [-90 90] and elevation [-65 65]
- We position an object at a discrete interval of 10 → 19 positions for azimuth and 14 for elevation
- For example starting with input example 1 at (-65, -90), 2 at (-55, -90), continuing to 266 at (65, 90)

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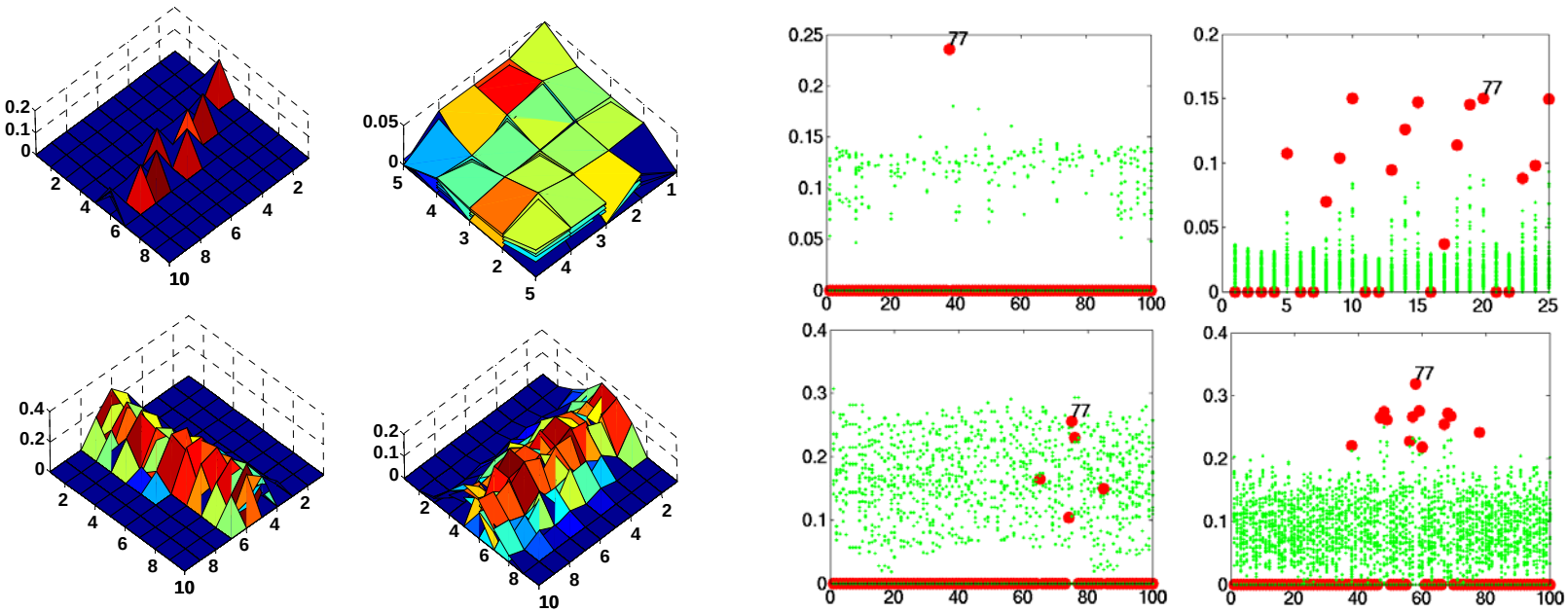
Experiment 1: Results and Analysis

Experiment Aim: Test the model's topographic capabilities on 2D abstract stimuli (Gaussian activation patterns). Examine specificity of activated areas depending on width of receptive field. Examine effect of conditioning.

Method: Training occurs per layer. Pre-conditioning has the US off and post-conditioning with US on.

Results: Expected topographic properties are shown in layers in which were applied. We observe topographic alignment that shows that topographical properties are carried on to higher layers. Finally, conditioning affects the conditioned stimulus and neighbouring stimuli.



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Experiment 2: Input

Emotional Face Input

• 598 frames of one subject depicting the 6 basic emotions from the MMI face expression database

• Frames are taken from videos containing transitions from neutral to an emotional expression that reaches a peak (peak frame) and from there returning to neutral.

• 2 subjects were chosen for testing, S002 for anger happiness sadness and S031 for fear surprise and disgust of a total of 121 frames.

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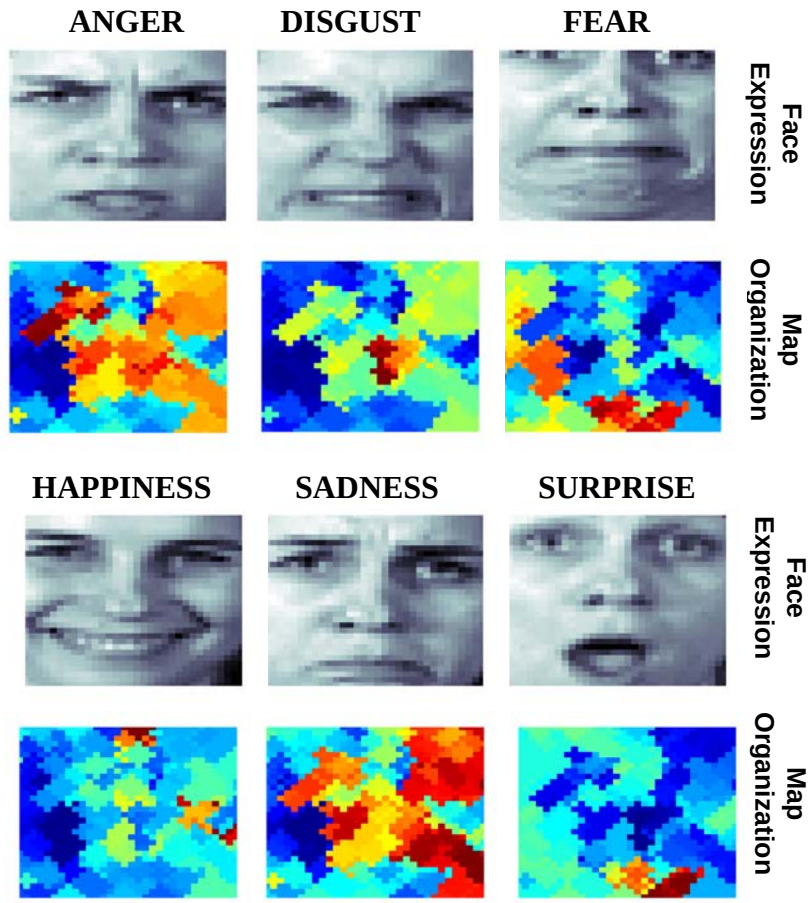
Experiment 2: Results and Analysis

Experiment Aim: Neurobiological studies [Morris, 1999] have shown that emotional faces elicit sub-cortical pathway responses. We want to observe whether the simple properties of the model are adequate to handle such inputs.

Method: Minimal image pre-processing. Repeat pre-conditioning training phase in a similar fashion as previously but only on LP.

Results: Each emotional expression is represented on the map on distinct clusters.



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Experiment 2: Results and Analysis

Experiment Aim: Apply conditioning on an emotion (in particular anger) that was poorly classified.

Method: Perform post-conditioning on previously trained map.

Results: Conditioning increased activations of selected stimuli and resulted in better classification.

	Pre-conditioning								Post-conditioning							
	An	Di	Fe	Ha	Sa	Su	NK	Accuracy	An	Di	Fe	Ha	Sa	Su	NK	Accuracy
Anger (S002)	**0**	0	0	0	21	0	0	0%	**21**	0	0	0	0	0	0	100%
Disgust (S031)	3	**3**	0	0	12	0	3	14%	3	**4**	0	0	8	0	6	19%
Fear (S031)	0	0	**16**	0	0	0	5	76%	0	0	**21**	0	0	0	0	100%
Happiness (S002)	0	0	0	**19**	2	0	0	90%	0	0	0	**21**	0	0	0	100%
Sadness (S002)	0	0	0	0	**21**	0	0	100%	0	0	0	0	**21**	0	0	100%
Surprise (S031)	0	0	2	0	0	**19**	0	90%	0	0	12	0	0	**9**	0	43%

Confusion matrix of the number of successfully classified frames for the top 20% of active neurons, shown for pre- and post-conditioning (on the peak frame of the angry face). The training peak frames were compared to 21 testing frames per emotion. Unclassified patterns are shown as NK.

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Conclusion and Future Work

Conclusion

• The model has shown to organise topographically, align coordinates in higher layers and condition on abstract stimuli.

• Conditioning is successful on complex stimuli whilst enhancing classification.

• Overall classification percentage of 77% , without manual pre-specification of features.

• The model although abstract shows potential of balancing upon utilisation within the neuroscience domain as well as in real world applications.

Future Work

• Use more examples.

• Use of the whole architecture on complex stimuli and evaluate the model's classification percentages per module (effects of neighbourhood specificity).

• Introduce temporal characteristics on algorithm.

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