Computational Neuroscience: Neuronal Dynamics of Cognition

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Continuum models:

Cortical fields and perception

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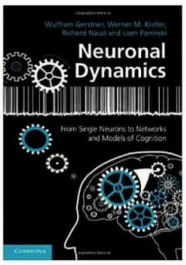
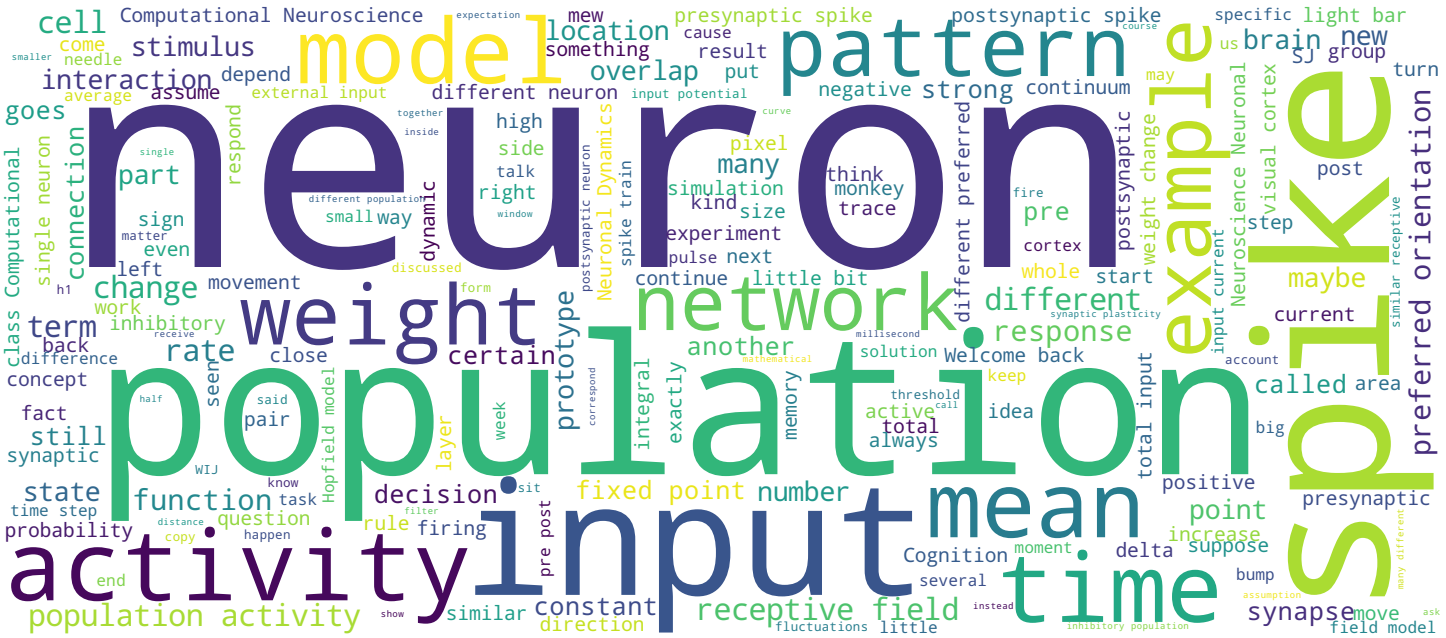
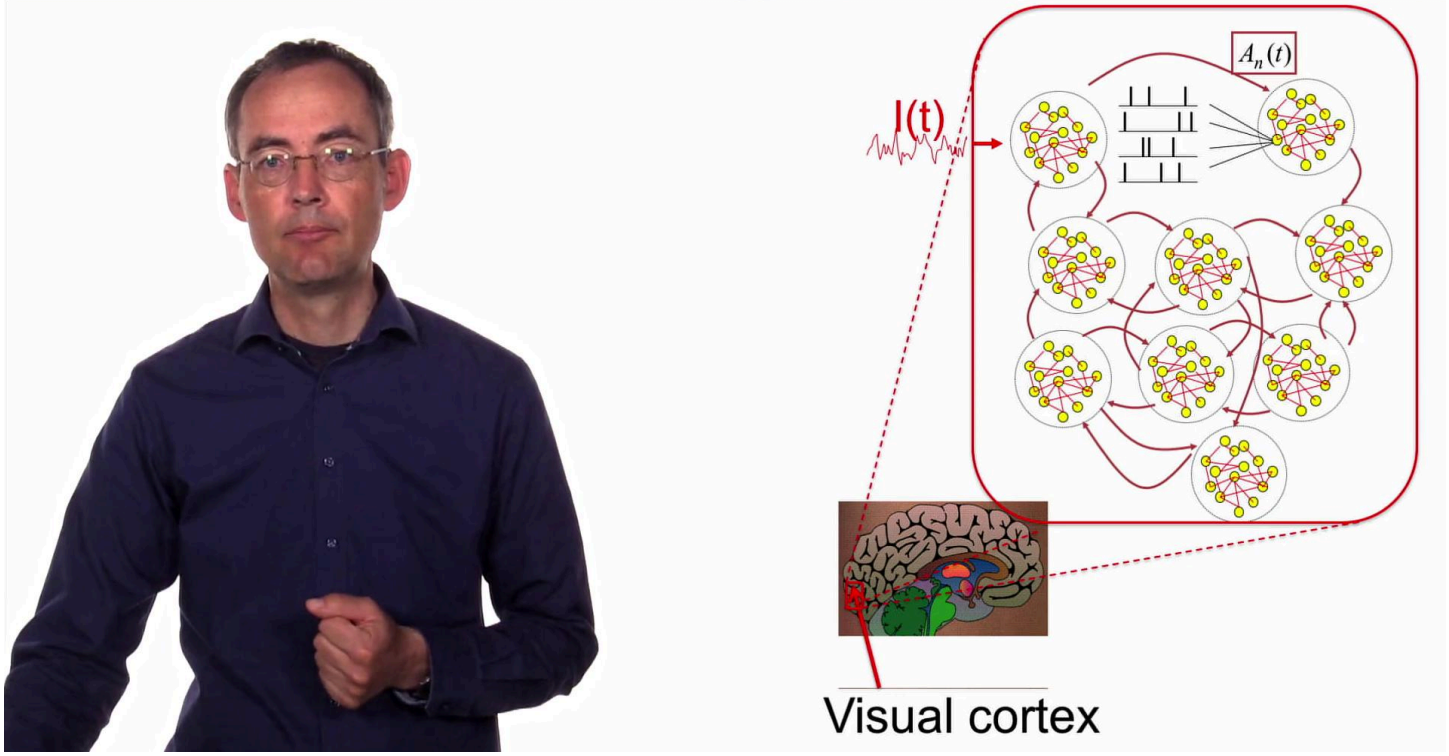
Reading:
NEURONAL DYNAMICS
Ch. 18 +
+Ch. 12.3.7+Ch 15.1-15.2.3
Cambridge Univ. Press



1. **Aims and challenges**
   - review: mean-field arguments
2. **Transients**
   - generalized integrate-and-fire model
   - transients can be sharp or slow
3. **Spatial continuum (cortex)**
   - orientation columns
4. **Spatial continuum (model)**
   - field equations
5. **Solution types**
   - uniform solution
   - bump solution
6. **Perception**
7. **Head direction cells**



3. Interacting Populations: how many populations?



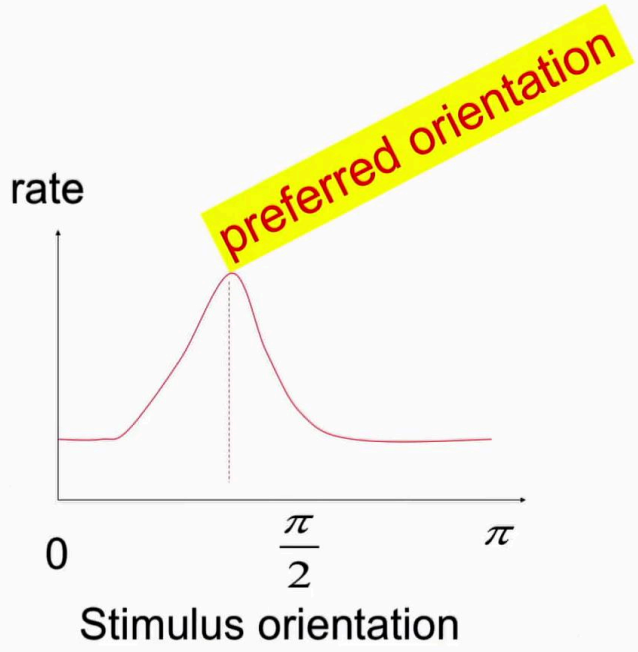
So welcome back to the class Computational Neuroscience: Neuronal Dynamics of Cognition. Before we continue with the mathematical development, I need to explain to you why we can think of the cortex as a spatial continuum. In fact, in the visual cortex, there are many different populations. Neurons have localised receptive fields, different neurons have different receptive fields, nearby neurons have similar receptive fields. Neurons can also have different preferred orientations which means different responses to an oriented light bar. And so, if you build a model, a couple of questions arise. So, how many populations should we choose in the model? Are there discreet populations in the first place, or should we rather think of a continuum?

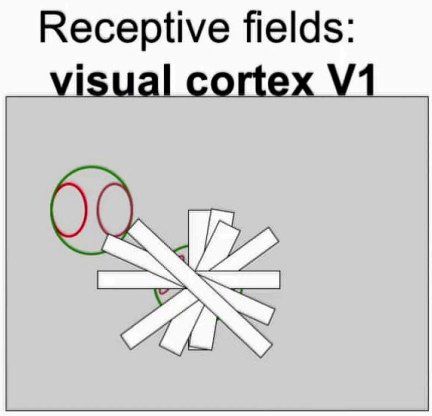
Notes

Summary

0m 17s

3. Review: Receptive fields with Orientation Tuning





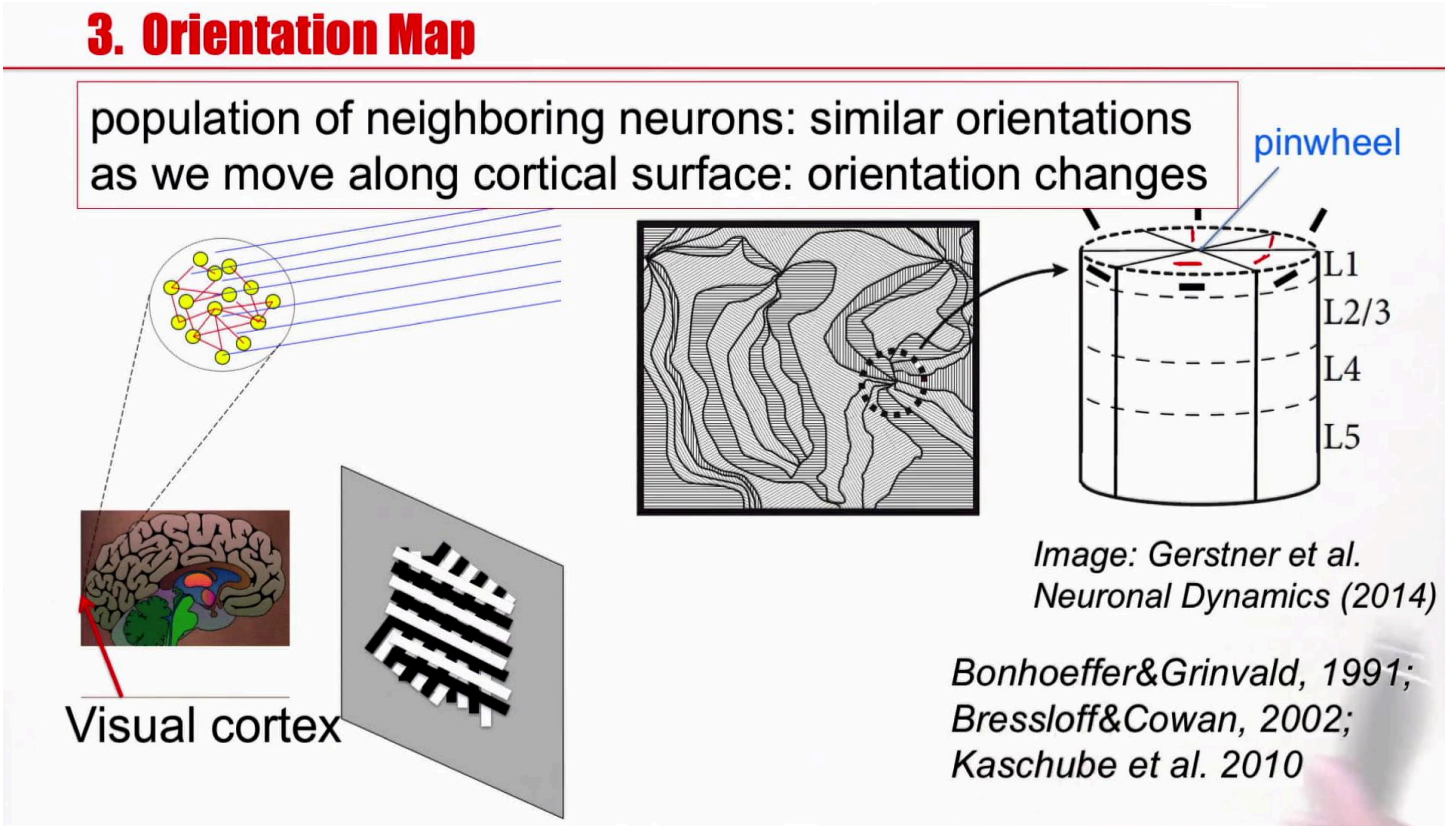
So just as a review, if you have one single neuron, and it has a receptive field in here, and then we turn a light bar slowly around, we find that the fine rate of the neuron is maximal at one specific orientation, and this is the preferred orientation of this neuron.

Notes

Summary

0m 51s

3. Orientation Map



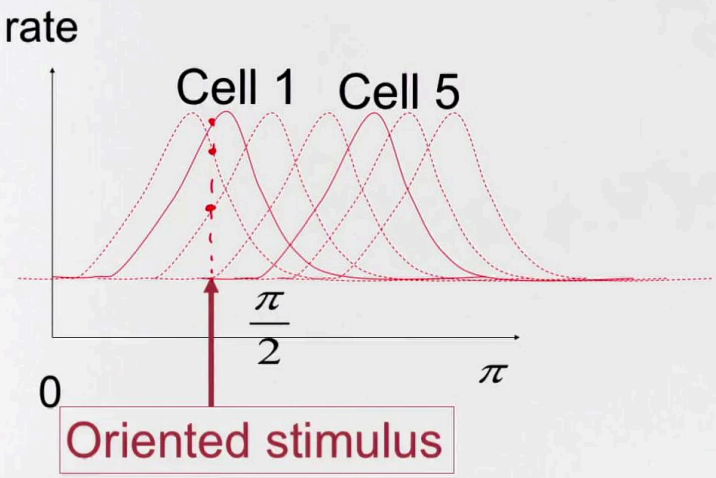
Now, importantly, neighbouring neurons have similar receptive fields and similar preferred orientations. So, if I look at the flattened out visual cortex, and if I walk around this dash line, I would first see neurons that have a preferred orientation horizontal, then maybe 30, then maybe 60, then maybe 90, and so forth. So, the responses, if we walk around, change.

Notes

Summary

1m 12s

3. Do Orienation colums exist? Do identical cells exist?



Coarse coding

Many cells
(from different columns)
respond to a single
stimulus with different rate

→ no discrete columns

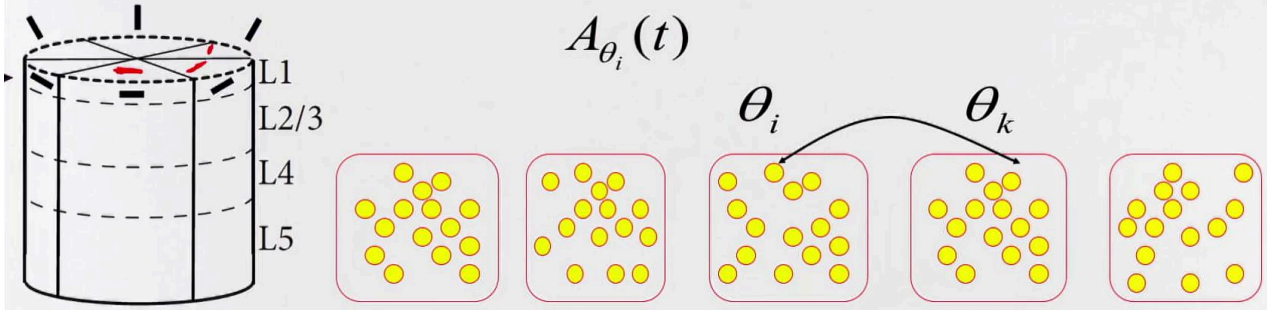
Now -- now, if I give a certain stimulus, for example at this location here, different cells will respond. There's response from this cell, will be that much; there's the response of this cell here, which responds this much; there's the response of this cell here, which responds that much. So, many cells, from different columns or with different preferred orientation respond to a single stimulus with a slightly different rate. So in a way, this idea of discrete columns is a bit misleading.

Notes

Summary

1m 46s

3. multiple populations → continuum



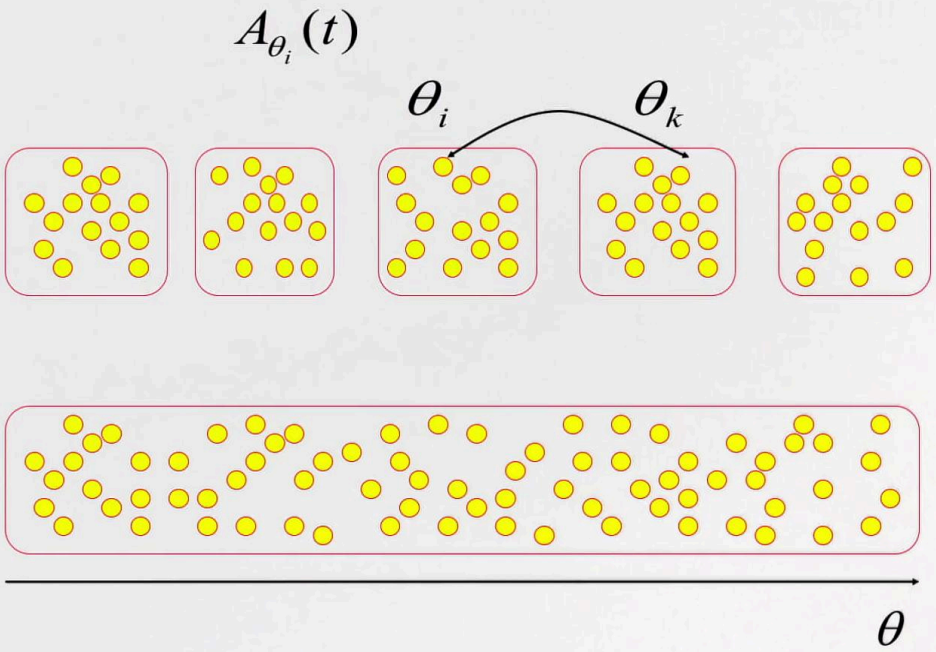
So instead of thinking of discrete columns, there are all these neurons here prefer horizontal, all these prefer 60, you should rather think of a continuum where different neurons have different preferred orientations.

Notes

Summary

2m 26s

3. multiple populations → continuum



And I would like to take this as a motivation and as a starting point to develop a mathematical model of a continuum of population activity. And this will be the field model, which is the main topic of this week's lecture.

Notes

Summary

2m 45s