Computational Segmentation of the Turtle Visual Cortex

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Abstract

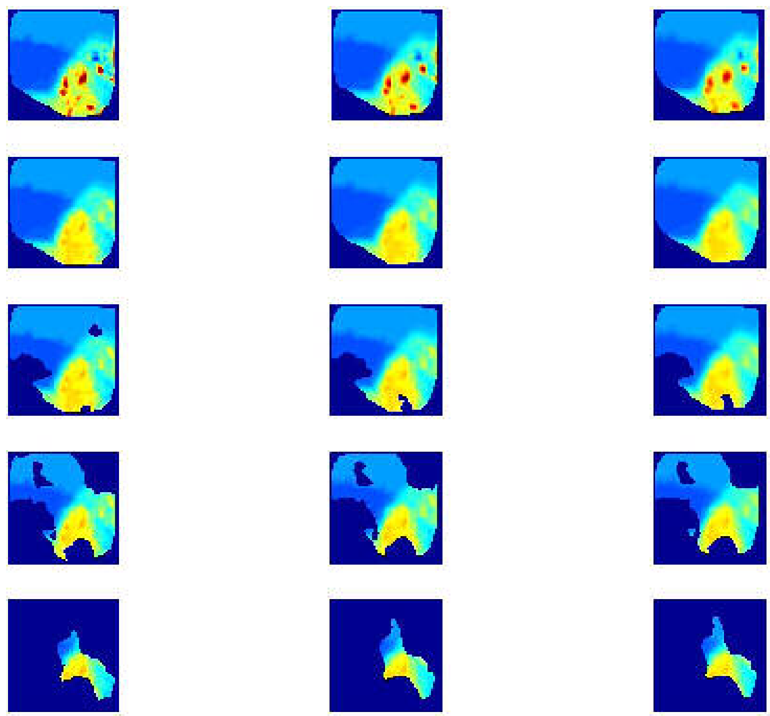
Visual stimuli elicit depolarizing waves that propagate across the visual cortex in freshwater turtles. Recent work has suggested that the dynamics of the cortical wave in the turtle visual cortex might be responsible for encoding information about the position of stimuli in visual space. A large scale model of the visual cortex has been constructed that includes inputs from the dorsal lateral geniculate complex. The constructed model accurately simulates cortical waves following the presentation of simulated retinal flashes. An important problem is to be able to decode the position of the retinal flash from the associated cortical wave. This paper presents an approach using wavelet decomposition to represent the cortical signal at various resolutions. Based on such a decomposition, we are able to isolate the region in the visual cortex where the temporal activity of the wave is predominant.

Summary

A computational model of the turtle visual cortex has been developed using anatomical and physiological data (Nenadic, 2001) and a KL decomposition algorithm is used to compress the data (Bijoy). The advantage of the KL decomposition is that only a few coefficients are needed to represent the signal since the basis vectors are global. But it is also because the basis is global that the local properties of the signal can not be represented explicitly. Wavelet decomposition makes it possible to represent the signal at different resolutions and what is more, to zoom in to look into the detail of the signal in both time and space. Unlike KL decomposition, wavelet uses basis vectors which are local and needs a lot more coefficients to do the representation.

In the following figure, the 3 images in the first line are the wavelet decomposition of the output of the turtle visual cortex model. What is shown is the decomposition at level 1, 2, and 3 and the representation changes from finer to coarser resolution. Based on the wavelet coefficients, we can select the regions of the cortex that are more active and predictably more involved in processing the visual information. Images on line 3, 4, and 6 show the regions that are selected with gradually higher threshold, i.e. only the most active regions are kept.

From the figure, we can see that the representation at level 3 (the right-most image on the first line) is greatly different from the that at level 1 (the left most image on the same line), while the representation at level 3 consists of only half of the number of coefficients at level 1. Thus, compression can be achieved with only a small distortion.



In summary, wavelet decomposition methods have been introduced to isolate the most temporally active regions of the visual cortex. The associated cortical wave is easily visualized in that region.

References:

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