

Dendritic Ca^{2+} as a Predictor of Stimulus Perception and Behavior

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INTRODUCTION

Dendritic calcium spikes in the dendrites of layer 5 (L5) pyramidal neurons have been hypothesized to play a role in conscious perception (see [1]). One responsible mechanism proposed by Matthew Larkum explains this, among other things, by back-propagating action potential activated Ca^{2+} firing (BAC firing) [2]. Naoya Takahashi found a correlation of activity in dendrites of certain L5 pyramidal neurons in the somatosensory cortex (S1) of mice with the chance of perceptual detection of a stimulus [3].

Takahashi has used a strictly univariate approach in his analysis, examining the correlation of dendritic activity with perception separately for each dendrite, yet it seems plausible that a neuron coding for perception would make use of information from many different dendrites simultaneously. Therefore our main goal is to use a multivariate approach on Takahashi's data and investigate if it has any advantage over a univariate one. In order to achieve that we use support vector machines (SVMs) and a novel approach by Mante, Sussillo et al. described in [4].

We start out by describing the BAC firing mechanism. Then we look at the experiment in which the data were gathered and briefly review the analysis done by Takahashi. We then proceed with a univariate SVM analysis of the data, followed by multivariate SVM and finally Mante and Sussillo's approach.

BAC FIRING

It is common knowledge in Neuroscience that action potentials (APs) are initiated at the axon hillock of a neuron and then propagate down the axon. However, since the membrane of the soma and the dendritic tree is also excitable, such an action potential can also propagate backwards through the dendritic tree.

One special thing about L5 pyramidal neurons is that besides the axonal AP-initiation zone they have a dendritic one as well. There, the crossing of a high threshold causes strong calcium influx into the membrane, resulting in a so-called calcium action potential. It appears that a single backpropagating AP is not sufficient to cross this threshold and therefore cause such a calcium-AP, but its combination with sufficient additional input further up the dendritic tree can be. The calcium-spike in turn propagates down to the soma, where it can cause another AP and so on, resulting in a burst of action potentials [2].

Math

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$$\cos^3 \theta = \frac{1}{4} \cos \theta + \frac{3}{4} \cos 3\theta \quad (1)$$

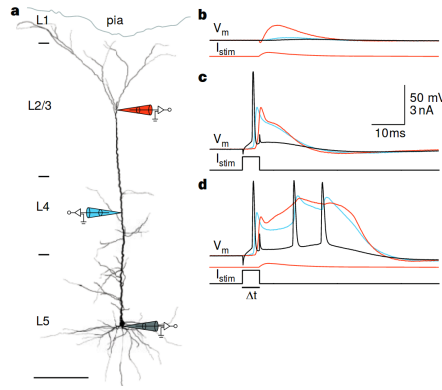


Figure 1: From Larkum 1999. **a**, schematic of pyramidal neuron with indication of injection/recording sites. The gray pipette is positioned at the soma. **b**, EPSP-shaped injection at distal dendritic tuft, no injection at the soma. The signal is very weak when it arrives at the soma and is not sufficient for any kind of AP. **c**, Injection at soma but not at the distal dendritic tuft. We see a sodium-AP but no BAC firing, since the threshold for a dendritic AP has not been reached. **d**, Injections at soma and distal dendritic tuft. We see dendritic spikes and a burst of APs at the soma.

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Definition 1 (Gauss). To a mathematician it is obvious that $\int_{-\infty}^{+\infty} e^{-x^2} dx = \sqrt{\pi}$.

Theorem 1 (Pythagoras). *The square of the hypotenuse (the side opposite the right angle) is equal to the sum of the squares of the other two sides.*

Proof. We have that $\log(1)^2 = 2\log(1)$. But we also have that $\log(-1)^2 = \log(1) = 0$. Then $2\log(-1) = 0$, from which the proof. \square

RESULTS AND DISCUSSION

Reference to [Figure 2 on the following page](#).

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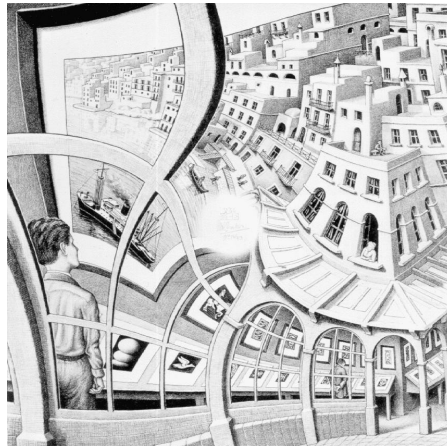


Figure 2: An example of a floating figure (a reproduction from the *Gallery of prints*, M. Escher, from <http://www.mcescher.com/>).

Subsection

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Subsubsection

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WORD Definition

CONCEPT Explanation

IDEA Text

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- First item in a list
- Second item in a list
- Third item in a list

Table

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Table 1: Table of Grades		
Name		
First name	Last Name	Grade
John	Doe	7.5
Richard	Miles	2

Reference to Table 1.

Figure Composed of Subfigures

Reference the figure composed of multiple subfigures as Figure 3 on the following page. Reference one of the subfigures as Figure 3b on the next page.

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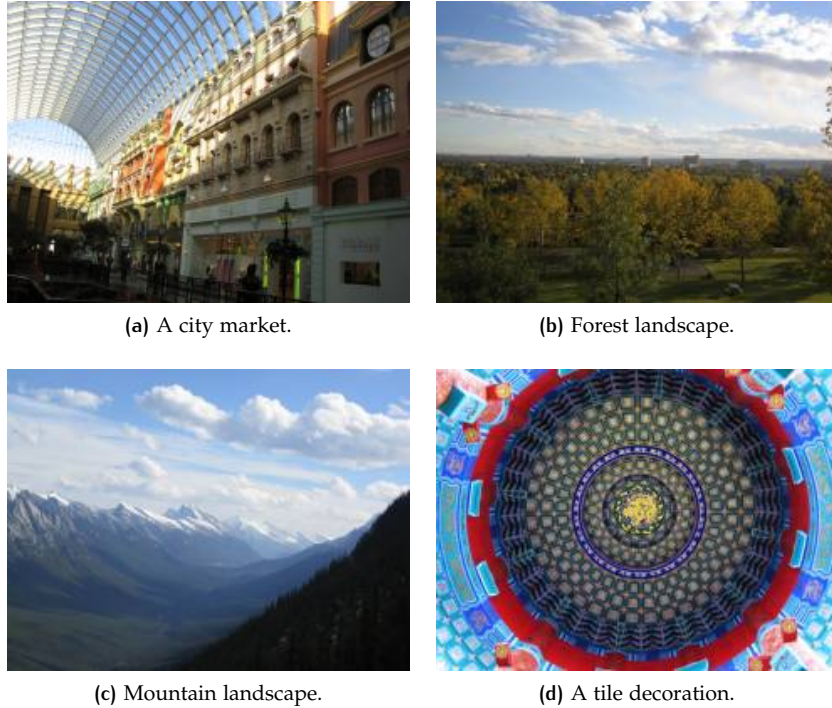


Figure 3: A number of pictures with no common theme.

dictum. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Aenean quis mauris sed elit commodo placerat. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Vivamus rhoncus tincidunt libero. Etiam elementum pretium justo. Vivamus est. Morbi a tellus eget pede tristique commodo. Nulla nisl. Vestibulum sed nisl eu sapien cursus rutrum.

REFERENCES

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