Automatic Neuronal Cell Classification in Calcium Imaging with Convolutional Neural Networks

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Introduction

- Automated cell extraction methods, such as PCA/ICA and CNMF, have been introduced to sort the cells and widely used.
- However, each candidate needs manual check, as the it may contain noise, false positive, etc.
- Most attempts on the classification with neural networks focused only on the shape of cell candidates as their inputs.

Problem Statement

- Use PCA/ICA processed data, which are the shapes (ROI) and intensity change overtime (trace), for the inputs of classification.
- We introduce Cell Classification ConvNet (3CNet) for the classification and verify the feasibility.
- Compare the classification results on cell candidates with the human-labeled results to evaluate the accuracy.
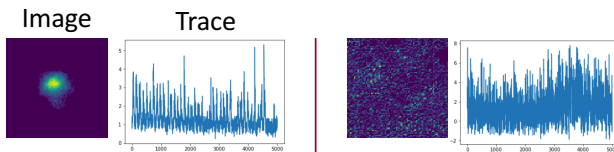

Figure 1. Cell Classification Problem

Dataset

- PCA/ICA processed dataset of cell candidates from one-photon calcium imaging on prefrontal cortices of two mice.
- Measures of ROIs and traces are not uniform.
- While most ROIs have pixel sizes around 90x90, some ROIs have small sizes (Table 1).

	Mouse 1	Mouse 2	Total
Number of Sets	6	10	16
Number of Samples	7284	16142	23426
Minimum ROI size	5 X 10	5 X 3	5 X 3
Maximum ROI size	90 X 85	89 X 91	89 X 91
Minimum Trace Size	11878	12696	11878
Maximum Trace Size	19414	25810	25810
Cell to Not Cell Ratio	1:1.55	1:2.27	1:2.00

Table 1. Dataset statistics

Methods

- Preprocessing images in the dataset: each ROI was extracted and then zero-centered.
- The ROIs and traces were inputted to 3CNet.
- Human-labeled results were used as truths.
- We constructed 3CNet shown Figure 2.
- General 3 FC and 2 CNN layers were used to compare the accuracy.

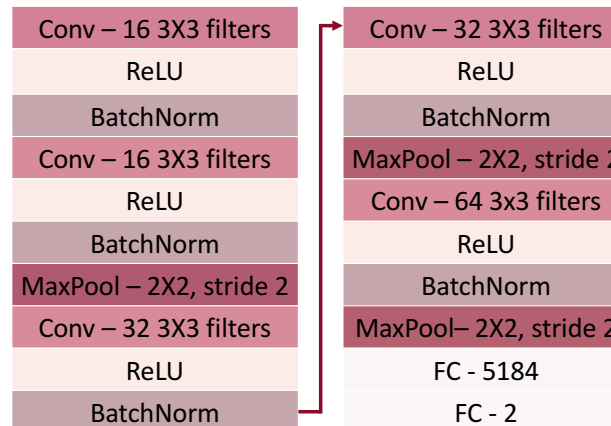|	
Conv – 16 3X3 filters	Conv – 32 3X3 filters
ReLU	ReLU
BatchNorm	BatchNorm
Conv – 16 3X3 filters	MaxPool – 2X2, stride 2
ReLU	Conv – 64 3x3 filters
BatchNorm	ReLU
MaxPool – 2X2, stride 2	BatchNorm
Conv – 32 3X3 filters	MaxPool– 2X2, stride 2
ReLU	FC - 5184
BatchNorm	FC - 2

Figure 2. 3CNet Architecture

Experimental Evaluation and Findings

- 85.0% accuracy for 3CNet (Table 2).
- Compared to simple 2 fully connected layers and CNNs, 3CNet is more accurate than others.
- Information truncated during preprocessing may affect 3CNet to predict incorrectly (Figure 3).

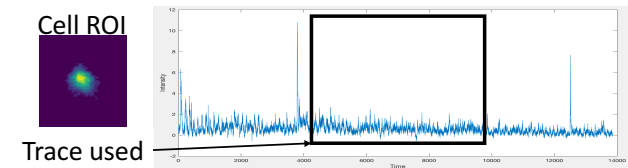|	3 FCs	2 CNNs	3CNet
Accuracy (%)	74.2	75.6	85.0
Memory (bytes)	272k	10.4M	9.36M
Parameters	289M	922k	27.3M

Table 2. Result summary

Cell ROI

Trace used

Figure 3. Possible case of wrong prediction

Discussions

- Uncertainties in human labeling.
- Further improvements on 3CNet.
- Try 3CNet on other dataset from different brain areas, such as cerebral cortex.

Acknowledgements