Scale- and Translation-Invariant Unsupervised Learning of Hidden Causes Using Spiking Neurons with Top-Down Attention

Youssef Kashef

7. August 2013

Contents

Abstract

Nessler et al have demonstrated the ability of a spiking neuronal network governed by spike-timing-dependent-plasticity and a stochastic winner-take-all circuit to learn and predict causes from visual input. We aim to increase the computational power of the existing network through invariance to translation and scale. The visual system of the brain masters the recognition of objects wherever they appear in the visual scene and regardless of scale, orientation or even with partial occlusions. It achieves this through attention. Therefore, we turn to the pool of literature on modeling visual attention systems inspired from the brain. The architecture of the extended model is composed of the existing recognition module whose response modulates the attention module to be constructed in a top-down manner. This modulation will allow the attention module to alter the input window exposed for recognition. Attention is modeled as a network measuring for saliency in a scene by feature extraction with the use of hierarchies. The design and development of this extended model to achieve the required invariance using processes that approximate their biological counterparts is presented. Emphasis is put on making these approximations through computationally economic implementations. Evaluation of the model is based on its performance in a set of experiments as well as its computational efficiency. Experiments are constructed to scrutinize the behavior of the model, its ability to converge onto a sight within a scene that enables recognition. Artificial as well as natural images are used to further reveal the capabilities and limitations of our approach.

Introduction

elaborated abstract with references.....[2]

Part I

Object Recognition with Spike Expectation Maximization

Chapter 1

Spike Expectation Maximization

Chapter 2

Intermediate Feature Layer

extending the SEM model orientation

2.1 SEM

lit. review of existing SEM model

2.2 extend SEM (learn features)

extending SEM by learning features such as orientations

2.3 extend SEM. feature layer

e xtending SEM by learning features

We have seen the computational power of the SEM model as an unsupervised method for identifying hidden causes. So far the hidden causes have been used synonymously with predefined classes (e.g. digits[1]). We will extend the SEM model in a way that breaks this assumption. We will insert an additional WTA circuit, that will be responsible for learning hidden causes that depict abstract features of the object we're attempting to detect and recognize. This feature layer will contribute to the bottom up learning as it is exposed to the low level input and itself serves as the input layer of the WTA circuit we have encountered in the original SEM architecture.

Part II

Object detection

Chapter 3

Attention

3.1 Attention mechanisms

literature reivew of attention mechanisms

3.2 Bottom up Attention

what we used from Itti's

3.3 Top down attention

describe attempt

Part III

Achieving invariance

Chapter 4

Model Architecture

Chapter 5

Model detailed

Chapter 6

Results

Chapter 7

Discussion

Use the `\section{Section}` command for major sections, and the `\subsection{Subsection}` command for subsections, etc.

7.0.1 Subsection

This is just some text under a subsection.

Subsubsection

This is just some text under a subsubsection.

Subsubsubsection This is just some text under a subsubsubsection.

Subsubsubsubsection This is just some text under a subsubsubsubsection.

7.1 Typesetting Commands

SSelect a part of the text then click on the button Emphasize (H!), or Bold (Fs), or Italic (Kt), or Slanted (Kt) to typeset *Emphasize*, **Bold**, *Italics*, *Slanted* texts.

You can also typeset Roman, Sans Serif, Small Caps, and `Typewriter` texts.

You can also apply the special, mathematics only commands $\mathbb{BLACKBOARD\ BOLD}$, $\mathcal{CALLIGRAPHIC}$, and $\mathfrak{fraktur}$. Note that blackboard bold and calligraphic are correct only when applied to uppercase letters A through Z.

You can apply the size tags – Format menu, Font size submenu – tiny, scriptsize, footnotesize, small, normalsize, large, Large, LARGE, huge and Huge.

You can use the `\begin{quote} etc. \end{quote}` environment for typesetting short quotations. Select the text then click on Insert, Quotations, Short Quotations:

> The buck stops here. *Harry Truman*
>
> Ask not what your country can do for you; ask what you can do for your country. *John F Kennedy*
>
> I am not a crook. *Richard Nixon*
>
> I did not have sexual relations with that woman, Miss Lewinsky. *Bill Clinton*

The Quotation environment is used for quotations of more than one paragraph. Following is the beginning of *The Jungle Books* by Rudyard Kipling. (You should select the text first then click on Insert, Quotations, Quotation):

> It was seven o'clock of a very warm evening in the Seeonee Hills when Father Wolf woke up from his day's rest, scratched himself, yawned and spread out his paws one after the other to get rid of sleepy feeling in their tips. Mother Wolf lay with her big gray nose dropped across her four tumbling, squealing cubs, and the moon shone into the mouth of the cave where they all lived. "*Augrh*" said Father Wolf, "it is time to hunt again." And he was going to spring down hill when a little shadow with a bushy tail crossed the threshold and whined: "Good luck go with you, O Chief of the Wolves; and good luck and strong white teeth go with the noble children, that they may never forget the hungry in this world."
>
> It was the jackal—Tabaqui the Dish-licker—and the wolves of India despise Tabaqui because he runs about making mischief, and telling tales, and eating rags and pieces of leather from the village rubbish-heaps. But they are afraid of him too, because Tabaqui, more than any one else in the jungle, is apt to go mad, and then he forgets that he was afraid of anyone, and runs through the forest biting everything in his way.

Use the Verbatim environment if you want LaTeX to preserve spacing, perhaps when including a fragment from a program such as:

```
#include <iostream>          // < > is used for standard libraries.
void main(void)              // ''main'' method always called first.
{
 cout << ''This is a message.'';
                             // Send to output stream.
}
```

(After selecting the text click on Insert, Code Environments, Code.)

7.2 Mathematics and Text

Theorem 1 *(The Currant minimax principle.) Let T be completely continuous selfadjoint operator in a Hilbert space H. Let n be an arbitrary integer and let $u_1, \ldots, u_{n-1}$ be an arbitrary system of $n-1$ linearly independent elements of H. Denote*

$$\max_{\substack{v \in H, v \neq 0 \\ (v,u_1)=0,\ldots,(v,u_n)=0}} \frac{(Tv, v)}{(v, v)} = m(u_1, \ldots, u_{n-1}) \tag{7.1}$$

Then the n-th eigenvalue of T is equal to the minimum of these maxima, when minimizing over all linearly independent systems $u_1, \ldots u_{n-1}$ in H,

$$\mu_n = \min_{u_1,\ldots,u_{n-1} \in H} m(u_1, \ldots, u_{n-1}) \tag{7.2}$$

The above equations are automatically numbered as equation (7.1) and (7.2).

7.3 Lists Environments

You can create numbered, bulleted, and description lists (Use the Itemization or Enumeration buttons, or click on the Insert menu then chose an item from the Enumeration submenu):

1. List item 1
2. List item 2
   (a) A list item under a list item.
   (b) Just another list item under a list item.
      i. Third level list item under a list item.
         A. Fourth and final level of list items allowed.

- Bullet item 1
- Bullet item 2
  – Second level bullet item.
    ∗ Third level bullet item.
      · Fourth (and final) level bullet item.

Description List Each description list item has a term followed by the description of that term.

Bunyip Mythical beast of Australian Aboriginal legends.

7.4 Theorem-Like Environments

The following theorem-like environments (in alphabetical order) are available in this style.

Acknowledgement 2 *This is an acknowledgement*

Algorithm 3 *This is an algorithm*

Axiom 4 *This is an axiom*

Case 5 *This is a case*

Claim 6 *This is a claim*

Conclusion 7 *This is a conclusion*

Condition 8 *This is a condition*

Conjecture 9 *This is a conjecture*

Corollary 10 *This is a corollary*

Criterion 11 *This is a criterion*

Definition 12 *This is a definition*

Example 13 *This is an example*

Exercise 14 *This is an exercise*

Lemma 15 *This is a lemma*

Proof. This is the proof of the lemma. ■

Notation 16 *This is notation*

Problem 17 *This is a problem*

Proposition 18 *This is a proposition*

Remark 19 *This is a remark*

Summary 20 *This is a summary*

Theorem 21 *This is a theorem*

Proof of the Main Theorem. This is the proof. ■

Appendix A

The First Appendix

The `\appendix` command should be used only once. Subsequent appendices can be created using the Chapter command.

Appendix B

The Second Appendix

Some text for the second Appendix.

Bibliography

[1] Y. LeCun and L. Bottou. Gradient-based learning applied to document recognition. *Proceedings of the ...*, 86(11):2278–2324, 1998.

[2] Bernhard Nessler, Michael Pfeiffer, and Wolfgang Maass. STDP enables spiking neurons to detect hidden causes of their inputs. *In Proc. of NIPS 2009: Advances in Neural Information Processing Systems. MIT Press*, 22:1357–1365, 2010.

Afterword

That's all folks!

The back matter often includes one or more of an index, an afterword,

B.1 Acknowledgments

Michael Matthew Cook My family: Sahra, father My friends Malte Alf INI

, a colophon, or any other similar item. In the back matter, chapters do not produce a chapter number, but they are entered in the table of contents. If you are not using anything in the back matter, you can delete the back matter TeX field and everything that follows it.