Implement Serialization of HTM Classifier

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*Abstract*—The Hierarchical Temporal Memory (HTM) classifier is a powerful machine learning algorithm inspired by the functioning of the human brain. Serialization is the process of converting an object or data structure into a format that can be easily stored or transmitted over a network. In this project, we implement serialization of the HTM classifier. This allows for the efficient storage and retrieval of trained HTM models and enables their use in distributed computing environments. We demonstrate the effectiveness of our approach by training and serializing an HTM classifier on a large dataset of images, and then using the serialized model to classify new images. Our results show that serialization of the HTM classifier is a useful and practical tool for machine learning practitioners and researchers working with large datasets.

Keywords— Hierarchical temporal memory, Neocortex,spatiotemporal, Spatial Pooler, Sparse DistributedRepresentations, Serialization, Deserialization.

# Introduction

The brain receives a vast amount of information from the environment through sensors that convert light, sound, and touch into electrical signals. These signals are processed by cortical neurons, which establish synaptic connections to other neurons to create an activity pattern that represents the sensory input. The overall activity pattern of groups of neurons influences our perception and behavior. Neuroscience has shown that individual cortical neurons can respond to specific patterns of sensory input, and groups of neurons can represent the characteristics of the stimuli in a flexible, dynamic, and robust manner.

The Hierarchical Temporal Memory (HTM) algorithm is currently widely used to detect anomalies in streaming data. This approach is based on the study of the neurology and anatomy of the mammalian brain, particularly the human brain, and the engagement of pyramid-shaped neurons in the Neocortex region.

The Hierarchical Temporal Memory (HTM) learning algorithm is also referred to as cortical learning algorithm (CLA). It uses a data format called sparse distributed representations, which consists of binary elements, either 1 or 0, and the number of 1 bits is relatively small compared to the number of 0 bits. This format represents brain activity more realistically, using a neuron model that is biologically plausible. The HTM algorithm consists of two key components: the spatial pooling algorithm, which generates sparse distributed representations as output, and the sequence memory algorithm, which adapts to depict and predict complex sequences.

The layers and minicolumns of the cerebral cortex play a partial role in representing and processing information. In particular, each layer in the Hierarchical Temporal Memory (HTM) consists of interconnected minicolumns that generate a sparse distributed representation of the input. This means that only a fixed proportion of minicolumns are active at any given time. A minicolumn is a collection of cells that share the same receptive field, and there are several cells within each minicolumn that can recall past states. These cells can be classified into three states: active, inactive, and predictive.

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*a**b* 

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| Table column subhead | Subhead | Subhead |
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Figure Example Figure Caption

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Referencing Code in your text should be avoided unless necessary. In such cases it can be inserted as a listing as shown in **Error! Reference source not found.**

Listing Code Reference Example

Console.WriteLine(“Referencing code”, var);

// using tab can be replaced with 4 spaces

Do not pass code as image. When referring to variable in **Error! Reference source not found.**, italics should be used for example *var.* Code flows and logic should be presented better as Graph or Diagram instead of words.

Code Block which is too big to put in the textbox can be reference as Listing 2.

Listing Unit Test [EncodeDateTimeTest](https://github.com/ddobric/neocortexapi/blob/0348ffb99739ddf8c8c3a875f8162a18073938ca/source/UnitTestsProject/EncoderTests/DateTimeEncoderExperimentalTests.cs#L34-L49)

public void EncodeDateTimeTest(int w, double r, …)

{

…

DateTimeEncoderExperimental encoder = new…

var result = encoder.Encode(input);

…

Assert.IsTrue(result.SequenceEqual(expected…

}

##### Acknowledgment *(Heading 5)*

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1. G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*
2. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
3. I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
4. K. Elissa, “Title of paper if known,” unpublished.
5. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
6. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
7. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

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