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.

# Serialization and deserialization

Serialization refers to the process of converting an item into a series of bytes, which can be stored or transferred to memory, a database, or a file. The primary purpose of serialization is to store an item's state so that it can be reconstructed later. The opposite of serialization is deserialization. The serialization of an object involves converting its data into a stream, which may include information about the object's version, culture, and assembly name. The resulting stream can be used to save the item in a database, file, or memory. Serialization enables the storage of objects as well as data exchange, making it useful for various tasks such as sending an object to a remote application through a web service, passing an object between domains, transmitting an object as a JSON or XML string through a firewall, and maintaining security or user-specific information across applications.

Serialization can be accomplished through various methods, including XML Serialization. This method involves converting an object's public fields, properties, or method parameters and return values into an XML stream that adheres to a particular XML Schema Definition (XSD) specification. XML serialization results in highly typed classes with public properties and XML-converted fields. The System.Xml.Serialization namespace includes XML serialization and deserialization classes, and you can use attributes on classes and class members to manage how an XmlSerializer serializes or deserializes a class instance.

To specify instances of the type, you can apply the SerializableAttribute property to a type. If you attempt to serialize a type that does not have the SerializableAttribute attribute, an error is thrown. You can use the NonSerializedAttribute attribute to prevent a field from being serialized. If a field of a serialized type contains a pointer, handle, or other specialized data structure that is not significantly reconstituted in a new environment, you may choose to make it nonserializable.

When a serialized class contains references to SerializableAttribute objects of other classes, these objects will also be serialized. However, XML is more verbose than necessary at times, and parsing XML software is a slow and tedious process that can be memory-intensive. JSON, on the other hand, is less verbose and faster, and JSON documents are often more readable than XML.

The Text.Json namespace provides classes that enable the serialization and deserialization of data in JavaScript Object Notation (JSON) format. JSON is an open standard that is widely used for exchanging data over the web.

JSON serialization involves converting an object's public properties into a string, byte array, or stream. To customize the serialization or deserialization process, you can use a JsonSerializerOptions object or apply attributes from the System.Text.Json.Serialization namespace to classes or properties.

Private properties are not serialized by the JSON Serialization process. Additionally, the resulting data is more compact and easier to read when stored in a text file. Reflection can be used to achieve this.

Reflection refers to the set of programming functionalities that enable a programmer to observe and modify code elements without prior knowledge of their identity or formal structure. Inspection, on the other hand, involves studying objects and types to collect structured information about their definition and behavior. This process is typically carried out with minimal prior knowledge of the objects or types being inspected.

Reflection allows programmers to access custom attributes, dynamically load assemblies, create instances, invoke methods, and learn about private and public methods.

# Results

This Part of the text describes results of your works. There can only be mentioned references, MUST point back to Methods and Intro chapter. No more external references.

Code examples must be provided to demonstrate how to use the algorithm/module. Provide a reference to more unit tests, which show the same in more detail. Also provide all diagrams with comments and reference to unit tests, which generate diagrams.

# Discussion

Conclusion of your work should be precise and concise. How was the project, what is done, what is the result... There can be discussion on further work and direction.

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*a**b* 

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## Some Common Mistakes

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* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
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For adding object other than text (tables, equations, graphs, figures, code…), **there must be at least one cross reference** to it. Figure 1 is an example

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1. Table Type Styles

| Table Head | Table Column Head | | |
| --- | --- | --- | --- |
| Table column subhead | Subhead | Subhead |
| copy | More table copya |  |  |

1. Sample of a Table footnote. (*Table footnote*)



Figure Example Figure Caption

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## Code References:

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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7. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

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