***ML 22/23-5 Refactoring HtmSerializer***

line 1: 1st Given Name Surname   
line 2: email address

line 1: 2nd Given Name Surname  
line 2: email address

line 1: 3rd Given Name Surname  
line 2: email address

*Abstract*—Hierarchical temporal memory (HTM) provides a theoretical framework that models several fundamental computational principles of the Neocortex. Hierarchical Temporal Memory (HTM) serialization refers to the process of converting HTM objects, such as HTM models or network configurations, into a format that can be stored or transferred between systems. HTM serialization typically involves converting the object into a binary or text-based format that can be easily transmitted or stored, while preserving the key properties of the object. The resulting serialized object can then be used to recreate the original HTM object, either on the same or a different system. Deserialization is opposite of the serialization. HTM serialization unit tests are automated tests that are designed to verify that the serialization and deserialization functionality of an HTM serializer works as expected. A software testing process known as unit testing involves testing each individual unit or component of a software system separately to make sure they function as intended. The purpose of this project is refactoring the code of the HTMSerializer File. This means making the code more legible and understandable.

Keywords—hierarchical temporal memory, Neocortex, Serialization, Deserialization, Unit Test, Refactoring

# Intro (*Heading 1*)

A Hierarchical Temporal Memory (HTM) serializer is a software component that is designed to convert HTM objects into a serialized format. HTM is a machine learning algorithm developed by “Numenta” that is based on principles of neuroscience and is designed to recognize patterns in data streams, such as those found in sensor data or natural language.

A developing machine learning approach called hierarchical temporal memory (HTM) may make it possible to make predictions on spatiotemporal data. The neocortex-inspired algorithm does not yet have a complete mathematical foundation. In this work, the spatial pooler (SP), a crucial learning component in HTM, is brought together under a single, overarching framework. In order to determine the level of permanence updating, a maximum likelihood estimator for the basic learning mechanism is proposed. The study of the boosting processes reveals that they constitute a secondary learning mechanism. The SP is shown to perform remarkably well on categorical data in both spatial and categorical multi-class categorization. A comparison between HTM and well-known algorithms like competitive learning and attribute bagging is made. There are ways to use the SP for both dimensionality reduction and classification. Evidence from experiments shows that the SP may be utilized for feature learning when the appropriate parameterizations are applied. [1]

Several of the neocortex structures and functions are modeled by HTM at a high level. Its structure resembles that of the cortical minicolumns, where an HTM region is made up of numerous columns made up of various numbers of cells each. A level is formed by one or more regions. The whole network shown in Figure 1 is made up of levels that are stacked hierarchically in a tree-like structure. Synapses are used to create feedforward and adjacent connections in HTM, respectively. Proximal and distal synapses are used in these connections.

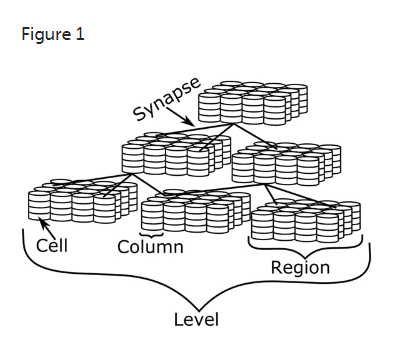


Figure 1: Depiction of HTM

The HTM cortical learning method was succeeded by the present version of HTML. The spatial pooler (SP) and the temporal memory algorithm are the two main algorithms in the current version of HTM (TM). An SDR is a binary vector that typically has a sparse number of active bits or a bit with the value "1," and the SP is in charge of receiving input in the form of an SDR and producing a new SDR. The SP can be thought of as a function that maps the input domain to a new feature domain in this way. Similar SDRs from the input domain should be represented by a single SDR in the feature domain. The algorithm uses a type of vector quantization that resembles self-organizing maps. It is a type of unsupervised competitive learning algorithm. Making predictions and learning sequences are tasks for the TM. Using this technique, connections are made between cells that have previously been active. The development of those linkages could lead to the learning of a sequence. The TM can then make predictions using the sequences it has learned about. [1]

The second generation of HTM learning algorithms, often referred to as cortical learning algorithms (CLA), was drastically different. It uses a sparse distributed representations data structure to describe brain activity and a more biologically accurate neuron model. The data structure's parts are binary, 1 or 0, and the number of 1 bits is minimal relative to the number of 0 bits (often also referred to as cell, in the context of HTM). Its HTM generation consists mostly of a sequence memory algorithm that learns to record and anticipate complex sequences and a spatial pooling technique that generates sparse distributed representations (SDR).

The cerebral cortex's layers and minicolumns are discussed and partially modeled in this latest generation. Each HTM layer is made up of a number of intricately interconnected minicolumns, which should not be confused with an HTM level of an HTM hierarchy. A fixed percentage of the minicolumns in an HTM layer's sparse distributed representation are active at any given time [clarification needed]. A minicolumn is a collection of cells with a same receptive field. A few of the cells in each minicolumn can recall many past states. There are three possible states for a cell: active, inactive, and predictive. [2]

Since HTM was first created as a neocortical abstraction, it lacks a formal mathematical formulation. Without a mathematical foundation, it is challenging to comprehend the main traits of the program and how it might be enhanced. Generally speaking, very little research has been done on the mathematics underlying HTM. [1]

**-Spatial Pooling**

Each minicolumn receptive field consists of a fixed number of inputs drawn at random from a much larger pool of node inputs. Certain minicolumns will be more or less related with the active input values depending on the (particular) input pattern. The most active minicolumns are chosen by spatial pooling, and other minicolumns close to the active ones are inactivated (inhibited). A stable set of minicolumns is typically activated by similar input patterns. Each layer's memory consumption can be altered to learn more intricate spatial patterns or less sophisticated ones.[2]

-**Active, inactive and predictive cells**

As was already established, a cell (or neuron) of a minicolumn may be in an active, inactive, or predictive state at any given time. Cells are inactive at first. They will be the sole cells to become active in the current time step if one or more active minicolumn cells are in the predicted state. The cells in the active minicolumn are made active if none of them are in the predicted state (which occurs during the first time step or when the activation of this minicolumn was unexpected). As a cell becomes active, it gradually establishes connections with cells in the area that have typically been active for a number of earlier time steps. In this way, a cell can recognize a recognized sequence by determining whether the cells it is attached to are active. This cell enters the predictive state in expectation of one of the few future inputs of the sequence if a significant number of related cells are active. A layer's output contains minicolumns that are both active and predictive.

Because minicolumns are active over extended periods of time, the parent layer observes more temporal stability.[2]

**-Comparing HTM and neocortex**

HTM is an effort to mimic the operation of a set of cortical areas in the neocortex that are connected hierarchically. The hippocampus is distantly similar to the highest HTM level, while a portion of the neocortex corresponds to one or more HTM levels. A single HTM node may stand in for a collection of cortical columns in a specific area. Although the HTM is largely a functional model, there have been various attempts to link its algorithms to the organization of neural connections in the neocortex's layers. Six horizontal layers arranged vertically compose the neocortex. It is

incorrect to equate the six layers of neocortical cells with the tiers of an HTM hierarchy. [2]

# Methods

**-Serialization and Deserialization**

Serialization is the process of converting an object or data structure into a format that can be easily transmitted or stored. In the case of HTM, serialization allows trained HTM models or network configurations to be saved, loaded, and shared between systems.

An HTM serializer typically consists of a set of functions or methods that are used to convert HTM objects into a standardized format, such as a binary or text-based format. The serialized HTM objects can then be transmitted, stored, or loaded into an HTM system for further processing. HTM serializers can be implemented in a variety of programming languages and are often used in conjunction with other HTM software components, such as HTM learning algorithms or anomaly detection systems.

The process of serialization involves changing an object's state into a format that can be stored or transferred. Serialization's counterpart, deserialization, transforms a stream into an object. These procedures work together to make it possible to store and send data. Deserialization is opposite of the Serialization. [3]

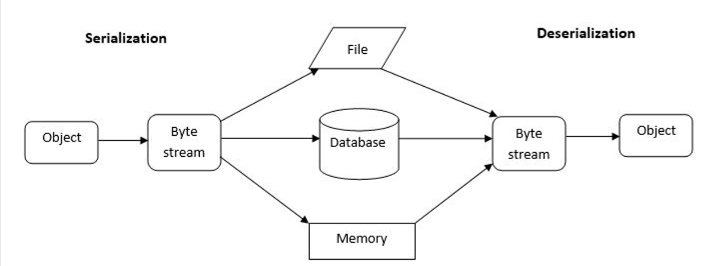


Figure 2: Serialization and Deserialization of an Object

In C#, a serializer is used to convert an object to a format that can be easily transported or stored, such as JSON or XML. The most commonly used serialization methods in C# are:

**a) Binary Serialization:** This method converts an object to a binary format, which can be easily transported or stored. It is useful for situations where data needs to be sent over a network or saved to a file.

Because binary serialization maintains type fidelity, the entire state of the object is preserved, and when you deserialize, an exact copy is produced. The status of an object can be preserved using this type of serialization between application calls. For instance, serializing an object to the Clipboard allows you to share it between many apps. An item can be serialized to a stream, a disk, memory, across the network, and other locations. To transfer things “by value” from one computer or application domain to another, remote access requires serialization. [3]

**b) XML and SOAP Serialization:** This method converts an object to an XML format, which can be easily read and understood by both humans and machines. It is useful for situations where data needs to be exchanged between systems or platforms.

Just public properties and fields are serialized using XML and SOAP, and type fidelity is not maintained. When you wish to supply or consume data without limiting the program that consumes the data, this is helpful. XML is a popular option for Web-based data sharing because it is an open standard. Being an open standard, SOAP is a desirable option. [3]

**c) JSON Serialization:** This method converts an object to a JSON format, which is a lightweight data-interchange format that is easy for humans to read and write and easy for machines to parse and generate.

JSON serialization serializes only public properties and does not preserve type fidelity. An appealing option for data sharing over the web is the open standard JSON. [3]

All above serialization method are supported by .NET framework, you can use any of them based on your requirement and compatibility.

**-Refactoring**

Refactoring a Hierarchical Temporal Memory (HTM) serializer would involve making improvements to the design, structure, or functionality of the serializer without changing its overall purpose. Refactoring is typically done to improve the code's maintainability, extensibility, and readability, and to reduce technical debt.

Some possible refactoring tasks for an HTM serializer might include:

\* Improving the performance of the serializer by optimizing its algorithms or data structures.

\* Simplifying the codebase by removing redundant or unnecessary code.

\* Refactoring the serializer to conform to a consistent coding style or design pattern.

\* Adding new functionality to the serializer, such as support for additional data formats or compression algorithms.

\* Improving the error handling or logging mechanisms of the serializer to make it easier to diagnose and fix problems.

Refactoring an HTM serializer can help to ensure that it remains maintainable and up-to-date as new requirements or technologies emerge. This can be particularly important in the field of machine learning, where the pace of development is often rapid, and the requirements can be complex.

Our task is refactoring the code of the HTMSerializer File. This means making the code more legible and understandable. In order to do that, we are going to separate the methods that use serialize and deserialize in two classes. The class 1 will correspond to those methods that are formatting the code while the second class will correspond to the actual serializing and deserializing methods. These methods are used in a wide variaty of projects. Our task is trying to encapsulate this methods so every project can use them (is like a library, you can take it and adapt it to your own work).

The outline of this project can mainly be described in four parts as following:

1) Analyzing the serializer and solving the errors of UnitTests.

2) Splitting the Formatting code methods from the Serialization code methods (SerializeValue/DeserializeValue from all other methods).

3) Implementing all formatting methods with create an interface IHtmSerializationFormatter and class HtmDefaultTextFormatter which interface contains all formatting methods. Then, copy all formatting methods from HtmSerializer into that class and doing refactoring.

4) Improving Unit Tests after refactoring.

-**Serialize() and Deserialize() Methods**

Two methods named Serialize() and Deserialize have been implemented inside the classes in under NeoCortexApi directory in HTM and they are the two main methods of our project. This Seralize function creates an instance of the HtmSerializer class and initiates functions called SerializeBegin and SerializeEnd.

The methods Serialize Begin and Serialize End are both methods that use sw.Write(). In the project it says we should name this methods SerializeValue, but they are not serializing any value itself, just saying when the start and end of the serialized object is, so its logical to call them SerializeObject instead Also we can make the code more compact by doing only one method:

public void SerializeObject(String typeName, StreamWriter sw, bool isBegin)

{

sw.WriteLine();

if (isBegin)

{

sw.Write($"{TypeDelimiter} BEGIN '{typeName}' {TypeDelimiter}");

}

else

{

sw.Write($"{TypeDelimiter} END '{typeName}' {TypeDelimiter}");

}

Figure 3: Calling SerializeBegin and SerializeEnd in

SerializeObject class

To make the class start and end in a text file clear to the user, serialize Begin and serializeEnd are used. The SerializeValue method is used to implement serialization for fundamental properties like int, double, bool, string, array, list, and dictionary.

The current serializer implementation contains the serialization logic code and serialization formatting code. Formatting code is in methods that use sw.Writer() or sw.Read() methods. Also, name all these methods SerializeValue and DeserializeValue. Formatting code methods are needed to perform the refactoring. Then, the interface and the class to be created containing these formatting methods from HtmSerializer. So, all formatting code methods and other serialization code methods are listed below.

|  |  |
| --- | --- |
| Formatting Codes | Other Serialization/Deserialization Codes |
| SerializeBegin() | ReadBegin() |
| SerializeEnd() | ReadEnd() |
| SerializeValue(int) | ReadIntValue() |
| SerializeValue(double) | ReadDoubleValue() |
| SerializeValue(string) | ReadStringValue() |
| SerializeValue(long) | ReadLongValue() |
| SerializeValue(bool) | ReadBoolValue() |
| SerializeValue(object) | Serialize/DeserializeKeyValuePair() |
| SerializeValue(array) | Serialize/DeserializeDictionary() |
| SerializeValue(double[]) | Serialize/DeserializeObject() |
| SerializeValue(int[]) | Serialize/DeserializeDistalDendrite() |
| SerializeValue(cell[]) | Serialize/DeserializeHtmConfig() |
| SerializeValue(Dictionary) | Serialize/DeserializeIEnumerable() |

Table 1: Splitting formatting methods from other methods

**-Unit Tests**

HTM serialization unit tests are automated tests that are designed to verify that the serialization and deserialization functionality of an HTM serializer works as expected.

Unit testing is a software testing methodology in which individual units or components of a software system are tested in isolation to ensure that they work correctly. In the case of an HTM serializer, unit tests would typically involve testing the serializer's ability to convert HTM objects, such as HTM models or network configurations, into a serialized format and then back into the original object without loss of data or functionality.

HTM serialization unit tests might include the following types of tests:

(a) **Serialization tests:** These tests would verify that the serializer correctly converts an HTM object into a serialized format.

(b) **Deserialization tests:** These tests would verify that the deserializer correctly converts a serialized HTM object back into its original form.

(c) **Round-trip tests:** These tests would verify that the serializer and deserializer together can correctly serialize and deserialize an HTM object, with no loss of data or functionality.

(d) **Error handling tests:** These tests would verify that the serializer and deserializer correctly handle error conditions, such as invalid input data or unexpected data formats.

HTM serialization unit tests are an important part of the software development process, as they help to ensure that the serializer works correctly and is free of bugs or errors. By automating these tests, developers can catch problems early in the development process and reduce the likelihood of bugs being introduced into the codebase.

Sometimes some unit tests related to our project may give errors when we debug. We are also making some changes in the source code to eliminate these errors. Let’s see some examples from source code changeable to solve unit test errors. It is HtmSerializationTests which are unit tests related to our project.

\*Example of the solving Unit Test: First example unit test error is from our “SerializeDistalDendrite (1,2,2,1,100)” test. When we debugged this unit test, we encountered an error, but we solved the error by making changes to the source code.

Unit Test HtmSerializationTests.cs (line 590)

public void SerializeDistalDendrite(int flatIdx, long lastUsedIteration, int ordinal, double synapsePermConnected, int numInputs)

{

…

…

…

using (StreamReader sr = new StreamReader($"ser\_{nameof(SerializeDistalDendrite)}.txt"))

{

HtmSerializer ser = new HtmSerializer();

DistalDendrite distSegment1 = ser.DeserializeDistalDendrite(sr);

Assert.IsTrue(distSegment1.Equals(distSeg1));

}

}

Figure 4: Original source code of the “SerializeDistalDendrite” Unit Test

The error here is that the value of DistSegment1 is equal to 0. In order to the DistSegment1 variable not to be 0, we must first equalize the DistSeq1 value to the DistSegment1 value. So, need to add equation for equal DistSegment1 variable value to DistSeq1 variable value (DistSegment1=DistSeq1).

public void SerializeDistalDendrite(int flatIdx, long lastUsedIteration, int ordinal, double synapsePermConnected, int numInputs)

{

…

…

…

using (StreamReader sr = new StreamReader($"ser\_{nameof(SerializeDistalDendrite)}.txt"))

{

HtmSerializer ser = new HtmSerializer();

DistalDendrite distSegment1 = ser.DeserializeDistalDendrite(sr);

**DistSegment1 = DistSeg1 //Add this code to solve**

Assert.IsTrue(distSegment1.Equals(distSeg1));

}

}

Figure 5: Modified source code of the “SerializeDistalDendrite” Unit Test (add line 623 code)

\*Example of the solving Unit Test: Second example unit test error is from our “SerializeDictionarystringintA” test. When we debugged this unit test, we encountered an error, but we solved the error by making changes to the source code.

Unit Test HtmSerializationTests.cs (line 368)

public void SerializeDictionarystringintA()

{

HtmSerializer htm = new HtmSerializer();

Dictionary<String, int[]> keyValues = new Dictionary<String, int[]>

…

…

string[] str = data.Split(HtmSerializer.ParameterDelimiter);

for (int i = 0; i < str.Length; i++) {

switch (i) {

case 0:

keyValuePairs = htm.ReadDictSIarray(str[i]);

break;

default:

break;

}

}

}

}

}

Assert.IsTrue(keyValuePairs.SequenceEqual(keyValues));

}

Figure 6: Original source code of the “SerializeDictionarystringintA” Unit Test

To solve that error, we can get “Assert.IsTrue(keyValuePairs.SequenceEqual(keyValues));” code line into the switch case loop. Because we need to verify that the Assert.IsTrue statement at the end of the method is correctly comparing the key value pairs. Depending on the implementation of the HtmSerializer, the comparison may need to be modified to account for any differences in the serialized and deserialized data.

public void SerializeDictionarystringintA()

{

HtmSerializer htm = new HtmSerializer();

Dictionary<String, int[]> keyValues = new Dictionary<String, int[]>

…

…

string[] str = data.Split(HtmSerializer.ParameterDelimiter);

for (int i = 0; i < str.Length; i++) {

switch (i) {

case 0:

keyValuePairs = htm.ReadDictSIarray(str[i]);

break;

default:

break;

Assert.IsTrue(keyValuePairs.SequenceEqual(keyValues));

}

}

}

}

}

}

Figure 7: Modified source code of the “SerializeDictionarystringintA” Unit Test (add code line 413 from line 420)

# 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.

# Ease of Use

## Selecting a Template (Heading 2)

First, confirm that you have the correct template for your paper size. This template has been tailored for output on the A4 paper size. If you are using US letter-sized paper, please close this file and download the Microsoft Word, Letter file.

## Maintaining the Integrity of the Specifications

The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

# Prepare Your Paper Before Styling

Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections A-D below for more information on proofreading, spelling and grammar.

Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

## Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

## Units

* Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.
* Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
* Do not mix complete spellings and abbreviations of units: “Wb/m2” or “webers per square meter”, not “webers/m2”. Spell out units when they appear in text: “. . . a few henries”, not “. . . a few H”.

may use the solidus ( / ), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

*a**b* 

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “(1)”, not “Eq. (1)” or “equation (1)”, except at the beginning of a sentence: “Equation (1) is . . .”

## Some Common Mistakes

* The word “data” is plural, not singular.
* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
* In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
* A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
* Do not use the word “essentially” to mean “approximately” or “effectively”.
* In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
* Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.
* Do not confuse “imply” and “infer”.
* The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
* There is no period after the “et” in the Latin abbreviation “et al.”.
* The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

An excellent style manual for science writers is [7].

# Using the Template

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

## Authors and Affiliations

**The template is designed for, but not limited to, three authors.** A minimum of one author is required for all report articles. Author names should be listed starting from left to right and then moving down to the next line. This is the author sequence that will be used in future citations and by indexing services. Names should not be listed in columns nor group by affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization).

### For papers with more than three authors: Add author names horizontally, moving to a third row if needed for more than 8 authors.

### For papers with less than three authors: To change the default, adjust the template as follows.

#### Selection: Highlight all author and affiliation lines.

#### Change number of columns: Select the Columns icon from the MS Word Standard toolbar and then select the correct number of columns from the selection palette.

#### Deletion: Delete the author and affiliation lines for the extra authors.

## Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is “Heading 5”. Use “figure caption” for your Figure captions, and “table head” for your table title. Run-in heads, such as “Abstract”, will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced. Styles named “Heading 1”, “Heading 2”, “Heading 3”, and “Heading 4” are prescribed.

## Figures and Tables

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

#### Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1”, even at the beginning of a sentence.

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 1 Example Figure Caption

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

## 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 1 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 2 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)*

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

##### References

The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use “Ref. [3]” or “reference [3]” except at the beginning of a sentence: “Reference [3] was the first ...”

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors’ names; do not use “et al.”. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [4]. Papers that have been accepted for publication should be cited as “in press” [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

1. J. Mnatzaganian, E. Fokoue, and D. Kudithipudi, “A Mathematical Formalization of Hierarchical Temporal Memory’s Spatial Pooler,”, 30January2017. <https://www.frontiersin.org/articles/10.3389/frobt.2016.00081/full>
2. Authors unpublished, Vikipedia, “Hierarchical temporal memory”, <https://en.wikipedia.org/wiki/Hierarchical_temporal_memory>
3. Gewarren, TimShererWithAquent, tdykstra, nschonni, mairaw, Mikejo5000, “Serialization in .NET”, 23 September 2022, <https://learn.microsoft.com/en-us/dotnet/standard/serialization/>
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.

**This report template contains guidance text for composing and formatting technical reports. Please ensure that all template text is removed from your report prior to submission to the examination office. Failure to remove template text from your paper may result in your paper being degraded.**

We suggest that you use a text box to insert a graphic (which is ideally a 300 dpi TIFF or EPS file, with all fonts embedded) because, in an MSW document, this method is somewhat more stable than directly inserting a picture.

To have non-visible rules on your frame, use the MSWord “Format” pull-down menu, select Text Box > Colors and Lines to choose No Fill and No Line.