Improvement for Large-Scale Image Data using Fuzzy Rough C-Mean Based Unsupervised CNN Clustering: Case Study designbyhumans.com

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Clustering analysis, specifically, for large image data are increasingly being applied in various fields such as finance, risk management, prediction, etc., and has been an interesting subject in many science discussions. Deep learning, a widely used approach, along with classical methods is being used to address sophisticated classification problems stem from real world cases. In this study we will be taking various approaches to the classification problems and, measure their effectiveness by combining different methods using the results taken from different scenarios in this study. Initial evaluations will be conducted on a dataset that we have been able to collect from the website designbyhumans.com and the result will be analyzed in detail with each technique and will be compared with other similar and different approaches.

CCS CONCEPTS • Insert your first CCS term here • Insert your second CCS term here • Insert your third CCS term here

**Additional Keywords and Phrases:** FRCM, CNN

ACM Reference Format:

First Author’s Name, Initials, and Last Name, Second Author’s Name, Initials, and Last Name, and Third Author’s Name, Initials, and Last Name. 2018. The Title of the Paper: ACM Conference Proceedings Manuscript Submission Template: This is the subtitle of the paper, this document both explains and embodies the submission format for authors using Word. In Woodstock ’18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages. NOTE: This block will be automatically generated when manuscripts are processed after acceptance.

1. Introduction

Since the beginning of the information technology era, image processing has become an important research field, its necessity has been heavily implied in computer vision applications, where even a single image can potentially contain valuable information. 3.2 billion images are uploaded to the Internet every day with different purposes, that huge number indicated the demand of integrating large scale image data into several different fields. A huge number of efforts have been made to meet those artificial demands, such as reducing a few samples from the already enlarged dataset or encoding image features within the dataset as there might and usually exists redundant and noise samples scattered throughout the dataset with varied magnitude.

Unsupervised learning is a popular machine learning tool to visualize the structure beneath the huge dataset. An unsupervised method must be able to reproduce the result without too much prior knowledge from previous learning from unlabeled datasets, which is commonplace in the real world and typically unknown before applying cluster analysis techniques. Distinctive or so-called “hard” clustering methods such as hierarchical, density-based, centroid-based and graph theoretical have been used extensively for prediction on these structures with commendable precision. However, with the existence of high-quality image data with great depth to their perception, these “hard” methods are left exposed to a huge challenge: The amount of immeasurable vagueness, uncertainty or overlapping of samples from the clusters is nearly impossible to make precise predictions to each sample.

Because of such uncertainties, Rough Set and Fuzzy Set theory have been introduced and implemented as cluster analysis methods, so-called “soft” methods opposed to “hard” methods in order to highlight the blurry nature of the data that might be an oversight to well-known “hard” methods. Two prominent methods are Fuzzy C-means and Rough C-means, which use probability-based weighting values to identify the clusters. Rough C-means describes a cluster with a centroid which is initialized by choosing data points randomly, and a pair of lower and upper approximation with different weighting values. Fuzzy C-means on the other hand use weight calculation formula to impose different weighting values based on distances to cluster centers. Fuzzy Rough C-means (FRCM) is the combination of these abovementioned to overcome both the overlapping nature and uncertainty of image data. It incorporated elements of the two: A center, a crisp lower approximation and a fuzzy boundary approximation, classifying based on rough approximation and calculating based on fuzzy approximation.

Deep learning is also a trending topic in recent years because of its specialization in solving certain problems, especially in analyzing large image data. Some architectures that represent its robustness include Deep Belief Network, Deep Boltzmann Machine, Deep Autoencoder and Convolutional Neural Networks. For video and imagery applications, we’ve already had CNN-based architectures: AlexNet, ResNet, VGG and FCN. These architectures demonstrated robust accuracy in image data classification tasks with sufficient labeled training set.

Clustering algorithm’s performance depends greatly on noise reduction and feature representation power. Deep learning architectures rely on accurate labeled data, which is usually not available in the real-world applications and does not applicable in cluster analysis applications. Therefore, the model can be pre-trained on existing dataset with reliable labeling process and using transfer learning and proper tuning to be able to identify such inconsistency.

Many efforts have been done to combine cluster analysis with representation learning. Hsu[citation] proposed CNN-based joint clustering in which Mini-batch K-Means algorithm is executed to assign cluster labels. However, it carries the cons of the hard-clustering method, is the deterministic model that incomprehensible with the inconsistency of the image dataset. Xie[citation] proposed Autoencoder-based deep learning, followed by K-Means to get initial clusters, but the autoencoder cannot properly learn representative features for high dimensional data.

In this paper, we will be using combined CNN and FRCM architecture provided from the paper[citation] but with some modification in order to fit in the basic concepts that has been cited in the given paper using our own dataset from the website designbyhumans.com and we will be comparing the performance between the dataset and MNIST dataset.

* 1. Background
     1. Fuzzy Rough C-means (FRCM) clustering algorithm:

As stated by Hu et al. [citation], the FRCM algorithm is a combination of both Fuzzyand Rough C-means. FCM maps each data points into a membership matrix which ranges from 0 to 1, each points belong to some or all the clusters to some degree probabilistically and calculate the centroids based on distances to each of the cluster centers that have been initialized by random sampling. RCM classifies the points into two parts: The lower approximation, upper approximation; those who belong in the lower approximation are guaranteed to be a data point of that cluster, and the ones in the upper part belong to a cluster by some extent with respect to their different weighting values. Inspired by these concepts, FRCM integrated all of these elements and imposed fuzzy membership values of each sample to the lower and upper area of the clusters.

Let a set of image data , where d is the dimension of the data points. Each cluster , where k denotes the number of clusters, is regarded as a rough set. The data points are categorized into the lower approximation and the upper approximation . Let be a vector composed of k centers of clusters, where . The points in lower approximation are guaranteed to be in the clusters and take the same weight value, while the ones that are in the upper region have diverse effects on the centers and clusters, therefore different weighting values must be imposed on only the points belong to the upper region to compute new cluster centers.

Let be a membership matrix, we have the membership function:

(1)

The exponent m > 1 is the parameter to change the weighting impact of membership values, usually in range from 1.5 to 2.5 as different methods suggested. The new cluster center is computed according to the function:

(2)

And the objective function for FRCM is as follows:

(3)

To wrap up, the algorithm is formulated as follows:

ALGORITHM 1: Fuzzy Rough C-Means

Unlabeled data I, number of clusters k, threshold parameter T, exponent index m, stop criterion .

Membership matrix u, k cluster centers

Let , initialize membership matrix u randomly

while , do

calculate pairwise distances between each data points and calculate cluster centers using randomly initialized membership matrix u and equation (2)

assign data points to the approximations:

calculate its closest center and distance set as follows:

classify data points based on distance set A:

compute new membership values using equation (1)

compute cost using equation (3)

* + 1. Fuzzy Rough UCNN Clustering Architecture:

To be able to enhance clustering algorithm’s performance, unsupervised CNN is integrated along with Fuzzy Rough C-Means clustering algorithm. There are two parts in this architecture: The pre-clustering stage and further joint clustering and representation learning. The clusters are updated by using the FRCM algorithm in the forward pass of the architecture and optimized by the stochastic gradient descent in the backward pass.

In the pre-clustering stage, the size of the dataset will determine how large the respective multi-convolutional layers will be and will generally requires large-scale networks in case the dataset is huge enough. For the imagenet dataset used in this paper, the AlexNet architecture is proven to be effective enough to implement the training. The architecture consists of 5 convolutional layers (Conv1 – Conv5) used in AlexNet, followed along by 3 adjustment layers (Conv6, Conv7, CConv) with channel number 6144, 2048 and k, connected with a fully connected (FC) layer and a softmax layer to extract the image features and predict the cluster labels.

[Image of the architecture goes here]

* 1. Related Work

Hu et al. and Yu et al.[citation] proposed a clustering algorithm which is the combination of Fuzzy C-means and Rough C-means that perceive real world applications of unstable and blurry data. Each data point is categorized based on threshold value and its membership value into lower and upper approximation. The centers are re-calculated using randomly created membership matrix and new membership value, correspond with data point’s coordinates and membership value, along with an exponent index value, usually stable at 2.0.

Hsu et al. and Lin et al.[citation] proposed a clustering CNN architecture and representation learning method to cluster image data based on their extracted visual representations. A clustering algorithm is utilized to support the CCNN by assigning the labels to each image in the dataset as truth labels and cluster the extracted salient features at each selected output. The CCNN is the primary method as it uses randomly selected samples to feed forward and updates the extracted features of those samples and fine tune its parameters.

Riaz et al., Arshad et al., Jiao et al.[citation] utilized a CCNN architecture based upon FRCM for large image data problem. The architecture has been proven to be better than existing methods for image data clustering problem

1. 2. Materials and Methods
   1. Image data pre-processing

To increase sample variety during the pre-clustering process, the data is pre-processed by using random flip horizontally and random crop at 227 by 227 pixels, as standards before deploying AlexNet to train Conv1 – Conv5 parameters.

* 1. Cluster centroids calculating

Let be the set of images. We will be using the membership matrix from the result of the ground truth from applying FRCM to the dataset with the extracted centroid features using UCNN from the FC layer as extracted dataset features initial centroids in order to minimize the gap between using independent features and dataset. The FRCM is performed to update the cluster centroids by the objective function:

And the centroids are calculated by the function:

* 1. Representation learning

By using the UCNN architecture, features of the images in the dataset are extracted by using the FC layer and salient features are extracted using CConv layer. To learn the parameter of FC and softmax layer, we will be using SGD process, where omega subscript r i end subscript belongs to the FC layer and omega subscript i j end subscript belongs to the softmax layer, respectively. We will start with the objective function:

where k is denoted as the number of clusters, y with overparenthesis on top subscript j is the predicted jth cluster label using the UCNN and y subscript j is the predicted jth cluster label using FRCM as pseudo ground truth. Then by using chain rule and calculating gradient, we have the functions for updating FC and softmax layers:

(5)

(6)

* 1. The complete algorithm:

ALGORITHM 2: Cluster centroids updating

Image dataset I, k number of clusters, randomly selected data , learning rate , max iteration , Extracted image features of centroids of FC layer.

Final cluster centroids, final weights ()

For t = 1 to , do:

Calculate cluster label using FRCM as ground truth on randomly utilized centroids to speedup algorithm’s convergence

Forward feed the centroids and extract the features from UCNN’s clustering layer and FC layer.

Update cluster centroids by using FRCM on randomly sampled centroids in the FC layer and find the predicted cluster label based on the updated centroids.

Update the weights of FC layer and softmax layer by using function (5) and (6)

Fine tune the UCNN by using the objective function

end

* 1. Experiment:
     1. Data preparations:

In this paper, Python 3.9 was utilized as our programming tool because of its compatibility with various libraries and frameworks. ILSVRC19 train set in ImageNet is used in pre-training stage with our representation of AlexNet; it consists of over 1.2 million training images of size 256 x 256-pixels collected from 1000 categories. As mentioned above, our provided by DesignedByHumans dataset is used to evaluate the performance of this approach, which consists of over 52000 images of size 1200 x 1200-pixels downscaled to 28 x 28-pixels collected from 69 different categories includes sub-categories and possibly belong to many categories as once, which emulates real world example of unstable data for semi-supervised learning method.

The hardware we will be using is a personal computer using Ryzen 7 4800HS CPU and NVIDIA GTX 1650 with 16GB of RAM updated with newest drivers on Tensorflow 2.9.

Table 1: Datasets used for evaluation

| Dataset | No. of samples | No. of classes | Image size |
| --- | --- | --- | --- |
| ILSVRC19 | 1,281,167 | 1000 | 256x256 |
| DesignByHumans dataset | 52,361 | 69 | 28x28 |

* + 1. Evaluation metrics:

Since we will be using our dataset, as stated in data preparation step, our dataset has a possibility of different samples belong to many categories, sub-categories included, overlapping each other on different clusters, so the metrics we will be using are popular metrics used to evaluate unsupervised learning methods with unknown ground truth.

The Silhouette Coefficient score, which is used when the ground truth is unknown and evaluation is performed using the model. A higher silhouette coefficient score indicates a model with better defined clusters:

where a is the mean distance between a sample and all other points in the same class, b is the mean distance between a sample and all other points in the next nearest cluster. The best value is 1 and the worst is -1 and the value near 0 indicates overlapping clusters.

* + 1. Comparison and evaluate:

To evaluate the performance of the method and compare it with other methods using the same dataset, we will be conducting our tests in comparison with KMeans since 1. KMeans is the most popular clustering algorithm used in most of the comparison and 2. It’s performance in synthetic and large data is still questionable in terms of overall performance

* + 1. Implementations and practices:

We began using the pre-trained AlexNet on the updated ILSVRC19 training set of ImageNet as our basic convolutional model and data augmentation methods: random flip left and right as well as random cropping samples to size 227x227 during the pre-training process to increase samples variety.

The proposed model consists of 5 convolutional layers taken from the pre-trained AlexNet, with the same configurations as the original model, concatenated with 2 adjustment layers with filter size 6144 & 2048, with kernel size 3 x 3 and a clustering convolutional layer with k channel size and the same kernel size as the adjustment layers, and followed by a global max pooling layer with 1 x k output, k is denoted as the number of clusters.

We evaluated the model on our dataset, consists of over 50000 RGB images of size 1200 x 1200 . The output of the FC layer is considered the centroids of the clusters and is updated in the forward propagation stage using FRCM and SGD in the backward propagation stage.

Our dataset is resized to 28 x 28 due to GPU memory constraints, as well as the model.

1. Results
   1. Performance measures:
   2. Computational time:
   3. Impact on performance:
2. Discussion

Dataset quality is our main concern because as stated, the number of features in a HD quality image is demanding for the hardware, and the fact that we had to face constraints in computational power reflected this. The model is also taxing on the GPU memory that the performance may suffered heavily.

FRCM is also an inconsistent method, as it tends not to converge in many situations during our implementation. Although the Fuzzy C-means is guaranteed to reach a convergence point, there is no hypothetical guarantee that FRCM algorithm reach convergence for large and inconsistent dataset as ours

1. Conclusions

In this documentation, we have applied the CNN model on our synthetic dataset based on the Fuzzy Rough C-means clustering algorithm. The algorithm can provide and be improved for better results on large scale, high dimensions image data by using iterations between updating cluster centroids using FRCM algorithm and fine-tuning process of the initial model. The CNN model was able to effectively extract salient features from the clustering layer as cluster centroids and features and updated in the forward pass. Comparison with KMeans proved the effectiveness of the method on selective dataset and the robustness of the algorithm with one of the most popular unsupervised learning methods. However, its uncertainty and defect in the operation will be obstacles that need to be address and improved upon. Being self-adaptive will be the objective of this learning method in the future

1. Introduction

ACM's new manuscript submission template aims to provide consistent styles for use across ACM publications, and incorporates accessibility and metadata-extraction functionality necessary for future Digital Library endeavors. Numerous ACM and SIG-specific templates have been examined, and their unique features incorporated into this single new template. If you are new to publishing with ACM, this document is a valuable guide to the process of preparing your work for publication. If you have published with ACM before, this document provides insight and instruction into the current process for preparing` your manuscript.

This submission template allows authors to submit their papers for review to an ACM Conference or Journal without any output design specifications incorporated at this point in the process. The ACM “Submission Template” is a single column MS-Word document that allows authors to type their content into the pre-existing set of paragraph formatting styles applied to the sample placeholder text here, or copy-and-paste their text and then apply the respective paragraph styles (**Windows**: you can open the Styles task pane from the **Home** tab [it can also be opened with the keyboard shortcut Alt+Ctrl+Shift+S]; **MAC16**: you can access the Styles pane at the right of the **Home** toolbar.) Highlight a section that you want to designate with a certain style, and then select the appropriate style from the list. To view which style is being used in any part of this document, place your cursor on your text and look at the “Current style” field in the Styles pane.

It is beneficial to create your document in draft mode with the style panel open in the left-side panel. If the panel is not immediately visible when the Submission Template is opened, you will need to open the panel manually—for Windows: click on the following from the main ribbon above: File > Options > Advanced > Display > Style area pane width in Draft and Outline views. Set the style area width (1–1.5" is a good starting value.); for MAC: go to the “**View**” menu and select “**Draft**”; then go to the “**Word**” menu and select “**Preferences**” and then “**View**,” under the “**Window**” section insert “1.5” inches under the style area width.

All style elements are specified in this template to facilitate the production of your paper and to have the styles consistent throughout. The paragraph styles are built-in and examples of the styles are provided throughout this document. Save as you go and backup your work regularly!

* 1. Accessibility

Following the guidelines throughout this template will also improve the accessibility of your manuscript and increase the audience for your work. Ensure that heading styles are applied as instructed, tables are created using Word’s table feature (rather than an image), figures have a text equivalent, and list styles are applied as instructed.

To increase the accessibility of your manuscript, you should set the title and language metadata. On Word for Windows, open the File tab and click on Info. On Word for Mac, click the File Menu and select Properties, then click the Summary tab. Fill in the title of your document. For anonymous review, clear the ‘author’ field.

To set the document language, click the Review tab in the Ribbon. On Word for Windows: Click the Language button and select “Set Proofing Language.” Verify the language is set correctly. On Word for Mac: Click the Language button and select the document language from the pop-up.

* 1. More about the submission template

Thissubmission version of your paper should not have headers or footers, these will be added when your manuscript is processed after acceptance. It should remain in a one-column format—please do not alter any of the styles or margins.

*If a paper is accepted for publication*, authors will be instructed on the next steps. Authors must then follow the submission instructions found on their respective publication’s web page. Once your submission is received, your paper will be processed to produce the formatted Word, PDF, and HTML5 output formats, which will be provided to you for review, revision/resubmission (if applicable), and approval.

* 1. Inserting CCS concepts

The new template enables you to import required indexing concepts for your article from the [ACM Computing Classification System (CCS)](http://www.acm.org/publications/class-2012) using an [indexing support tool](http://dl.acm.org/ccs/ccs.cfm?) found in the ACM Digital Library (DL). The tool generates formatted text after you have selected your terms. To insert CCS terms into your document, copy and paste the formatted text from the CCS tool using the “<https://dl.acm.org/ccs/ccs.cfm>” link into the “CCS CONCEPTS” section.

An additional step is necessary to ensure that the proper CCS terms are added to the Digital Library citation page: from the “view CCS TeX Code” listing, click on “Show the XML Only.” Highlight and copy the XML code from the window. You must insert the XML code into your Word document’s properties: from your Word document, click on “**File**”, then click on the “**Info**” tab on the left-hand side panel, then click “**Properties**” and select “**Show All Properties.**” Click within the “Comments” metadata field and paste the XML data.

1. Inserting Content Elements

The next subsections provide instructions on how to insert figures, tables, and equations in your document.

* 1. Tables

Tables are “float elements” which should be inserted after their first text reference and have specific styles for identification. Do not use images to present tables, or they will be inaccessible to readers using assistive technologies.

Authors can insert tables by using the MS Word option (INSERT ->Table) and providing the required row and column size. Every table must have a caption (title) above it, which must have the **“TableCaption**” style applied. Please note that tables **should not** be supplied as image files, but if they are images they must have the “Image” style applied. As an example, Table 1 shows all the styles available in this template, to be applied to the respective element of your text.

Table 1: Styles available in the Word template

| Style Tag | Definition | Style Tag | Definition |
| --- | --- | --- | --- |
| Title\_document | main title of article | ListParagraph | list items |
| Subtitle | subtitle of article | Statements | math statements |
| Authors | author name | Extract | block quotations |
| Affiliation | author affiliation information | Algorithm Caption | caption for algorithm |
| AuthNotes | footnote to author(s) | AckHead | heading for acknowledgements |
| Abstract | abstract text | AckPara | acknowledgements text |
| CCSHead | heading for CSS Concepts | GrantSponsor | sponsor of grant |
| CCSDescription | CSS terms | GrantNumber | number for the grant |
| KeyWordHead | heading for keywords | ReferenceHead | heading for references |
| Keywords | keywords text | Bib\_entry | references |
| ORCID | author's ORCHID # | AppendixH1 | appendix heading level 1 |
| Head1 | heading level 1 | AppendixH2 | appendix heading level 2 |
| Head2 | heading level 2 | AppendixH3 | appendix heading level 3 |
| Head3 | heading level 3 | TableCaption | title of table |
| PostHeadPara | first paragraph after a heading | TableHead  TableFootnote | column head of table  footnote to table |
| Para | Subsequent paragraphs of general text | Image | figures |
| ParaContinue  DisplayFormula | flush left text after display items like math equations, lists etc.  numbered math equation | DOI | Digital object identifier |
| DisplayFormulaUnnum | unnumbered equations | Label | labela |
| ComputerCode | Display Computer codes | In-text code | intext computer code |
| Short Title | Short title of article |  |  |

a This is example of table footnote.

Tables can be very difficult for people using screen reader technology to understand unless they include markup that explicitly defines the relationships between all the parts (i.e.: headers and data cells). *A key to making data tables accessible to screen reader users is to clearly identify column and row headers.* In Word, authors should identify which row or rows contain column headers. Below are the steps to do this:

1. Select that table’s row, then right-click the row and select “Table Properties”;
2. In the *Table Properties* window, click the *Row* tab and select the box that says “Repeat as header row at the top of each page.”

Or

Apply the “table head” style by highlighting the respective row and applying the “**TableHead**” style found in the “Body Element” section of the ACM Primary Article Template.

* 1. Figures

Figures are “float elements” which should be inserted after their first text reference, and have specific styles for identification. Insert a figure and apply the “**Image**” paragraph style to it. For the figure caption, apply the style “**FigureCaption.**”

To accommodate readers with color vision differences, figures should still be usable when printed in grayscale. Refer to elements of the figure with non-color terms, for example “indicated as squares” instead of “indicated in blue”. Use different patterns in bar charts, different line patterns in graphs, and different shapes in plots to distinguish groups of elements and reinforce color differences.

* + 1. Half Width Figures.

Figure 1 is an example of a figure and caption spanning the half-page width (one column in a two column format) with the styles applied. If your figure contains third-party material, you must clearly identify it as such, as shown in the example below.



Figure 1: 1907 Franklin Model D roadster. Photograph by Harris & Ewing, Inc. [Public domain], via Wikimedia Commons. (https://goo.gl/VLCRBB)

* + 1. Full Width Figures.

Figure 2 is an example of a figure and caption spanning the full-page width with the styles applied. If your figure contains third-party material, you must clearly identify it as such, as shown in the examples.



Figure 2: Mockup of a bombe machine at Bletchley Part. Photograph by Sarah Hartwell. [Public domain], via Wikimedia Commons. (<https://commons.wikimedia.org/wiki/File:TuringBombeBletchleyPark.jpg>)

* + 1. Multi-part figure.

Authors can also insert a multi-part figure above a single caption. Every inserted figure must have the “Image” style applied. Below are instructions regarding how to insert a multi-part figure in your paper.

* If the author wants to insert two multi-part images, they must draw a one row and one column table and insert the images one-by-one in the cells.
* If the author wants to insert three multi-part images, they must draw a one-row and three-column table and insert the images one by one in all three cells.
* If the author wants to insert four multi-part images, they must draw a two-row and two-column table and insert the images one-by-one in all four cells. (see the following example):

| Figure 2: The layout of multipart images should be as per the above example within the table in image 1. | Figure 2: The layout of multipart images should be as per the above example within the table in image 2. |
| --- | --- |
| Figure 2: The layout of multipart images should be as per the above example within the table in image 3. | Figure 2: The layout of multipart images should be as per the above example within the table in image 4. |

Figure 3: The layout of multipart images should be as per the above example within the table. All images must have the “Image” style applied.

* + 1. Figure Descriptions.

Every figure should have a figure description unless it is purely decorative. These descriptions convey what’s in the image to someone who cannot see it. They are also used by search engine crawlers for indexing images, and when images cannot be loaded.

A figure description must be unformatted plain text less than xxx characters long. Figure descriptions should not repeat the figure caption – their purpose is to capture important information that is not already provided in the caption or the main text of the paper. For figures that convey important and complex new information, a short plain text description may not be adequate. More complex alternative descriptions can be placed in an appendix and referenced in a short figure description. For example, provide a data table capturing the information in a bar chart, or a structured list representing a graph. For additional information regarding how best to write figure descriptions and why doing this is so important, please see [https://www.acm.org/accessibility.](https://www.acm.org/accessibility)

The instructions below describe the required steps authors need to follow in order to insert descriptive text for figures (alt-txt value) in **MS Word 2019 on Windows or Word 2016 and later on Mac**:

1. Insert a picture in the document.
2. Right-click the image and select “Edit Alt Text”.
3. In the “alt text” section, provide your text description of the image.

Below are the steps to insert figure descriptions in **MS Word 2013 and 2016**:

1. Insert a picture in the document.
2. Right click on the inserted picture and select the **Format Picture** option.
3. In the settings at the right side of the window, click on the “Layout & Properties” icon (3rd option).
4. Expand **Alt Txt** option.
5. In the “Title” and “Description” text boxes, type the text you want to represent the figure, and then click “Close.”

Below are steps to insert the alt-txt value in **MS Word 2010/2011 for Windows\***:

1. Insert a picture in the document.
2. Right click on the inserted picture and select the **Format Picture** option.
3. Select the **Alt Txt** option from the left-side panel options.
4. In the “Title” and “Description” text boxes, type the text you want to represent the picture, and then click “Close.”  
   \* The Mac 2011 version 14.0.0 and later allows the option for inserting “alt-text.” In the MAC version of Word 2016, right-click on the image and select “Edit Alt Text” from the pop-up menu and then enter the description for the alt text.
   1. Quotations and Extracts

There are styles for block quotations, which should be used for quotes that are separated from in-line text. Below is an example.

“Microsoft tried to revive the idea of an assistant with Clippy, who began popping up in Microsoft Office in 1997. Its creator, Kevan Atteberry, was actually contracted by Microsoft to design Clippy, which, funnily enough, he did on a Mac … Sure, people could disable Clippy, but the fact he was on by default angered people.” [10]

* 1. Equations

There are two types of math equations: the *numbered display math equation* and the *un-numbered display math equation*. Below are examples of both.

* + 1. DisplayFormula.

The **DisplayFormula** style is applied in the numbered math equation. A numbered display equation always has an equation number (label) on the right.

(1)

* + 1. DisplayFormula.Unnum.

The **DisplayFormulaUnnum** style is applied only in unnumbered equations. An unnumbered display equation never contains an equation number Bertot and Grimes (2012) on the right—this element distinguishes it from the numbered equation.

Please note: the subsequent text after the **DisplayFormula** (numbered equation) or **DisplayFormulaUnnum** (unnumbered equation) must have the paragraph style **ParaContinue** applied.

* 1. Math statements

Math statements should have the “Statement” style applied.

**Theorem/Proof/Lemma.** Math statements should have the “**Statement**” style applied. This paragraph is an example of the “**Statement**” style.

* 1. Algorithms

Algorithms use the styles “AlgorithmCaption” and “Algorithm”.

ALGORITHM 1: Iterative Algorithm

current\_position center

current\_direction up

current\_position is inside circle

while current\_position is inside circle, do

neighborhood all grid hexes within two hexes from current\_position

for each hex in neighborhood, do

for each neuron in hex do

convert neuron\_orientation to vector

scale vector by neuron\_excitation

vector\_sum vector\_sum + vector

end

end

normalize vector\_sum

end

1. COMPUTER CODE

Display Computer codes can be inserted using “ComputerCode” style.

CHAT Start

SAY Welcome to my world

WAIT 1.2

SAY Thanks for Visiting

ASK Do you want to play a game?

OPT Sure

OPT No Thanks

Similary, this is an example of intext code text.

Similary, this is an example of intext code text.

1. Citing Related Work

This section cites a variety of journal [5, 15], conference [1, 6, 8, 12, 13], and magazine [3] articles to illustrate how they appear in the references section. It also cites books [9, 10], a technical report [7], a PhD dissertation [4], an online reference [14], a software artifact [11], and a dataset [2].

As you build your article, you should note where you will be placing citations. If you are using numbered citations and references, the reference number - "...as shown in [5]..." is sufficient. If you are using the "author year" style, a reasonable placeholder is the primary author's last name and the year of publication - "...as shown in [Harel 1978]..." - we will be updating this placeholder later in the process with the citation label as generated by the Word macros in the "primary template.

ACKNOWLEDGMENTS

Acknowledgments are placed before the references. Add information about grants, awards, or other types of funding that you have received to support your research. Author can capture the **grant sponsor information**, by selecting the grant sponsor text and apply style ‘GrantSponsor’. After this, select grant no and apply ‘GrantNumber’ from style panel. Example of Grant sponsor: Competitive Research Programme and example of Grant no: CRP 10-2012-03.

REFERENCES

1. Atul Adya, Paramvir Bahl, Jitendra Padhye, Alec Wolman, and Lidong Zhou. 2004. A multi-radio unification protocol for IEEE 802.11 wireless networks. In Proceedings of the IEEE 1st International Conference on Broadnets Networks (BroadNets’04) . IEEE, Los Alamitos, CA, 210–217. https://doi.org/10.1109/BROADNETS.2004.8
2. Sam Anzaroot and Andrew McCallum. 2013. UMass Citation Field Extraction Dataset. Retrieved May 27, 2019 from <http://www.iesl.cs.umass.edu/data/data-umasscitationfield>
3. Martin A. Fischler and Robert C. Bolles. 1981. Random sample consensus: a paradigm for model fitting with applications to image analysis and automated cartography. Commun. ACM 24, 6 (June 1981), 381–395. https://doi.org/10.1145/358669.358692
4. Chelsea Finn. 2018. Learning to Learn with Gradients. PhD Thesis, EECS Department, University of Berkeley.
5. Jon M. Kleinberg. 1999. Authoritative sources in a hyperlinked environment. J. ACM 46, 5 (September 1999), 604–632. https://doi.org/10.1145/324133.324140
6. Matthew Van Gundy, Davide Balzarotti, and Giovanni Vigna. 2007. Catch me, if you can: Evading network signatures with web-based polymorphic worms. In Proceedings of the first USENIX workshop on Offensive Technologies (WOOT ’07) . USENIX Association, Berkley, CA, Article 7, 9 pages.
7. James W. Demmel, Yozo Hida, William Kahan, Xiaoye S. Li, Soni Mukherjee, and Jason Riedy. 2005. Error Bounds from Extra Precise Iterative Refinement. Technical Report No. UCB/CSD-04-1344. University of California, Berkeley.
8. David Harel. 1979. First-Order Dynamic Logic. Lecture Notes in Computer Science, Vol. 68. Springer-Verlag, New York, NY. <https://doi.org/10.1007/3-540-09237-4>
9. Jason Jerald. 2015. The VR Book: Human-Centered Design for Virtual Reality. Association for Computing Machinery and Morgan & Claypool.
10. Prokop, Emily. 2018. The Story Behind. Mango Publishing Group. Florida, USA.
11. R Core Team. 2019. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/
12. Brian K. Reid. 1980. A high-level approach to computer document formatting. In Proceedings of the 7th Annual Symposium on Principles of Programming Languages. ACM, New York, 24–31. <https://doi.org/10.1145/567446.567449>
13. John R. Smith and Shih-Fu Chang. 1997. VisualSEEk: a fully automated content-based image query system. In Proceedings of the fourth ACM international conference on Multimedia (MULTIMEDIA ’96). Association for Computing Machinery, New York, NY, USA, 87–98. https://doi.org/10.1145/244130.244151
14. TUG 2017. Institutional members of the LaTeX Users Group. Retrieved May 27, 2017 from <http://wwtug.org/instmem.html>
15. Alper Yilmaz, Omar Javed, and Mubarak Shah. 2006. Object tracking: A survey. ACM Comput. Surv. 38, 4 (December 2006), 13–es. https://doi.org/10.1145/1177352.1177355

Patricia S. Abril and Robert Plant. 2007. The patent holder's dilemma: Buy, sell, or troll? Commun. ACM 50, 1 (Jan. 2007), 36-44. DOI: <https://doi.org/10.1145/1188913.1188915>

Sarah Cohen, Werner Nutt, and Yehoshua Sagic. 2007. Deciding equivalences among conjunctive aggregate queries. J. ACM 54, 2, Article 5 (April 2007), 50 pages. DOI: https://doi.org/10.1145/1219092.1219093

David Kosiur. 2001. Understanding Policy-Based Networking (2nd. ed.). Wiley, New York, NY.

Ian Editor (Ed.). 2007. The title of book one (1st. ed.). The name of the series one, Vol. 9. University of Chicago Press, Chicago. DOI:https://doi.org/10.1007/3-540-09237-4

Donald E. Knuth. 1997. The Art of Computer Programming, Vol. 1: Fundamental Algorithms (3rd. ed.). Addison Wesley Longman Publishing Co., Inc.

Sten Andler. 1979. Predicate path expressions. In Proceedings of the 6th. ACM SIGACT-SIGPLAN Symposium on Principles of Programming Languages (POPL '79), January 29 - 31, 1979, San Antonio, Texas. ACM Inc., New York, NY, 226-236. <https://doi.org/10.1145/567752.567774>

Joseph Scientist. 2009. The fountain of youth. (Aug. 2009). Patent No. 12345, Filed July 1st., 2008, Issued Aug. 9th., 2009.

David Harel. 1978. LOGICS of Programs: AXIOMATICS and DESCRIPTIVE POWER. MIT Research Lab Technical Report TR-200. Massachusetts Institute of Technology, Cambridge, MA.

Kenneth L. Clarkson. 1985. Algorithms for Closest-Point Problems (Computational Geometry). Ph.D. Dissertation. Stanford University, Palo Alto, CA. UMI Order Number: AAT 8506171.

David A. Anisi. 2003. Optimal Motion Control of a Ground Vehicle. Master's thesis. Royal Institute of Technology (KTH), Stockholm, Sweden.

Harry Thornburg. 2001. Introduction to Bayesian Statistics. (March 2001). Retrieved March 2, 2005 from http://ccrma.stanford.edu/~jos/bayes/bayes.html

ACM. Association for Computing Machinery: Advancing Computing as a Science & Profession. Retrieved from http://www.acm.org/.

Wikipedia. 2017. WikipediA: the Free Encyclopedia. Retrieved from https://www.wikipedia.org/.

Dave Novak. 2003. Solder man. Video. In ACM SIGGRAPH 2003 Video Review on Animation theater Program: Part I - Vol. 145 (July 27-27, 2003). ACM Press, New York, NY, 4. DOI:https://doi.org/99.9999/woot07-S422

Barack Obama. 2008. A more perfect union. Video. (5 March 2008). Retrieved March 21, 2008 from http://video.google.com/videoplay?docid=6528042696351994555

Martha Constantinou. 2016. New physics searches from nucleon matrix elements in lattice QCD. arXiv:1701.00133. Retrieved from https://arxiv.org/abs/1701.00133

A  APPENDICES

In the appendix section, three levels of Appendix headings are available.

A.1 General Guidelines (AppendixH2)

1. Save as you go and backup your file regularly.
2. Do not work on files that are saved in a cloud directory. To avoid problems such as MS Word crashing, please only work on files that are saved locally on your machine.
3. Equations should be created with the built-in Microsoft® Equation Editor included with your version of Word. (Please check the compatibility at <http://tinyurl.com/lzny753> for using MathType.)
4. Please save all files in DOCX format, as the DOC format is only supported for the Mac 2011 version.
5. Tables should be created with Word’s “Insert Table” tool and placed within your document. (Tables created with spaces or tabs will have problems being properly typeset. To ensure your table is published correctly, Word’s table tool must be used.)
6. Do not copy-and-paste elements into the submission document from Excel such as charts and tables.
7. Footnotes should be inserted using Word’s “Insert Footnote” feature.
8. Do not use Word’s “Insert Shape” function to create diagrams, etc.
9. Do not have references appear in a table/cells format as it will produce an error during the layout generation process.
10. MS Word does not consistently allow the original formatting to be modified in the text. In these cases, it is best to copy all the document’s text from the specific file and paste into a new MS Word document and then save it.
11. At times there are font problems such as “odd” stuff/junk characters that appear in the text, usually in the references. This can be caused by a variety of reasons such as copying-and-pasting from another file, file transfers, etc. Please review your text prior to submission to make sure it reads correctly.

A.1.1 Preparing Graphics (AppendixH3)

1. Accepted image file formats: TIFF (.tif), JPEG (.jpg).
2. Scalable vector formats (i.e., SVG, EPS and PS) are greatly preferred.
3. Application files (e.g., Corel Draw, MS Word, MS Excel, PPT, etc.) are NOT recommended.
4. Images created in Microsoft Word using text-box, shapes, clip-art are NOT recommended.
5. IMPORTANT: All fonts must be embedded in your figure files.
6. Set the correct orientation for each graphics file.

A.2 Placeholder Text

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