Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

CLASSIFICATION OF WWII TANKS AND VEHICLES IMAGES FROM CONVOLUTIONAL NEURAL NETWORKS

CLASSIFICAÇÃO DE IMAGENS DE TANQUES E VEÍCULOS DA SEGUNDA GUERRA DAS REDES NEURAIS CONVOLUCIONAIS

CLASIFICACIÓN DE IMÁGENES DE TANQUES Y VEHÍCULOS DE LA SEGUNDA GUERRA MUNDIAL A PARTIR DE REDES NEURONALES CONVOLUCIONALES

Leonardo Lago[1]
Centro Universitário UNDB, São Luís, Maranhão

Rodrigo Lima[2]
Centro Universitário UNDB, São Luís, Maranhão

Allan Cruz[3]
Programa de Pós-Graduação Doutorado em Ciência da Computação - Associação UFMA/UFPI, São Luís, Maranhão

Pamela Cruz[4]
Faculdade de Letras da Universidade de Coimbra, Coimbra, Portugal

ABSTRACT

This paper describes an analysis of the application and development of a Convolutional Neural Network (CNN) applied in the binary classification of World War II vehicle images, allowing the evaluation of the applied concepts, project feasibility and results obtained. Using a grayscale image base, with about 122 training images for the CNN and 15 images for validation, it was possible to

[1] Especialista em Ciências de Dados. Centro Universitário UNDB. leonardohslago@gmail.com.
[2] Mestre em Ciência da Computação. Centro Universitário UNDB. rodrigomonteiro89@hotmail.com.
[3] Doutorando em Ciência da Computação. UFMA/DCCMAPI. allankassio@gmail.com.
[4] Doutoranda em Ciência da Informação. Universidade de Coimbra. pam.tmaia@gmail.com.

REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

identify an average hit rate of 86.666% among the tests performed, demonstrating that it is It is possible to use a CNN to classify images of WWII vehicles automatically with an acceptable degree of accuracy.

Keywords: Neural networks; Classification; vehicles; Second World War.

RESUMO

Este artigo descreve uma análise da aplicação e desenvolvimento de uma Rede Neural Convolucional (CNN) aplicada na classificação binária de imagens de veículos da Segunda Guerra Mundial, permitindo a avaliação dos conceitos aplicados, viabilidade do projeto e resultados obtidos. Utilizando uma base de imagens em tons de cinza, com cerca de 122 imagens de treino para a CNN e 15 imagens para validação, foi possível identificar uma taxa de acerto média de 86,666% dentre os testes realizados, demonstrando que é possível utilizar uma CNN para classificar imagens de veículos Segunda Guerra de forma automática com um grau aceitável de acerto.

Palavras-chave: Redes Neurais; Classificação; Veículos; Segunda Guerra Mundial.

RESUMEN

Este artículo describe un análisis de la aplicación y desarrollo de una Red Neuronal Convolucional (CNN) aplicada en la clasificación binaria de imágenes de vehículos de la Segunda Guerra Mundial, que permite evaluar los conceptos aplicados, la factibilidad del proyecto y los resultados obtenidos. Utilizando una base de imágenes en escala de grises, con cerca de 122 imágenes de entrenamiento para la CNN y 15 imágenes de validación, se logró identificar una tasa de acierto promedio de 86.666% entre las pruebas realizadas, demostrando que es posible utilizar una CNN para clasificar imágenes de vehículos de la Segunda Guerra Mundial automáticamente con un grado aceptable de precisión.

Palabras clave: Redes neuronales; Clasificación; vehículos; Segunda Guerra Mundial.

REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

1 INTRODUCTION

Automate everyday tasks with the use of Artificial Intelligence it is more common each day. Through robust models and tests, companies use Neural Networks and Machine Learning concepts to predict results with their products, find customer profiles, automatically choose the best options and other actions. This full set is amplified when taken to the Data Science sector, an area where professionals must work with a huge contingency of information and scientific models, to add value to the company and area of study, through works that are often complex and high impact.

Artificial Intelligence has a skillful use when it comes to image processing, an area where there is a large distribution of data and unstructured information, making it difficult for both the machine and the working professionals, and therefore, Artificial Intelligence is widely used. in image identification, content categorization, object tracking, transformation and internal filtering. An example of this is a work conducted by Braga (2018), where a set of data and research in the health area was analyzed, finding diagnoses and prognoses that could be improved with the use of Machine Learning techniques. Emerson (2018) conducted a work presenting the comparative ability of the ability to find and classify images from different convolutional neural networks, whose basic concept will be presented in the future in this work.

An area that always needs the treatment of images is the area of World History, where historians receive and analyze images daily to find their historical concept, impacts on society and present conditions. Through the work of historians, it is possible to show the main moments that made humanity what it is today, and to learn from past mistakes and successes. Many historians must analyze vast amounts of images and content daily, and often, these images are not of decent quality or have obstacles that make their interpretation difficult, delaying the professional's work.

Based on the previous paragraphs, a point of interest was identified in joining the concepts of Artificial Intelligence with image processing in historical concepts, carrying out a work that allows the identification of objects in black and white images (shades of gray), allowing the classification and categorization of

REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

these objects quickly and automatically, thus being able to assist in the work of historians and, in the future, to apply them optimally in the modern environment of the same context, allowing automatic analysis of images from the contemporary era in which the work has similarity.

2 THEORETICAL REFERENCE

In this chapter, the main concepts and theories involved throughout the work are presented, to welcome the reader in knowledge about the techniques present in Artificial Intelligence and Data Science. The theoretical framework was obtained through research in articles, documents, and reliable information present on the internet, presenting from primordial concepts of Artificial Intelligence, such as similar works, which can support the proposed hypothesis.

2.1 Concepts of Artificial Intelligence

Artificial Intelligence is a large area of modern computing, having its concept created after the Second World War, by scholars such as John McCarthy (1956), Herbert A. and Allen Newell. Its first concept was created from the Turing Test, created by Allan Turing with the premise of developing a machine that can replicate behavior like human behavior. Despite this, the most widespread concept of Artificial Intelligence is the one created by Minsky (1968), where he presents his vision of an Artificial Intelligence being a machine capable of taking actions that would be fully dependent on human intellect.

Over time, Artificial Intelligence (AI) has improved, receiving more concepts and works, deepening knowledge such as Machine Learning and Neural Networks. For Gardner (1995), for example, Artificial Intelligence presents a vision where problem solving and product development can be done automatically, knowing the inserted environment, and capturing knowledge through sensors. Machine Learning, also known as Machine Learning, is a scientific method addressed in AI where, through data sets, whether structured or unstructured, they allow AI to find patterns in an automated way and, through these patterns, elaborate decision-making that has the highest probability of success in achieving its specific aim. Meanwhile, Neural Networks are a concept that improves Machine Learning, because, through a set of interconnected

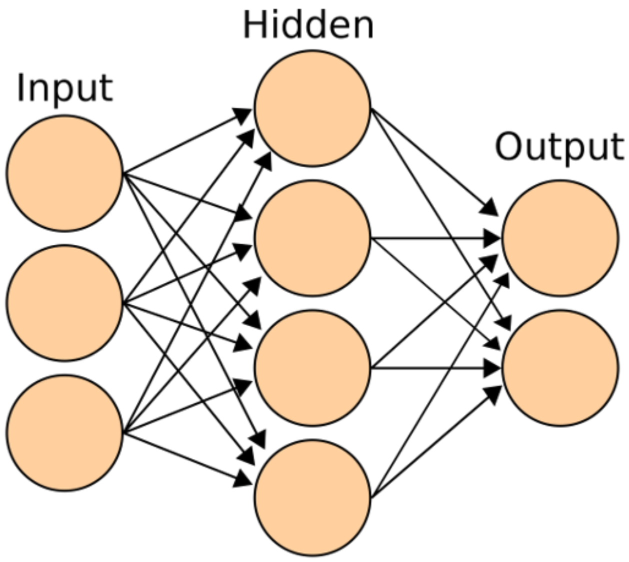
REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

networks, to mimic human neurons, they enable an exchange of information and more in-depth machine learning, thus having a higher success rate and pattern identification. The first Neural Network was created by Pitts and McCulloch (1943), where they created a simple Neural Network with electronic circuits, to present in an article how human neurons work, however, it was by Fukushima (1975) that the first multilayer Neural Network was created, already with applied AI concepts. These concepts can be further deepened and improved, such as the use of Deep Learning, however, in this work, the main feature is the development of a Convolutional Neural Network.

2.2 Neural Network and Convolutional Neural Network

As explained earlier, a Neural Network is a set of sensors, usually called "Perceptrons" or Neurons, that receive inputs from a system, and, through the analysis of these inputs, perform tests with different attributes, separating those that have obtained inputs (Li et. al., 2021). higher hit rate, and so they do more tests with values close to the success attributes, thus increasingly perfecting the results, according to the size of the Neural Network, and thus "learning" how the system works and confirming this model. The first concept was created by Rosenblatt (1958), presenting a network of multiple discriminating neurons, giving its name of "Perceptron". Figure 1 presents the logical example of the functioning of a Neural Network of few layers:

Figure 1 – Example of Neural Network Operation



REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

Source: Prepared by the author based on the research carried out.

This type of Neural Network is quite common, mainly in its use for Machine Learning with structured data, however, for unstructured data, such as images, for example, it is interesting to use a Convolutional Neural Network. Convolutional Neural Networks are Neural Networks that use the principle of Convolution, created by French Yann LeCun (1998). This principle is nothing more than, through an input matrix, it is possible to use a secondary matrix to multiply the values of the primary matrix, thus resulting in a new matrix at the end (Ajit, Acharya & Samanta, 2020). This secondary matrix can be called a “filter”, as it is a set of specific data that has the purpose of transforming an image, for example, into a new image, with more specified details, facilitating the identification of image characteristics and patterns. Ketkar & Moolayil (2021) assert that these resulting images, as previously told, allow greater clarity in showing unique features of the image, and, therefore, allow the machine to "learn" these features repeatedly, as the Convolution process occurs many times, depending on the quality and need of the Convolutional Neural Network.

In research conducted by Ziajia Z. (2018) and Cao Z. (2017), different projects are conducted based on the same premises: Categorization and Classification of images using CNN. In the first work, image recognition was performed using small samples and CNN, while in the second, more solid and larger-based images were recognized using deep learning concepts, thus presenting the potential of a Convolutional Neural Network.

2.3 Classification Process

Tripathi, M. (2021) claims of the classification process is where, through the inputs of these matrices and the results of the convolutions, the characteristics are learned in depth, and, through a numerical result, it presents the probability of an object present in the image being one or the other.

An easy example is to think of the image of a fruit. Through the application of a CNN, it is possible to identify as characteristics that the color of the fruit is yellow and it has an almost cylindrical shape, and, if there are only two options for classifying (binary classification), such as Banana and Apple. The

REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

analyzed fruit has a higher probability of being Banana than Apple, and thus the classification takes place (Rodriguez, Pastor & Ugarte, 2021).

Classification can be different, according to the number of possible objects to be identified and the network architecture, but in the binary classification process, as will be applied in this work, the options are reduced to object 0 and object 1. If the CNN classification result gives a value of 0.68, this value is closer to 1 than to 0, so the image is classified as object 1 (Naranjo-Torres et. al., 2020). These output values depend on the weight of each characteristic employed in the system.

3 CLASSIFICATION OF IMAGES WITH CNN

In the project presented, the need was to create a Convolutional Neural Network that could classify images in shades of gray from the Second World War, being able to classify images of vehicles and find which objects would be in the images in question. For the success of this project, a 4-step plan was set up, namely: Definition of the Image Base, Definition of Categories, Application and Tests of Convolutional Neural Network and finally, Presentation and Discussion of Results.

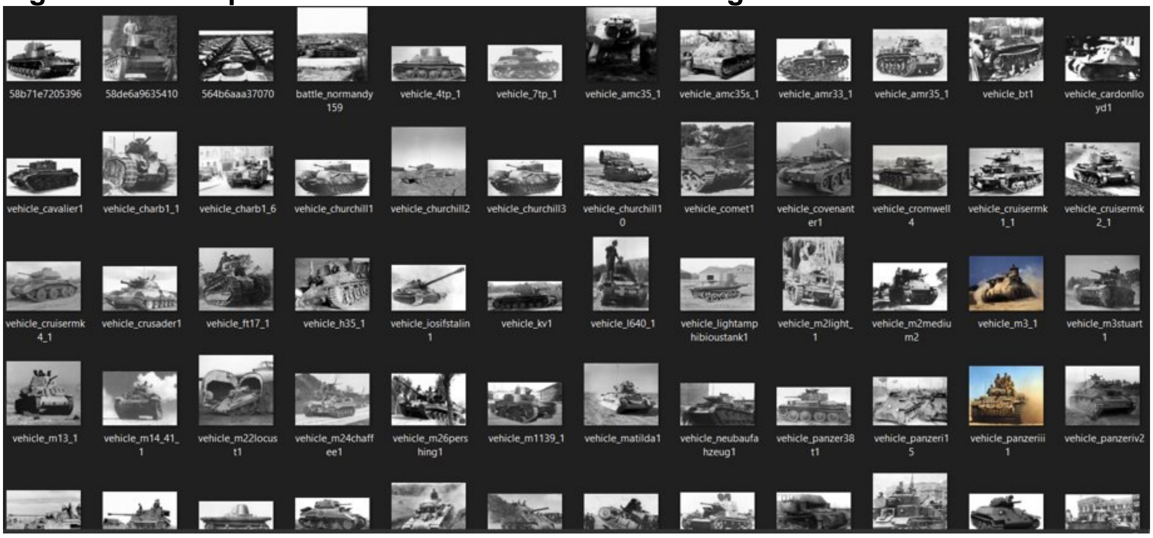
3.2 Definition of the Base of Images and Categories

Through research on quality images of the Second World War, an open database was found, available online and free of charge on the “World War II Database” website. With an in-depth analysis, several images of World War II vehicles did collect, enabling a Classification process to abstract the characteristics of the vehicles from these images. With all the images collected and stored, 180 different images were totaled, with assorted sizes, quality, types and colors.

In manual analysis of this image bank, it was possible to find that most vehicles were divided between War Tanks and Common Military Vehicles, so it was defined that the Convolutional Neural Network Classification would be binary, dividing these images between these two categories. Figure 2 shows the example of the image bank used in the project, without being properly standardized:

REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

Figure 2 – Example of the de-standardized Tank Image Database



Source: Prepared by the author based on the research carried out.

It was necessary to apply a treatment in the processing of the images, enabling a Standardization and Normalization of the base content. In addition, it was necessary to adjust specific conditions of the images available in the database, such as variable size of these images and coloring. These treatments were possible using Python language codes and the OpenCV library for image manipulation.

After the end of the treatment, all images, which had variable sizes and color patterns, were defined as 300x300 size, and their color was set to standardized grayscales.

As the image bank was not excessively large, initially having 180 images, it was possible to perform a manual analysis of each image, thus naming its qualities and deficiencies. Thus, some images were removed from the work base, as they were categorized as problematic for the learning and classification process, such as images with great difficulty in interpretation, decentralized images and images with multiple contrasting objects. In Figure 3, there is an example of the image bank properly standardized and treated to be used in the Convolutional Neural Network:

Figure 3 – Example of the standardized Tank Image Database

REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

Source: Prepared by the author based on the research carried out.

Continuing the work, two image banks derived from the original image bank were divided, one of only War Tanks, and the other of Common Military Vehicles. Most of the images were separated for training the Convolutional Neural Network, while the others were separated for validation of the result. Therefore, the final distribution of the bank was as follows:

- Images of Training Tanks: 79.
- Images of Vehicles for training: 43.
- Images of Tanks for validation: 9.
- Vehicle Images for validation: 6.

Therefore, from the original value of 180 untreated images, 137 treated images remained, 122 for training and 15 for validation. Most of these images were of Common Military Vehicles, which did not have enough characteristics for learning, or had contrasting characteristics with War Tanks, or had problems such as those presented above.

3.3 Architecture and Development of the Convolutional Neural Network

Using the image base presented above, the concepts were applied to create a Convolutional Neural Network for the purpose of Classification of World War II images, having as binary values the number 0, showing the classification of a Vehicle, and the value 1, showing the classification of a Tank.

During the creation, Jupyter Notebook, as a control environment, Python, as the programming language of the Network, and the Tensorflow and

REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

Keras libraries, were used as development materials, to generate the Convolutional Neural Network in an optimized way.

The data is entered in batches of 16, until the 122 training images are finished. The classification occurs in a binary way, as shown above. An RGB color model was used during the classification, even having only grayscale images, as the result of using RGB was higher in success rate and learning than the grayscale mode. For each test performed, the “Shuffle” function was used to mix the images each time the Network was evaluated, ensuring a degree of non-linearity and more diverse tests. In Figure 4, the architecture of the Convolutional Neural Network used in the work is presented.

Figure 4 – Convolutional Neural Network Architecture

```
Found 122 images belonging to 2 classes.
Model: "sequential_6"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_30 (Conv2D)          (None, 298, 298, 16)      448

 max_pooling2d_30 (MaxPoolin  (None, 149, 149, 16)     0
 g2D)

 conv2d_31 (Conv2D)          (None, 147, 147, 32)      4640

 max_pooling2d_31 (MaxPoolin  (None, 73, 73, 32)       0
 g2D)

 conv2d_32 (Conv2D)          (None, 71, 71, 64)        18496

 max_pooling2d_32 (MaxPoolin  (None, 35, 35, 64)       0
 g2D)

 conv2d_33 (Conv2D)          (None, 33, 33, 64)        36928

 max_pooling2d_33 (MaxPoolin  (None, 16, 16, 64)       0
 g2D)

 conv2d_34 (Conv2D)          (None, 14, 14, 64)        36928

 max_pooling2d_34 (MaxPoolin  (None, 7, 7, 64)         0
 g2D)

 flatten_6 (Flatten)         (None, 3136)              0

 dense_12 (Dense)            (None, 512)               1606144

 dense_13 (Dense)            (None, 1)                 513

=================================================================
Total params: 1,704,097
Trainable params: 1,704,097
```

Source: Prepared by the author based on the research carried out.

For the CNN architecture, several tests were conducted, and the one that presented the highest rate of learning and success was using 5 convolutional layers, 5 of Pooling and 5 of ReLU, classifying through 15 epochs (number of times a value passes by CNN), with a learning rate equivalent to 0.001.

4 CONCLUSION

Through the development of CNN, it was possible to find an average hit rate during all tests of approximately 86.66%, being, during the main test, 13 hits out of 15 attempts. The main errors occurred in the identification of Tanks, which were wrongly classified as Vehicles, while the vehicle’s hit rate was close to 100%. Figure 5 shows the results obtained in the work during the validation.

Figure 5 – Validation of tests performed

REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897

Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

```
./test\tank1.jpg
[0.]
./test\tank1.jpg is a tank
./test\tank2.jpg
[3.0514336e-31]
./test\tank2.jpg is a tank
./test\tank3.jpg
[0.]
./test\tank3.jpg is a tank
./test\tank4.jpg
[0.]
./test\tank4.jpg is a tank
./test\tank5.jpg
[0.]
./test\tank5.jpg is a tank
./test\tank6.jpg
[0.]
./test\tank6.jpg is a tank
./test\tank7.jpg
[1.]
./test\tank7.jpg is a vehicle
./test\tank8.jpg
[1.]
./test\tank8.jpg is a vehicle
./test\tank9.jpg
[0.]
./test\tank9.jpg is a tank
./test\vehicle1.jpg
[1.]
./test\vehicle1.jpg is a vehicle
./test\vehicle2.jpg
[1.]
./test\vehicle2.jpg is a vehicle
./test\vehicle3.jpg
[1.]
./test\vehicle3.jpg is a vehicle
./test\vehicle4.jpg
[1.]
./test\vehicle4.jpg is a vehicle
./test\vehicle5.jpg
[1.]
./test\vehicle5.jpg is a vehicle
./test\vehicle6.jpg
[1.]
./test\vehicle6.jpg is a vehicle
```

Source: Prepared by the author based on the research carried out.

With this, it is possible to say that it was possible to classify images in shades of gray from the Second World War with a good success rate, however, for future works, it would be interesting to optimize the functioning of the Network, as well as working with a higher amount of images and diversity, leveraging the binary classification for a large-scale classification of objects and general vehicles of the Second World War, such as boats and planes, for example.

As future work, in addition to the optimization of the Network and more in-depth and continuous tests, it would be interesting to apply the same logic in the classification of modern military vehicles, as this could be used in the future as a military identification and tracking technique, helping the government and private organizations.

REFERENCES

Ajit, A., Acharya, K., & Samanta, A. (2020). “A review of convolutional neural networks”. In 2020 international conference on emerging trends in information technology and engineering (ic-ETITE) (pp. 1-5). IEEE.

Braga, V., Lins, F., Soares, S., Et al. (2018) “Inteligência Artificial na Medicina”, 15ª Amostra de Saúde, XI Evento Científico, CIPEEX.

Emerson, R. V., (2018) “Um Estudo Comparativo Entre Redes Neurais Convolucionais Para Classificação de Imagens”, Universidade Federal do Ceará, Campus Quixadá.

GARDNER, H. (1995) “Inteligências Múltiplas: a teoria na prática”. Porto Alegre: Artes Médicas.

REVISTA DE ESTUDOS MULTIDISCIPLINARES ISSN 2238-7897
Revista de Estudos Multidisciplinares, São Luís, v. 3, n. 1 (Número Especial XV Encontro Científico da UNDB), jan./mar. 2023. ISSN 2238-7897.

Jiajia, Z., Kun, S., Xing, L. (2018) “Small sample image recognition using improved Convolutional Neural Network”, Journal of Visual Communication and Image Representation, Volume 55, 2018, Pages 640-647, ISSN 1047-3203.

Ketkar, N., & Moolayil, J. (2021). “Convolutional neural networks”. In Deep Learning with Python" (pp. 197-242). Apress, Berkeley, CA.

L. Ye, Z. Cao and Y. Xiao (2017) "DeepCloud: Ground-Based Cloud Image Categorization Using Deep Convolutional Features," in IEEE Transactions on Geoscience and Remote Sensing, vol. 55, no. 10, pp. 5729-5740, Oct. 2017, doi: 10.1109/TGRS.2017.2712809.

Lecun, Y.; Bottou, L.; Bengio, Y.; Haffner, P. (1998) “Gradient-based learning applied to document recognition”. Proc. of the IEEE.

Li, Z., Liu, F., Yang, W., Peng, S., & Zhou, J. (2021). A survey of convolutional neural networks: analysis, applications, and prospects. IEEE transactions on neural networks and learning systems.

Mcculloch, Warren S.; Pitts, Walter. (1943) “A logical calculus of the ideas immanent in nervous activity”. Bulletin of Mathematical Biophysics, Vol. 5, p. 115-133.

Minsky, M. (1985) “The Society of Mind”. New York, USA: Touchstone.

Naranjo-Torres, J., Mora, M., Hernández-García, R., Barrientos, R. J., Fredes, C., & Valenzuela, A. (2020). “A review of convolutional neural network applied to fruit image processing”. Applied Sciences, 10(10), 3443.

Rodrigues, Diego (2018) “Deep Learning e Redes Neurais Convolucionais: reconhecimento automático de caracteres em placas de licenciamento automotivo”., Centro de Informática, João Pessoa, Universidade Federal da Paraíba.

Rodriguez, M., Pastor, F., & Ugarte, W. (2021). “Classification of fruit ripeness grades using a convolutional neural network and data augmentation”. In 2021 28th Conference of Open Innovations Association (FRUCT) (pp. 374-380). IEEE.

Rosenblatt, F. (1958) “The Perceptron: A Probabilistic Model for Information Storage and Organization in The Brain”. Psychological Review, Vol. 65, Nº 6, p. 386-408.

Tripathi, M. (2021). “Analysis of convolutional neural network-based image classification techniques”. Journal of Innovative Image Processing (JIIP), 3(02), 100-117.