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Research Article

Analysis of SEM Images with Artificial Intelligence Methods

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Abstract

Today, the quality of Nanotechnology and Nanoscience working with Artificial Intelligence is increasing day by day. Gains the importance of materials science effectively. Examination of SEM Images with Artificial Intelligence Methods represents a multidisciplinary field. In forming the data used in the experimental part, 22,000 SEM data are publicly available. It is known that CNR-IOM's TASC laboratory in Trieste was obtained as a result of 5 years of work of 100 scientists with the ZEISS SUPRA 40 resolution device. After examining the resolution, image size and quality one by one for the selection of the data in the prototype created for the experimental study, the feature that is considered is the image quality. In the creation of this data, after 100 image data are manually selected and arranged in nano and micro dimensions; A total of 1000 image data were created in 10 data sets. Then, artificial intelligence training was carried out using the CNN classification technique in the experimental study using the unsupervised learning method through machine learning. The approach used here enables the application of new methods and tools by adjusting to develop suitable parameters to solve specific properties of nanomaterials that can be applied to a wide variety of nanoscience use cases. Using it to create a materials science library may pave the way for future studies in the field of artificial intelligence and nanotechnology.

Keywords: Nanotechnology, Nanoscience, Artificial Intelligence, SEM, Materials Science.

SEM Görüntülerinin Yapay Zekâ Yöntemleriyle Analizi

Öz

Günümüzde, nanoteknoloji ve nanobilimin, yapay zekâ ile çalışma niteliğinin günden güne artması; malzeme biliminin önem kazanmasında etkili olmaktadır. SEM Görüntülerinin yapay zekâ metotları ile incelenmesi, multidisipliner bir alanı ifade etmektedir.Deneysel kısımda kullanılan verilerin oluşumu; halka açık erişim olarak sunulan 22.000 SEM verisinin; Trieste'deki CNR-IOM'un TASC laboratuvarında bulunan ZEISS SUPRA 40 çözünürlüklü cihaz ile 5 yıl boyunca 100 bilim insanının çalışmaları sonucunda elde edildiği bilinmekle birlikte; deneysel çalışma için oluşturulan prototipte yer alan verilerin seçimi için; tek tek çözünürlüğü, görüntü boyutu ve kalitesine göre incelenmesinin ardından, dikkate alınan özellik, görüntü kalitesi olmakla birlikte; bu verilerin oluşumunda 100 görüntü verisi elle manuel olarak nano boyutta ve mikro boyutta seçilip, düzenlendikten sonra; toplamda 1000 görüntü verisi 10 veri seti içerisinde oluşturuldu.Deneysel çalışmada CNN sınıflandırma tekniği ile yapay zekâ eğitimi gerçekleştirildi.Burada kullanılan yaklaşım, çok çeşitli nanobilim kullanım durumlarına uygulanabilen, nanomalzemelerin belirli özelliklerini çözmek için uygun parametreler geliştirilecek şekilde ayarlanarak yeni yöntem ve araçların uygulanmasına giden yolu makine öğrenmesinin ürüne dönüşüm boyutunda; malzeme bilimi kütüphanesi oluşturmak adına kullanımının, yapay zekâ ve nanoteknoloji alanındaki gelecek çalışmaların önünün açabilmesine katkısı olabilir.

Anahtar Kelimeler: Nanoteknoloji, Nanobilim, Yapay Zekâ, SEM, Malzeme Bilimi.

1. Introduction

Today, Nanotechnology and Nanoscience are gaining importance; working with artificial intelligence increases the awareness of the nature of these concepts day by day. Simultaneous use can pave the way for rapid developments in engineering and production, especially in the field of materials science [1], [3], [10-12].

2. Material and Method

While classifying in CNN, is one of the deep learning techniques; It is as important as possible to perform artificial intelligence training by making different function entries according to the data set. Here, the method used in the coding phase of the training with SEM images is the unsupervised learning technique of machine learning and the CNN classification technique [1], [8].

2.1. The Place and Importance of 10 Experimentally Used Datasets in Nanotechnology

Nanomaterials are important as a part of the produced system and it is known within the scope of scientific studies that materials show different properties in macro, micro, and nano dimensions. The figure shows the visuals of the SEM images used in the data sets [1], [2], [6,7].

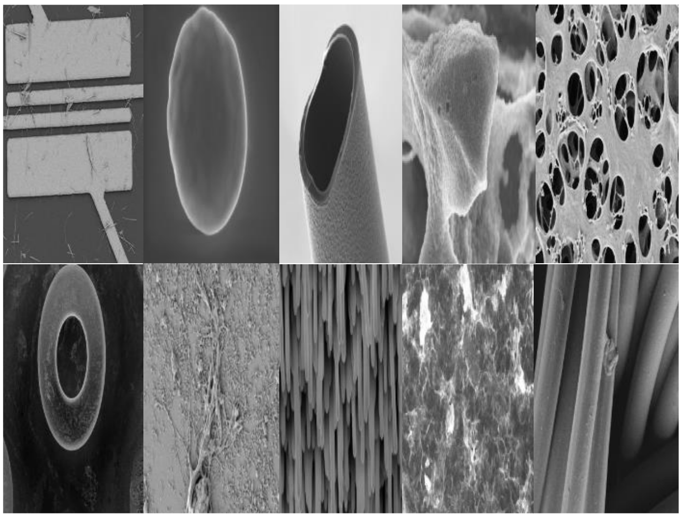

Figure 1. Fibres,Nanowires, Patterned_surface, Films_Coated_Surface, Biological,Porous_Sponge,Powder,Tips,Particles,MEMS_devices_and_electrodes

2.1.1. Convolutional Neural Network Architectures (CNN)

CNN is a subcategory of deep neural networks most commonly applied for image classification and recognition. Three types of layers are generally used to create the CNN architecture between the input and output. These layers are; the convolutional layer, the pooling layer, and the fully connected layers[3-5], [8-11].

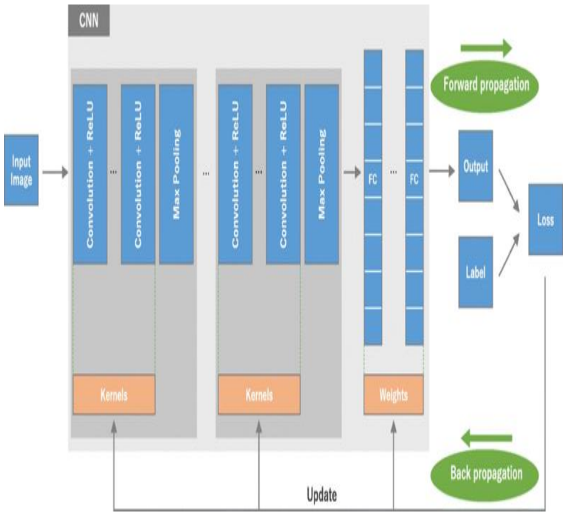

Figure 2. Image of CNN network

To elaborate, three primary operations are performed for the direct input/data line:

1. Preprocessing of the data in the dataset,

2. Mixing the dataset,

3. Aggregate sets within the dataset

In the experimental study, the coding phase was carried out by applying the unsupervised learning technique of machine learning and the CNN methodology used to classify images in the deep learning subcategory [5],[8].

The method used during the experiment; With "RELU-softmax" activation function, RMSprop and Adam = 0.000001 as parameters in two different speed cycles, epoch parameters are set as "25" and "100", the data can be trained by classification method in CNN with unsupervised learning technique. Carried out; The value results obtained from the graphical data obtained in matplotlib are evaluated comparatively in a comparative way.

3. Results and Discussion

When the graphical values of the findings are tabulated and all "Model accuracy rates" are examined, it can be concluded that the best value of the classification value resulted in model training with CNN, since the epoch value was 100 in the RMSprop used. It was carried out with the RELU-softmax activation function. Of course, the values here vary according to the data trained in the model data set, the number of data, the number of trainings, and the parameters.

3.1. Model training with RMSprop on CNN

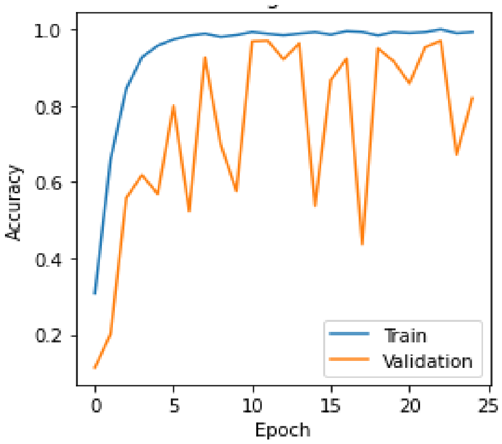

Figure 3. Graphic value of model accuracy rate with Matplotlib inCNN classification training realized by setting Epoch value to 25 with RMSprop function in experimental evaluation

If we want to interpret the graph, the value approaching 1 in the model training indicates that successful training has taken place with AI.

3.2. Model training with Adam on CNN

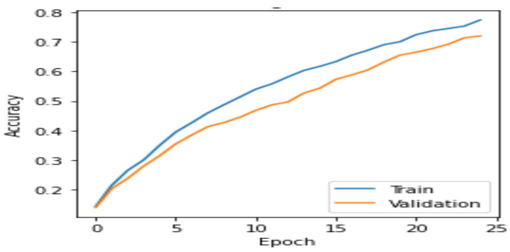

Figure 5. Graphic value of model accuracy rate with Matplotlib in CNN classification training realized by setting Epoch value to 25 with Adam=0.000001 function in experimental evaluation

If we want to interpret the graph, the value of 0.72 shows an important dimension on the basis of comparing the results in future studies by increasing the number of data here as a correlation; AI shows poor training performance compared to RMSprop.

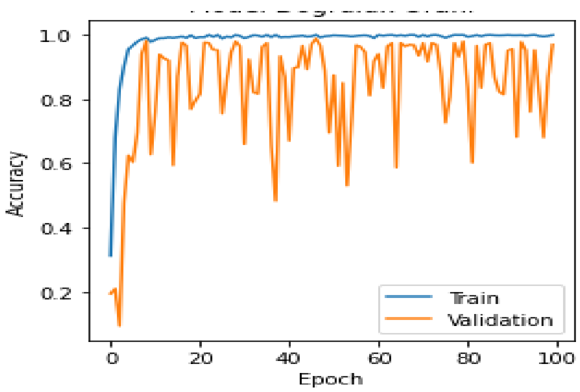

Figure 4. Graphic value of model accuracy rate with Matplotlib in CNN classification training realized by setting Epoch value to 100 with RMSprop function in experimental evaluation

If we need to interpret the graph, the model training is more successful than the first training and the value approaching 1 can be explained as successful training with artificial intelligence.

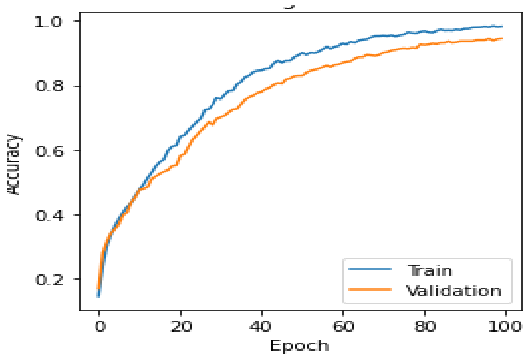

Figure 6. Graphic value of model accuracy rate with Matplotlib in CNN classification training realized by setting Epoch value to 100 with Adam=0.000001 function in experimental evaluation

In addition to the fact that the value formed in the graph is lower than the RMSprop, it can be said that it is more successful because it gives a result close to 1 than the training result value made by entering Adam=0.000001 and 25 epochs.

4. Conclusions and Recommendations

Table-1 Experiment Results

Epoch	RMSprop	Adam = 0.000001
25	0.97	0.72
100	0.98	0.94

When all the "model accuracy rates" in the result table are examined, it can be concluded that the classification value result in model training with CNN has the best value when using the RELU-Softmax activation function with an epoch value of 100 with RMSprop. While performing image training in CNN, one of the deep learning sub-branches of the study; It is as important as possible in terms of evaluating the results of graphs and graph values formed by using different parameters according to activation functions and data sets. Classifying the result values according to the level of compliance with the data results and the training parameters, tabulating the model accuracy rates; Comparing the best result value are extremely important in terms of SEM image training and increasing the number of images to obtain the best result may pave the way for better studies in terms of analysis.

References

[1]Akhtar, K., Khan, S.A., Khan, S.B., Asiri, A.M. (2018). Scanning Electron Microscopy: Principle and Applications in Nanomaterials Characterization In: *Sharma, S. (eds) Handbook of Materials Characterization. Springer, Cham*.

[2]Topcu, İ. (2018). Investigation of Mechanical Behavior of Carbon Nanotube Reinforced Aluminum Matrix AlMg/CNT Composites. *Çanakkale Onsekiz Mart University Journal of ScienceInstitute*,4(1),99-109.

[3]Acı, M., Avcı M. (2016). ‘’Artificial neural network approach for atomic coordinate prediction of carbon nanotubes’’, *Appl. Phys.*, 122, 631.

[4]Raitoharju, J., (2022).‘’Chapter 3 - Convolutional neural networks’’, *Editor(s): Al. Iosifidis, A. Tefas, Deep Learning for Robot Perception and Cognition,Academic Press,* 35-69, ISBN 9780323857871.

[5]Sowmya, B. P., Supriya,M. C. (2021). ‘’Convolutional Neural Network (CNN) Fundamental Operational Survey’’, *Learning and Analytics in Intelligent Systems, 21, Springer, Cham.*

[6]Topcu, İ., Muhammet, C., Yılmaz, E.B. “Experimental investigation on mechanical properties of Multi Wall Carbon Nanotubes (MWCNT) reinforced aluminium metal matrix composites’’, *Journal of Ceramic Processing Research,* 21 (5), 596-601.

[7]Rauniyar,A., Hagos,D., Bağcı,U.(2022). ‘’Federated Learning for Medical Applications: A Taxonomy, Current Trends, Challenges, and Future Research Directions’’.

[8]Yamashita, R., Nishio, M., Do, R.K.G. *et al*,.(2018). ‘’Convolutional neural networks: an overview and application in radiology. *Insights Imaging* 9’’, 611–629.

[9]Virtanen, P., Gommers, Oliphant, R., T. E., et al.(2020). ‘’SciPy 1.0: fundamental algorithms for scientific computing in Python. Nat Methods’’ ,17,261–272.

[10]LeCun,Y.,Bengio,Y.,Hinton,G.E.(2015)‘’Deeplearning’’, *Nat ure* ,521,436–444.

[11]Turing,A. M.(2009). ‘’Computing Machinery and Intelligence’’, *In: Epstein R., Roberts G., Beber G. (eds) Parsing the Turing Test. Springer,* Dordrecht.

[12]Booth,T. J.,Baker, M.A.B.(2017). ‘’Chapter 32 - Nanotechnology: Building and Observing at the Nanometer Scale’’, *Pharmacognosy,Academic Press*,633-643.