|  |  |
| --- | --- |
| **Midterm Quiz** | |
| Name: John Lloyd Renzo R. Castillo | Date: October 15, 2023 |
| Section: CPE41S3 | Instructor: Engr. Cris Garcia Hate |

1. **What is Convolution?**

* is a mathematical method of merging two signals to create a third signal. It is the single important method of digital signal processing [1].

1. **What are some applications of Convolution?**
   1. **Image Processing**

* Image processing in the spatial realm is a visually rich field of research that deals with pixel manipulation techniques. Different procedures are done on images, which are simply handled as two-dimensional arrays [2].
  1. **Signal Filtering**
* Filtering is the process of modifying a measured or computed signal with an algorithm and/or logic to remove unwanted features of the signal before it is utilized in a calculation or a controller [3].
  1. **Audio Processing**
* To distinguish audio processing performed by computers from that conducted by the biological auditory system, audio signal processing is frequently used. The most common use of audio processing is to clean up or improve an audio signal before it is broadcast [4].
  1. **Artificial Intelligence**
* Artificial intelligence (AI) is the emulation of human intelligence using software-coded heuristics. This code is now found in everything from cloud-based commercial applications to consumer apps and even embedded firmware [5].
  1. **Analyzing Documents**
* Convolutional neural networks may also be used to analyze documents. This is not only beneficial for handwriting analysis, but it also has a significant impact on recognizers. A machine must perform over a million commands per minute in order to scan an individual's writing and then compare it to a large database. [6]

1. **What are some common convolution kernels? List 5 and discuss their function.**
   1. **Separable Convolution**

* Separable Convolution refers to splitting down the convolution kernel into lesser dimension kernels [7].
* Deep learning and computer vision techniques known as separable convolution split a normal convolution process into two distinct steps: a depth-wise convolution and a point-wise convolution. Convolutions may be efficiently and quickly computed using this method, especially for deep neural networks, which can greatly reduce the computational complexity of convolutions [8].
  1. **1D, 2D and 3D Convolutions**
* As 1D input is typically employed in such situations, 1D convolutions are frequently used for time series data processing. The 1D data input can include a number of channels, as was previously indicated. The output of the filter is 1D since it can only travel in one direction. One channel, one-dimensional convolution is seen below [7].
* Convolutional Neural Networks (CNNs) use several convolutional operations to extract features from input data. Convolutional operations slide a filter along one dimension to capture patterns in sequential data, such as time series or text, which is the main use for 1D convolutions. Images are frequently processed using 2D convolutions, where the filter moves over the image's height and width dimensions to capture spatial patterns. With the addition of a third dimension, 3D convolutions are often used with volumetric data, such as 3D photos or films, where the filter travels along three axes (width, height, and depth). These convolutions are crucial to CNN feature extraction because they let the networks learn hierarchical data representations [9].

1. **Can convolution be used in image processing? How?**

* Yes, convolution is frequently used in image processing to apply many effects to pictures, including blurring, sharpening, edge detection, and more. Convolution in image processing includes applying a filter or kernel to an input picture. The filter is a tiny matrix that moves over the picture and computes a weighted sum of the pixel values in its receptive area at each place. This procedure aids in feature extraction and picture manipulation. Applying a blurring filter, for instance, can smooth the picture, while an edge detection filter draws attention to the image's edges. Convolution is a fundamental image processing technique that is essential for operations like feature extraction, noise reduction, and picture enhancement [9].

1. **How about in AI? How?**

* Yes, AI can analyze images especially when using deep learning techniques. An example of a deep learning model is Convolutional Neural Networks (CNNs), which have achieved outstanding results in various image-related tasks. CNNs can recognize patterns, edges, forms, and textures by using many layers of convolutions and pooling to learn hierarchical features from pictures. AI systems can now carry out tasks like picture categorization, object identification, segmentation, style transfer, image synthesis, and more [10]

# References

|  |  |
| --- | --- |
| [1] | The Scientist and Engineer's Guide to Digital Signal Processing, "Analog Devices," [Online]. Available: https://www.analog.com/media/en/technical-documentation/dsp-book/dsp\_book\_ch6.pdf. [Accessed 16 October 2023]. |
| [2] | S. H.L., "Better Insight into DSP: 10 Applications of Convolution in Various Fields," ALL ABOUT CIRCUITS, 19 July 2017. [Online]. Available: https://www.allaboutcircuits.com/technical-articles/dsp-applications-of-convolution-part-2/. [Accessed 16 October 2023]. |
| [3] | M. Darby and G. McMillan, "Signal filtering: Why and how," CONTROL, [Online]. Available: https://www.controlglobal.com/print/content/11300650. [Accessed 16 October 2023]. |
| [4] | C.B. Fox, "What is Audio Processing?," EastTechJunkie, 8 October 2023. [Online]. Available: https://www.easytechjunkie.com/what-is-audio-processing.htm. [Accessed 16 October 2023]. |
| [5] | J. Frankenfield, "Artificial Intelligence: What It Is and How It Is Used," Investopedia, 24 April 2023. [Online]. Available: https://www.investopedia.com/terms/a/artificial-intelligence-ai.asp#:~:text=Artificial%20intelligence%20(AI)%20refers%20to%20the%20simulation%20or%20approximation%20of,industries%20from%20finance%20to%20healthcare.. [Accessed 16 October 2023]. |
| [6] | Flatworld Solutions, [Online]. Available: https://www.flatworldsolutions.com/data-science/articles/7-applications-of-convolutional-neural-networks.php. [Accessed 16 October 2023]. |
| [7] | P. Ganesh, "Types of Convolution kernels: Simplified," Towards Data Science, 18 October 2019. [Online]. Available: https://towardsdatascience.com/types-of-convolution-kernels-simplified-f040cb307c37. [Accessed 16 October 2023]. |
| [8] | A. G. Howard, M. Zhu, B. Chen, D. Kalenichenko, W. Wang, T. Weyand, M. Andreetto and H. Adam, "MobileNets: Efficient Convolutional Neural Networks for Mobile Vision Applicat," arXiv, 17 April 2017. [Online]. Available: https://arxiv.org/abs/1704.04861. [Accessed 16 October 2023]. |
| [9] | I. Shafkat, "Intuitively Understanding Convolutions for Deep Learning," Towards Data Science, 2 Jun 2018. [Online]. Available: https://towardsdatascience.com/intuitively-understanding-convolutions-for-deep-learning-1f6f42faee1. [Accessed 16 October 2023]. |
| [10] | J. J. Shubham, "Solving Multi-Label Classification Problems (Case studies included)," Anlytics Vidhya, 16 June 2022. [Online]. Available: https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-classification/. [Accessed 16 October 2023]. |

.