**PART I:**

**AI Deep Learning: Recurrent Neural Networks (50 Points) SUBMISSION REQUIREMENT #1:**

**--) Provide an overview of the recurrent neural network and compare it with the convolutional neural network (at a minimum of 2 pages, including images)**

**Answer:**

**Overview of the Recurrent Neural Network:**

Recurrent Neural Network is a type of neural network which is suitable to work on sequential data like timeseries, speech, text etc. One interesting feature of RNN is that it can remember the previous inputs and use them for the upcoming inputs. This property makes them instrumental for applications like speech recognition, translation etc.

Example: Siri, Google Translate

The below diagram shows a Recurrent Neural Network

A diagram of a network

Description automatically generated

Figure: Recurrent Neural Network (Source: Week 6\_02\_ann\_rnn\_recurrent\_neural\_networks)

* **Recurrent Neural Network (RNN) Fundamentals:**
  + **Memory Mechanism of RNN:**

The memory mechanism is the core feature of RNN which differentiates it from the other neural networks.

The below diagram shows a memory mechanism for a single unit.

* U: Sequence input
* V: Sequence output
* W: Memory I/O

A diagram of a mechanism

Description automatically generated

Figure: Memory mechanism for a single unit of RNN

Source: Week 6\_02\_ann\_rnn\_recurrent\_neural\_networks

* + **The fundamental feature of RRN include:**
    - Feed-back connection: The RNN contains minimum of feed back loop. This allows the activation to flow in a loop. The loop enables the network to perform temporal processing and learn sequences.

Example: temporal association or prediction or perform sequence recognition/reproduction.

The below figure shows an RNN

A diagram of a computer component

Description automatically generated

Figure: RNN (Source: Week 6\_02\_ann\_rnn\_recurrent\_neural\_networks)

* + **Architecture of Recurrent Neural Network:**
    - **MLP:**  commonly used type of RNN consists of a Multi-Layered Perceptron (MLP) with added loops. This form of RNN can utilize the robust non-linear mapping capabilities of MLP and incorporate the memory features.
    - **Uniform structures:** Other architectures have uniform structures where every neuron is connected to others and may have stochastic activation function.
* **Fully Recurrent Neural Networks**

A Multi-Layered Perceptron is a simplest form of fully recurrent neural network

• The simplest form of fully recurrent neural network:

The below figure shows the MLP with a previous set of hidden unit activations are fed back to the network with the inputs.

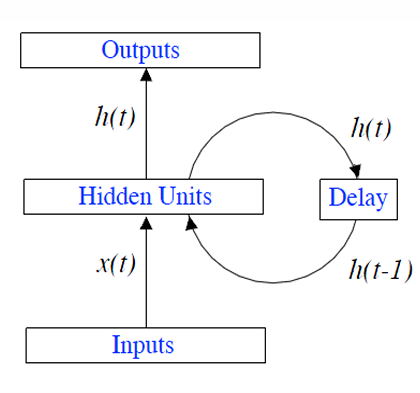


Figure: Fully Recurrent Neural Network

Source: Week 6\_02\_ann\_rnn\_recurrent\_neural\_networks

**Comparing RNN and CNN:**

* **CNN:**

A Convolutional Neural Network (CNN) is a neural network has convolution layers which play the primary role of feature extraction from the input data. It mostly used for computing on grid-like data, such as images. It consists of three main layers which are:

* + **Convolutional Layers**: This layer apply convolution operations to the input and capturing spatial features. There can be more than one convolution layer in a CNN.
  + **Pooling Layers**: This layer is used for dimension reduction of the data, which makes the processing more efficient. There can be more than one pooling layer in a CNN.
  + **Fully Connected Layers**: This layer is used at the last section of the of the network to make predictions. There can be more than one FC layers.

The below figure shows a CNN with the convolution, pooling and fc layers.

A diagram of several squares

Description automatically generated

Figure: CNN (Source: Week 6\_02\_ann\_rnn\_recurrent\_neural\_networks)

**Applications of CNN:** As CNN is used on grid-like data it is best suited for image related applications like:

* + Image classification
  + image recognition
  + object detection

**Comparison between CNN and RNN:**

|  |  |  |
| --- | --- | --- |
| **Property** | **RNN** | **CNN** |
| Data Type | Sequential data | grid-like data |
| Memory | have memory capability | no memory |
| Application | NLP and time series prediction | image processing |
| Training | More challenging to train | Comparatively easier to train |

**PART II:**

**AI Deep Learning: Generative Adversarial Networks (50 Points) SUBMISSION REQUIREMENT #2:**

**--) Provide an overview of the generative adversarial network and compare it with the convolutional neural network (at a minimum of 2 pages, including images)**

**Answer:**

**Overview of Generative adversarial network (GAN)**

Generative Adversarial Networks (GANs) are a generative modelling framework. GAN consist of two neural networks, the generator and the discriminator, pitting one against the other. Hence it is an adversarial network.

**Generator**: this is the network which generates new data that is like the training data. The input to this network is random noise and the output is a data sample resembling the training data. It models the distribution of each class.

**Discriminator**: This is the network which evaluates the generated data for authenticity. It differentiates real data which is from the training set and fake data which is generated by the generator. Discriminative models identify the separation between classes.

In the training process, the generator generates the data that can fool the discriminator and the discriminator tries to identify the fake data.

In this way the two networks work against each other, and the model keeps learning from this eventually becoming a strong one.

The below figure shows how a GAN works

A diagram of a network

Description automatically generated

Figure: GAN (Source: Week 6\_03\_ann\_rnn\_recurrent\_neural\_networks)

When both these networks are trained enough to produce the required accuracy, it can be used in real world applications.

**Comparing GAN with CNN:**

The generator and discriminator network in a GAN could possibly use CNN for training and detection. The generator could implement a CNN to process an image and produce the new data whereas the discriminator network can implement the CNN to identify if the authenticity of the data.

The below figure shows the CNN implementation in the generator network.

A diagram of a network

Description automatically generated

Figure: Generator network (Source: Week 6\_03\_ann\_rnn\_recurrent\_neural\_networks)

The below figure shows the implementation of CNN in the discriminator network

A diagram of a deep convolutions

Description automatically generated

Figure: Generator network (Source: Week 6\_03\_ann\_rnn\_recurrent\_neural\_networks)

The below table shows the difference between GAN and CNN

|  |  |  |
| --- | --- | --- |
| **Property** | **GAN** | **CNN** |
| Purpose | generate new data like the training data | pattern recognition and classification |
| Architecture | consists of generator and discriminator | consists of convolutional, pooling and fully connected layers |
| Training Data | trained on real, unlabelled data | trained on labelled data |
| Complexity | more complex due to adversarial training | comparatively simple |
| Application | image generation, creative tasks | image recognition, object detection, natural language processing |

**References:**

<https://www.ibm.com/topics/recurrent-neural-networks>

[A Gentle Introduction to Generative Adversarial Networks (GANs) - MachineLearningMastery.com](https://machinelearningmastery.com/what-are-generative-adversarial-networks-gans/)

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