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**REPORT ON**

**INTRODUCTION TO DEEP LEARNING**

SUBMITTED BY:-

**Deep learning**

**INTRODUCTION:-**

Deep learning is part of machine learning where systems can be trained to execute tasks within seconds without any human interference. The task could be like voice or image recognition.A specific model doesn't matter on higher abstraction level since all architectures of deep learning models are the same.

**What’s the Difference Between Machine Learning vs. Deep Learning?**

* Machine learning and deep learning share some characteristics. That’s not surprising — deep learning is one type of machine learning, so there’s bound to be some overlap.
* But the two aren’t quite the same. So what's the difference between machine learning and deep learning?
* When comparing machine learning vs. deep learning, machine learning focuses on structured data, while deep learning can better process unstructured data. Machine learning data is neatly structured and labeled. And if unstructured data is part of the mix, there’s usually some pre-processing that occurs so that machine learning algorithms can make sense of it.
* With deep learning, data structure matters less. Deep learning skips a lot of the pre-processing required by machine learning. The algorithms can ingest and process unstructured data (such as images) and even remove some of the dependency on human data scientists.
* For example, let’s say you have a collection of images of fruits. You want to categorize each image into specific fruit groups, such as apples, bananas, pineapples, etc. Deep learning algorithms can look for specific features (e.g., shape, the presence of a stem, color, etc.) that distinguish one type of fruit . another. What’s more, the algorithms can do so without first having a hierarchy of features determined by a human data expert.
* Another differentiation between deep learning vs. machine learning is the types of learning each is capable of. In general terms, machine learning as a whole can take the form of supervised learning, unsupervised learning, and reinforcement learning.
* Supervised learning requires labeled or structured datasets. This type of learning requires human intervention to ensure data is labeled appropriately.
* Unsupervised machine learning doesn’t require datasets to be labeled. Instead, it focuses on pattern recognition in the data and will connect the dots based on shared characteristics. As you may have guessed, there’s no human involvement in feeding unlabeled data into an unsupervised machine learning algorithm.
* Then we have deep reinforcement learning, where a model “learns” to become more accurate based on a feedback and reward system. This technique is considered semi-supervised.
* Reinforcement learning trains machine learning models to make a series of decisions while earning penalties or rewards based on the effectiveness of its decisions.
* Deep learning applies mostly to unsupervised machine learning and deep reinforcement learning. By making sense of data and making complex decisions based on large amounts of data, companies can improve the outcomes of their models, even when some information is unknown.effect rom another. What’s more, the algorithms can do so without first having a hierarchy of features determined by a human data expert.
* As the algorithm learns, it can become better at identifying and predicting new photos of fruits — or whatever use case applies to you.

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**Types of Deep Learning vs. Machine Learning**

Another differentiation between deep learning vs. machine learning is the types of learning each is capable of. In general terms, machine learning as a whole can take the form of supervised learning, unsupervised learning, and reinforcement learning.

**Supervised learning** requires labeled or structured datasets. This type of learning requires human intervention to ensure data is labeled appropriately.

**Unsupervised machine learning** doesn’t require datasets to be labeled. Instead, it focuses on pattern recognition in the data and will connect the dots based on shared characteristics. As you may have guessed, there’s no human involvement in feeding unlabeled data into an unsupervised machine learning algorithm.

Then we have deep **reinforcement learning**, where a model “learns” to become more accurate based on a feedback and reward system. This technique is considered semi-supervised.

Reinforcement learning trains machine learning models to make a series of decisions while earning penalties or rewards based on the effectiveness of its decisions.

Deep learning applies mostly to unsupervised machine learning and deep reinforcement learning. By making sense of data and making complex decisions based on large amounts of data, companies can improve the outcomes of their models, even when some information is unknown.

**How Does Deep Learning Work?**

* In deep learning, a computer model learns to perform tasks by considering examples rather than being explicitly programmed. The term "deep" refers to the number of layers in the network — the more layers, the deeper the network.
* Deep learning is based on artificial neural networks (ANNs). These are networks of simple nodes, or neurons, that are interconnected and can learn to recognize patterns of input. ANNs are similar to the brain in that they are composed of many interconnected processing nodes, or neurons. Each node is connected to several other nodes and has a weight that determines the strength of the connection.
* Layer-wise, the first layer of a neural network extracts low-level features from the data, such as edges and shapes. The second layer combines these features into more complex patterns, and so on until the final layer (the output layer) produces the desired result. Each successive layer extracts more complex features from the previous one until the final output is produced.
* This process is also known as forward propagation. Forward propagation can be used to calculate the outputs of deep neural networks for given inputs. It can also be used to train a neural network by back-propagating errors from known outputs.
* Backpropagation is a supervised learning algorithm, which means it requires a dataset with known correct outputs. Backpropagation works by comparing the network's output with the correct output and then adjusting the weights in the network accordingly. This process repeats until the network converges on the correct output. Backpropagation is an important part of deep learning because it allows for complex models to be trained quickly and accurately.
* This process of forward and backward propagation is repeated until the error is minimized and the network has learned the desired pattern.

**Deep Learning Models**

Let's look at some types of deep learning models and neural networks:

1. Convolutional Neural Networks (CNN)
2. Recurrent Neural Networks (RNN)
3. Long Short-Term Memory (LSTM)

**Convolutional Neural Networks (CNN)**

Convolutional neural networks (or just convolutional networks) are commonly used to analyze visual content.

They are similar to regular neural networks, but they have an extra layer of processing that helps them to better identify patterns in images. This makes them particularly well suited to tasks such as image recognition and classification.

**Recurrent Neural Networks (RNN)**

A recurrent neural network (RNN) is a type of artificial neural network where connections between nodes form a directed graph along a sequence. This allows it to exhibit temporal dynamic behavior.

Unlike feedforward neural networks, RNNs can use their internal memory to process sequences of inputs. This makes them valuable for tasks such as unsegmented, connected handwriting recognition or speech recognition.

**Long Short-Term Memory (LSTM)**

Long short-term memory networks are a type of recurrent neural network that can learn and remember long-term dependencies. They are often used in applications such as natural language processing and time series prediction.

LSTM networks are well suited to these tasks because they can store information for long periods of time. They can also learn to recognize patterns in sequences of data.

**How Can You Apply Deep Learning to Your Business?**

Wondering what challenges deep learning and AI can help you solve? Here are some practical examples where deep learning can prove invaluable.

Using Deep Learning for Sentiment Analysis

Improving Business Processes

Optimizing Your Marketing Strategy

If there’s one thing marketers don’t need more of, it’s guesswork. Connecting with your target audience and catering to their specific needs can help you stand out in a sea of sameness. But to make these deeper connections, you need to know your target audience well and be able to time your outreach.

One way to use deep learning in sales and marketing is to segment your audience. Use customer data (such as demographic information, purchase history, and so on) to cluster customers into groups. From there, you can use this information to provide customized service to each group.

Another way to use deep learning for marketing and customer service is through predictive analysis. This involves using past data (such as purchase history, usage patterns, etc.) to predict when customers might need your services again. You can send targeted messages and offers to them at critical times to encourage them to do business with you.

**How Meltwater Helps You Harness Deep Learning Capabilities**

Advances in machine learning, like deep learning models, give businesses more ways to harness the power of data analytics. Taking advantage of purpose-built platforms like Meltwater gives you a shortcut to applying deep learning in your organization.

At Meltwater, we use state-of-the-art technology to give you more insight into your online presence. We’re a complete end-to-end solution that combines powerful technology and data science technique with human intelligence. We help you turn data into insights and actions so you can keep your business moving forward.

**Convolutional Neural Networks (CNNs)**

Convolutional Neural Networks (CNNs) are a type of deep learning model that anaylze visual data, such as images and videos.

Purpose of CNNs :- CNNs are used for tasks like image recognition, object detection, and video analysis. They are well-suited for these tasks because they can learn to identify patterns in images and videos directly from the data.

**Working of CNNs :-**

1.Convolutional Layers

The convolutional layers are the core building blocks of a CNN.They apply a set of learnable filters (or kernels) to the input image, where each filter extracts a specific feature like edges, shapes, or textures.It performs dot product between the filter weights and input making an activation map .

2.Activation Function

A rectified linear activation function (ReLU) is applied after each convolution operation.ReLU introduces non-linearity, allowing the network to learn complex patterns in the data.

3.Pooling Layers

Pooling layers follow the convolutional layers and perform a down-sampling operation.They reduce the spatial dimensions of the feature maps, making the representations more compact and robust to small translations.

4.Fully Connected Layers

The final layers of a CNN are typically fully connected layers.

These layers take the high-level features extracted by the convolutional and pooling layers and use them to perform classification or regression tasks.

5.Training

CNNs are trained using backpropagation to minimize a loss function.The model learns to extract relevant features from the input data and associate them with the correct output labels.

**Advantages of CNNs :-**

1. CNNs can automatically learn and extract relevant features from the input data, without the need for manual feature engineering.

2. CNNs are highly scalable and can process large amounts of data quickly .

3. CNNs minimize parameter sharing, which reduces the number of parameters required to train the model.

**Disadvantages of CNNs :-**

1.Computationally expensive to train and require a lot of memory.

2.Requires large amounts of labeled data.

**Application of CNNs** :- Image recognition

Object detection

Medical Diagnosis

Natural language processing

Face recognition

**Transformers**

The paper "Attention is All You Need" by Vaswani et al introduced transformers as a form of deep learning model. Their efficient handling of long-range dependencies has led to a revolution in natural language processing (NLP) and other fields. Transformers are notable for the following reasons:

**Attention Mechanism:** Transformers utilize the attention mechanism, which permits them to concentrate on different segments of the input sequence while processing each word or token. This capability allows them to capture connections between words regardless of their positions in the sequence.

Transformers utilize an encoder-decoder structure, which can also function in encoder-only or decoder-only modes. The encoder handles the input sequence, while the decoder produces the output sequence. Both the encoder and decoder layers consist of multiple self-attention layers and feedforward neural networks.

Self-attention enables each word in a sequence to attend to all other words, resulting in a set of attention scores that signify the importance of each word in relation to the others. This mechanism allows transformers to capture dependencies across long distances.  
  
To address the fact that transformers do not inherently grasp the order of the sequence, positional encoding is incorporated to provide information about the position of each word in the input sequence.  
Transformers have demonstrated significant success in numerous NLP applications, such as machine translation (e.g., Google's Transformer model), text generation, sentiment analysis, and more. Additionally, they have found utility in non-NLP tasks, including image processing and time series analysis.

Large pre-trained transformer models like BERT (Bidirectional Encoder Representations from Transformers), GPT (Generative Pre-trained Transformer), and their variations have attained leading-edge performance across a diverseset of benchmarks. These models are frequently adapted to specific tasks through fine-tuning with comparatively limited amounts of task-specific.

**Recurrent Neural Network**

Recurrent Neural Network (RNN) is an artificial neural network specifically meant for processing sequential data through memory retention. Here are some fundamental aspects of RNNs:

RNNs excel in handling sequential data by giving importance to the order of inputs. For instance, this type of data includes time series, text, and speech.

In contrast to traditional feedforward neural networks, RNNs possess internal memory, enabling them to retain information about previous inputs to influence the current output.

The structure of RNNs is similar to a chain, with each neuron executing a task using its current input and the output from the preceding neuron in the sequence.

They find wide applications in tasks such as language modeling, machine translation, and text generation within natural language processing (NLP). Additionally, RNNs are utilized in speech recognition, time series prediction, and handwriting recognition.

**Challenges:** RNNs may encounter issues such as vanishing gradients, in which gradients become extremely small during training, posing difficulties in learning long-term dependencies. This has prompted the emergence of more sophisticated architectures such as Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) to tackle these issues.

**Training:** The training of RNNs revolves around optimizing weights using gradient descent and backpropagation through time, involving the calculation of gradients across multiple time steps.

**Github repository link:-** https://github.com/Arshiya109/Fundamentals-of-Deep-Learning