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Artificial Intelligence and Machine Learning (6CS012)

Task-3

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Question1:

You are a Machine Learning Engineer at a growing e-commerce company preparing to implement and scale machine learning systems.

• List and explain at least three real-world challenges you expect during ML model development, deployment, or maintenance (e.g., data drift, imbalanced data, systemlatency).

• For each challenge:

– Discuss potential consequences if not properly addressed.

– Propose technical or organizational solutions you would implement (e.g., retraining pipelines, feature monitoring, distributed serving, MLOps practices).

• Finally, reflect on how cross-functional collaboration (between data scientists, engineers, product teams) can help mitigate these challenges more effectively.

Ans: As, a Machine Learning Engineer at a growing e-commerce company like Daraz, I expect to face variety of challenges while developing, deploying, and maintaining the model and some of the challenges are like:

- Changing Customer Behaviour:

  Customer preferneces continue to change over time. If the model keeps relying on outdated data, it may end up recommending products that customers are no longer interested in leading to a decrease in customer satisfaction and potentially sales. To address this issue, I would implement automatic retraining pipelines so that the system can update itself with fresh data. In addition, the utilization of feature monitoring instruments would enable the system to recognize when there is a significant change in customer's behaviour so that the system stays aligned with evolving preferences. Regularly updating the model in this way offers more accurate and relevant product recommendations, enhancing both sales as well as customer experience.

- Unequal product Interaction

  In some cases, some categories of prodcuts like elecrtronics, may have much more information that others, like books. This imbalance will lead to biased recommendations, where popular products are shown more and less pipular products are neglected. As a result, customers are not introduced to products that they might be interested in, which can result in lower customer satisfaction in general. To solve this, I would employ methods like resampling, weighted loss functions, or data augementation during trainning of the model. These methods balance out the data and give all products categories get fair visibility, improving customer discovery.

- Slow System Performance

  Machine learning models need to be capable of responding quickly when users engage in action like searching or getting recommendations. If the system is too slow, users will get frustrated and leave the platform, hence decreasing engagement and leading to fewer sales. To address this, I would focus on model optimization, distributed model serving, and caching techniques. They reduce the response time, improving the system's speed and performance in general, and keeping the user engaged.

- Cross-Functional Collaboration:

  Working together with data scientists, engineers, and product managers is really important. Data scientists make the model technically good, engineers ensure that it fits into the system, and product team deliver feedback from real users. This cooperation results in the creation of machine learning systems that work technically well but also meet business objectives and user needs.

Question 2:

2.1: In the context of machine learning:

- **Define and differentiate between overfitting and underfitting.**
- **Explain why both are problematic for model performance.**
- **Illustrate your explanation with simple examples (e.g., overfitting a training dataset, underfitting a complex pattern).**

Ans: In machine learning, overfitting and underfitting are two common issues that play a major role in affecting model performance.

Overfitting occurs when a model becomes too complex and learns the training data too well -even the noise or the unrelated information. While the model performs very well on the training data, it does not generalize well to unseen data. It's like a student memorizes answers to some questions but can't answer new or different questions. For example, a decision tree that correctly classifies all trainning data but performs poorly on new test data is overfitting.

Underfitting is a condition where the model is too simple to able to learn the patterns within the data. It performs poorly on the trainning data and the new data as it is not able to learn the complexity of the problem. It is just like trying to solve a very complex puzzle using not enough pieces. For instance, fitting non-linearly related data with a linear model creates underfitting.

Question 2.2 Neural Network Architecture:

Difference between CNN and RNN:

• Explain the fundamental differences between a Convolutional Neural Network (CNN) and a Recurrent Neural Network (RNN).

– Provide examples of scenarios where one would be more suitable than the other (e.g., image recognition vs. time-series prediction).

• Briefly discuss common challenges faced during the training of deep learning models (e.g., vanishing gradients, overfitting).

– Provide possible solutions or techniques to address these challenges (e.g., batch normalization, early stopping).

Ans: Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN) are both deep learning models used for processing different kinds of data.

CNN is mostly used for image-related tasks. It works by detecting patterns such as edges, shapes, or textures using filters. CNN is best to handle spatial data. Example CNN is used in image classification, eg., whether and image contains dog or a cat.

RNN is used with sequential data. RNN has memory, meaning it can remember previous steps and uses them for making the current prediction. RNN is best for time-series or language data. Example: Language translation, text generation, or stock price prediction uses RNN.

The Key differences are: CNN considers data altogether (better for images), and RNN considers information step by step (better for sequences). CNN is suitable with fixed-size input. RNN is more appropriate for variable-length input such as text.

Challenges in Deep Learning Models:

Vanishing Gradients: In RNNs in deep network, the gradients becomes too small, and the model struggles to learn long-terms patterns. The solution can be substitue standard RNN with LSTM, and apply batch normalization. Use techniques like dropout, early stopping, or data augmentation. Both RNN and. CNN are powerful, but choosing the right based on the nature of data and using proper training techniques is required for maximum performance.