Executive Summary: Neural Network Models (ANN and CNN) Performance Analysis

Project objective: To develop and assess two distinct deep learning algorithms: an Artificial Neural Network (ANN) and a Convolutional Neural Network (CNN), for the task of multi-class image classification using the Fashion-MNIST dataset.

Overview of Neural Network Models: This analysis involved constructing two models to classify 10 categories of clothing – such as shirts, trousers, and coats – from 28x28 greyscale pixel images. The 70,000-image dataset was divided into a training set (50,000), test set (10,000), and validation set (10,000) for the model's development.

- **ANN**: A standard, fully connected model that requires images to be flattened into a single vector. This model is inspired by the structure and function of the human brain, which allows computers to learn from data.
- **CNN**: An advanced architecture employing convolutional and pooling layers to automatically learn spatial hierarchies and patterns from the 2D image data.

Major Findings: The ANN model without dropout narrowing demonstrated the best overall performance and achieved the highest recorded accuracy. Interestingly, both models showed a slight decrease in performance when using dropout regularisation. In an unusual outcome, the ANN consistently outperformed the CNN, achieving higher accuracy and lower loss (a measure of how wrong a model's predictions are) while requiring fewer epochs to train.

Metrics	ANN	CNN	ANN (dropout)	CNN (dropout)
Initial accuracy	0.7776	0.6460	0.7583	0.6219
Final accuracy	0.9219	0.8940	0.9114	0.8805
Overall accuracy	0.8831	0.8777	0.8805	0.8747

Methodology and Innovation: Developing the model demonstrated several key techniques to ensure optimal performance, prevent overfitting, and provide a detailed evaluation.

- **Adam optimiser**: used by all models for its efficiency in handling sparse gradients and its adaptive learning rate capabilities, enabling a quick convergence during training.
- **Dropout regularisation**: Implemented in both networks to mitigate overfitting, which improved generalisation on unseen test data.
- **Visualisation**: Multiple graphs and confusion matrices were generated for both models. This analysis showed common misclassifications, such as confusion between visually similar classes like 'shirt', 't-shirt', and 'pullover', identifying areas for improvement.
- **Preprocessing techniques**: Data augmentation and one-hot encoding were utilised to artificially increase the size and diversity of training data and convert the data into the correct numerical format, respectively.

Conclusion and Insights: While CNNs typically outperform ANNs in image classification tasks, this analysis showed the opposite; the ANN performed better than the CNN, both with and without regularisation. This could be attributed to a more optimal design of the ANN compared to CNN, or it could be the nature of the dataset itself; the images are only 28x28 greyscale, which may limit the spatial complexity that CNNs are designed to exploit.