Please fill all the blanks in this **ANSWER SHEET**.

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| --- | --- | --- | --- |
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**Laboratory 3: Image Recognition - Introduction to Edge Machine Learning**

1.1 Table for deep learning platforms and the advantages.

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| --- | --- | --- | --- |
| **Platform** | **1** | **2** | **3** |
| Name | TensorFlow | PyTorch | PaddlePaddle |
| Official website | https://www.tensorflow.org | https://pytorch.org/ | https://www.paddlepaddle.org.cn/ |
| advantage | * Open source * Run in many environments and languages * Easily run in browser * GPU support | 1,Open source  2,Run in many environments and languages  3,GPU suppor  4,Powerful Automatic Differentiation  5,Extensive Community Support  6,Dynamic Computation Graph | 1,Advantages in Multi-Endpoint Deployment  2,Easily run in browser  3Open source |

2.1 The accuracy and the loss of the trained model.

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| --- | --- |
| Accuracy: | 0.9803 |
| Loss: | 0.0741 |

2.2 One of the image in the testing set and the recognition result.

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| --- | --- |
|  | |
| Recognition result: | 1 |

3.1 Answers of the last question in each exercise of Python.

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| --- | --- | --- |
| **No** | **Section** | **Answer** |
| 1 | Python Syntax |  |
| 2 | Python Comments |  |
| 3 | Python Variables |  |
| 4 | Python Data Types |  |
| 5a | Python Lists |  |
| 5b | Access List Items |  |
| 5c | Change List Items |  |
| 6 | Python For Loops |  |
| 7 | Python Classes/Objects |  |
| 8 | Python Modules |  |

3.2 Answers of the last question in each exercise of NumPy.

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| --- | --- | --- |
| **No** | **Section** | **Answer** |
| 1 | NumPy Getting Started | N/A |
| 2 | NumPy Creating Arrays |  |
| 3 | NumPy Array Indexing |  |
| 4 | NumPy Array Slicing |  |
| 5 | NumPy Array Shape |  |
| 6 | NumPy Array Iterating |  |
| 7 | NumPy Trigonometric Functions |  |

3.3 Figure of the plotted array.

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| --- |
| (Paste the image here) |

3.4 Figure of the parabola.

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| (Paste the image here) |

3.5 Figure of the plotted 2D array.

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| --- |
| (Paste the image here) |

4.1 Concepts about neural network.

Discribe the following concepts:

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| --- | --- |
| **Concept** | **Discription** |
| Sigmoid neurons | Sigmoid neurons are a type of artificial neuron. They are similar to perceptrons but have some key differences. Their inputs can take on any values between 0 and 1, not just 0 or 1 like perceptrons. They also have weights and a bias. The output is calculated using the sigmoid function. The important thing about sigmoid neurons is that small changes in their weights and bias cause only a small change in their output. This property allows a network of sigmoid neurons to learn. The sigmoid function makes the neuron's behavior smooth, which helps in the learning process of the neural network. |
| Weight | Weights are like little knobs that adjust how neurons talk to each other. When an input comes into the network, it gets multiplied by these weights. Each weight decides how much influence a particular input has on the next layer of neurons.During training, the neural network tries to find the best set of weights. It does this by comparing its predictions to the correct answers and making small changes to the weights to get better and better at making accurate predictions. |
| Bias | Bias can be thought of as a measure of how easy it is to make the perceptron output a 1. A large positive bias makes it easier for the perceptron to output 1, while a very negative bias makes it difficult. |
| Sigmoid Function | The sigmoid function is an important part of the sigmoid neuron. It takes the weighted sum of the inputs and the bias as its input. Its output is a value between 0 and 1. When the input is a large positive number, the output is close to 1, similar to the behavior of a perceptron when it outputs 1. When is a large negative number, the output is close to 0. The shape of the sigmoid function is a smoothed version of a step function. |
| Neural Network  (NN) | A neural network is a system designed to solve problems like recognizing handwritten digits. It consists of artificial neurons such as perceptrons and sigmoid neurons. Perceptrons take binary inputs, have weights and a threshold (or bias), and produce a binary output based on a weighted sum comparison. Sigmoid neurons are similar but can take inputs between 0 and 1 and their output is determined by the sigmoid function of the weighted sum, which allows for small changes in weights and bias to cause only small changes in output, enabling learning. Neural networks have an architecture with input, hidden, and output layers. They learn by using algorithms like gradient descent with a cost function (such as the quadratic cost function) to minimize errors. Stochastic gradient descent is often used to speed up learning by estimating gradients from small batches of training data. |
| Input Layer | The input layer in a neural network is the starting point. It's where the raw data, like images, text, or numbers, first enters the network. Each neuron in the input layer represents a single feature of the data. For instance, in an image recognition task, each neuron could correspond to a pixel value. The input layer then passes this data on to the next layers in the network |
| Output Layer | The output layer in a neural network is the final stop in the data - processing journey. It takes the transformed data passed from the hidden layers and generates the network's final result. |
| Hidden Layer | The hidden layer in a neural network is the in between part that processes input data using weights and biases to extract meaningful patterns before passing the transformed data to the output layer. |
| Training Dataset | The training dataset is a collection of data, like images with labels or numerical values, that a neural network uses to learn patterns and relationships so it can make accurate predictions later |
| Input in Dataset  (Image) | In a dataset for images, the input consists of the actual visual data of the images, which could be represented as arrays of pixel values along with associated metadata like dimensions, and is used to train or test a model to perform tasks such as image classification or object detection. |
| Output in Dataset  (Correct Classification) | In a dataset for correct classification, the input is the data (such as images, text, or numerical values) that is fed into a model, while the output is the corresponding correct label or category that the model aims to predict, like classifying an image as a cat or a dog where the image is the input and the "cat" or "dog" label is the correct classification output. |
| Testing Dataset | The testing dataset is a set of data separate from the training data, used to evaluate how well a trained model, like a neural network, can make accurate predictions on new, unseen data. |
| NN Learning | NN Learning (Neural Network Learning) refers to the process by which a neural network adjusts its weights and biases through various algorithms to minimize errors and improve its ability to process and learn from input data in order to make accurate predictions or classifications. |
| Gradient Descent | Gradient Descent is an optimization algorithm used in neural networks to iteratively update model parameters in the direction of the negative gradient of the loss function, aiming to minimize the loss and find the optimal parameter values. |
| Cost Function | Cost Function is a mathematical function in neural networks that measures the difference between the predicted output and the actual output, serving as an indicator of how well the model is performing and being used to guide the training process by minimizing its value. |
| Learning Rate | Learning Rate is a hyperparameter in neural network training that determines the step size at which the model's parameters are updated during optimization, controlling the speed and stability of the learning process. |
| Stochastic  Gradient Descent | Stochastic Gradient Descent is an optimization algorithm that updates the model parameters using the gradient of a single training example or a small batch at each iteration in neural networks, reducing computational cost and increasing training speed while introducing some randomness to help avoid getting stuck in local minima. |
| Mini-batch | mini-batch refers to a small subset of the training data that is used to update the model's parameters in each iteration, which helps speed up training and reduce memory usage compared to using the entire dataset at once. |
| Epoch | epoch is defined as one complete pass through the entire training dataset during the training process of the model, used to measure the progress of training. |

4.2 Details of the QuickStart.

Write down the details of the QuickStart code:

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| --- | --- | --- |
| **Section** | **Parameter** | **Value** |
| TensorFlow | Version | 2.18.0 |
| Dataset | Name of the data set | MNIST |
| Number of training sample | 60000 |
| Number of testing sample | 10000 |
| Neural Network  (NN) | Number of Input Neurons | 784 |
| Number of Output Neurons | 10 |
| Number of Hidden Layers | 1 (Dropout layer is not usually regarded as a separate hidden layer) |
| Learning | Name of the Optimization Method | Adam Optimization Method |
| Name of the Cost Function | losses.SparseCategoricalCrossentropy() |
| Learning Rate | 0.001 |
| Number of Epochs | 5 |
| Evaluation | Accuracy | 0.9860 |
| loss | 0.0429 |

5.1 Figure of the first sample.

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| 081783061ede3c49d4ca57c541fa8df7 |

5.2 Output of your model evaluation.

|  |
| --- |
| 4c1e759307c0e37015ffdc92acf1305d |

5.3 Recognition of the draw symbol.

|  |  |  |
| --- | --- | --- |
| 17334799dd70cb0e0b47b38f433cde80) | | 9c2194740a2e0856ef0c8be78b3aea84 |
| Output Probabilities: | 0.98 | |

5.4 Take a video or screen record for the model training process and the image recognition; upload it to Moodle with the file name ”lab3\_v54”.