LSTM for RadioFrequencyFingerprint

1. Data Preprocessing

    The raw data will be processed in a way that the head of each sample starts from when there is actual reading. The threshold is ±**0.002**. The dataset will be divided into three parts: dataI, dataQ, labels. For dataI and dataQ, each row represents a sample, there are **20122** samples in total.Also, each sample is mapped to [0,1] space.

    Most of data ranged from position approximately 800 to 7000. Here only use the first constant 5000 data points as the sample.

    In the end, the dataset is shuffled and divided into train set and test set csv files.

1. LSTM

    To simplify the model, only data I is used here. The LSTM setting is similar to the one for MNIST. 80% of the dataset is used as training set and 20% is used as testing set. Training set size: 16096 Testing set size: 4024

1. Number of Samples &  Sequences

    current number of train samples: 16096

Testing accuracy at 2500 steps using I+Q

Reducing the number in the sequence is by downsampling for every 1,2,3,6,12 points

example: python LSTM.py 16096 6

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Samp/Seq | 6000\*(I+Q) | 3000 | 2000 | 1000 | 500 | 100 |
| 16096 | 0.997763 | 0.995775 | 0.993042 | 0.993539 | 0.97341 | 0.964463 |
| 8048 | 0.989314 | 0.991551 | 0.983847 | 0.992296 | 0.98832 | 0.97341 |
| 4024 | 0.994284 | 0.992296 | 0.992048 | 0.990805 | 0.973907 | 0.96173 |
| 2012 | 0.986829 | 0.981859 | 0.980368 | 0.98161 | 0.969682 | 0.946322 |
| 1006 | 0.965209 | 0.967942 | 0.952783 | 0.964463 | 0.954026 | 0.949553 |
| 200 | 0.836481 | 0.789513 | 0.872764 | 0.837227 | 0.819583 | 0.863569 |
| 50 | 0.655318 | 0.669483 | 0.667744 | 0.639414 | 0.650596 | 0.66675 |

python LSTM.py 16096 60 && python LSTM.py 8048 60 && python LSTM.py 4024 60 && python LSTM.py 2012 60 && python LSTM.py 1006 60 && python LSTM.py 200 60 && python LSTM.py 50 60

python LSTM.py 200 6 && python LSTM.py 200 12 && python LSTM.py 50 1 && python LSTM.py 50 2 && python LSTM.py 50 3 && python LSTM.py 50 6 && python LSTM.py 50 12

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Samp/Seq | 6000\*(I+Q) | 3000 | 2000 | 1000 | 500 | 100 |
| 20000 | 0.993787 | 0.989066 | 0.993539 | 0.990805 | 0.978877 | 0.952783 |
| 10000 | 0.989066 | 0.988817 | 0.989066 | 0.984344 | 0.976392 | 0.9334 |
| 5000 | 0.987823 | 0.989563 | 0.98509 | 0.984593 | 0.980368 | 0.946074 |
| 2000 | 0.980368 | 0.977386 | 0.977883 | 0.976889 | 0.963469 | 0.934145 |
| 1000 | 0.950795 | 0.947068 | 0.942346 | 0.943588 | 0.935636 | 0.920974 |
| 200 | 0.812624 | 0.809145 | 0.802435 | 0.760934 | 0.75174 | 0.73335 |
| 50 | 0.501988 | 0.491551 | 0.526839 | 0.493787 | 0.479871 | 0.479871 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Seq/Samp | 6000 | 3000 | 2000 | 1000 | 500 | 100 |
| 20000 | 0.993787 | 0.97875 | 0.99025 | 0.99 | 0.9685 | 0.43925 |
| 10000 | 0.989066 | 0.99125 | 0.98475 | 0.9965 | 0.9825 | 0.7965 |
| 5000 | 0.987823 | 0.98775 | 0.98175 | 0.9955 | 0.96575 | 0.80125 |
| 2000 | 0.980368 | 0.975 | 0.97725 | 0.996 | 0.9535 | 0.81275 |
| 1000 | 0.950795 | 0.943 | 0.95075 | 0.9895 | 0.935636 | 0.68375 |
| 200 | 0.812624 | 0.8035 | 0.862 | 0.90625 | 0.87825 | 0.802 |
| 50 | 0.501988 | 0.5005 | 0.51625 | 0.60625 | 0.56425 | 0.52775 |

、

6 Classes

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Seq/Samp | 6000 | 3000 | 2000 | 1000 | 500 | 100 |
| 12000 | 0.995 | 0.993 | 0.990333 | 0.954 | 0.900667 | 0.593333 |
| 6000 | 0.995 | 0.996 | 0.988333 | 0.865 | 0.901333 | 0.567667 |
| 3000 | 0.989 | 0.989333 | 0.992 | 0.935333 | 0.898333 | 0.580667 |
| 1000 | 0.965667 | 0.950667 | 0.948 | 0.908 | 0.805 | 0.557333 |
| 500 | 0.912333 | 0.923333 | 0.902 | 0.887333 | 0.767 | 0.592333 |
| 100 | 0.723 | 0.699667 | 0.634 | 0.625667 | 0.484 | 0.403667 |

1. Add noise to training samples

    Use RMS to calculate the average magnitude

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Seq\Noise | 5% | 10% | 20% | 40% | 80% | 150% | 300% |
| 12000 | 0.997667 | 0.993 | 0.994 | 0.992 | 0.986667 | 0.954667 | 0.802667 |