
Implementing Complex Valued Neural Networks

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Abstract

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2 1 Introduction

3 Complex valued neural networks (CVNNs) offer several potential advantages over real valued neural
4 networks (RVNNs). By incorporating both phase and magnitude in each value, CVNNs allow for a
5 richer representation of data. This increased information content in each input and parameter can
6 lead to a reduction in the number of parameters, subsequently lowering the likelihood of exploding
7 and vanishing gradients while also reducing the need for regularization. Furthermore, some types of
8 data are naturally suited for representation using complex numbers.

9 CVNNs hold great promise in domains where complex values are already extensively utilized, such
10 as quantum computing and signal processing. Outputs from Fourier transforms and other complex
11 representations can be directly fed into the network, eliminating the need to separate or remove
12 information from each value as required with RVNNs. Additionally, certain complex transforms and
13 filters can be applied to images, thereby reducing the need for convolutions in image classification
14 tasks¹.

15 Despite these advantages, many popular neural network frameworks, such as PyTorch and Keras
16 with TensorFlow, offer limited support for complex valued neural networks by default. Nevertheless,
17 TensorFlow does provide support for complex tensors, which enables the implementation of CVNNs
18 by defining custom layers. In this project, we take advantage of this functionality to explore the
19 potential of CVNNs further.

20 2 Related Works

21 **Akira Hirose (2012). *Complex-Valued Neural Networks, 2nd Edition***

22 This book provides an overview of complex valued neural networks and some applications. Much of
23 the implementation is based on concepts from this author's works.

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26 **Manny Ko et al. (2022). *CoShNet: A Hybrid Complex Valued Neural Network using Shearlets*.**
27 **arXiv: 2208.06882 [cs.CV]**

28 In this paper they explore shearlets and CVNNs in image processing to reduce the need for
29 convolution, increase efficiency and improve performance. This is an excellent demonstration that
30 CVNNs are worth investigating.

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¹See Ko et al. 2022

33 **Ryan Yu et al. (2022). *Biologically Plausible Complex-Valued Neural Networks and Model***
34 ***Optimization*. Ed. by Ilias Maglogiannis et al. Cham**

35 The primary motivation for this project was the potential of CVNNs to more accurately approximate
36 biological networks. The paper investigates CVNNs, which are designed to be more similar to
37 biological neural networks than their real-valued neural network (RVNN) counterparts, demonstrating
38 superior performance in certain tasks. However, the paper's main drawback lies in its reliance on
39 gradient descent as a training method, as this is likely an unrealistic learning mechanism for biological
40 systems (Hinton 2022).

41 **3 Description**

42 **4 Experiments**

43 **4.1 MNIST**

44 To test the implementation we do a trial run on MNIST data set to verify the implementation is
45 functioning. For the real neural network we use 32 filter 4 by 4 kernels with softmax output layer.
46 The complex network has 16 filters of 4 by 4 kernels to halve the number of parameters. CVNNs do
not offer much benefit in a simple case like this, but is a convenient test set.

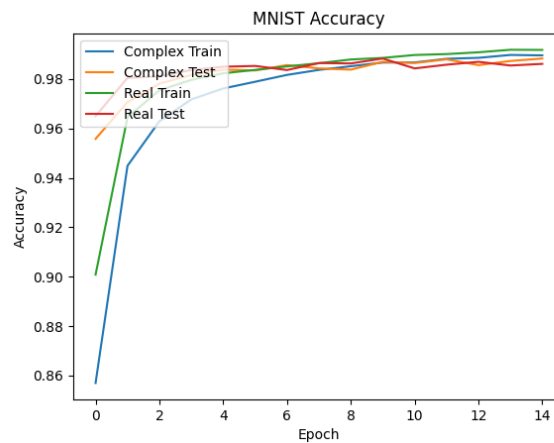


Figure 1: As expected we get similar performance.

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