Discovering Applicability of Quantum Neuron Models in Classification of Medical Images

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*The real science

Introduction

In 1997 Thoru Nitta published a paper “An Extension of the Back-Propagation Algorithm to Complex Numbers” after that in 2003 Noriaki Kouda and his colleagues establish a similarity between neurons and qubits. Based on this similarity they proposed new neural network named “Qubit Neural Network”. They implemented and tested this neural network on few most popular datasets and found good and very comparative results. Then the trend started and people implemented Qubit Neural Network for different cases like time series forecasting and so, found quite good results. Masterwork is intended to research on properties of “Quantum Neural Network” model for data augmentation and improvement classification accuracy during medical image processing. For the test we use brain tumor recognition problem (BRaTS 2018) of the two following tasks: tumor segmentation and tumor classification.

Relation B/W Classical Neuron Model and Qubit Neuron Model

Classical Neuron Model :

$$u = \sum_{m=0}^{M} w_m x_m - v \tag{1}$$

$$y = (1 + e^{-u})^{-1} \tag{2}$$

where, u is the internal state of a neuron y. x_m is the neuron state of the m-th neuron.w_m and v are the weight connection between x_m and y and the threshold value respectively.

Complex Neuron Model:

$$U = \sum_{l}^{L} W_l X_l - V \tag{3}$$

$$y = (1 + e^{-Re(U)})^{-1} - (1 + e^{-Im(U)})^{-1} \tag{4}$$

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First variation of QN

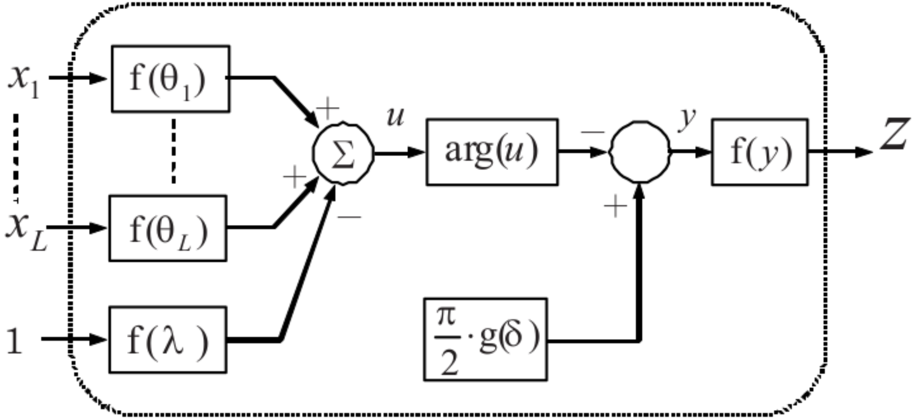
Qubit Neuron Model :

$$U = \sum_{l}^{L} f(\theta_l)x_l - f(\lambda) = \sum_{l}^{L} f(\theta_l)f(y_l) - f(\lambda) \tag{5}$$

$$y = \pi/2g(\delta) - arg(u) \tag{6}$$

Here, u is the internal state of a qubit neuron z. x_l is the qubit neuron state of the l-th neuron as one of inputs from L other qubit neurons θ_l and λ are the phases regarded as the weight connecting x_l to z and the threshold value, respectively.g is the sigmoid function with the range (0,1)

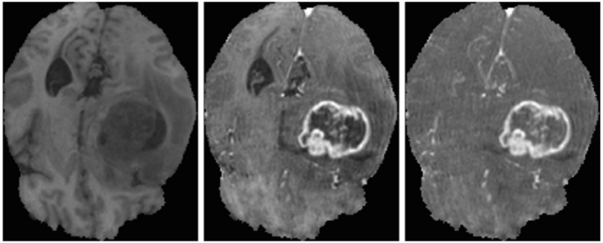
Qubit Neuron Model



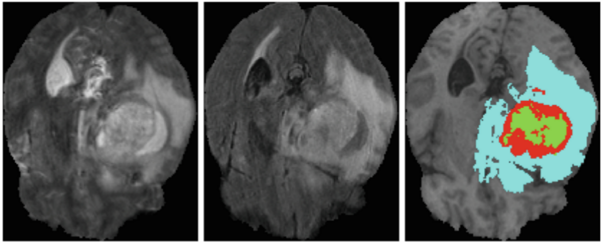
Available MRI Datasets

BraTS 2018 dataset and implemented NN:

- Data-set contains 286 MRI-scans from 19 different patients,
- T1 and T1 post-contrast(T1CE)
- T2 and T2 Fluid Attenuated Inversion Recovery(Flair)
- Hand annotated expert labels
- For Segmentation two 3dunet networks are used.
- As per paper accuracy is 0.536 in 200 epochs
- As per my implementation of network, accuracy is 0.21 in 20 epochs

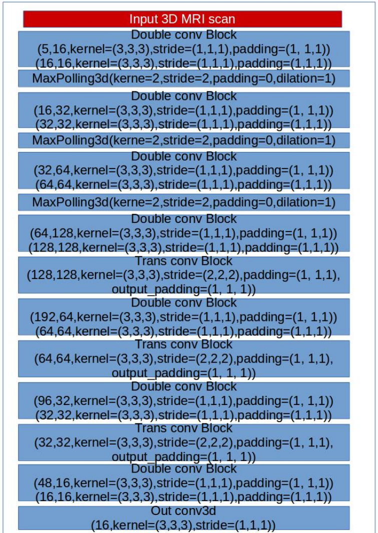


(a) T1 weighted (b) T1 post-contrast (c) Subtraction image



(d) T2 weighted (e) T2 Flair (f) T1 with labels

3dUnet model used in testing



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Available MRI Datasets

StructSeg 2019 dataset:

- Data-set contains 50 MRI-scans from 10 different patients,
- T1
- Hand annotated expert labels
- For Segmentation Resnet3d network is used.
- Accuracy is 0.58

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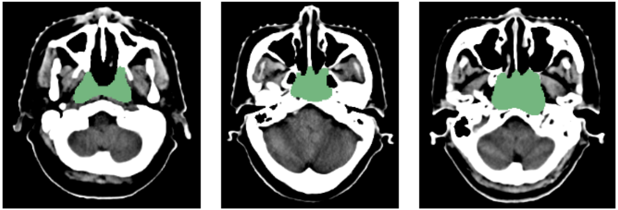
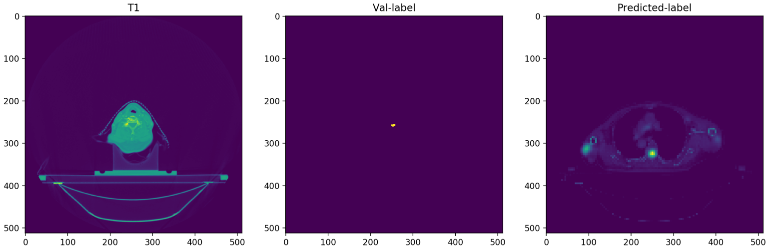


Result



Thanks