Quantum-inspired NN for IR

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Why need inspiration outside CS



Energy funtion Vs Boltzmann Machine

Why need inspiration outside CS



local receptive field Vs CNN/Attention

Quantum-inspired NN

• Examples

- Deep complex Network [ICLR 2018]
- LSTM + (weak value/two-state vector formulation) [ICONOP 2017]
- CNN + (wave function + superpostion collapse) [ICBI 2016]
- QLM for QA [AAAI 2018]

Examples: Complex Network [ICLR 2018]

Complex number Complex convolution

$$\begin{bmatrix} \Re(\mathbf{W} * \mathbf{h}) \\ \Im(\mathbf{W} * \mathbf{h}) \end{bmatrix} = \begin{bmatrix} \mathbf{A} & -\mathbf{B} \\ \mathbf{B} & \mathbf{A} \end{bmatrix} * \begin{bmatrix} \mathbf{x} \\ \mathbf{y} \end{bmatrix}$$

Complex-valued activations

$$modReLU(z) = ReLU(|z|+b) e^{i\theta_z} = \begin{cases} (|z|+b)\frac{z}{|z|} & \text{if } |z|+b \ge 0, \\ 0 & \text{otherwise,} \end{cases}$$

Complex weight initialization

Examples: LSTM with Quantum Attention [ICONIP 2017]





Fig. 4. Quantum Attention Mechanism.

weak value as attention weight

$$W_i = \frac{\langle c_i^{fin} | E_x x_i | c_i^{in} \rangle}{\langle c_i^{fin} | c_i^{in} \rangle}$$

Examples: QCNN [ICBI 2017]



Fig. 1. Illustration of quantum convolutional neural network

Examples: QLM in NN [AAAI 2018]



NN in IR

• Classification: assigning a label to a string

 $S \rightarrow C$

• Matching: matching two strings

 $s, t \rightarrow \mathbf{R}^+$

• Translation: transforming one string to another

$$s \rightarrow t$$

• Structured prediction: mapping string to structure

 $s \rightarrow s'$

Potencial

- Representation of information
 - complex word embedding
- Matching Process
 - Quantum Neural Matching with Interference
- Translation
 - Sequential modelling with Quantum Mechanism
 - Translation with Entanglement

Schedule

Lecture Topics	Lecture(s)	Date	Start	End
Introduction to Quantum	Prof. Massimo		9:30	11:00
Mechanics	Melucci			
Questions	-		11:00	11:15
Physical Mechanisms in Neural	Prof. Yuexian		12:00	13:30
Networks	Hou			
Questions			13:30	13:15
Quantum-inspired Neural	Prof. Peng		15:00	16:30
Networks in IR	Zhang			
Questions	-		16:30	16:45
Hand on Session (Implementing Quantum-Inspired	Benyou Wang		17:00	18:00
Neural Networks in Python)				

References

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