

Introductory Course to Tensor Networks

Monday, 25 September 2023 - Thursday, 28 September 2023

IGFAE - CESGA



Book of Abstracts

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Introduction to the Many-body problem

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1. Introduction to the many-body problem (1.5 hours)
 - 1.1. Tensor Networks
 - 1.1.0 Motivation
 - 1.1.1 Why to use tensor networks
2. (a) Building block 1.2.0 Vectors matrices tensors and their contractions in Penrose notation
 - 1.2.1 Tensor contractions, vector norms matrix vector multiplication, generalization
3. (a) The idea of data compression 1.3.0 Counting strings of bits 1.3.1 Counting strings of bits with constraints 1.3.2 From strings of bits to probability distributions of classical spins

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Entanglement

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1. Tensor networks for the many body problem 2.0 Defining many body systems 2.1 Without interaction, the product states 2.2 With interactions, strongly interacting problems in physics 2.3 The exponential scaling 2.4 Classes of states that can be represented efficiently

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Python tutorial 1

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Exact diagonalization of local Hamiltonians in 1D and the entanglement of their ground states

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Tensor networks

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1. Tensor networks (1.5 hours) 1.0 Basic definitions, and examples of networks 1.1 Cost of tensor contractions, the pairwise strategy, finding the correct sequence 1.2 Matrix factorization, the SVD, QR and higher order SVDs and QR decompositions 1.3 Special tensors unitaries and Isometries

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Gauge freedom and gauge fixing

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1. Gauge freedom and gauge fixing 2.0 Gauge freedom in TN 2.1 The orthogonality center of a TN, gauge fixing 2.2 Standard forms for creating the orthogonality center, direct decomposition and pulling through 2.3 Tensor decompositions inside a tensor network

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Python tutorial 2

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Using ncon to contract exemplary TN, e.g an MPS scalar product the expectation of a local operator in a MERA

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Matrix product states

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1. Matrix product states 1.0 Properties of MPS, correlation functions, reduced density matrices. 1.1 Standard MPS gauge fixing forms 1.2 Infinite matrix product states 1.3 The transfer matrix and its eigenvalues

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Connections with stat-mech

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1. Connections with stat-mech 2.0 Matrix product operators 2.1 The 2D classical Ising partition function 2.2 Matrix product operators 2.3 Boundary contraction of the 2D Ising partition function and TEBD

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Python tutorial 3

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Contracting the Ising partition function on an infinite plane, the boundary strategy and the corner transfer matrix

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Variational algorithms

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1. Variational algorithms 1.0 DMRG as a variational algorithm on MPS. 1.1 DMRG as a RG algorithm

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Overview of time dependence and higher dimensions

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1. Overview of time dependence and higher dimensions 2.0 Entanglement in time evolution, the exponential complexity 2.1. Time dependent DMRG 2.2 Higher dimensional TN, PEPS and MERA 2.3 Approximate contraction of PEPS wavefunctions

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Python tutorial 4,

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Quench in the Ising model with TEBD.

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Tensor Networks for the Industry: Ibermática.

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Tensor Networks are a Quantum-Inspired technology with utility far beyond basic research. Their great capacity to carry out complex calculations with few resources and emulate quantum systems

make them one of the great tools for the current and future industry. From Ibermática, different innovative methods have been investigated and applied to real industrial cases. In this presentation we will talk about some of these cases, with applied examples that can also be extrapolated to basic research.

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Fujitsu

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Tensor Networks for the Industry: Multiverse Computing

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Tensor Networks for the Industry: Fujitsu