Workshop on Tensor Theory and Methods

Paris, November 23-24, 2022

Welcome Address

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A Century (almost!) of Research on Tensors

From 1927…

Journal of Mathematics and Physics, 1927

THE EXPRESSION OF A TENSOR OR A POLYADIC AS A SUM OF PRODUCTS

By Frank L. Hitchcock

1. Addition and Multiplication.

Tensors are *added* by adding corresponding components. The *product* of a covariant tensor $A_{i_1 \cdots i_p}$ of order p *into* a covariant tensor $B_{i_{p+1} \cdots i_{p+q}}$ of order q is defined by writing

$$A_{i_1 \cdots i_p} B_{i_{p+1} \cdots i_{p+q}} = C_{i_1 \cdots i_{p+q}} \qquad (1)$$

where the product $C_{i_1 \cdots i_{p+q}}$ is a covariant tensor of order $p+q$. When no confusion results indices may be omitted giving

$$\mathbf{AB} = \mathbf{C} \qquad (1_a)$$

equivalent to the n^{p+q} equations (1). Boldface type is convenient for indicating that the letters do not denote merely numbers or scalars. Products of contravariant and of mixed tensors may be similarly defined.

A partial statement of the problem to be considered is as follows: to find under what conditions a given tensor can be expressed as a sum of products of assigned form. A more general statement of the problem will be given below.

2. Polyadic form of a tensor.

Any covariant tensor $A_{i_1 \cdots i_p}$ can be expressed as the sum of a finite number of tensors each of which is the product of p covariant vectors,

$$A_{i_1 \cdots i_p} = \sum_{j=1}^{j=h} a_{1j,\, i_1}\, a_{2j,\, i_2} \cdots a_{pj,\, i_p} \qquad (2)$$

where $a_{1j,\, i_1}$, etc., are a set of hp covariant vectors. When the indices $i_1 \cdots i_p$ can be omitted this may be written

$$\mathbf{A} = \sum_{j=1}^{j=h} \mathbf{a}_{1j} \mathbf{a}_{2j} \cdots \mathbf{a}_{pj}. \qquad (2_a)$$

The right member is now identical in appearance with a Gibbs

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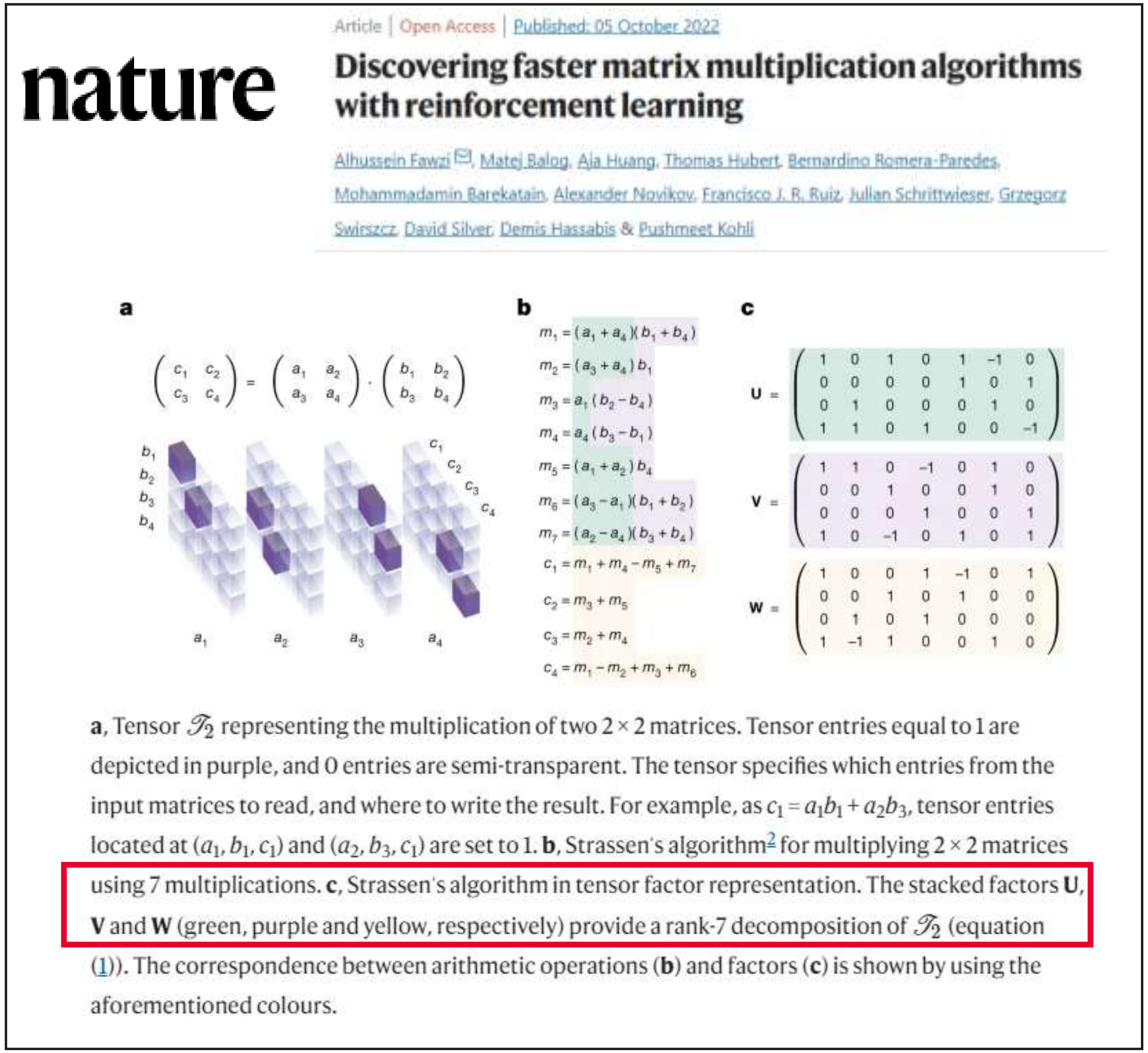
…to today



nature

Article | Open Access | Published: 05 October 2022

Discovering faster matrix multiplication algorithms with reinforcement learning

Alhussein Fawzi, Matej Balog, Aja Huang, Thomas Hubert, Bernardino Romera-Paredes, Mohammadamin Barekatain, Alexander Novikov, Francisco J. R. Ruiz, Julian Schrittwieser, Grzegorz Swirszcz, David Silver, Demis Hassabis & Pushmeet Kohli

a, Tensor $\mathcal{T}_2$ representing the multiplication of two 2×2 matrices. Tensor entries equal to 1 are depicted in purple, and 0 entries are semi-transparent. The tensor specifies which entries from the input matrices to read, and where to write the result. For example, as $c_1 = a_1b_1 + a_2b_3$, tensor entries located at (a_1, b_1, c_1) and (a_2, b_3, c_1) are set to 1. **b**, Strassen's algorithm[2] for multiplying 2×2 matrices using 7 multiplications. **c**, Strassen's algorithm in tensor factor representation. The stacked factors **U**, **V** and **W** (green, purple and yellow, respectively) provide a rank-7 decomposition of $\mathcal{T}_2$ (equation (1)). The correspondence between arithmetic operations (**b**) and factors (**c**) is shown by using the aforementioned colours.

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Workshop Schedule – Day 1

Time (CET)	Title	Speaker
9:30 – 10:00	Welcome Coffee (for on-site participants)	
10:00 – 10:15	Opening Speech	Dr. Maxime Guillaud, Huawei (France)
10:15 – 10:30	Challenges of Deep Learning Algorithm and Domain Specific Silicon Architecture	Dr. Wen Tong, CTO of Huawei Wireless (Canada)
10:30 – 11:20	Tensor Modeling Based Wireless Communications	Prof. André de Almeida, Federal University of Ceará (Brazil)
11:20 – 12:10	Neural networks, flexible activation functions and tensor approximation	Dr. Konstantin Usevich, CNRS/CRAN (France)
12:10 – 14:00	Lunch (for on-site participants)	
14:00 – 14:50	Guarantees for well-posedness of canonical polyadic approximation and numerical linear algebra based estimation	Prof. Lieven De Lathauwer, KU Leuven (Belgium)
14:50 – 15:40	Tensor PCA; detecting and finding a signal in random tensors	Prof. Gerard Ben Arous, New York University (USA)
15:40 – 16:00	Coffee Break	
16:00 – 16:50	Tropical linear regression and low-rank approximation — a first step in tropical data analysis	Dr. Yang Qi, INRIA and École Polytechnique (France)
16:50 – 17:40	Nonnegative Tucker Decomposition: applications, algorithms and open questions	Dr. Jeremy Cohen, CREATIS CNRS (France)
19:00	Dinner (for on-site participants)	

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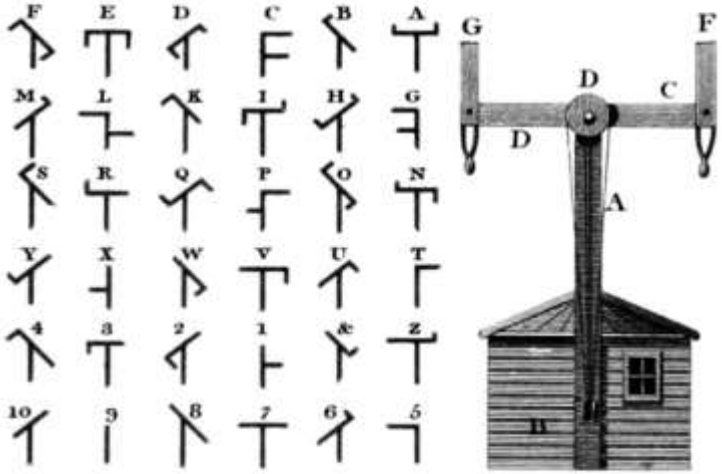
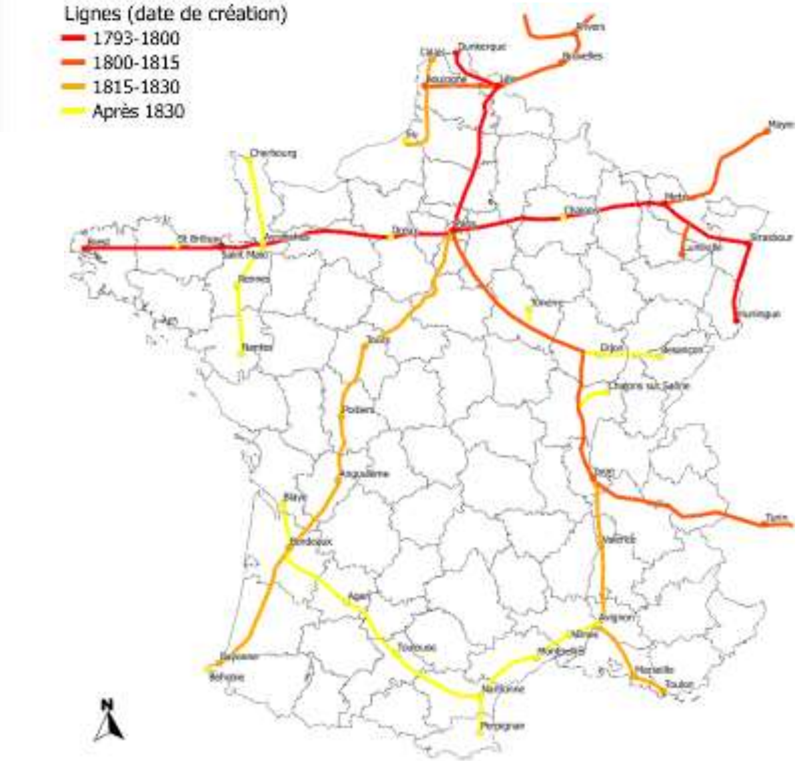
Workshop Schedule – Day 2

Time (CET)	Title	Speaker
9:00 – 9:50	A random matrix perspective on random tensors	Prof. Henrique de Morais Goulart, INP Toulouse (France)
9:50 – 10:40	Efficient Maximum Likelihood Estimation of a Low-Rank Probability Mass Tensor from Partial Observations	Prof. Martin Haardt, TU Ilmenau (Germany)
10:40 – 11:00	Coffee Break	
11:00 – 11:50	Coupled Tensor Decompositions for Hyperspectral Super Resolution	Prof. David Brie, CRAN, Lorraine University (France)
11:50 – 12:40	Asymptotic Analysis of Asymmetric Spiked Tensor Models with Random Matrix Theory	Dr. Mohamed El Amine Seddik, Huawei (France)
12:40	Lunch (for on-site participants)	

A Historical Location

Napoleonic Telecommunications: The Chappe Telegraph System





The regulator could be positioned vertically or horizontally (when it was in an oblique, or diagonal, position, it was not transmitting a signal). Each indicator could be placed at one of seven angles, each 45 degrees apart (excluding the position in which an indicator was extending the regulator). This resulted in a total of 98 (2 x 7 x 7) unique positions. Six positions were reserved for control signals, leaving 92 positions for coded signals (letters of the alphabet, numbers, frequently-used syllables).

In 1795, a 92-page code book was introduced, along with a two-step signalling system. The first signal indicated the page of the code book; the second indicated the line (individual words, abbreviations, sentences, etc., numbered from 1 to 92) on that page. This meant that 8464 (92 x 92) codes could be transmitted. Later refinements eventually resulted in 40,000 codes.

(From *Napoleonic Telecommunications* by Shannon Selin)

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Thank you.

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每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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