# Vedran Novaković

*curriculum vitæ / résumé*

*Vankina ulica 15*
*HR-10020 Zagreb, Croatia*
*+385989764688*
*venovako@gmail.com*
`https://venovako.eu`

## Personal, contact, and activity details

| | |
|---|---|
| at present | unemployed; *titular research associate* [ "znanstveni suradnik" ] since 2018-05-08 (the lowest of four old, life-long Croatian research titles held irrespecitvely of employment) |
| other emails | venovako@venovako.eu & venovako@math.hr |
| ORCID | `https://orcid.org/0000-0003-2964-9674` |
| WoS record | `https://www.webofscience.com/wos/author/rid/G-2568-2011` |
| arXiv | `https://arxiv.org/a/novakovic_v_1.html` |
| GitHub | `https://github.com/venovako` |
| social | I have *no* accounts on social networks (Facebook, Instagram, LinkedIn, X, etc.). |

## Education

| | |
|---|---|
| – 2017-12-15 | PhD in mathematics (since November 2006 with multiple long breaks); University of Zagreb, Faculty of Science, Department of Mathematics (advisor: Sanja Singer[†]) |
| thesis & title | *Parallel Jacobi-type algorithms for the singular and the generalized singular value decomposition* [ in English, `https://urn.nsk.hr/urn:nbn:hr:217:515320` ] [dr. sc.] |
| field of study | numerical mathematics and scientific computing (parallel numerical linear algebra) |
| – 2006-05-15 | a four-year program in mathematics with a specialization in computer science in the last two years; University of Zagreb, Faculty of Science, Department of Mathematics |
| thesis & title | *Formal software specification and verification* [ in Croatian ] [ dipl. ing. (original old title) / univ. mag. inf. et math. ] |
| high school | four-year secondary education at XV. Gymnasium (MIOC), Zagreb |

## Employment (full-time)

• Universitat Jaume I / Universidad Jaime I (Castellón de la Plana, Spain)

2018-03 – 2018-09 *researcher* [ "técnico superior (investigador)" ] funded by INTERTWinE, collaborating on OPRECOMP ("Open Transprecision Computing"), EU Horizon 2020 projects; transforming the BLAS and the LAPACK (the LU factorization and the singular value decomposition routines) numerical linear algebra libraries to employ reduced floating-point precision datatypes provided by the FloatX library, testing and contributing to papers (person in charge: Enrique S. Quintana-Ortí)

• Science and Technology Facilities Council, Daresbury Laboratory (UK)

2016-10 – 2017-10 *computational scientist* at the Hartree Centre; software testing, benchmarking, and debugging on "Parallel Numerical Linear Algebra for Extreme Scale Systems" EU Horizon 2020 FET-HPC project (NLAFET), related to an in-house, hybrid CPU+GPU direct solver for sparse linear systems (person in charge: Iain Duff)

2015-02 – 2016-09 *computational scientist* at the Scientific Computing Department, Technology Division, Application Performance Engineering group; HPC benchmarking of the storage systems & the FFT libraries, and software prototyping for the Square Kilometre Array (SKA) radiotelescope project's Science Data Processor consortium, ARCH.SWE and PROT.ISP workpackages (person in charge: Mike Ashworth)

• University of Zagreb / Sveučilište u Zagrebu (Croatia)

2007-12 – 2014-11 *teaching assistant* [ "asistent" ] at Faculty of Mechanical Engineering and Naval Architecture, Chair of Mathematics; assisting with teaching and grading of the basic univariate and multivariate real calculus, complex and numerical analysis, linear algebra, and probability undergraduate classes for the engineering students

2007-01 – 2007-11 *professional associate* [ "stručni suradnik" ] at Faculty of Mechanical Engineering and Naval Architecture, working as a software developer on the industrial project "OpenIPMP" (PI: Dean Rosenzweig†), funded by ObjectLab LLC from New York; co-developing a Java-based server-side public key infrastructure implementation of Open Mobile Alliance Digital Rights Management for Nokia mobile devices

2006-07 – 2006-12 *professional associate* [ "stručni suradnik" ] at Faculty of Science, Department of Mathematics, working as a software developer on the technology project "CRO-GRID Applications" funded by the Croatian science ministry (PI: Robert Manger); investigating grid execution engines

## Research engagement not related to employment

2019-09 – present independent researcher on the topics of personal interest

2015-05 – 2019-08 researcher on the "Matrix Factorization and Block Diagonalization Algorithms" project (MFBDA) funded by the Croatian Science Foundation (PI: Vjeran Hari)

2008-10 – 2013-12 researcher on the project "Numerical methods in geophysical models" funded by the Croatian science ministry (PIs: Mladen Rogina†, later Saša Singer†)

since August 2010 participated in research and teaching related to the NVIDIA Academic Partnership Program with University of Zagreb (PI: Zlatko Drmač, co-PI: Sanja Singer)

## Teaching engagement not related to employment

2006-10 – 2014-12 titular teaching assistant on a part-time contractual basis at Department of Mathematics, Faculty of Science, University of Zagreb, responsible for the "practical" part (known as "exercises" in Croatia) of various undergraduate and graduate computing-related courses, and for grading written exams and student projects

2008-10 – 2009-01 helped grading of the graduate course "Advanced algorithms and data structures" at Faculty of Electrical Engineering and Computing, University of Zagreb

## Research summary and contributions as a co-author

My research field is *numerical linear algebra* in general, and *parallelization* and computational aspects of the dense matrix decomposition and factorization algorithms in particular, with a major focus on parallelization (including vectorization [3, 6, 7]) of the Jacobi-type algorithms for the (generalized and/or hyperbolic) singular value decomposition (SVD) on CPU and GPU clusters. In publications [4–7, 9, 11–14], covering the topics of the (generalized) eigendecomposition and the SVD-like methods, I redesigned the sequential algorithms for efficient parallel execution and improved floating-point stability, written the entire GPU code and most of the newer CPU code (from 2015 onwards), or the parallel parts of the implementation, co-designed the testing data and methodology, performed testing,

and written the respective parts of the papers (figures mostly not included). The secondary research objective is improving *reproducibility and accuracy* of the output of such algorithms by a targeted usage of the modern features of computer arithmetic in the algorithms' building blocks, like the Jacobi rotations, the Euclidean norm computation, etc., what is addressed in publications [2–7, 11]. My contribution to the other journal papers is also from the numerical linear algebra perspective. For [8], I translated the Fortran BLAS and parts of the LAPACK library concerning the LU factorization and the SVD to C++, adapted them to compute with a set of reduced-precision floating-point types, provided by the FloatX library, tested those modifications and wrote the corresponding parts the paper. For [10], I implemented and tested HySimeSA, a parallel extension of the QR factorization. For [15], I set up the symbolic computations of the condition numbers of some matrices induced by the B-spline collocation and helped relating their smallest eigenvalues with certain integer sequences.

## Teaching summary

I was assisting with teaching (exercises and exam grading) at *Faculty of Mechanical Engineering and Naval Architecture* of the undergraduate courses *Mathematics I*, *II*, *3*, *IIIA*, *IIIB*, *IV*, *IVA* in the respective semesters during several years, covering basic univariate, multivariate, and complex-variable calculus, linear algebra, elements of probability and numerical analysis for the engineering students.
At *Department of Mathematics*, I co-designed (with Sanja Singer) the syllabus for the exercises (15 hours/semester) for the elective graduate courses *Introduction to parallel computing* (fall) and *Applications of parallel computers* (spring), consisting of the basic POSIX threading, MPI, OpenMP, and CUDA programming. Also, I contributed to the syllabus for the exercises (30 hours/semester) for the compulsory undergraduate courses *Programming 1* (fall) and *Programming 2* (spring) in C.
All courses for which I held exercises at Department of Mathematics: *Computer Science Lab 4* (C++, compulsory for the specialization in computer science, fall semester of the fourth year, 60 hours, 2006/07), *Programming 1 & 2* (first year, 2008/09 – 2009/10), *Introduction to parallel computing* (2008/09 – 2013/14) and *Application of parallel computers* (2008/09 – 2012/13), and the precursors of the latter two, *Parallel Algorithms 1 & 2*, respectively (fall & spring semester, elective in the last two years, 30 hours each, 2007/08). I also assisted several master students supervised by Sanja Singer with the parallel computing parts of their theses; in the case of Gayatri Čaklović, her thesis influenced [7].

## Service activities

| | |
|---|---|
| peer review (journals) | - IEEE Transactions on Geoscience and Remote Sensing (1)<br>- SIAM Journal on Matrix Analysis and Applications (1)<br>- Software: Practice and Experience (1)<br>- The Journal of Supercomputing (2) |
| peer review (conferences) | International Conference on Parallel Processing and Applied Mathematics PPAM: 2015 (1), 2017, 2022 |
| other review | Mathematical Reviews/MathSciNet (2) |
| organizing committee | Co-organized the Parallel Numerics workshop (ParNum 2019); Dubrovnik, Croatia, 28–30 October 2019 (set up the web registration system, helped with procurement, applications for funding, web design, and the participants' email inquiries). |
| system administration | Helped with procurement and administration of a small Intel Xeon Phi cluster and some GPU-equipped systems at Department of Mathematics, University of Zagreb. |

## Conferences/workshops/seminars attended with a presentation

... excluding the events where I was a participant only and the PhD-related seminar talks in Croatian. Also, the SKA-related events and activities are omitted since those were regular business meetings.

Where a talk (T) or a poster (P) has more than one author, the presenting one is underlined.

PMAA18 $10^{\text{th}}$ International Workshop on Parallel Matrix Algorithms and Applications; 27–29 June 2018, Zürich, Switzerland
- T VN. *A GPU variant of the implicit Hari–Zimmermann algorithm for the generalized SVD.*
- T Sanja Singer, Edoardo di Napoli, VN, Gayatri Čaklović. *Parallel solution of the generalized eigenvalue problem given in a factored form.*

seminar talk VN. *The implicit Jacobi-type methods for the (generalized) singular value decomposition on the GPU(s).* IBM Research Zürich; 26 June 2018.

PMAA14 $8^{\text{th}}$ International Workshop on Parallel Matrix Algorithms and Applications; 2–4 July 2014, Lugano, Switzerland
- T VN. *A blocked Jacobi SVD algorithm for single and multiple GPU(s).*
- T Sanja Singer, VN, Saša Singer. *Parallelization of the Falk–Langemeyer method.*

IWASEP 10 $10^{\text{th}}$ International Workshop on Accurate Solution of Eigenvalue Problems; 2–5 June 2014, Dubrovnik, Croatia
- P VN. *A hierarchically blocked Jacobi SVD algorithm for single and multiple GPU(s).*

seminar talk VN. *A fast Jacobi-type SVD for the graphics processors.* Numerical Analysis and Scientific Computing Seminar, Manchester Institute for Mathematical Sciences, The University of Manchester, UK; 9 September 2013.

PIMS Workshop on Numerical Linear Algebra and Optimization; 8–10 August 2013, Vancouver (BC), Canada
- P VN. *A Parallel Jacobi-type SVD Algorithm for the GPU Clusters.*

IWASEP 9 $9^{\text{th}}$ International Workshop on Accurate Solution of Eigenvalue Problems; 4–7 June 2012, Napa Valley (CA), USA
- T Sanja Singer, VN. *Kogbetliantz-like Method for the Hyperbolic SVD.*
- T VN, Sanja Singer. *Towards Multi-GPU Jacobi (H)SVD.*

SC2011 International Conference on Scientific Computing; 10–14 October 2011, S. Margherita di Pula (SAR), Italy
- T Sanja Singer, VN. *Kogbetliantz-like method for hyperbolic SVD.*

ApplMath11 $7^{\text{th}}$ Conference on Applied Mathematics and Scientific Computing; 13–17 June 2011, Trogir, Croatia
- T VN, Saša Stanko, Sanja Singer. *Parallel Hybrid CPU-GPU Full-Block Jacobi Algorithm for Hyperbolic SVD.*

IWASEP 8 $8^{\text{th}}$ International Workshop on Accurate Solution of Eigenvalue Problems; 28 June – 1 July 2010, Berlin, Germany
- P VN, Sanja Singer. *A GPU-based hyperbolic SVD algorithm.*

BIT50 BIT50 Trends in Numerical Computing; 17–20 June 2010, Lund, Sweden
- T VN, Sanja Singer. *A GPU-based hyperbolic SVD algorithm.*

LA09 SIAM Conference on Applied Linear Algebra; 26–29 October 2009, Seaside (CA), USA
- T Sanja Singer, Saša Singer, VN. *Orthosymmetric Block Reflectors and QR Factorizations.*

ApplMath09 $6^{\text{th}}$ Conference on Applied Mathematics and Scientific Computing; 14–18 September 2009, Zadar, Croatia
- T VN, Sanja Singer, Saša Singer. *Cardinal Splines, Töplitz Matrices and Circulants.*
- T Vjeran Hari, Saša Singer, VN, Sanja Singer. *Parallelization and pivoting in one-sided Jacobi algorithms.*

NACONF 23rd Biennial Conference on Numerical Analysis; 23–26 June 2009, Glasgow (SCO), UK
T Vjeran Hari, Saša Singer, VN, Sanja Singer. *New Advances in One-Sided Jacobi Algorithms.*

ConTEL 2007 9th International Conference on Telecommunications; 13–15 June 2017, Zagreb, Croatia
T Matko Botinčan, VN. *Model-based testing of the Conference Protocol with Spec Explorer.*

## Languages (human and computer)

Croatian native speaker *understanding of other south Slavic languages/dialects to various extents*
English reasonably proficient in reading (used daily) and writing *somewhat less in conversation*
programming C, Fortran, C++, Matlab, Mathematica; a few others *in order of skills and preference*

## Publications

[1] V. Novaković, *Arithmetical enhancements of the Kogbetliantz method for the SVD of order two*, arXiv:2407.13116 [math.NA]. [accepted for publication in Numerical Algorithms] https://doi.org/10.1007/s11075-025-02035-7

IN JOURNALS

[2] V. Novaković, *Accurate complex Jacobi rotations*, J. Comput. Appl. Math., 450 (2024), art. no. 116003, https://doi.org/10.1016/j.cam.2024.116003. [short communication]

[3] V. Novaković, *Vectorization of a thread-parallel Jacobi singular value decomposition method.* SIAM J. Sci. Comput., 45 (2023), pp. C73–C100, https://doi.org/10.1137/22M1478847. Erratum: Sect. 5.3.1, $r_U = \|U^*U - I\|_F^2$ and $r_V = \|V^*V - I\|_F^2$.

[4] V. Novaković and S. Singer, *A Kogbetliantz-type algorithm for the hyperbolic SVD.* Numer. Algorithms, 90 (2022), pp. 523–561, https://doi.org/10.1007/s11075-021-01197-4.

[5] V. Novaković and S. Singer, *Implicit Hari–Zimmermann algorithm for the generalized SVD on the GPUs*, Int. J. High Perform. Comput. Appl., 35 (2021), pp. 170–205, https://doi.org/10.1177/1094342020972772.

[6] V. Novaković, *Batched computation of the singular value decompositions of order two by the AVX-512 vectorization*, Parallel Process. Lett., 30 (2020), art. no. 2050015, https://doi.org/10.1142/S0129626420500152.

[7] S. Singer, E. Di Napoli, V. Novaković, and G. Čaklović, *The LAPW method with eigendecomposition based on the Hari–Zimmermann generalized hyperbolic SVD*, SIAM J. Sci. Comput., 42 (2020), pp. C265–C293, https://doi.org/10.1137/19M1277813.

[8] G. Flegar, F. Scheidegger, V. Novaković, G. Mariani, A. E. Tomás, A. C. I. Malossi, and E. S. Quintana-Ortí, *FloatX: A C++ library for customized floating-point arithmetic*, ACM Trans. Math. Software, 45 (2019), art. no. 40, https://doi.org/10.1145/3368086.

[9] V. Novaković, S. Singer, and S. Singer, *Blocking and parallelization of the Hari–Zimmermann variant of the Falk–Langemeyer algorithm for the generalized SVD*, Parallel Comput., 49 (2015), pp. 136–152, https://doi.org/10.1016/j.parco.2015.06.004.

[10] P. Benner, V. Novaković, A. Plaza, E. S. Quintana-Ortí, and A. Remón, *Fast and reliable noise estimation for hyperspectral subspace identification*, IEEE Geosci. Remote Sens. Lett., 12 (2015), pp. 1199–1203, https://doi.org/10.1109/LGRS.2014.2388133.

[11] V. Novaković, *A hierarchically blocked Jacobi SVD algorithm for single and multiple graphics processing units*, SIAM J. Sci. Comput., 37 (2015), pp. C1–C30, https://doi.org/10.1137/140952429.

[12] S. Singer, S. Singer, V. Novaković, D. Davidović, K. Bokulić, and A. Ušćumlić, *Three-level parallel J-Jacobi algorithms for Hermitian matrices*, Appl. Math. Comput., 218 (2012), pp. 5704–5725, https://doi.org/10.1016/j.amc.2011.11.067.

[13] S. Singer, S. Singer, V. Novaković, A. Ušćumlić, and V. Dunjko, *Novel modifications of parallel Jacobi algorithms*, Numer. Algorithms, 59 (2012), pp. 1–27, https://doi.org/10.1007/s11075-011-9473-6.

[14] V. Novaković and S. Singer, *A GPU-based hyperbolic SVD algorithm*, BIT, 51 (2011), pp. 1009–1030, https://doi.org/10.1007/s10543-011-0333-5.

[15] V. Novaković, S. Singer, and S. Singer, *Estimates for the spectral condition number of cardinal B-spline collocation matrices*, Math. Commun., 15 (2010), pp. 503–519. https://hrcak.srce.hr/61876.

IN CONFERENCE PROCEEDINGS

[16] H. Anzt, G. Flegar, V. Novaković, E. S. Quintana-Ortí, and A. E. Tomás, *Residual replacement in mixed-precision iterative refinement for sparse linear systems*, in ISC High Performance 2018 International Workshop on "Approximate and Transprecision Computing on Emerging Technologies" (ATCET 2018), Frankfurt, Germany, vol. 11203 of Lecture Notes in Computer Science, 2018, pp. 554–561, https://doi.org/10.1007/978-3-030-02465-9_39.

[17] M. Ashworth, J. Meng, V. Novaković, and S. Siso, *Early application performance at the Hartree Centre with the OpenPOWER architecture*, in ISC High Performance 2016 International Workshop on OpenPOWER for HPC (IWOPH'16), Frankfurt, Germany, vol. 9945 of Lecture Notes in Computer Science, 2016, pp. 173–187, https://doi.org/10.1007/978-3-319-46079-6_13.

[18] M. Botinčan and V. Novaković, *Model-based testing of the Conference Protocol with Spec Explorer*, in 9th International Conference on Telecommunications (ConTEL 2007), Zagreb, Croatia, 2007, pp. 131–138, https://doi.org/10.1109/CONTEL.2007.381861.

IN POPULAR SCIENCE VENUES

[19] M. Doko and V. Novaković, *Izračunljivost i apstraktni strojevi* (Computability and abstract machines), Math.e, 9 (2006), pp. 30–48. https://hrcak.srce.hr/6217.

 March 5, 2025