LIBRSB

Journey from PhD By-product to universally usable Sparse Linear Algebra Library

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$C = A \cdot B$

$C = \overbrace{\begin{bmatrix} [\cdot] & [\cdot] \\ [\cdot] & [\cdot] \end{bmatrix}}^{\text{sparse } A} \cdot B$

$$C = \begin{bmatrix} [\cdot] & \begin{pmatrix} 0 & \begin{pmatrix} 0 & [\cdot] \\ [\cdot] & [\cdot] \end{pmatrix} \\ [\cdot] & [\cdot] \end{pmatrix} \\ \begin{pmatrix} [\cdot] & \begin{pmatrix} 0 & [\cdot] \\ [\cdot] & [\cdot] \end{pmatrix} \\ \begin{pmatrix} [\cdot] & [\cdot] \\ [\cdot] & [\cdot] \end{pmatrix} & [\cdot] \end{pmatrix} & [\cdot] \end{bmatrix} \cdot B$$

LIBRSB

Universal *Sparse BLAS* Library

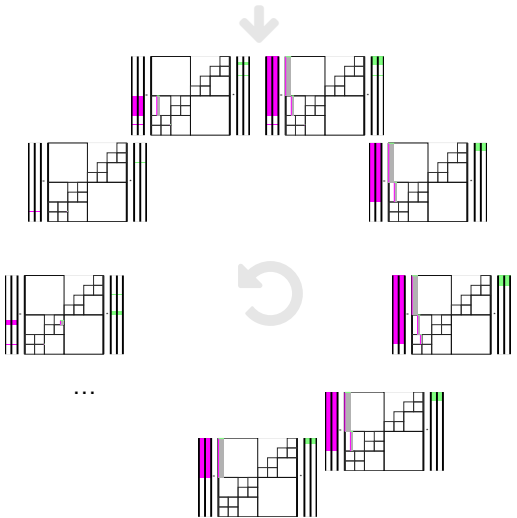
THE C PROGRAMMING LANGUAGE

C++

SciPy.org

GNU Octave

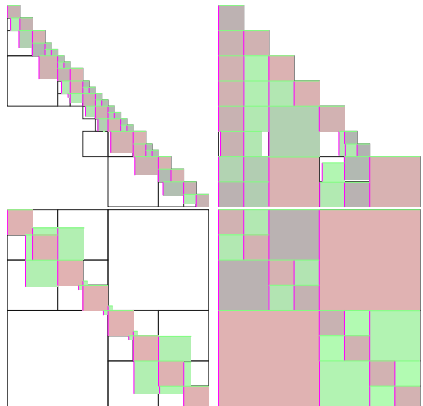
...



https://librsb.sf.net

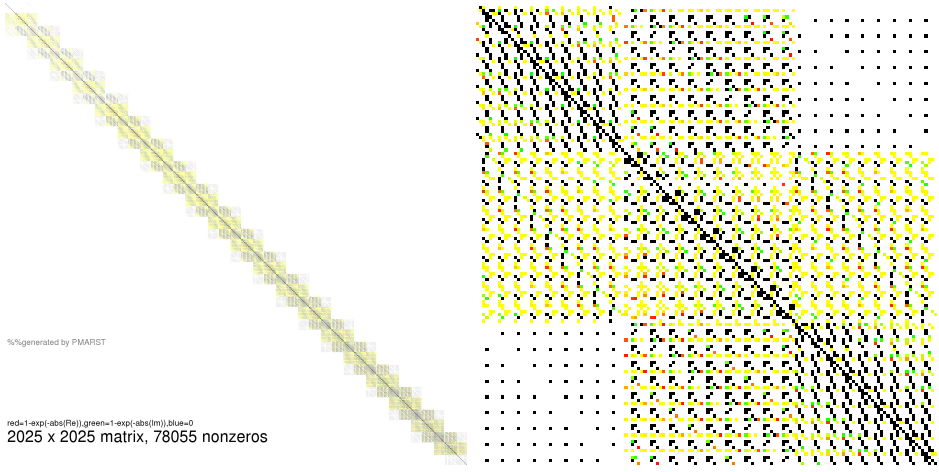
apt install librsb-dev # spack install librsb # guix install librsb # eb search librsb

- BLAS Technical Forum Sparse BLAS API:
  - Manage sparse matrix A
  - SpMM/SpMV variants:
  - $C \leftarrow C + A \cdot B$
  - $C \leftarrow C + A^T \cdot B$
  - $C \leftarrow C + A' \cdot B$
  - Variations: symmetry, diagonal, type, stride, ...
  - More operations ...
- LIBRSB uses RSB layout, see samples $\Longrightarrow$



existing matrices in RSB layout

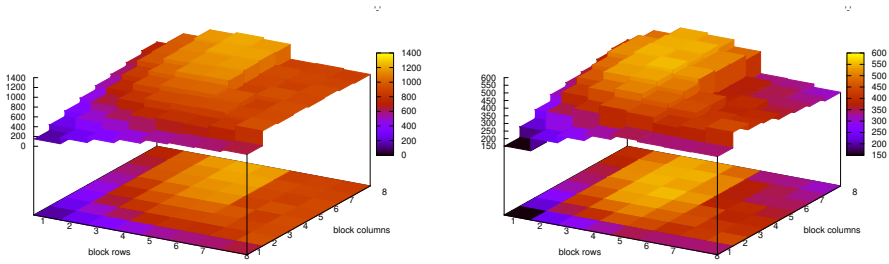
2007 Linear Algebra software: sparse vs dense



MARST (plasma physics) matrix (l) and detail on a panel (r). Own rendering.

- SuperLU vs ScaLAPACK study

2008 “SpMV is worth a PhD research”

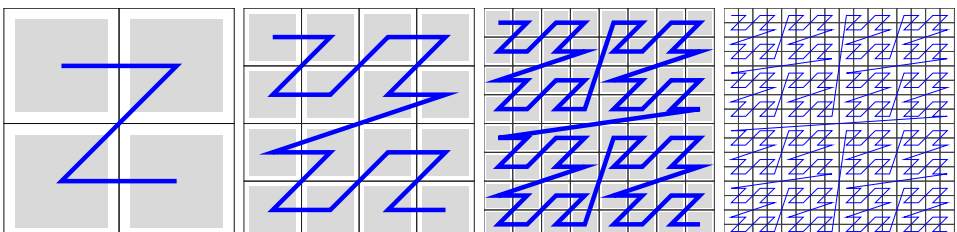


Bogus (l) and effective (r) MFLOPS in BCSR. Own work.

- Small dense blocking aka BCSR (see picture, from my experiments)
- Cache blocking
- Empirical (static) performance tuning

2009 Let's empty the ocean with a spoon

- Code generator with BCSR
- Block recursion



Recursive subdivision in action. Blue line is order in memory.

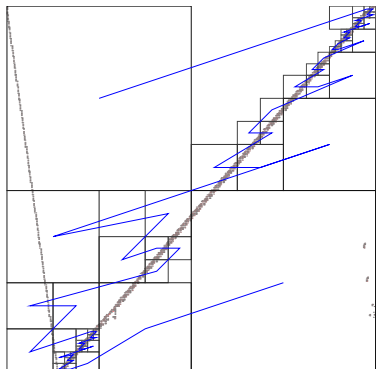
2010 RSB: Convergence or divergence?

- Added:
  - SpSV ($T^{-1} \cdot X$ or *triangular solve*)
  - `short` indices optimization
  - Recursion and parallel assembly
- Removed: BCSR

Harihara. Unknown author. Public domain, via Wikimedia Commons

2011 RSB for PhD

- RSB consolidated
- Dig extra bibliography...
- Prepare thesis



2012 Idea or sought-after *Artifact*?

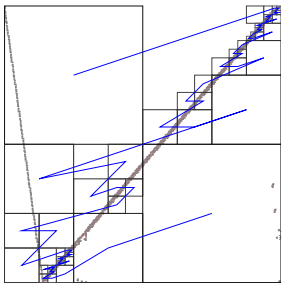
- Sparse BLAS =
  - create matrix
  - SpMM
  - SpSM (triangular solve)
  - destroy matrix
  - format is hidden thing
  - lots of small options
- Rush into cleanup
  - symbols rename
  - documentation and examples
  - error checks

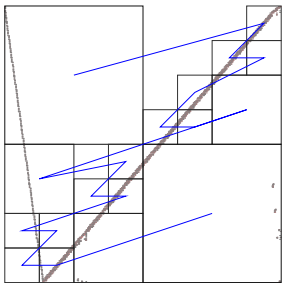
Holy Grail, Dante Gabriel Rossetti, 1874. Public domain, via Wikimedia Commons

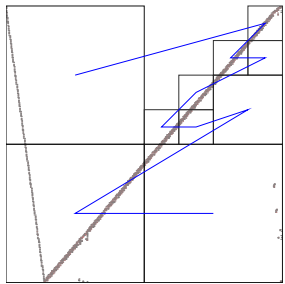
2013

- Release 1.0!
- New developments
  - `sparsersb` for GNU Octave
  - Introduce *autotuning*

2014 Refine







- Better autotuning (dynamic)
- Began a librsb-1.3 split branch
- Performance reporting

2015

- Performance reporting
- Minor bugs

Beetle. Own photo.

2016

- Polishing corner cases...
- Bugs shock! (1.2.0-rc3)

Another bug. Own photo.

2017

- PyRSB: LIBRSB for Python
- Bugs

Yet another bug. Own photo.

2018 I find more bugs

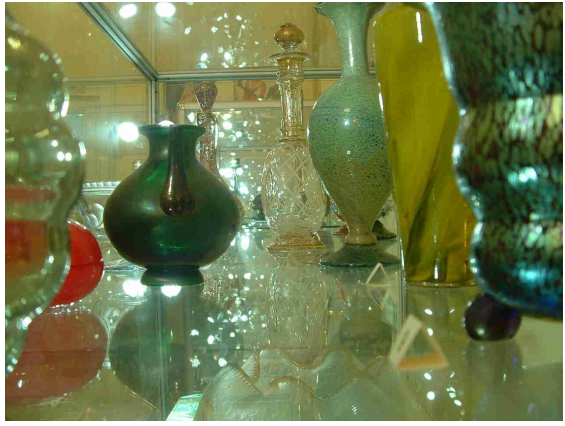
How to stop them?

2019–2021 PRACE collaboration

- PRACE (Partnership for Advanced Computing in Europe) grant
- Both HPC and *code sustainability* aspects
- Collaboration with Inria (France) and CaSToRC (Cyprus)

2019–2020 Just don't break anything

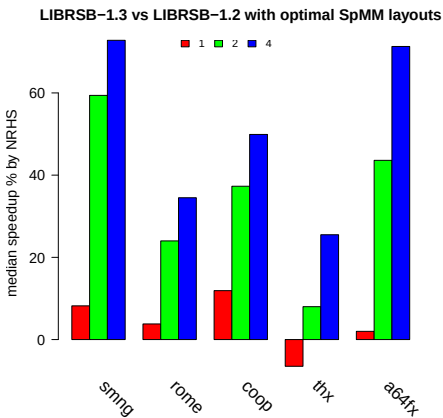
- Increase coverage from 35%...
- Fix petty bugs



Etnographic Museum, Lviv, Ukraine. Own photo.

2020–2021 Faster!

- Improve SpMM performance with new C++ kernels
- Reach coverage of L:92%, F:99%!
- C++20 API (template `class RsbMatrix`)



2022 Unforeseen bug and methodic fix

- gcc-11 bug affecting dozens of functions
- Fix: conditional COCCINELLE *semantic patch* to the code[1]

```
@pragma_inject@
identifier i =~ "rsb__BCSR_spmv_sasa_double_complex_[CH]__t[NTC]_r1_c1_uu_s[HS]
    _dE_uG";
type T;
@@
+ #pragma GCC push_options
+ #pragma GCC optimize "-O3", "-fno-tree-loop-vectorize"
T i(...)
{
 ...
}
+ #pragma GCC pop_options
```

[1] https://coccinelle.gitlabpages.inria.fr/

Reflections

- Distractions:
  - `svn`, `git`, `hg`
  - GitHub, Savannah, SourceForge
  - Fortran, C, C++, m4
  - Python, Octave

Own photo.

Resiliency

- Remove code, compact it, make uniform
- *Common case* is shifting
- How to refactor a large test suite?

Clothes iron. Etnographical Museum of Berat, Albania. Own photo.

Grand Architectures

Colosseum in Rome, Italy. Own photo.

- Maintenance can be challenging
- Need good engineering