



## Research interests:

Formal derivation of algorithms; linear and multilinear algebra; high-performance computing

## Project ideas:

Taking FLAME in more challenging directions:

- Factorization of skew-symmetric matrices
- Contraction with structured tensors
- In-place tensor factorization

## Collaborators:

- UT Austin: Formal derivation, high-performance linear algebra
- SMU: Computational chemistry
- CMU: Formal methods and high-performance computing

## Projects:

- PLAPACK
- FLAME
- libflame
- SuperMatrix
- Elemental
- ROTE
- DxTer
- BLIS

**The FLAME Workflow**

1.  $A = LL^H$

2.  $\begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix} = \begin{pmatrix} L_{TL} & * \\ L_{BL} & L_{BR} \end{pmatrix} \wedge \begin{pmatrix} \hat{A}_{TL} = L_{TL}L_{TL}^H & * \\ A_{BL} = L_{BL}L_{TL}^H & A_{BR} = L_{BL}L_{BL}^H + L_{BR}L_{BR}^H \end{pmatrix}$

3. Invariant:  $\begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix} = \begin{pmatrix} L_{TL} & * \\ L_{BL} & L_{BR} \end{pmatrix} \wedge \begin{pmatrix} \hat{A}_{TL} = L_{TL}L_{TL}^H & * \\ A_{BL} = L_{BL}L_{TL}^H & A_{BR} = L_{BL}L_{BL}^H + L_{BR}L_{BR}^H \end{pmatrix}$

4.  $A \rightarrow \begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix} \rightarrow \begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix} \rightarrow \begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix} \rightarrow \begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix}$

5. Algorithm:  $|A| = \text{CHOL\_BLK}(A)$

6.  $\begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix} \rightarrow \begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix} \rightarrow \begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix} \rightarrow \begin{pmatrix} A_{TL} & A_{TR} \\ A_{BL} & A_{BR} \end{pmatrix}$

7.  $\text{FLA\_Part\_2x2}(A, \&ATL, \&ATR, \&ABL, \&ABR, 0, 0, \text{FLA\_TL});$

8.  $\text{FLA\_Repart\_2x2\_to\_3x3}(\text{ATL}, \&*/ \&ATR, \&A00, \&*/ \&A01, \&A02, \&*/ \&A10, \&*/ \&A11, \&A12, \&A20, \&*/ \&A21, \&A22, \text{ABL}, \&*/ \&ABR, \text{b}, \text{b}, \text{FLA\_BR});$

9.  $\text{FLA\_Chol\_internal}(\text{FLA\_LOWER\_TRIANGULAR}, \text{A11}, \text{FLA\_Cnt1\_sub\_chol}(\text{cnt1}));$

10.  $\text{FLA\_Trsm\_internal}(\text{FLA\_RIGHT}, \text{FLA\_LOWER\_TRIANGULAR}, \text{FLA\_CONJ\_TRANPOSE}, \text{FLA\_NONUNIT\_DIAG}, \text{FLA\_ONE}, \text{A11}, \text{A21}, \text{FLA\_Cnt1\_sub\_trsm}(\text{cnt1}));$

11.  $\text{FLA\_Herk\_internal}(\text{FLA\_LOWER\_TRIANGULAR}, \text{FLA\_NO\_TRANPOSE}, \text{FLA\_MINUS\_ONE}, \text{A21}, \text{FLA\_ONE}, \text{A22}, \text{FLA\_Cnt1\_sub\_herk}(\text{cnt1}));$

12.  $\text{FLA\_Cont\_with\_3x3\_to\_2x2}(\&ATL, \&*/ \&ATR, \text{A00}, \text{A01}, \&*/ \&A02, \text{A10}, \text{A11}, \&*/ \&A12, \&ABL, \&*/ \&ABR, \text{A20}, \text{A21}, \&*/ \&A22, \text{FLA\_TL});$

R. van de Geijn and M. Myers. "Applying Dijkstra's Vision to Numerical Software." In *Edsger Wybe Dijkstra: His Life, Work, and Legacy* (Apt and Hoare, Eds.). ACM. 2022

