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### 6.4.3 Formal derivation of LU factorization

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Robert also teaches an introductory graduate level course on Numerical Linear Algebra. One of the lectures, about half way into the course, discusses how to derive LU factorization algorithms in a goal-oriented fashion that would have (perhaps) made Dijkstra proud. You may want to revisit [Unit 2.5.1](#) (in particular, the paper "The Science of Deriving Dense Linear Algebra Algorithms") and then watch the below video. The discussion on derivation starts around minute 9 or 10.

(Robert simply set up a camera in his classroom, so the quality is pretty low. This also convinced us that making people watch hour long videos is probably hard on people's attention span...)

For more info on this class (and the notes), visit [www.ulaff.net](http://www.ulaff.net) (bottom of the page).

No transcript for the below YouTube embedded video.

Video

Determining loop-invariants

Start with the PME:

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) = \left(\begin{array}{c|c} L \backslash U_{TL} & U_{TR} \\ \hline L_{BL} & L \backslash U_{BR} \end{array}\right)$$
$$\wedge \begin{array}{c|c} L_{TL}U_{TL} = \hat{A}_{TL} & L_{TL}U_{TR} = \hat{A}_{TR} \\ \hline L_{BL}U_{TL} = \hat{A}_{BL} & L_{BL}U_{TR} + L_{BR}U_{BR} = \hat{A}_{BR} \end{array}$$

The PME captures *all* computation that must be performed in order to compute the *final* result, in terms of the submatrices/vectors that are encountered.

A loop invariant indicates *some* of this computation has been completed. For example

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) = \left(\begin{array}{c|c} L \backslash U_{TL} & U_{TR} \\ \hline L_{BL} & \hat{A}_{BR} - L_{BL}U_{TR} \end{array}\right)$$
$$\wedge \begin{array}{c|c} L_{TL}U_{TL} = \hat{A}_{TL} & L_{TL}U_{TR} = \hat{A}_{TR} \\ \hline L_{BL}U_{TL} = \hat{A}_{BL} & L_{BL}U_{TR} + L_{BR}U_{BR} = \hat{A}_{BR} \end{array}$$

31:20 / 1:06:14

2.0x

Discussion

Topic: Week 6 / 6.4.3

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Two Cents

I value these kind of traditional / longform lectures. I am aware that studies support breaking down lectures into manageable chunks. It is practi...

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