

Design Patterns for High-Performance Matrix Computations

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Abstract: For modeling, simulation and design of complex systems, high-performance and easy-to-use matrix computation software is always needed. Traditionally, one would make use of standard software packages written in FORTRAN, such as LINPACK, EISPACK and LAPACK. Today, the availability of commercial products like MATLAB makes matrix computations almost as simple as just writing down mathematical expressions on the paper. Although these software products have proved to be very powerful and useful for many purposes, there are situations where a special matrix library is needed, e.g. for real-time (and distributed) simulations and real-time control implementations. Besides the question of licensing price, it is often claimed that program codes generated by universal tools are neither efficient enough nor easily embeddable into real-time applications.

The combination of object-oriented programming methods and the supports from a high-level language like C++ *allows* the development of very flexible and highly reusable software. But object-oriented design is hard and object-oriented design of a high-efficient, elegant, flexible and reusable matrix library is even harder. In fact, there are many matrix libraries freely available from the Internet, but very few of them have been well designed in the author's viewpoint. The most critical design challenge involves the trade-offs between diverse requirements, which are often in conflict to each other. This paper makes a contribution to the developer and user community of matrix computation software by presenting the *design patterns* in FMOL++ (*Fundamental Mathematical Object Library*) – a C++ template library written by the author. Through over a decade of evolutions, these patterns have proved to provide best-practice solutions to most common problems in the context of high-performance matrix computations.

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