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Title: Parallel adaptive methods for Feynman loop integrals.

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The computation of loop integrals is required in high energy physics to obtain higher order terms for perturbation calculations of the scattering amplitude in quantum field theory. We devised effective multivariate methods by iterated (repeated) adaptive numerical integration and extrapolation, applicable for some problem classes where standard multivariate integration techniques fail through integrand singularities in the interior of the domain and/or infrared singularities emerging on the boundaries, without resorting to Monte-Carlo techniques. The low memory use of the method is an added benefit. Hybrid parallelizations, for distributed and multi-core environments, are suitable on various problem levels. Parallelizations on the integral level can target sub-problems of reductions. We applied sector decompositions to one-loop multi-leg diagrams through the hexagon by a fully numerical computation based on extrapolation and on adaptive integration for box and vertex problems. Integral level parallelization is effective on cluster and multi-core systems. In repeated integration, the function evaluations for the outer integral are independent integral computations for the next lower level and can be distributed to threads in a multi-core parallelization on the function evaluation level. The distribution level determines the number of dimensions in the inner integral below it and thus the granularity of the computation. We discuss an implementation over OpenMP for the local box integration, which can be combined with MPI in a cluster environment. Furthermore, in earlier work we applied task partitioning on the region level for general adaptive algorithms and analyzed its parallel overheads. The need for large numbers of compute-intensive integrals arising in quantum field theory perturbation calculations justifies the parallelization for loop integrals. We discuss the quality of the results and parallel efficiencies.