COMMON SUB-EXPRESSION ELIMINATION USING SUBTREE ISOMORPHISMS

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Abstract

The purpose of this work is to improve the run time of the numerical simulation of binary black hole mergers and the estimation of their signatures of the resulting gravitational wave emission. Binary black hole mergers are modeled using the BSSN formulation of the Einstein equation. The BSSN equations consist of several complex partial differential equations and to model these equations the value of each variable is computed once per time step in the model. The overall model is constructed by calculating millions of timesteps to see how black holes interact with each other. Each timestep must solve the partial differential equations. This process is automated using the python package SymPy. SymPy takes mathematical expressions and generates python code to solve each expression. However due to the complexity of the BSSN differential equations, the auto generated code consists of thousands of temporary variables. Due to the number of temporary variables, modern compilers are unable to effectively optimize the code causing the code to become incredibly inefficient. This thesis illustrates a technique to use Subtree Isomorphisms and common sub-expression elimination to improve the run time. The focus of this work is to use a bottom up approach to find an efficient way to solve for the values of the partial differential equations for each timestep. The strategy is to convert the all temporary variable computations into expression trees. Once the expression trees are created, a subtree isomorphism analysis is performed to determine which temporary variables consist of the same expressions. Once the subtree isomorphisms are determined, the expression trees can be rebuilt to take advantage of caching for the targeted memory architecture.