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Analyzing Convergence of Schwarz Waveform Relaxation Methods Using Exponential Weighting

The Schwarz Waveform Relaxation (SWR) method represents a class of numerical domain decomposition techniques developed for solving space-time partial differential equations using iterative procedures. The approach begins by dividing the physical spatial domain into several overlapping or non-overlapping subdomains. For each subdomain, the corresponding time-dependent problem is solved independently and in parallel over the entire time interval. After solving, information at the subdomain interfaces is exchanged across the entire time window. This process is repeated iteratively, with updated interface values, until the global solution converges. Analyzing and predicting their convergence behavior can be challenging. In many cases, the convergence estimates require evaluating inverse Laplace transforms of complicated expressions. Unfortunately, for some types of interface conditions, there are no known explicit formulas for these inverse transforms. To overcome this obstacle, we will show how exponential weighting techniques can be used to derive superlinear convergence estimates without computing the inverse Laplace transform explicitly. These techniques simplify the analysis while still capturing the essential features of the SWR iteration. It will be used to analyze the convergence of SWR with the Dirichlet and Robin transmission conditions.