FFT-based evaluation of nonlocal terms in PDE systems

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Cellular adhesion or repulsion is an important aspect in many biological systems and has been implicated in processes related the pigmentation pattern in fish, the sorting of cells in embryonal tissue, the invasion of healthy tissue by cancer cells and also tissue growth in bioreactors. In PDE-type modelling of these processes this aspect is often successfully accounted for by a solution-dependent spatially nonlocal term. The nonlocality here represents the observation that the state of the sourrounding tissue of a cell influences its adhesive or repulsive behaviour. The evaluation of the nonlocal term in such models often amounts to the computational bottleneck in numerical schemes.
In this presentation we outline an efficient FFT-based technique for the evaluation of this nonlocal term on one- and higher dimensional uniform grids and for spatially periodic boundary conditions. We also show how more general boundary condition can be accomodated for by slightly increasing the problem dimension and at a moderate increase in computational cost. The methodology is also applicable in the case of certain iterated integrals. We finally also discuss an application of the method on unstructured grids and/or non-box shaped spatial domains.