Discrete positive invariance of sets

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As a generalization of positivity, we consider positive invariance of closed, convex sets for differential equations and their discretizations with Runge-Kutta methods. The aim is to find a step size for invariance, i.e. the time step size for the discretization method that guarantees preservation of the positive invariance of the set under consideration. In addition to the usual sufficient assumption with the Explicit Euler condition, we shall conclude step sizes for invariance from more relaxed conditions as well.

Moreover, we shall investigate the positive invariance of certain convex and some non-convex sets as well, with examples arising from dicretization of inertial manifolds. We shall see that in this case the step size for invariance is much larger than that resulting from the Explicit Euler condition (if the latter applies).

Finally, we demonstrate our findings with examples from different diffusion-reaction systems.