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Introduction and Application of the Augmented Phase Portrait

We introduce the next-iterate operators and corresponding next-iterate root-sets and root-curves associated with the nullclines of discrete planar systems. The signs of these next-iterate operators are used to augment the standard phase portrait that includes the direction field and the nullclines, to determine whether a point is mapped above or below the corresponding nullcline. This method identifies positively invariant regions and regions that can give rise to periodic solutions. The construction of the augmented phase portrait is demonstrated using an example of a rational planar map that arises in population modeling. We show that the augmented phase portrait can provide an elementary, alternative approach for determining the global dynamics of this model. The potential and limitations of the augmented phase portrait are explored using several examples that have applications in population dynamics, epidemiology, and delay difference equations.