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Ordinary Differentiation Equations (ODE) Reconstruction of High-Dimensional Genetic Networks through Game Theory with Application to Dissecting Tree Salt Tolerance

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Abstract : Ordinary differentiation equations (ODE) have proven to be powerful for reconstructing precise and informative gene regulatory networks (GRNs) from dynamic gene expression data. However, joint modeling and analysis of all genes, essential for the systematical characterization of genetic interactions, are challenging due to high dimensionality and a complex pattern of genetic regulation including activation, repression, and antitermination. Here, we address these challenges by unifying variable selection and game theory through ODE. Each gene within a GRN is co-expressed with its partner genes in a way like a game of multiple players, each of which tends to choose an optimal strategy to maximize its “fitness” across the whole network. Based on this unifying theory, we designed and conducted a real experiment to infer salt tolerance-related GRNs for Euphrates poplar, a hero tree that can grow in the saline desert. The pattern and magnitude of interactions between several hub genes within these GRNs were found to determine the capacity of Euphrates poplar to resist to saline stress.

Keywords : gene regulatory network, ordinary differential equation, game theory, LASSO, saline resistance
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