Inferring Gene Regulatory Network Models from Time-Series Data Using Metaheuristics

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This supplementary material presents additional tabular results that were obtained by the proposed method when solving the 10-variable Circadian Rhythm.

1 Temporal Behavior

- $\frac{dA}{dt} = \frac{1}{\tau_A} \times (1 - \frac{J^{nAJ}}{(J^{nAJ}+kAJ^{nAJ})} - A)$

- $\frac{dB}{dt} = \frac{1}{\tau_B} \times (\frac{E^{nBE}}{(E^{nBE}+kBE^{nBE})} - B)$

- $\frac{dC}{dt} = \frac{1}{\tau_C} \times ((\frac{B^{nCB}}{(B^{nCB}+kCB^{nCB})} \times (1 - \frac{F^{nCF}}{(F^{nCF}+kCF^{nCF})}) \times (1 - \frac{A^{nCA}}{(A^{nCA}+kCA^{nCA})}) \times (1 - \frac{B^{nCB}}{(B^{nCB}+kCB^{nCB})}) \times (\frac{F^{nCF}}{(F^{nCF}+kCF^{nCF})}) \times (1 - \frac{A^{nCA}}{(A^{nCA}+kCA^{nCA})}) + (1 - \frac{B^{nCB}}{(B^{nCB}+kCB^{nCB})}) \times (1 - \frac{F^{nCF}}{(F^{nCF}+kCF^{nCF})}) \times (\frac{A^{nCA}}{(A^{nCA}+kCA^{nCA})}) + \frac{B^{nCB}}{(B^{nCB}+kCB^{nCB})} \times (\frac{F^{nCF}}{(F^{nCF}+kCF^{nCF})}) \times (\frac{A^{nCA}}{(A^{nCA}+kCA^{nCA})}) + (1 - \frac{B^{nCB}}{(B^{nCB}+kCB^{nCB})}) \times (\frac{F^{nCF}}{(F^{nCF}+kCF^{nCF})}) \times (\frac{A^{nCA}}{(A^{nCA}+kCA^{nCA})}) + (\frac{B^{nCB}}{(B^{nCB}+kCB^{nCB})}) \times (\frac{F^{nCF}}{(F^{nCF}+kCF^{nCF})}) \times (\frac{A^{nCA}}{(A^{nCA}+kCA^{nCA})}) - C)$

- $\frac{dD}{dt} = \frac{1}{\tau_D} \times (\frac{F^{nDF}}{(F^{nDF}+kDF^{nDF})} - D)$

- $\frac{dE}{dt} = \frac{1}{\tau_E} \times (1 - \frac{J^{nEJ}}{(J^{nEJ}+kEJ^{nEJ})} - E)$

- $\frac{dF}{dt} = \frac{1}{\tau_F} \times (\frac{A^{nFA}}{(F^{nFA}+kFA^{nFA})} - F)$

- $\frac{dG}{dt} = \frac{1}{\tau_G} \times ((\frac{B^{nGB}}{(B^{nGB}+kGB^{nGB})} \times (1 - \frac{F^{nGF}}{(F^{nGF}+kGF^{nGF})}) \times (1 - \frac{A^{nGA}}{(A^{nGA}+kGA^{nGA})}) \times (1 - \frac{B^{nGB}}{(B^{nGB}+kGB^{nGB})}) \times (\frac{F^{nGF}}{(F^{nGF}+kGF^{nGF})}) \times (1 - \frac{A^{nGA}}{(A^{nGA}+kGA^{nGA})}) + (1 - \frac{B^{nGB}}{(B^{nGB}+kGB^{nGB})}) \times (1 - \frac{F^{nGF}}{(F^{nGF}+kGF^{nGF})}) \times (\frac{A^{nGA}}{(A^{nGA}+kGA^{nGA})}) + \frac{B^{nGB}}{(B^{nGB}+kGB^{nGB})} \times (\frac{F^{nGF}}{(F^{nGF}+kGF^{nGF})}) \times (\frac{A^{nGA}}{(A^{nGA}+kGA^{nGA})}) + (1 - \frac{B^{nGB}}{(B^{nGB}+kGB^{nGB})}) \times (\frac{F^{nGF}}{(F^{nGF}+kGF^{nGF})}) \times (\frac{A^{nGA}}{(A^{nGA}+kGA^{nGA})}) + (\frac{B^{nGB}}{(B^{nGB}+kGB^{nGB})}) \times (\frac{F^{nGF}}{(F^{nGF}+kGF^{nGF})}) \times (\frac{A^{nGA}}{(A^{nGA}+kGA^{nGA})}) - G)$

- $\frac{dH}{dt} = \frac{1}{\tau_H} \times (\frac{F^{nHF}}{(F^{nHF}+kHF^{nHF})} - H)$

- $\frac{dI}{dt} = \frac{1}{\tau_I} \times (\frac{G^{nIG}}{(G^{nIG}+kIG^{nIG})} \times \frac{H^{nIH}}{(H^{nIH}+kIH^{nIH})} - I)$

- $\frac{dJ}{dt} = \frac{1}{\tau_J} \times (\frac{I^{nJI}}{(I^{nJI}+kJI^{nJI})} - J)$

2 Numerical Coefficients

- $\frac{dA}{dt} = \frac{1}{1.73} \times \left(1 - \frac{\frac{J}{max(J)}^{20}}{(\frac{J}{max(J)}^{20}+0.45^{20})} - \frac{A}{max(A)}\right)$

- $\frac{dB}{dt} = \frac{1}{2.14} \times \left(\frac{\frac{E}{max(E)}^{9}}{(\frac{E}{max(E)}^{9}+0.56^{9})} - \frac{B}{max(B)}\right)$

- $\frac{dC}{dt} = \frac{1}{0.81} \times \left(\left(\frac{\frac{B}{max(B)}^{24}}{(\frac{B}{max(B)}^{24}+0.99^{24})} \times \left(1 - \frac{\frac{F}{max(F)}^{12}}{(\frac{F}{max(F)}^{12}+0.77^{12})}\right) \times \left(1 - \frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.71^{2})}\right) \times \left(1 - \frac{\frac{B}{max(B)}^{24}}{(\frac{B}{max(B)}^{24}+0.99^{24})}\right) \times \right.$
$\left(\frac{\frac{F}{max(F)}^{12}}{(\frac{F}{max(F)}^{12}+0.77^{12})}\right) \times \left(1 - \frac{A^{2}}{(A^{2}+0.71^{2})}\right) + \left(1 - \frac{\frac{B}{max(B)}^{24}}{(\frac{B}{max(B)}^{24}+0.99^{24})}\right) \times \left(1 - \frac{\frac{F}{max(F)}^{12}}{(\frac{F}{max(F)}^{12}+0.77^{12})}\right) \times \left(\frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.71^{2})}\right) +$
$\frac{\frac{B}{max(B)}^{24}}{(\frac{B}{max(B)}^{24}+0.99^{24})} \times \left(\frac{\frac{F}{max(F)}^{12}}{(\frac{F}{max(F)}^{12}+0.77^{12})}\right) \times \left(\frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.71^{2})}\right) + \left(1 - \frac{\frac{B}{max(B)}^{24}}{(\frac{B}{max(B)}^{24}+0.99^{24})}\right) \times \left(\frac{\frac{F}{max(F)}^{12}}{(\frac{F}{max(F)}^{12}+0.77^{12})}\right) \times \left(\frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.71^{2})}\right) +$
$\left(\frac{\frac{B}{max(B)}^{24}}{(\frac{B}{max(B)}^{24}+0.99^{24})}\right) \times \left(\frac{\frac{F}{max(F)}^{12}}{(\frac{F}{max(F)}^{12}+0.77^{12})}\right) \times \left(\frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.71^{2})}\right) - \frac{C}{max(C)}\right)$

- $\frac{dD}{dt} = \frac{1}{0.11} \times \left(\frac{\frac{F}{max(F)}^{2}}{(\frac{F}{max(F)}^{2}+0.66^{2})} - \frac{D}{max(D)}\right)$

- $\frac{dE}{dt} = \frac{1}{1.23} \times \left(1 - \frac{\frac{J}{max(J)}^{6}}{(\frac{J}{max(J)}^{6}+0.42^{6})} - \frac{E}{max(E)}\right)$

- $\frac{dF}{dt} = \frac{1}{1.78} \times \left(\frac{\frac{A}{max(A)}^{4}}{(\frac{A}{max(A)}^{4}+0.48^{4})} - \frac{F}{max(F)}\right)$

- $\frac{dG}{dt} = \frac{1}{1.14} \times \left(\left(\frac{\frac{B}{max(B)}^{7}}{(\frac{B}{max(B)}^{7}+0.66^{7})} \times \left(1 - \frac{\frac{F}{max(F)}^{24}}{(\frac{F}{max(F)}^{24}+0.99^{24})}\right) \times \left(1 - \frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.85^{2})}\right) \times \left(1 - \frac{\frac{B}{max(B)}^{7}}{(\frac{B}{max(B)}^{7}+0.66^{7})}\right) \times \right.$
$\left(\frac{\frac{F}{max(F)}^{24}}{(\frac{F}{max(F)}^{24}+0.99^{24})}\right) \times \left(1 - \frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.85^{2})}\right) + \left(1 - \frac{\frac{B}{max(B)}^{7}}{(\frac{B}{max(B)}^{7}+0.66^{7})}\right) \times \left(1 - \frac{\frac{F}{max(F)}^{24}}{(\frac{F}{max(F)}^{24}+0.99^{24})}\right) \times \left(\frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.85^{2})}\right) +$
$\frac{\frac{B}{max(B)}^{7}}{(\frac{B}{max(B)}^{7}+0.66^{7})} \times \left(\frac{\frac{F}{max(F)}^{24}}{(\frac{F}{max(F)}^{24}+0.99^{24})}\right) \times \left(\frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.85^{2})}\right) + \left(1 - \frac{\frac{B}{max(B)}^{7}}{(\frac{B}{max(B)}^{7}+0.66^{7})}\right) \times \left(\frac{\frac{F}{max(F)}^{24}}{(\frac{F}{max(F)}^{24}+0.99^{24})}\right) \times \left(\frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.85^{2})}\right) +$
$\left(\frac{\frac{B}{max(B)}^{7}}{(\frac{B}{max(B)}^{7}+0.66^{7})}\right) \times \left(\frac{\frac{F}{max(F)}^{24}}{(\frac{F}{max(F)}^{24}+0.99^{24})}\right) \times \left(\frac{\frac{A}{max(A)}^{2}}{(\frac{A}{max(A)}^{2}+0.85^{2})}\right) - \frac{G}{max(G)}\right)$

- $\frac{dH}{dt} = \frac{1}{1.04} \times \left(\frac{\frac{F}{max(F)}^{7}}{(\frac{F}{max(F)}^{7}+0.61^{7})} - \frac{H}{max(H)}\right)$

- $\frac{dI}{dt} = \frac{1}{3.47} \times \left(\frac{\frac{G}{max(G)}^{21}}{(\frac{G}{max(G)}^{21}+0.55^{21})} \times \frac{\frac{H}{max(H)}^{20}}{(\frac{H}{max(H)}^{20}+0.46^{20})} - \frac{I}{max(I)}\right)$

- $\frac{dJ}{dt} = \frac{1}{3.21} \times \left(\frac{\frac{I}{max(I)}^{3}}{(\frac{I}{max(I)}^{3}+0.17^{3})} - \frac{J}{max(J)}\right)$