Differential Equations

The population dynamics of human civilians (H), human military (M_H), alien civilians (A), alien military (M_A), hybrid population (Hyb), resources (R), and the war state (W) are governed by the following equations:

$$\frac{dH}{dt} = r_H H - \text{recruitment}_H - \text{death}_H^{\text{scarcity}} - \text{combat}_H^{\text{loss}}$$

$$\frac{dM_H}{dt} = \text{recruitment}_H - \text{combat}_H^{\text{loss}}$$

$$\frac{dA}{dt} = r_A A - \text{recruitment}_A - \text{death}_A^{\text{scarcity}} - \text{combat}_A^{\text{loss}}$$

$$\frac{dM_A}{dt} = \text{recruitment}_A - \text{combat}_A^{\text{loss}}$$

$$\frac{dHyb}{dt} = r_{Hyb} Hyb + \text{hybridCreation} - \text{death}_{Hyb}^{\text{scarcity}}$$

$$\frac{dR}{dt} = \theta R \left(1 - \frac{\text{totalPopulation}}{\text{maxPopulation}}\right) - \sigma \cdot \text{totalPopulation}$$

Where the total population is:

$$\text{totalPopulation} = H + M_H + A + M_A + Hyb$$

The war state (W) evolves as:

$$W = \begin{cases} 1 & \text{if } (R < R_{\text{threshold}}) \text{ or } (\text{totalPopulation} > \text{maxPopulation}) \\ 0 & \text{if } (R \geq R_{\text{threshold}}) \text{ and } (\text{totalPopulation} \leq \text{maxPopulation}) \end{cases}$$

Parameters and Their Meanings

- $r_H = 0.0003$: Human civilian growth rate.
- $r_A = 0.0001$: Alien civilian growth rate.
- $r_{Hyb} = 0.0002$: Hybrid civilian growth rate.
- $k_{H_{\text{peace}}} = 0.001$, $k_{H_{\text{war}}} = 0.02$: Human military recruitment rates during peace and war.
- $k_{A_{\text{peace}}} = 0.001$, $k_{A_{\text{war}}} = 0.02$: Alien military recruitment rates during peace and war.
- $\alpha = 0.0005$: Alien military death rate due to human military.
- $\beta = 0.0005$: Human military death rate due to alien military.

- $\gamma_H = 0.002$, $\gamma_A = 0.002$, $\gamma_{Hyb} = 0.0015$: Death rates from resource scarcity.
- $\sigma = 0.05$: Resource consumption rate proportional to total population.
- $\theta = 0.05$: Resource replenishment rate.
- $R_{\text{threshold}} = 500$: Resource threshold for triggering scarcity and war.
- maxPopulation = 3000: Maximum carrying capacity of the environment.
- hybridCreationRate = 0.00005: Rate of hybrid creation from human-alien interaction.

Initial Conditions and Simulation Details

- $H(0) = 1000$: Initial human civilian population.
- $M_H(0) = 0$: Initial human military population.
- $A(0) = 800$: Initial alien civilian population.
- $M_A(0) = 0$: Initial alien military population.
- $Hyb(0) = 0$: Initial hybrid population.
- $R(0) = 1000$: Initial resources.
- $W(0) = 0$: Peace at the start ($0 = \text{peace}, 1 = \text{war}$).

Key Terms in the Equations

- $\text{recruitment}_H, \text{recruitment}_A$: Recruitment rates of human and alien military, adjusted for peace/war states.
- $\text{death}_H^{\text{scarcity}}, \text{death}_A^{\text{scarcity}}, \text{death}_{Hyb}^{\text{scarcity}}$: Deaths due to resource scarcity, proportional to the shortfall from $R_{\text{threshold}}$.
- $\text{combat}_H^{\text{loss}}, \text{combat}_A^{\text{loss}}$: Deaths due to combat, active only during war.
- hybridCreation: Creation of hybrids from human-alien interaction.