Differential Equations

The system of equations representing the interaction between human civilians ($H(t)$), human military forces ($M(t)$), and aliens ($A(t)$) is given by:

$$\frac{dH}{dt} = r_H H - \beta MA - \delta HA - kH$$

$$\frac{dM}{dt} = kH - \beta MA$$

$$\frac{dA}{dt} = r_A A - \alpha MA - \gamma A - C\lambda H$$

Constants and Their Meanings

- $r_H = 0.03$: Human civilian population growth rate. Represents the natural growth of the civilian population.
- $k = 0.02$: Recruitment rate of civilians into the military. Determines how many civilians join the military.
- $r_A = 0.005$: Alien population growth rate. Represents the natural growth of the alien population.
- $\alpha = 0.0005$: Death rate of aliens due to military combat. Determines the effectiveness of military forces against aliens.
- $\beta = 0.005$: Death rate of human military due to aliens. Indicates how lethal aliens are to the military.
- $\gamma = 0.00001$: Death rate of aliens due to environmental adaptation challenges.
- $\lambda = 0.00002$: Death rate of aliens due to non-military human actions. Represents the impact of civilians resisting the aliens.
- $\delta = 0.00001$: Death rate of civilians due to alien actions. Models the lethality of alien attacks on civilians.
- $C = 0.0005$: Probability factor for civilians killing aliens. Adjusts the impact of non-military human resistance on aliens.

Terms in the Equations

- $r_H H$: Natural growth of the civilian population.
- βMA: Losses to civilians and military due to combat with aliens.
- δHA: Civilian losses due to alien attacks.

- kH: Civilians recruited into the military.
- $kH - \beta MA$: Recruitment increases military population, but combat reduces it.
- $r_A A$: Natural growth of the alien population.
- αMA: Alien losses due to military combat.
- γA: Alien losses due to environmental factors.
- $C\lambda H$: Alien losses due to civilian resistance.

Differential Equations

The updated system of equations, considering a higher alien death rate due to environmental adaptation ($\gamma = 0.01$) and recruitment ceasing when aliens are eliminated, is given by:

$$\frac{dH}{dt} = r_H H - \beta M A - \delta H A - kH$$

$$\frac{dM}{dt} = kH - \beta M A$$

$$\frac{dA}{dt} = r_A A - \alpha M A - \gamma A - C\lambda H$$

Where recruitment (kH) ceases if $A = 0$.

Constants and Their Meanings

- $r_H = 0.03$: Human civilian population growth rate. Represents the natural growth of the civilian population.
- $k = 0.02$: Recruitment rate of civilians into the military. Determines how many civilians join the military. Recruitment ceases if aliens (A) are eliminated.
- $r_A = 0.005$: Alien population growth rate. Represents the natural growth of the alien population.
- $\alpha = 0.0005$: Death rate of aliens due to military combat. Determines the effectiveness of military forces against aliens.
- $\beta = 0.005$: Death rate of human military due to aliens. Indicates how lethal aliens are to the military.
- $\gamma = 0.01$: Death rate of aliens due to environmental adaptation challenges. Increased to model aliens struggling to adapt to Earth's environment.
- $\lambda = 0.00002$: Death rate of aliens due to non-military human actions. Represents the impact of civilians resisting the aliens.
- $\delta = 0.00001$: Death rate of civilians due to alien actions. Models the lethality of alien attacks on civilians.
- $C = 0.0005$: Probability factor for civilians killing aliens. Adjusts the impact of non-military human resistance on aliens.

Terms in the Equations

- $r_H H$: Natural growth of the civilian population.
- βMA: Losses to civilians and military due to combat with aliens.
- δHA: Civilian losses due to alien attacks.
- kH: Civilians recruited into the military. Recruitment ceases if aliens (A) are eliminated.
- $kH - \beta MA$: Recruitment increases military population, but combat reduces it.
- $r_A A$: Natural growth of the alien population.
- αMA: Alien losses due to military combat.
- γA: Alien losses due to environmental factors. Increased to model higher adaptation challenges.
- $C\lambda H$: Alien losses due to civilian resistance.

Differential Equations

The system of equations representing the interaction between humans ($H(t)$) and aliens ($A(t)$), considering alien-induced diseases and crop impact, is given by:

$$\frac{dH}{dt} = r_H(1 - \delta_F)(1 - \text{cropImpact})H - \delta_D HA$$

$$\frac{dA}{dt} = r_A A - \gamma A - \lambda H$$

Where: - $r_H(1 - \delta_F)(1 - \text{cropImpact})$ is the effective human population growth rate, accounting for fertility reduction and crop impact. - If the effective growth rate becomes negative, it is set to zero to prevent unrealistic behavior.

Constants and Their Meanings

- $r_H = 0.03$: Human population growth rate (birth rate).
- $r_A = 0.005$: Alien population growth rate.
- $\gamma = 0.00001$: Alien death rate due to environmental adaptation challenges.
- $\lambda = 0.00002$: Alien death rate due to human resistance.
- $\delta_D = 0.00001$: Disease-induced human mortality rate caused by alien diseases.
- $\delta_F = 0.5$: Reduction factor for human fertility due to alien-induced diseases.
- cropImpact = 0.4: Reduction in human population growth rate due to alien crop impact.

Terms in the Equations

- $r_H(1 - \delta_F)(1 - \text{cropImpact})H$: Human population growth rate, adjusted for fertility reduction and crop impact.
- $-\delta_D HA$: Loss of human population due to alien-induced diseases.
- $r_A A$: Natural alien population growth.
- $-\gamma A$: Alien losses due to environmental adaptation challenges.
- $-\lambda H$: Alien losses due to human resistance.

Initial Conditions and Simulation Details

- Initial human population: $H_0 = 500$.
- Initial alien population: $A_0 = 200$.
- Time span: $t \in [0, 500]$ days.

Differential Equations

The system of equations representing the dynamics of normal humans ($H_n(t)$), brainwashed humans ($H_b(t)$), and aliens ($A(t)$), including brainwashing effects, is given by:

$$\frac{dH_n}{dt} = r_H H_n - \text{conversionRate} \cdot H_n \cdot A - \beta_n H_n \cdot A - \alpha_b H_n \cdot H_b$$

$$\frac{dH_b}{dt} = \text{conversionRate} \cdot H_n \cdot A - \beta_b H_b \cdot A - \alpha_n H_n \cdot H_b$$

$$\frac{dA}{dt} = -\gamma A + \text{slaveEffect} \cdot H_b \cdot A - \lambda A$$

Where: - $r_H H_n$ represents the natural growth of the normal human population. - $-\text{conversionRate} \cdot H_n \cdot A$ represents the brainwashing of normal humans by aliens. - $-\beta_n H_n \cdot A$ and $-\beta_b H_b \cdot A$ represent the combat death rates of normal and brainwashed humans, respectively, against aliens. - $-\alpha_b H_n \cdot H_b$ and $-\alpha_n H_n \cdot H_b$ represent mutual combat losses between normal and brainwashed humans. - $-\gamma A$ represents the environmental adaptation challenges faced by aliens. - $\text{slaveEffect} \cdot H_b \cdot A$ represents the reduction in alien death rates due to brainwashed humans aiding the aliens. - $-\lambda A$ represents alien deaths due to resistance from normal humans.

Constants and Their Meanings

- $r_H = 0.03$: Human population growth rate (birth rate).
- $\gamma = 0.00001$: Alien death rate due to environmental adaptation.
- $\lambda = 0.00002$: Alien death rate due to human resistance.
- $\beta_n = 0.001$: Death rate of normal humans in combat with aliens.
- $\beta_b = 0.002$: Death rate of brainwashed humans in combat with aliens.
- $\alpha_n = 0.0015$: Death rate of brainwashed humans due to normal humans.
- $\alpha_b = 0.0001$: Death rate of normal humans due to brainwashed humans.
- conversionRate = 0.00003: Rate at which aliens brainwash normal humans.
- slaveEffect = 0.001: Reduction in alien death rate due to brainwashed humans aiding aliens.

Initial Conditions and Simulation Details

- Initial normal human population: $H_{n0} = 500$.
- Initial brainwashed human population: $H_{b0} = 0$.
- Initial alien population: $A_0 = 50$.
- Time span: $t \in [0, 200]$ days.

Terms in the Equations

- $r_H H_n$: Growth rate of normal humans.
- $-\text{conversionRate} \cdot H_n \cdot A$: Brainwashing conversion of normal humans by aliens.
- $-\beta_n H_n \cdot A$: Losses of normal humans in combat with aliens.
- $-\beta_b H_b \cdot A$: Losses of brainwashed humans in combat with aliens.
- $-\alpha_b H_n \cdot H_b$: Deaths of normal humans in combat with brainwashed humans.
- $-\alpha_n H_n \cdot H_b$: Deaths of brainwashed humans in combat with normal humans.
- $-\gamma A$: Deaths of aliens due to environmental adaptation.
- $\text{slaveEffect} \cdot H_b \cdot A$: Reduction in alien death rate due to brainwashed humans aiding aliens.
- $-\lambda A$: Deaths of aliens due to resistance from normal humans.

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.

Differential Equations

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

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

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

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

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

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

Where the total population is:

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

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.
- $k_{H_{\text{peace}}} = 0.001$, $k_{H_{\text{war}}} = 0.02$: 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.
- $\gamma_H = 0.002$, $\gamma_A = 0.002$: Death rates of civilians 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.

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.
- $R(0) = 2000$: 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.
- $\text{death}_H^{\text{scarcity}}, \text{death}_A^{\text{scarcity}}$: 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.