Love Differential Equation

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Differential Equation is a powerful tool to model how systems change over time. In this paper, I propose the differential equation architectures for love and see this model simulates the love dynamics well. Previous research suggested the linear differential equation model for love between two people. Here, I generalize this model to the loves between the n people and incorporate the idea of popularity, gender, and capacity into this model, which are impossible to consider in two people's love. Also, I will show this initial problem is well posed.

I. INTRODUCTION

$$\frac{dR}{dt} = \alpha_R J \tag{1}$$

$$\frac{dJ}{dt} = \alpha_J R \tag{2}$$

II. MODEL

To construct the model, first we define the feeling from i to j. Let us denote the i's feeling to j at time t by $x_{i,j}(t)$. Now, we assume that the change of i's feeling only depends on the feeling from i to j and the feeling from j to i. The ordinary differential equation is written like

$$\frac{dx_{i,j}}{dt} = \alpha_{i,j} x_{i,j} + \beta_{i,j} x_{j,i} \tag{3}$$

which is naturally induced from Eq. (3). $\alpha_{i,j}$ and $\beta_{i,j}$ are constants and defined by popularity and love constitution.

A. Popularity

To model the popularity of the person, we define

$$\alpha_{i,j} = \alpha'_{i,j} + p_j \tag{4}$$

$$\beta_{i,j} = \beta'_{i,j} + p_j \tag{5}$$

$\alpha'_{i,j}$ and $\beta'_{i,j}$ are i's love constitution, and p_j is the popularity of j. If p_j is big then j's popularity is high.

B. Capacity

In the real world, people cannot love all people. Therefore, we introduce the concept of capacity of love to this model.

$$\frac{dx_{i,j}}{dt} = \alpha_{i,j} x_{i,j} + \beta_{i,j} x_{j,i} + sgn(x_{i,j})\gamma_{i,j}(1 - |x_i|) \tag{6}$$

where $|x_i| = \sqrt{\sum_j x_{i,j}^2}$ and $\gamma_{i,j}$ is a constant.

C. Gender

To model gender, we initialize $x_{i,j}$ as

$$x_{i,j}^{(0)} = \begin{cases} 0 & (g(i) = g(j)) \\ f_{i,j} & (otherwise) \end{cases} \tag{7}$$

where

$$g(k) = \begin{cases} 0 & (k\ is\ male) \\ 1 & (k\ is\ female) \end{cases} \tag{8}$$

D. Matrix Form

$$\frac{dX}{dt} = A \otimes X + B \otimes X^T + sgn(X) \otimes \Gamma \otimes (\mathbf{1} - X_2) \tag{9}$$

where $X_{i,j} = x_{i,j}$, $sgn(X)_{i,j} = sgn(x_{i,j})$, $A_{i,j} = \alpha_{i,j}$, $B_{i,j} = \beta$, $\Gamma_{i,j} = \gamma_{i,j}$, $X_{2,i,j} = |x_i|$