

BİR BİLİŞSEL SÜREÇ OLARAK DAVRANIŞ SEÇMENİN DİNAMİK MODELİ

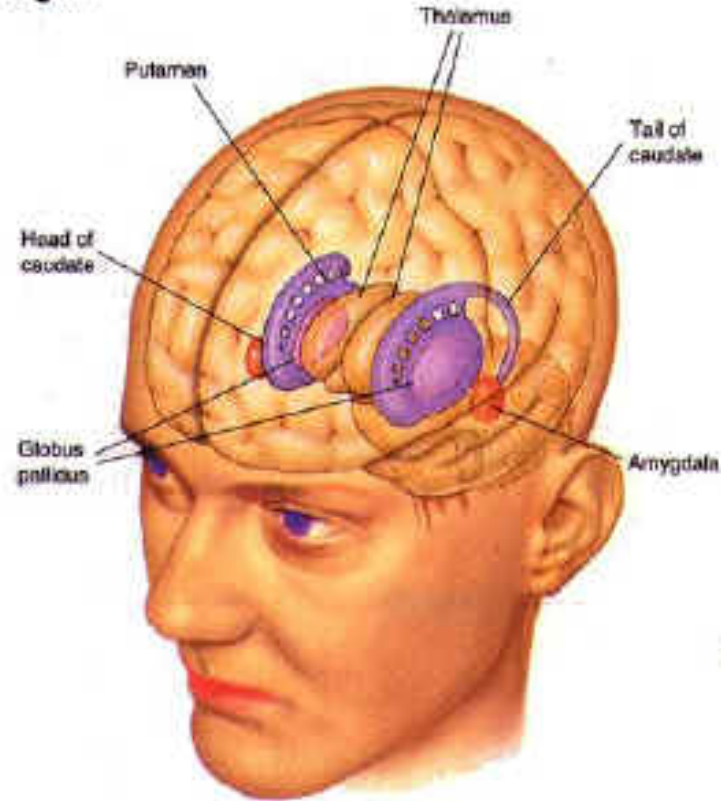
Özkan Karabacak
Neslihan Şengör

İçerik

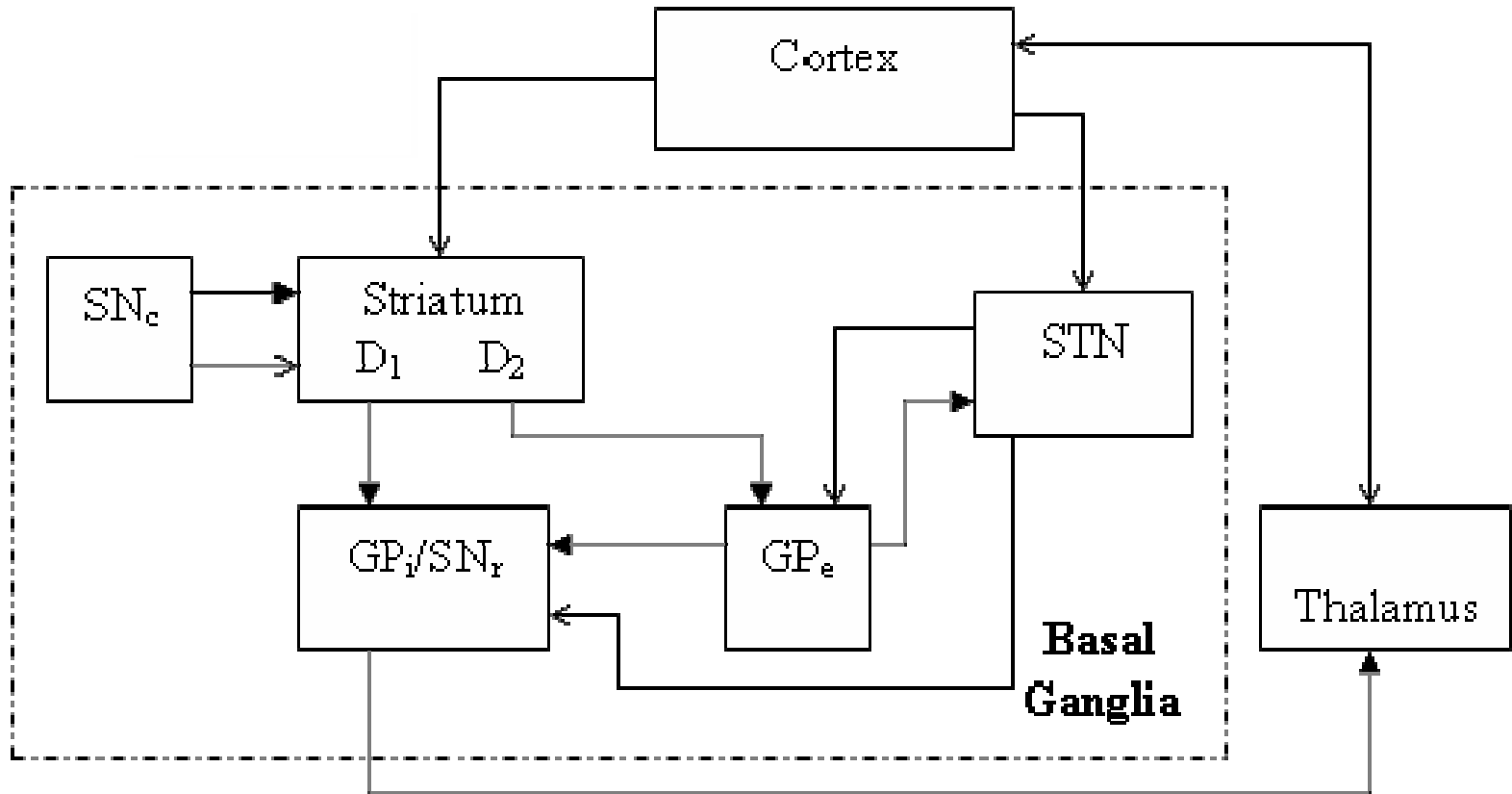
- Beynin alt bölümleri ve C-BG-TH çevrimi
- Dinamik hafıza(J.G. Taylor, N.R. Taylor)
- İşaret seçme(K. Gurney, T.J. Prescott, P. Redgrave)
- Kullanılan model ve analizi
- Hareket yapma
- Hareket seçme
- Dopaminin etkisinin modellenmesi

Beynin Alt Bölümleri ve C-BG-TH Çevrimi

► The Basal Ganglia



Beynin Alt Bölümleri ve C-BG-TH Çevrimi

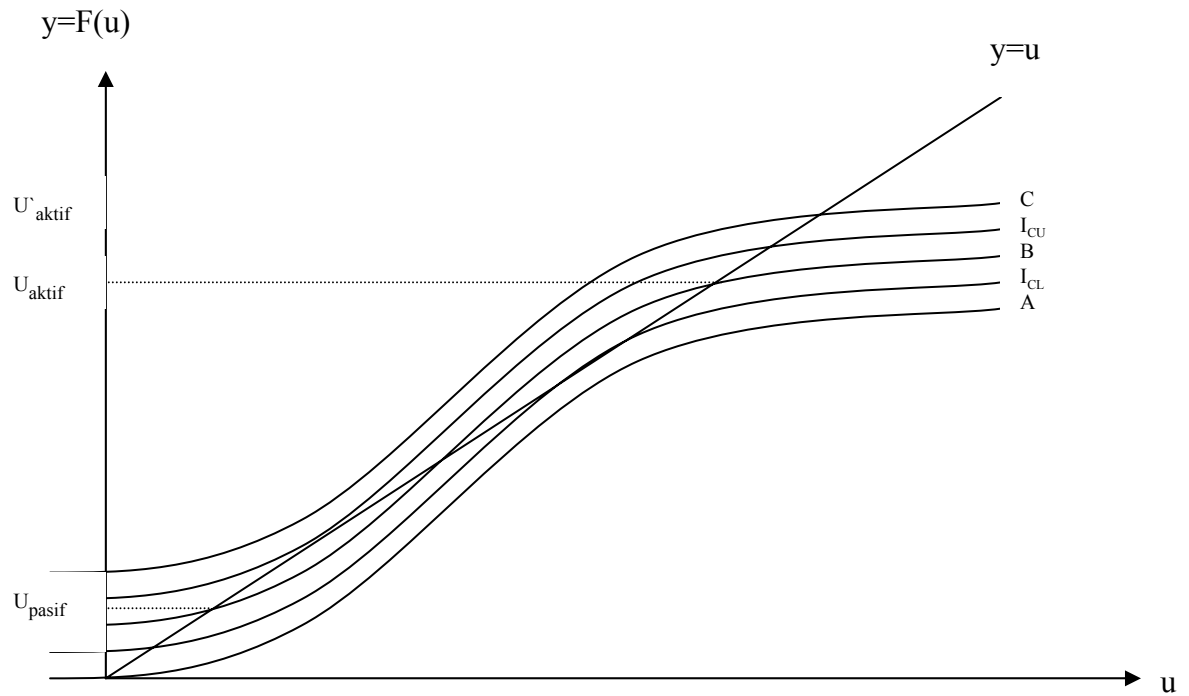
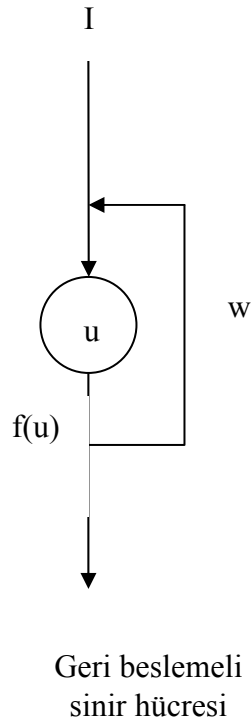


AZALTICI BAĞLANTILAR →
ARTTIRICI BAĞLANTILAR →

Dinamik Hafıza

(J.G. Taylor, N.R. Taylor)

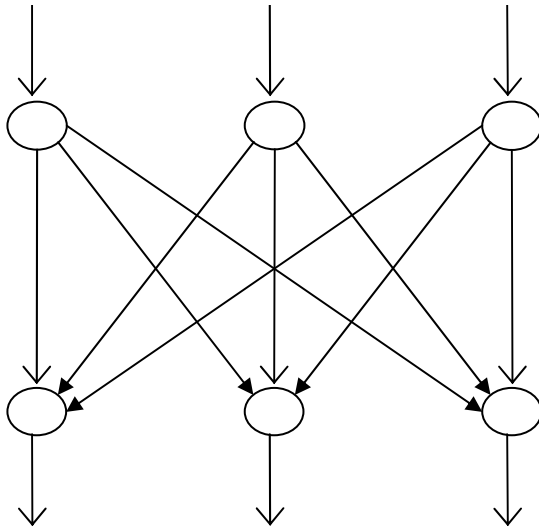
$$u(t + 1) = w \cdot f(u(t)) + I \quad , \quad f(u) \hat{=} \tanh(u)$$



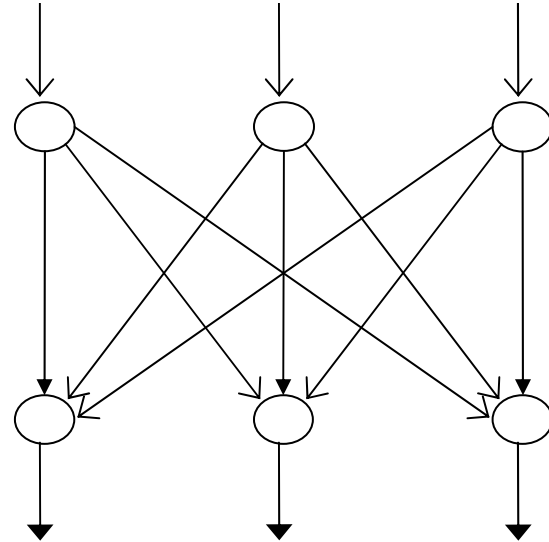
Farklı I parametreleri için çizilmiş $F(u)$ fonksiyonu

İşaret seçme

(K. Gurney, T.J. Prescott, P. Redgrave)



Büyük işaret seçme ağı
(on center off surround)

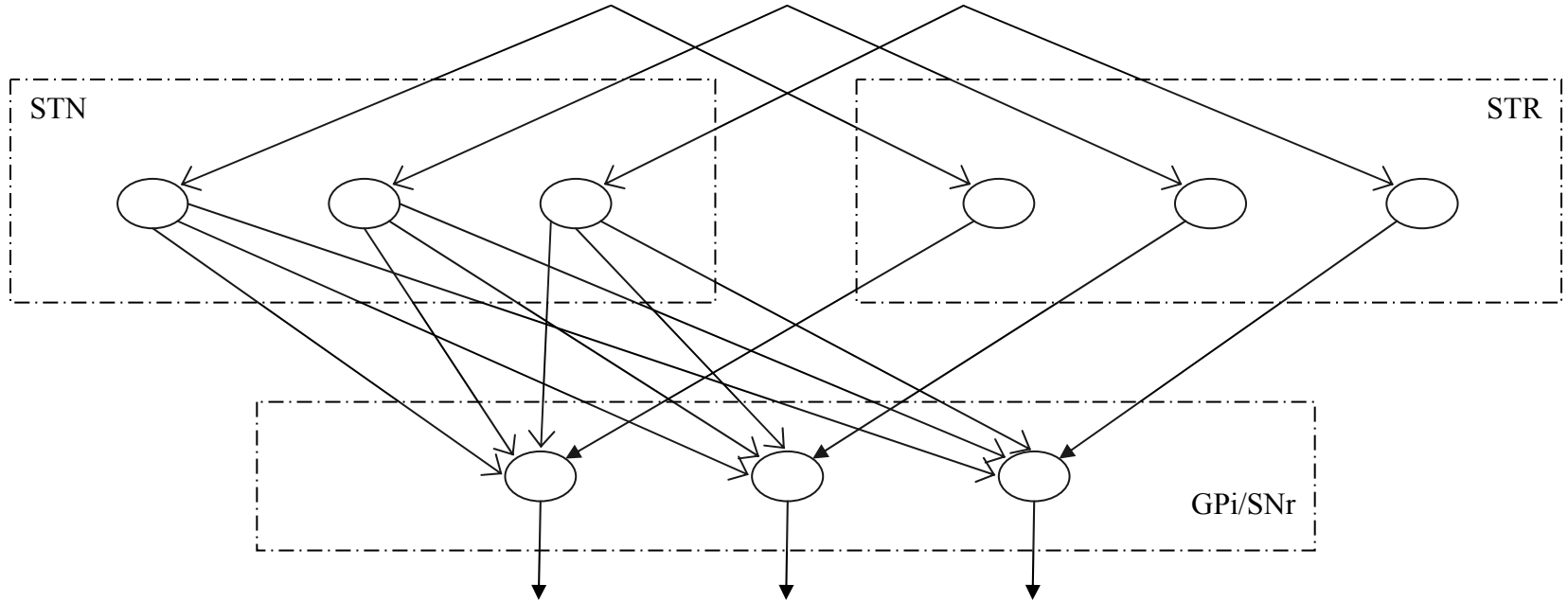


Küçük işaret seçme ağı
(off center on surround)

AZALTICI BAĞLANTILAR 
ARTTIRICI BAĞLANTILAR 

İşaret seçme

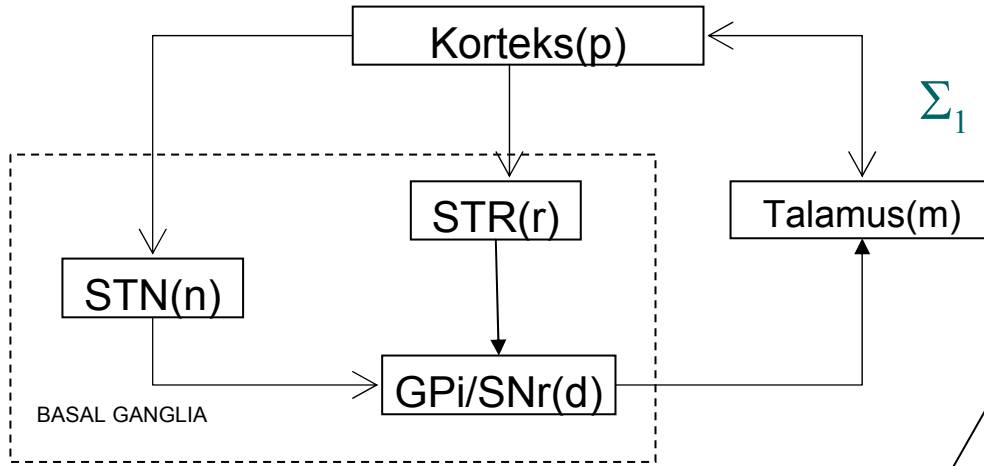
(K. Gurney, T.J. Prescott, P. Redgrave)



İşaret seçen BG modeli

AZALTICI BAĞLANTILAR $\longrightarrow$
ARTTIRICI BAĞLANTILAR $\longrightarrow$

Kullanılan model ve analizi



$\Sigma_1 :$

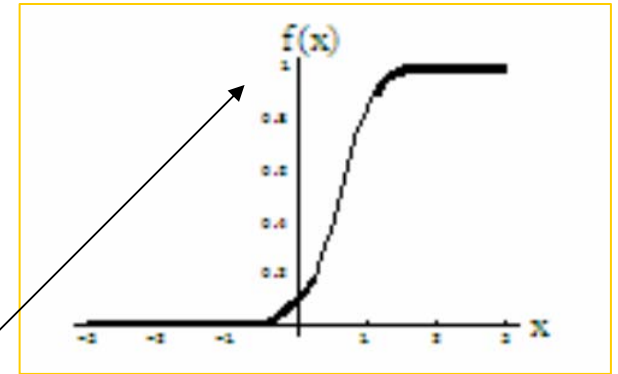
$$x(k+1) = \Gamma x(k) + \Lambda F(x(k))$$

C-BG-TH-C çevrimi

AZALTICI BAĞLANTILAR $\longrightarrow$

ARTTIRICI BAĞLANTILAR $\longrightarrow$

$$\begin{bmatrix} r(k+1) \\ n(k+1) \\ d(k+1) \\ m(k+1) \\ p(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \lambda & 0 \\ 0 & 0 & 0 & 0 & \lambda \end{bmatrix} \begin{bmatrix} r(k) \\ n(k) \\ d(k) \\ m(k) \\ p(k) \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ -a & b & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} g(r(k)) \\ f(n(k)) \\ f(d(k)) \\ f(m(k)) \\ f(p(k)) \end{bmatrix}$$



Bir hücrenin aktivasyon fonksiyonu ve doyma bölgeleri

$$g(x) = f(x - \theta)$$

Kullanılan model ve analizi

$$\Sigma_1 : \quad x(k+1) = \Gamma x(k) + \Lambda F(x(k))$$

- $\lambda < 1$ için çözümler sınırlı

$$\|x(n)\| \leq \|\Gamma\|^n \|x(0)\| + (\|\Gamma\|^{n-1} + \|\Gamma\|^{n-2} + \dots + \|I\|) \cdot \xi \quad \xi \triangleq \max \{\|\Lambda F(x(0))\|, \|\Lambda F(x(1))\|, \dots, \|\Lambda F(x(n-1))\|\}$$

- Doyma bölgeleri sistemin büzülme bölgeleri:

$$\|\Gamma\| + \alpha \|\Lambda\| < 1$$

$$\alpha \triangleq \max_{x \in \mathcal{R}} \left(\left\| \frac{df(x)}{dx} \right\|, \left\| \frac{dg(x)}{dx} \right\| \right)$$

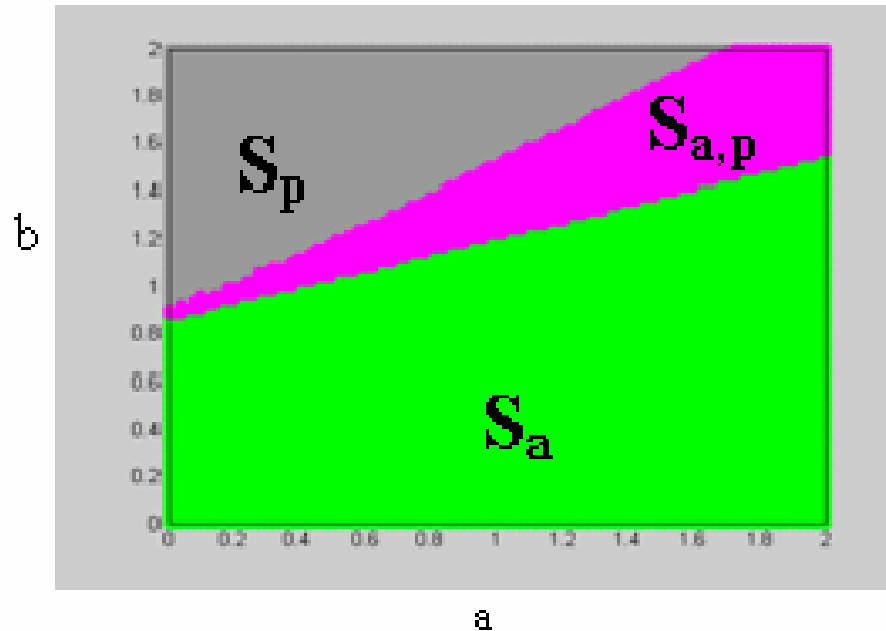
- Simülasyon sonuçları:

$$\begin{bmatrix} 0.9 & 0.9 & 0.2 & 1.8 & 1.8 \end{bmatrix}^T \quad \begin{bmatrix} 0.1 & 0.1 & 0.2 & -0.1 & 0.1 \end{bmatrix}^T$$

aktif nokta

pasif nokta

Hareket Yapma



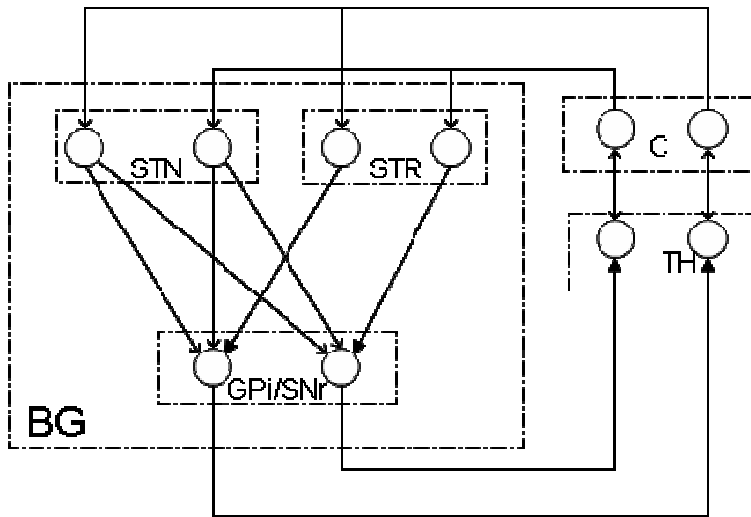
$$S_{a,p} : 0.34 \cdot a + 0.87 < b < 0.65 \cdot a + 0.9$$

$$S_a : b < 0.34 \cdot a + 0.87$$

$$S_p : b > 0.65 \cdot a + 0.9$$

Hareket Seçme

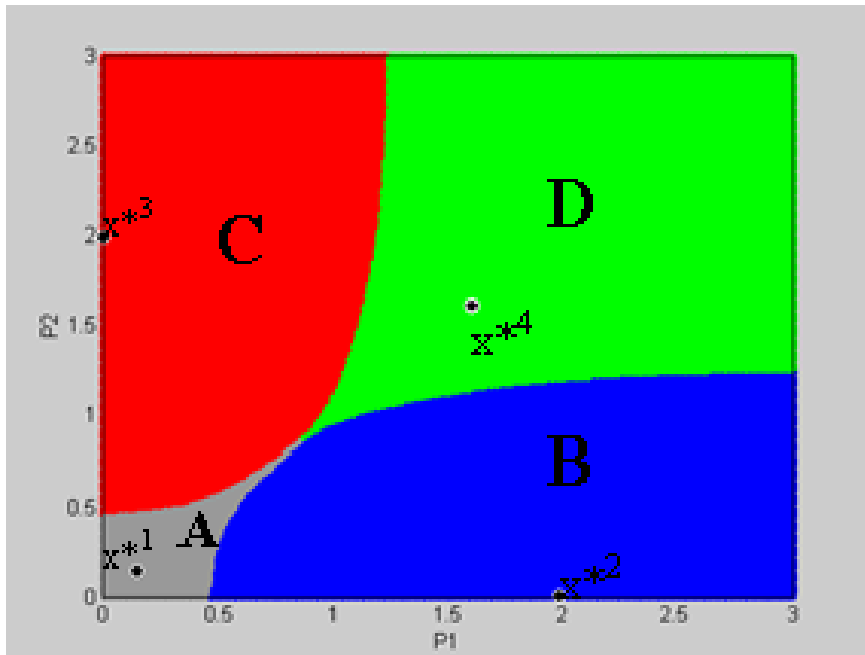
$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} \Gamma & 0 \\ 0 & \Gamma \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} \Lambda & \Pi \\ \Pi & \Lambda \end{bmatrix} \begin{bmatrix} F(x_1(k)) \\ F(x_2(k)) \end{bmatrix}$$



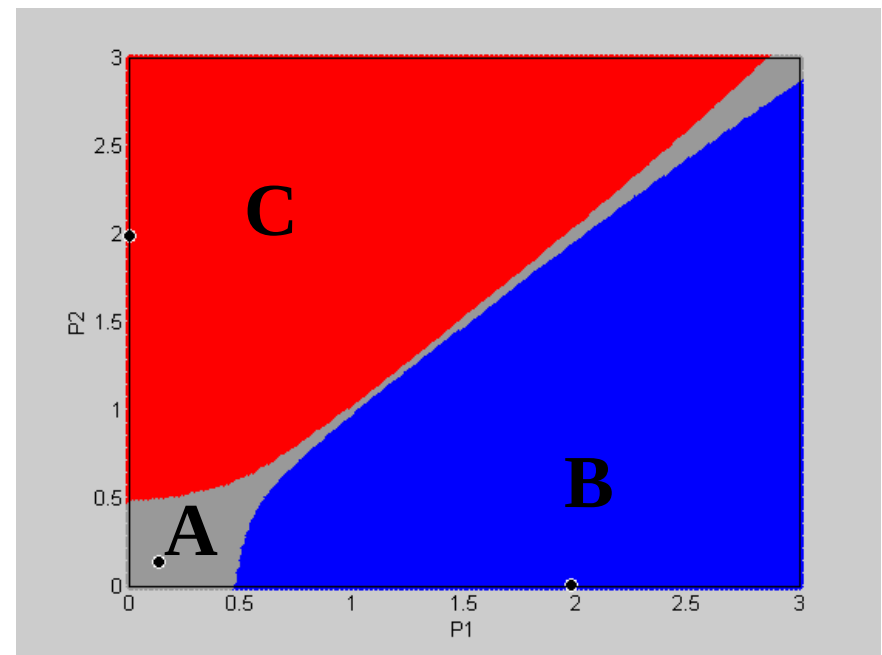
$$\Pi = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & c & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Hareket Seçme

Denge noktası artık $2 \times 2 = 4$ tane



$a=1.5$ $b=1$ $c=0.8$



$a=1.5$ $b=1$ $c=0.9$

Hareket Seçme

D bölgesi nasıl yok oluyor?

$x_1=x_2$ alt uzayına bakalım.

$$\Sigma_2 : \begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} \Gamma & 0 \\ 0 & \Gamma \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} \Lambda & \Pi \\ \Pi & \Lambda \end{bmatrix} \begin{bmatrix} F(x_1(k)) \\ F(x_2(k)) \end{bmatrix}$$

$$\Sigma'_2 : \begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} \Gamma & 0 \\ 0 & \Gamma \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} \Lambda + \Pi & 0 \\ 0 & \Lambda + \Pi \end{bmatrix} \begin{bmatrix} F(x_1(k)) \\ F(x_2(k)) \end{bmatrix}$$

$$x(k+1) = \Gamma x(k) + \Lambda_2 F(x(k)), \quad \Lambda_2 = \Lambda + \Pi$$

Hareket Seçme

Bulduğumuz eşitsizliklerde b yerine $b+c$ koyalım

$$b + c < 0.34 \cdot a + 0.87 \quad \longrightarrow \quad \text{A yok olur}$$

$$b + c > 0.65 \cdot a + 0.9 \quad \longrightarrow \quad \text{D yok olur}$$

$$0.34 \cdot a + 0.87 < b + c < 0.65 \cdot a + 0.9 \quad \longrightarrow \quad \text{İkisi de bulunur.}$$

Hareket Seçme

n hareketten l hareketi nasıl seçeriz?

$$\Sigma_n : \begin{bmatrix} x_1(k+1) \\ \vdots \\ x_\ell(k+1) \\ \vdots \\ x_n(k+1) \end{bmatrix} = \begin{bmatrix} \Gamma & 0 & 0 & \dots & 0 \\ 0 & \Gamma & \ddots & \ddots & \vdots \\ 0 & \ddots & \ddots & \ddots & 0 \\ \vdots & \ddots & \ddots & \ddots & 0 \\ 0 & \dots & 0 & 0 & \Gamma \end{bmatrix} \begin{bmatrix} x_1(k) \\ \vdots \\ x_\ell(k) \\ \vdots \\ x_n(k) \end{bmatrix} + \begin{bmatrix} \Lambda & \Pi & \Pi & \dots & \Pi \\ \Pi & \Lambda & \ddots & \vdots & \vdots \\ \Pi & \ddots & \ddots & \ddots & \Pi \\ \vdots & \ddots & \ddots & \ddots & \Pi \\ \Pi & \dots & \Pi & \Pi & \Lambda \end{bmatrix} \begin{bmatrix} F(x_1(k)) \\ \vdots \\ F(x_\ell(k)) \\ \vdots \\ F(x_n(k)) \end{bmatrix}$$

$$x_1 = x_2 = \dots = x_\ell \quad , \quad x_{\ell+1} = x_{\ell+2} = \dots = x_n = 0$$

ve $F(0) = 0$ yaklaşıklığını kullanırsak

$$\Sigma'_n : \begin{bmatrix} x_1(k+1) \\ x_2(k+1) \\ \vdots \\ x_\ell(k+1) \end{bmatrix} = \begin{bmatrix} \Gamma & 0 & \dots & 0 \\ 0 & \Gamma & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \dots & 0 & \Gamma \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ \vdots \\ x_\ell(k) \end{bmatrix} + \begin{bmatrix} \Lambda + (\ell-1) \cdot \Pi & 0 & \dots & 0 \\ 0 & \Lambda + (\ell-1) \cdot \Pi & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \dots & 0 & \Lambda + (\ell-1) \cdot \Pi \end{bmatrix} \begin{bmatrix} F(x_1(k)) \\ F(x_2(k)) \\ \vdots \\ F(x_\ell(k)) \end{bmatrix}$$

$$x(k+1) = \Gamma x(k) + \Lambda_\ell F(x(k)) \quad , \quad \Lambda_\ell = \Lambda + (\ell-1) \cdot \Pi$$

Hareket Seçme

Bulduğumuz eşitsizliklerde b yerine $b+(l-1)c$ koyalım.

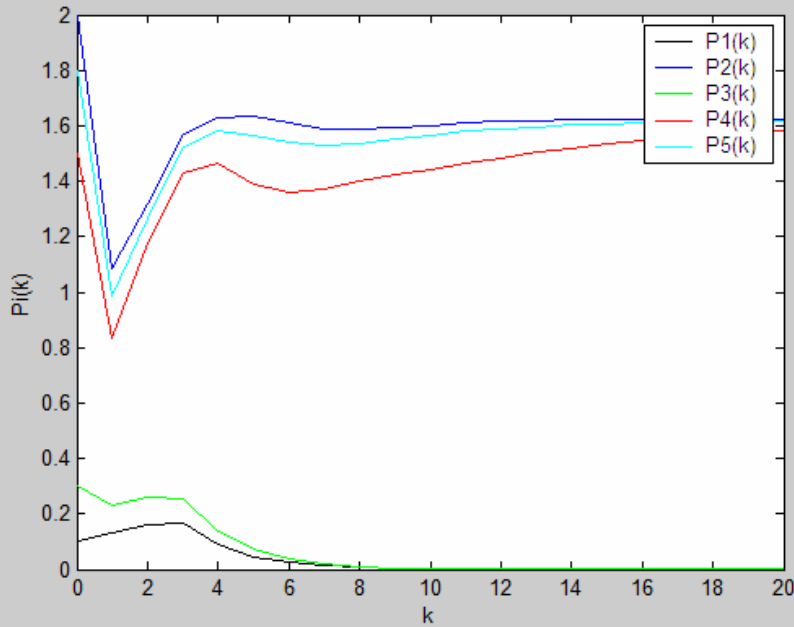
O zaman l hareketin seçilmesi için

$$b + (\ell - 1) \cdot c < 0.65 \cdot a + 0.9$$

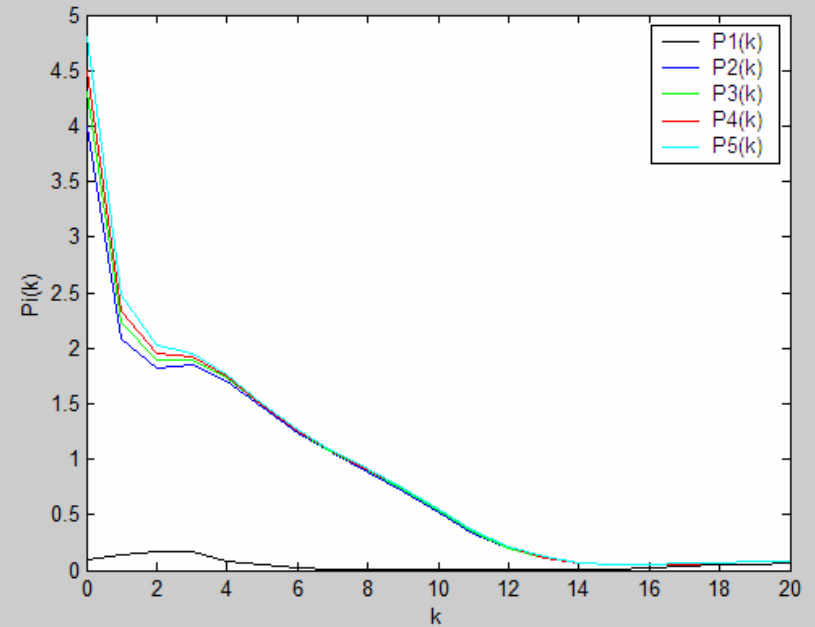
koşulu sağlanmalı.

ÖRNEK

Σ_5 sistemi $a=1.5$, $b=1$, $c=0.35$ parametre değerleri için eşitsizliği $l = 1, 2$ ve 3 için sağlar ama $l = 4$ için sağlamaz.



$p_1(0)=0.1$, $p_2(0)=2$, $p_3(0)=0.3$, $p_4(0)=1.5$, $p_5(0)=1.8$

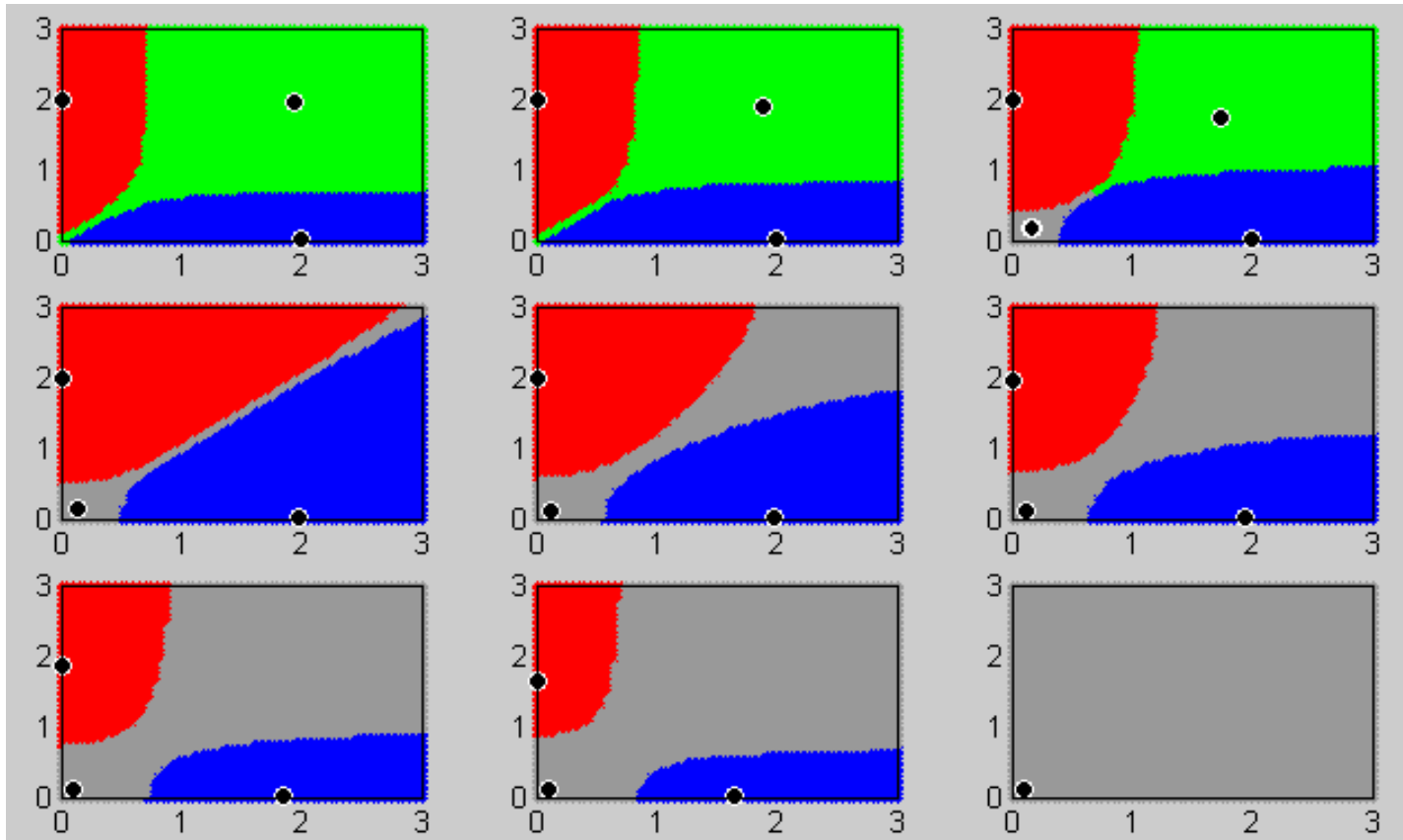


$p_1(0)=0.1$, $p_2(0)=4$, $p_3(0)=4.3$, $p_4(0)=4.5$, $p_5(0)=4.8$

Dopaminin etkisinin modellenmesi

Dopamin $\downarrow$ $\rightarrow$ parkinson

Dopamin $\uparrow$ $\rightarrow$ şizofreni



Kaynakça

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