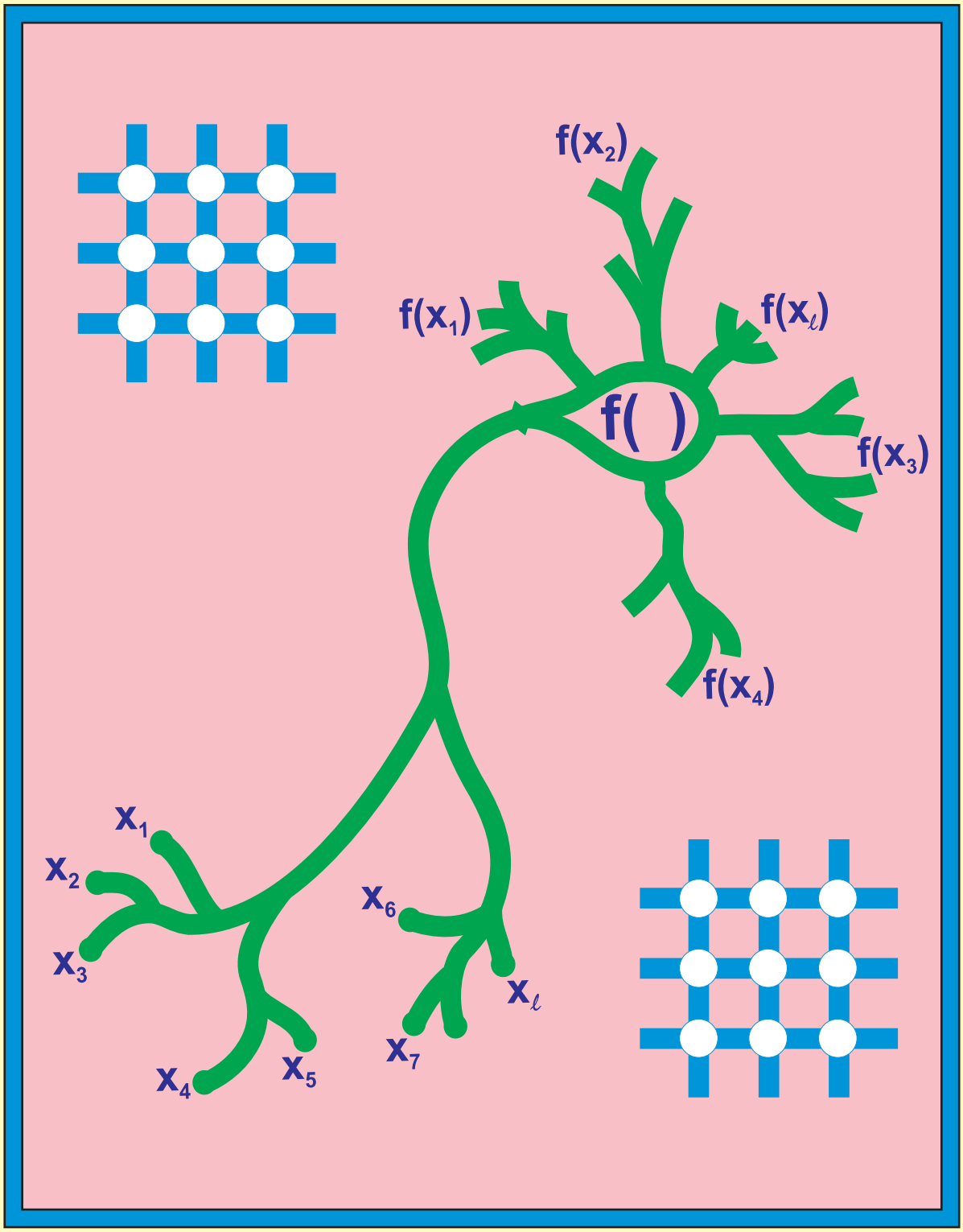
# Radial Base Function




A Radial Basis Function Artificial Neural Network.

Economics Letters 69, 15 - 23 - 2000

Blake, A. P. and Kapetanios

B F

# 4.2 Cálculo da Matriz Pseudo-Inversa

$$[R]\cdot[a]=A$$

$$\begin{bmatrix}0 & 3\\ 2 & 1\end{bmatrix}_{2\times2}\cdot\begin{bmatrix}2\\ 1\end{bmatrix}_{2\times1}=\begin{bmatrix}3\\ 5\end{bmatrix}_{2\times1}$$

A matrix $[a]=\begin{bmatrix}2\\ 1\end{bmatrix}$ foi obtida aplicando a matriz pseudo-inversa:

$$[a]=\left(\left[R\right]^{t}\cdot[R]\right)^{-1}\cdot\left[R\right]^{t}\cdot[A]$$

$$[a]=\left(\begin{bmatrix}0 & 2\\ 3 & 1\end{bmatrix}\cdot\begin{bmatrix}0 & 3\\ 2 & 1\end{bmatrix}\right)^{-1}\cdot\left[\begin{array}{cc}0 & 2\\ \hdashline 3 & 1\end{array}\right]_{2\times2}\cdot\begin{bmatrix}3\\ 5\end{bmatrix}_{2\times1}$$

$$[a]=\left(\left[\begin{array}{cc}0 & 2\\ \hdashline 3 & 1\end{array}\right]\cdot\left[\begin{array}{c:c}0 & 3\\ 2 & 1\end{array}\right]\right)^{-1}\cdot\begin{bmatrix}10\\ 14\end{bmatrix}_{2\times1}$$

$$[a]=\left(\left[\begin{array}{cc}4 & 2\\ \hdashline 2 & 10\end{array}\right]\right)^{-1}\cdot\begin{bmatrix}10\\ 14\end{bmatrix}_{2\times1}$$

$$[a]=\left[\begin{array}{cc}\frac{5}{18} & -\frac{1}{18}\\ \hdashline -\frac{1}{18} & \frac{2}{18}\end{array}\right]_{2\times2}\cdot\begin{bmatrix}10\\ 14\end{bmatrix}_{2\times1}$$

$$[a]=\begin{bmatrix}2\\ 1\end{bmatrix}_{2\times1}$$

Divisão Matricial

Pseudo-Inversa

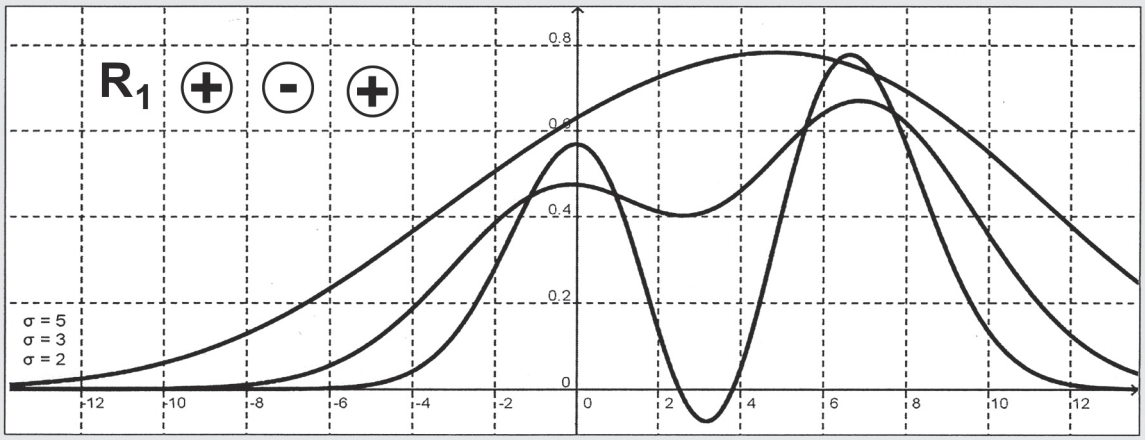
FBR

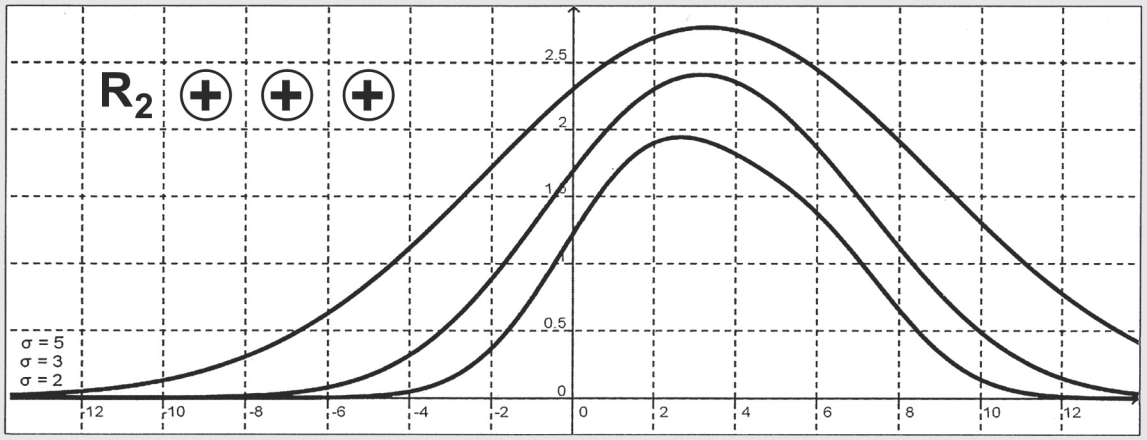
3 Polos

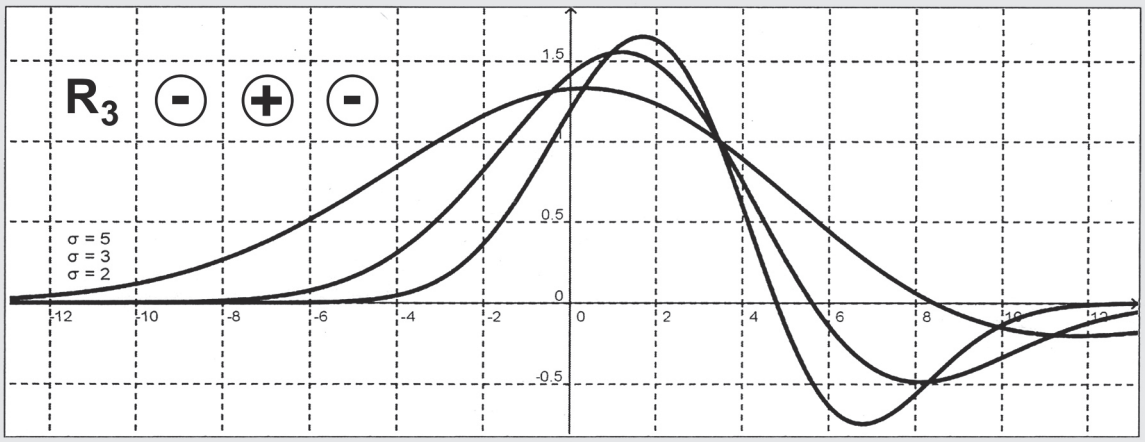
$$R_1(x) = +1 \cdot e^{\frac{-1}{2\sigma^2} \cdot \|X-1\|^2} \quad -1 \cdot e^{\frac{-1}{2\sigma^2} \cdot \|X-3\|^2} \quad +1 \cdot e^{\frac{-1}{2\sigma^2} \cdot \|X-6\|^2}$$

$$R_2(x) = +1 \cdot e^{\frac{-1}{2\sigma^2} \cdot \|X-1\|^2} \quad +1 \cdot e^{\frac{-1}{2\sigma^2} \cdot \|X-3\|^2} \quad +1 \cdot e^{\frac{-1}{2\sigma^2} \cdot \|X-6\|^2}$$

$$R_3(x) = -1 \cdot e^{\frac{-1}{2\sigma^2} \cdot \|X-1\|^2} \quad +1 \cdot e^{\frac{-1}{2\sigma^2} \cdot \|X-3\|^2} \quad -1 \cdot e^{\frac{-1}{2\sigma^2} \cdot \|X-6\|^2}$$



# 9.0 FBR de Três Variáveis com Dois Polos

## Quadro Aplicativo das Lições do Big Data

Etapa Prima

$$\mathbf{a}(X_\ell) \equiv \sum_{p=1}^{P} a_p \circ R_p + b$$

| Lições ($\ell$) | Dominus ($X_\ell$) | Functus $a(X_\ell)$ |
|---|---|---|
| $\ell = 1$ | $X_1 = (1,1,1)$ | $a = 2,18$ |
| $\ell = 2$ | $X_2 = (1,1,0)$ | $a = 1,83$ |
| $\ell = 3$ | $X_3 = (0,3,1)$ | $a = 1,31$ |
| $\ell = 4$ | $X_4 = (1,1,2)$ | $a = 2,79$ |
| $\ell = 5$ | $X_5 = (2,1,1)$ | $a = 2,49$ |
| $\ell = 6$ | $X_6 = (2,0,4)$ | $a = 3,95$ |
| $\ell = 7$ | $X_7 = (1,2,0)$ | $a = 2,11$ |

Coordenadas dos Polos

$$C_1 = (0,0,0) \quad , \quad C_2 = (2,0,4)$$

$$\sigma = \frac{D_{max}^{P'S}}{\sqrt{2P}} = \frac{\sqrt{20}}{\sqrt{2 \cdot 2}} = \sqrt{5} \quad , \quad \sigma^2 = 5$$

$$R_p = e^{-\frac{1}{2\sigma^2} \cdot \|(X_\ell) - (C_p)\|^2}$$

$$R_p = e^{-0,1 \cdot \|(X_\ell) - (C_p)\|^2}$$

Etapa Secunda

$$\mathbf{a}(X_\ell) \equiv \sum_{p=1}^{2} a_p \circ R_p + b$$

$$\mathbf{a}(X_\ell) \equiv a_1 \circ R_1 + a_2 \circ R_2 + b$$

$$\mathbf{a}(X_\ell) = a_1 \cdot e^{-0,1 \cdot \|(X_\ell) - (0,0,0)\|^2} + a_2 \cdot e^{-0,1 \cdot \|(X_\ell) - (2,0,4)\|^2} + b$$

## Função Epistêmica do Banco de Dados

# 10.0 Big Data FBR de Quatro Variáveis e Cinco Polos

FBR

| Rótulo | Entrada | | | | Saída | Dist. ent/ c1 | Dist. ent/ c2 | Dist. ent/ c3 | Dist. ent/ c4 | Dist. ent/ c5 |
|---|---|---|---|---|---|---|---|---|---|---|
| j =1 | 5 | 8 | 3 | 1 | 28,577 | 4,316248371 | 5,570457791 | 6,445928948 | 4,34281015 | 3,8 |
| j =2 | 2 | 4 | 2 | 6 | 41,138 | 3,772267223 | 3,74566416 | 2,924038303 | 5,464430437 | 5,141984053 |
| j =3 | 5 | 3 | 4 | 6 | 33,107 | 2,903446228 | 4,339354791 | 4,488875137 | 4,106093034 | 4,943682838 |
| j =4 | 4 | 7 | 1 | 5 | 48,312 | 3,167017524 | 3,380828301 | 5,054700782 | 3,668787266 | 2,2 |
| j=5 | 5 | 1 | 3 | 4 | 34,776 | 4,003748244 | 6,605300902 | 3,788139385 | 6,054750201 | 6,575712889 |
| j=6 | 6 | 8 | 2 | 3 | 62,687 | 3,553871129 | 4,79895822 | 6,553624951 | 3,009983389 | 1,907878403 |
| j=7 | 6 | 2 | 7 | 2 | 30,601 | 5,461684722 | 7,538567503 | 6,507687761 | 6,360817558 | 7,618398782 |
| j=8 | 8 | 7 | 4 | 1 | 38,406 | 4,902040392 | 7,002142529 | 7,908855796 | 4,34281015 | 4,737087713 |
| j=9 | 3 | 8 | 4 | 7 | 41,486 | 4,672258554 | 1,493318452 | 6,644546636 | 3,93192065 | 3,746998799 |
| j=10 | 5 | 2 | 1 | 6 | 32,614 | 4,126742056 | 6,101639124 | 4,376071297 | 5,870264049 | 5,8685603 |

| c1 | c2 | c3 | c4 | c5 |
|---|---|---|---|---|
| 4,9 | 3,1 | 1,9 | 6,1 | 5,5 |
| 5 | 6,9 | 2,9 | 6,8 | 7,5 |
| 3,1 | 4,1 | 2,2 | 4 | 2,5 |
| 4,1 | 6 | 3,3 | 4,9 | 4,7 |

Número de Pólos
5

| σ |
|---|
| 1,96596 |

| R (c1) | R (c2) | R(c3) | R(c4) | R(c5) |
|---|---|---|---|---|
| 0,089807 | 0,018057 | 0,00463 | 0,087174 | 0,154425 |
| 0,158678 | 0,162837 | 0,330853 | 0,021008 | 0,032698 |
| 0,33603 | 0,087513 | 0,073776 | 0,112916 | 0,042353 |
| 0,273202 | 0,227944 | 0,036688 | 0,175298 | 0,534656 |
| 0,125715 | 0,003538 | 0,156233 | 0,008716 | 0,003721 |
| 0,195168 | 0,050828 | 0,003863 | 0,309729 | 0,624445 |
| 0,021089 | 0,000641 | 0,004175 | 0,005331 | 0,000548 |
| 0,04466 | 0,001759 | 0,000306 | 0,087174 | 0,05486 |
| 0,059364 | 0,749397 | 0,003308 | 0,135335 | 0,162626 |
| 0,11046 | 0,008097 | 0,083965 | 0,011586 | 0,011616 |

| Resultado |
|---|
| 36,75177783 |
| 42,22665577 |
| 33,27254308 |
| 47,52109102 |
| 33,39788429 |
| 61,55434484 |
| 28,78412048 |
| 36,0186547 |
| 41,38387449 |
| 30,7930535 |

| Dist 1 e2 | Dist 1 e3 | Dist 1 e 4 | Dist 1 e 5 | Dist 2 e 3 | Dist 2 e4 | Dist 2 e5 |
|---|---|---|---|---|---|---|
| 3,385262176 | 3,854867 | 2,475884 | 2,707397 | 5,323533 | 3,198437 | 3,220248 |

| Dist 3 e 4 | Dist 3 e 5 | Dist 4 e 5 |
|---|---|---|
| 6,216912417 | 6,01415 | 1,772005 |

Max Dist
6,216912

$$\sigma = \frac{D_{max}^{P'S}}{\sqrt{2P}} = \frac{6{,}216912}{\sqrt{2 \cdot 5}} = 1{,}96596$$

MatrizR

| | | | | | |
|---|---|---|---|---|---|
| 0,089807 | 0,018057 | 0,00463 | 0,087174 | 0,154425 | 1 |
| 0,158678 | 0,162837 | 0,330853 | 0,021008 | 0,032698 | 1 |
| 0,33603 | 0,087513 | 0,073776 | 0,112916 | 0,042353 | 1 |
| 0,273202 | 0,227944 | 0,036688 | 0,175298 | 0,534656 | 1 |
| 0,125715 | 0,003538 | 0,156233 | 0,008716 | 0,003721 | 1 |
| 0,195168 | 0,050828 | 0,003863 | 0,309729 | 0,624445 | 1 |
| 0,021089 | 0,000641 | 0,004175 | 0,005331 | 0,000548 | 1 |
| 0,04466 | 0,001759 | 0,000306 | 0,087174 | 0,05486 | 1 |
| 0,059364 | 0,749397 | 0,003308 | 0,135335 | 0,162626 | 1 |
| 0,11046 | 0,008097 | 0,083965 | 0,011586 | 0,011616 | 1 |

Matriz Transposta de R

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0,089807162 | 0,158677778 | 0,336029517 | 0,273202 | 0,125715 | 0,195168 | 0,021089 | 0,04466 | 0,059364 | 0,11046 |
| 0,018056848 | 0,162836855 | 0,087513363 | 0,227944 | 0,003538 | 0,050828 | 0,000641 | 0,001759 | 0,749397 | 0,008097 |
| 0,00463017 | 0,330853299 | 0,073775614 | 0,036688 | 0,156233 | 0,003863 | 0,004175 | 0,000306 | 0,003308 | 0,083965 |
| 0,087174383 | 0,021007581 | 0,112915836 | 0,175298 | 0,008716 | 0,309729 | 0,005331 | 0,087174 | 0,135335 | 0,011586 |
| 0,154425026 | 0,03269805 | 0,042353355 | 0,534656 | 0,003721 | 0,624445 | 0,000548 | 0,05486 | 0,162626 | 0,011616 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Mult de Transpodta por R

| | | | | | |
|---|---|---|---|---|---|
| 0,292859 | 0,174981 | 0,117697 | 0,171862 | 0,315097 | 1,414173636 |
| 0,174981 | 0,65072 | 0,072689 | 0,172279 | 0,287506 | 1,310611775 |
| 0,117697 | 0,072689 | 0,147777 | 0,026144 | 0,038799 | 0,697796928 |
| 0,171862 | 0,172279 | 0,026144 | 0,173606 | 0,333025 | 0,954268335 |
| 0,315097 | 0,287506 | 0,038799 | 0,333025 | 0,732104 | 1,621948403 |
| 1,414174 | 1,310612 | 0,697797 | 0,954268 | 1,621948 | 10 |

Inversa da Mult

| | | | | | |
|---|---|---|---|---|---|
| 17,71316097 | 1,342955645 | -8,44096184 | -13,82931 | 0,465047 | -0,847691 |
| 1,342955645 | 2,362596786 | -0,88955422 | -4,115124 | 0,799922 | -0,174539 |
| -8,44096184 | -0,88955422 | 16,99156249 | 17,57569 | -2,299944 | -1,179535 |
| -13,8293146 | -4,11512437 | 17,57569113 | 91,27043 | -28,71364 | -2,783832 |
| 0,465046648 | 0,79992235 | -2,29994359 | -28,71364 | 12,46667 | 0,707906 |
| -0,84769061 | -0,17453913 | -1,17953498 | -2,783832 | 0,707906 | 0,475895 |

Mult Inversa pela Transposta de R

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| -0,405503 | -0,886357 | 3,057391 | 1,812414 | -0,053702 | -1,34794131 | -0,5819859 | -1,23688338 | -0,61363938 | 0,256206777 |
| -0,250595 | 0,068671 | -0,012918 | 0,404574 | -0,169222 | -0,57085358 | -0,16991608 | -0,42552768 | 1,245931981 | -0,12014447 |
| -0,698001 | 3,251953 | -0,953069 | -1,213703 | 0,555452 | 1,201001899 | -1,19473987 | -0,14690142 | -0,28647401 | -0,51551879 |
| -0,496392 | 1,145136 | 2,595397 | -6,207627 | -1,10233 | 4,714897731 | -2,53389817 | 2,977904058 | 1,051988305 | -2,14507531 |
| 0,175539 | -0,044556 | -1,949719 | 2,564852 | 0,205982 | -0,27826208 | 0,562379878 | -1,08979624 | -0,53119345 | 0,384774733 |
| 0,257792 | -0,112624 | -0,195606 | 0,051729 | 0,162796 | -0,12316158 | 0,438527659 | 0,233525054 | 0,029244943 | 0,257776199 |

| Matriz a |
|---|
| -28,04917 |
| -0,660207 |
| 47,34609 |
| 86,68716 |
| 18,13363 |
| 28,70631 |