Modeliranje gibanja pčele u simulatoru biohibridnih sustava

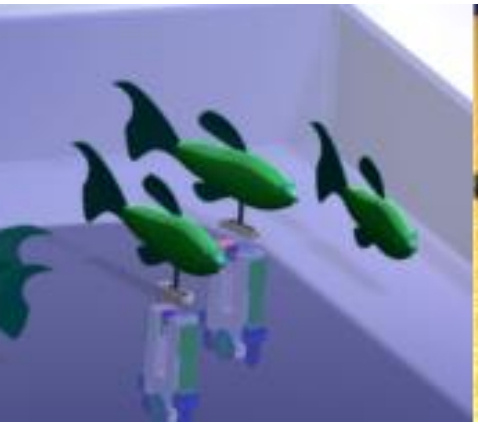
Una Pale

FER

Zagreb, srpanj 2014.

ASSISIbf

- Animal and robot Societies Self-organise and Integrate by Social Interaction - bees and fish
- Casu (Combined actuator sensor units) jedinice
  - interakcija s pčelama
  - mjerenja, analiza, učenje
  - gibanje pčele za gibanje Casu
- Samoorganizirajuća struktura robota i pčela

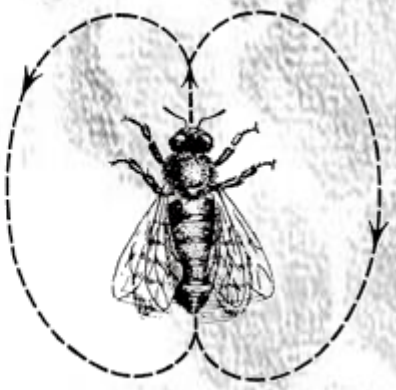



Postojeće ideje i saznanja

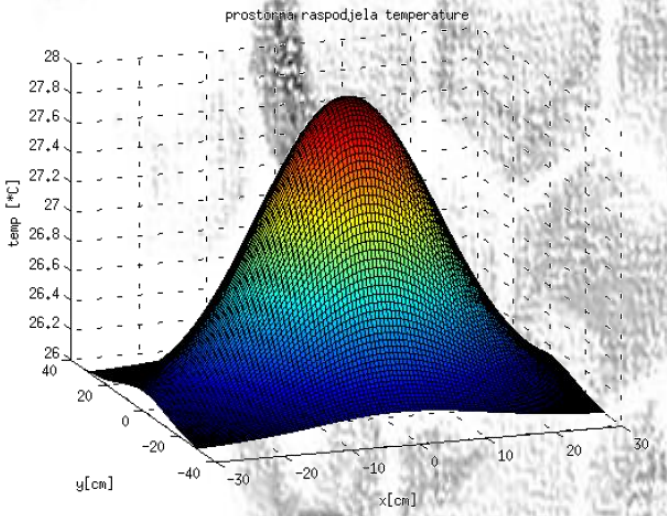
- Inteligencija decentraliziranih sustava
- CBM - composite Brownian motion
- CTCRW-continuous time correlated random walk

- Modeli cijelih skupina:
  - izviđači, „waggle” dance, traženje mete
  - traženje topline, susreti pčela, stajanje proporcionalno temperaturi…

- Pčele i toplina

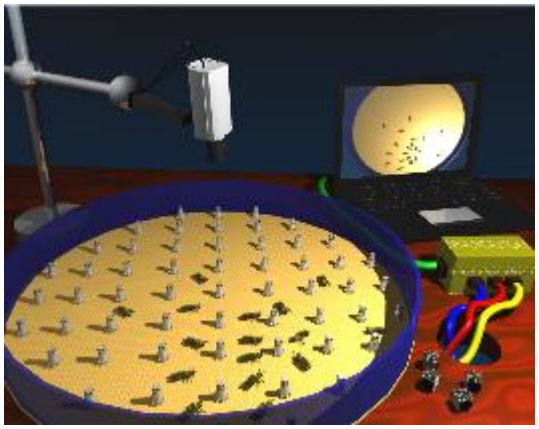


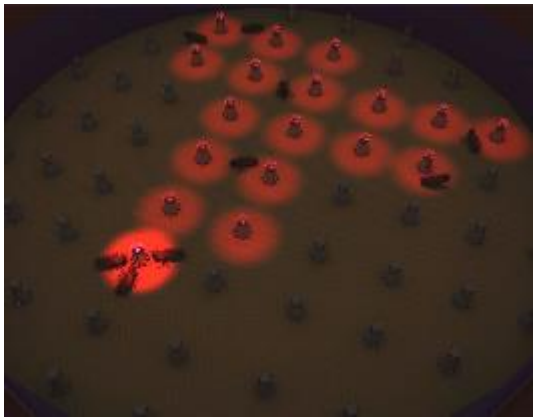
Model arene

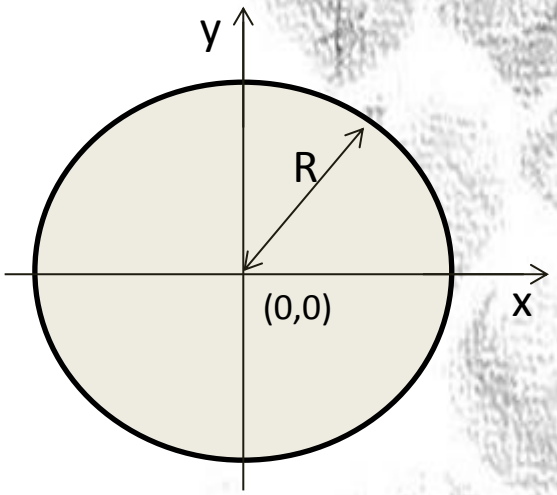


- Okrugla arena (R=30cm)
- Izvor topline - T_{max}, (txc,tyc)
  - na r=60cm T=26° C
  - T_{max} od 26 do 40° C,

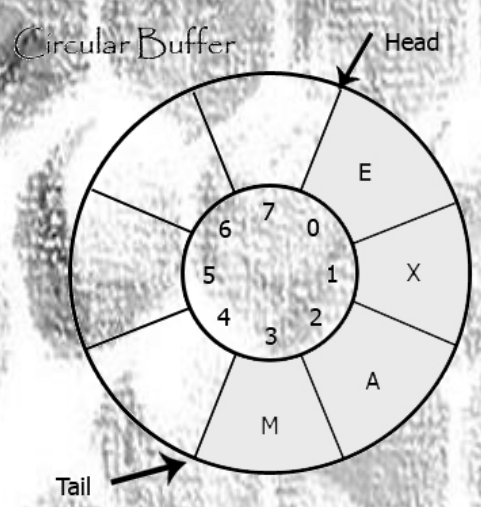
$$z = \frac{T_{max}\left(e^{-\gamma((x-txc)^2+(y-tyc)^2)} - e^{-\gamma*60^2}\right) + 26\left(1 - e^{-\gamma((x-txc)^2+(y-tyc)^2)}\right)}{1 - e^{-\gamma*60^2}}$$







Modeli pčele



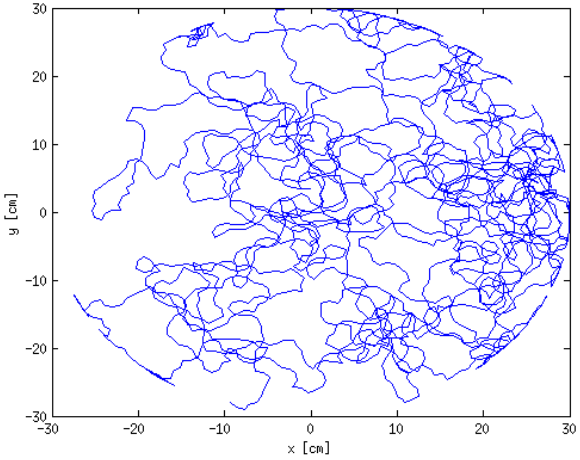
- Model pčele s memorijom
  - Ciklička memorija - (x,y,T)
- Model pčele s osjetom gradijenta temperature
  - Na ticalima osjetilo za toplinu

$$\phi_{uk} = \alpha * \phi_{temp} + (1 - \alpha) * \phi_{rand}$$

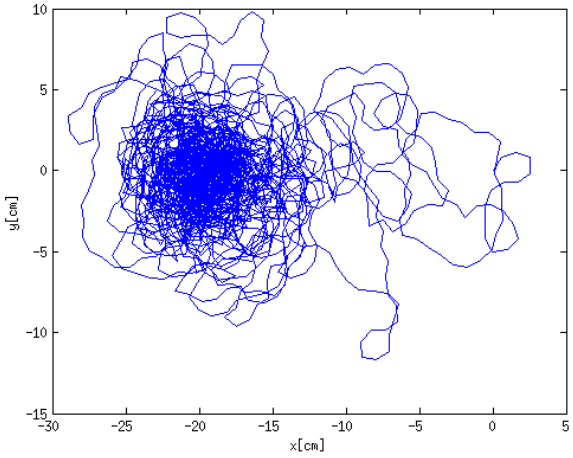
- Slučajno i određeno gibanje
  - slučajni kut – uniformno, normalno
  - termalni kut
  - $\alpha \in [0, 1]$ - udio termalnog kuta
  - najveći dopušteni kut zakreta ~35°

Modeli pčele

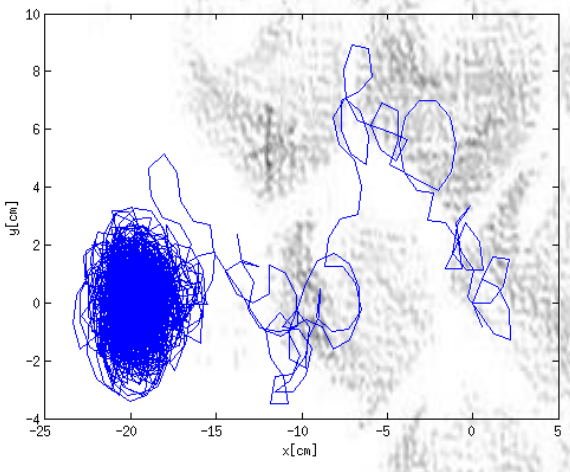
- Osnovni model
  - α - slobodan parametar
  - pri gibanju samo smjer gradijenta i najveće temperature uzet u obzir



α =0.0



α =0.5



α =1.0

Modeli pčele

- Cjeloviti model
  - utjecaj iznosa gradijenta i najveće temperature
    - memorija

$$\alpha(i) = (1-\beta)\frac{T(i)-T_{min}}{T_{max}-T_{min}} + \beta\frac{T_s-26}{40-26}$$

    - gradijent

$$\alpha(i) = (1-\beta)\frac{grad(i)}{grad_{max}} + \beta\frac{T_s-26}{40-26}$$

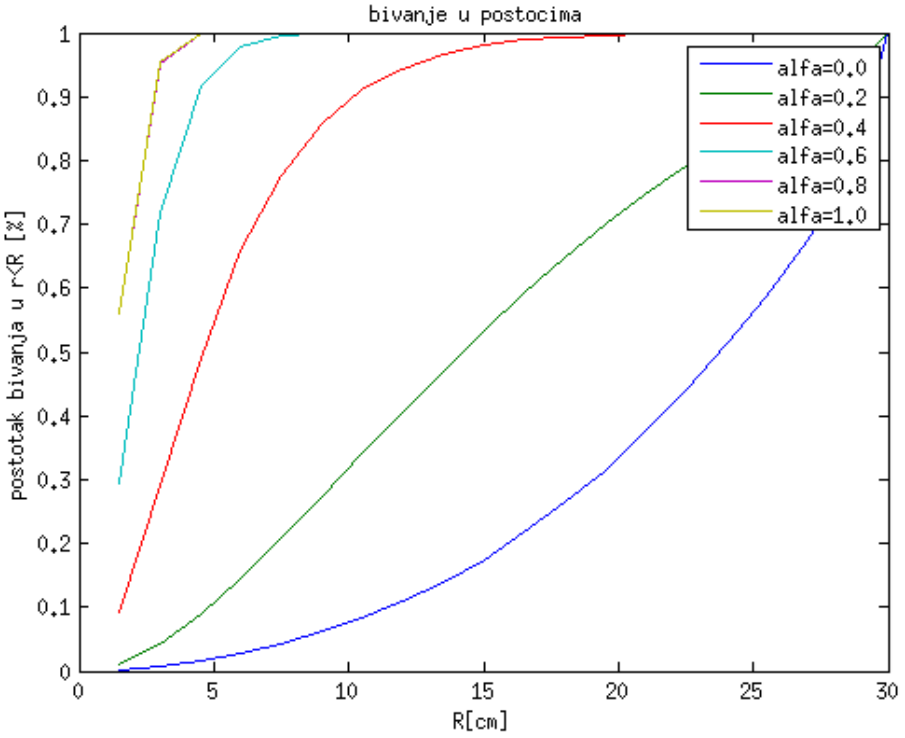
  - nemogućnost implementacije na robote

$$\alpha(i) = \beta\sqrt{\frac{T_{max}-26}{40-26}}$$

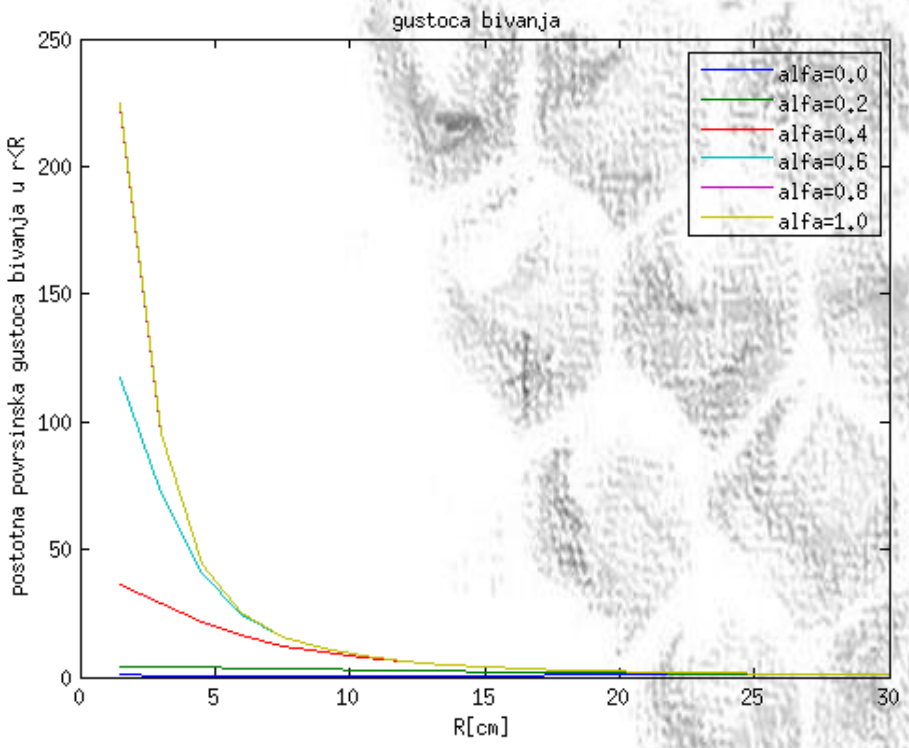
$\beta \in [0, 1]$ slobodan parametar

Metode analize gibanja – prostorna m.

- 20 kružnica
- boravak u postotnom vremenu
- gustoća boravka



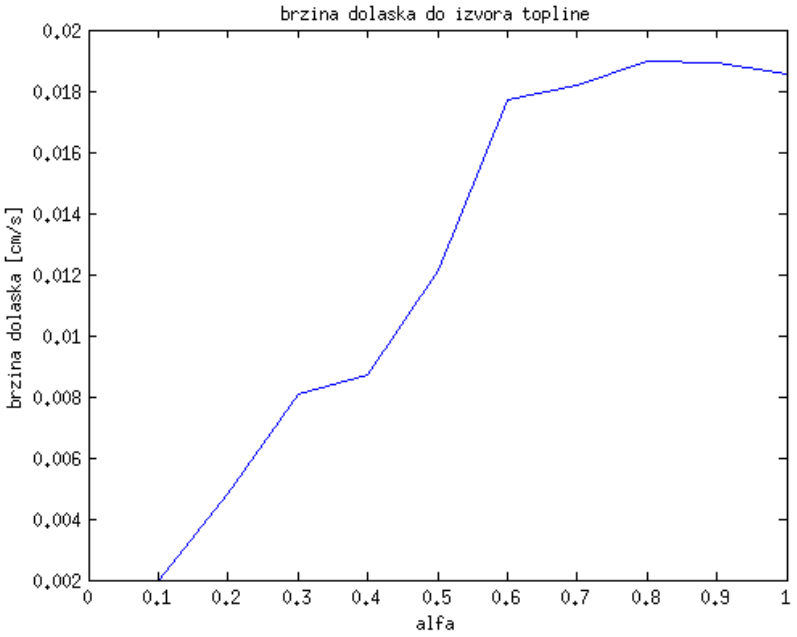
Boravak u postotnom vremenu u r<R



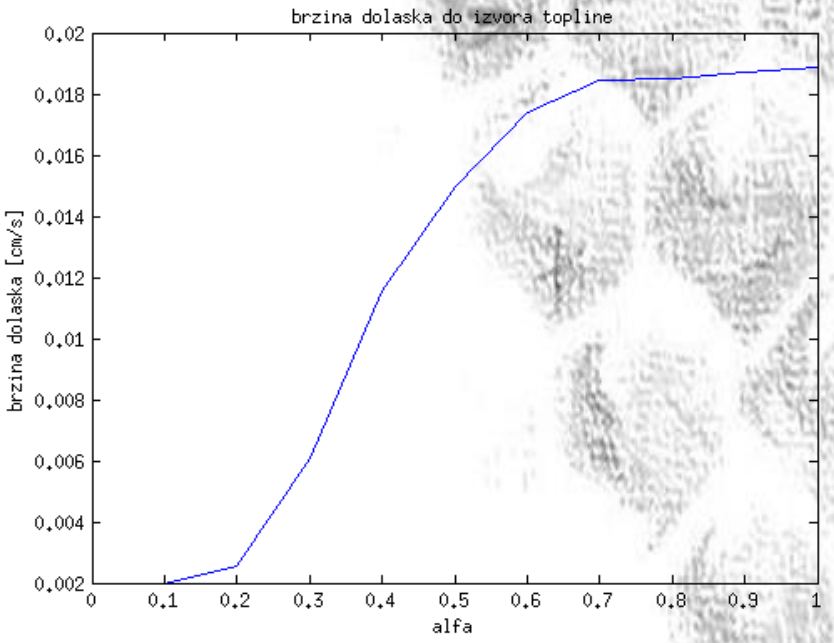
Gustoća boravka u r<R

Metode analize gibanja – vremenska m.

- veći gradijent brže pronalaženje izvora
- V1 - gustoća boravka unutar 2 radiusa veća od gustoća za ostale radiuse
- V2 – n-ti put unutar najmanja 2 radiusa
  - n - 10



Brzina dolaska do izvora topline – V1



Brzina dolaska do izvora topline – V2

Analiza modela – osnovni modeli

- Duljina simulacije
  - ne utječe ni na analizu prostornom ni vremenskom metodom
- Rasipanje karakteristike
  - više izraženo za manje α
- Udio temperaturnog kuta – α
  - najviše utječe
- Usporedba dva osnovna modela
  - zanemariva razlika

Analiza modela – osnovni modeli

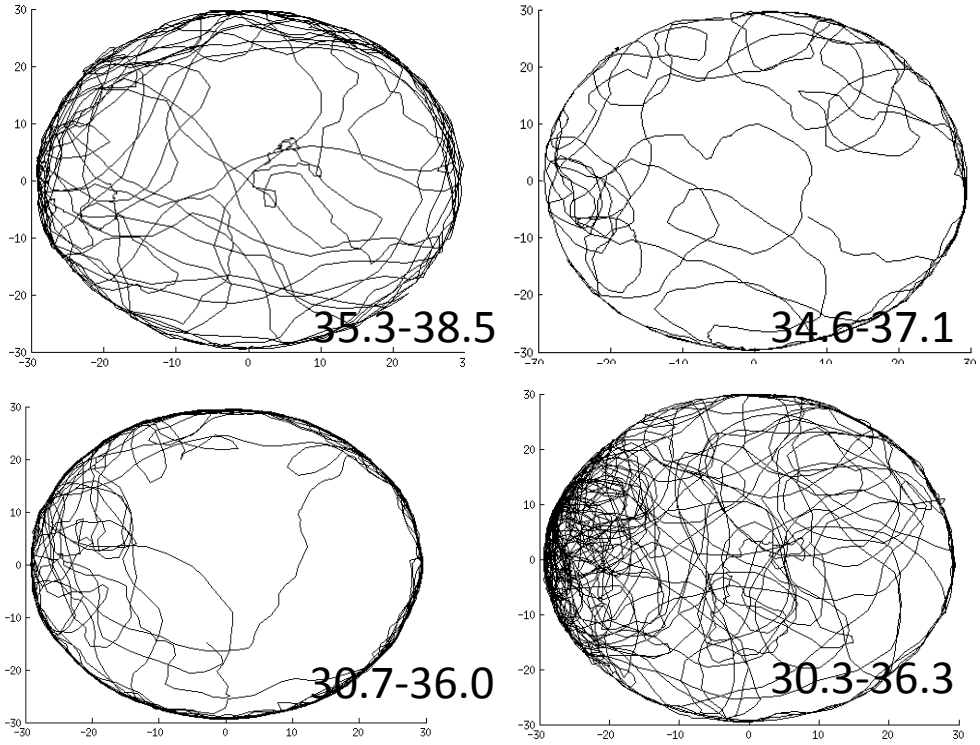
- Dozvoljeni kutovi zakreta
  - Maksimalni kut zakreta
    - manji dozvoljeni kut – kao manji α
    - veći dozvoljeni kut – brzina blago pada
  - Razdioba kuteva
    - normalna ili uniformna – nema velike razlike
    - σ i [-θmax, θmax] – nije dobro da su preveliki
      - preveliki dopušteni „slučajni” kutevi koji skreću s putanje
- Temperatura izvora topline
  - ne utječe na osnovni model

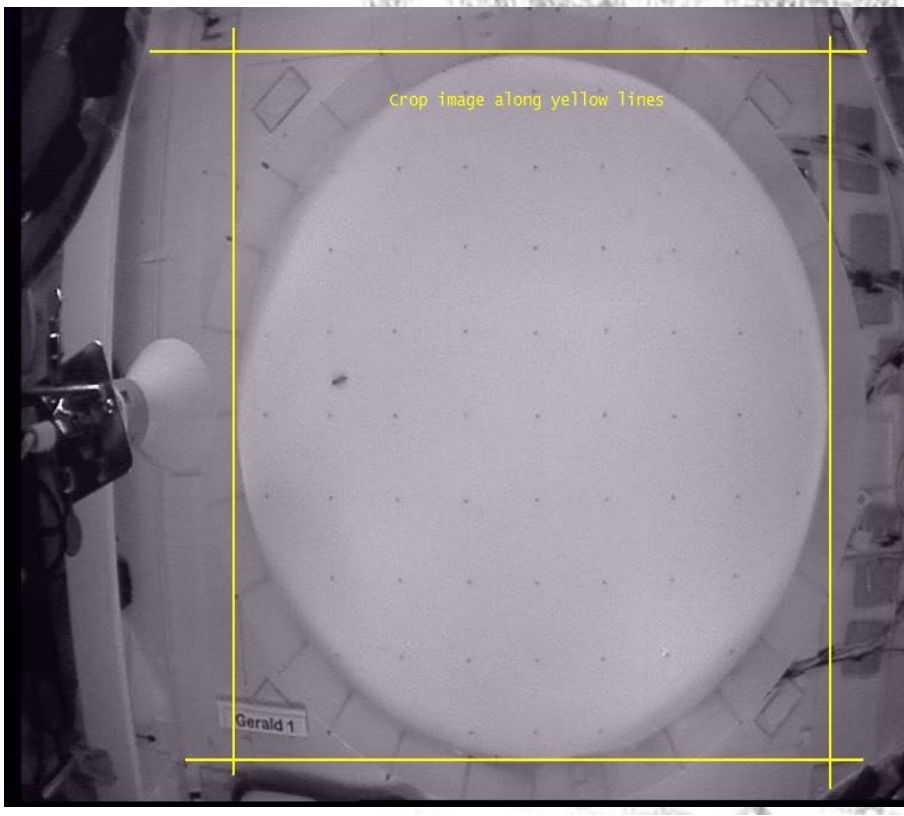
Analiza modela – cjeloviti modeli

- Temperatura izvora topline
  - za $\beta=1.0$ i $\beta=0.3$
  - za veći β brže pronalaženje izvora i gustoće veće
  - potrebno odabrati β tako da odgovara stvarnim brzinama i gustoćama pčele sa videa
- Ovisnost o duljini memorije
  - ne utječe zamjetno
- Usporedba dva modela
  - za različite α i β
  - model s gradijentom brži

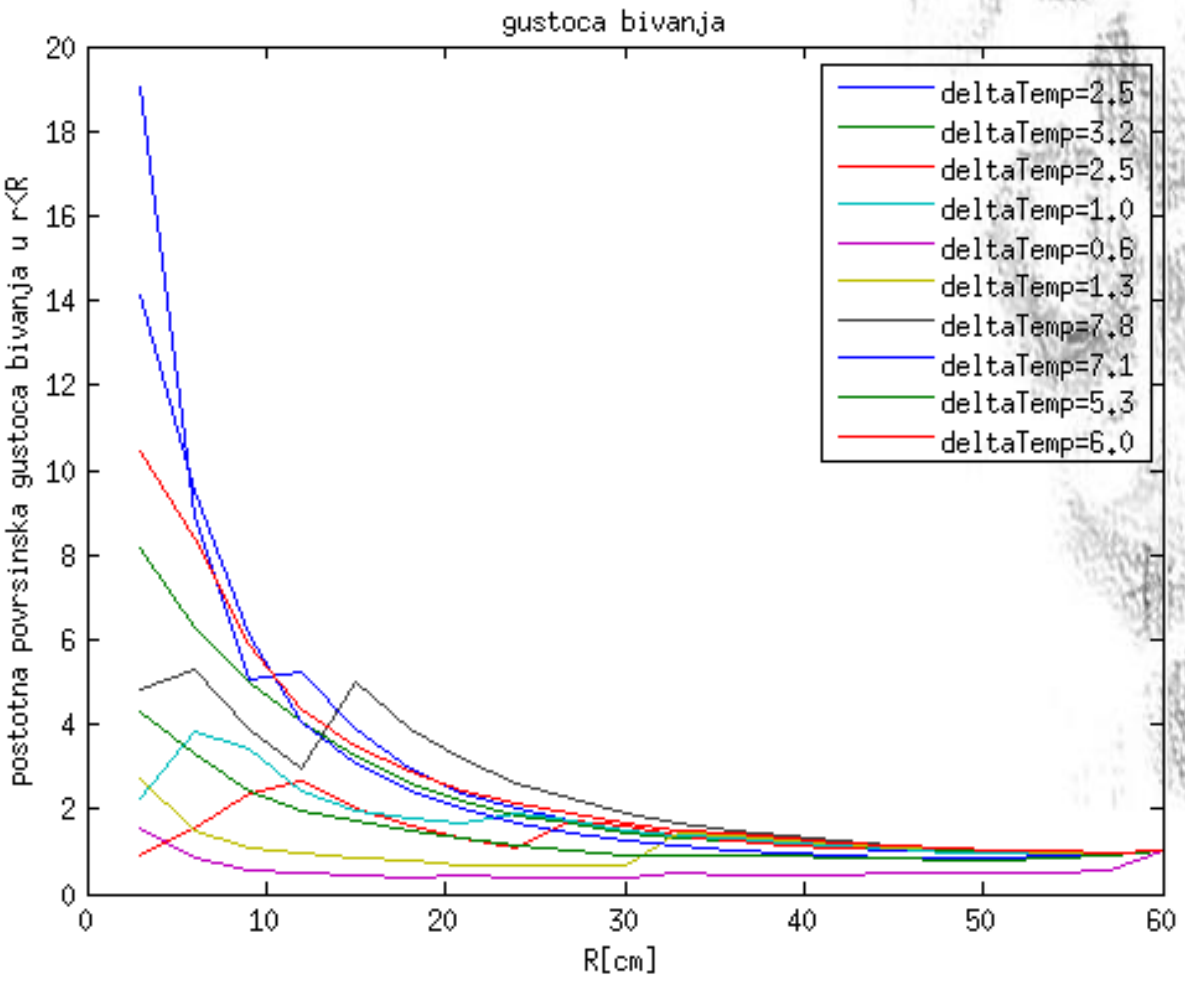
Stvarna gibanja pčele - videi

- (x,y) koordinate u vremenu
- za različite temperature izvora i okoline

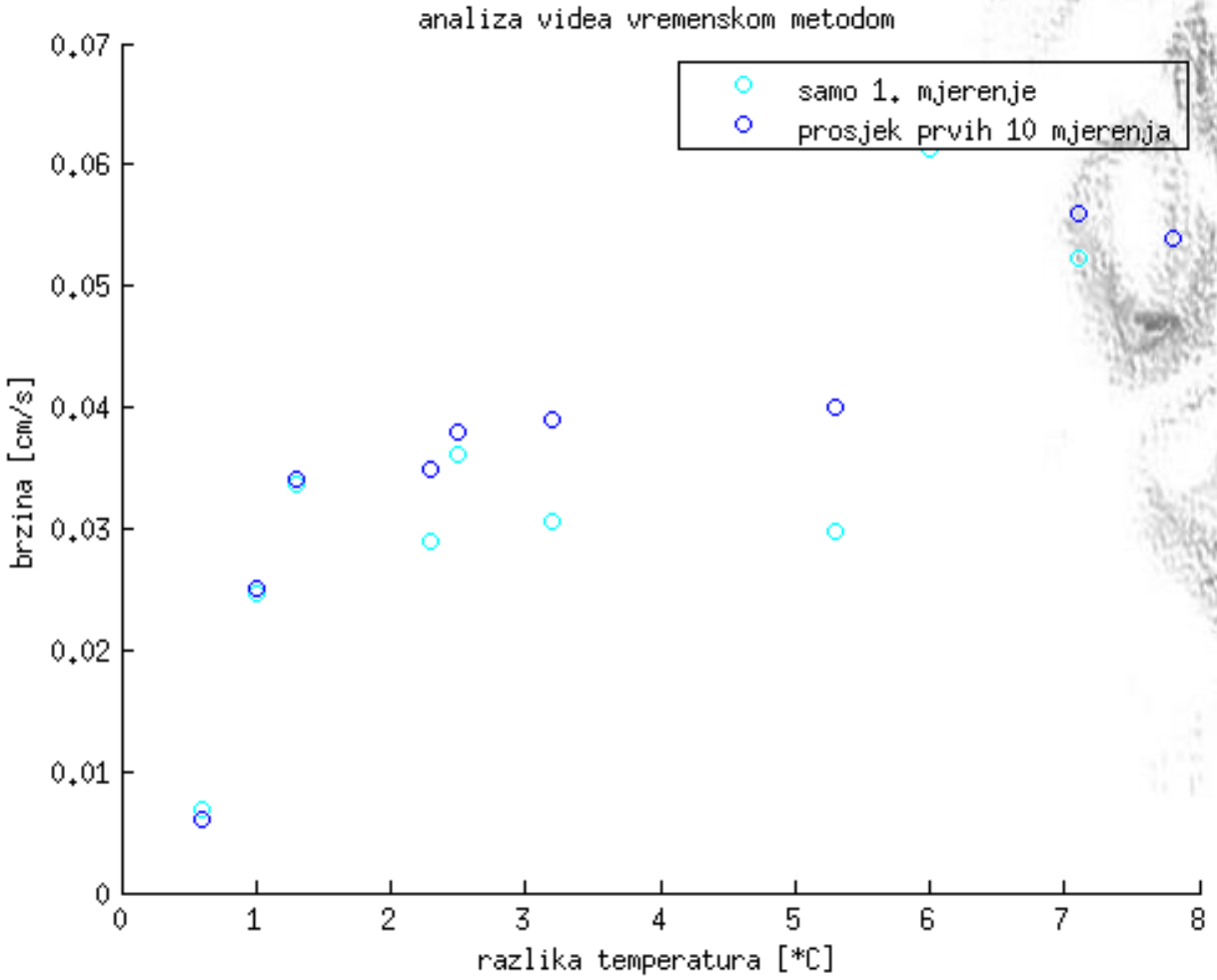




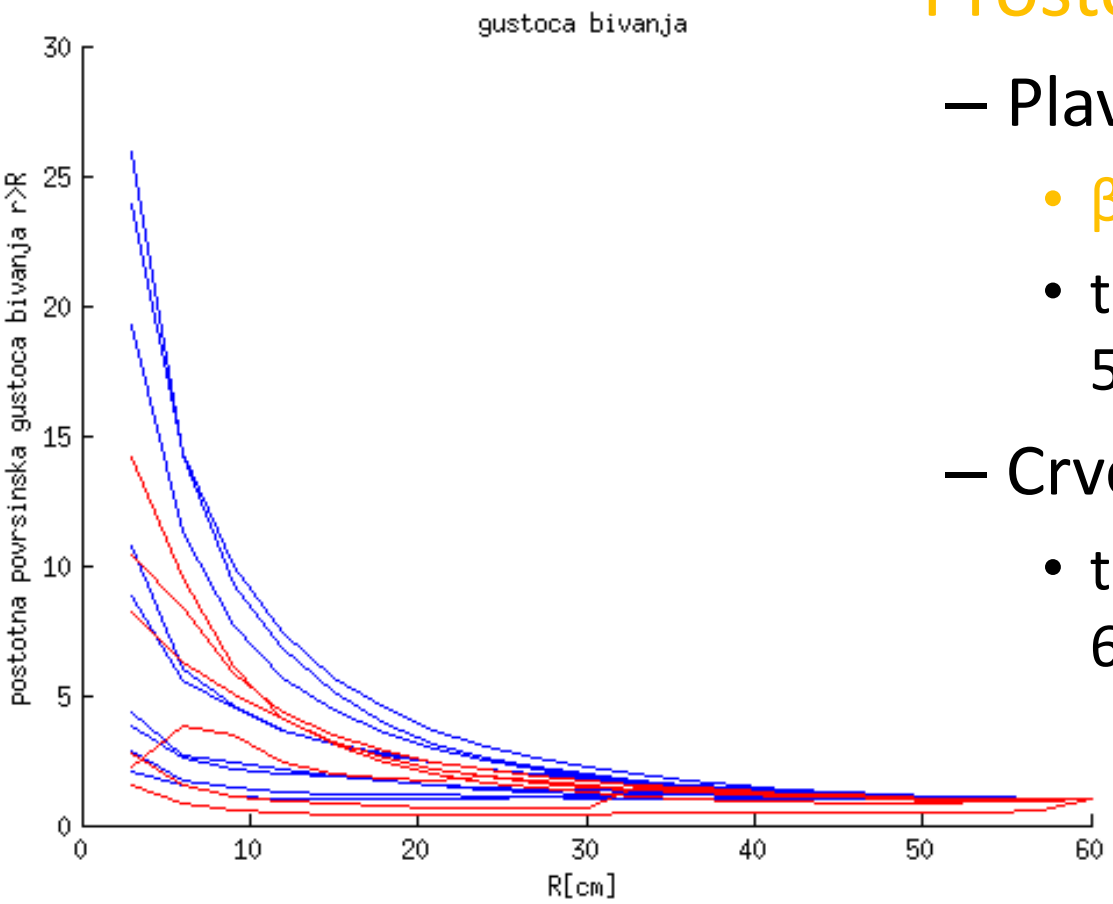
Stvarna gibanja pčele - prostorna metoda



Stvarna gibanja pčele - vremenska metoda

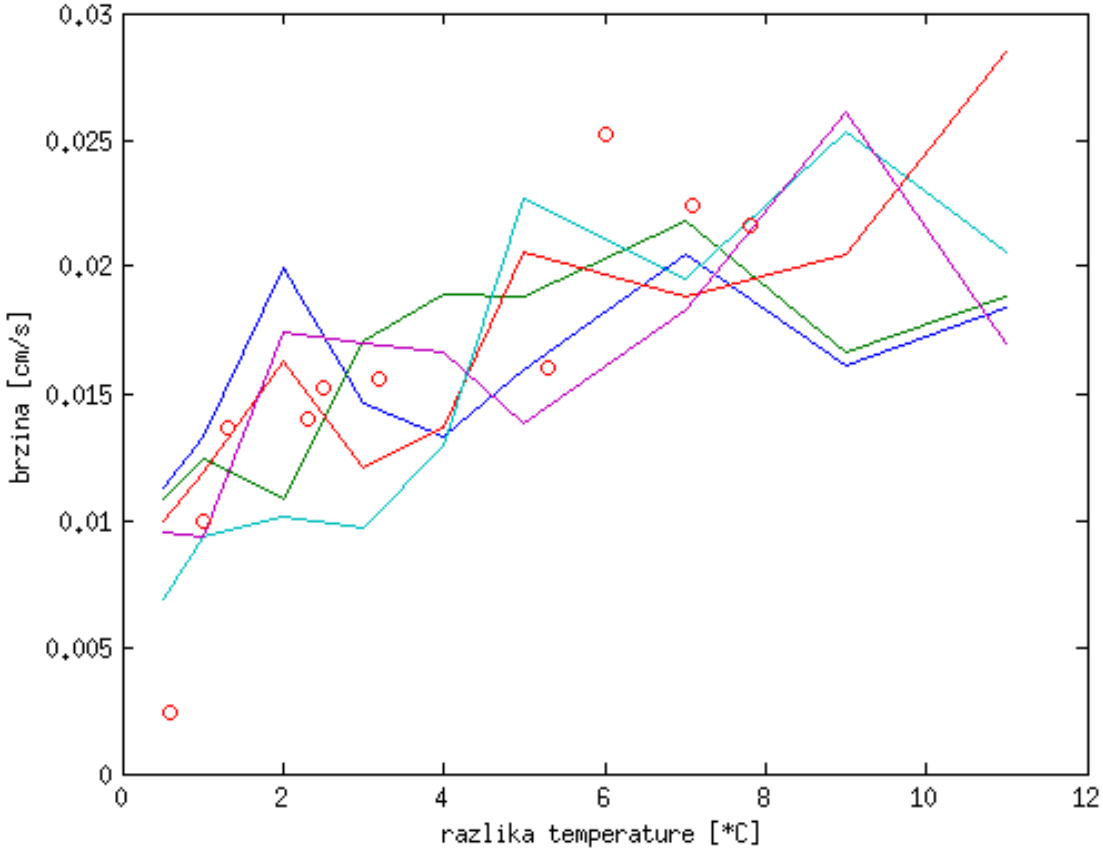


Usporedba modela sa stvarnim gibanjem pčele



- Prostorna metoda
  - Plavo – model (gradijent)
    - β=0.3
    - temp: 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 7.0, 9.0, 11.0 ° C
  - Crveno – videi
    - temp: 0.6, 1.0, 1.3, 3.2, 6.0,7.1 ° C

Usporedba modela sa stvarnim gibanjem pčele



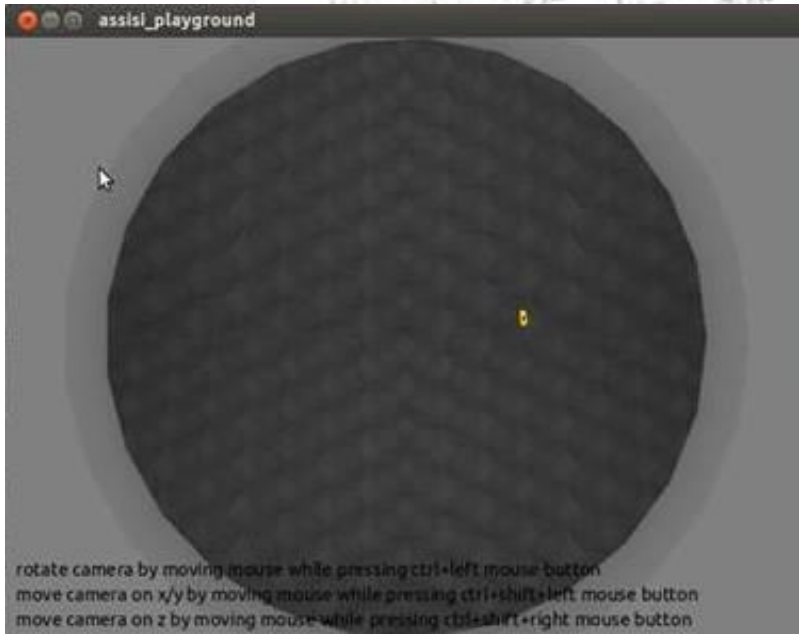
- Vremenska metoda
  - Model
    - s osjetom gradijenta
    - β=0.3
    - pomnoženo sa 2.5
    - rasipanje
  - Video
    - prosjek prvih 10 točaka
    - više videa za potvrdu

Implementacija u simulatoru biohibridnih sustava

- omogućiti kvalitativno modeliranje pčela u polju senzorsko-aktuatorskih uređaja (Casu)
- moduli: pčele, Casu, fizičkog objekta
- pčela
  - zadavanje brzine pojedinom kotaču
  - razni senzori
- implementirana oba modela

$$v = \frac{v_d + v_l}{2}$$

$$w = \frac{v_d - v_l}{2}$$



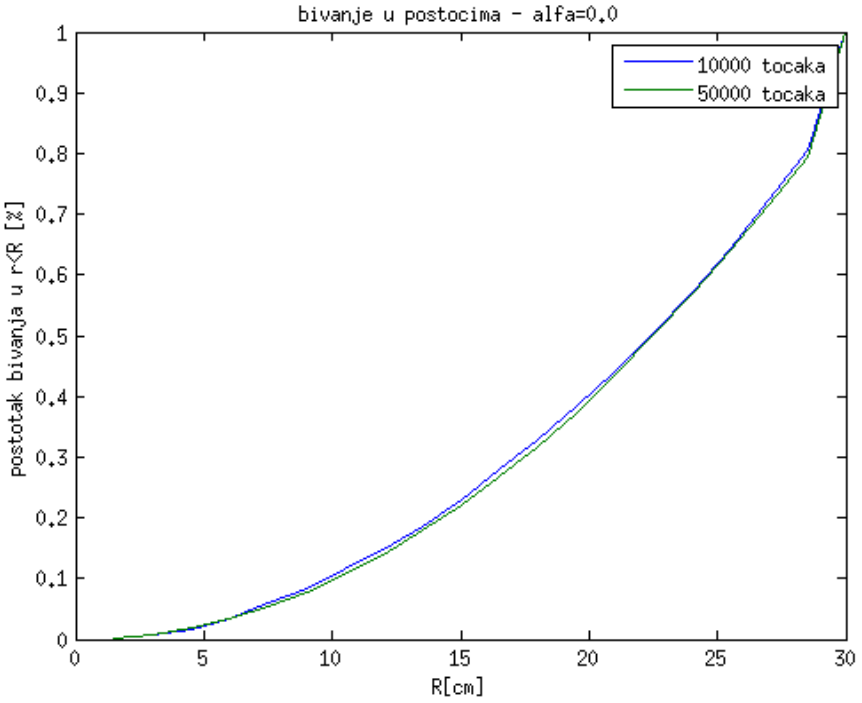
Zaključak

- Dva modela
- Dvije metode analize
- Analizirani modeli
- Analizirana gibanja sa videa
- Uspoređeni te pronađeni parametri tako da se iznosi brzina poklapaju
  - β=0.3
  - brzine iz modela x2.5
- Daljni rad
  - više videa te izračun prosjeka
  - mjerenje temperature u prostoru
  - ponovni izračun parametara

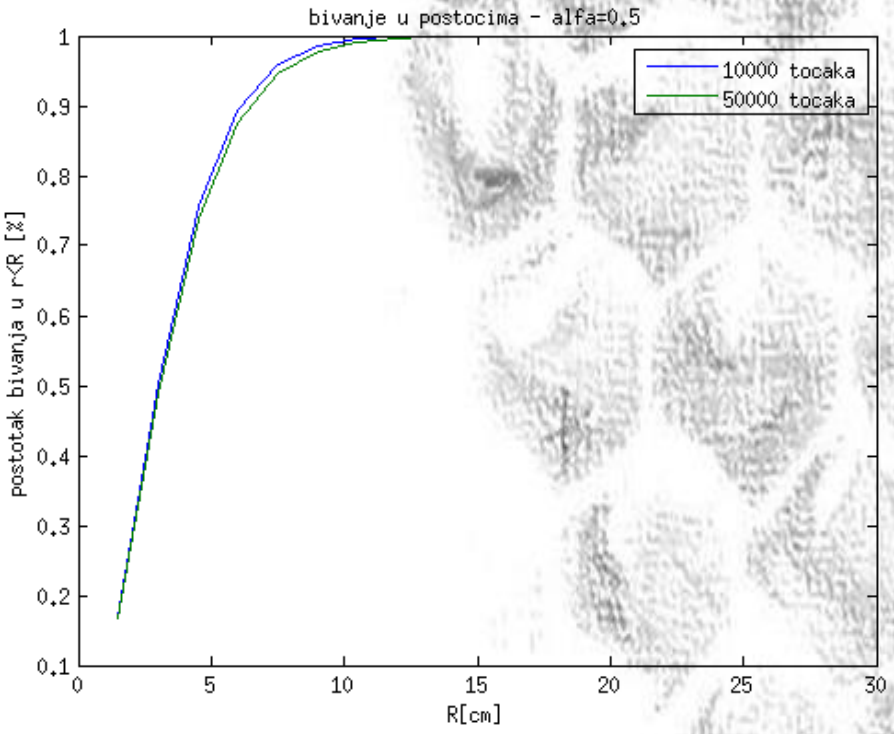

Hvala na pažnji!

Duljina simulacije

- Prostorna metoda



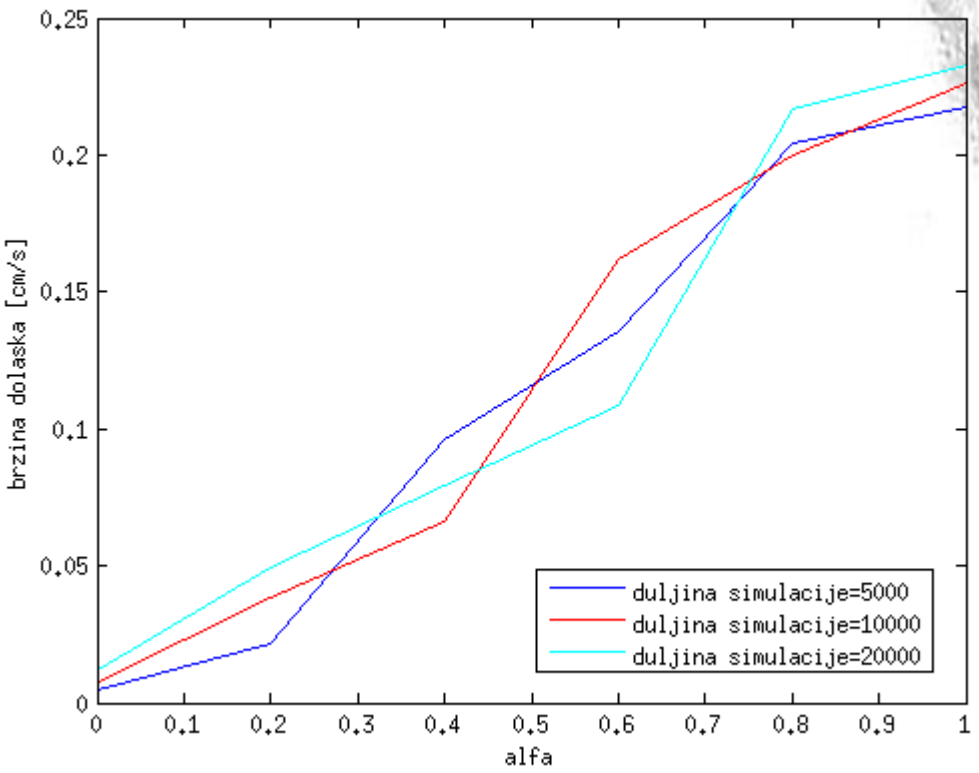
α =0.0



α =0.5

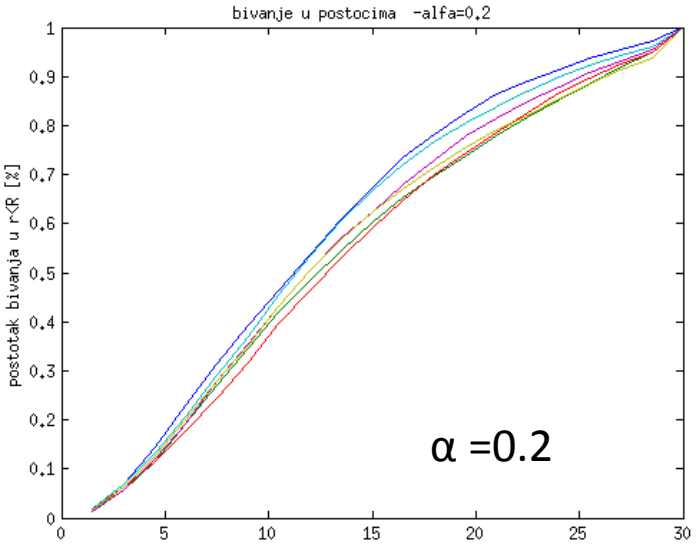
Duljina simulacije

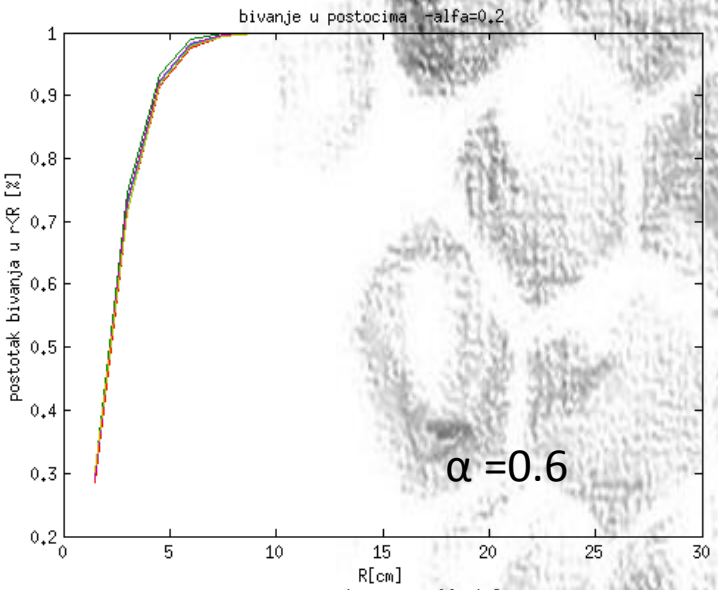
- Vremenska metoda

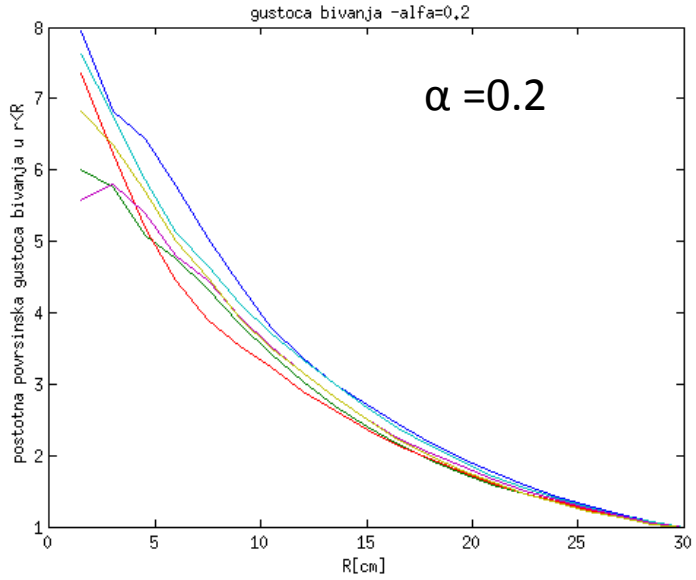


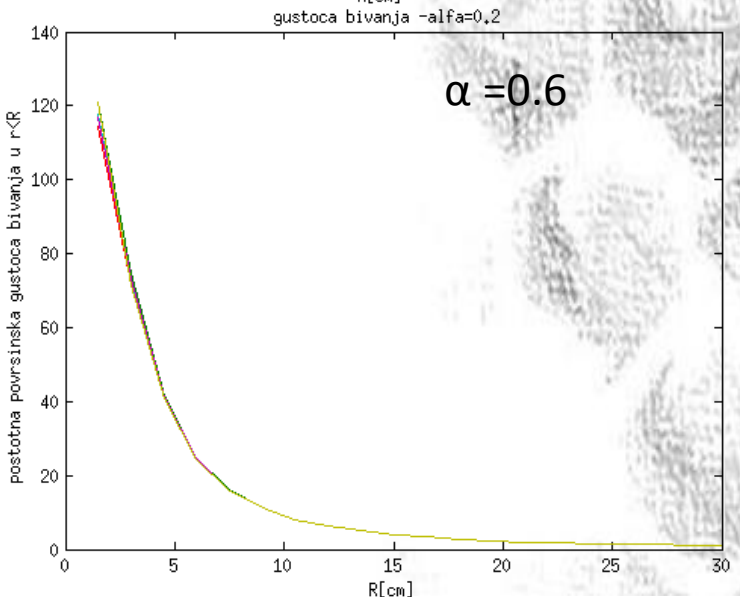
Rasipanje karakteristike

- Prostorna metoda



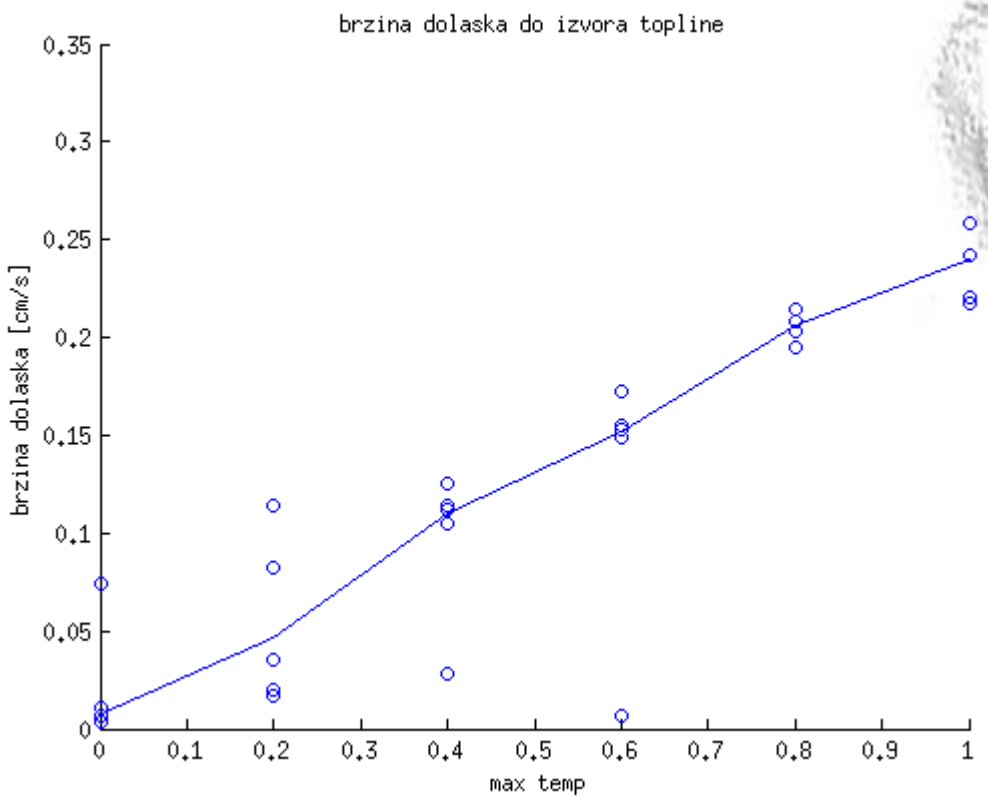






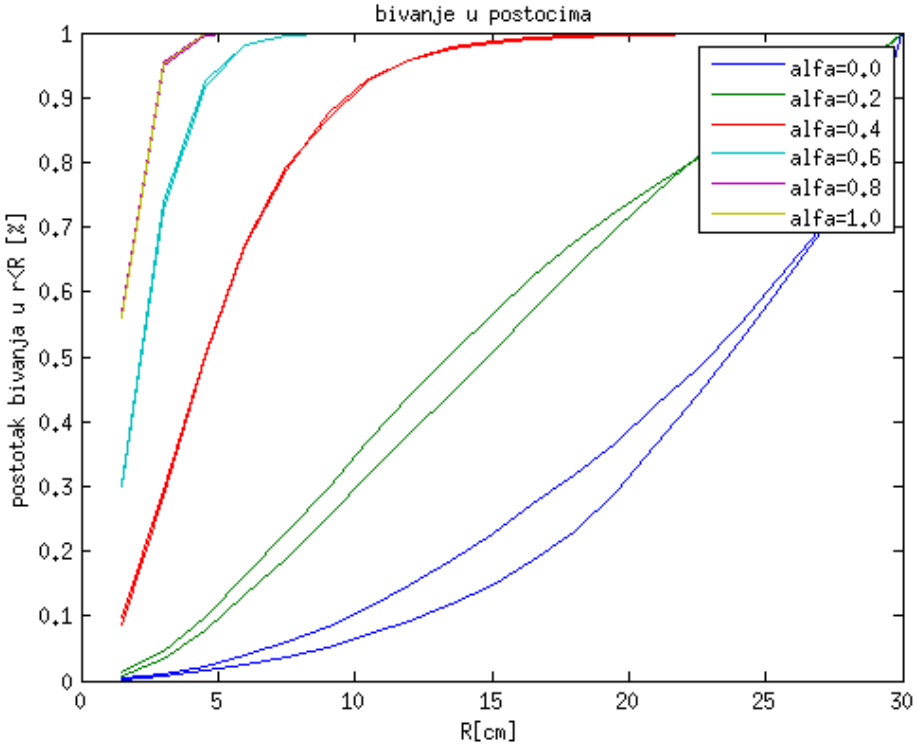
Rasipanje karakteristike

- Vremenska metoda

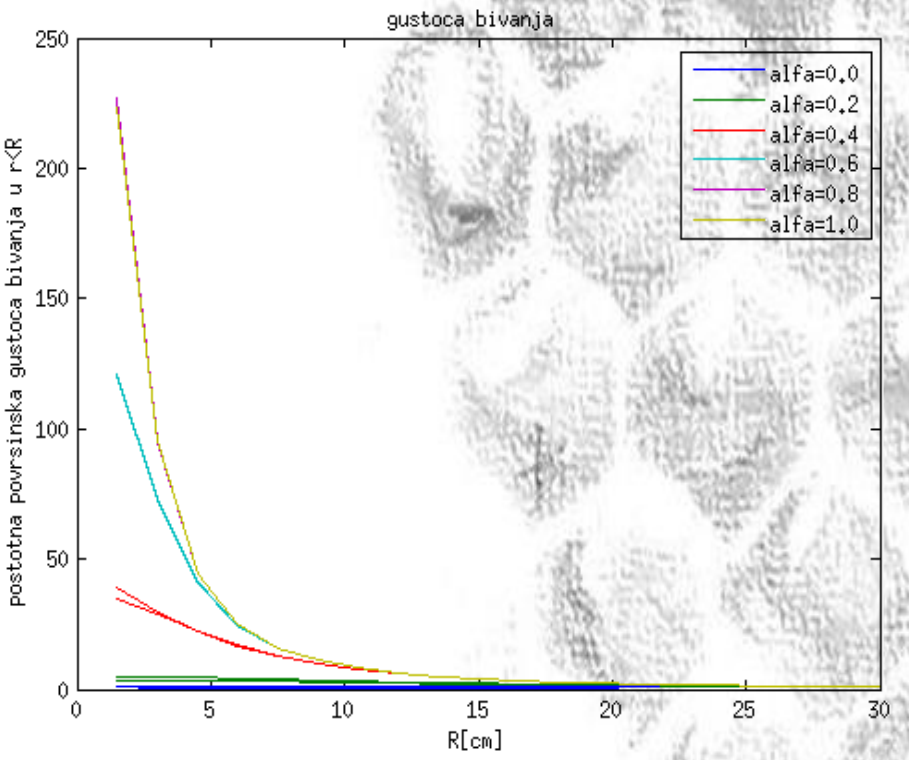


Usporedba dva osnovna modela

- Prostorna metoda



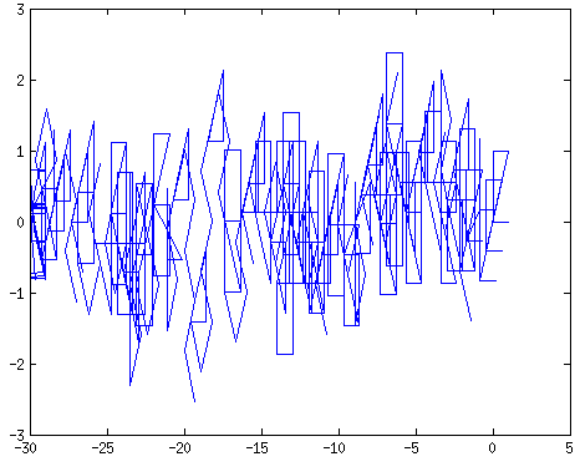
Boravak u postotnom vremenu u r<R



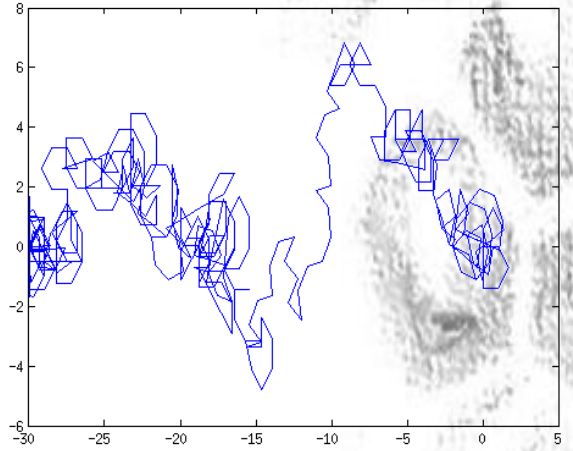
Gustoća boravka u r<R

Dozvoljeni kutovi zakreta

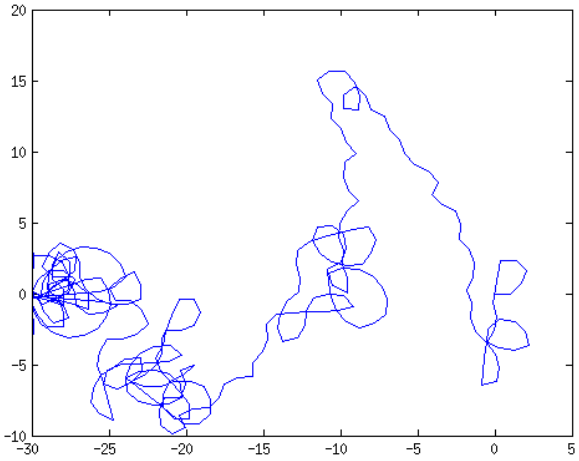
- Maksimalni kut zakreta



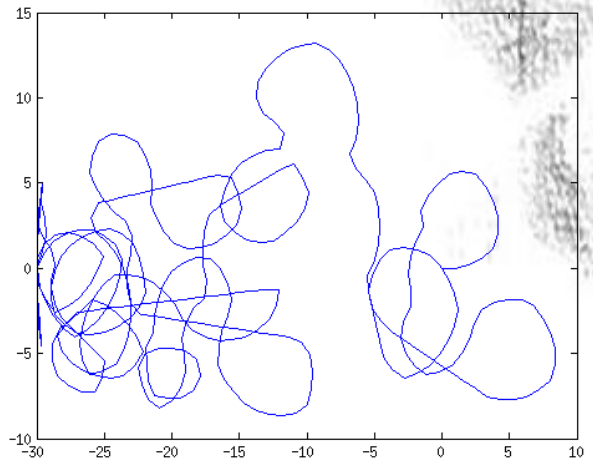
Θmax=pi/2



Θmax=pi/4



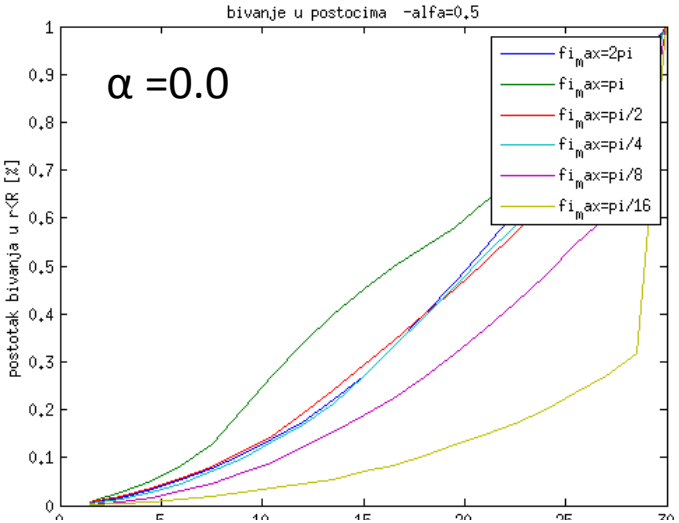
Θmax=pi/8

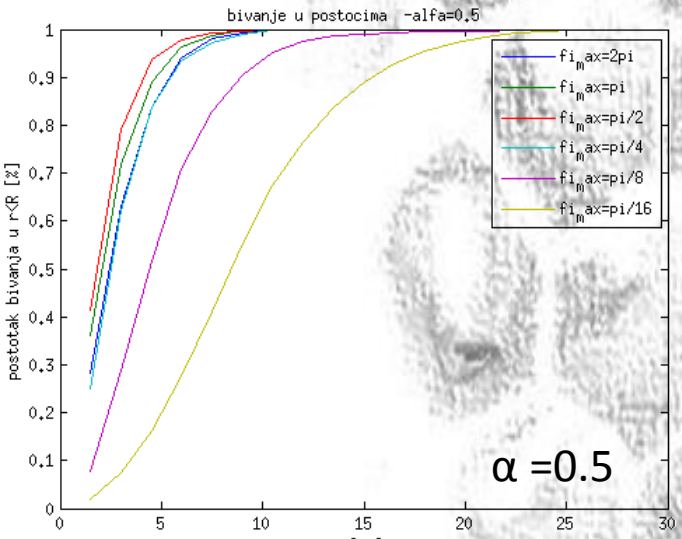


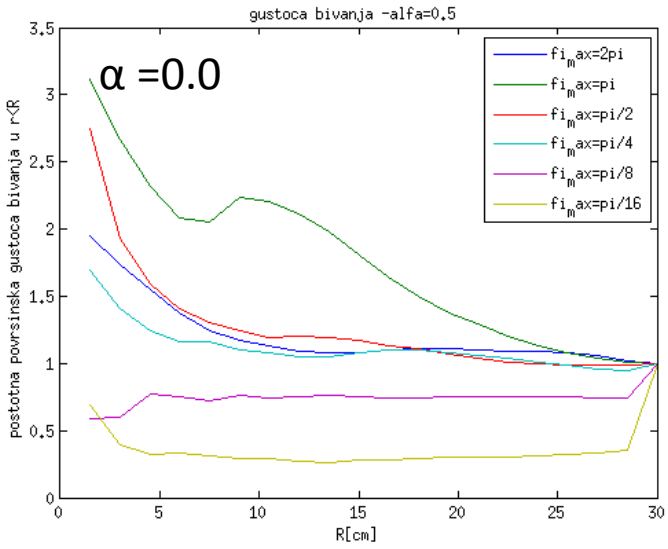
Θmax=pi/16

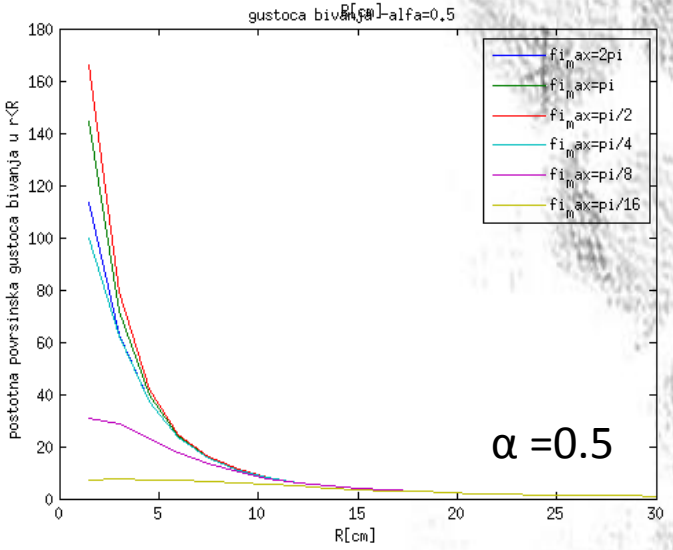
Dozvoljeni kutovi zakreta

- Maksimalni kut zakreta –prostorna metoda



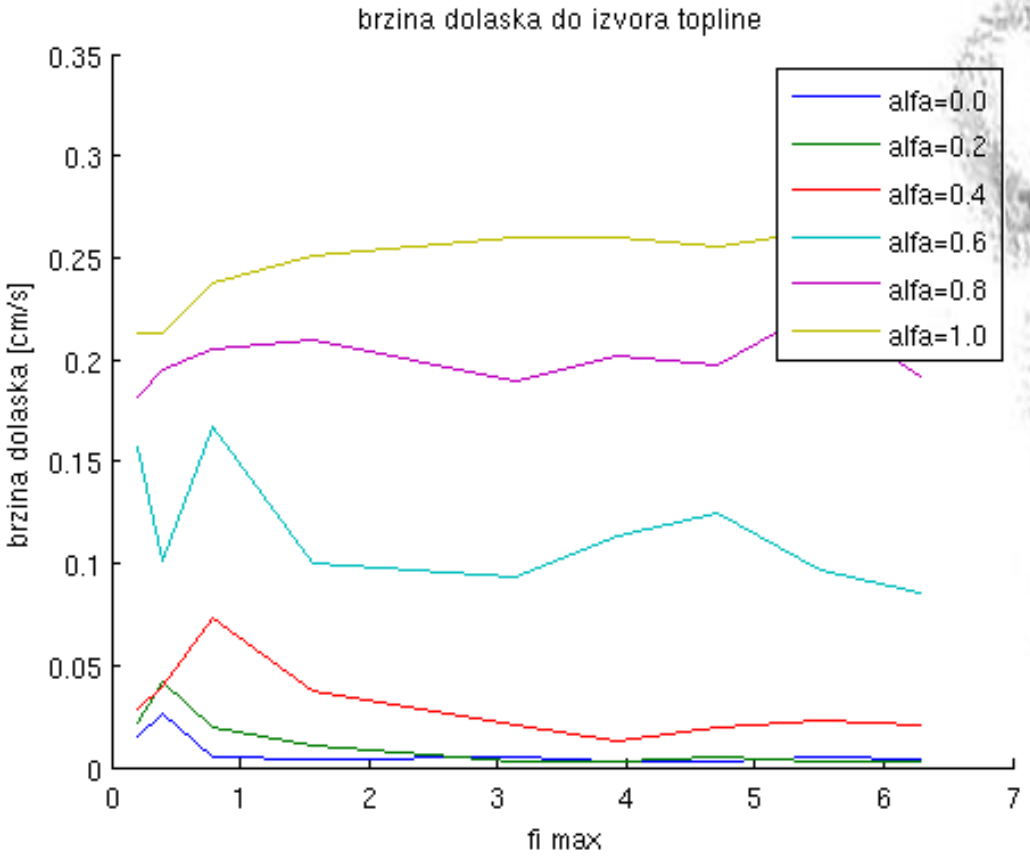






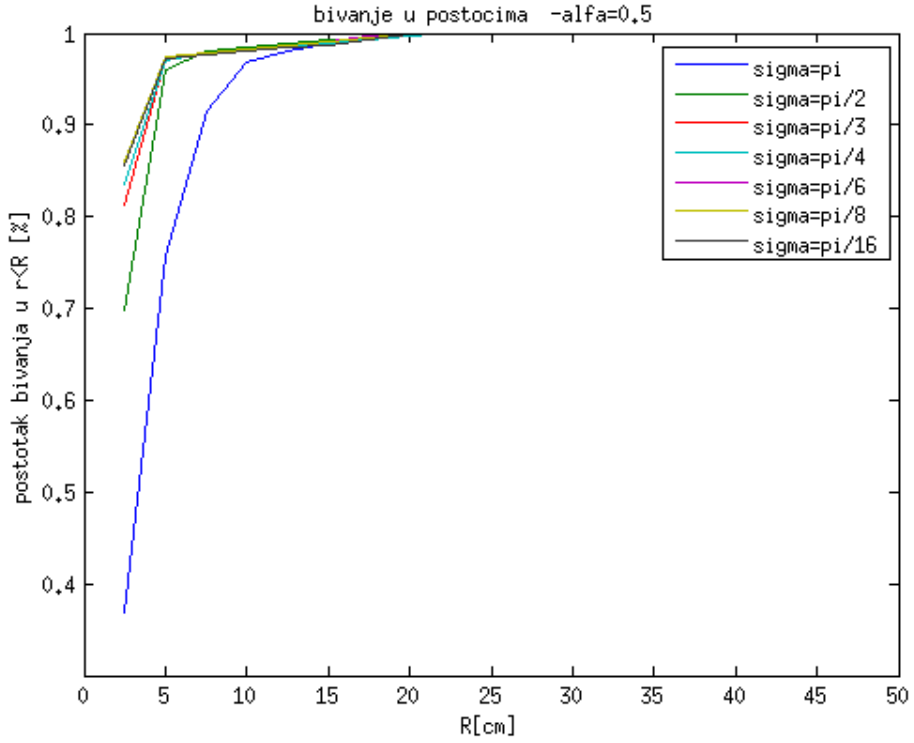
Dozvoljeni kutovi zakreta

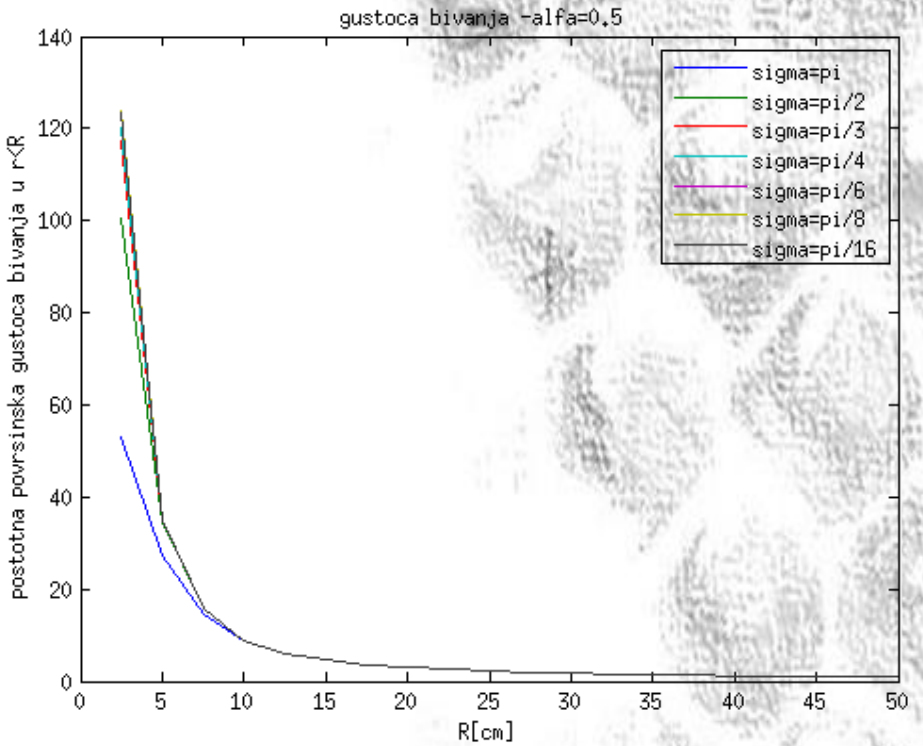
- Maksimalni kut zakreta –vremenska metoda



Dozvoljeni kutovi zakreta

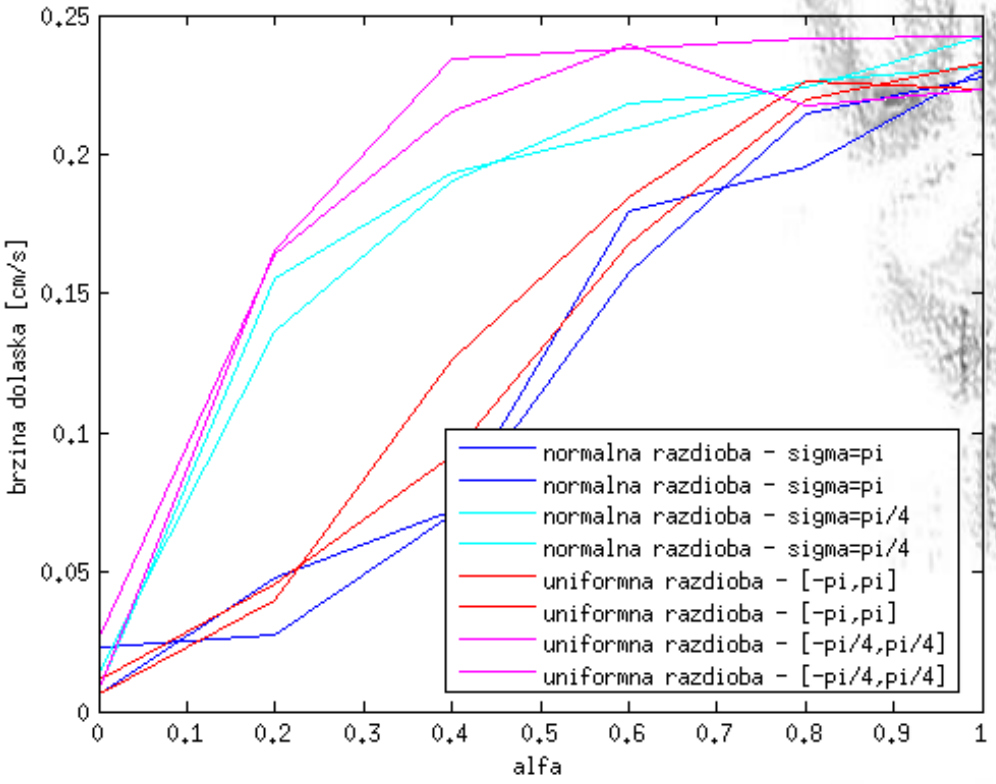
- Razdioba kutova – prostorna metoda
  - veoma slično kao i utjecaj maksimalnog kuta
  - preveliki dopušten kut -loše



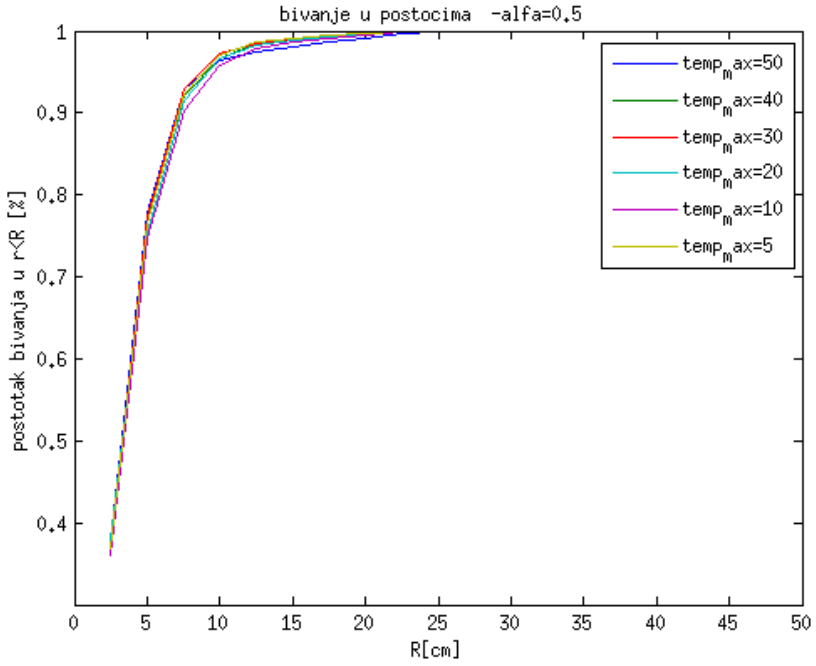


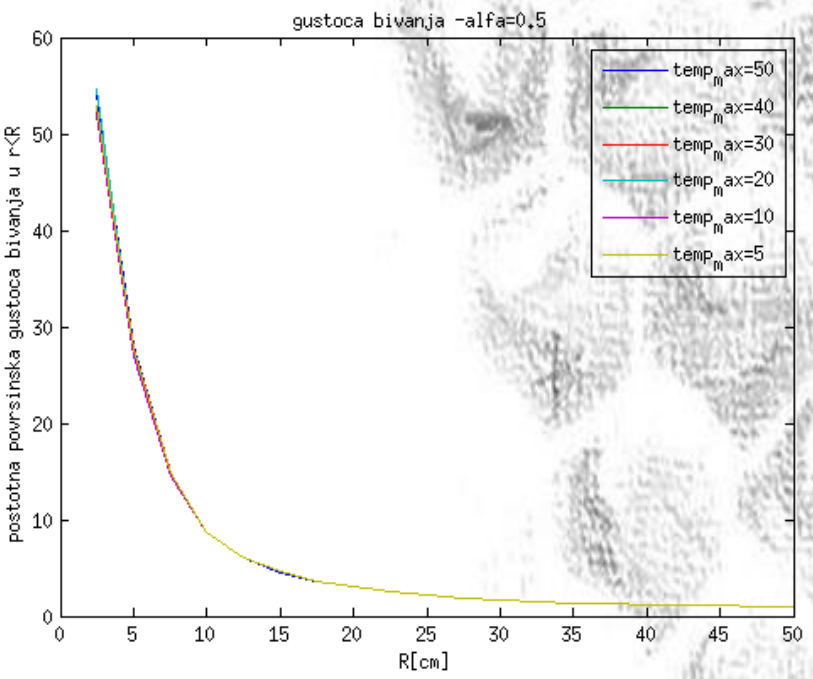
Dozvoljeni kutovi zakreta

- Razdioba kutova – vremenska metoda
  - mala razlika između uniformne i normalne razdiobe



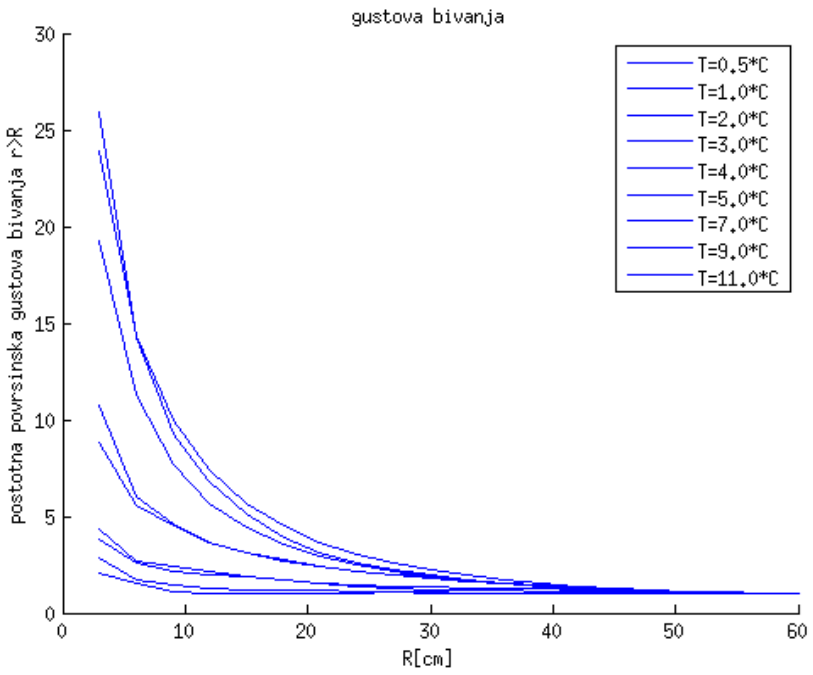
Utjecaj temperature izvora (osnovni model)



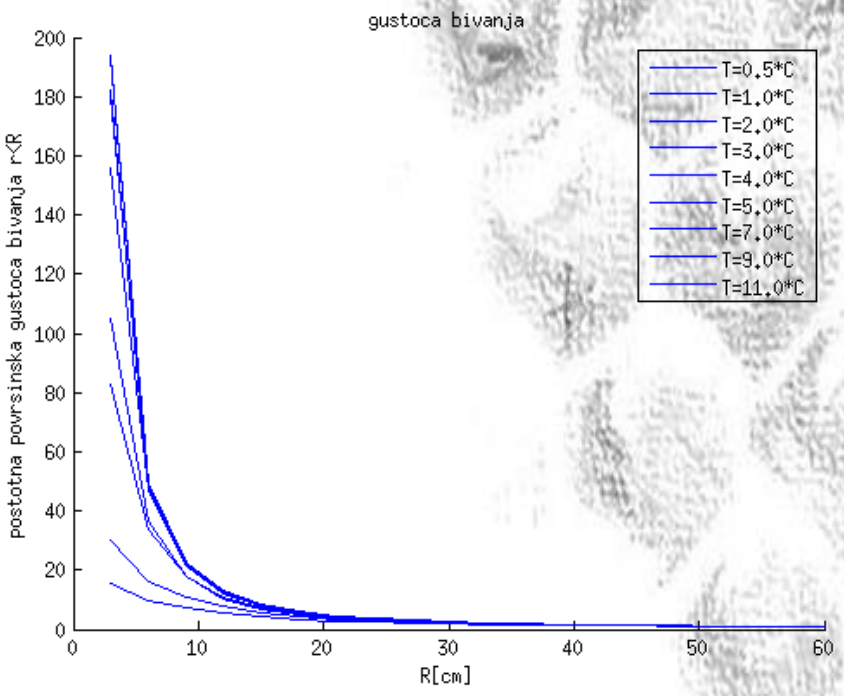


Temperatura izvora (cjeloviti model)

- Prostorna metoda
  - za β=1.0 i β=0.3



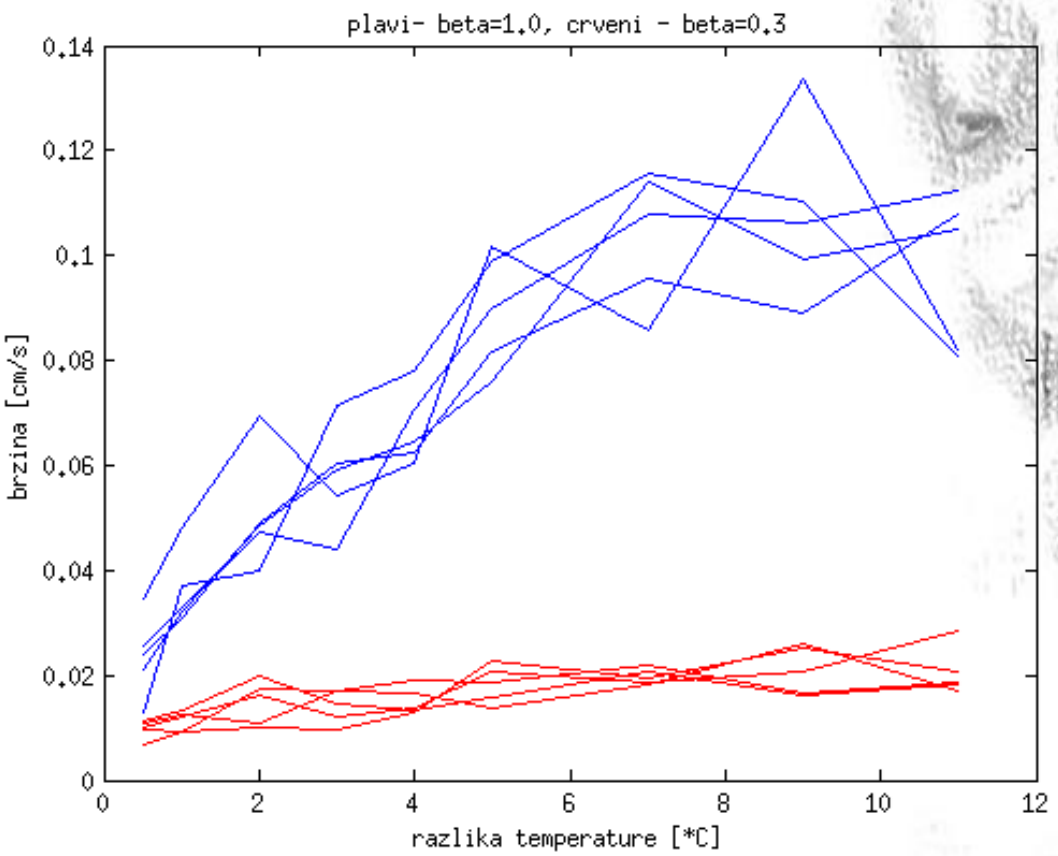
β=0.3



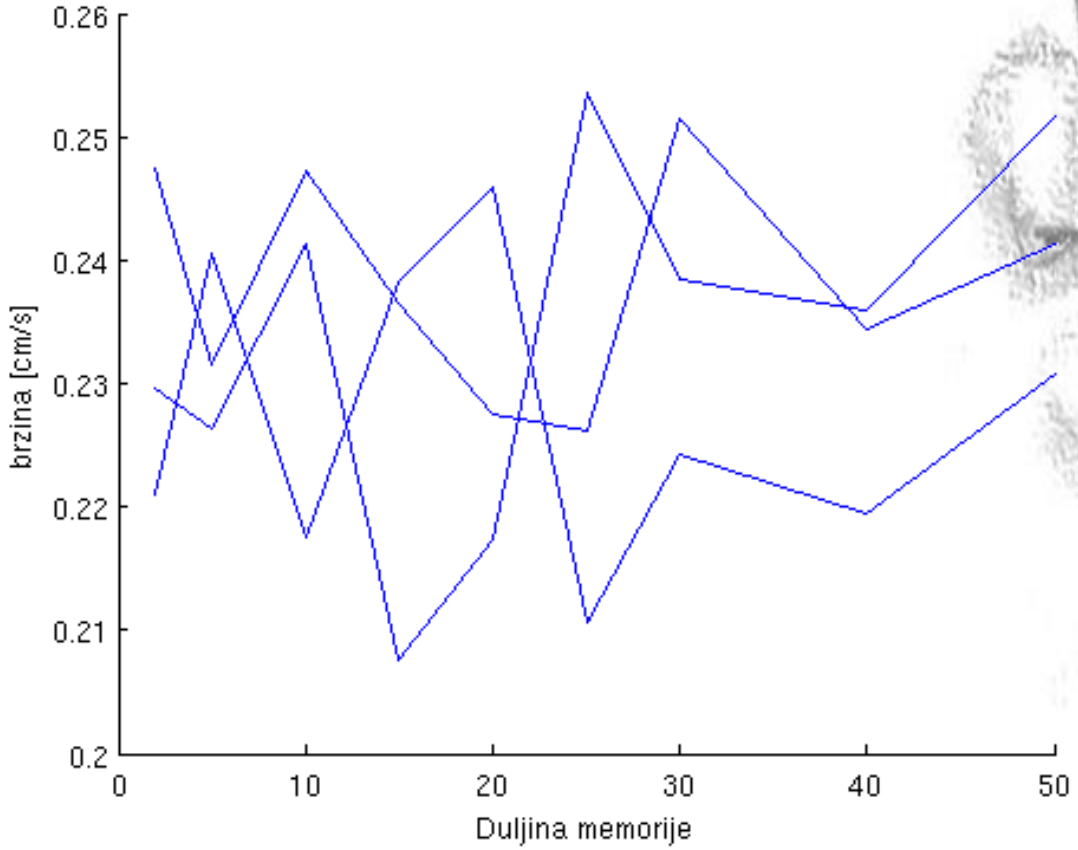
β=1.0

Temperatura izvora (cjeloviti model)

- Vremenska metoda
  - za β=1.0 i β=0.3



Duljina memorije



Usporedba dva cjelovita modela

- Vremenska metoda
  - za različite α i β