

# Geometrija podatkov



# Geometrija



Evklid



Gauss



Euler

Geometrija = klobuk

# Tema seminarja

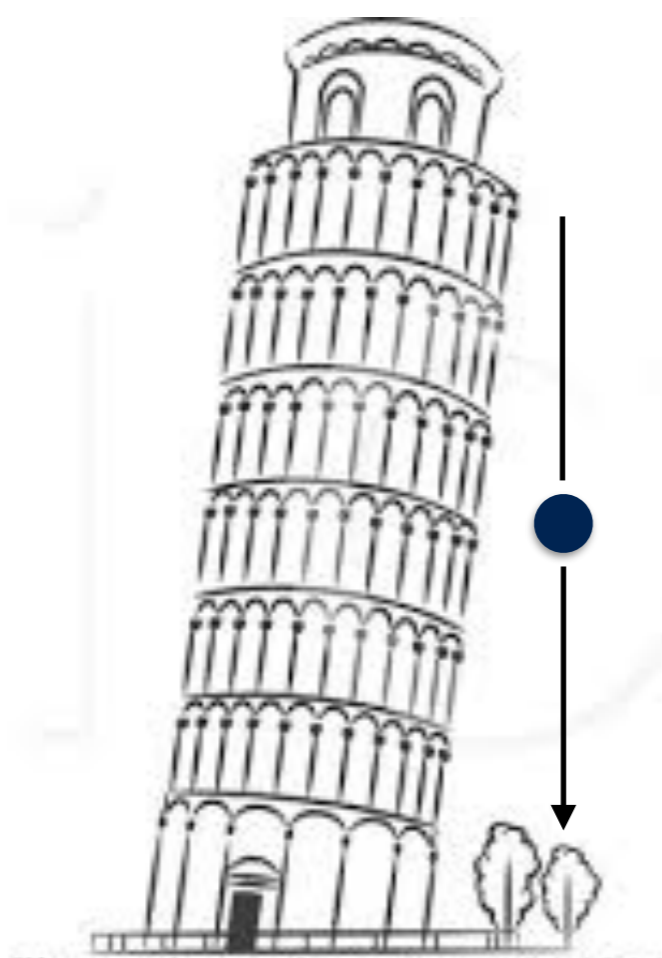
Kako nam geometrija lahko pomaga pri razumevanju sveta

računalništvo, statistika, strojno učenje, fizika, kaotični sistemi....

# Kje najdemo podatke?

Osnova znanosti

Višina stolpa: 56 m



Čas padanja: 3,44s

3,45s

3,41s

3,47s

3,50s

Galileo

$$g = 9,8m/s^2$$

# Kje najdemo podatke?

Danes imamo več naprav za meritve



CERN

1 petabyte/dan

# Kje najdemo podatke?

Proizvajamo veliko podatkov

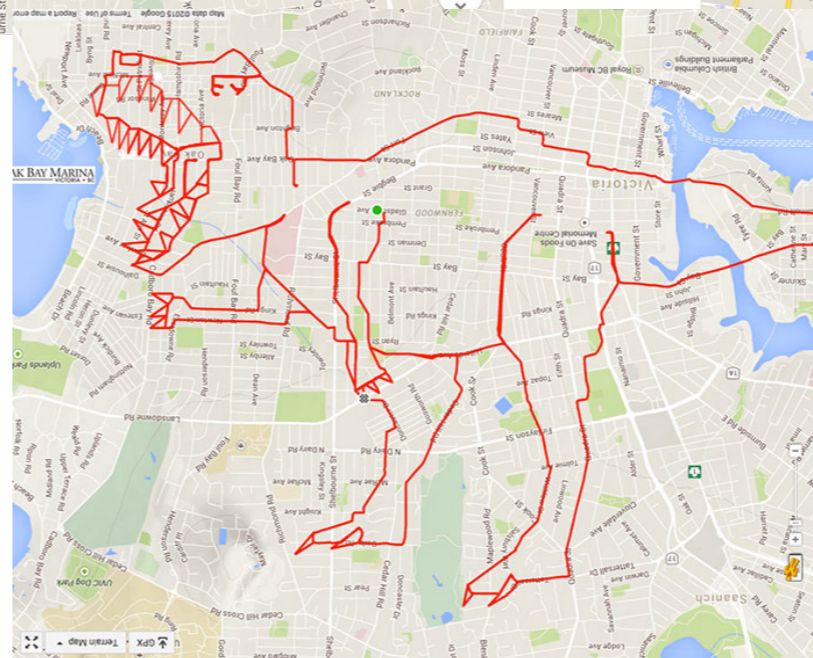
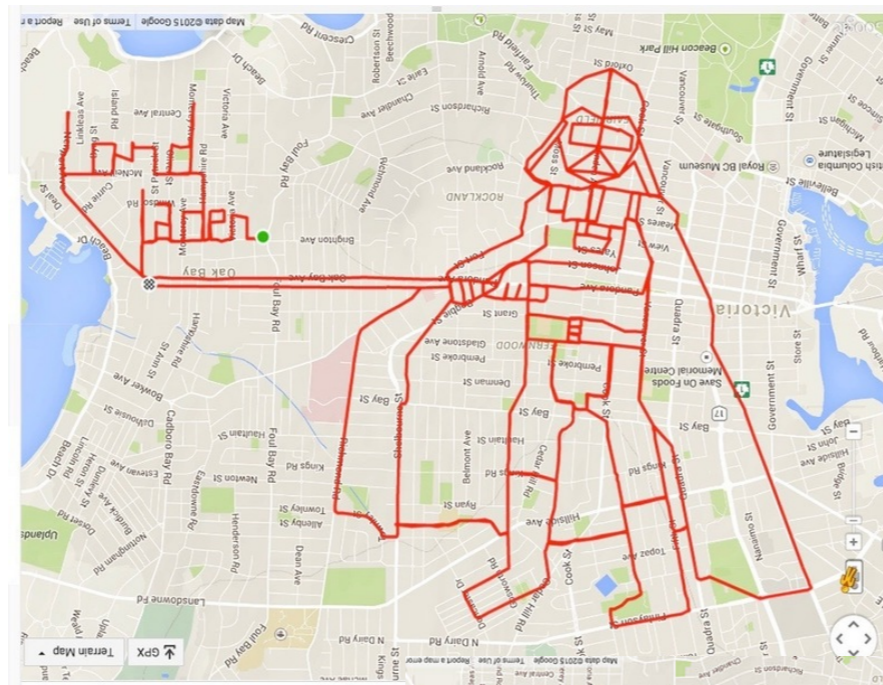


Vsaki dve minuti, vzamemo več slik kot v prvih 100 let fotografije

3.8 biljionov slik  $\sim 3.8 \times 10^{12}$

# Kje najdemo podatke?

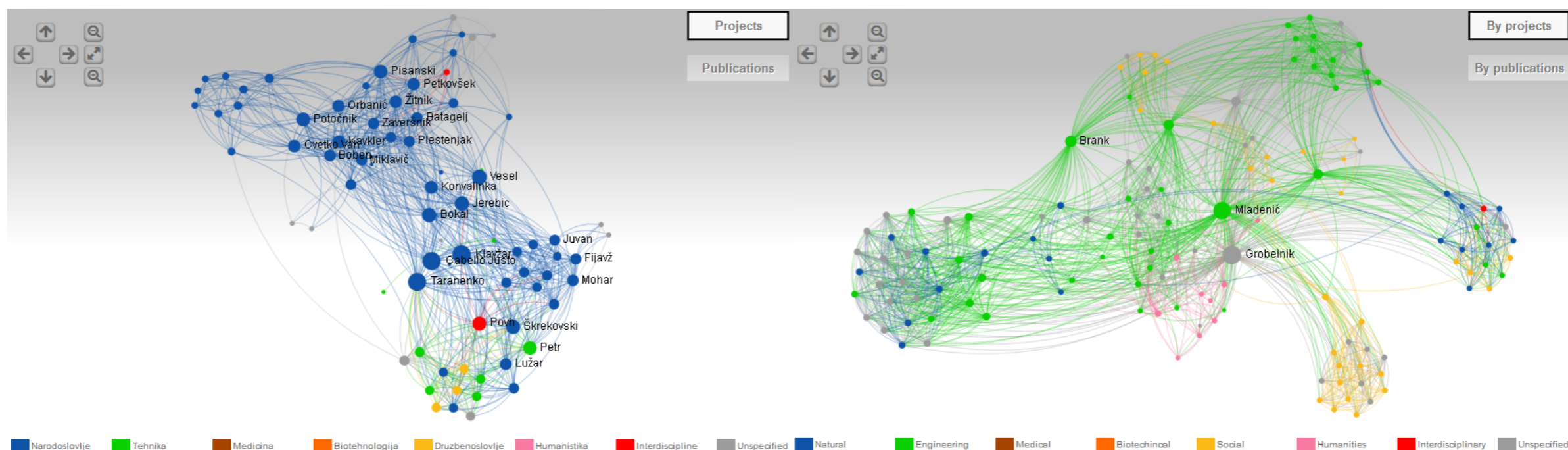
GPS nam omogoča slediti teku, poti, itn.



<http://gpsdoodles.com/>

# Kje najdemo podatke?

Podatki so lahko tudi virtualni



Facebook, Twitter, Snapchat, itn.



# Koordinate

## Kako opišemo podatke?

Seznam koordinat:

45,548979 S 13,727846 V

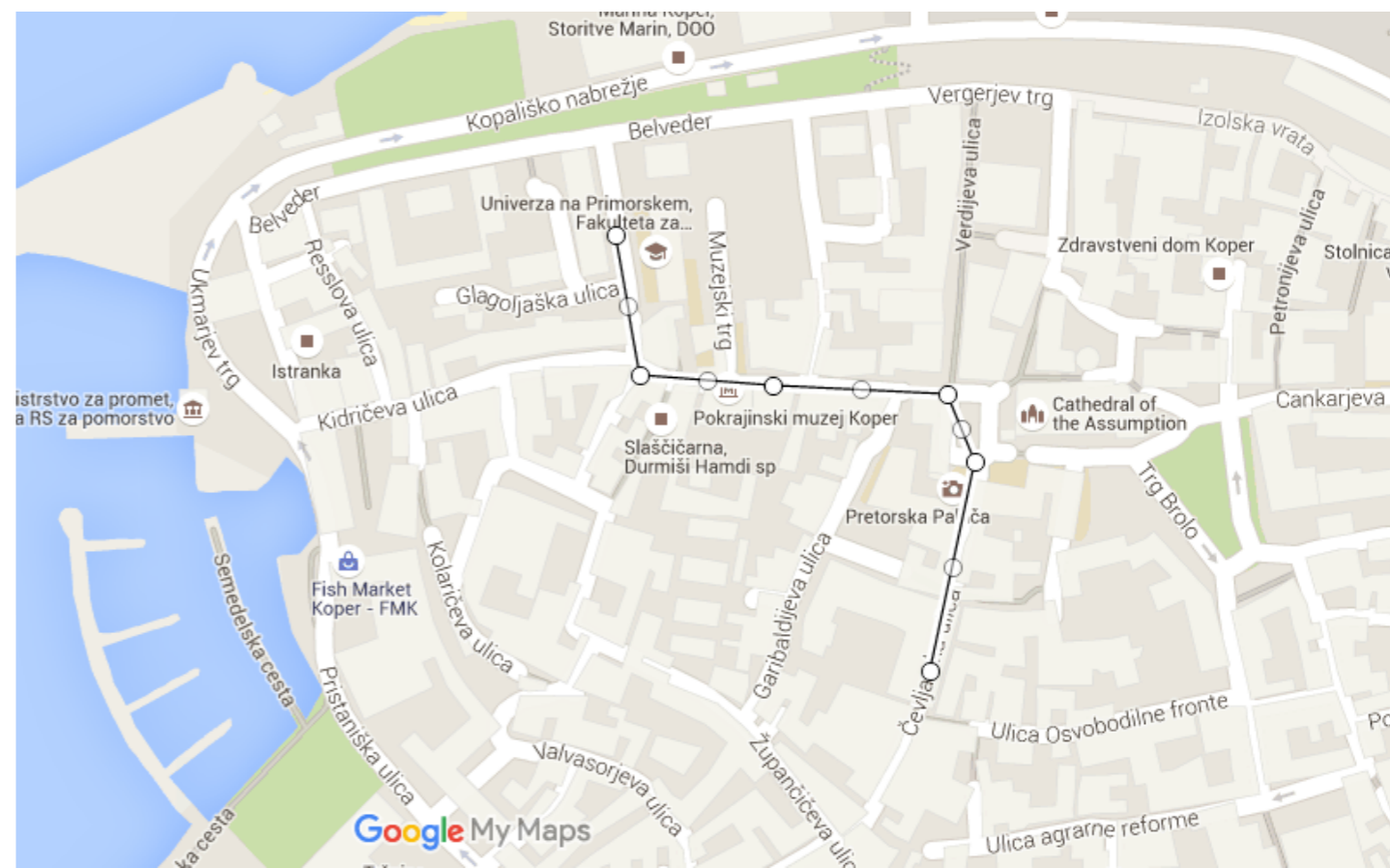
45,548558 S 13,727825 V

45,548378 S 13,728340 V

45,548047 S 13,729563 V

45,547657 S 13,729520 V

45,547041 S 13,729262 V



# Višje dimenzije

## lastnosti avtomobilov

Imamo lahko veliko koordinat

buying	maint	doors	persons	lug_boot	safety
vhigh	vhigh	2	2	small	low
vhigh	vhigh	2	2	small	med
vhigh	vhigh	2	2	small	high
vhigh	vhigh	2	2	med	low
vhigh	vhigh	2	2	med	med
vhigh	vhigh	2	2	med	high
vhigh	vhigh	2	2	big	low
vhigh	vhigh	2	2	big	med
vhigh	vhigh	2	2	big	high
vhigh	vhigh	2	4	small	low
vhigh	vhigh	2	4	small	med
vhigh	vhigh	2	4	small	high
vhigh	vhigh	2	4	med	low
vhigh	vhigh	2	4	med	med
vhigh	vhigh	2	4	med	high
vhigh	vhigh	2	4	big	low
vhigh	vhigh	2	4	big	med
vhigh	vhigh	2	4	big	high
vhigh	vhigh	2	more	small	low
vhigh	vhigh	2	more	small	med
vhigh	vhigh	2	more	small	high
vhigh	vhigh	2	more	med	low

# Višje dimenzije

Imamo lahko veliko koordinat

## bančni podatki

age	job	marital	education	default	balance	housing	loan	contact	day	month	duration	campaign	pdays	previous	poutcome	y
30	unemployed	married	primary	no	1787	no	no	cellular	19	oct	79	1	-1	0	unknown	no
33	services	married	secondary	no	4789	yes	yes	cellular	11	may	220	1	339	4	failure	no
35	management	single	tertiary	no	1350	yes	no	cellular	16	apr	185	1	330	1	failure	no
30	management	married	tertiary	no	1476	yes	yes	unknown	3	jun	199	4	-1	0	unknown	no
59	blue-collar	married	secondary	no	0	yes	no	unknown	5	may	226	1	-1	0	unknown	no
35	management	single	tertiary	no	747	no	no	cellular	23	feb	141	2	176	3	failure	no
36	self-employed	married	tertiary	no	307	yes	no	cellular	14	may	341	1	330	2	other	no
39	technician	married	secondary	no	147	yes	no	cellular	6	may	151	2	-1	0	unknown	no
41	entrepreneur	married	tertiary	no	221	yes	no	unknown	14	may	57	2	-1	0	unknown	no
43	services	married	primary	no	-88	yes	yes	cellular	17	apr	313	1	147	2	failure	no
39	services	married	secondary	no	9374	yes	no	unknown	20	may	273	1	-1	0	unknown	no
43	admin.	married	secondary	no	264	yes	no	cellular	17	apr	113	2	-1	0	unknown	no
36	technician	married	tertiary	no	1109	no	no	cellular	13	aug	328	2	-1	0	unknown	no
20	student	single	secondary	no	502	no	no	cellular	30	apr	261	1	-1	0	unknown	yes
31	blue-collar	married	secondary	no	360	yes	yes	cellular	29	jan	89	1	241	1	failure	no
40	management	married	tertiary	no	194	no	yes	cellular	29	aug	189	2	-1	0	unknown	no
56	technician	married	secondary	no	4073	no	no	cellular	27	aug	239	5	-1	0	unknown	no
37	admin.	single	tertiary	no	2317	yes	no	cellular	20	apr	114	1	152	2	failure	no
25	blue-collar	single	primary	no	-221	yes	no	unknown	23	may	250	1	-1	0	unknown	no
31	services	married	secondary	no	132	no	no	cellular	7	jul	148	1	152	1	other	no
38	management	divorced	unknown	no	0	yes	no	cellular	18	nov	96	2	-1	0	unknown	no
42	management	divorced	tertiary	no	16	no	no	cellular	19	nov	140	3	-1	0	unknown	no
44	services	single	secondary	no	106	no	no	unknown	12	jun	109	2	-1	0	unknown	no
44	entrepreneur	married	secondary	no	93	no	no	cellular	7	jul	125	2	-1	0	unknown	no
26	housemaid	married	tertiary	no	543	no	no	cellular	30	jan	169	3	-1	0	unknown	no
41	management	married	tertiary	no	5883	no	no	cellular	20	nov	182	2	-1	0	unknown	no

# Višje dimenzije

## Dokumenti



WIKIPEDIJA  
Prosta enciklopedija

Glavna stran  
Dobrodošli  
Izbrani članki  
Naključni članek  
Zadnje spremembe

Občestvo  
Portal občestva  
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Pomoč  
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V drugih jezikih  
Беларуская  
Català  
Čeština  
Deutsch  
English  
Español  
فارسی  
Français  
Galego

Stran Pogovor

Preberi Uredi Uredi kodo Zgodovina Iskanje

Delovanje in razvoj Wikipedije omogočajo vaši prispevki[skrij]

### Jurij Vega

Iz Wikipedije, proste enciklopedije  
(Preusmerjeno s strani Jurij Bartolomej Vega)

**Baron Jurij Bartolomej Vega** [júrij bartoloméj véga] (tudi **Veha**, *latinsko* *Georgius Bartholomaei Vecha*; *nemško* *Georg Freiherr von Vega*), slovenski matematik, fizik, geodet, meteorolog, plemič in topniški častnik, \* 23. marec 1754, Zagorica pri Dolskem, Kranjska, Sveto rimsko cesarstvo (sedaj Slovenija), † 26. september 1802, Nussdorf pri Dunaju, Sveto rimsko cesarstvo (sedaj Avstrija).

#### Vsebina [skrij]

- Življenje
- Delo v matematiki
- Delo v fiziki
- Priznanja
  - Poimenovanja
  - Druge zanimivosti
- Sklici
- Viri
- Zunanje povezave

### Življenje [uredi | uredi kodo]

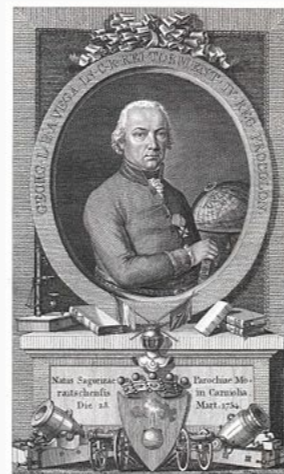


Kmetija, na kateri se je rodil Vega

Vega se je rodil v revni kmečki družini polgruntarja Jerneja Vege in Helene Vege (rojene Masel). Tja se je iz bližnje Sv. Trojice preselil njegov ded. Njegov oče je umrl, ko je bilo Juriju šest let. Osnovno znanje si je pridobil pri domačem duhovniku in v Moravčah. Ko je dopolnil 13 let, je leta 1767 začel obiskovati 6 letne jezuitske nižje študije (»gimnazijo«) v Ljubljani. Jezuiti so prav v njegovem času začeli v zadnjih dveh humanitetnih letnikih dajati večji pomen matematično naravoslovnim predmetom. Vega ju je obiskoval leta 1772 in 1773. Poleg matematike in naravoslovnih znanosti so bili predmeti, ki jih je Vega poslušal: latinščina, grščina, religija, nemščina, zgodovina, geografija.

Med letoma 1769 in 1785 sta na liceju v Ljubljani poučevala fiziko Gregor Schoettl (1732-1777) in Anton Amschel (1746-1821). Jezuitska gimnazija in kolegij z dijaškim domom sta v tem času stala pri cerkvi sv. Jakoba pod Ljubljanskim gradom. Komplex kolegija okoli cerkve je zajemal današnje šolo, Levstikov trg ter Gruberjevo in Virantovo hišo.

#### Jurij Vega



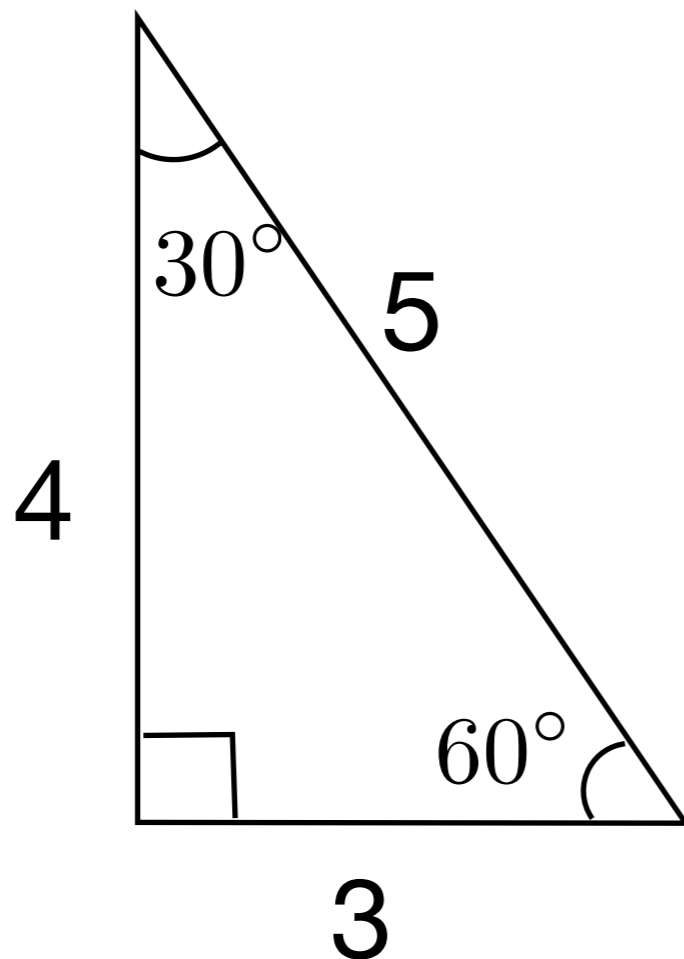
<b>Rojstvo</b>	<span><span><span>23. marec 1754</span></span></span> <div>Zagorica pri Dolskem, Kranjska, Sveto rimsko cesarstvo <span><span></span></span></div>
<b>Smrt</b>	<span><span><span>26. september 1802</span> <span>(48 let)</span></span></span> <div>Nussdorf pri Dunaju, Sveto rimsko cesarstvo <span><span></span></span></div>
<b>Bivališče</b>	<span><span></span></span> Sveto rimsko cesarstvo
<b>Narodnost</b>	<span><span></span></span> slovenska
<b>Področja</b>	matematika, fizika, geodezija, meteorologija
<b>Ustanove</b>	avstrijsko cesarska vojska
<b>Alma mater</b>	Jezuitska gimnazija Ljubljana, Licej v Ljubljani <div>doktorat 1775</div>
<b>Doktorski študenti</b>	Ignaz Lindner

Slovenija: 16  
matematika: 26  
gravitacija: 6  
astronomija: 5  
Euler: 3

# Geometrija

**geo** - zemlja

**metron** - mera

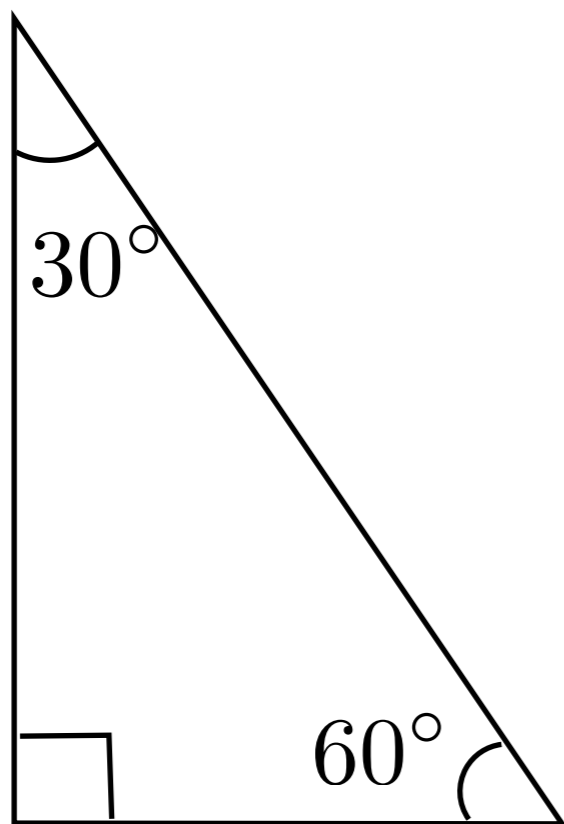


razdalje,  
koti,  
ploskve,  
itn.

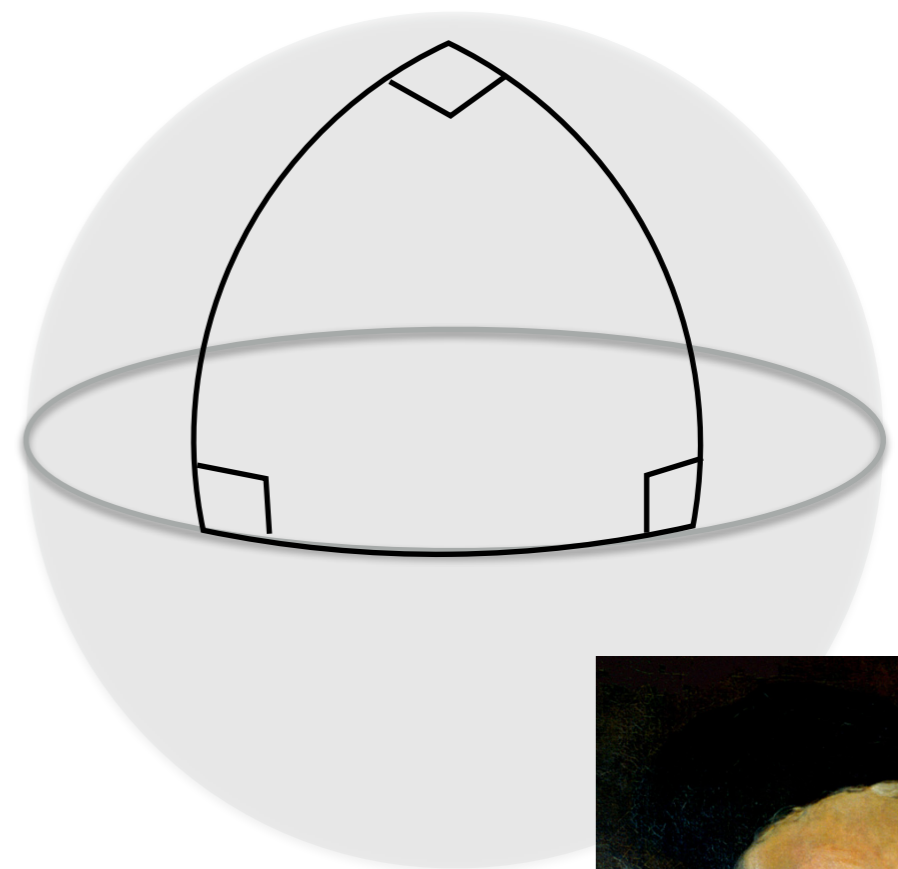
Evklidska geometrija

# Geometrija

Evklidska geometrija



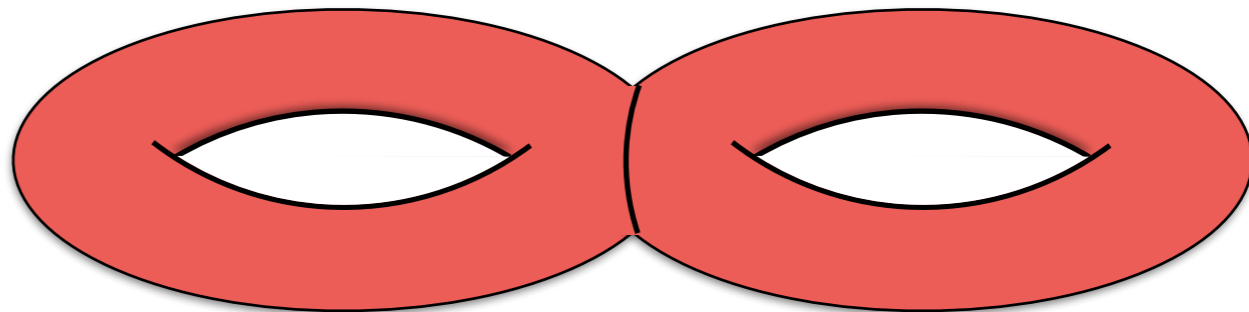
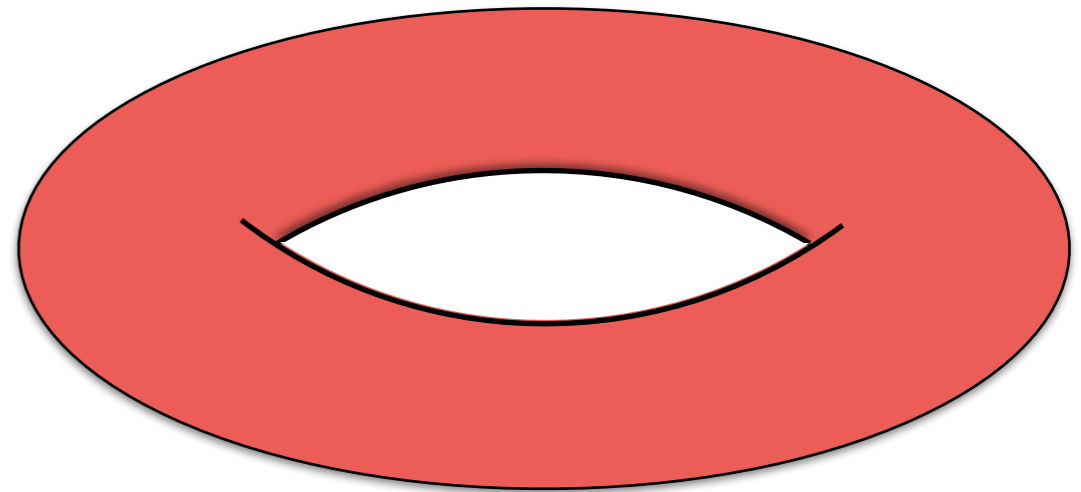
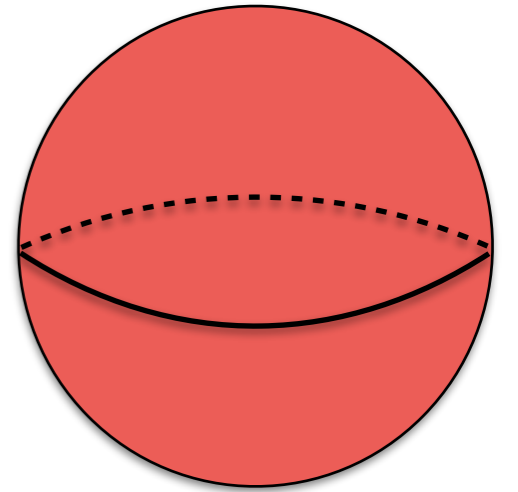
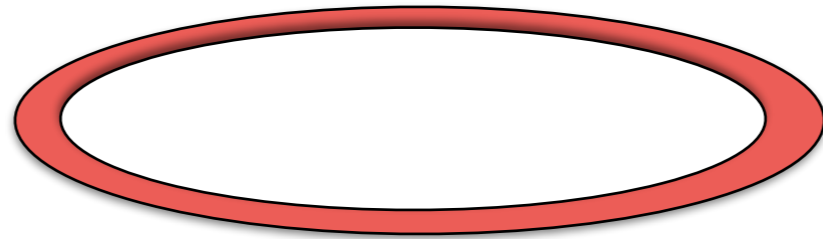
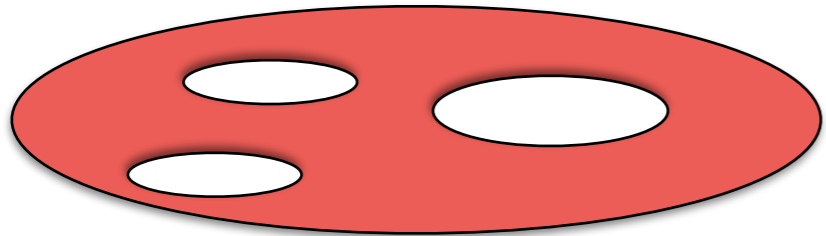
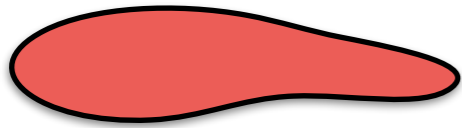
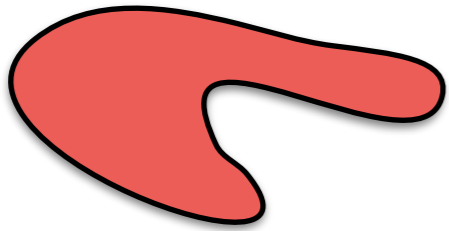
sferična geometrija



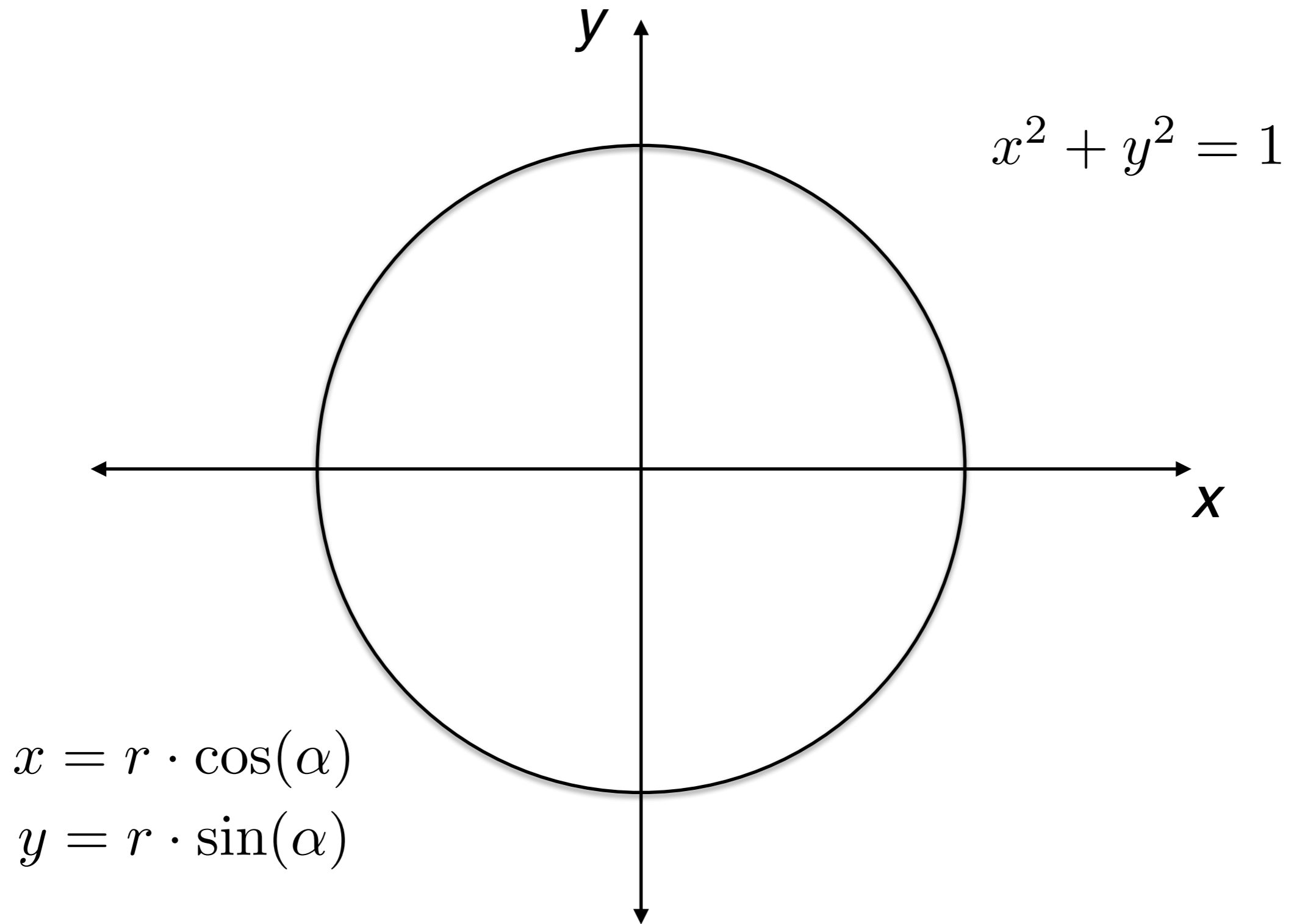
hiperbolična, diskretna geometrija



# Oblike

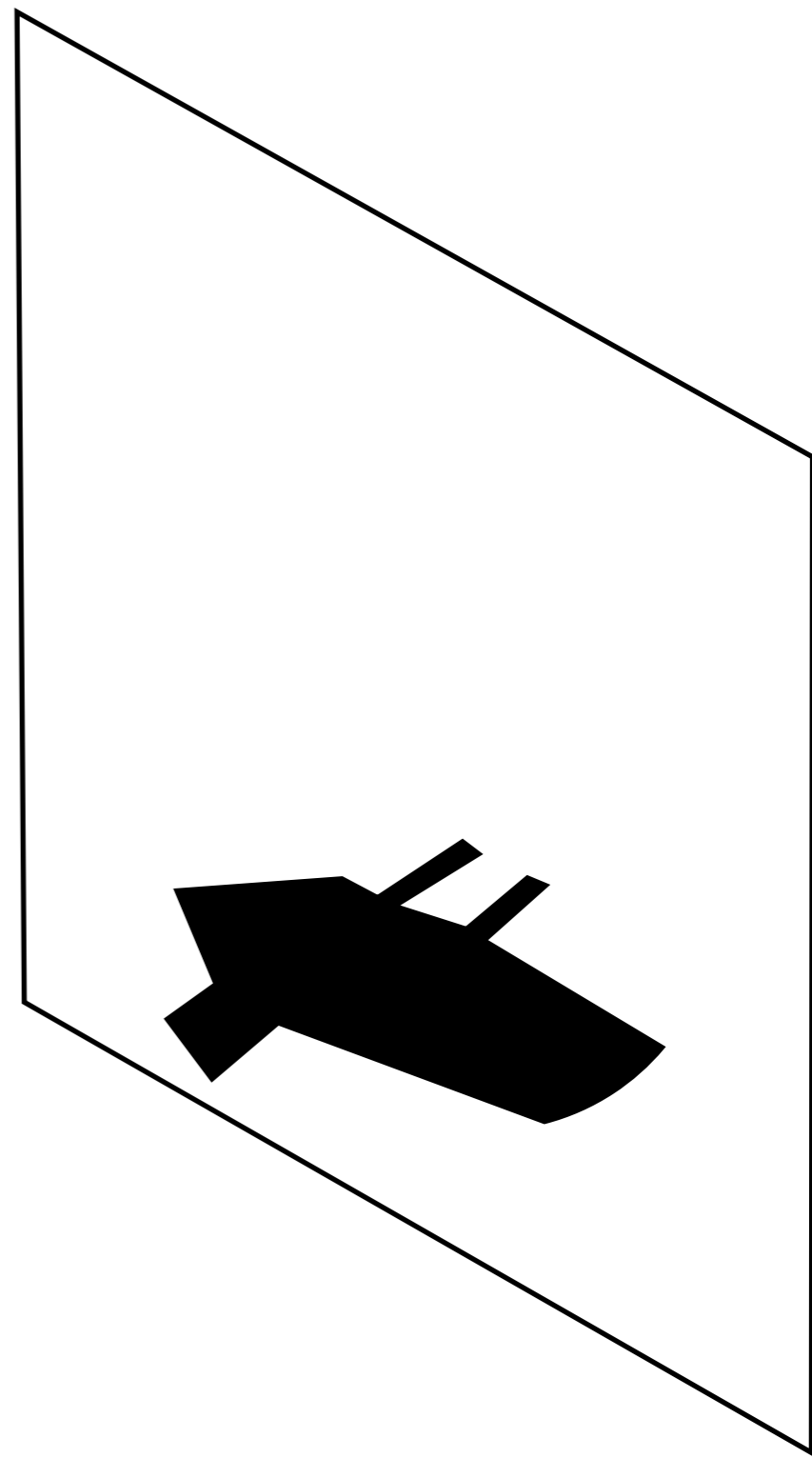
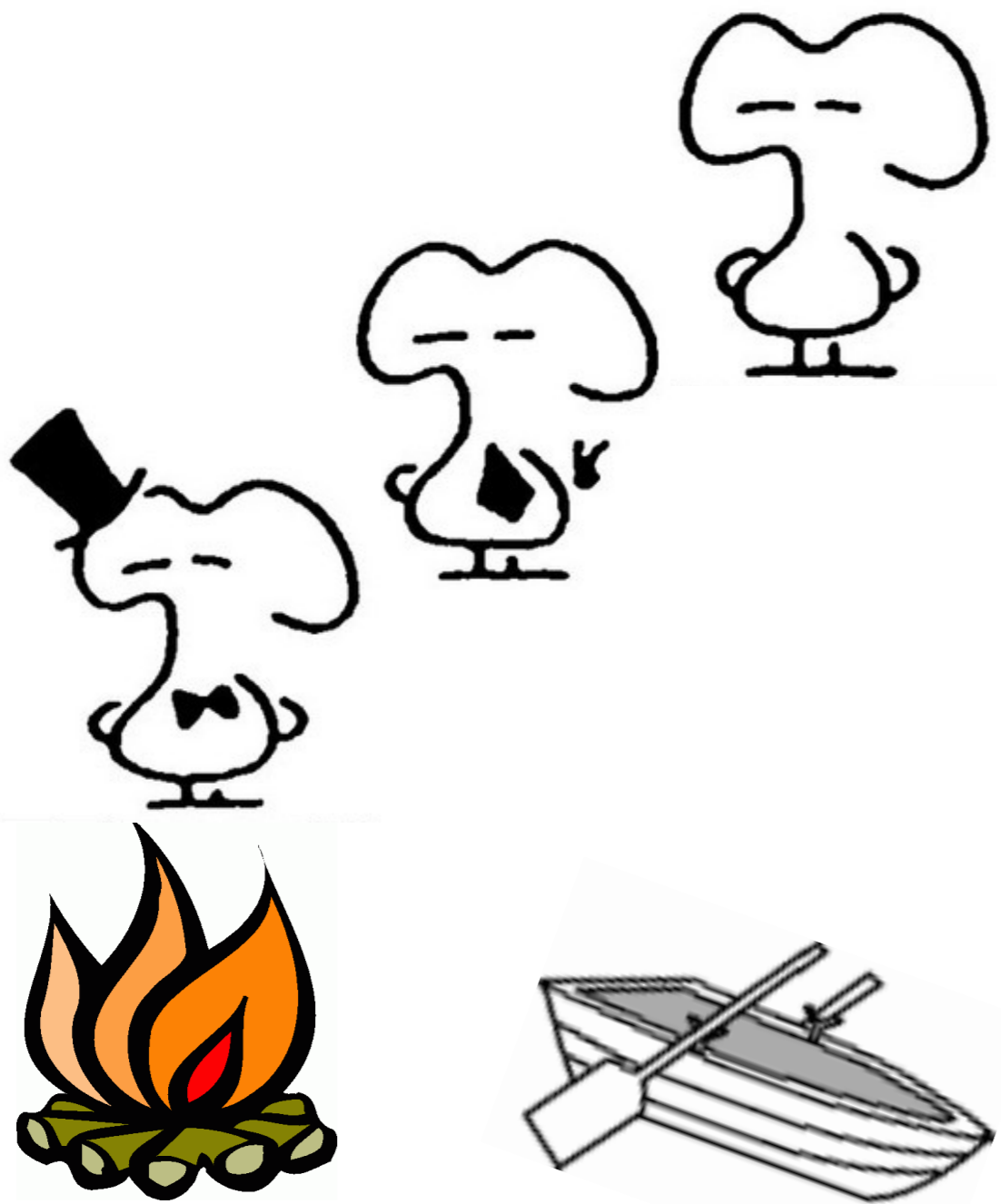


# Krog





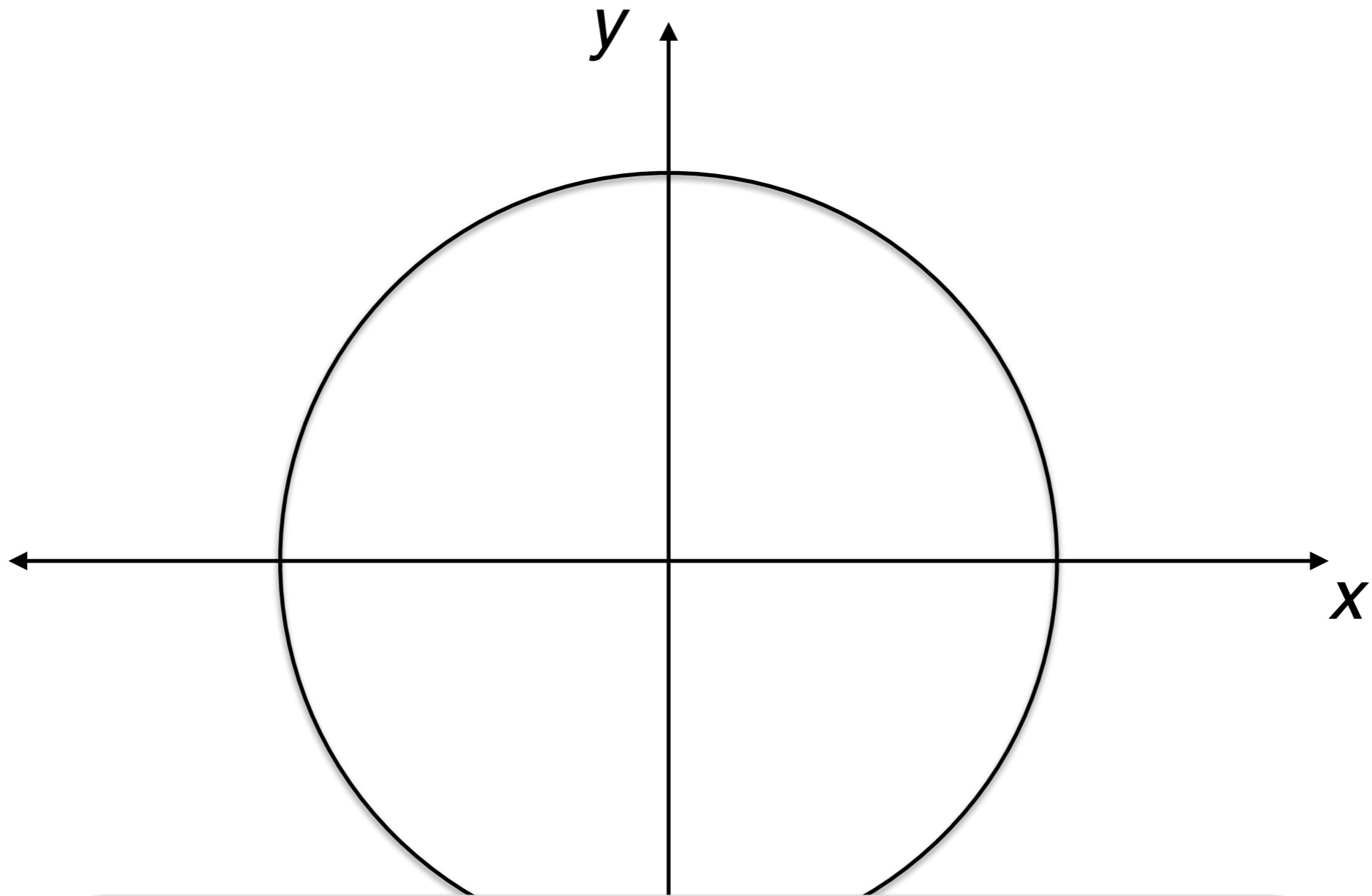
# Platon: Alegorija jame



# Platon: Alegorija jame

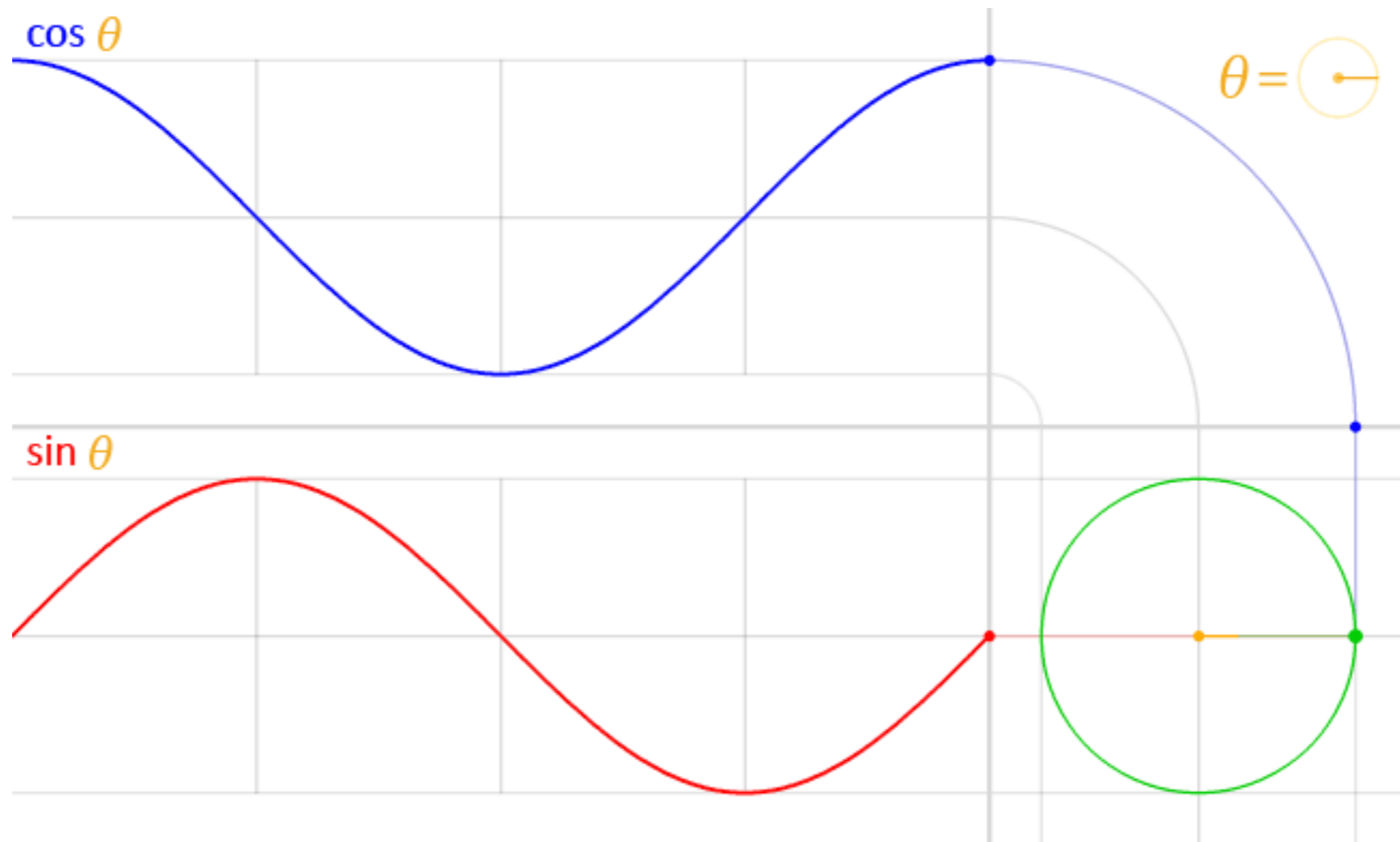


# Krog

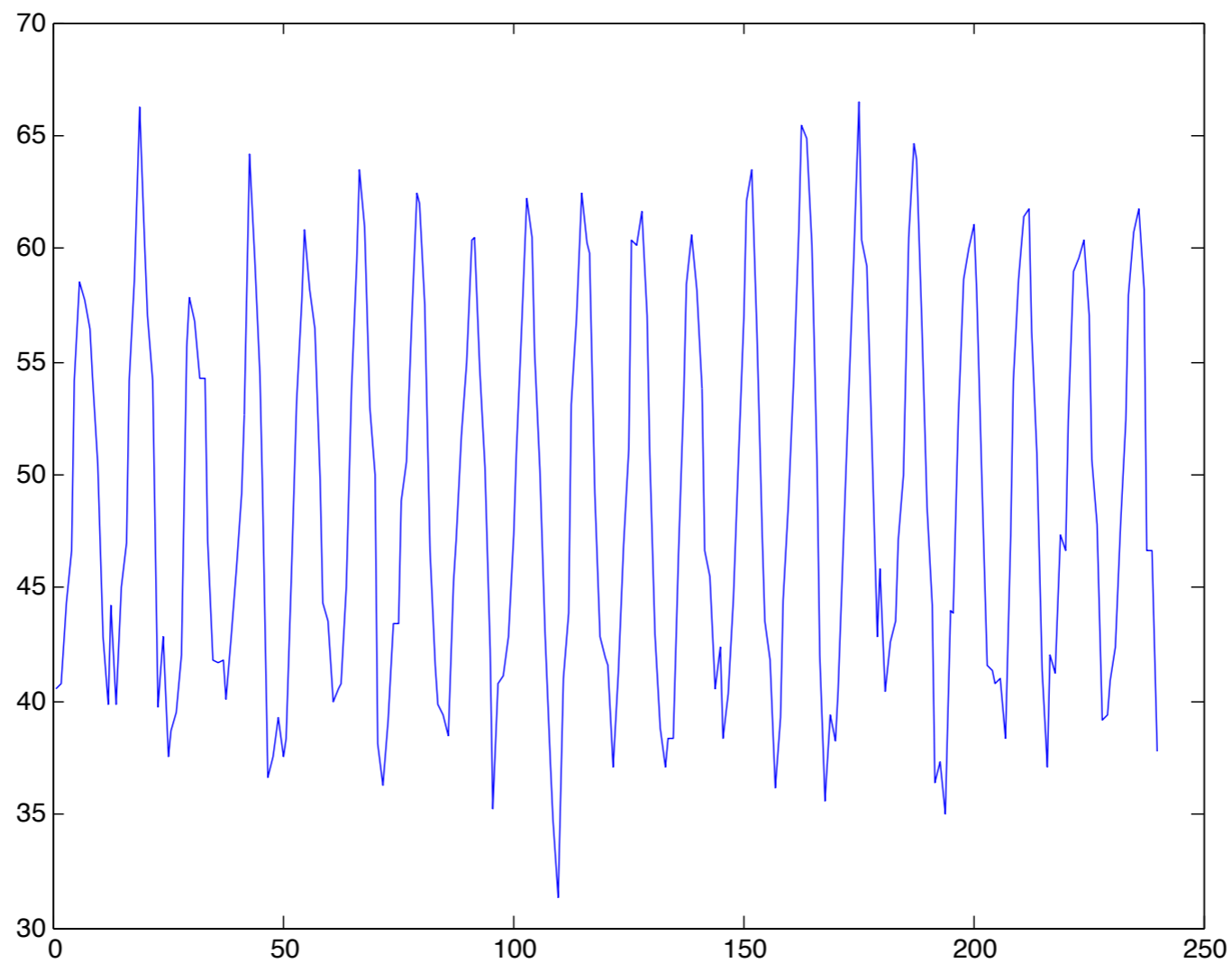


**Kako zgleda senca kroga?**

# Senca kroga



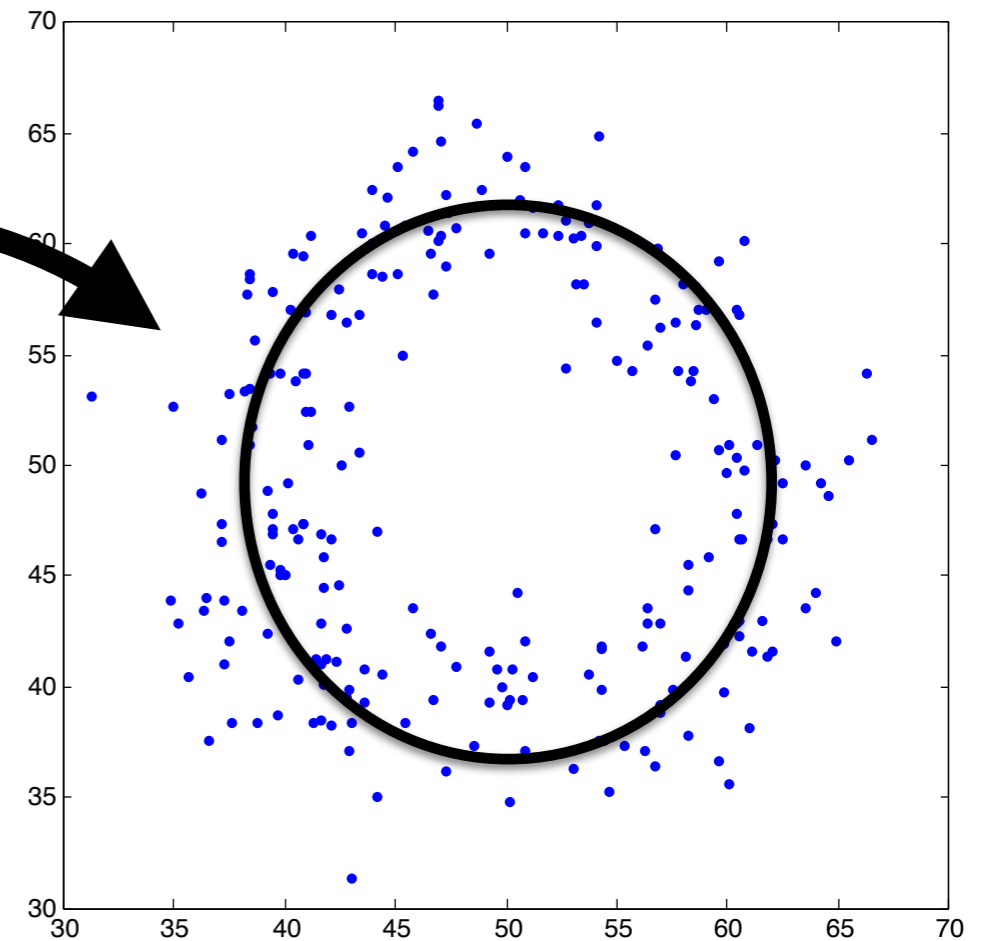
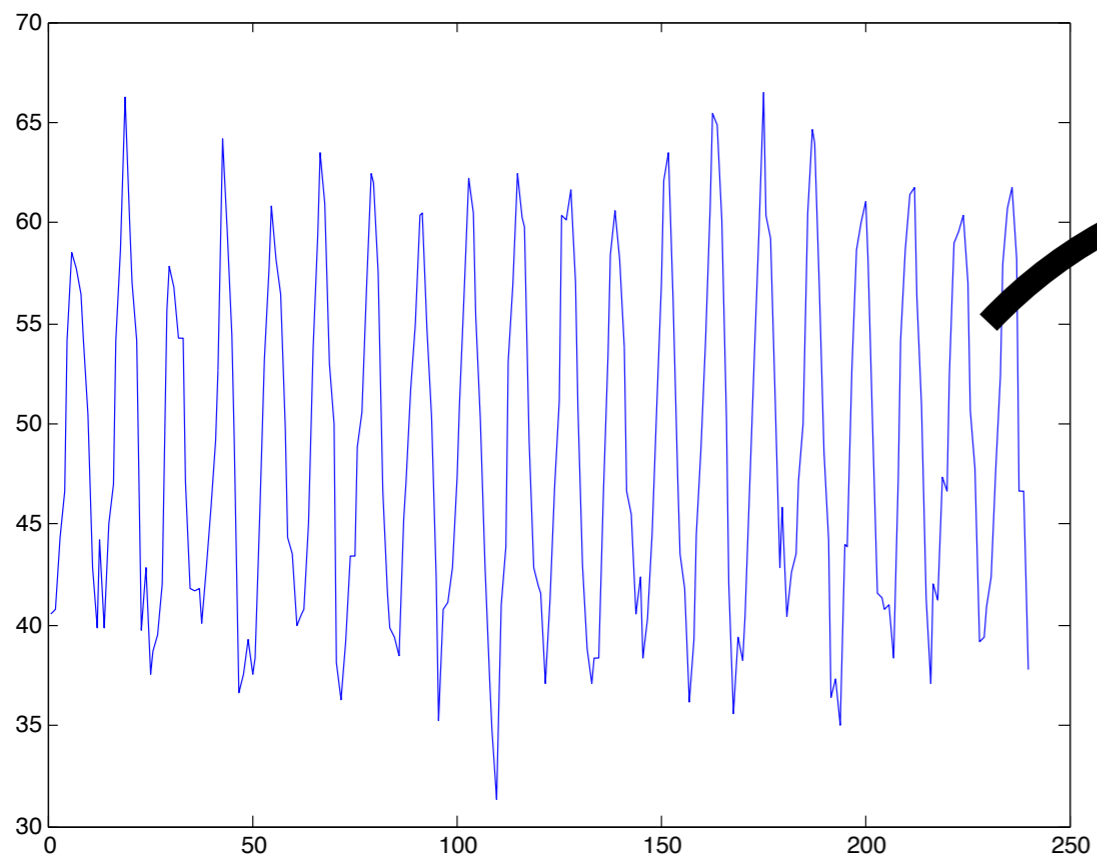
# Rekonstrukcija sence



temp. v Nottinghamu

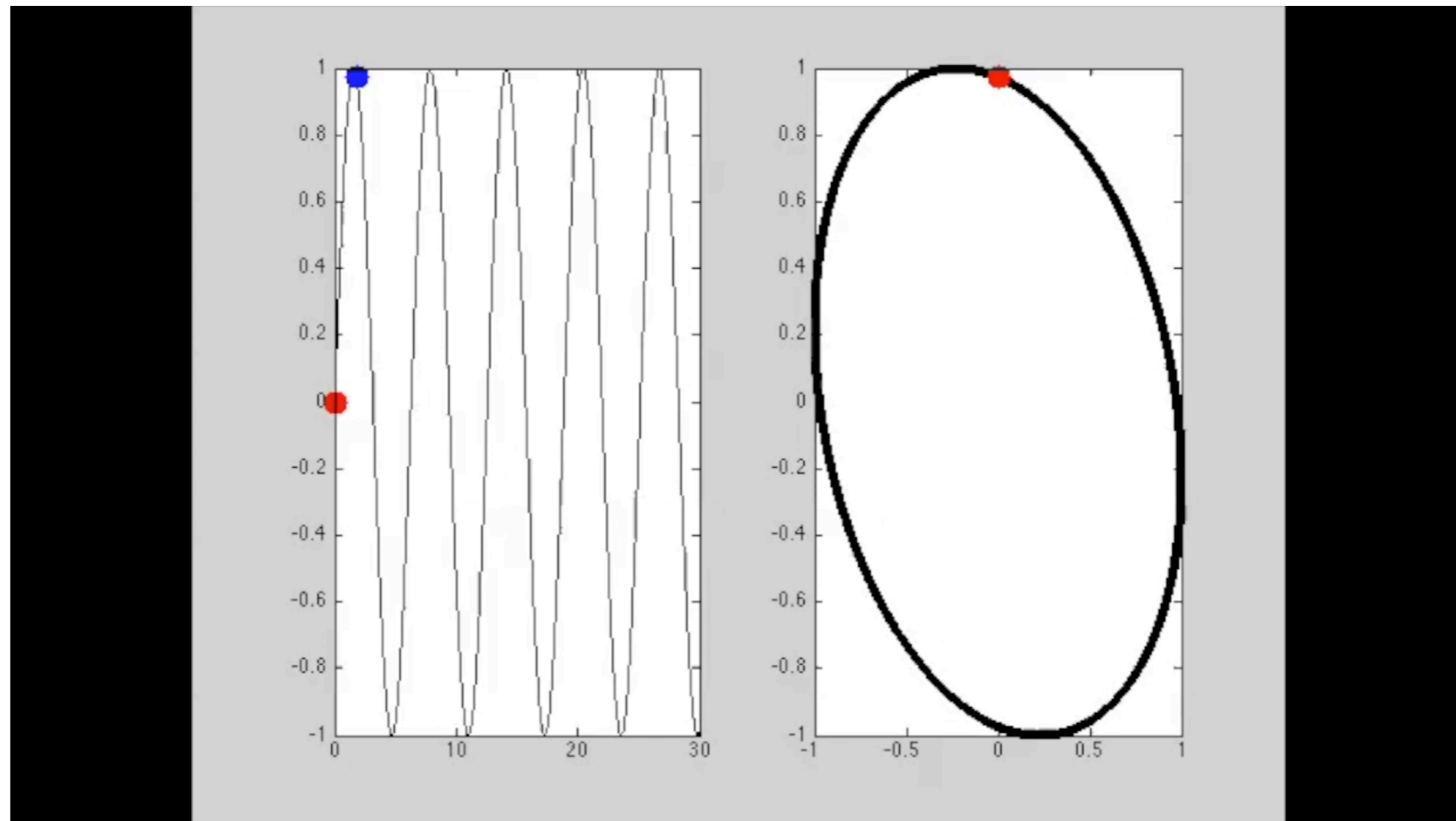
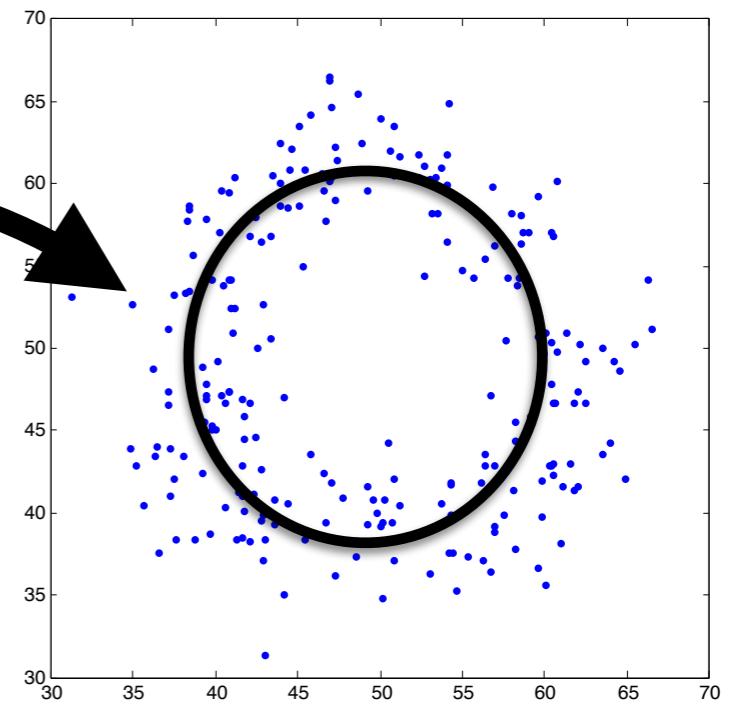
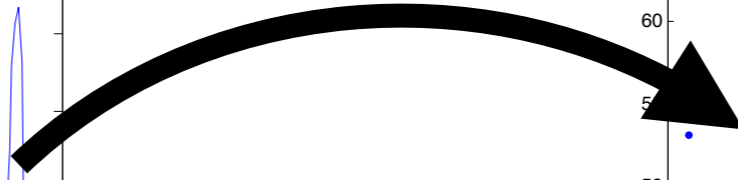
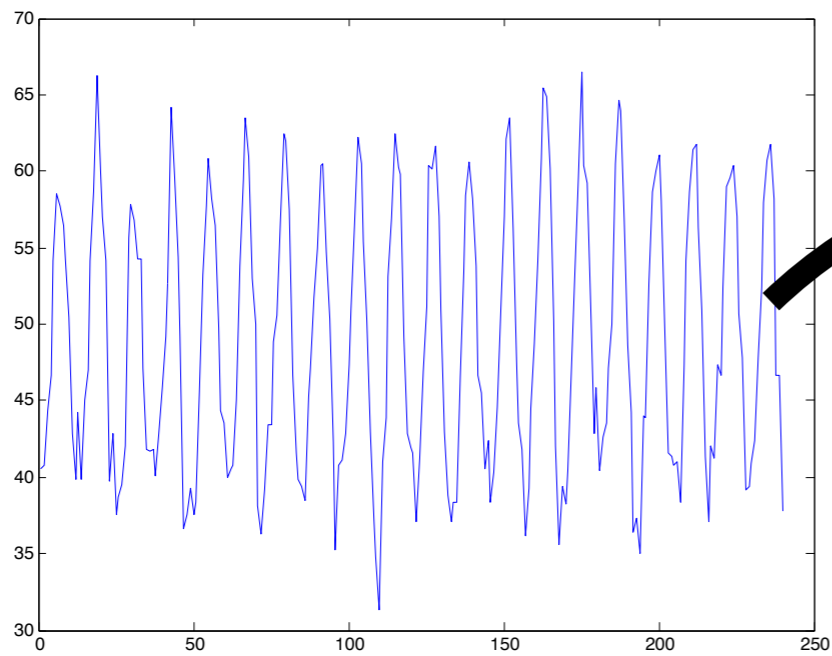
# Rekonstrukcija sence

1 krog = 1 leto

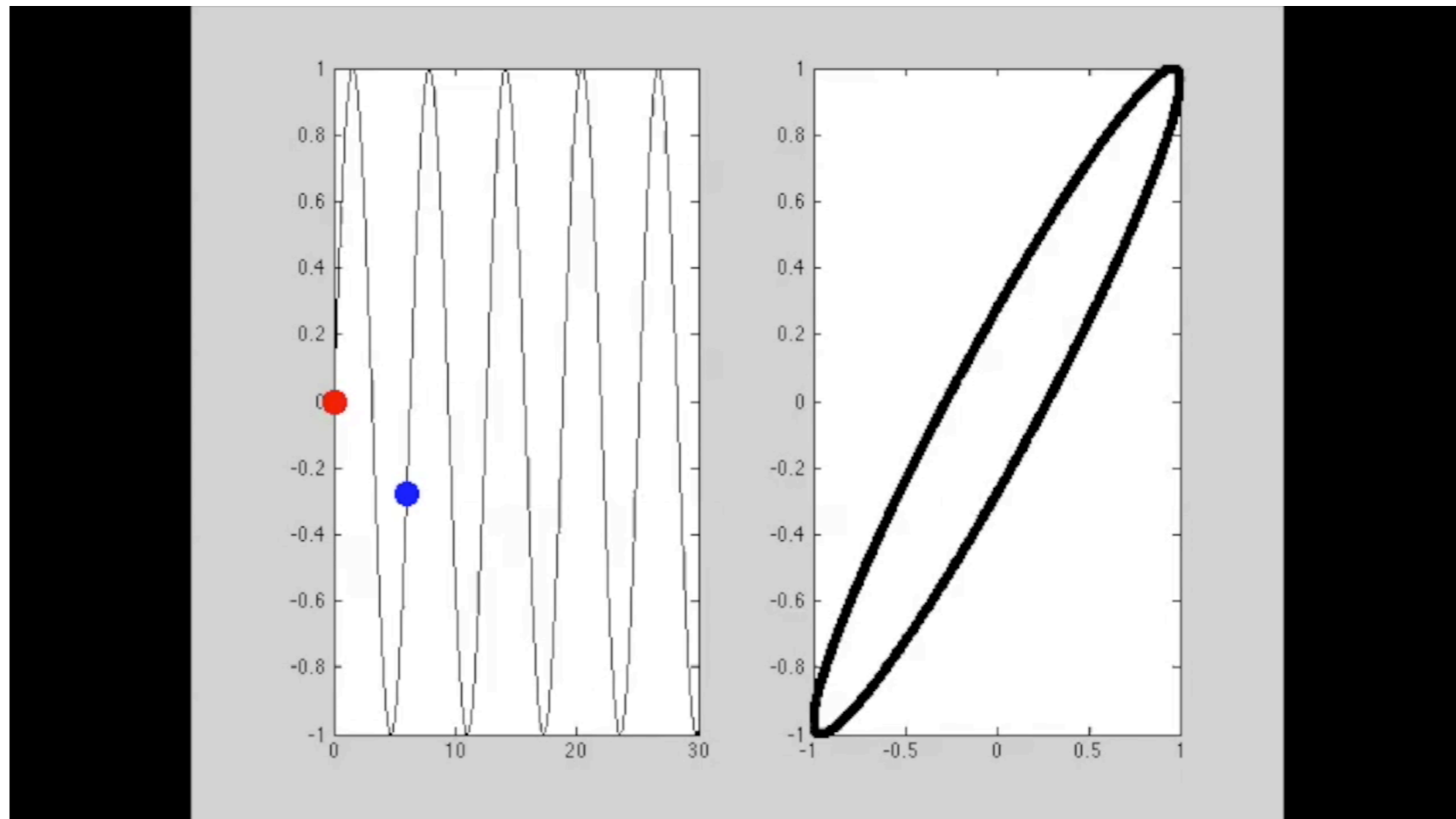
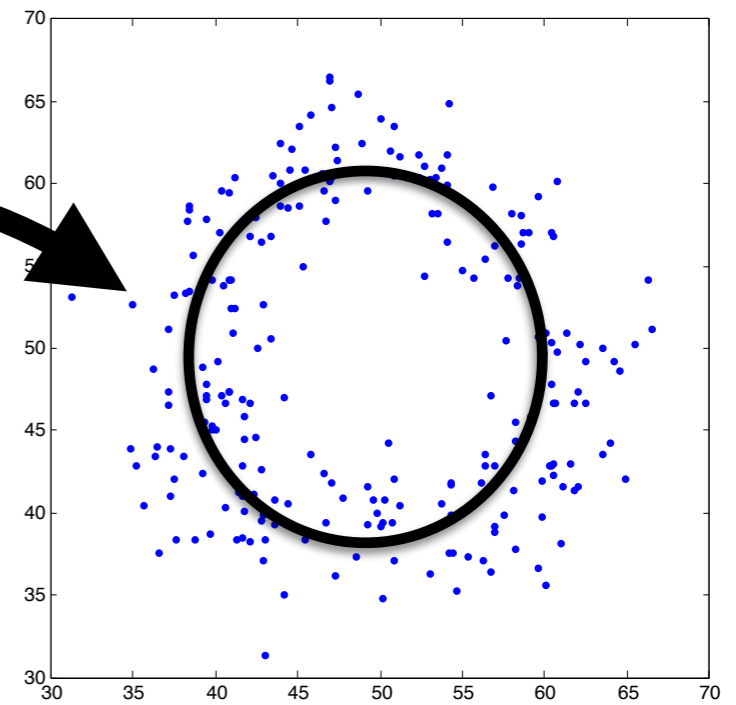
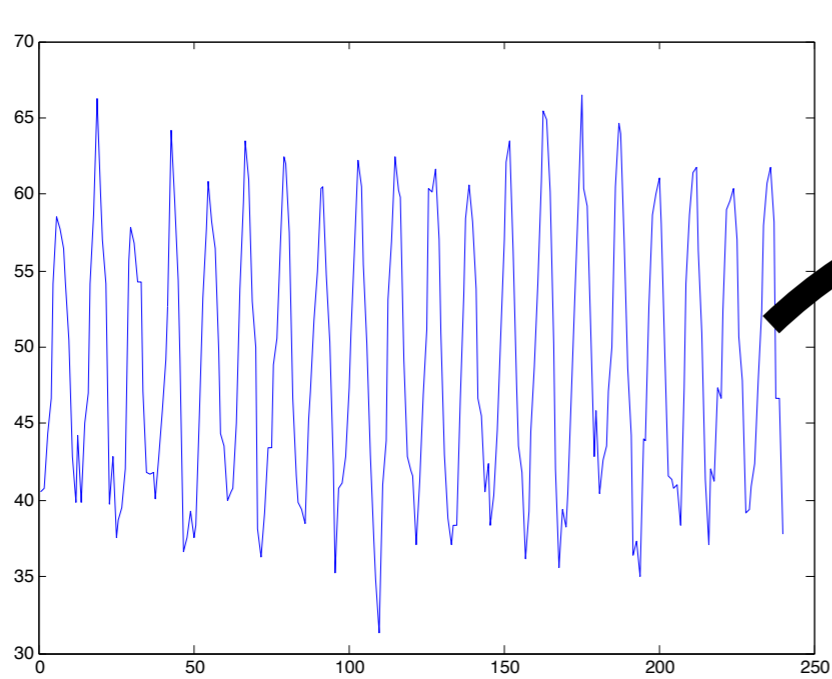


$$y(t) = (x(t), x(t + c))$$

# Gremo lahko nazaj



# Geometrija parametrov





# Visoke dimenzije

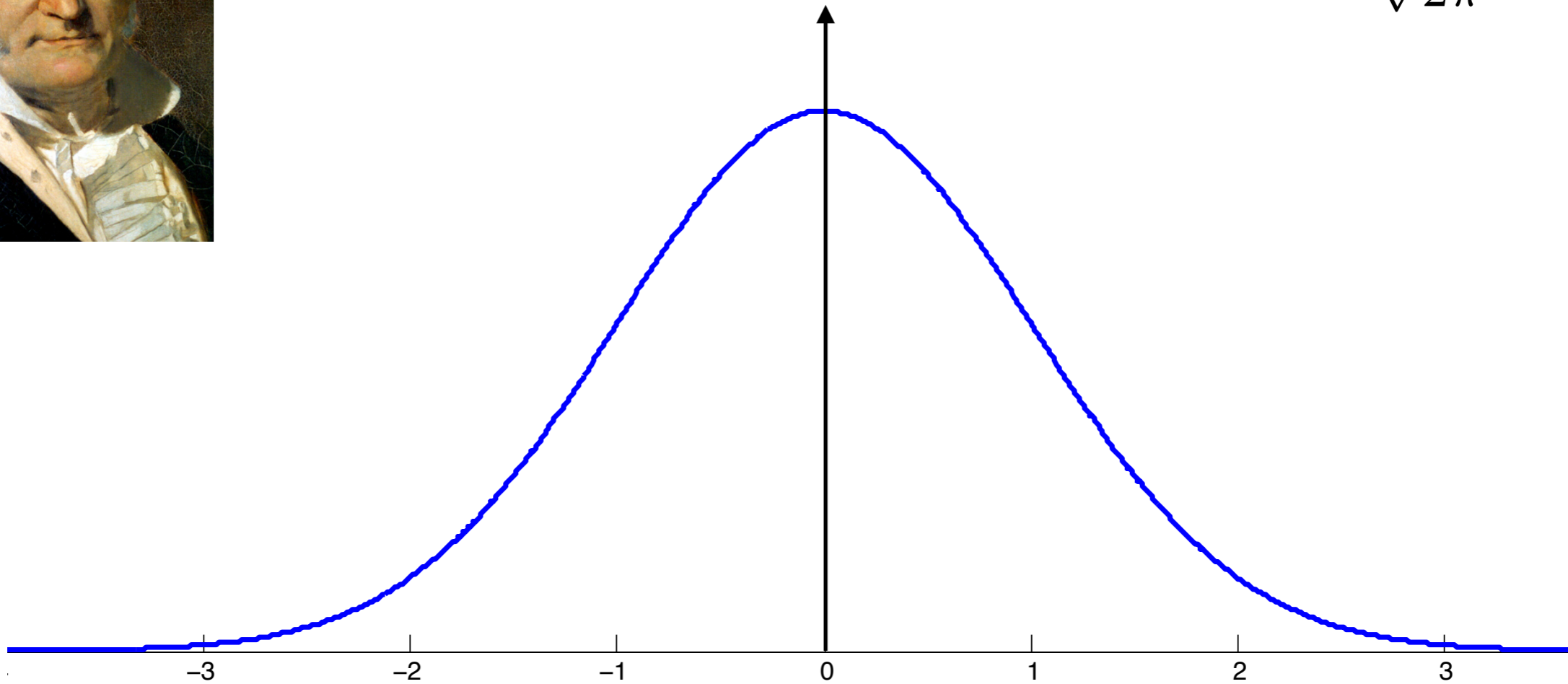
“Curiouser and curiouser!” cried Alice

-Alice v čudežni deželi, Lewis Carroll

# Gaussova krivulja



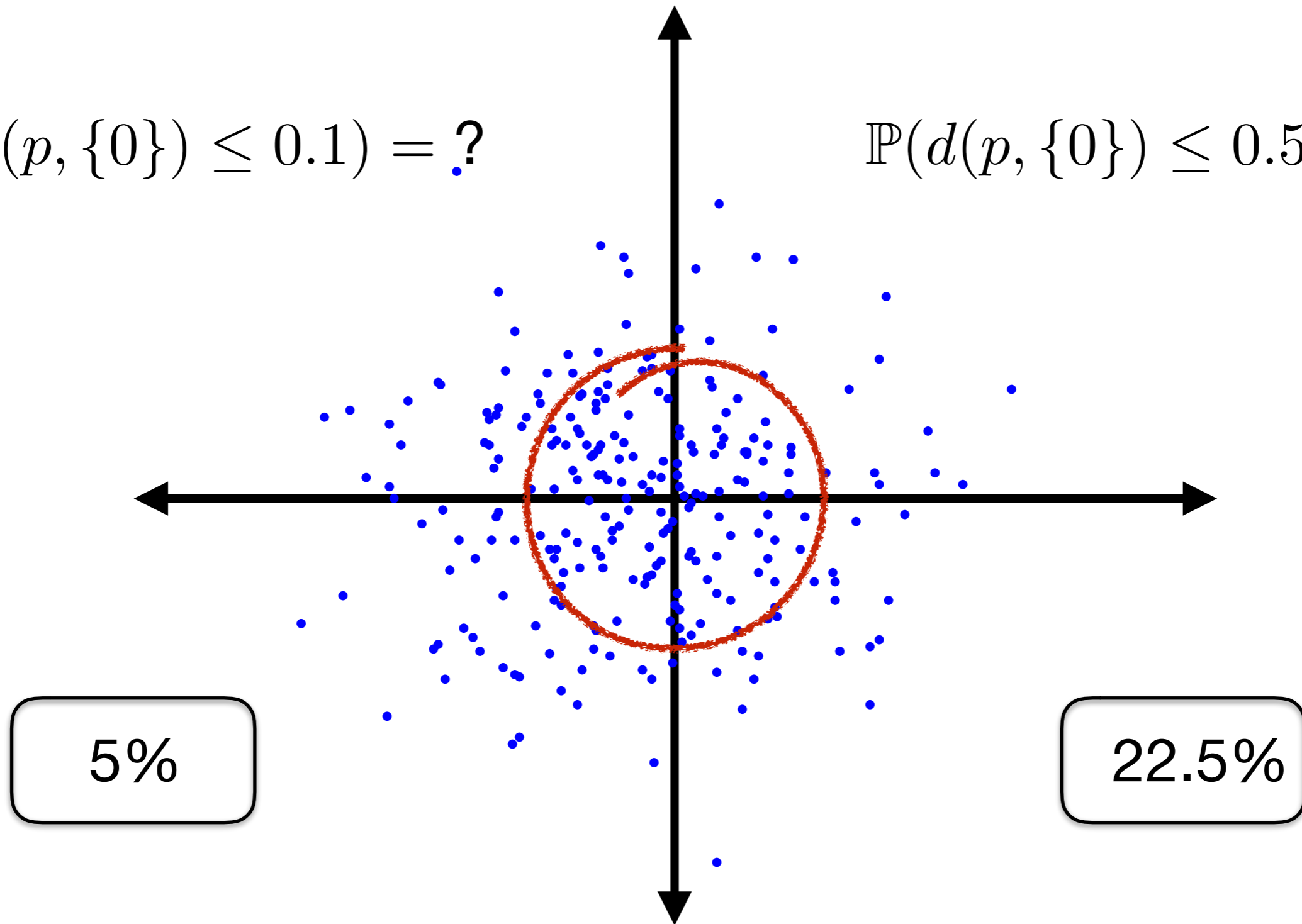
$$f(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}$$



# Visoke dimenzije

$$\mathbb{P}(d(p, \{0\}) \leq 0.1) = ?$$

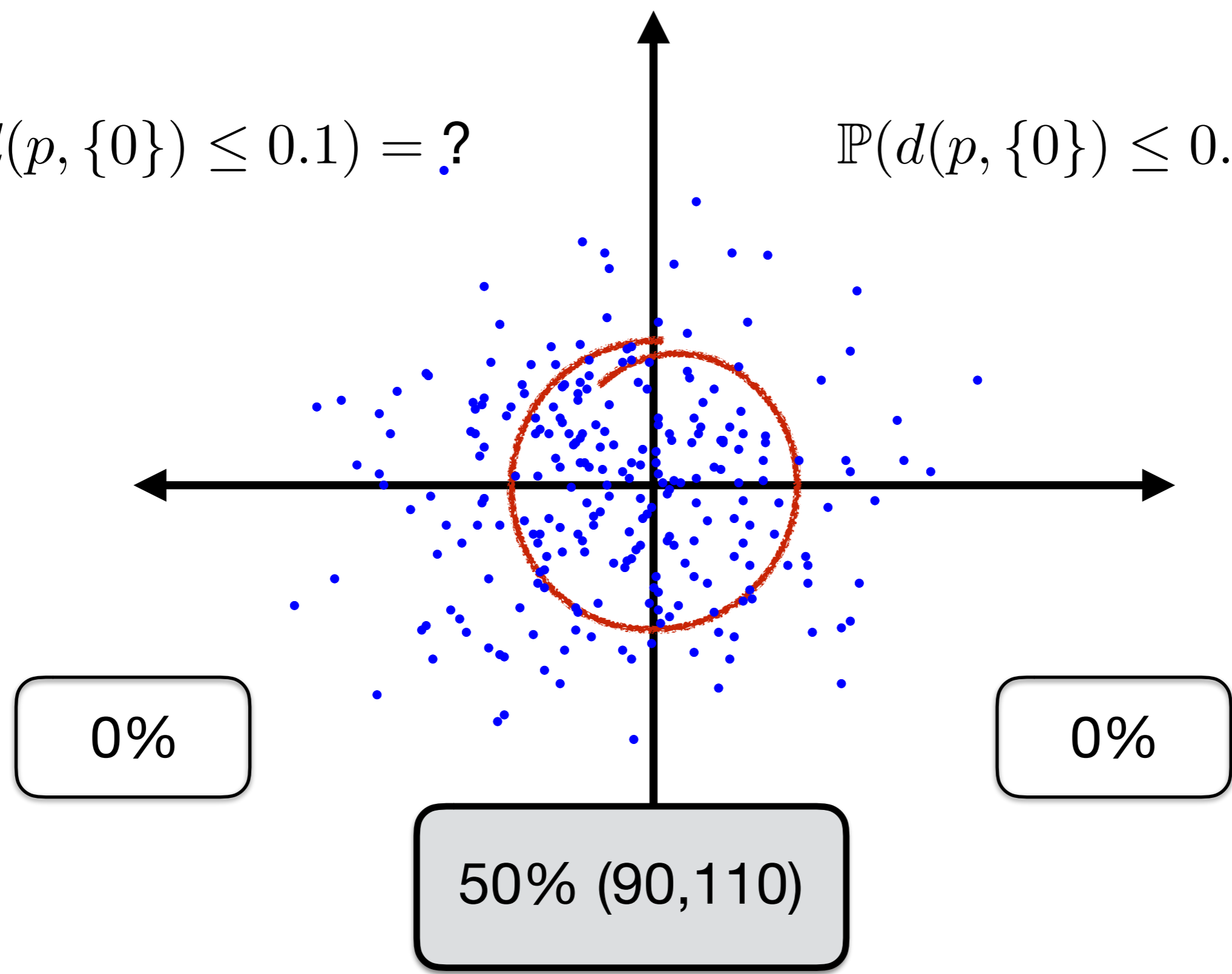
$$\mathbb{P}(d(p, \{0\}) \leq 0.5) = ?$$



# 100-dim vektor

$$\mathbb{P}(d(p, \{0\}) \leq 0.1) = ?$$

$$\mathbb{P}(d(p, \{0\}) \leq 0.5) = ?$$



# Zakaj?

Predstavljajmo si kovanec



50%



99%



50%



1%

100-dim



2-dim



$$\begin{aligned} \mathbb{P}(HH) &= (0,99)^2 \\ &= 0,98 \end{aligned}$$

$$\mathbb{P} = (0,99)^{100} = 0,37$$

$$\mathbb{P} = (0,90)^{100} \approx 0$$

# Problem

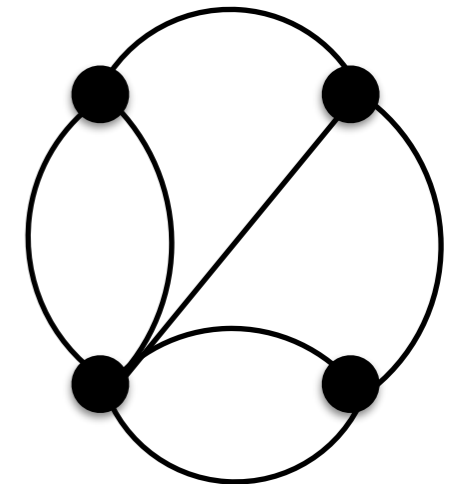
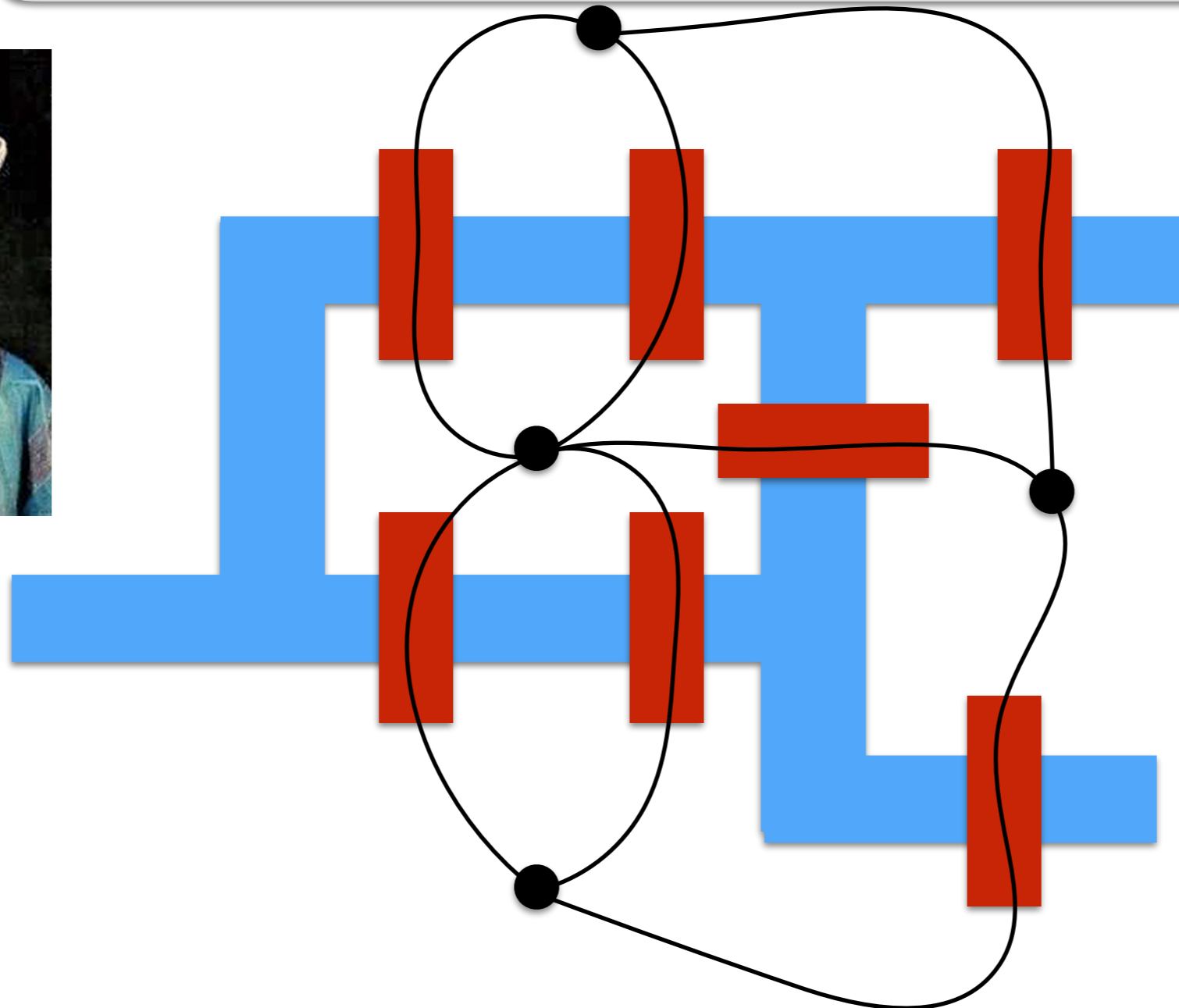
Geometrija je lahko zelo kompleksna v višjih dimenzijah...

# Topologija

Topo

Gremo lahko čez vsak most  
natanko enkrat?

rafija



# Topologija

**Topos** - prostor



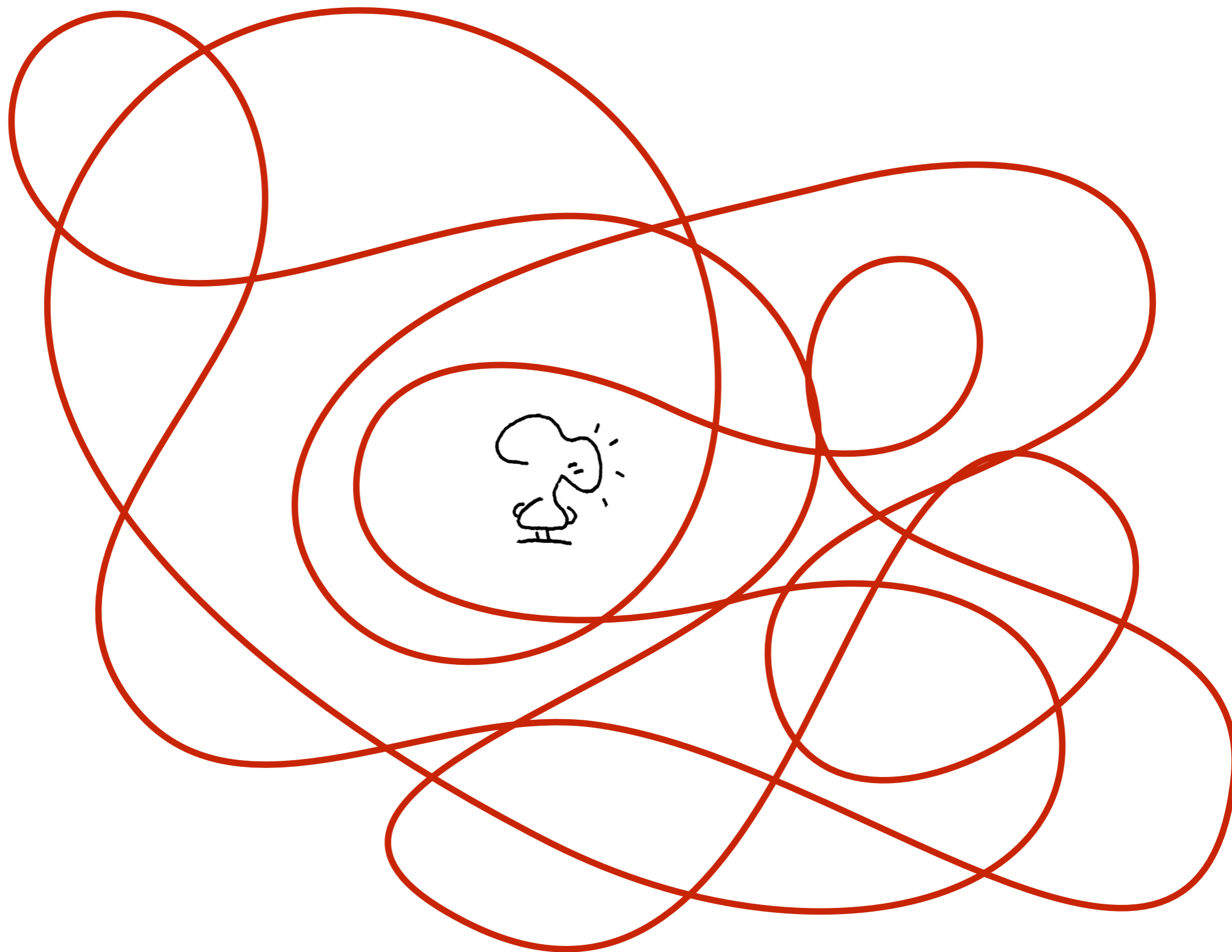
**geometrija gume**



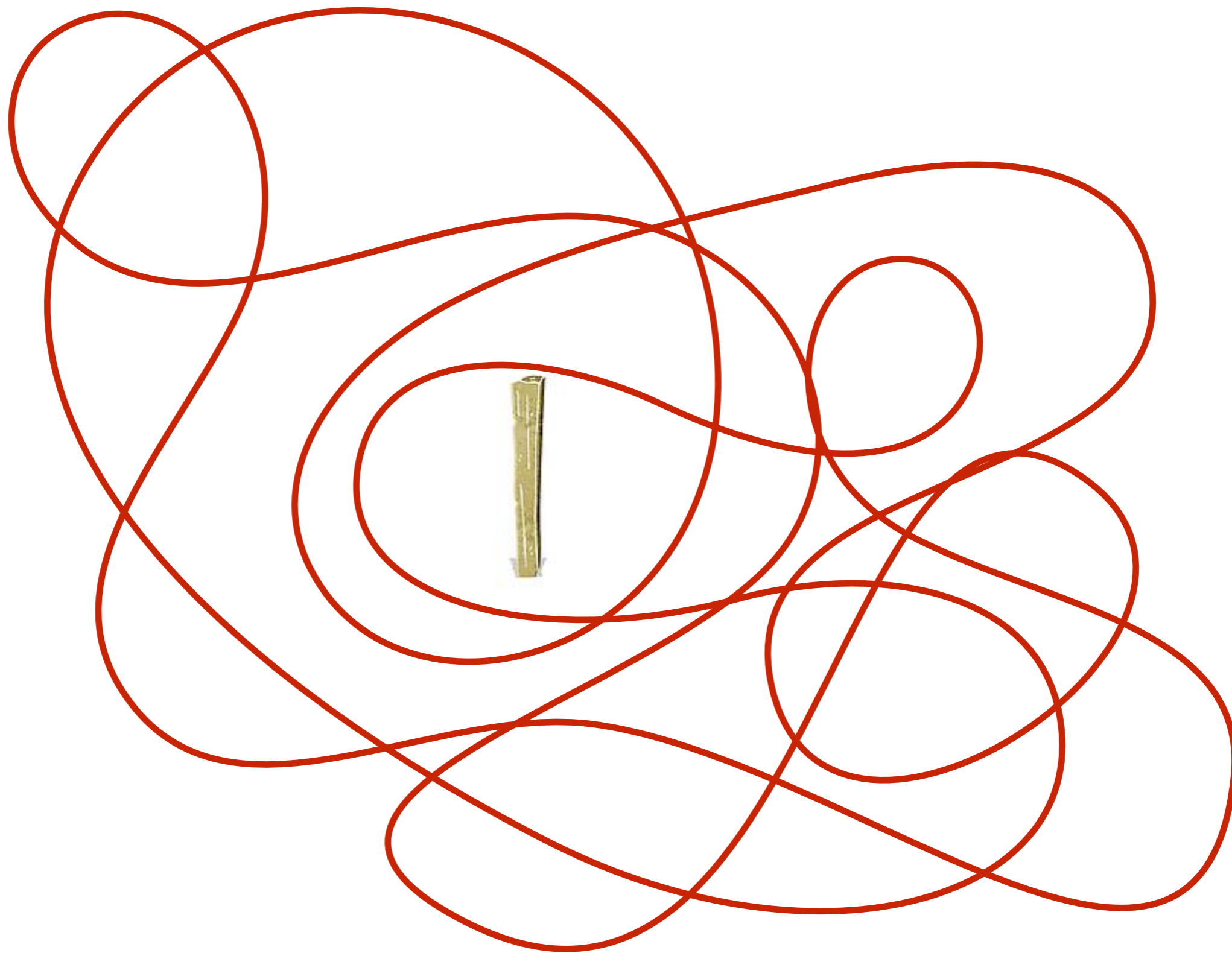
# Ovojno število



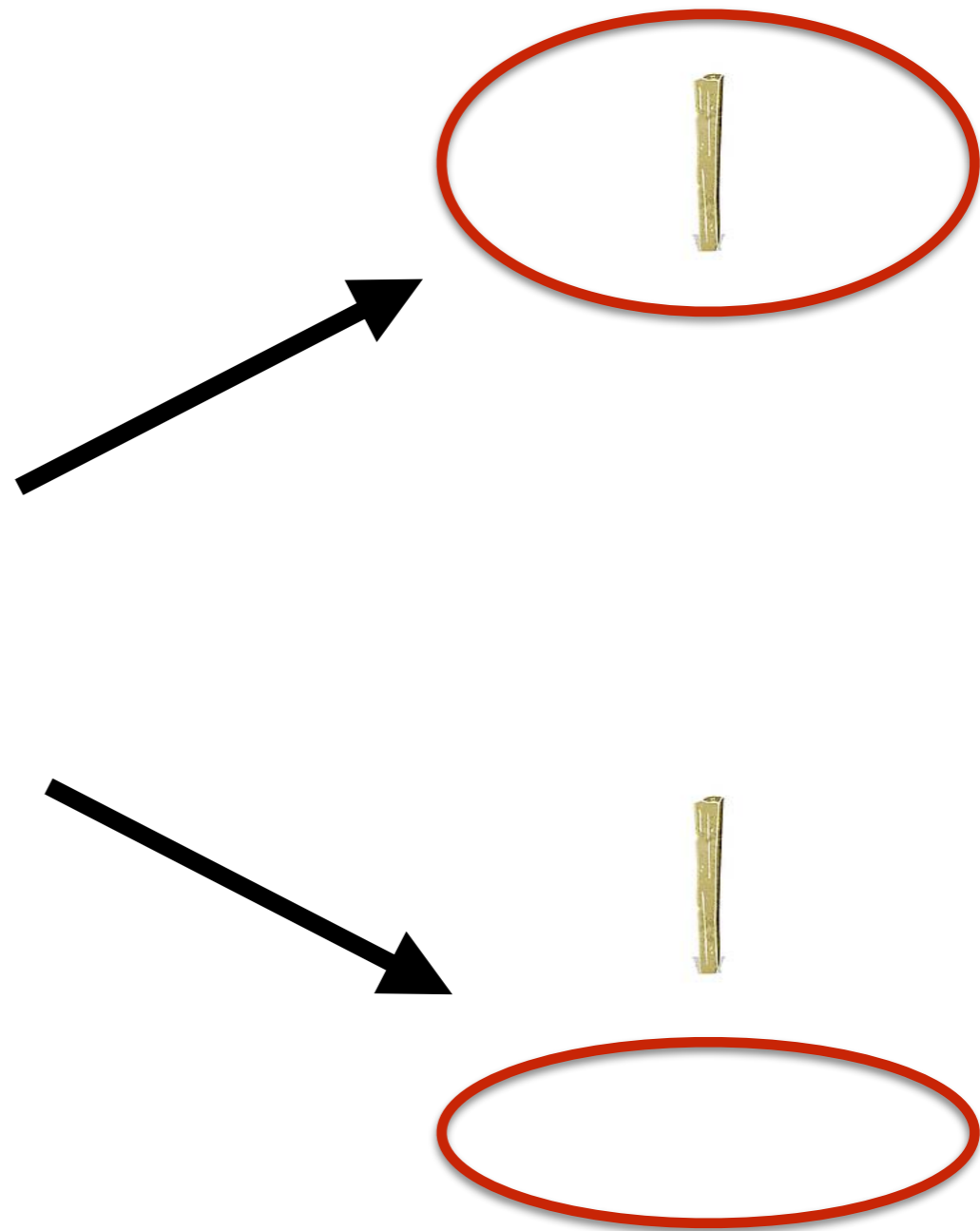
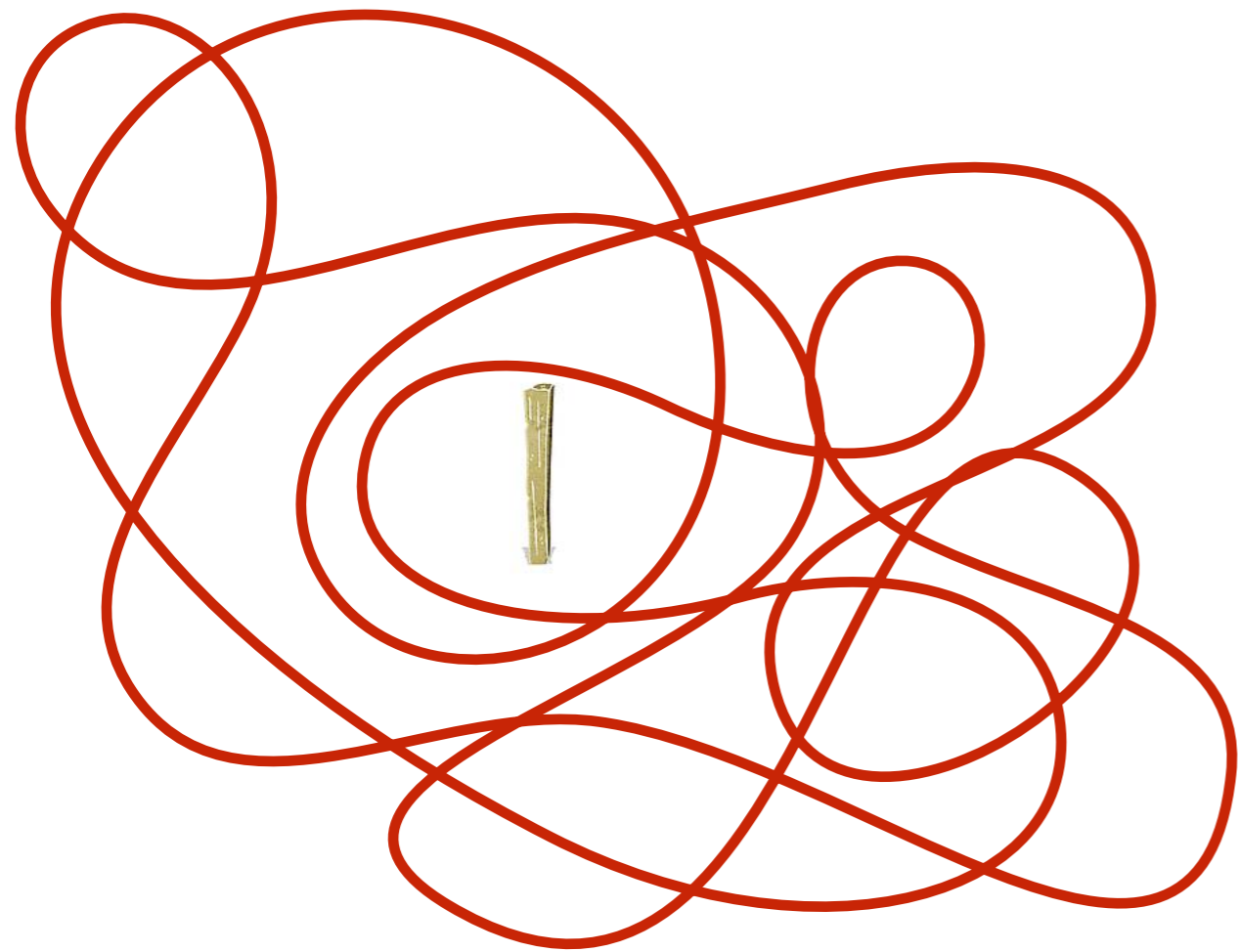
# Ovojno število



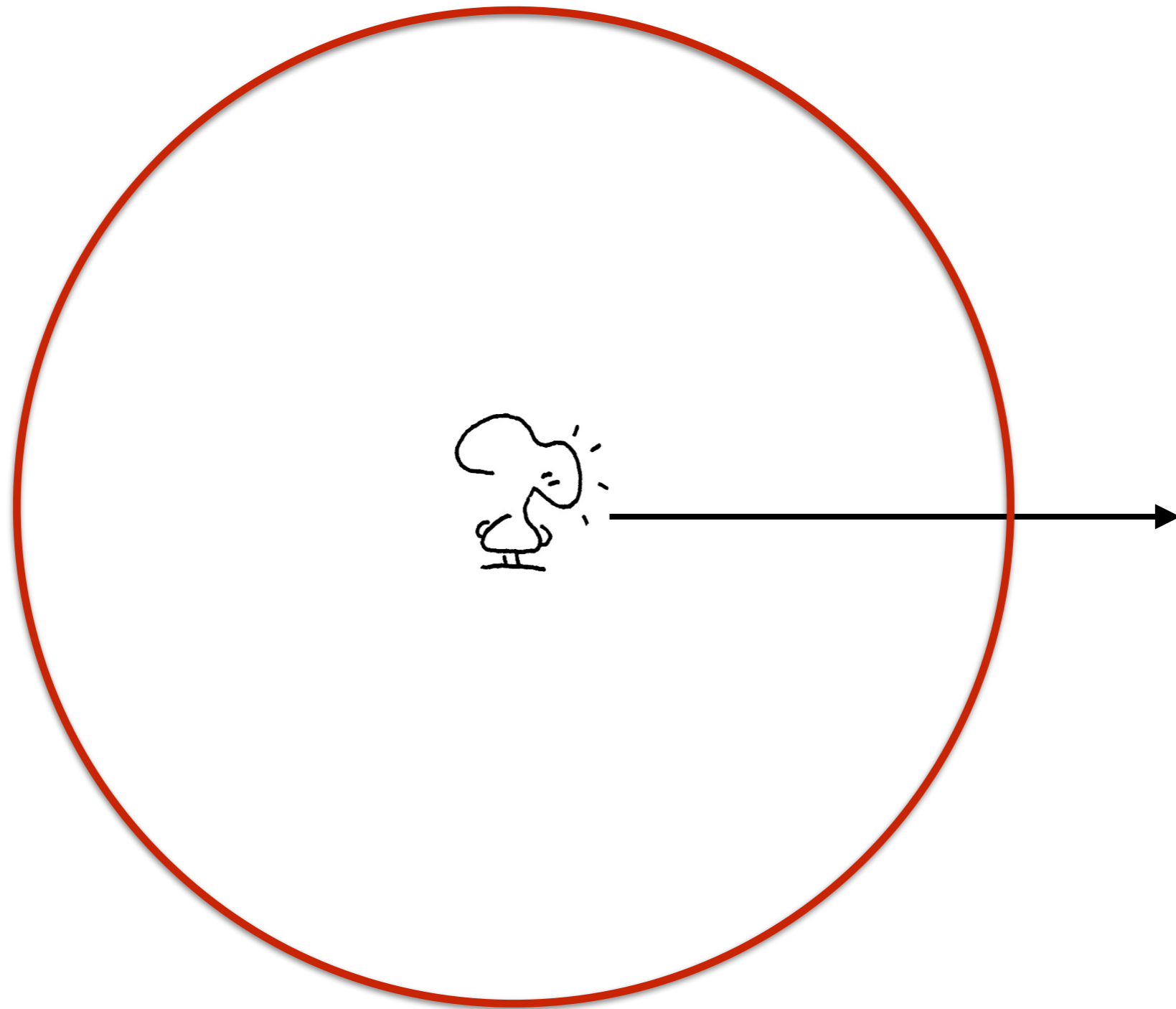
# Ovojno število



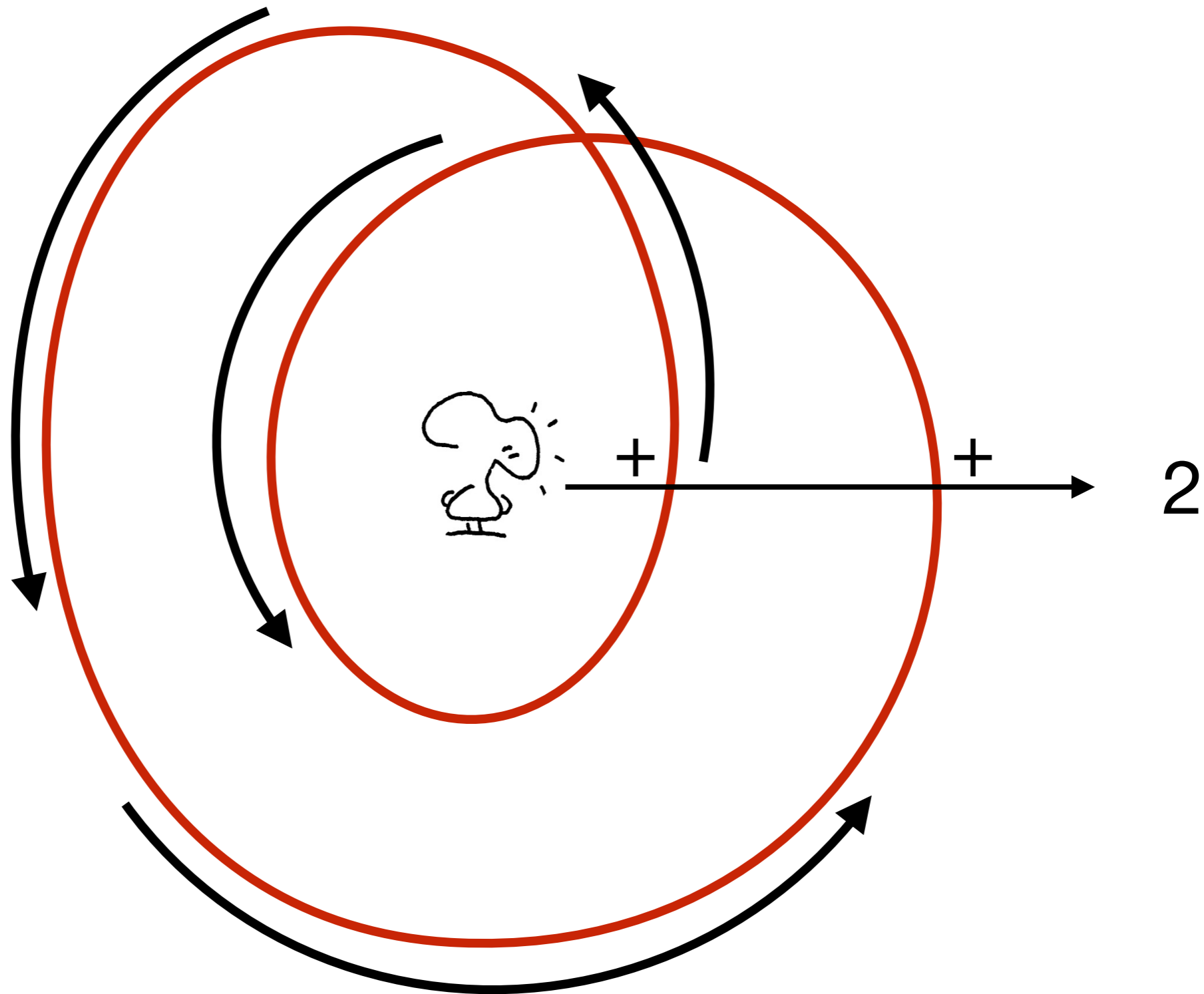
# Ovojno število



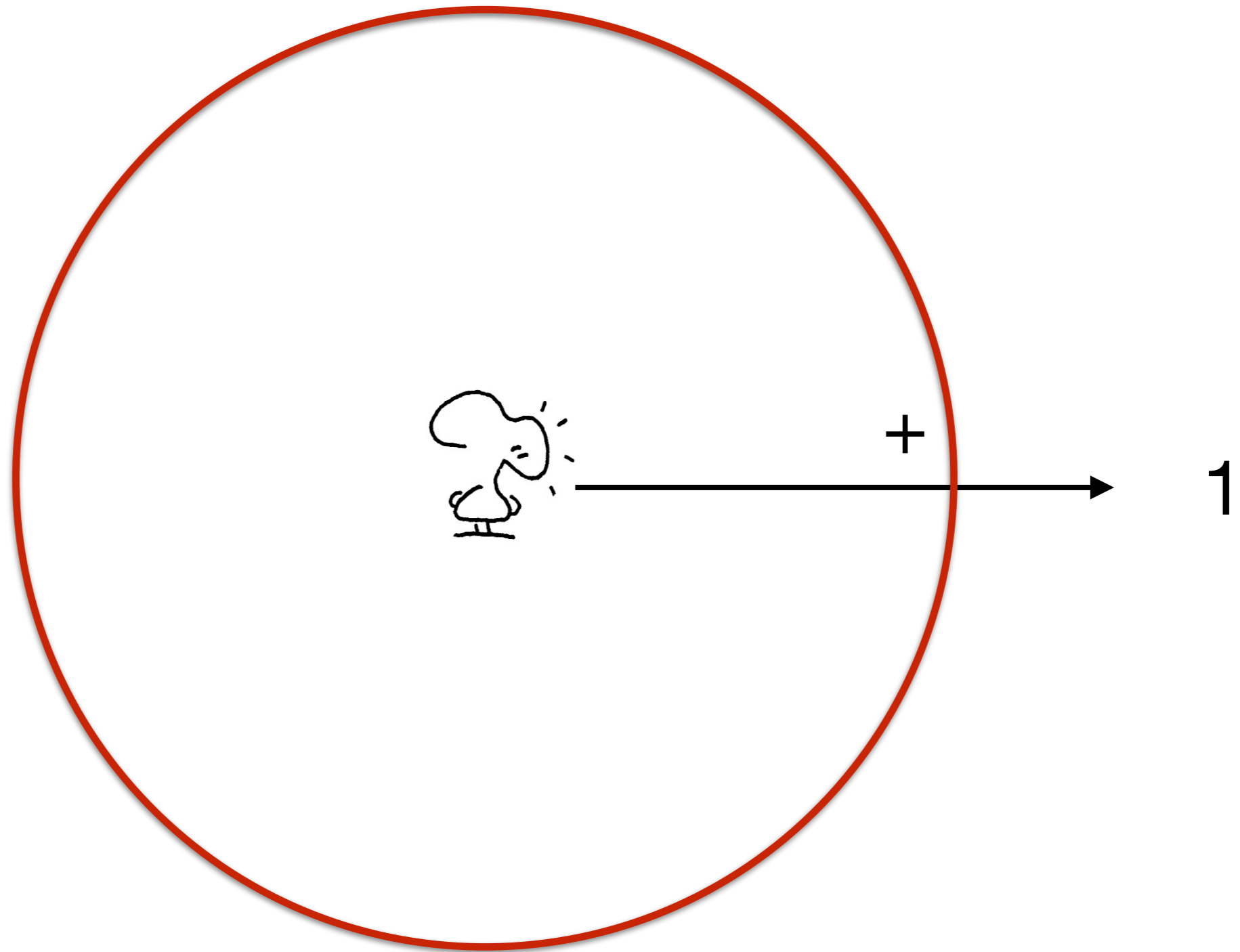
# Ovojno število



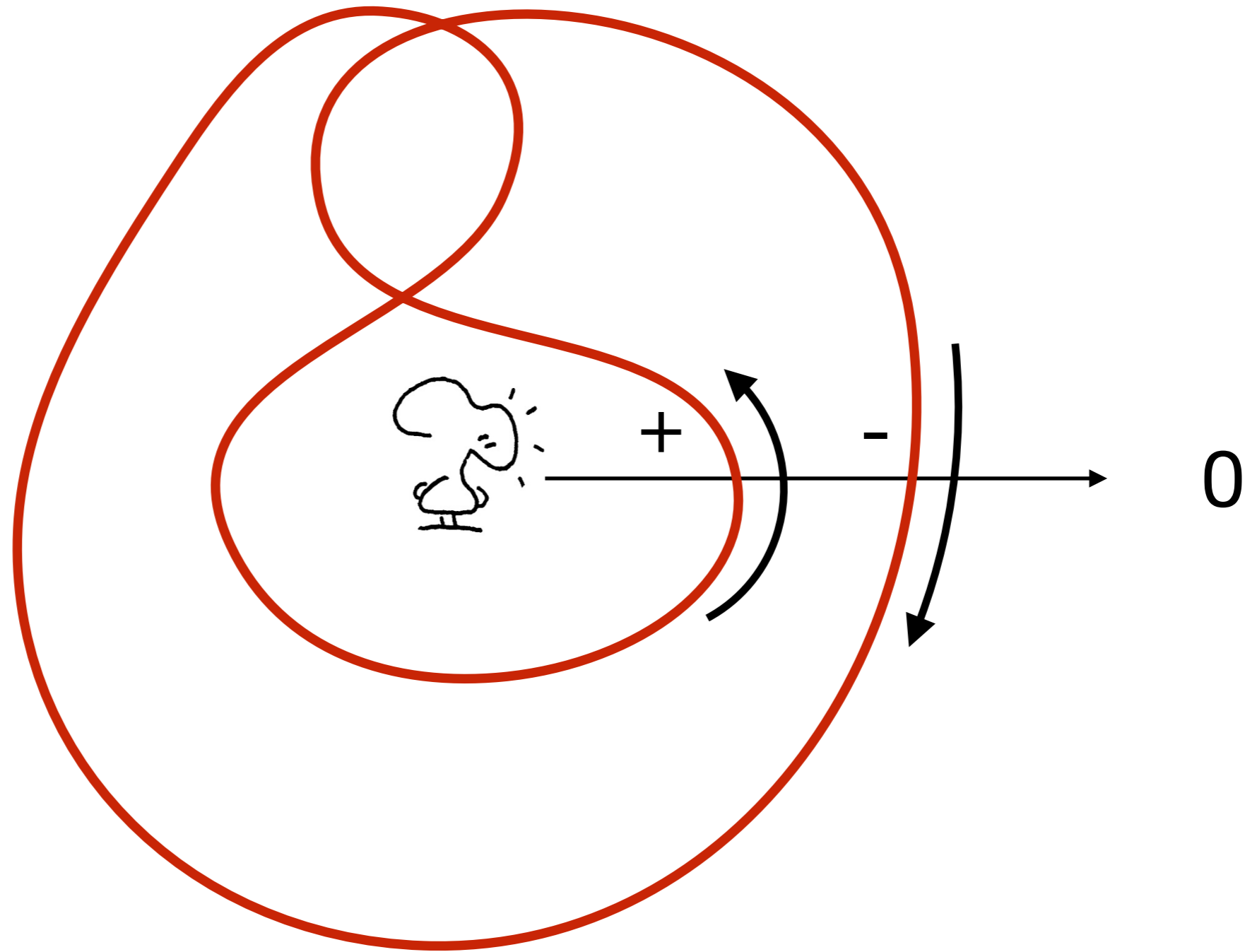
# Ovojno število



# Ovojno število

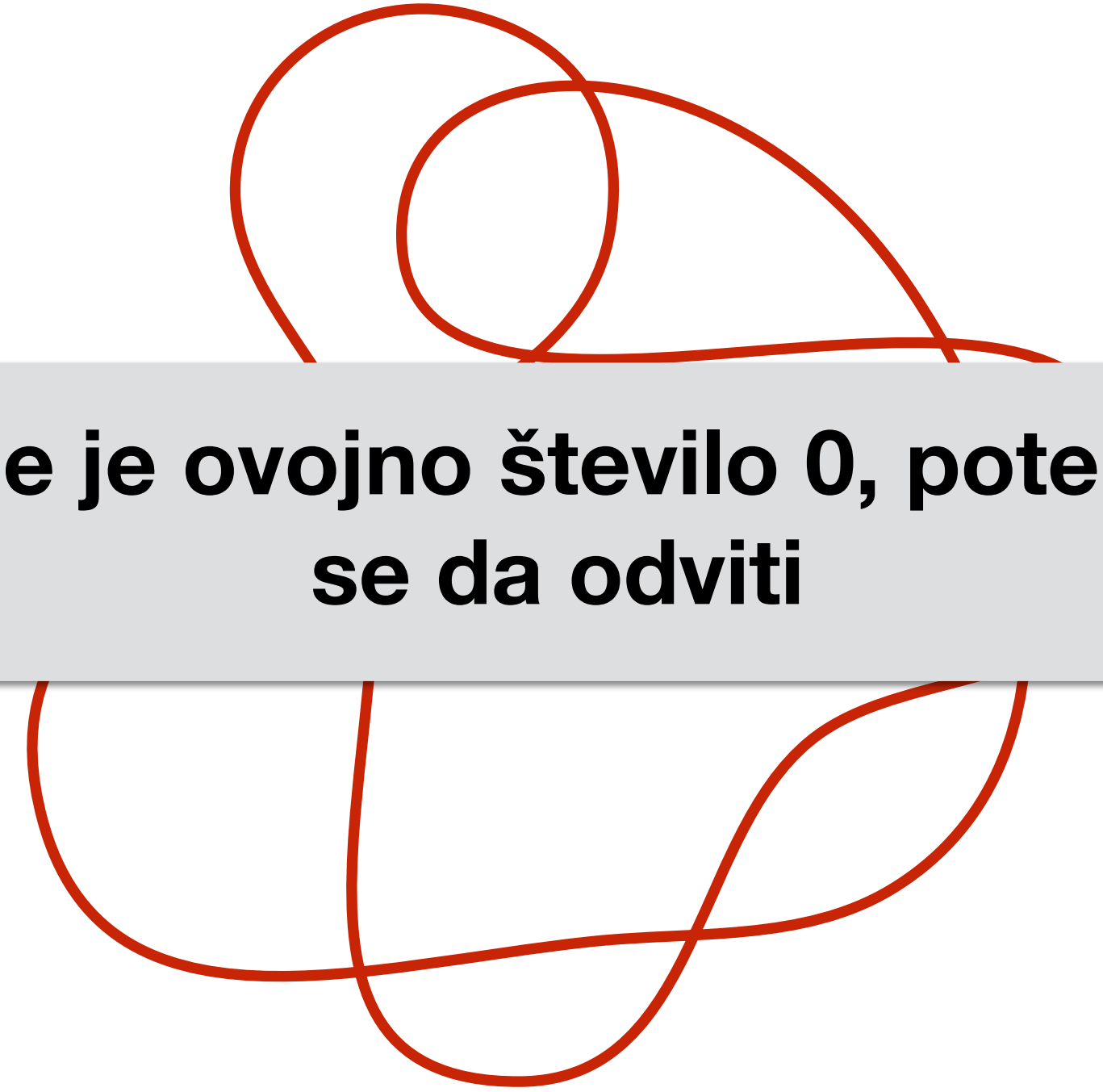


# Ovojno število





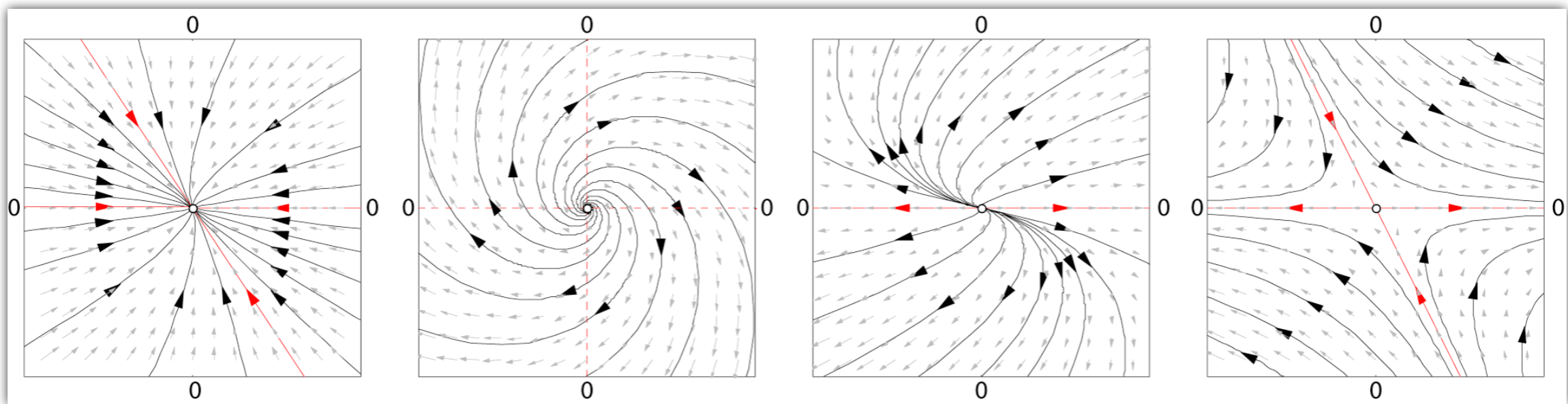
# Ovojno število



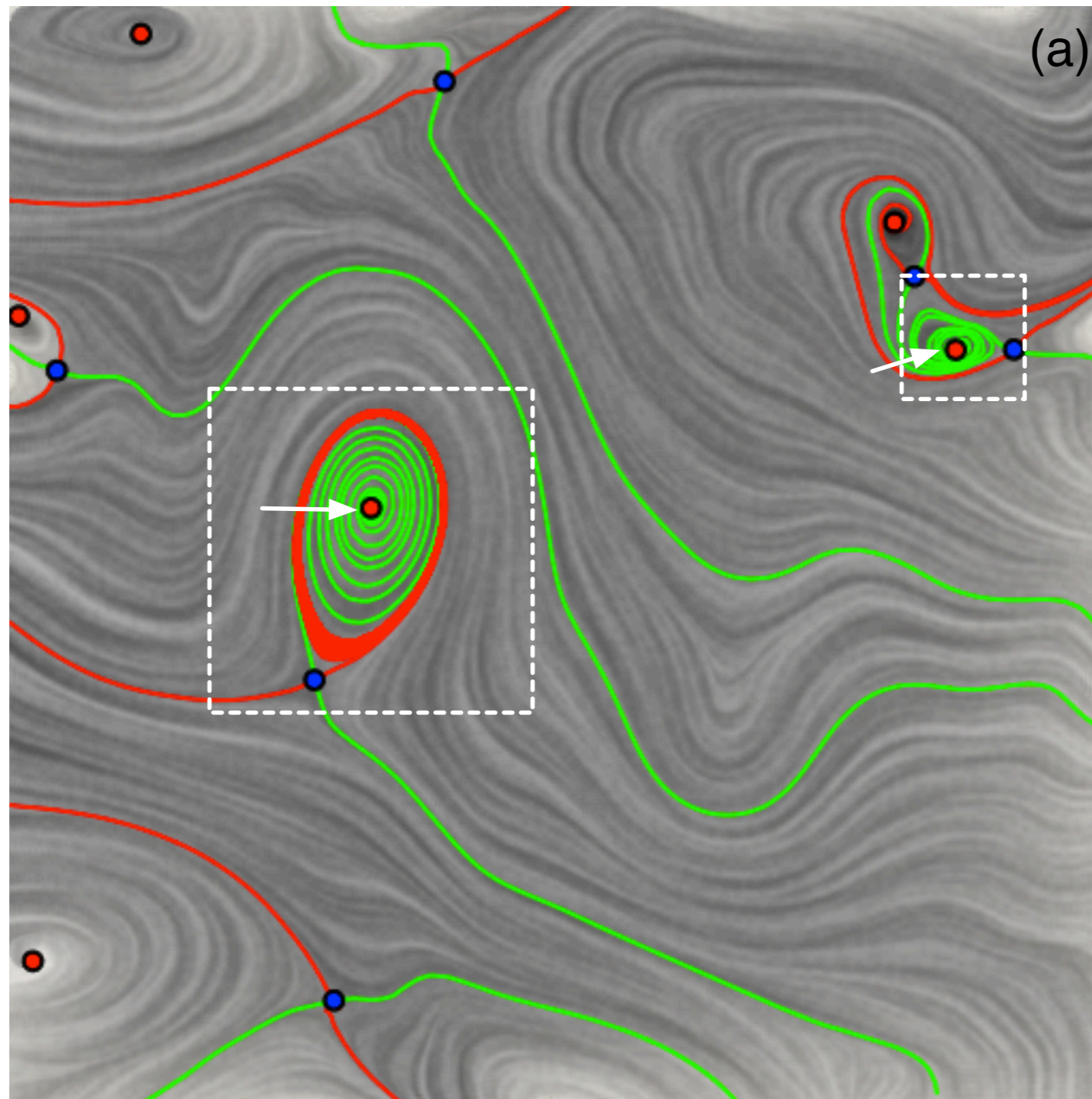
**Če je ovojno število 0, potem  
se da odviti**

# Aplikacija

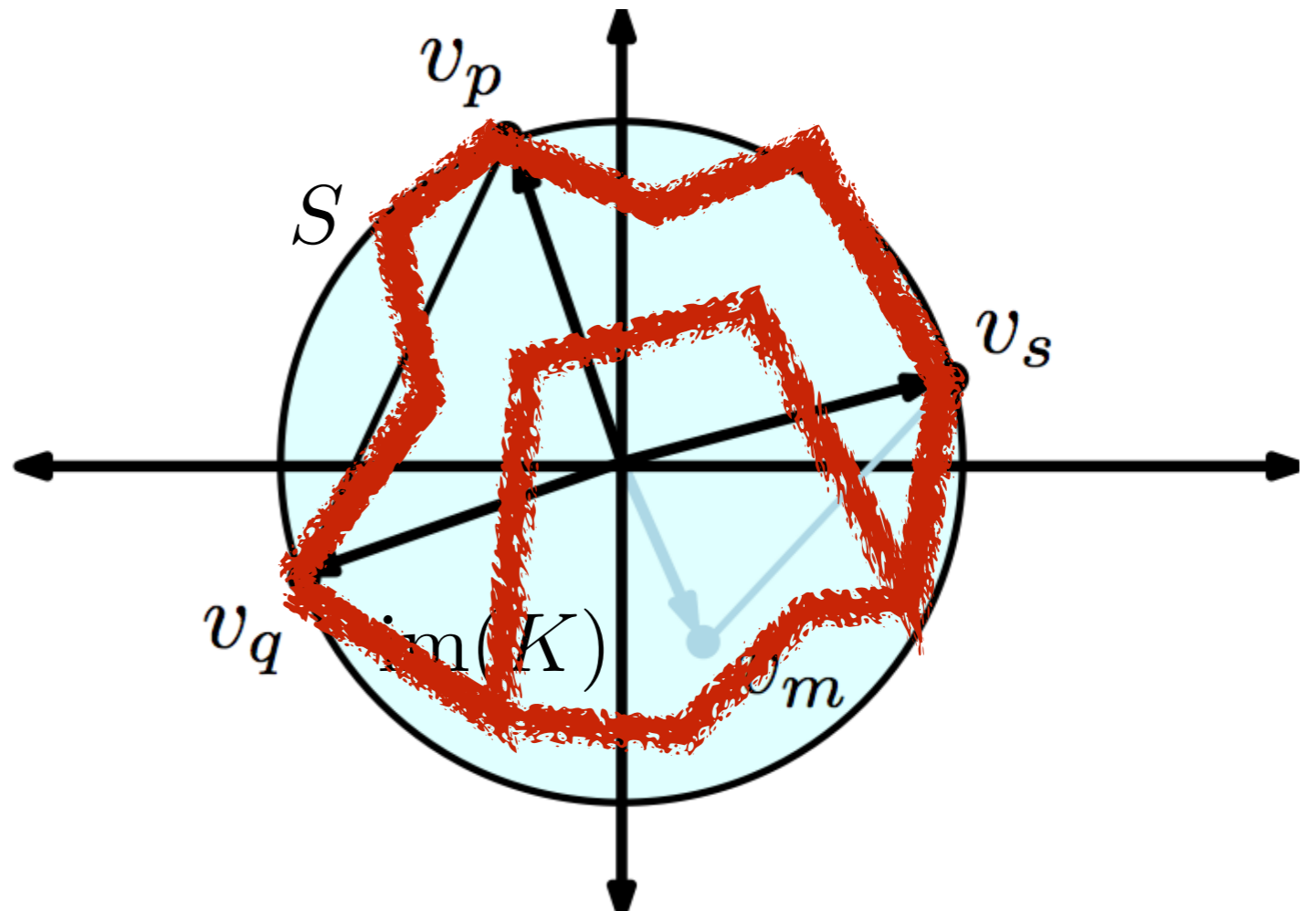
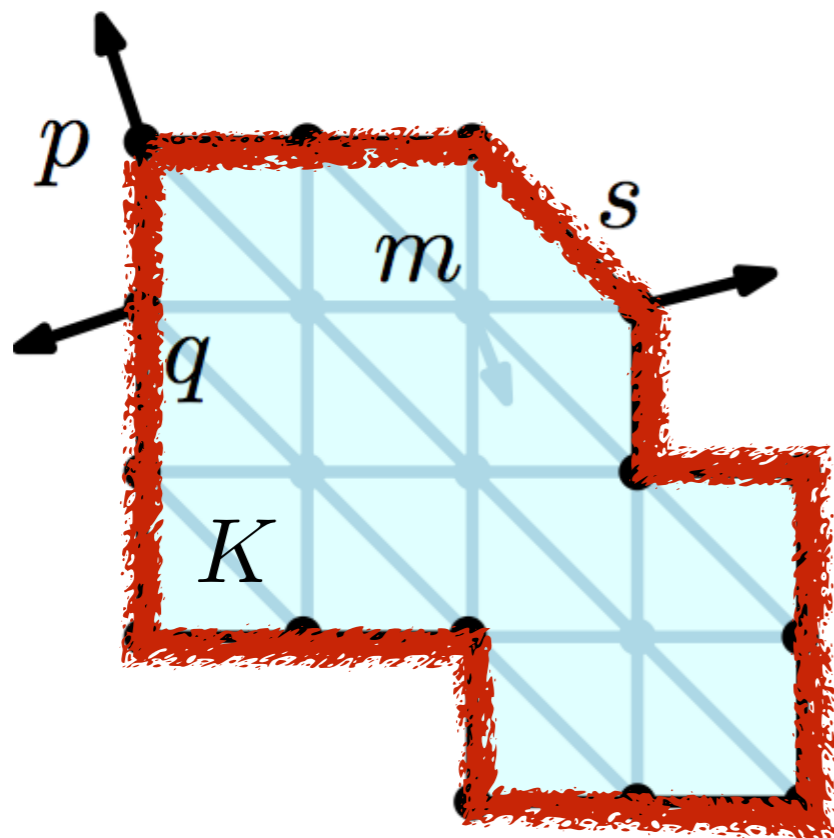
## Vektorska polja



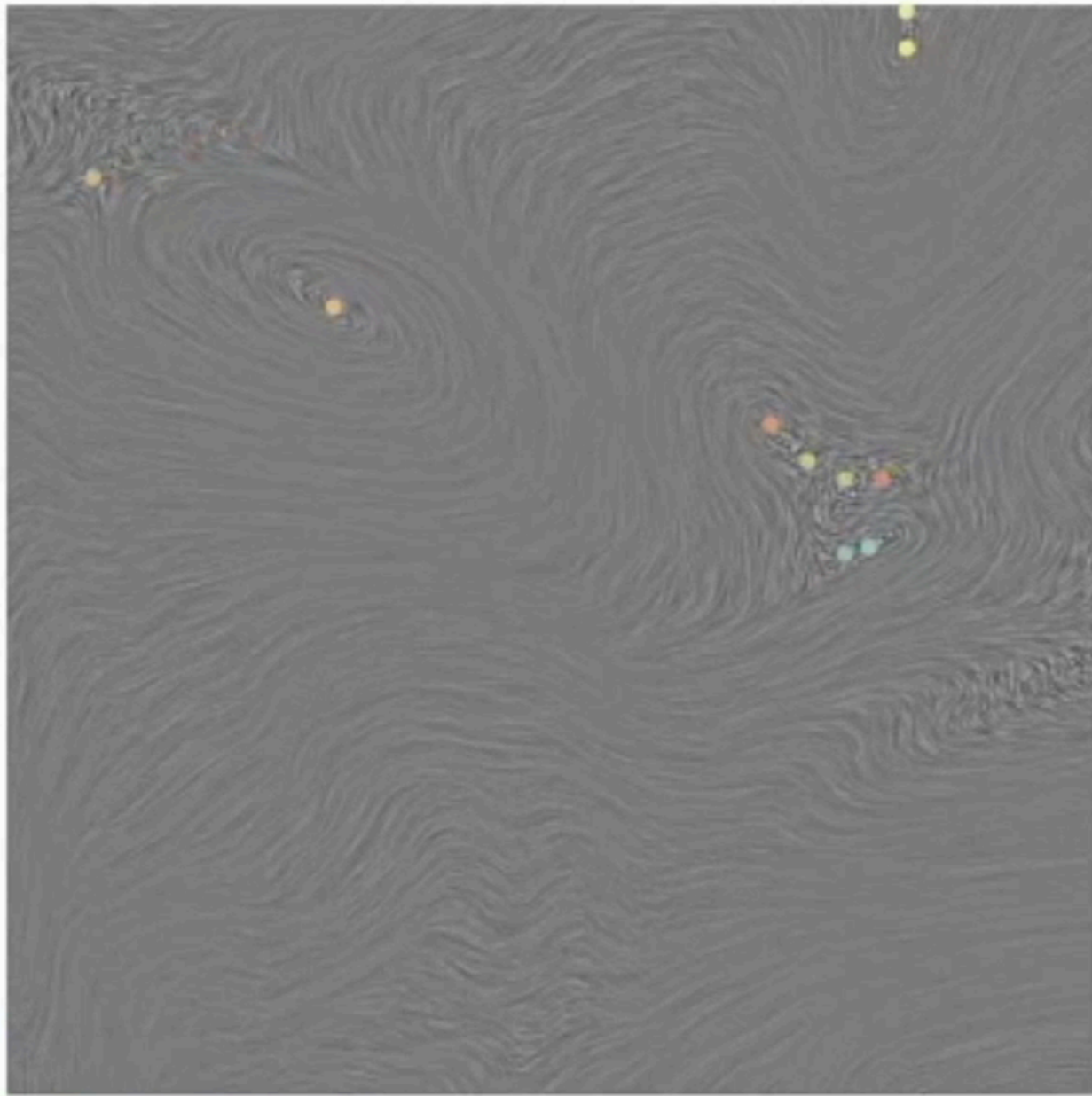
# Vektorska polja



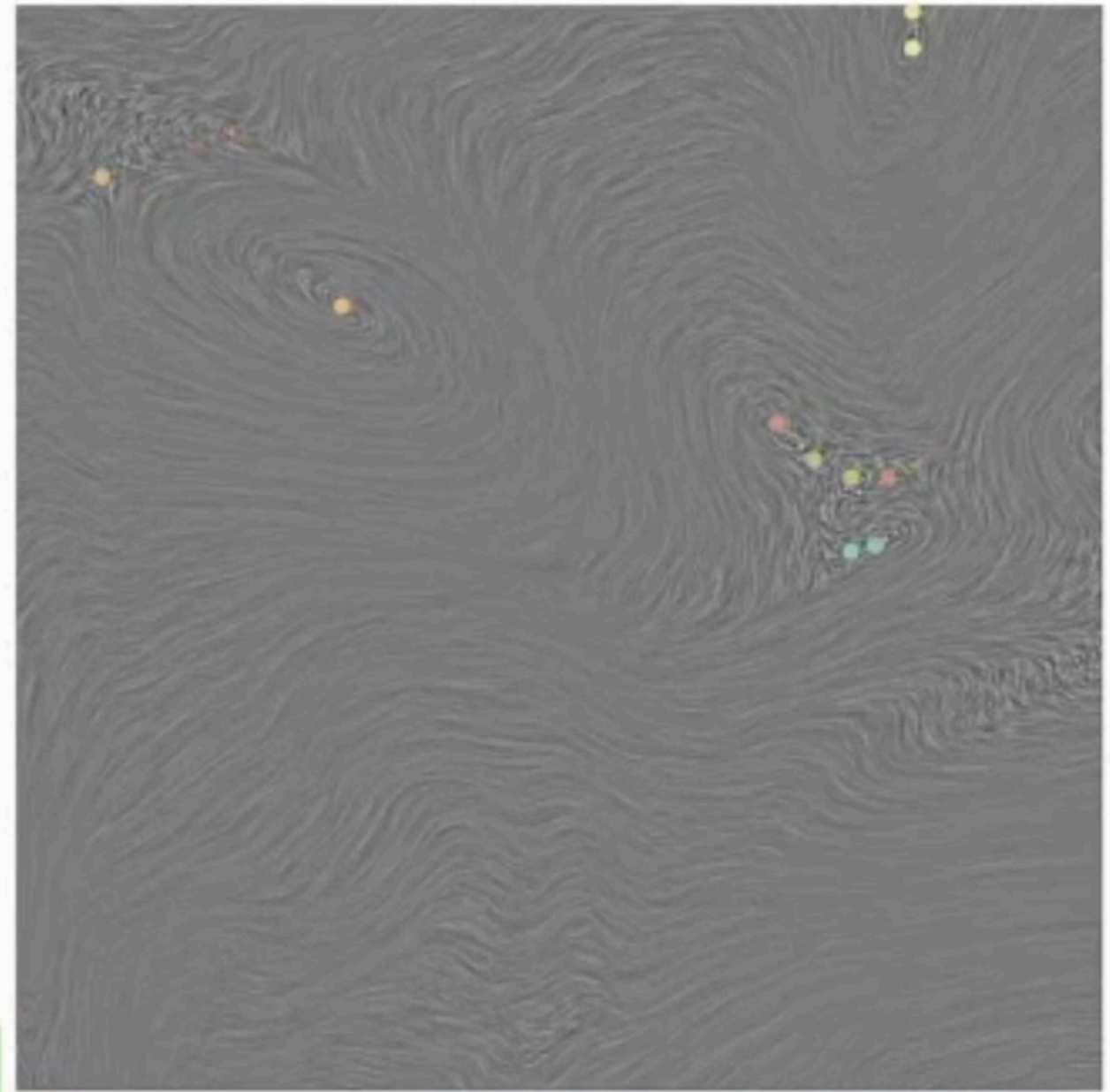
# Vektorska polja



# Vektorska polja

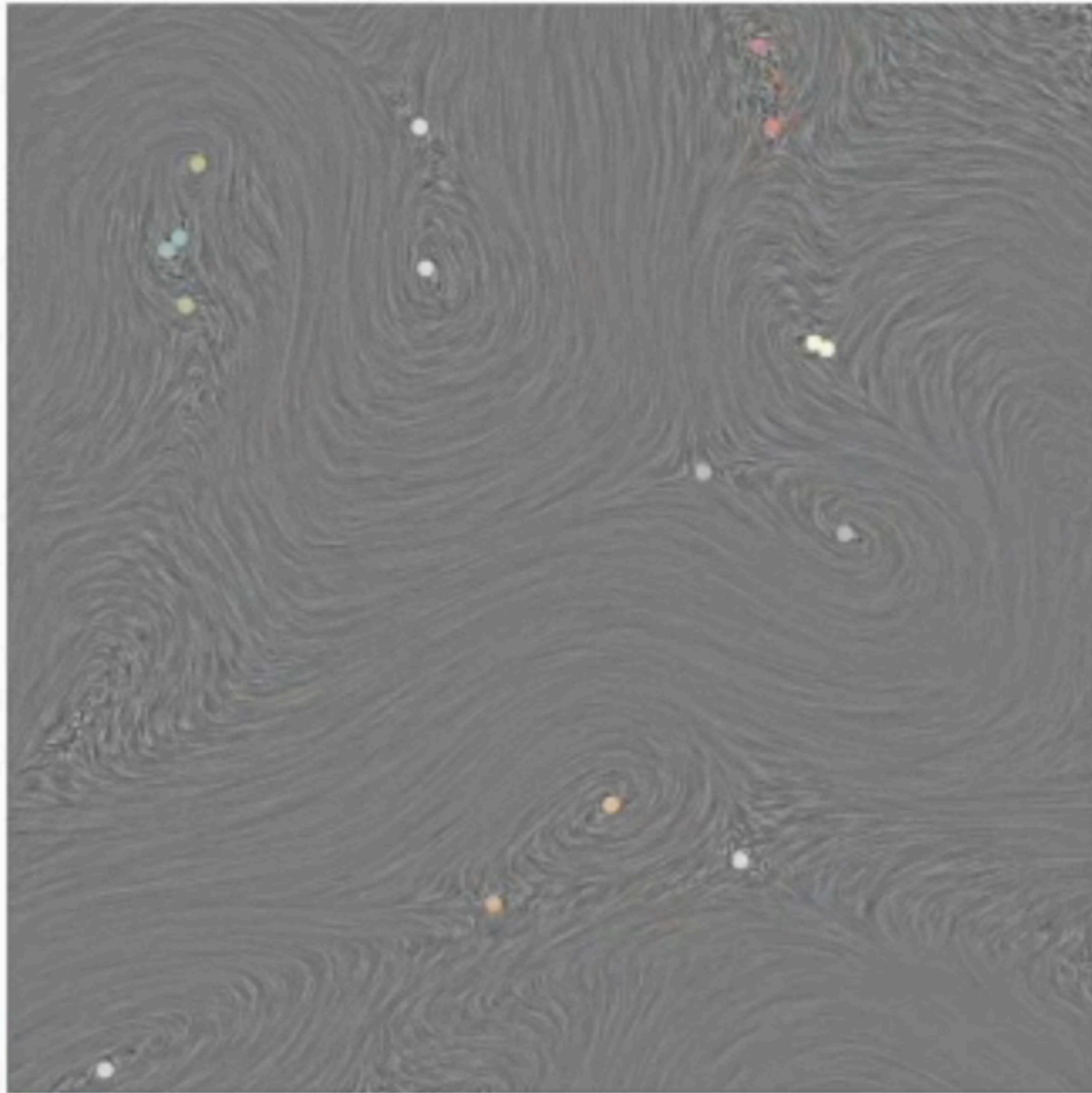


Before Simplification

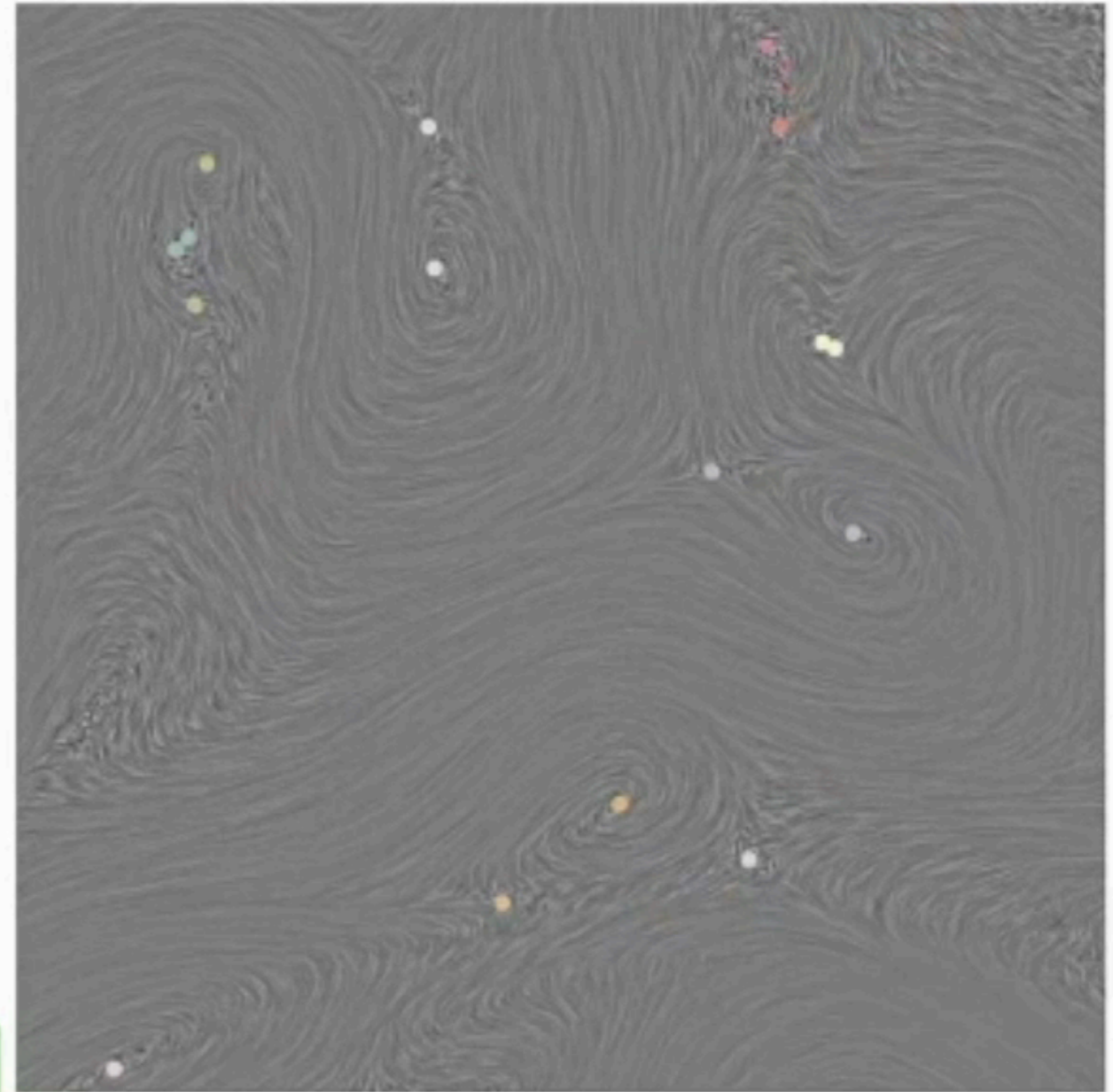


After Simplification

# Vektorska polja

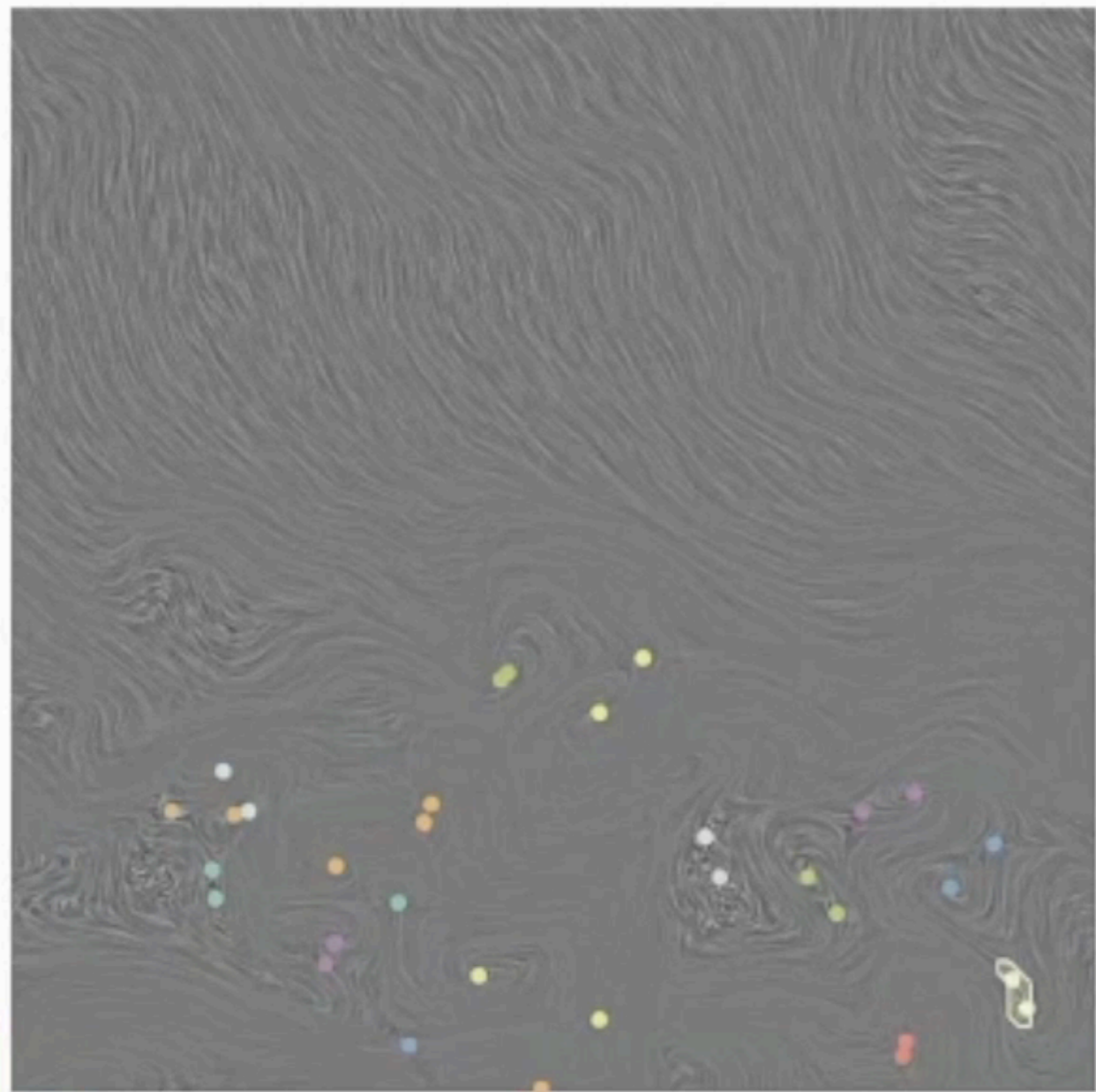


Before Simplification

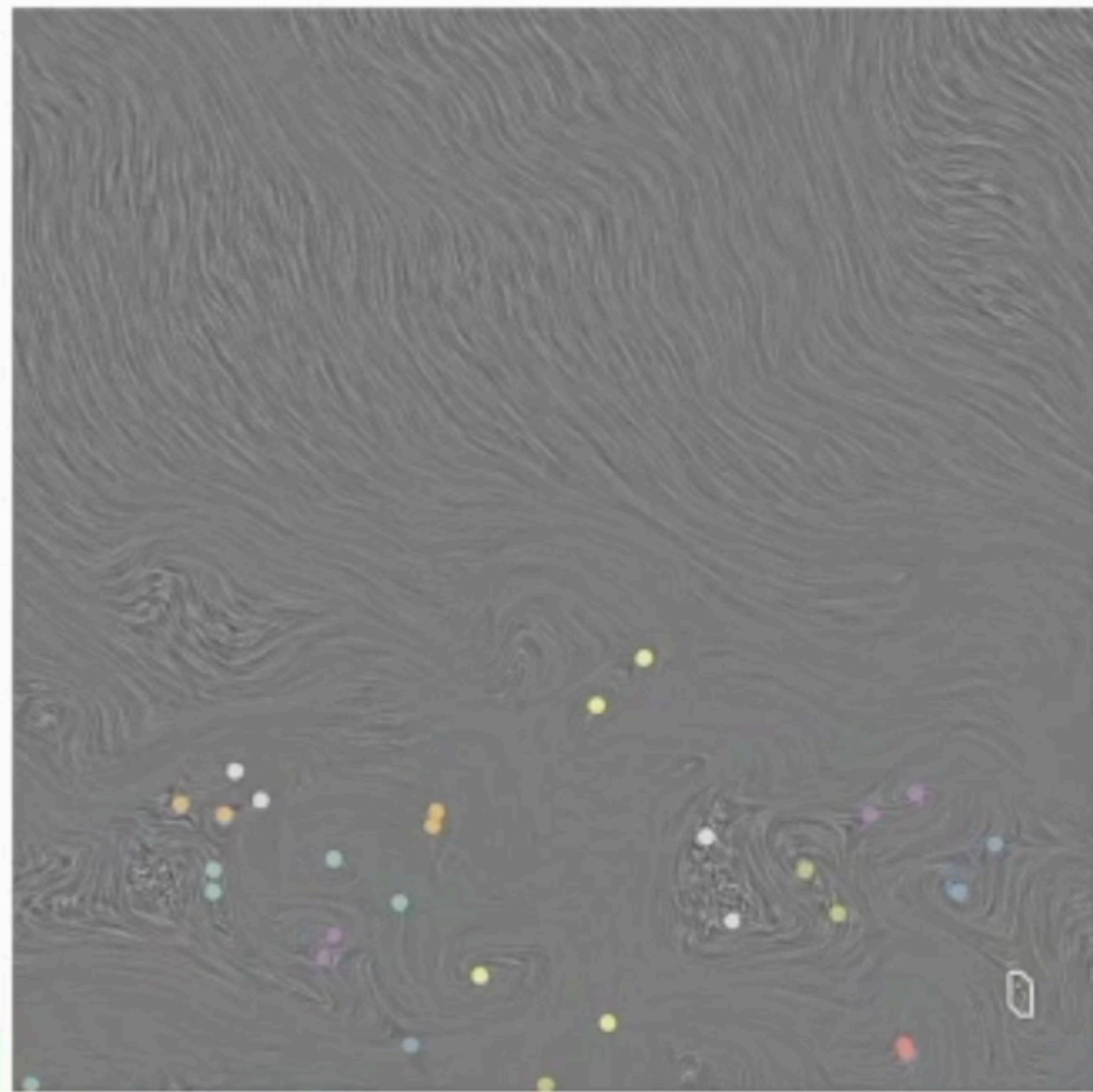


After Simplification

# Vektorska polja

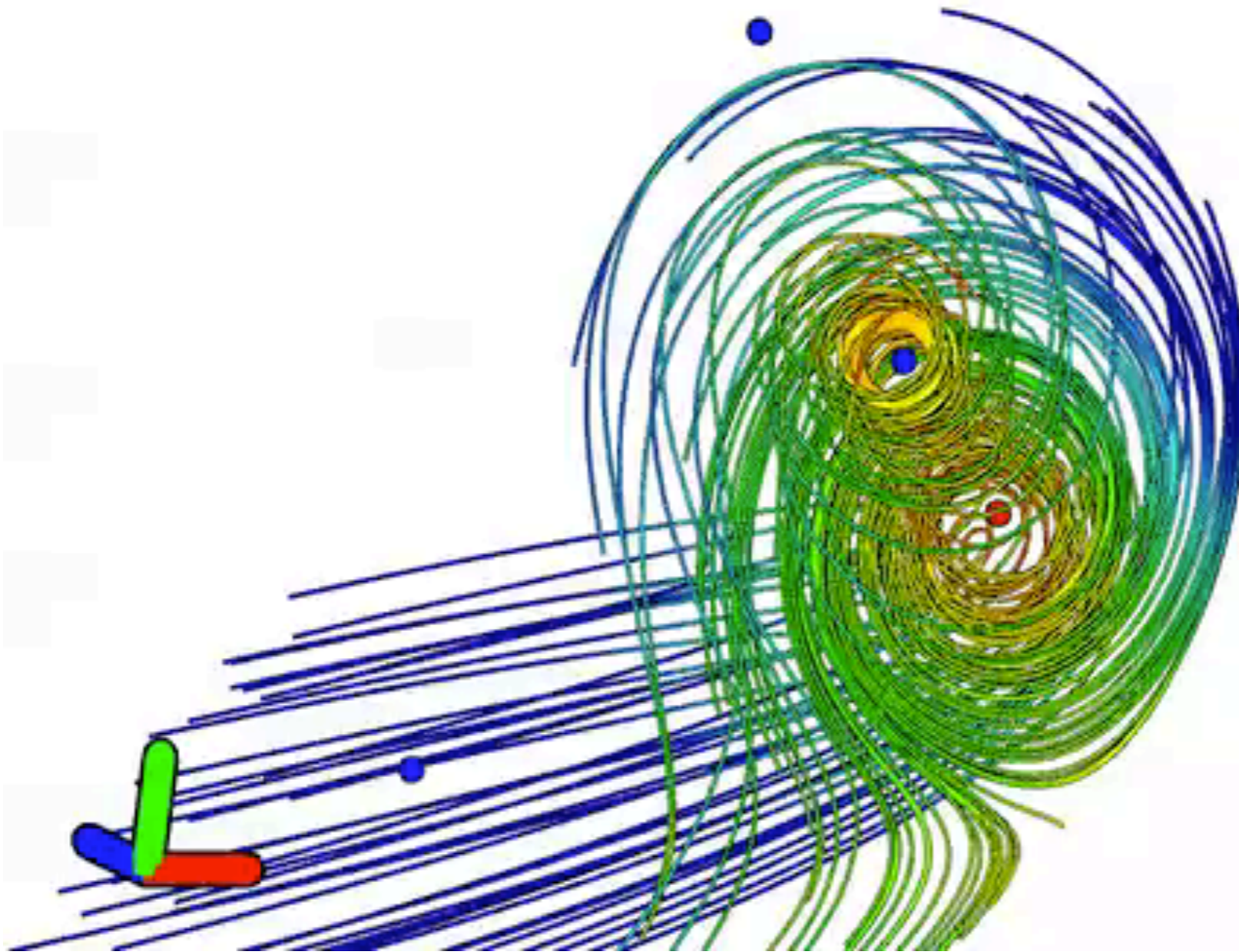


Before Simplification



After Simplification

# Vektorska polja



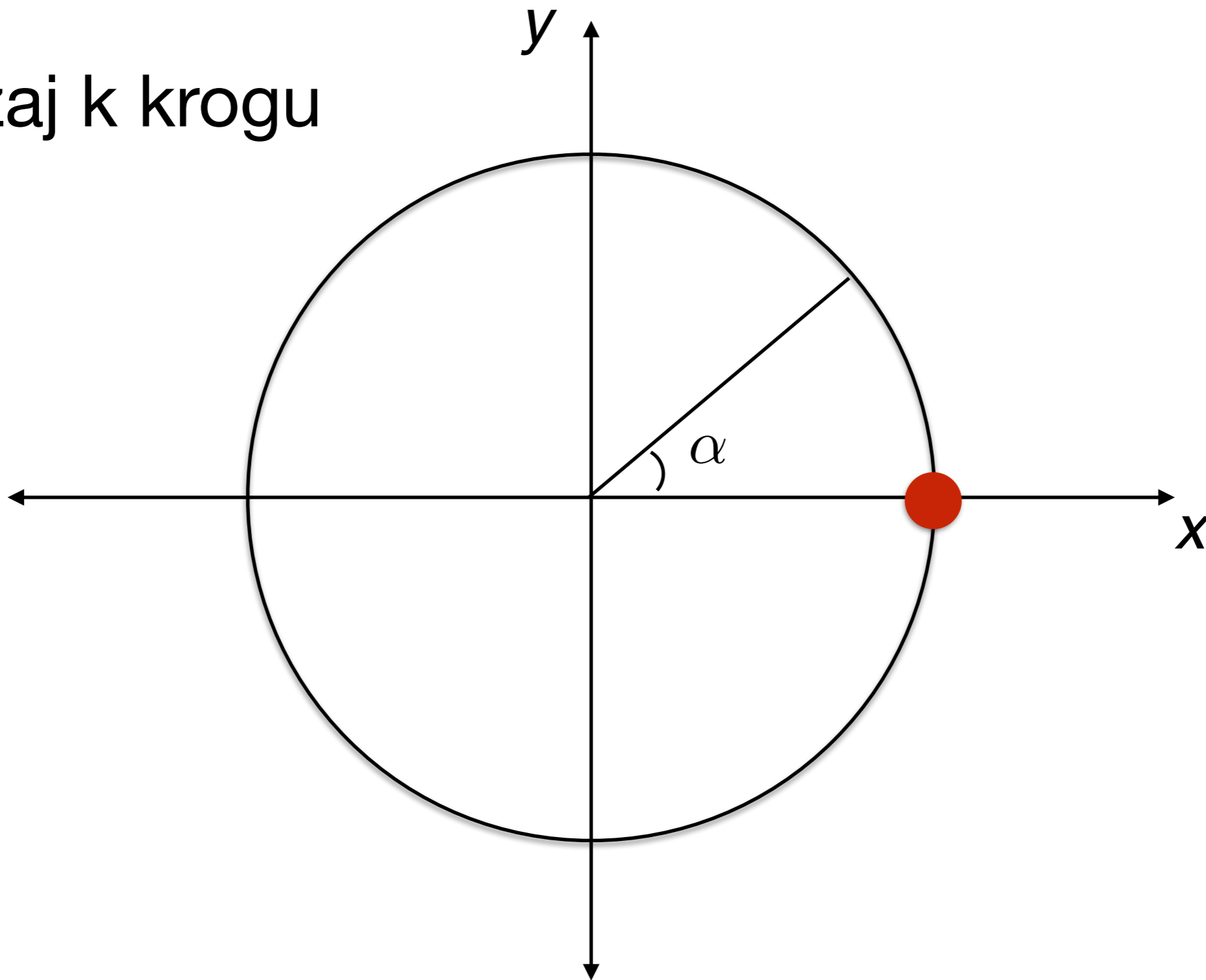


# Ponavljajoči sistem

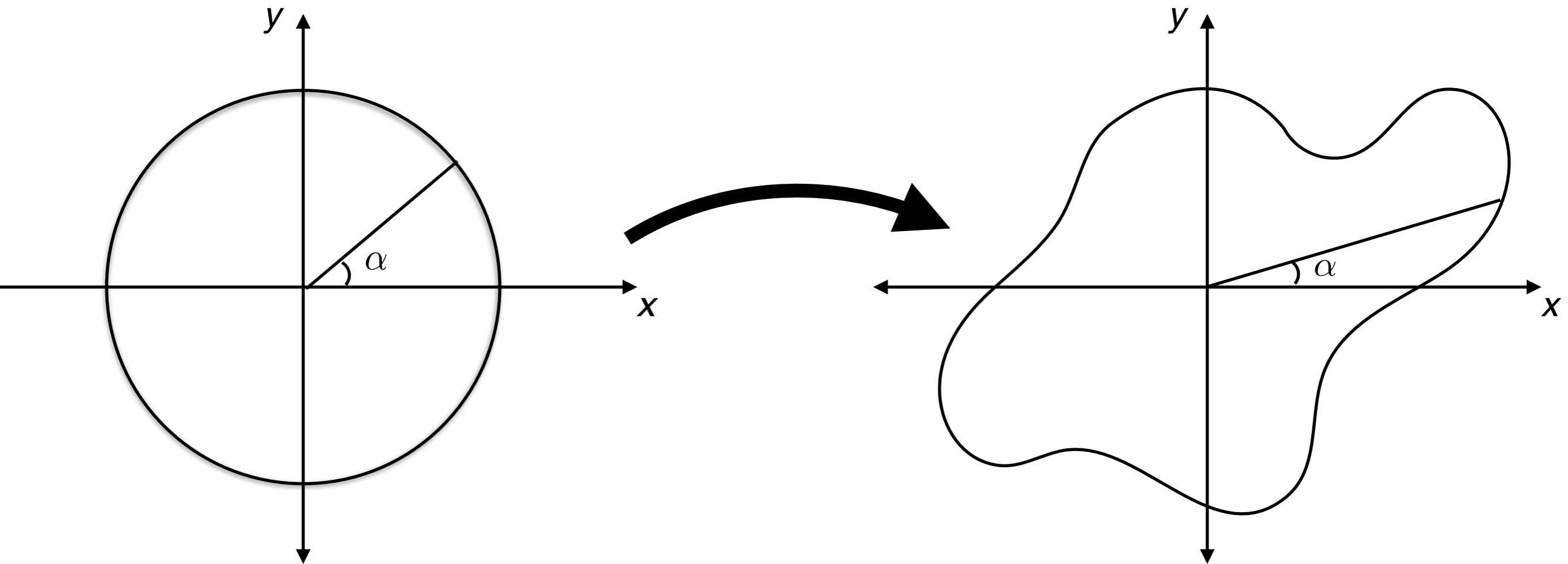
Nazaj k krogu

# Ponavljajoči sistem

Nazaj k krogu

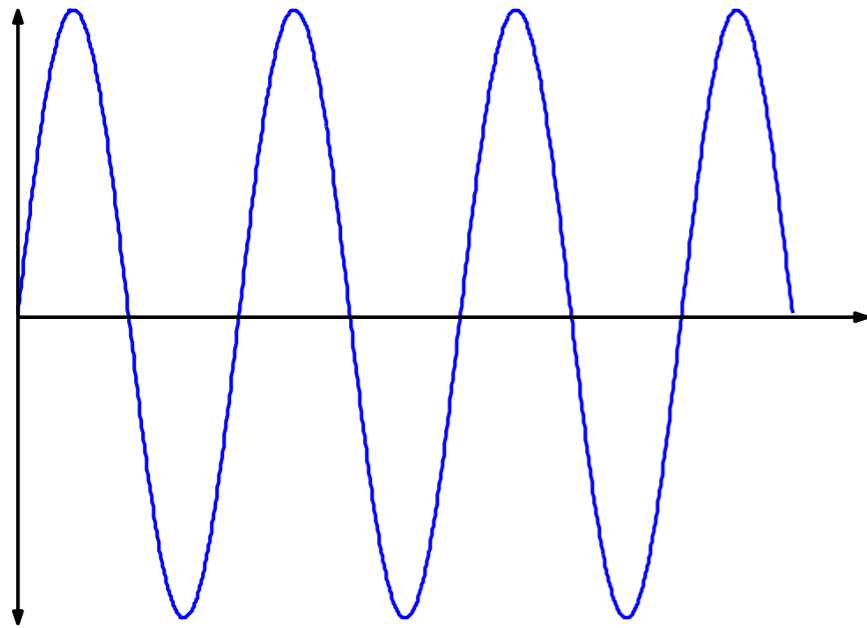


# Krog

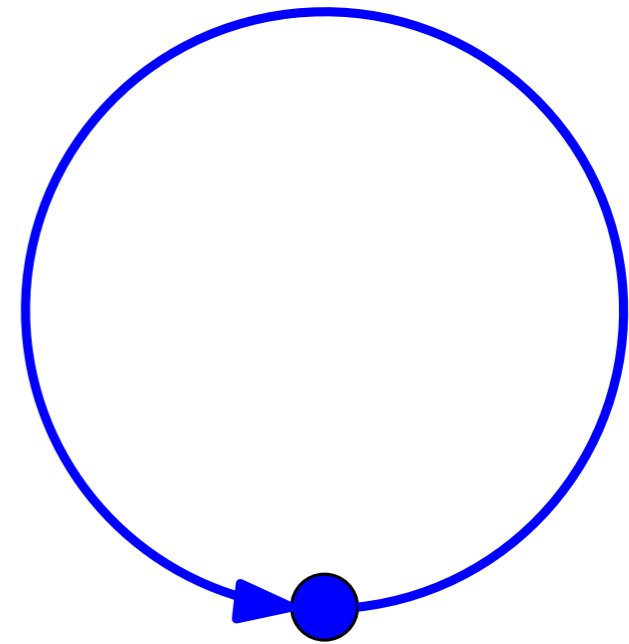


krog je 1-dim prostor

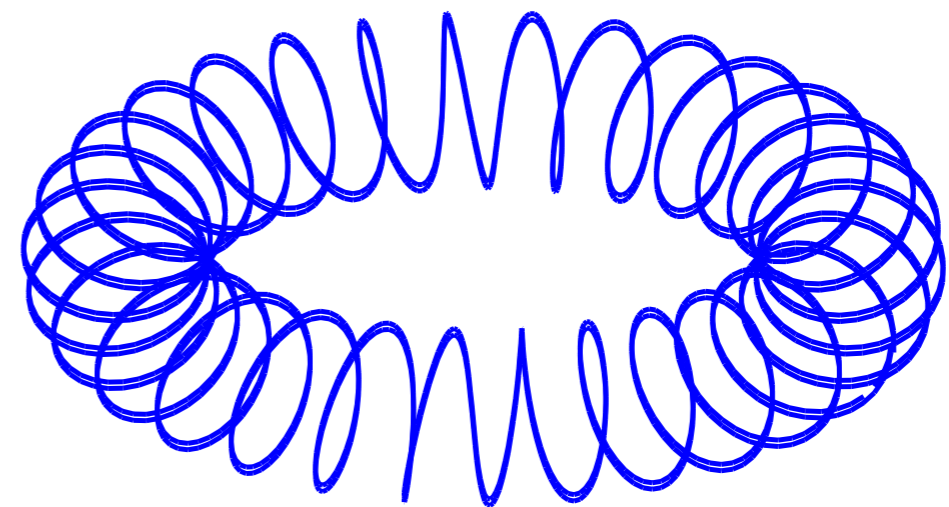
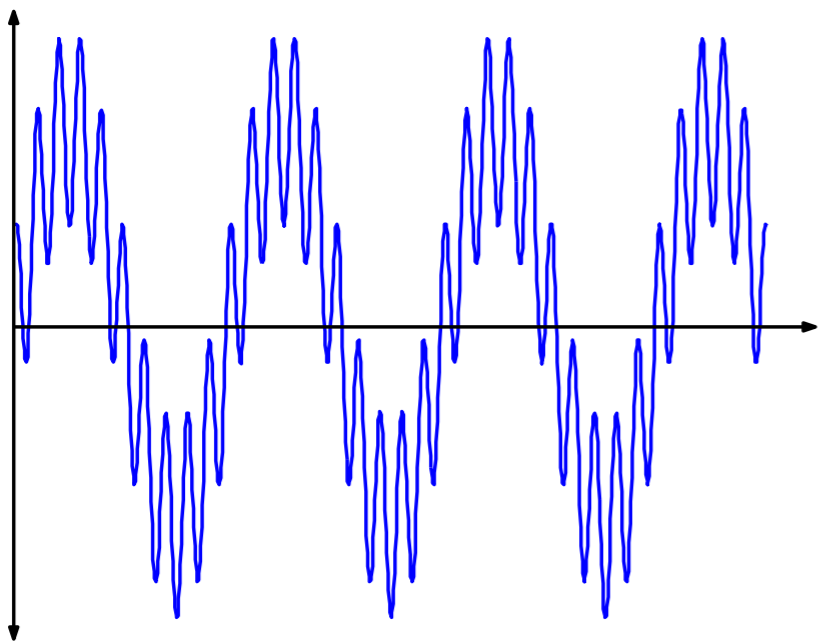
# Različni modeli



$$x = \sin(t)$$

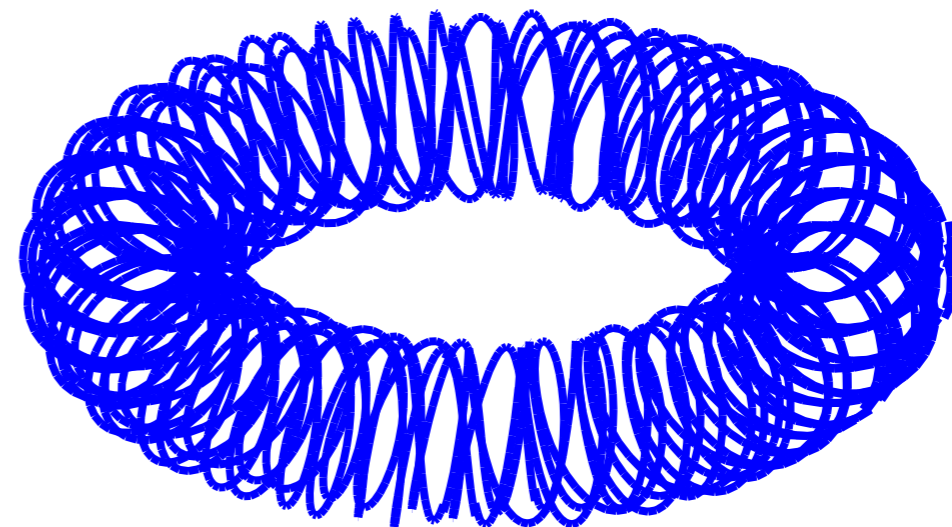
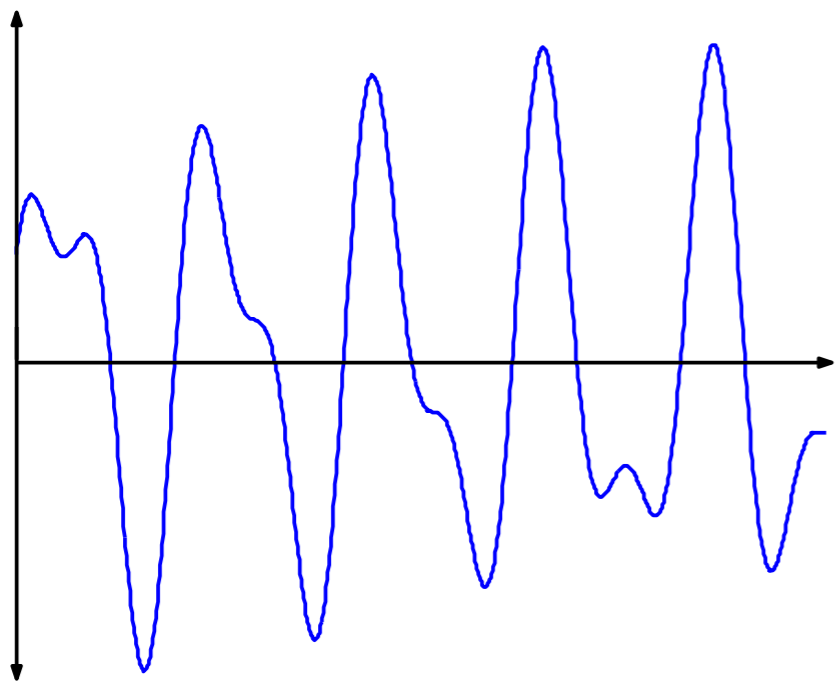


# Različni modeli



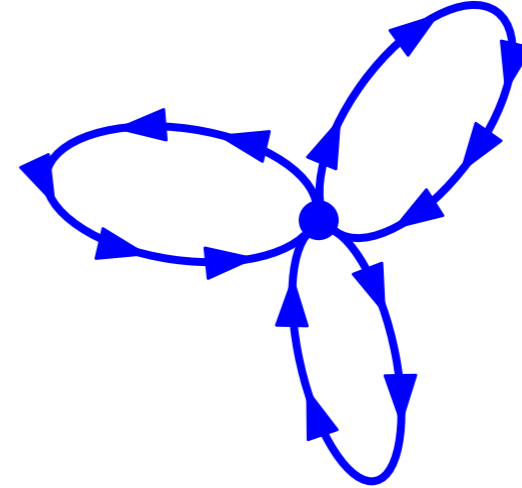
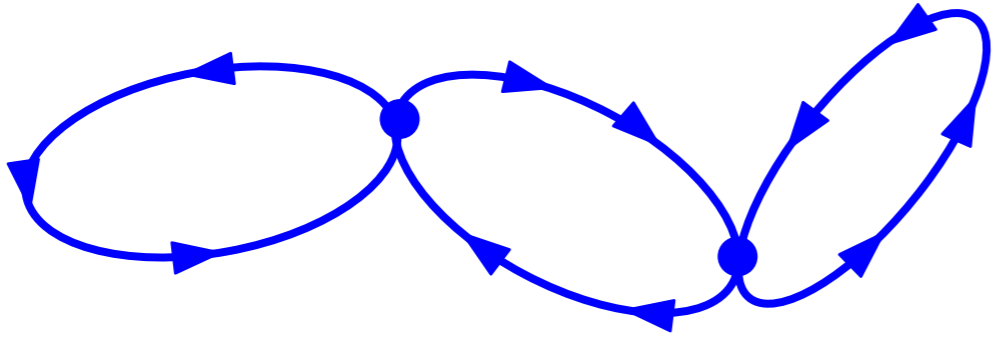
$$x = 2 \sin(t) + \cos(10t)$$

# Različni modeli

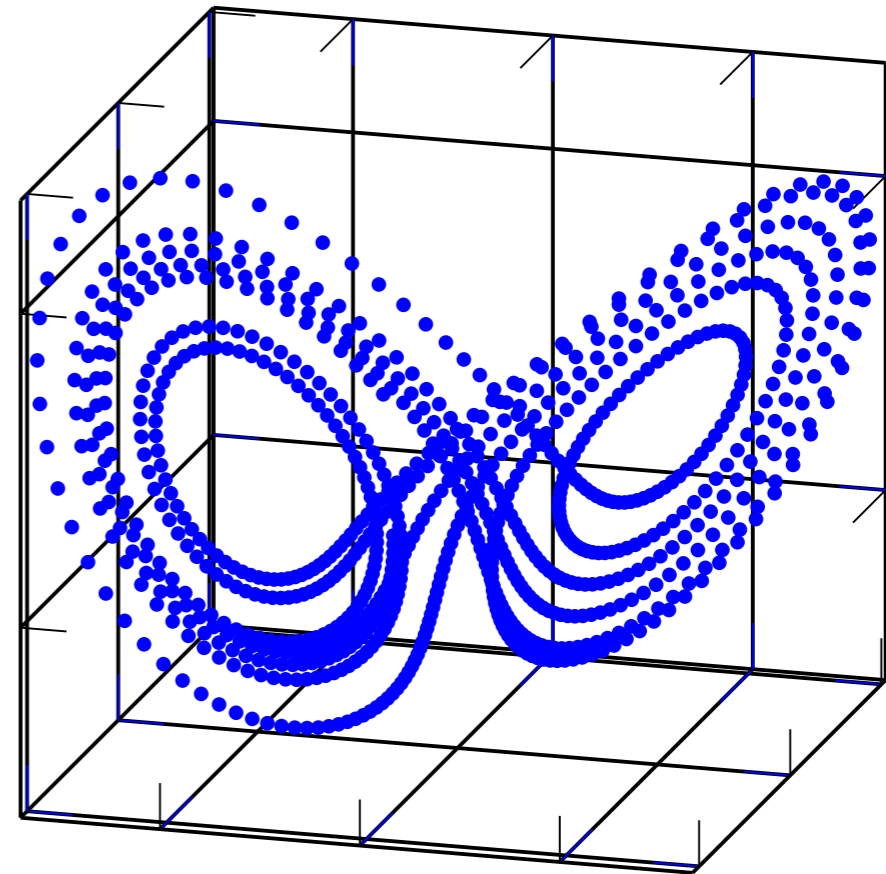


$$x = 2 \sin(\sqrt{2}t) + \cos(\sqrt{7}t)$$

# Različni modeli



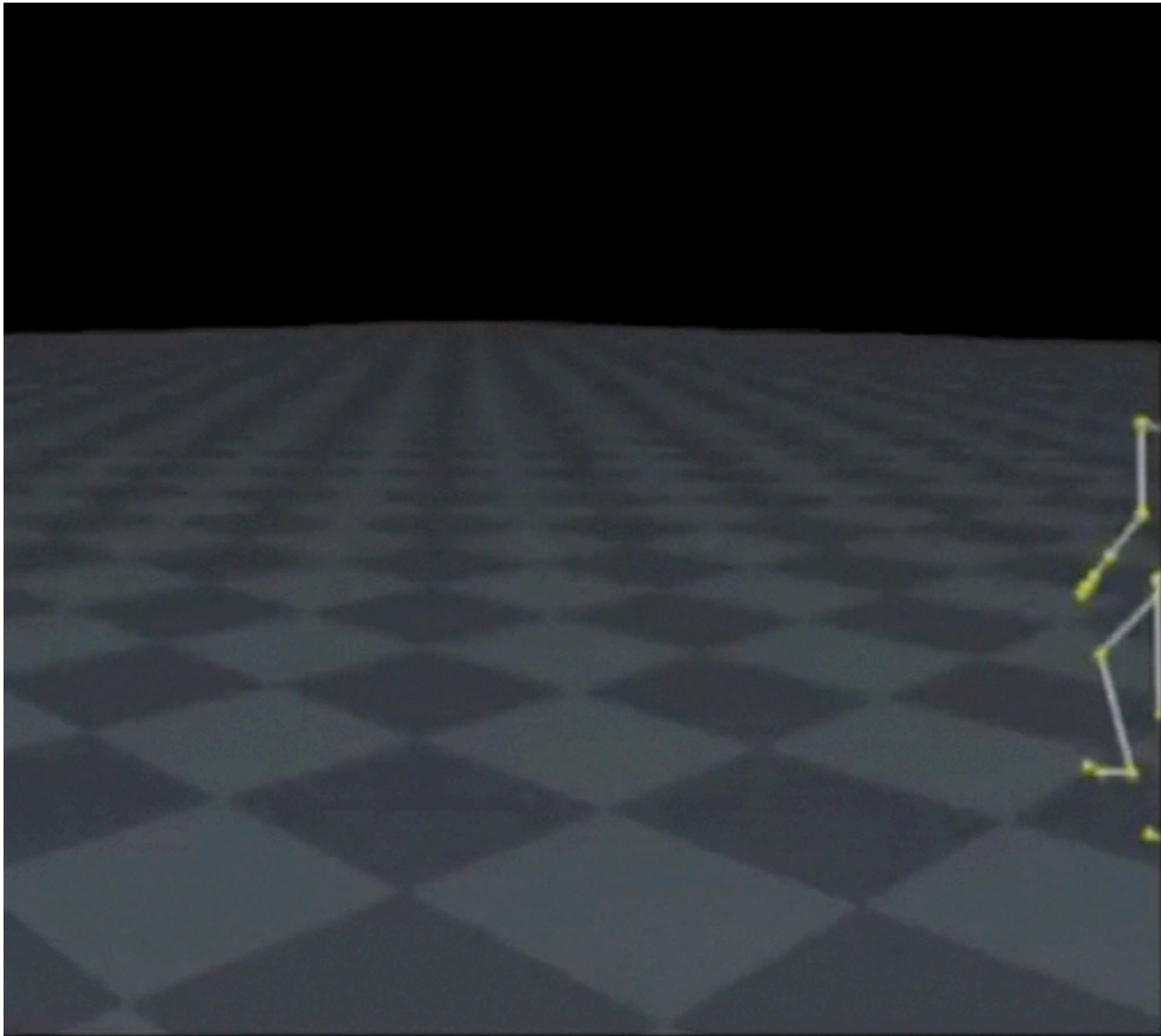
Lorenz sistem



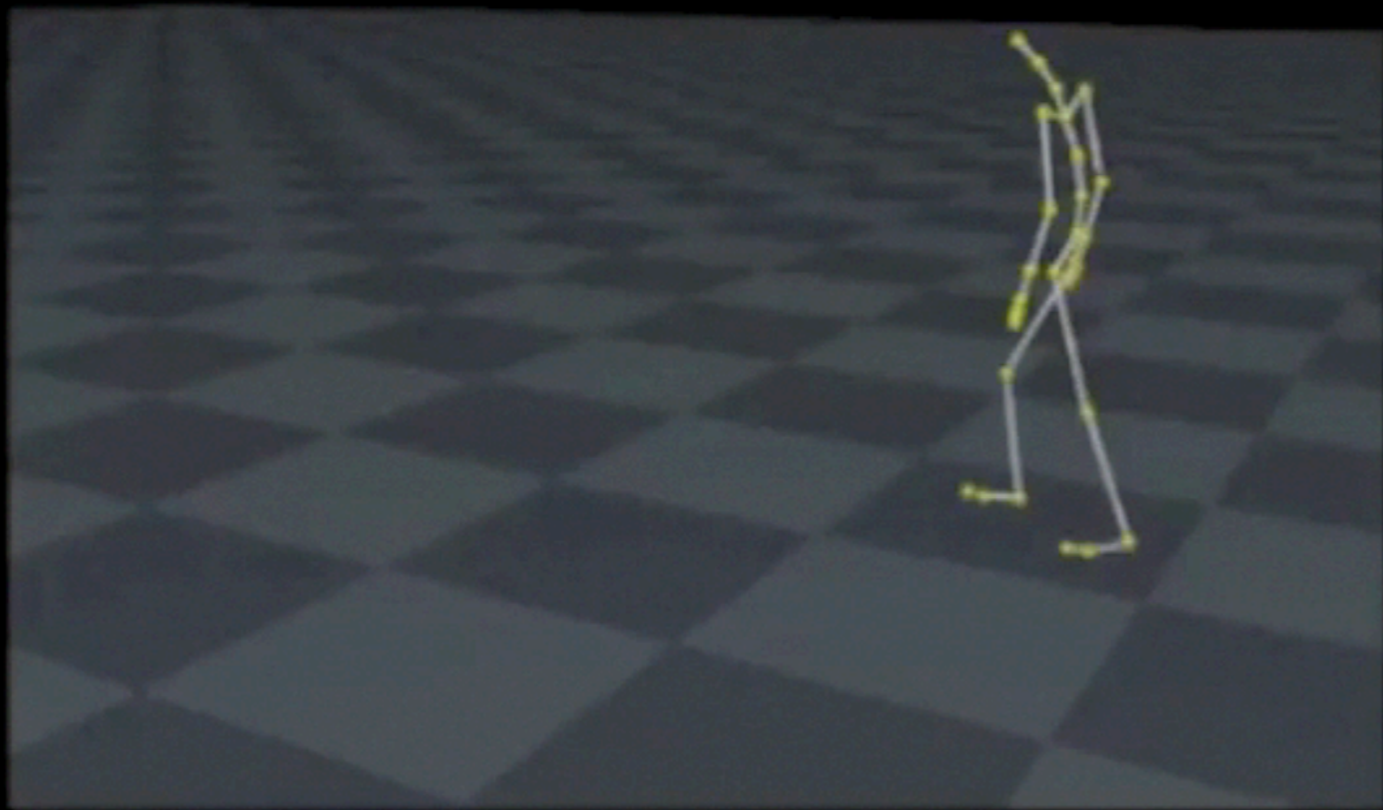
## Analiza človeških gibov



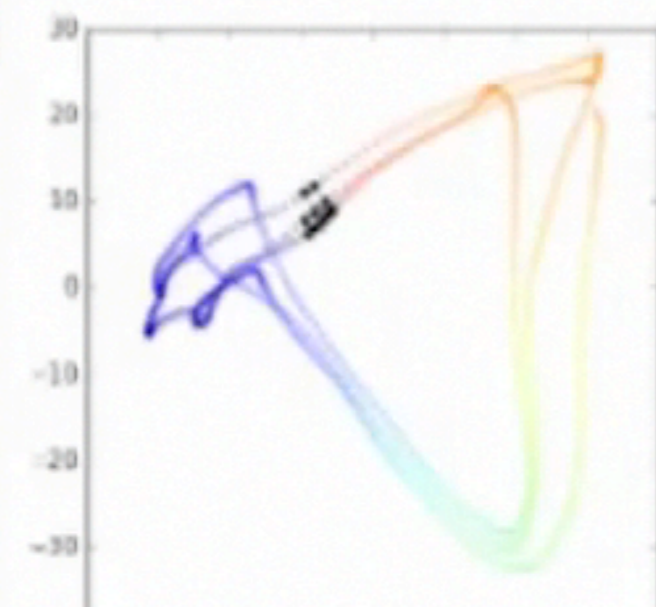
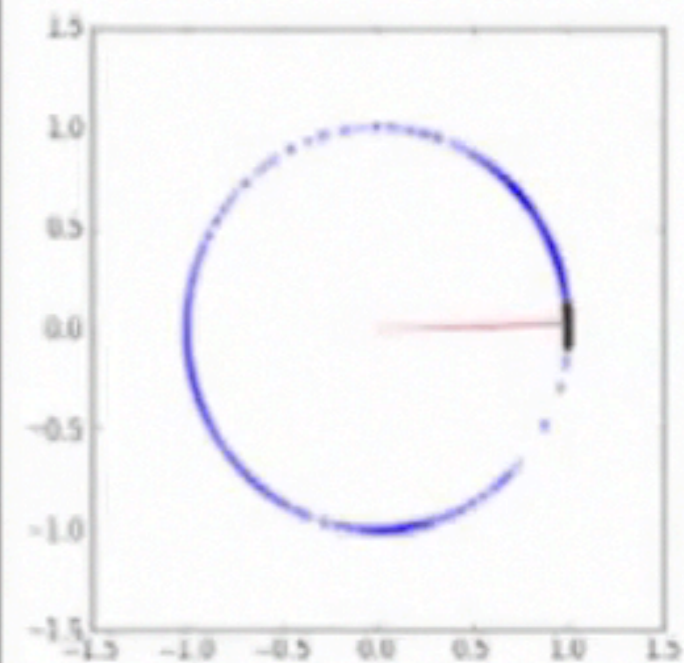
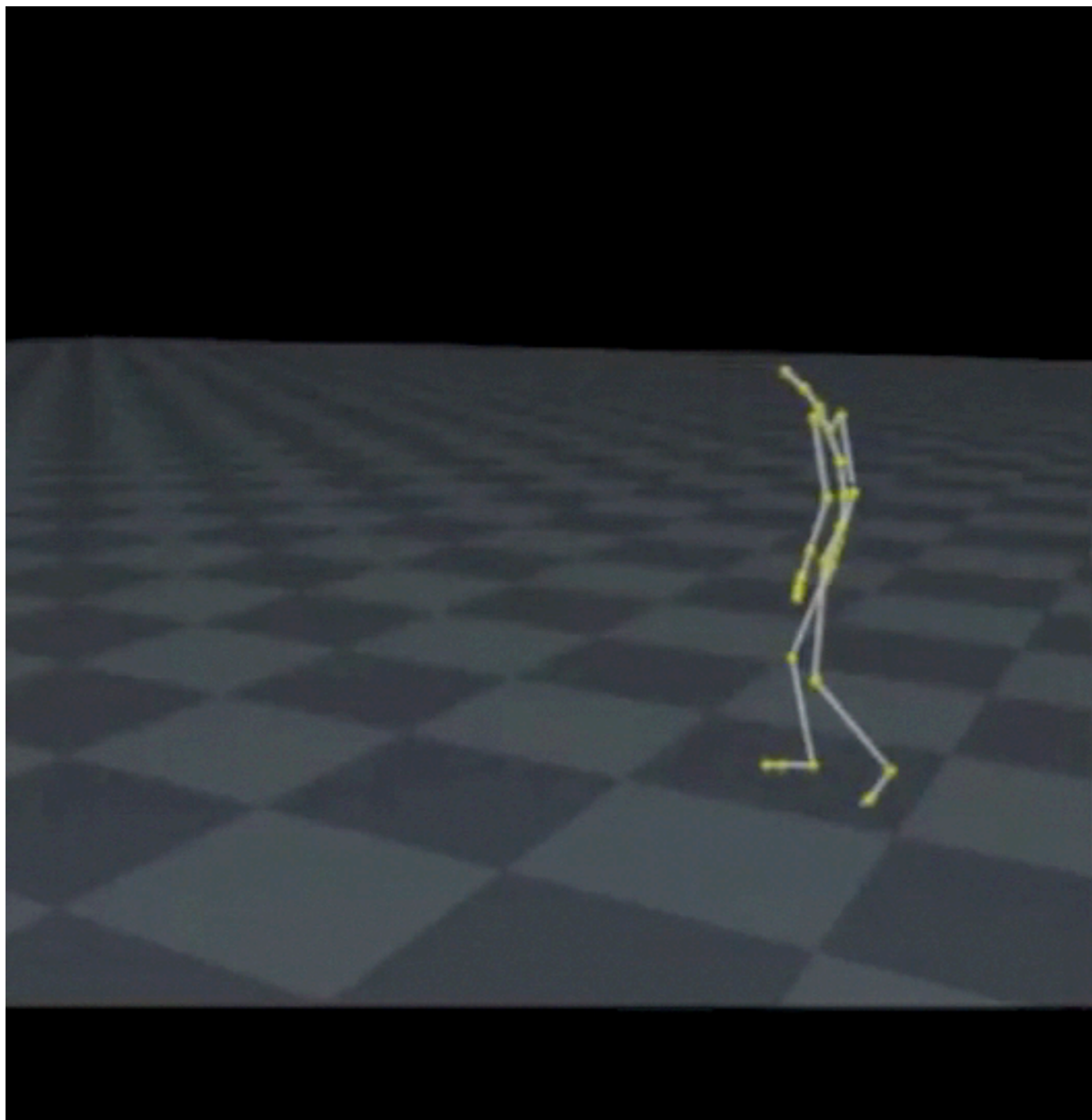
# Hoja



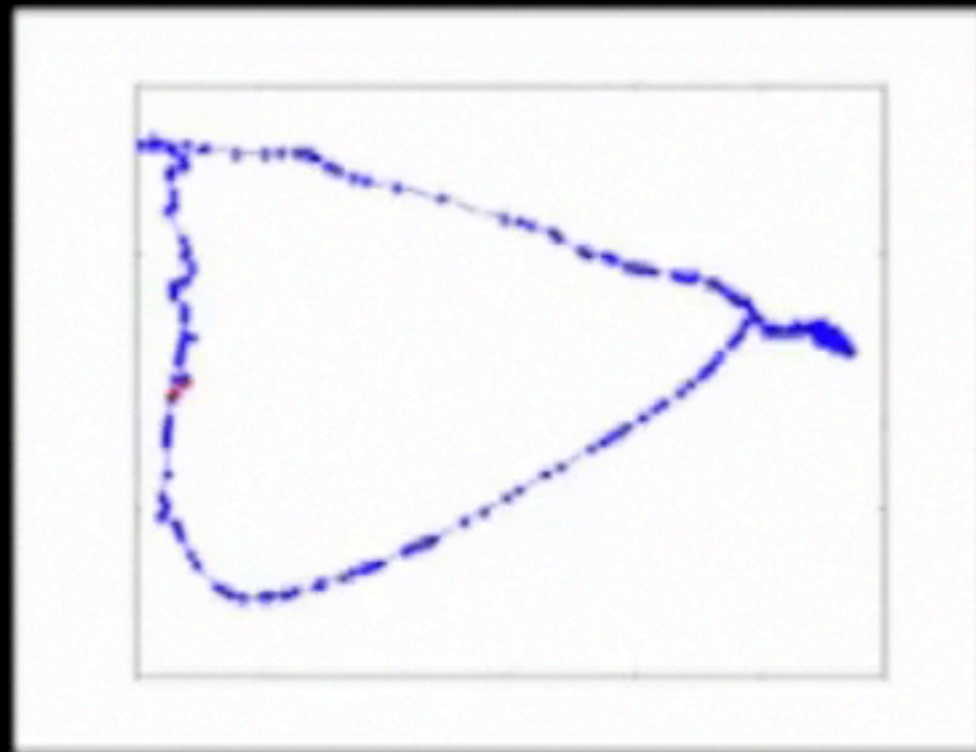
# Hoja



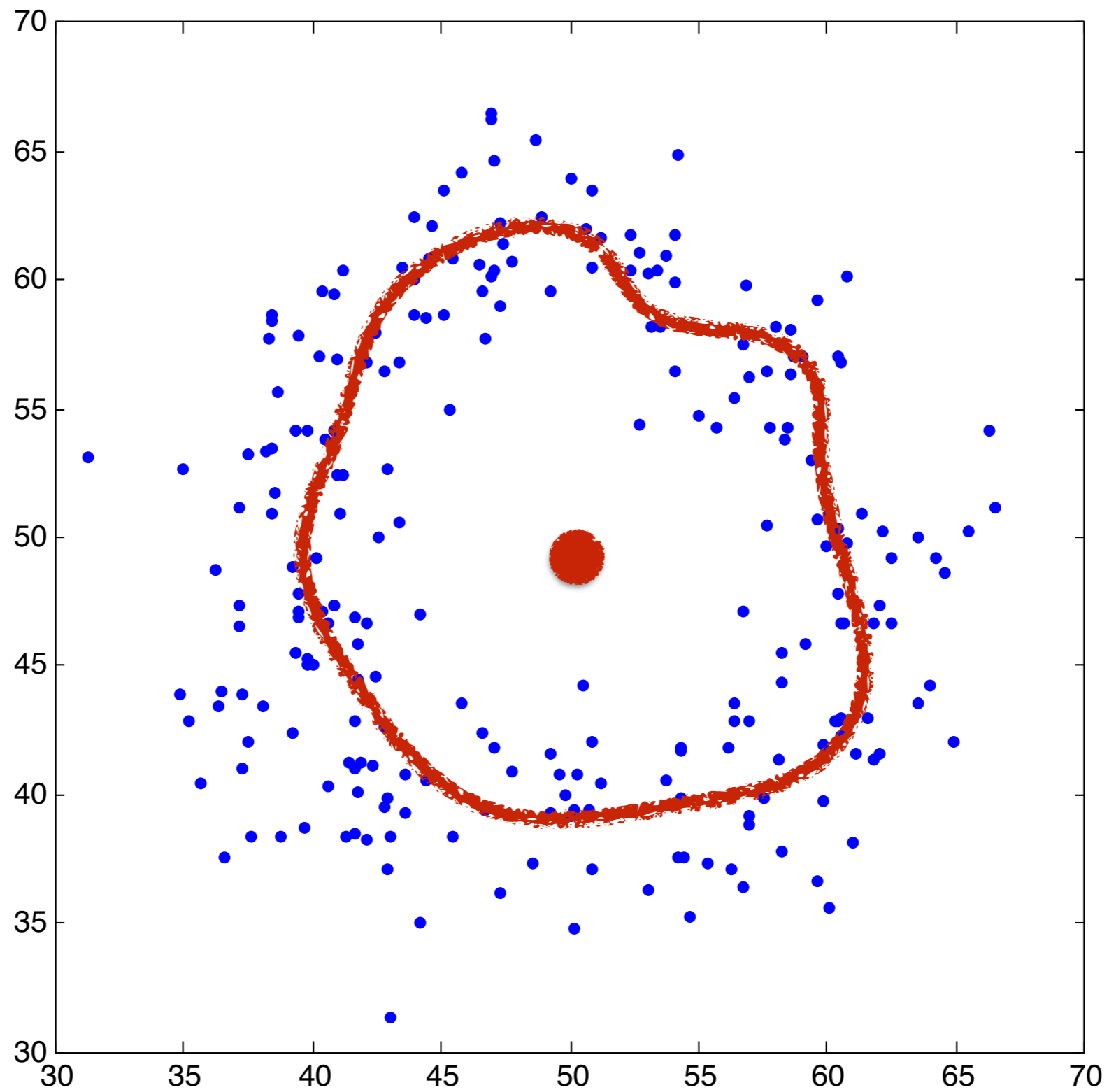
# Kot in čas



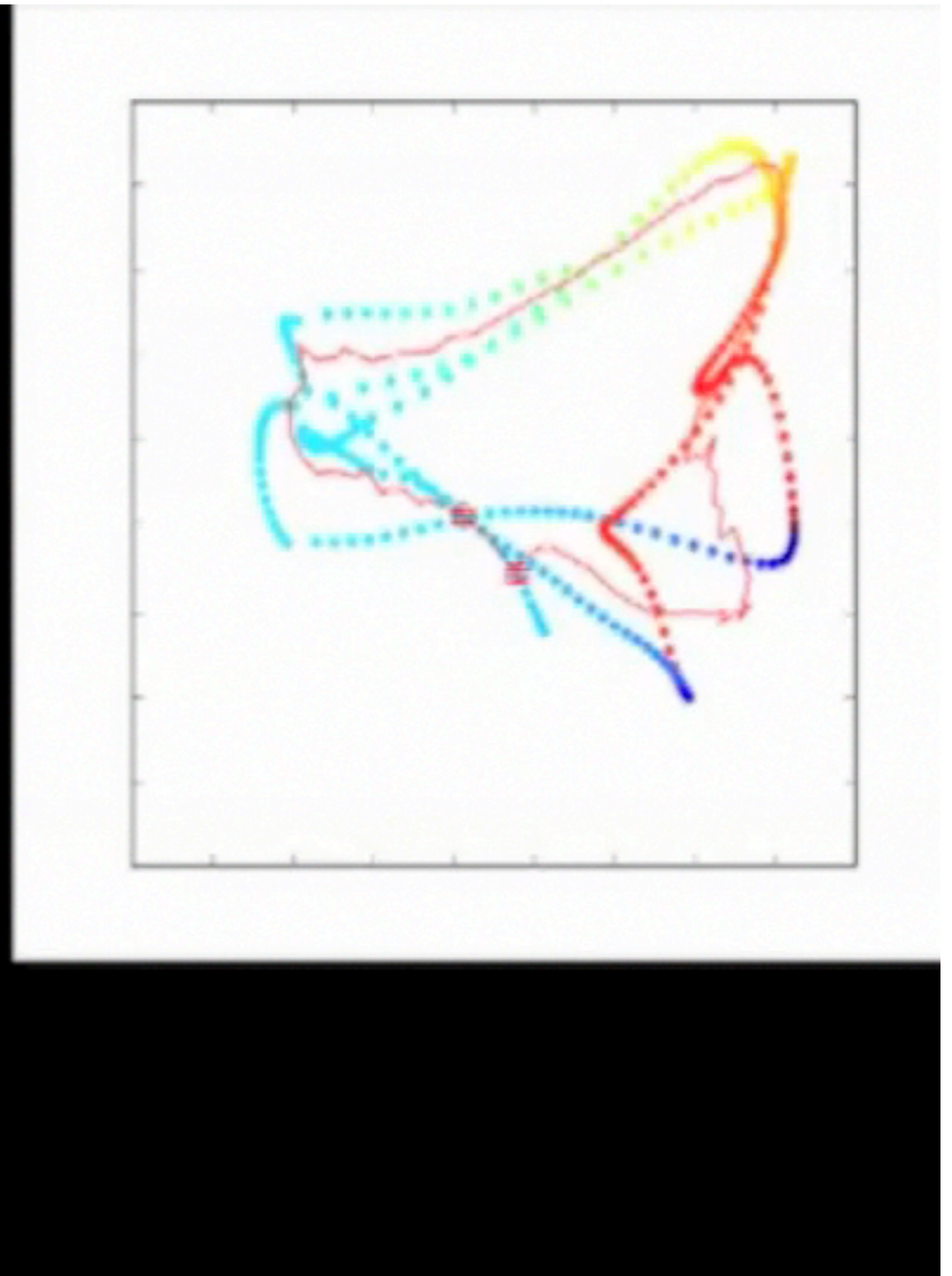
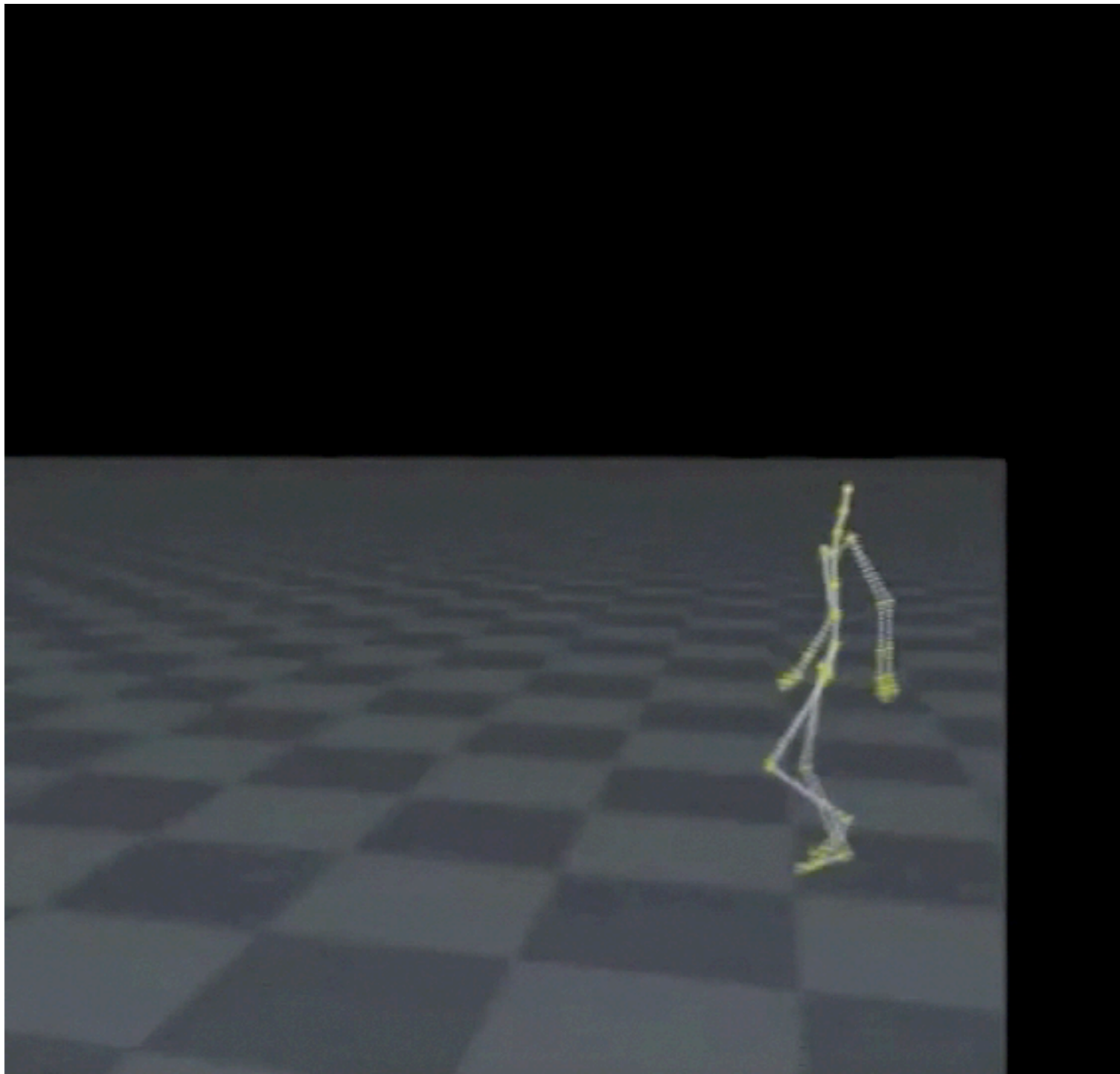
# Povprečje



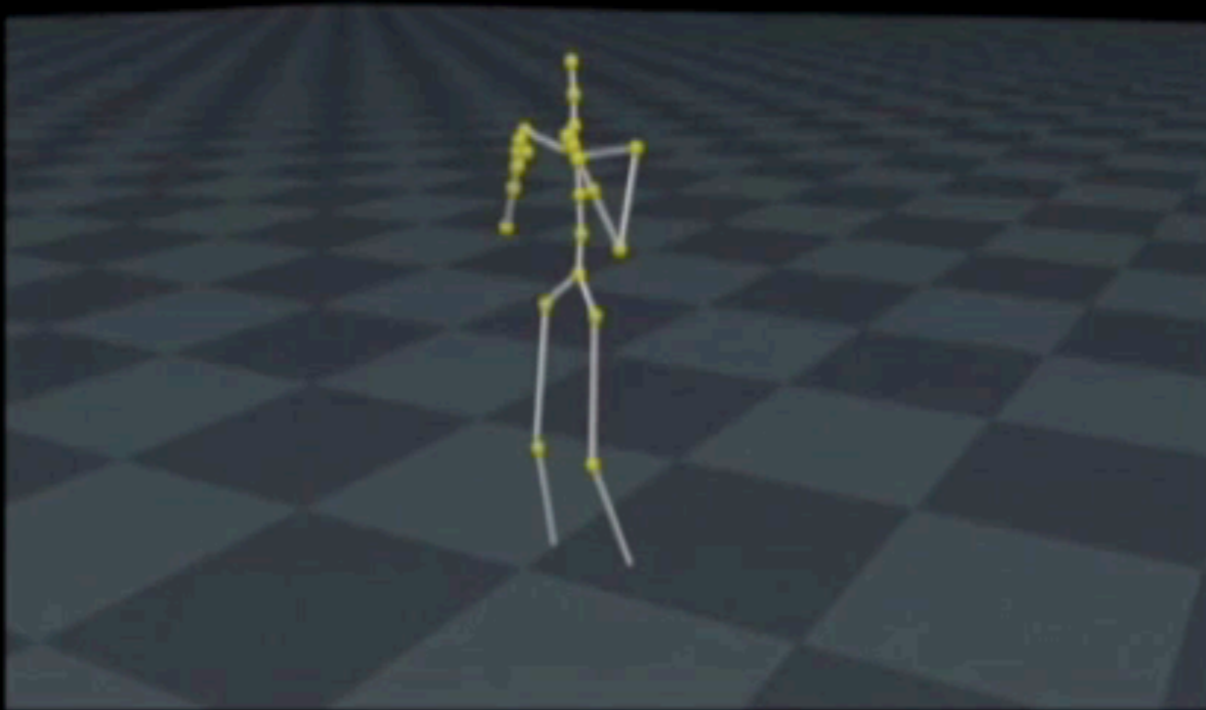
# Povprečje



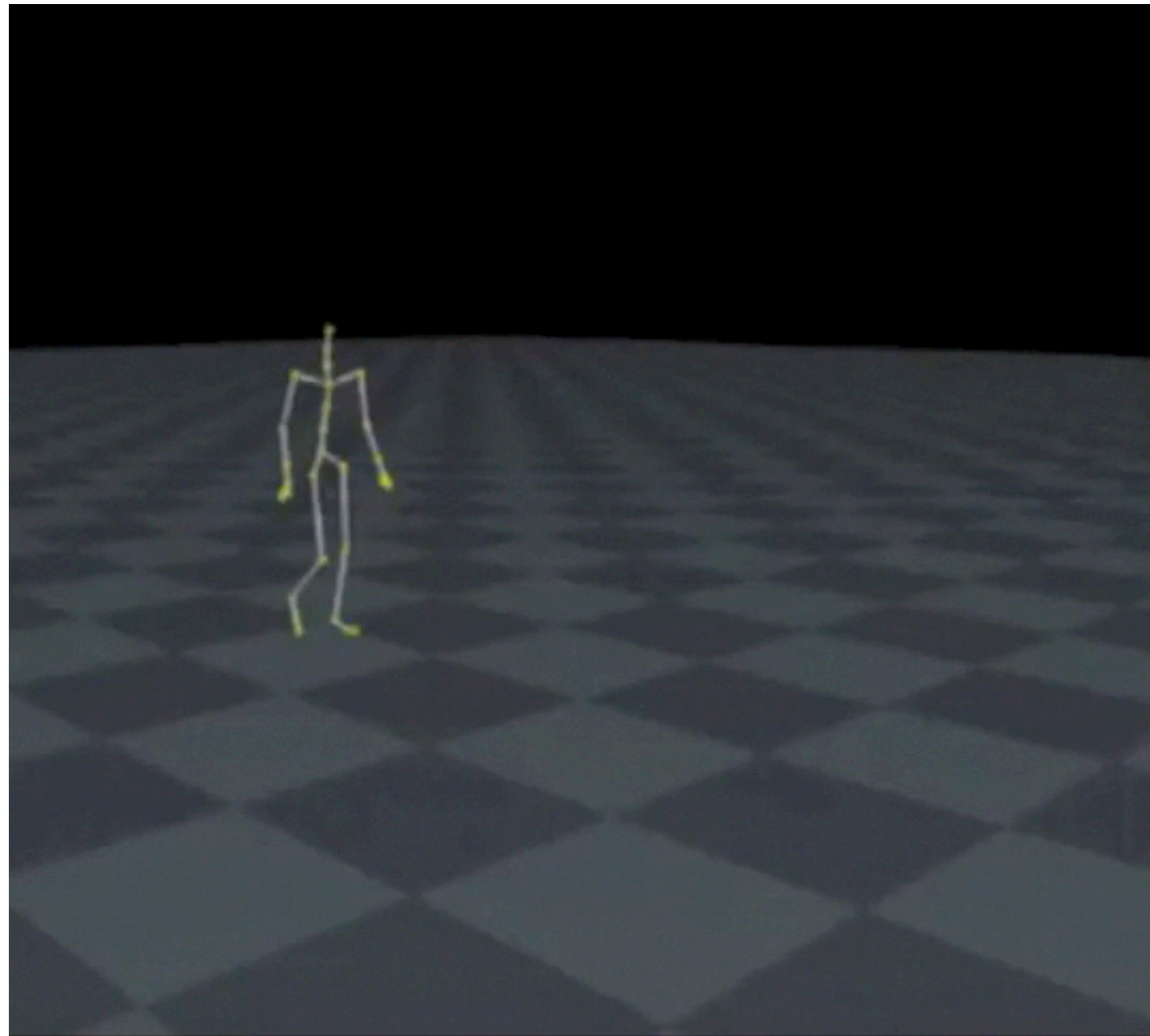
# Interpolacija hoje



# Različni gibi

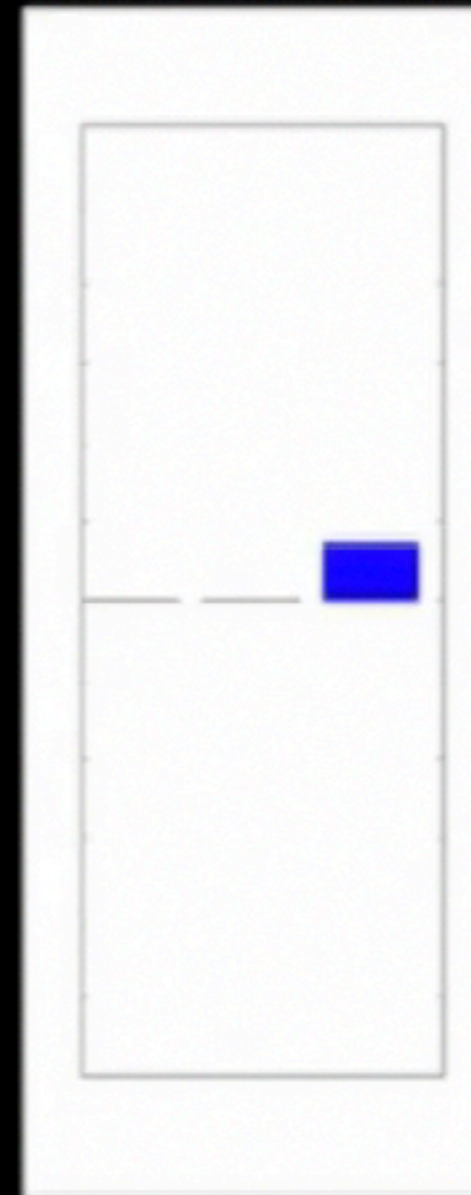


# Različni gibi



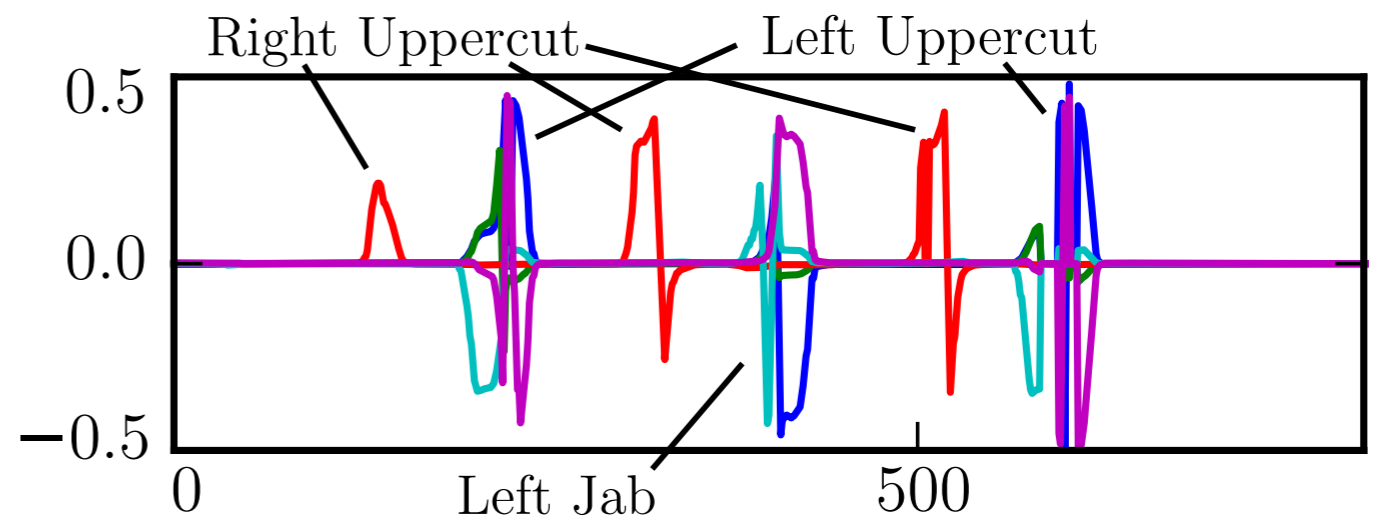
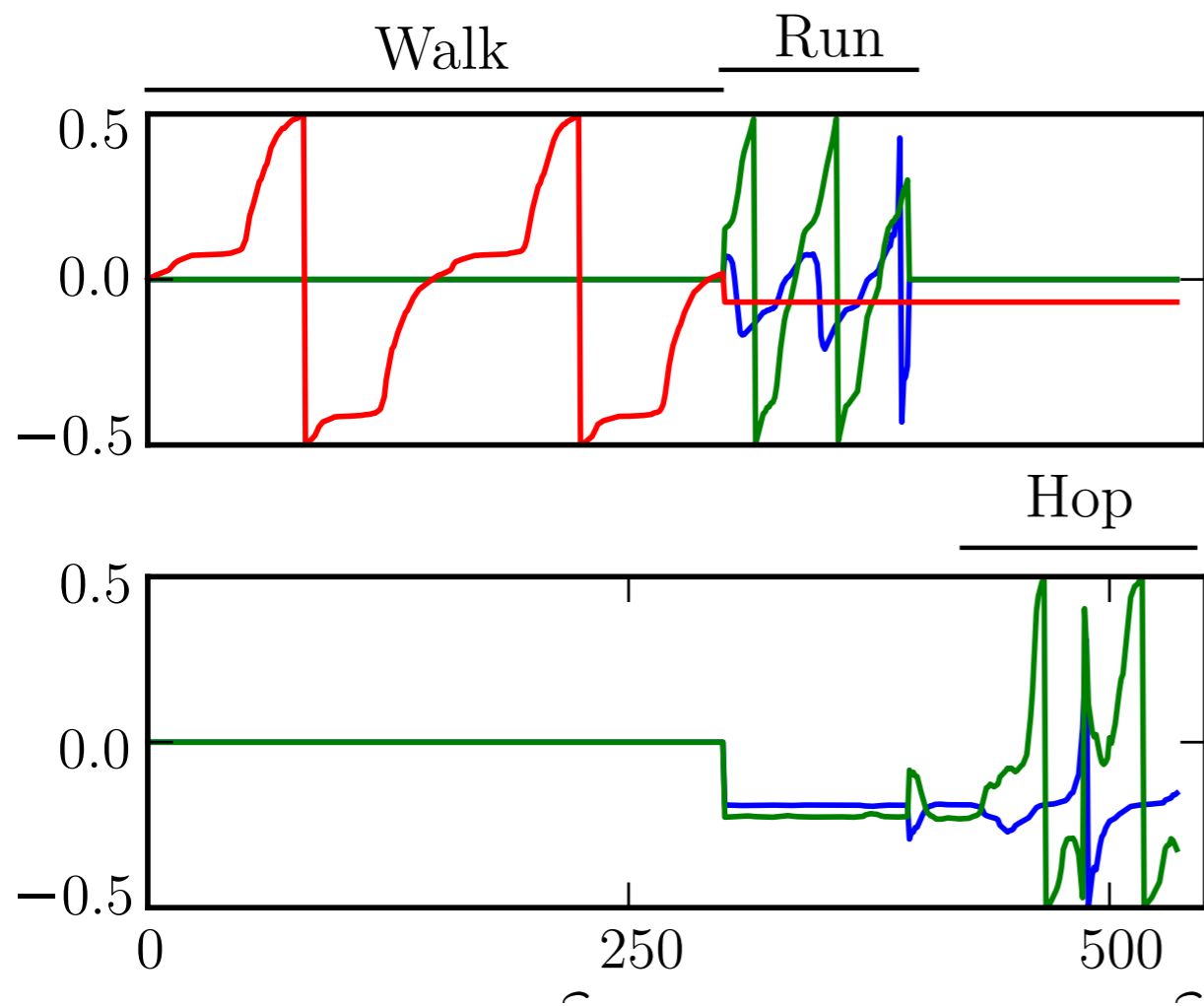
eps = 42.6

=100.0

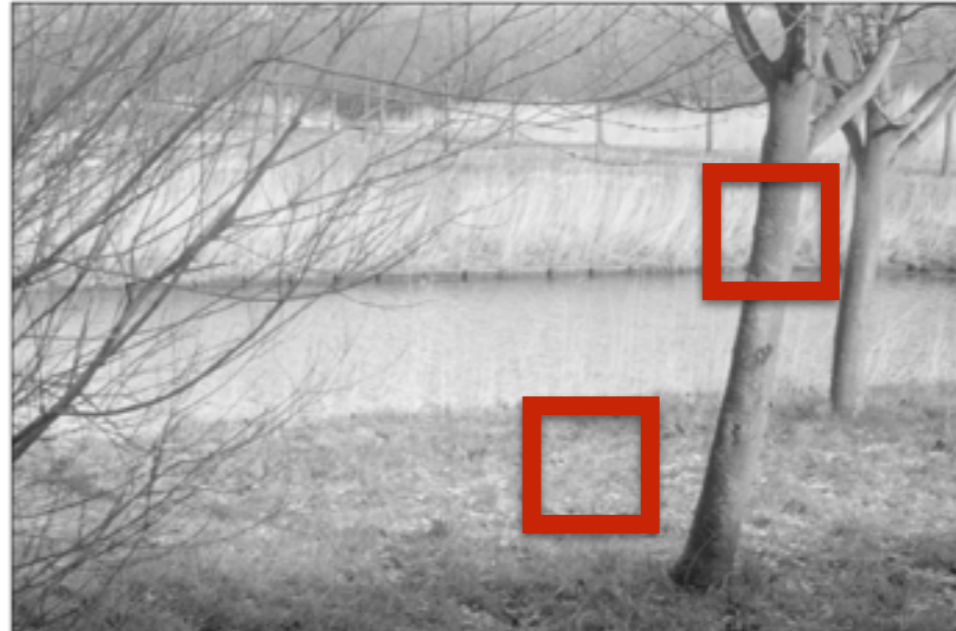
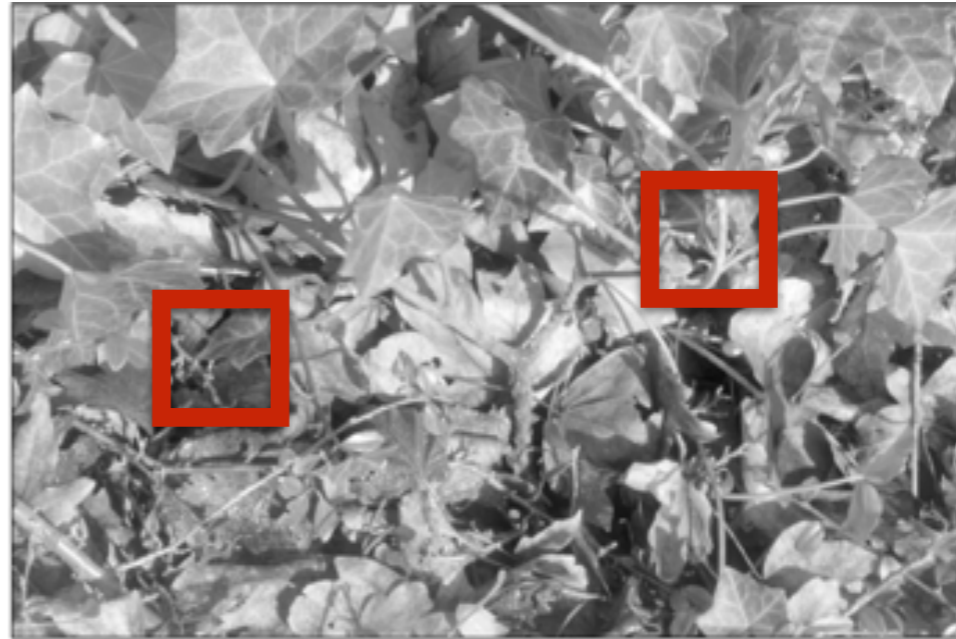




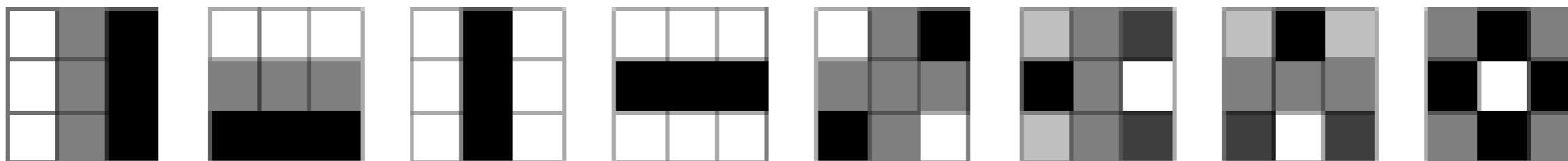
# Različni gibi



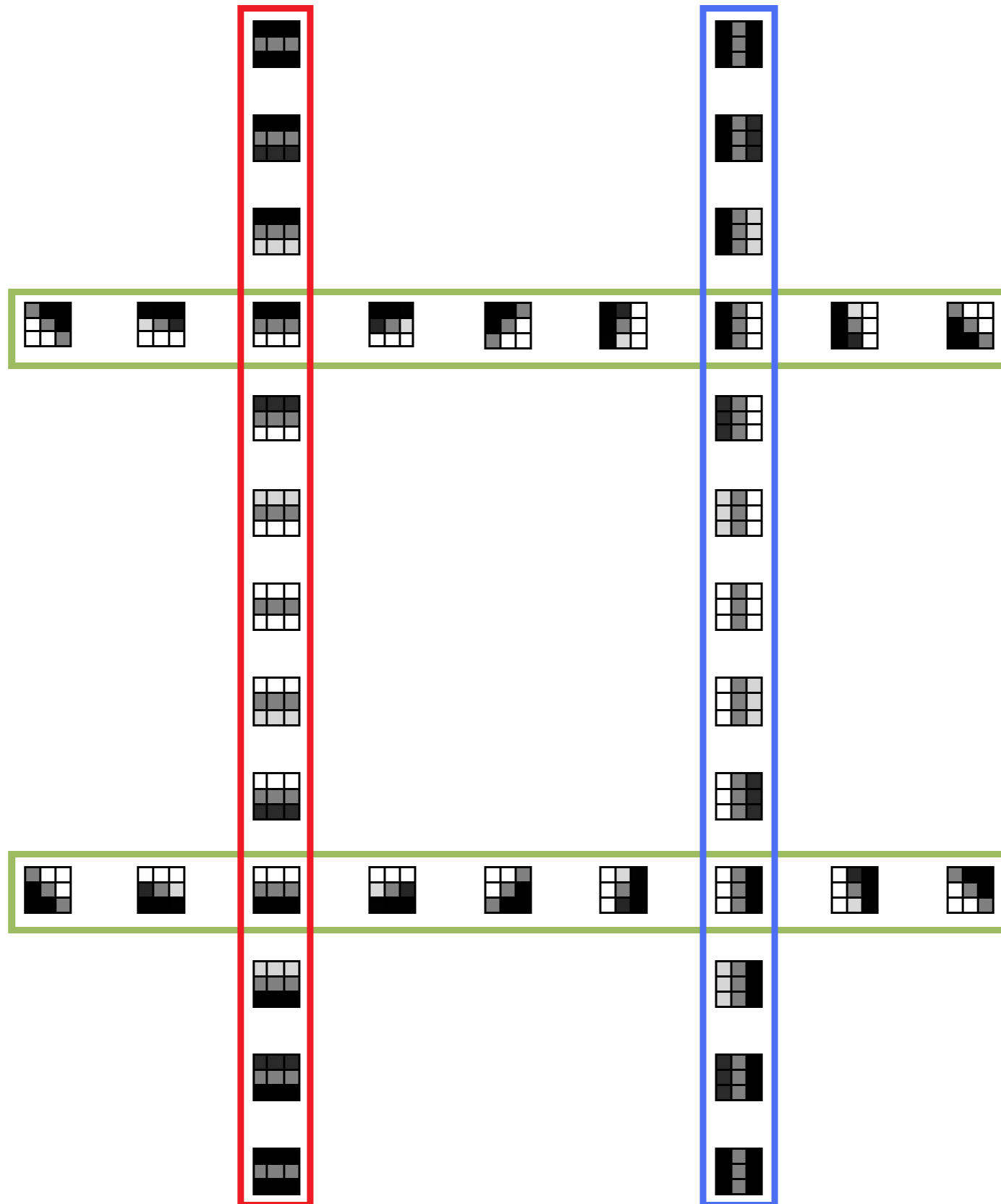
# Prostor naravnih slik



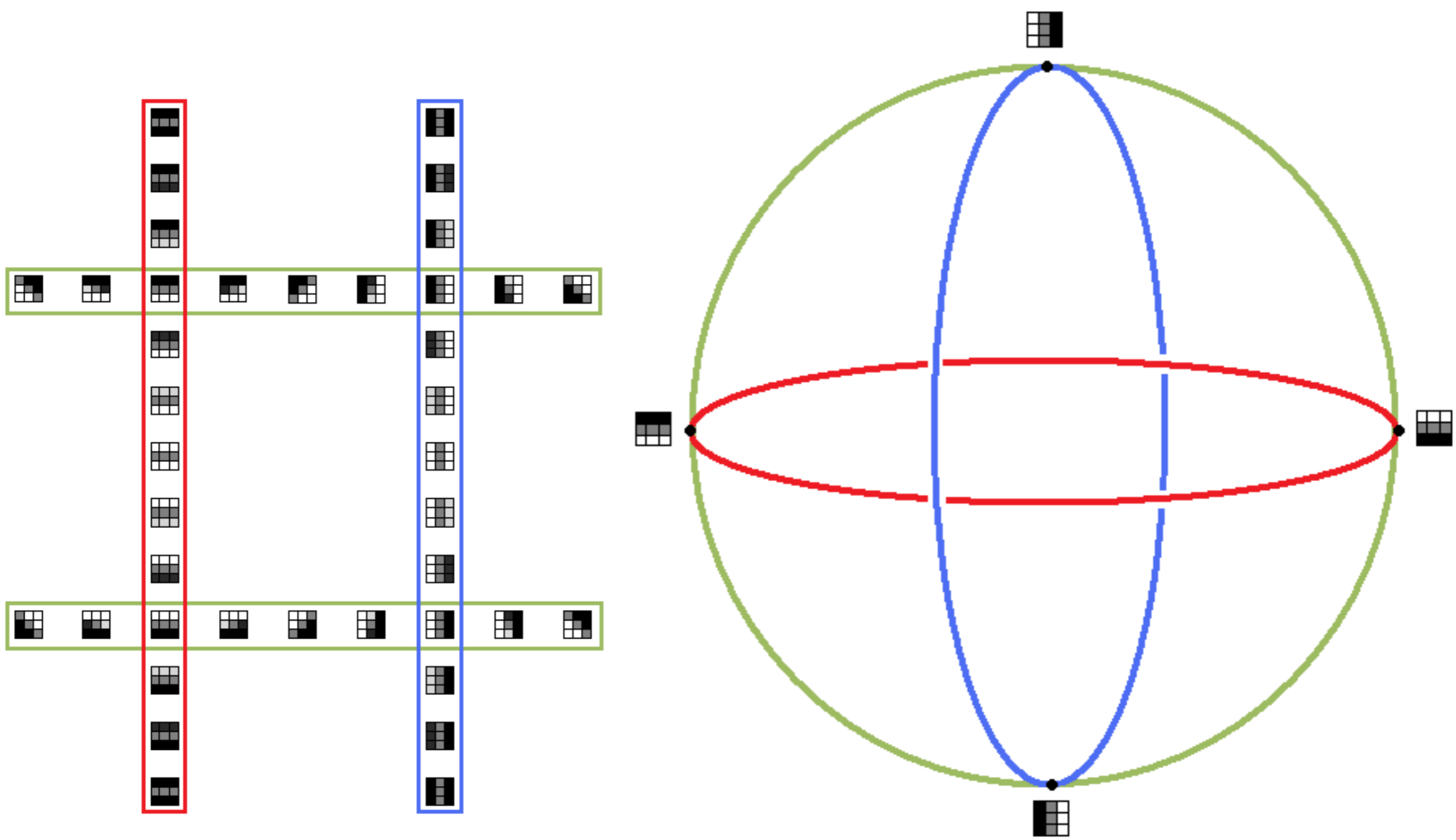
# Prostor naravnih slik



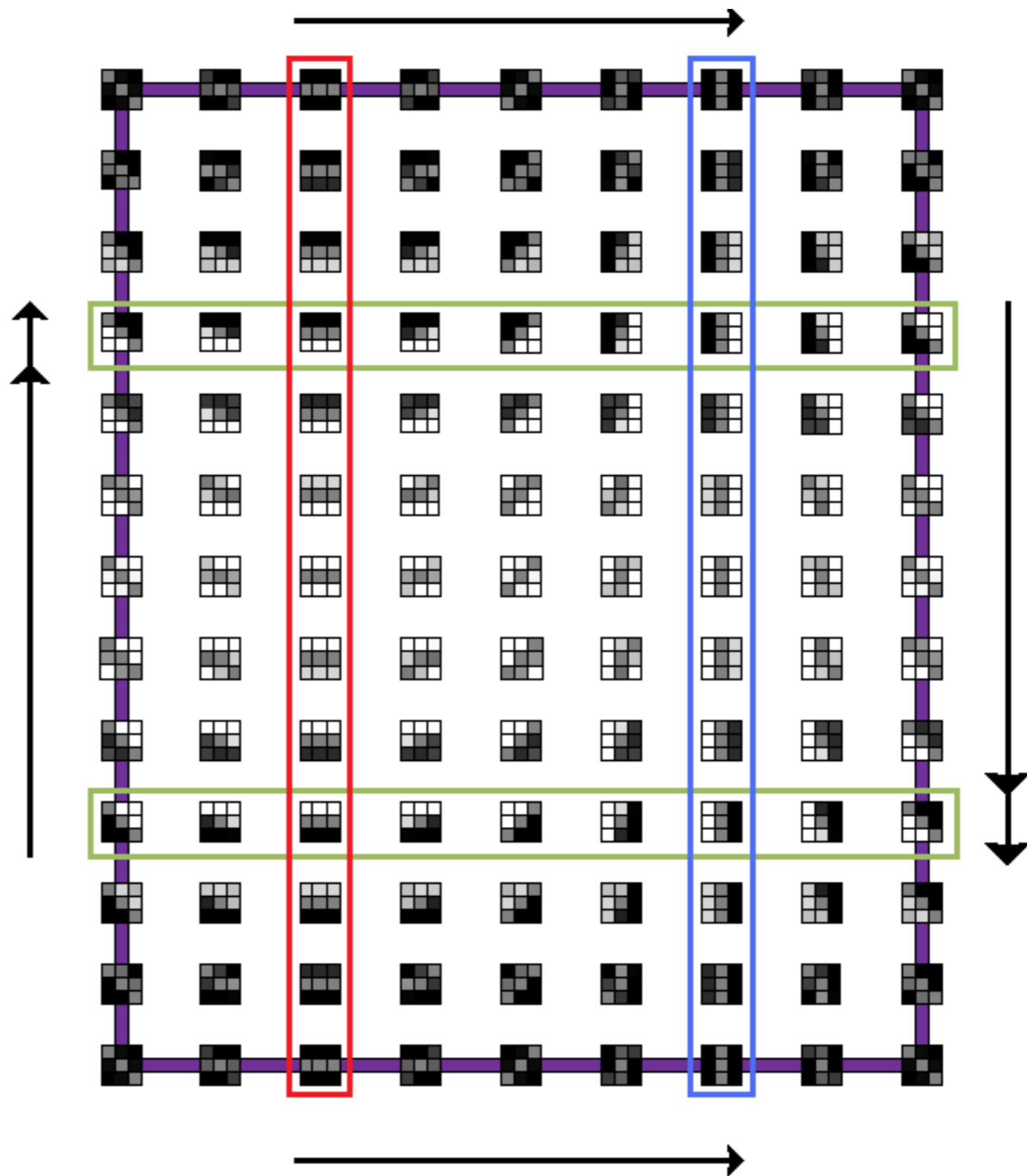
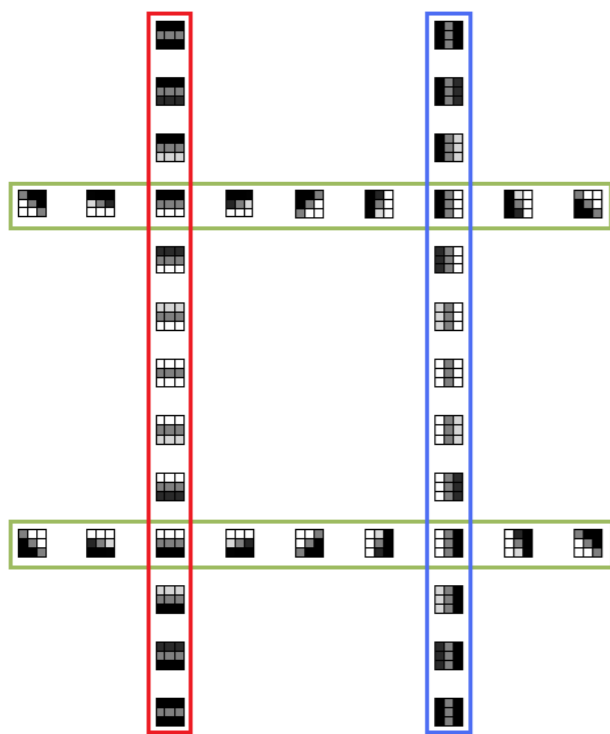
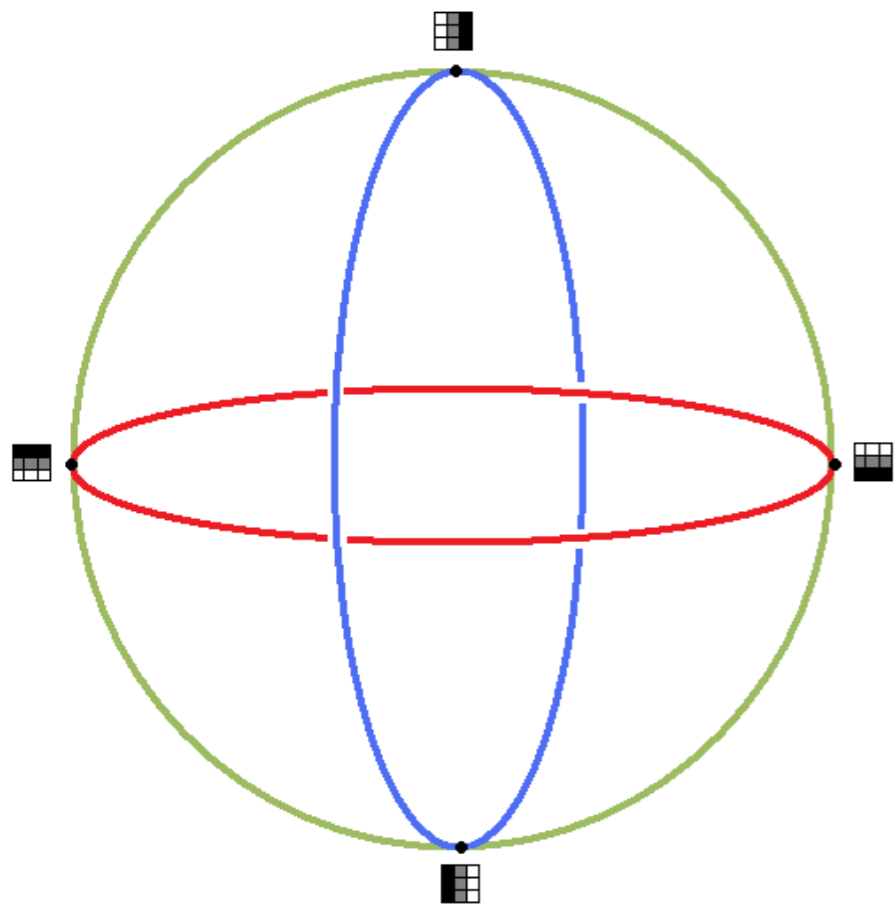
# Prostor naravnih slik



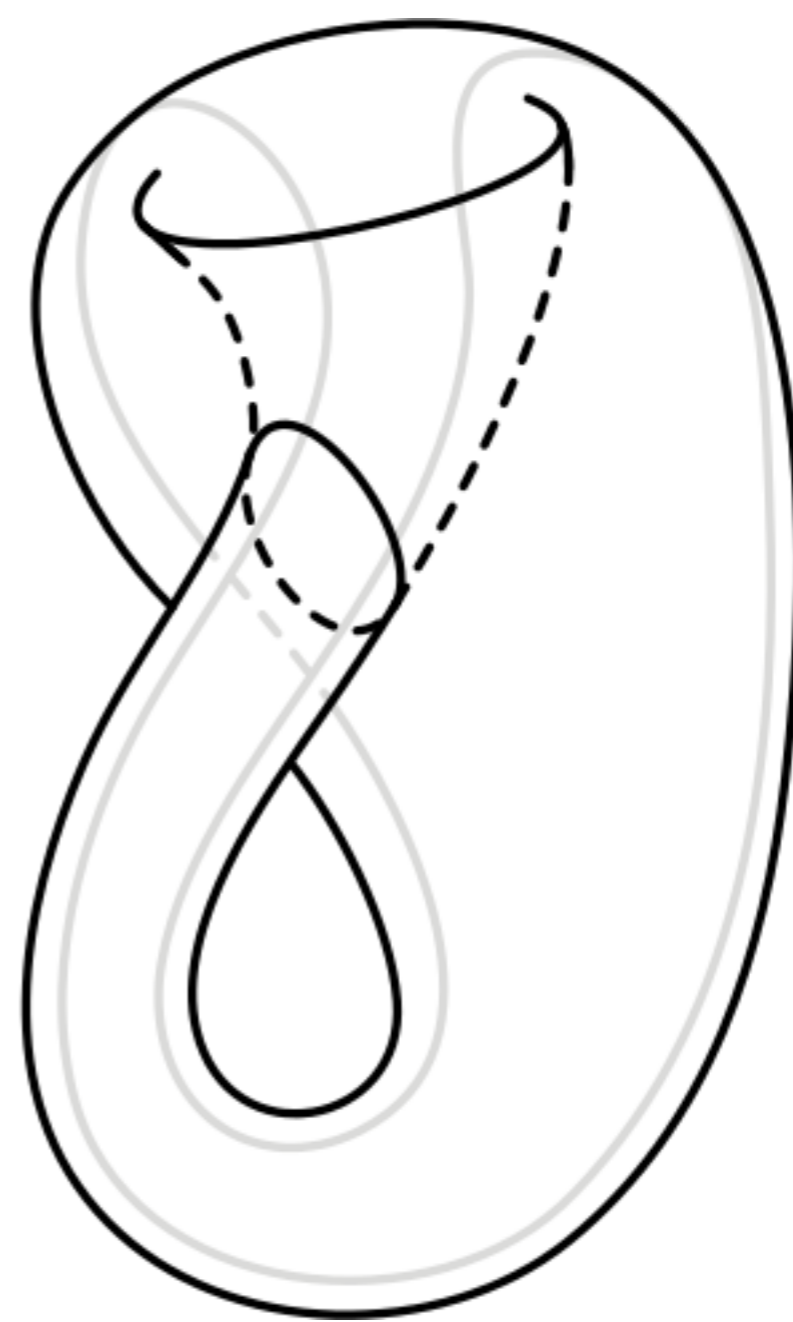
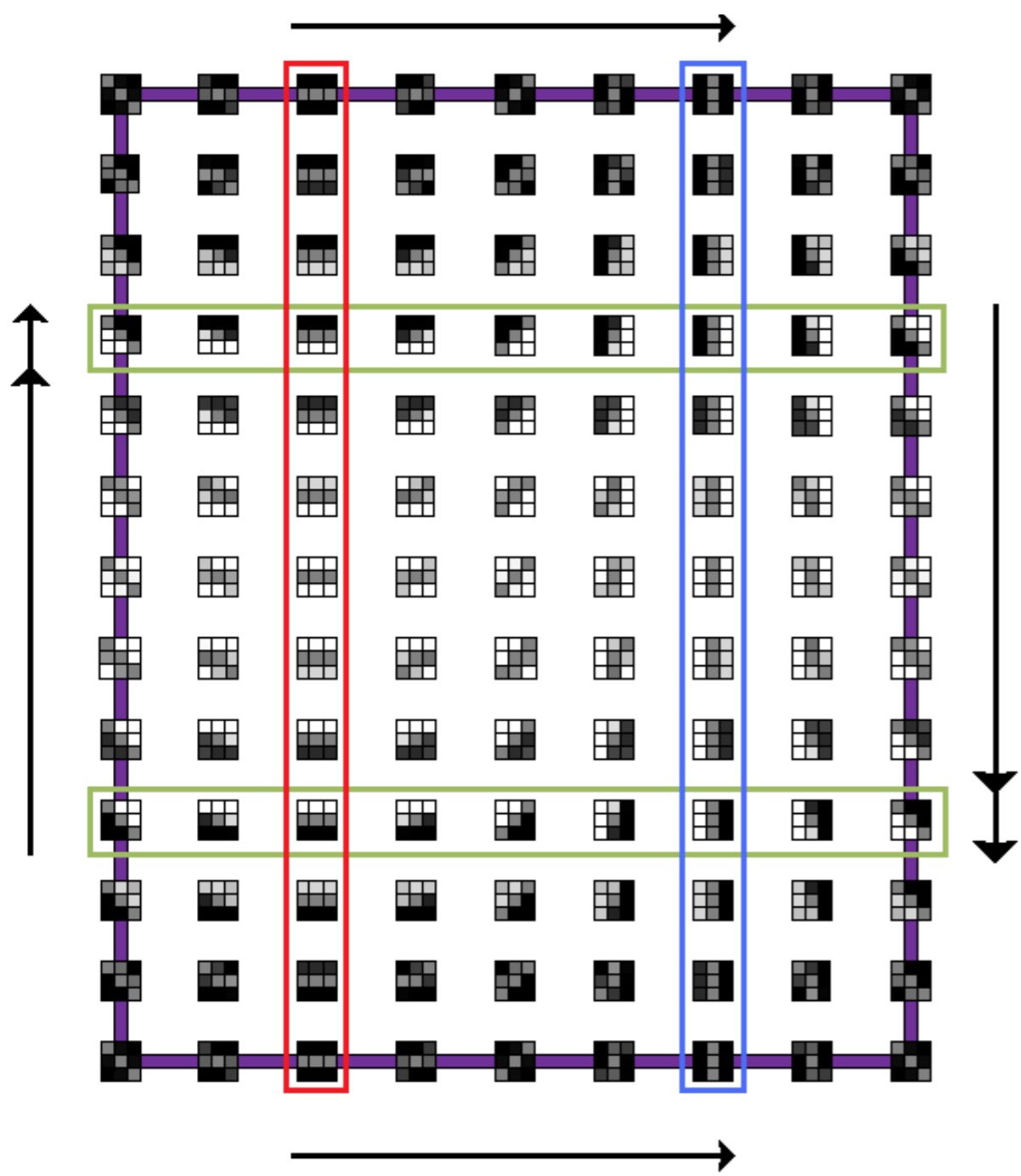
# Prostor naravnih slik



# Prostor naravnih slik



# Prostor naravnih slik



Kleinova steklenica

# Kam naprej?

- Podatki/mertive nam opišejo svet
- Geometrija in topologija
  - naravno omejuje modele
  - nam pomaga pri interpretaciji
- Iz lokalnega opisa v globalno obnašanje
- Samo začetek - npr. optimizacija, struktura socialnih omrežij,...



**Hvala**

Bei Wang

Paul Rosen

Guoning Chen

Valerio Pasucci

Harsh Batia

Amit Patel

Mikael Vejdemo-Johannson

Florian Pokorny

Danica Kragič

Vin de Silva

Jose Perea

Gunnar Carlsson