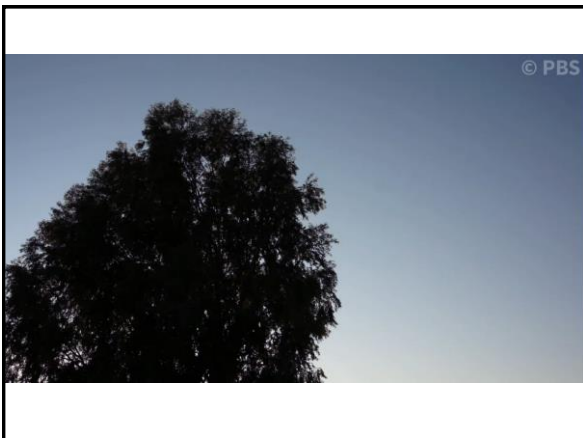


Collective behaviour

Behavioural animation

BEHAVIOURAL ANIMATION



behavioural animation

Hollywood

1992: Batman Returns
bat swarms
boids

1994: Lion King
stampede


...

2002: LoTR: The Two Towers
battle at Helm's Deep
massivesoftware

2003: The Matrix: Revolutions
sentinels at the city of Zion

...

2007: Resident Evil, Ratatouille,
Pirates of the Caribbean, 300, ...



MassiveSoftware



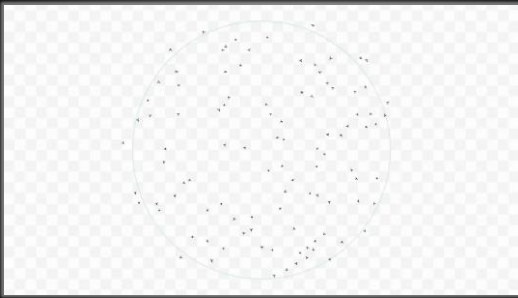
© www.massivesoftware.com, vimeo.com/38210543

Boids



© 1987, Craig W. Reynolds; 2007, research.scea.com, goo.gl/UCV600

Jate ptic modeliranje in simulacija



© Irs.fri.uni-lj.si/people/ilbajec

collective behaviour

modelling and simulation

Aoki I 1982 A simulation study on the schooling mechanism in fish. *Bulletin of the Japanese Society of Scientific Fisheries* 48(8), 1081-1088. doi:10.2331/suisan.48.1081

Okubo A 1986. Dynamical aspects of animal grouping: swarms, schools, flocks, and herds. *Advances in Biophysics* 22, 1-94. doi:10.1016/0065-227X(86)90003-1

Reynolds C W 1987. Flocks, herds, and schools: a distributed behavioral model. *Computer Graphics*, 21, 25-34. doi:10.1145/37402.37406

Heppner F H & Grenander U 1990 A stochastic nonlinear model for coordinated bird flocks. In: *The Ubiquity of Chaos* (Ed. by S. Krasner), pp. 233-238. Washington DC: American Association for the Advancement of Science.

Helbing D & Molnar P 1995 Social force model for pedestrian dynamics. *Physical Review E* 51 4282-4286. doi:10.1103/PhysRevE.51.4282

Vicsek T, Czirak A, Ben-Jacob E, Cohen I & Shochet O 1995 Novel type of phase transition in a system of self-driven particles. *Physical Review Letters* 75 1226-1229. doi:10.1103/PhysRevLett.75.1226

Couzin I D, Krause J, James R, Ruxton G D & Franks N R 2002 Collective memory and spatial sorting in animal groups. *Journal of Theoretical Biology* 219 1-11. doi:10.1006/jtbi.2002.3065

Lebar Bajec I, Zimic N & Mrzic M 2005 Simulating flocks on the wing: the fuzzy approach. *Journal of Theoretical Biology* 233 199-220. doi:10.1016/j.jtbi.2004.10.003

Hildenbrandt H, Carere C & Hemelrijk C H 2010 Self-organized aerial displays of thousands of starlings: a model. *Behavioral Ecology* 21 1349-1359. doi:10.1093/beheco/arq149

...

game of life

John Conway



bird flocks

modelling and simulation

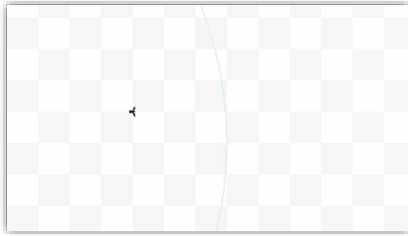
sintetični svet: množica sintetičnih ptic

sintetična ptica

- pozicija p
- smer in hitrost leta v z upoštevanjem
 - vztrajnosti (jadranje)
 - maksimalne hitrosti (trenje)
 - maksimalne sile (omejena količina energije)
- sposobnosti
 - zaznavanje okolice (relevantne informacije)
 - težnje (akcije; želene spremembe smeri in hitrosti leta)
 - združevanje akcij (nova smer in hitrost leta)

bird flocks

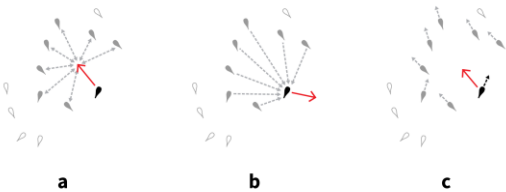
modelling and simulation
flight



$$a = F/m, \quad v += a\Delta t, \quad p += v\Delta t$$

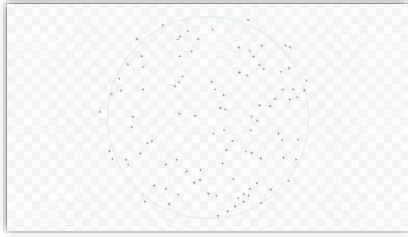
bird flocks

modelling and simulation
drives



bird flocks

modelling and simulation



The whole is more than the sum of its parts – Aristotle

Robert Hodgkin
Murmuration



Hodgin, 2014, Murmuration – 40000 starlings, goo.gl/hFPFUE
