GSC January@GSAS 2023 Mini-Course Introduction to Generative Art and Scientific Visualization Day 4: Tools for visualization

Processing and Boids Flocking Simulation





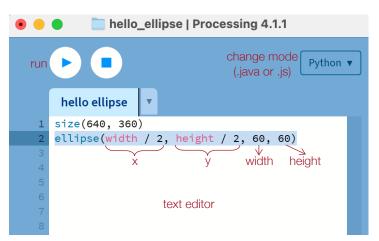


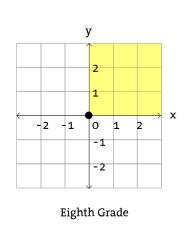


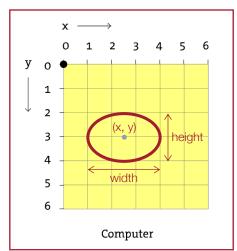


What is Processing?

- Processing is a flexible software sketchbook and a language for learning how to code¹:
 - promotes software literacy within the visual arts and visual literacy within technology;
 - ideal for quick prototyping and interactive design.



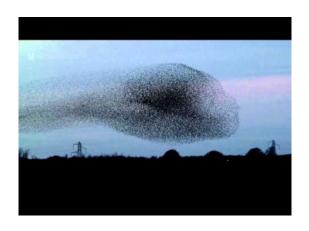




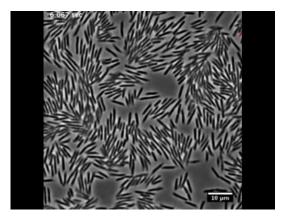
main Processing window

coordinate system in Processing²

Flocking behavior in nature







flock of birds¹

school of fish2

swarm of bacteria³

create an <u>interactive</u> code in <u>Processing</u> to simulate the flocking behaviors based on the <u>Boids</u> algorithm

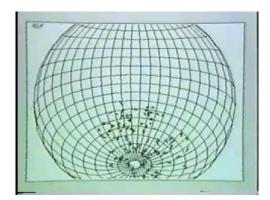
YouTube: "Gretna Green Starling Murmurations", https://youtu.be/M1Q-EbX6dso

² YouTube: "Sardine Feeding Frenzy with Sharks, Penguins and More | The Hunt | BBC Earth", https://youtu.be/6zOarcL1BSc ³ YouTube: "Motions of Swarming E coli Bacteria", https://youtu.be/q27Jn3h4kpE

\ A /				•	
1/1/	hat	IC	$H \cap$		6.1
VV	Hat	10		ľ	3 :

ARTICLES	CITED BY	CO-AUTHORS		
TITLE			CITED BY	YEAR
Flocks, herds and schools: A distributed behavioral model CW Reynolds Proceedings of the 14th annual conference on Computer graphics and			13532	1987

- Boids¹ is an artificial life program developed by Craig Reynolds to simulate flocking:
 - refers to simulated bird-like, "bird-oid" objects;
 - generically represents objects of polarized, noncolliding, aggregate motion, like school of fish;
 - has many applications/extensions in movies, also the scientific communities.



the original *Boids* program² (1986)



the bat swarming scene³ in Batman Returns (1992)

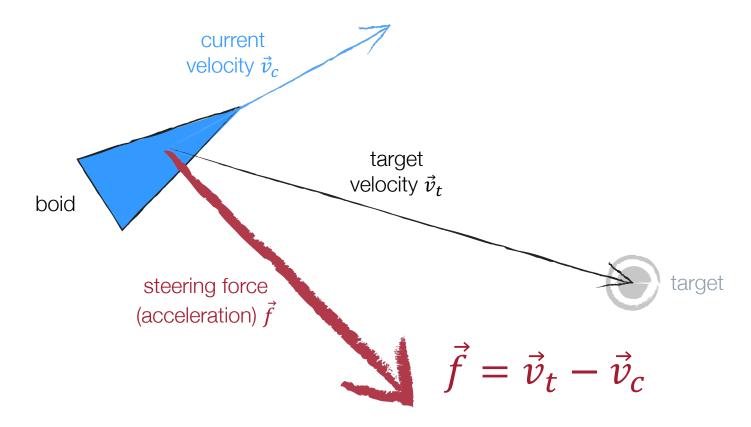


the stampede scene⁴ in *The Lion King* (1994)

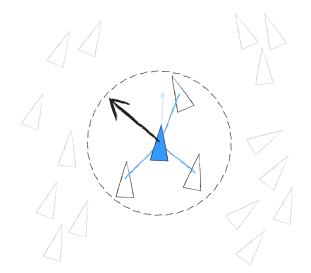
¹ Boids (background and update) by Craig Reynolds: https://www.red3d.com/cwr/boids/ ² YouTube: "Original 1986 Boids simulation", https://youtu.be/86iQiV3-3IA

³ YouTube: "Flock of bats (Batman Returns 1992)", https://youtu.be/A8Xt3DlrwhY ⁴ YouTube: "Stampede (The Lion King 1994)", https://youtu.be/x_EVWUT3A

Vector basics

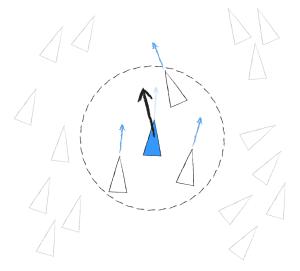


Three (basic) flocking rules¹



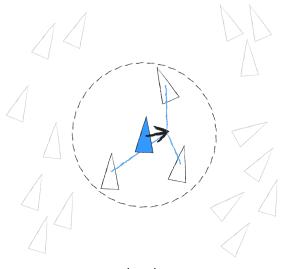
separation

steer to avoid colliding with local flockmates



alignment

steer towards the average direction of local flockmates



cohesion

steer towards the average position of local flockmates

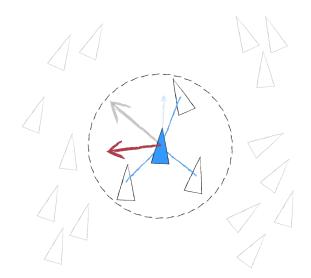
Three (basic) flocking rules¹

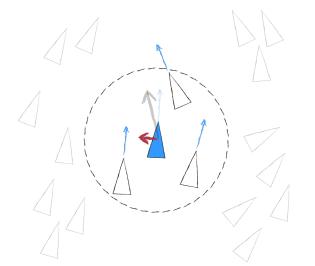
 \vec{x}_i : position of current boid \vec{v}_i : velocity of current boid

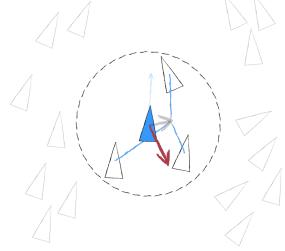
 \vec{x}_j : position of flockmates \vec{v}_i : velocity of flockmates

 v_m : maximum speed

 f_m : maximum force magnitude







separation
$$\frac{\vec{f}_s}{m} = \left(\frac{1}{n-1} \sum_{i \neq j}^{n-1} \frac{1}{\left\|\vec{x}_i - \vec{x}_j\right\|} \cdot \frac{\vec{x}_i - \vec{x}_j}{\left\|\vec{x}_i - \vec{x}_j\right\|}\right) - \vec{v}_i$$
weighted velocity
by distance direction

alignment
$$\frac{\vec{f_a}}{m} = \left(\frac{1}{n-1} \sum_{i \neq j}^{n-1} \vec{v_j}\right) - \vec{v_i}$$
 average velocity

cohesion
$$\frac{\vec{f_c}}{m} = \left(\frac{1}{n-1} \sum_{i \neq j}^{n-1} \vec{x_j}\right) - \vec{x_i} - \vec{v}$$
 average position