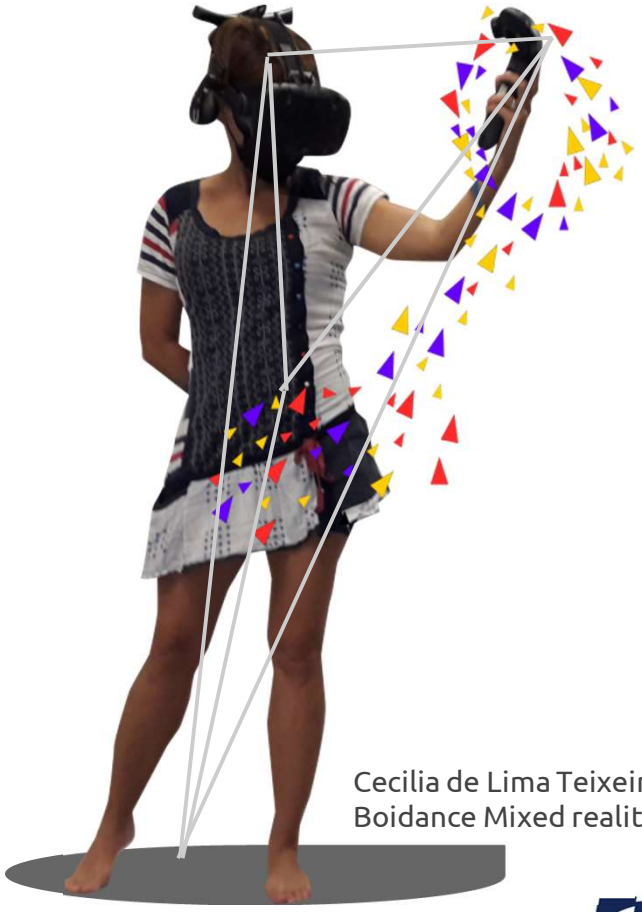


Cecilia de Lima Teixeira
Boidance Mixed reality

# Boidance

## Software Expanding Dance Using Virtual Reality, Boids and Genetic Algorithms

Clément Caporal; Cecília de Lima; Rui Filipe Antunes

26/11/2020

# From dance to *Boidance*

# Summary

1. Context: Between representation and interaction in virtual environment
2. Problem: ***How to enhance interaction between the dancer and the boids?***
3. Implementation and Results: Boids + Genetic Algorithm + VR & LMA
4. Outcome and Discussion

1. **Context:**
   Between representation and interaction in the Virtual Environment

A. Representation
B. Interaction

# Context : Previous examples

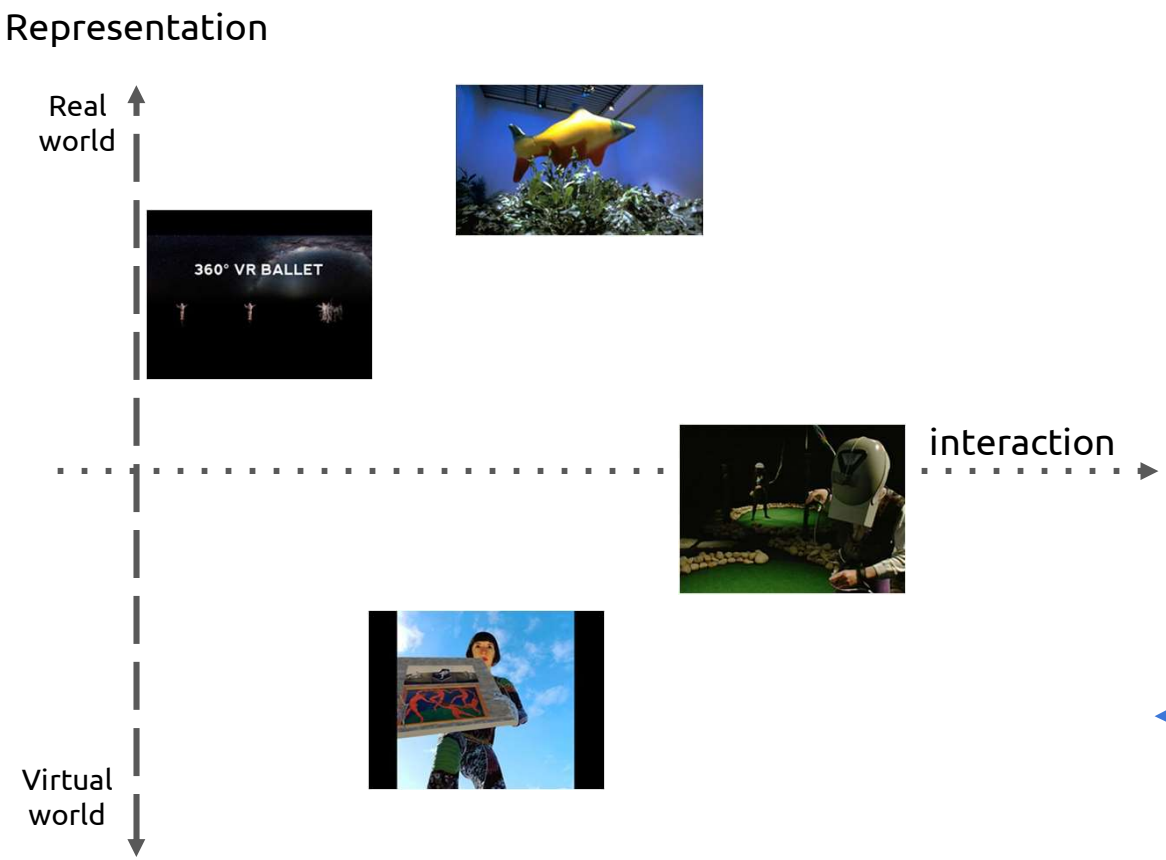
**Placeholder**, Brenda Laurel

**Uiapuru**, telepresence, Eduardo Kac


VR Ballet - **Silent Resonance**

**VR_I,** Gilles Jobin

# Context: Map between representation and interaction




2. Problem:

# How to enhance interaction between the dancer and the boids?

## 3. **Implementation** and Results

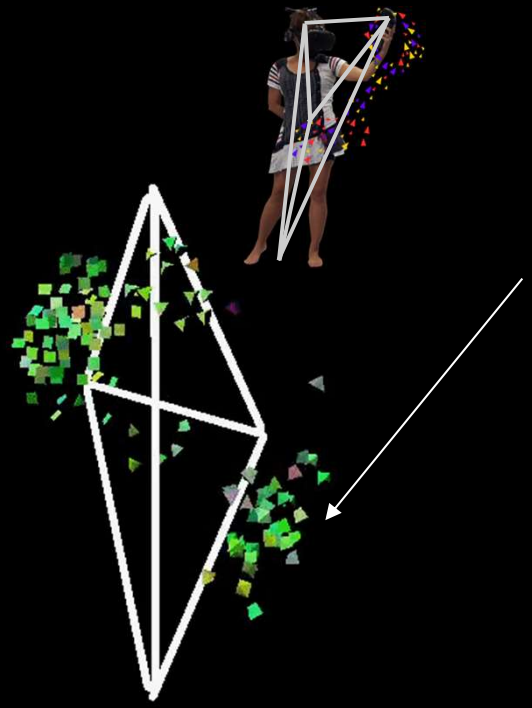
**Strategy**

A. Create and Populate the VR environment
B. Interaction research using Laban Movement Analysis

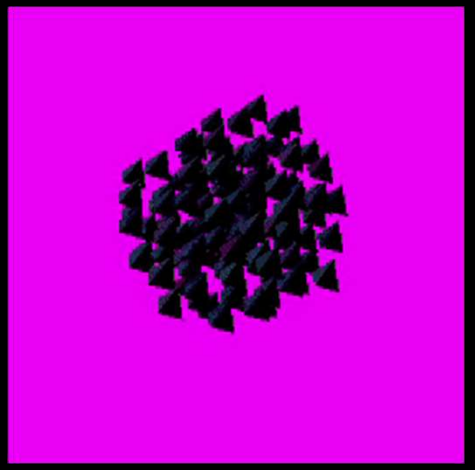
# A - Create and populated VR environment

**Boids algorithm**

→ Behaviors
- Cohesion
- Alignment
- Avoidance
- Follow head of user
- …



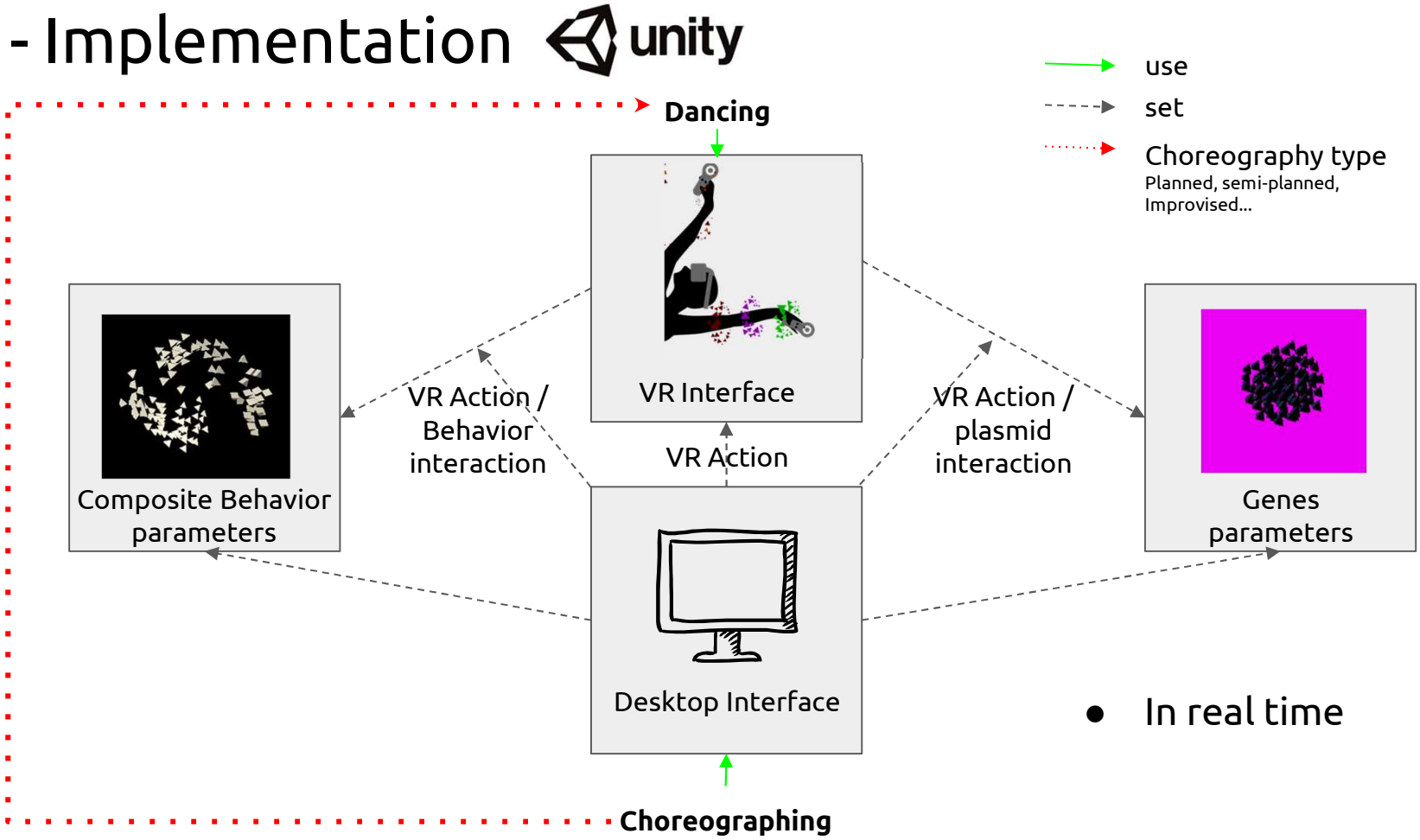
**Swarm behavior in VR**



**Genetic Algorithm**

→ Genes
- Colors
- Speed
- Shape
- ….

# A - Implementation

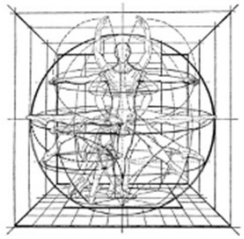


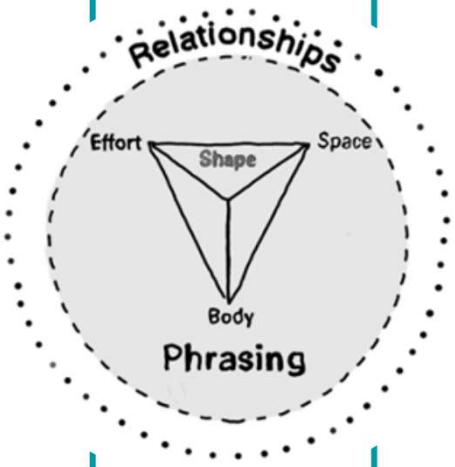

- In real time

# B- Introduction to Laban Movement Analysis Categories

## Space

**Physical and Psychological Kinesphere**
**Spatial dimensions and directions and intentions**






## Effort

| EFFORT ACTIONS | | |
|---|---|---|
| | Indulging | Contending |
| **Space** | Flexible | Direct |
| **Weight** | Light | Strong |
| **Time** | Sustained | Quick |
| **Flow** | Free | Bound |

## Body

**Breath**

**Active body parts**

**Movement sequencing**

**Movement patterns**

## Shape

**Static shapes**

**How shape changes**
**(in relation to the body and to the environment)**

**Quality of shape**

## **3 -** Implementation and **Results**: *Interaction using Laban Movement Analysis*

| | |
|---|---|
| **Space** | **Effort** |
| **Body** | **Shape** |

Performer and choreographer **: Michele Luceac**

# Discussion

## General Outcome

- Dancer and audience can interact with the environment in real time
- Laban Movement Analysis was a very useful tool to analyze and improve the movement interaction between the dancer and VR technology

## Outcome from the dance and choreographic perspective

- **Immaterial living interaction mode;**
- A kinesphere that **can be trespassed and trespasses the dancer's body** and that can be perceived as a **bodily extension;**
- Boidance as a ***Weightless Contact-Improvisation Dance***;
- Innovative aesthetic experience - "**Immaterial Somatic Perception**".

# Discussion

**To improve / to explore**

- Haptic response and more vr controllers/sensors
- Improve visualization by the audience (Mixed Reality, multi-users…?)
- Sounds: interaction
- Methodology to analyse dance movement in interaction with virtual reality

# Acknowledgements

ENSTA:

- Researcher/Teacher François Pessaux

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- Professor Luis Correia
- Assistant Professor Maria Beatriz Carmo
- Michele Luceac

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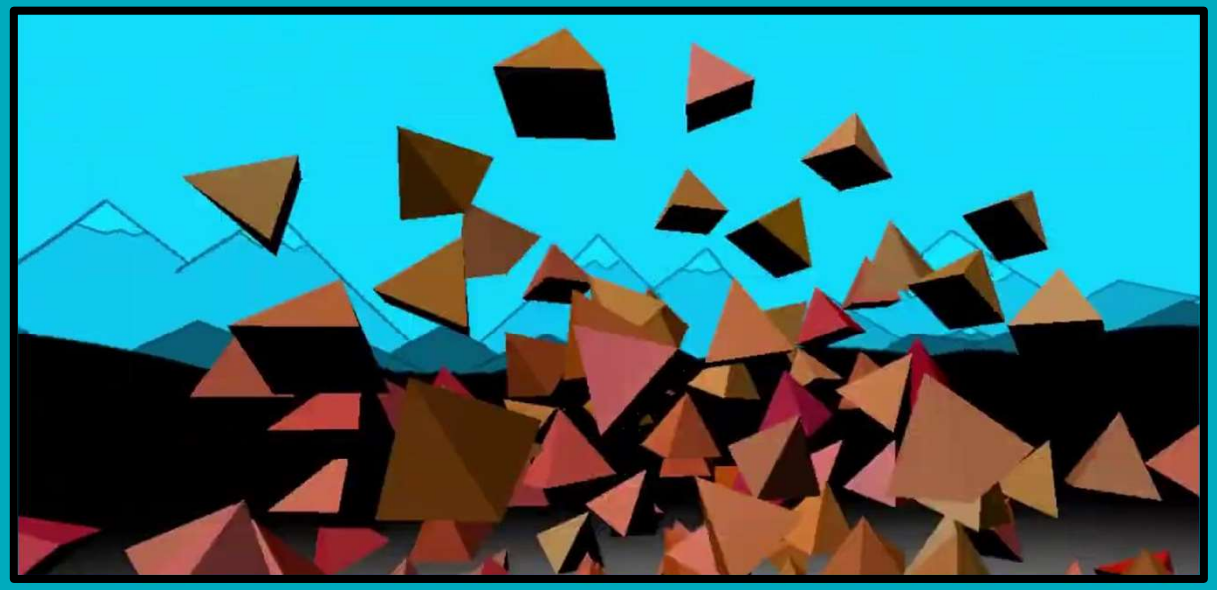
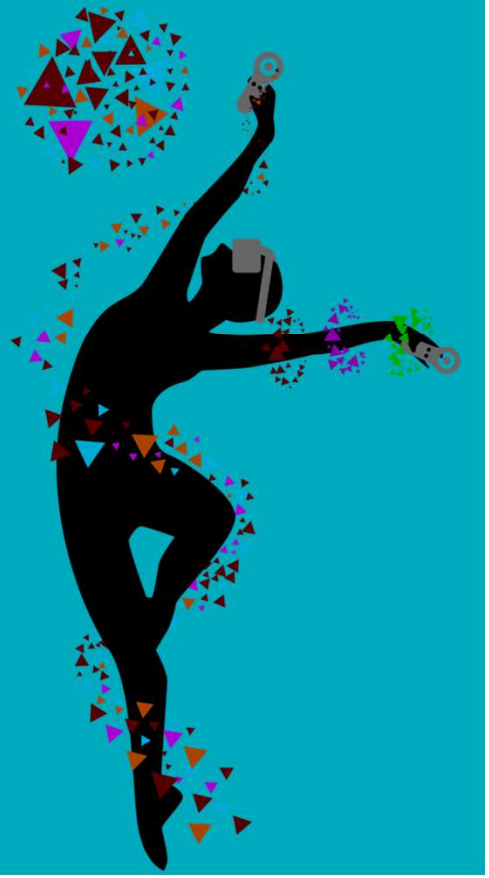
- Research project TEPe (Technologically Expanded Performance - PTDC/ART-PER/31263/2017)

ARTEFACTO

Cecilia de Lima Teixeira
Mixed reality





# Thank you for your attention!

ENSTA IP PARIS

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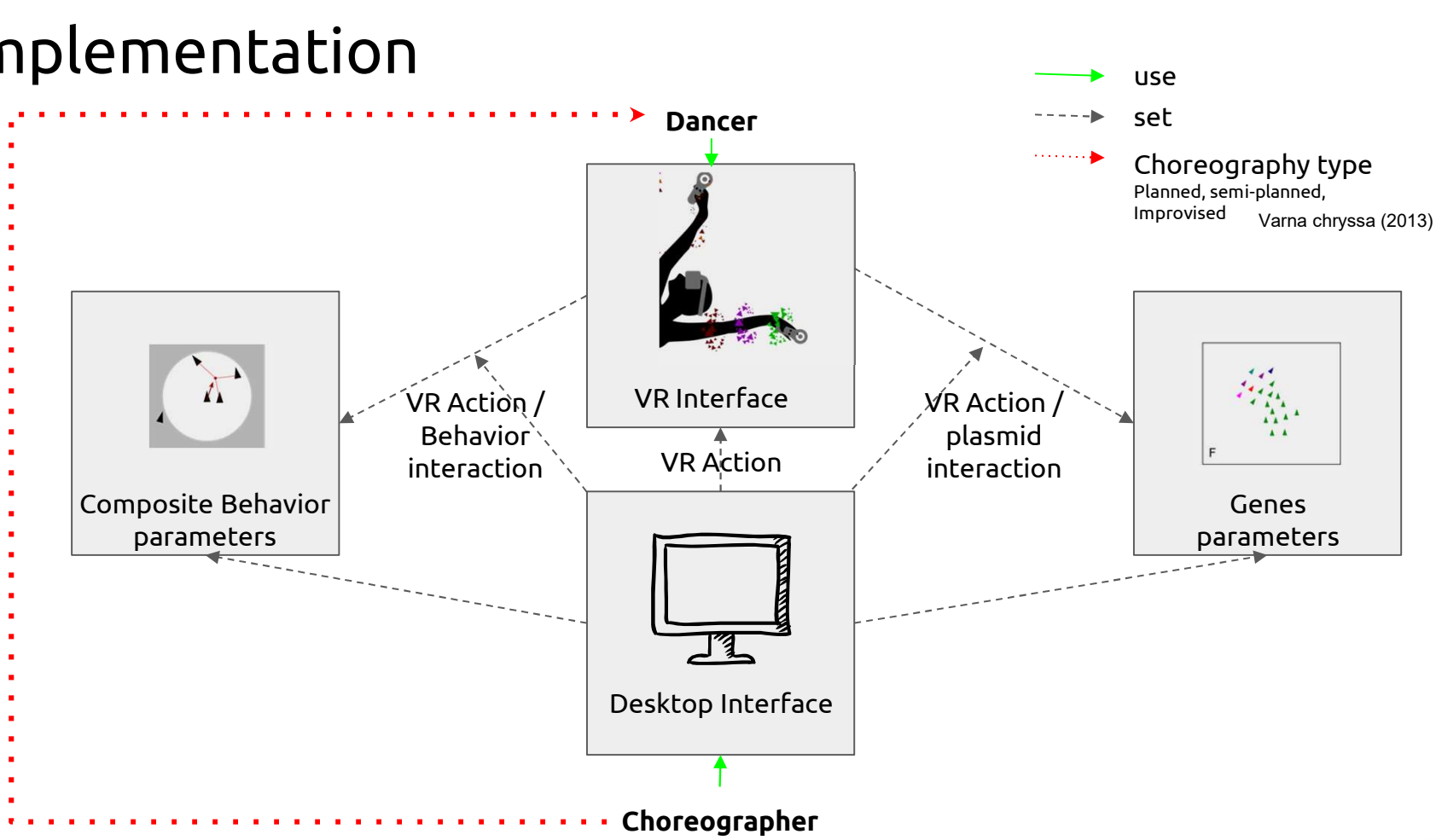
fMH

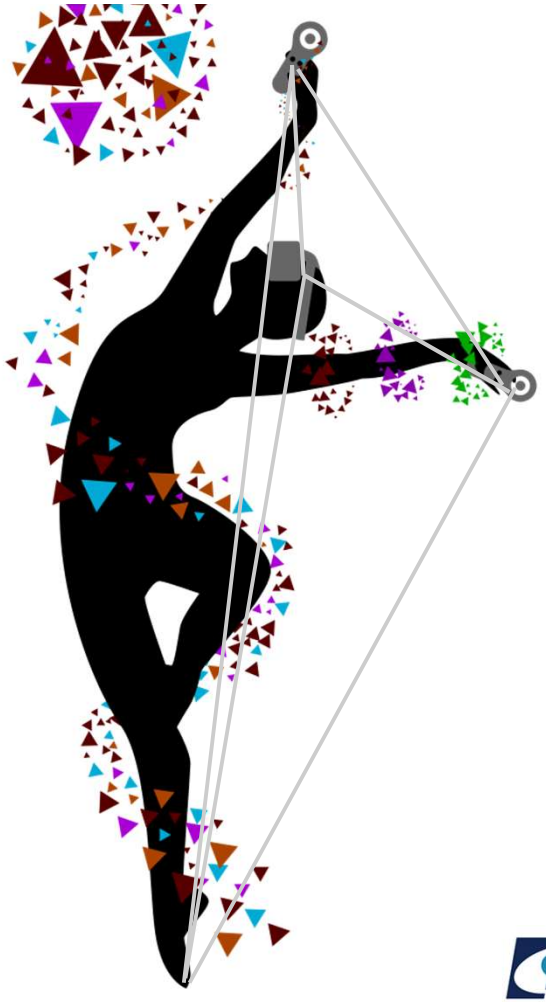
FC Ciências ULisboa

TEPe

# Annexes

# Implementation



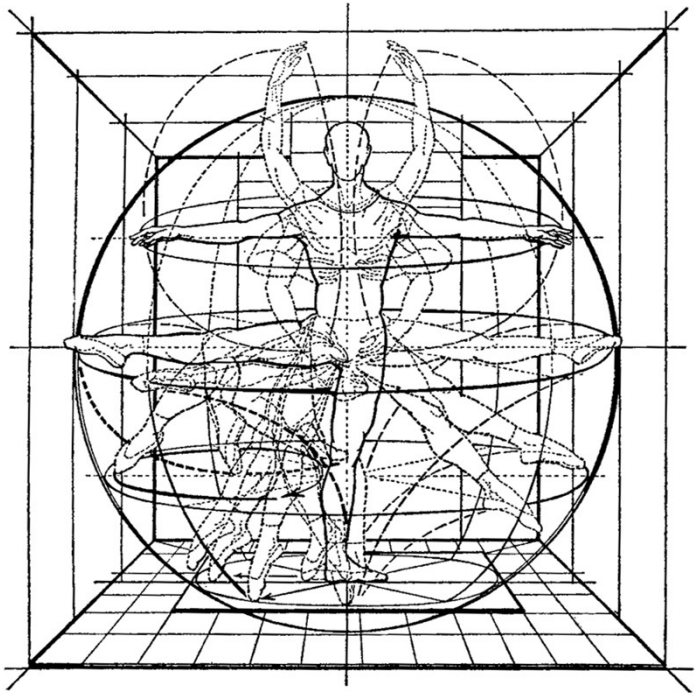


# Boidance

## Software Expanding Dance Using Virtual Reality, Boids and Genetic Algorithms

names

# The kinesphere, a subcategory of the space in LMA



*Published in A. Truong, H. Boujut and T. Zaharia, 2014.*

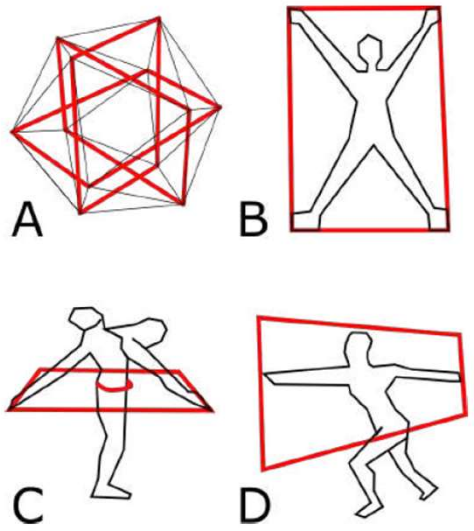
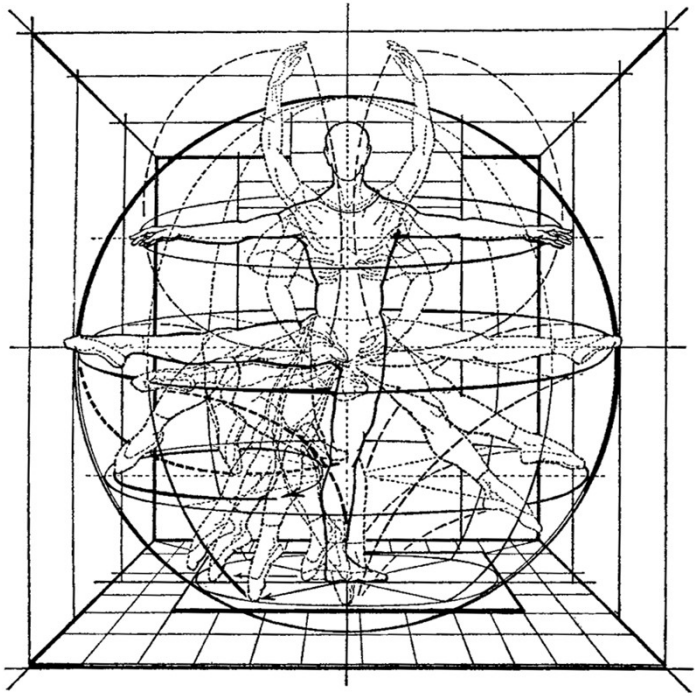



*Figure 4: icosahedron (A), Lateral (B), Horizontal (C) , Sagittal (D)*

**How to enlarge dancer movement through developing the kinesphere?**

Boidance - context | problem | implementation and results | outcomes and discussion

# The kinesphere, a subcategory of the space in LMA



*Published in A. Truong, H. Boujut and T. Zaharia, 2014.*

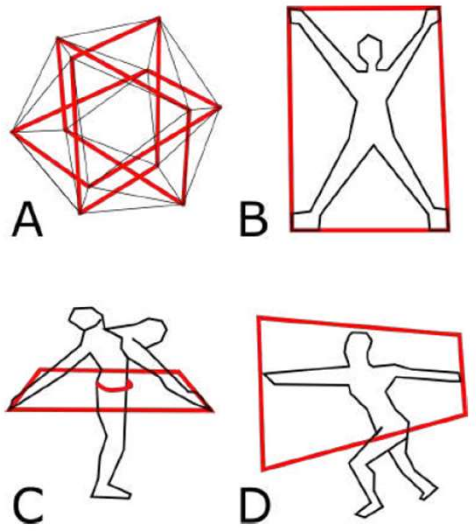



*Figure 4: icosahedron (A), Lateral (B), Horizontal (C) , Sagittal (D)*

**How to enlarge dancer movement through developing the kinesphere?**

Boidance - context | problem | implementation and results | outcomes and discussion

# Collective behaviors - Swarms

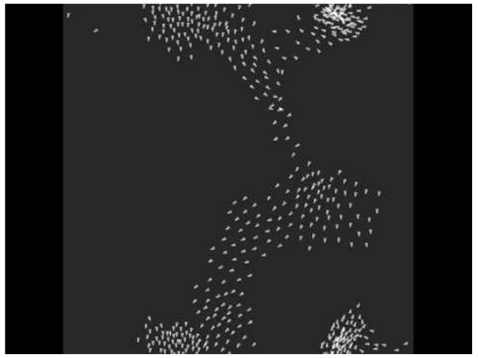
Swarm intelligence characteristics:

- Reactive agents / ~~cognitive agents~~
- Deterministic
- Chaotic

Research application

- Emerging behaviors
- Model natural behaviors
- Procedural natural movement
- Optimization

Shoal of Garapau - youtube



Dan Olner - youtube (Reynolds (1986))

**How to model biological systems of complex behaviors?**



Boidance - context | problem | implementation and results | outcomes and discussion

# Agents between boids and Genetic Algorithm

## Boids parameters

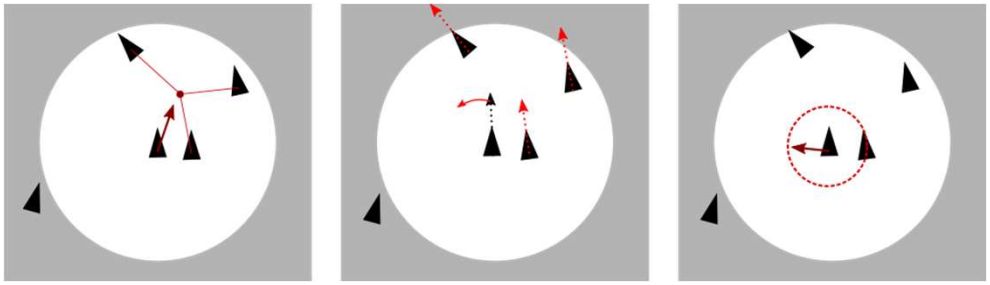



Figure 1 - Base behaviors by Reynolds (1986)

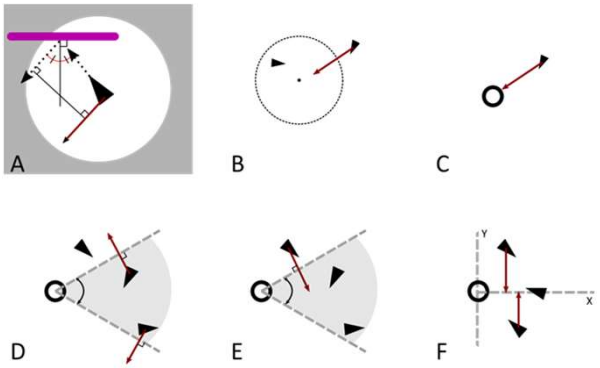
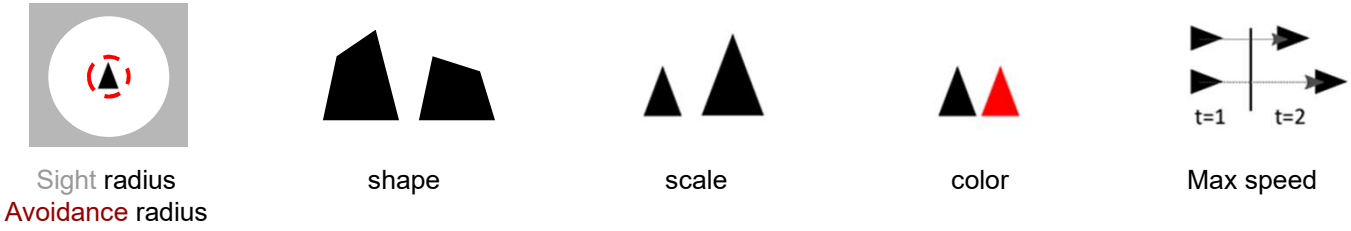



Figure 1 Available behaviors in boidance

## Genetic Algorithm




Sight radius
Avoidance radius

shape

scale

color

Max speed

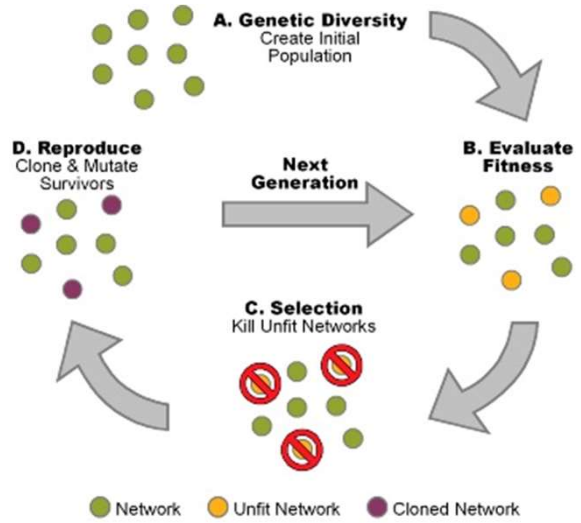
# Genetic Algorithm

Genetic Algorithm characteristics:

- Agents
- Fitness function
- Parent selection
- Mutation

Research application

- Optimization




**How to model biological systems of complex behaviors?**



Boidance - context | problem | implementation and results | outcomes and discussion

**How to enlarge dancer movement through developing the kinesphere?**

**How to model biological systems of complex behaviors?**

**How to perform a dancer-flock interaction using virtual reality?**

# How to perform a dancer-boids interaction using virtual reality?

1. How to model biological systems of a Flock?

# Agent parameters

## Behaviors

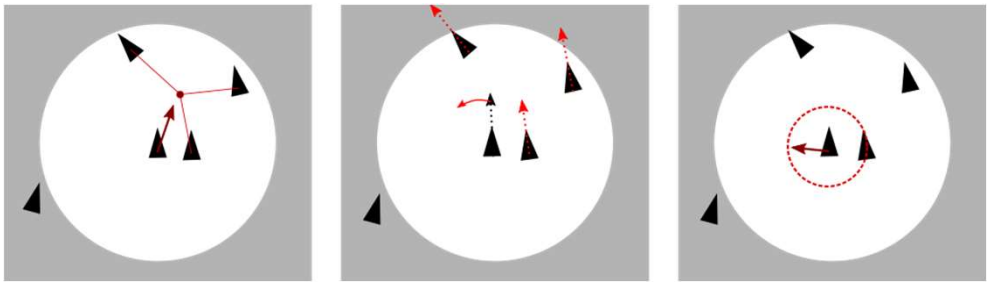



Figure 2 - Base behaviors by Reynolds (1986)

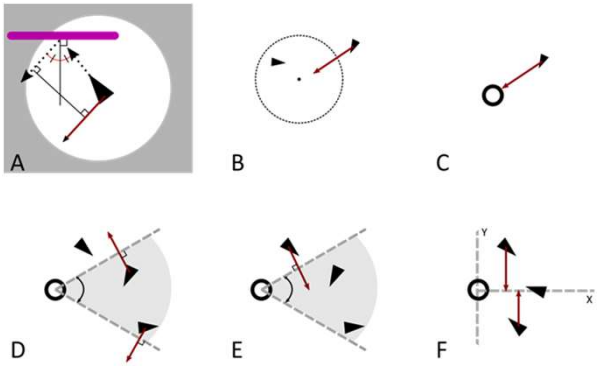
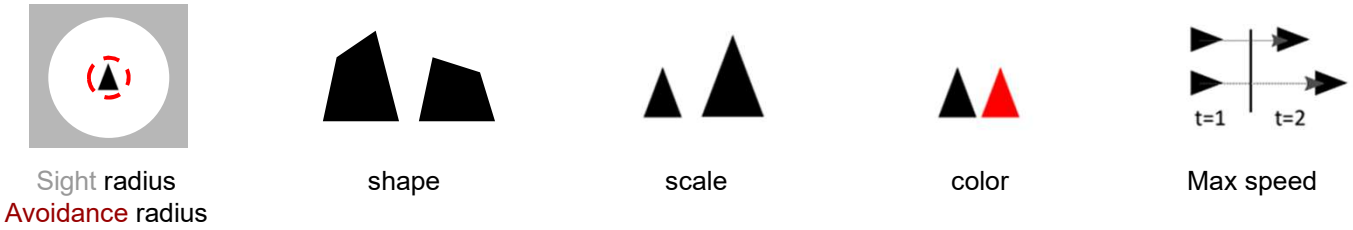



Figure 1.4. Boidance Behaviors

## Genes




Sight radius
Avoidance radius

shape

scale

color

Max speed

# Flocks Composite behaviors

At each frame:

```
public override Vector3 CalculateMove(FlockAgent agent, List<Transform> context, Flock flock)
```

Context calculation → Complexity: O(n²), n number of agents

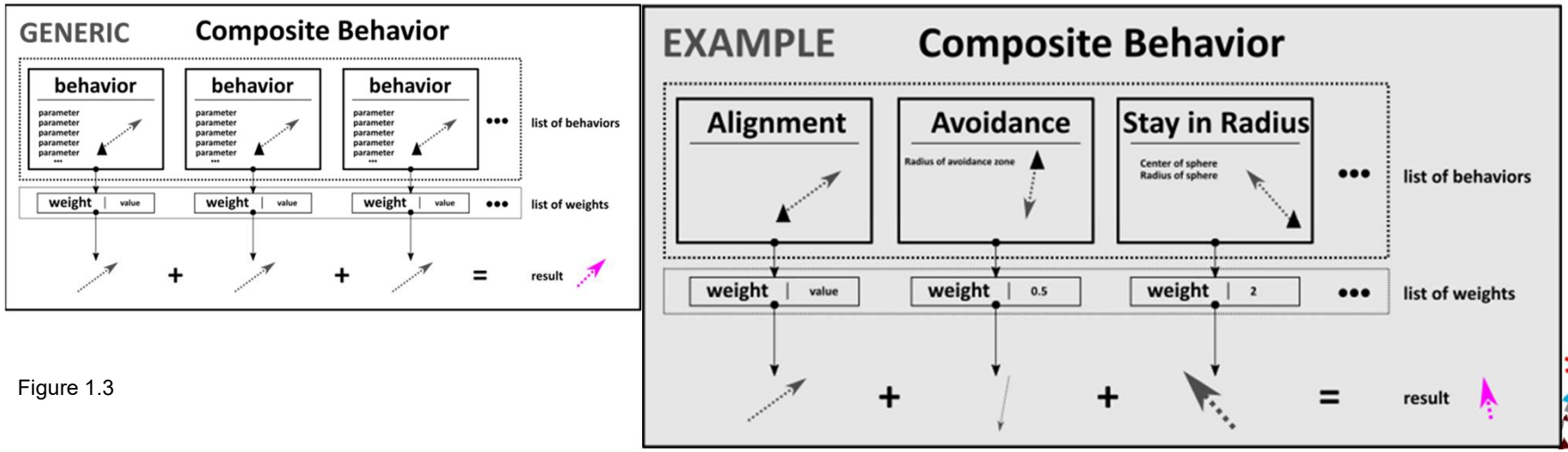



Figure 1.3



Boidance - context | problem | implementation and results | outcomes and discussion

# Flock “Plasmid” Genetic Algorithms parameters

Bioinspired by natural transformation Gregory J. Stewart and Christopher D. Sinigalliano (1990)

## Plasmid Parameters

- Mutation rate
- Mutation range
- Insertion rate
- Elitism threshold
- Lerp function

## Available Plasmids

- Color Plasmid
- Speed Plasmid

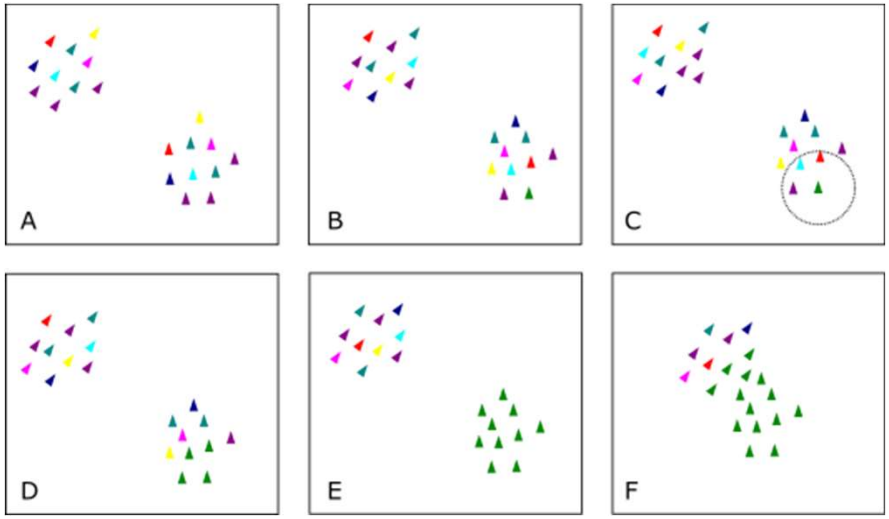



Figure 1.6: Sketch of plasmid genetic algorithm
Transformation radius = sight radius

Context calculation → Complexity: $O(n^2)$, n number of agents

# Generating flocks lead to reach flock equilibriums

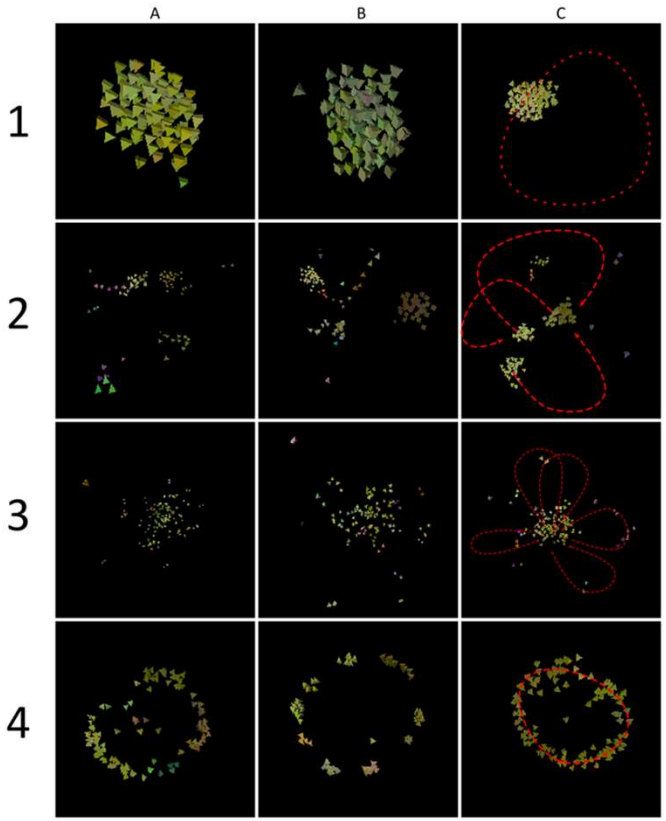
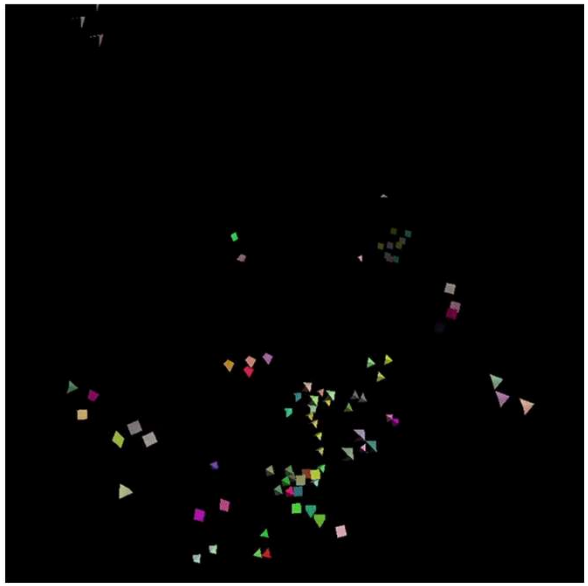



Figure 1.5 - 120 elements



Gif of system 2

| | Alignment | Avoidance | Cohesion | Stay in Radius |
|---|---|---|---|---|
| System 1 | 1 | 50 | 1 | 1 |
| System 2 | 50 | 1 | 1 | 1 |
| System 3 | 1 | 1 | 50 | 1 |
| System 4 | 1 | 5 | 20 | 2 |

Table 1

Emergence of collective dynamical behavior *Couzin et al. (2002)*



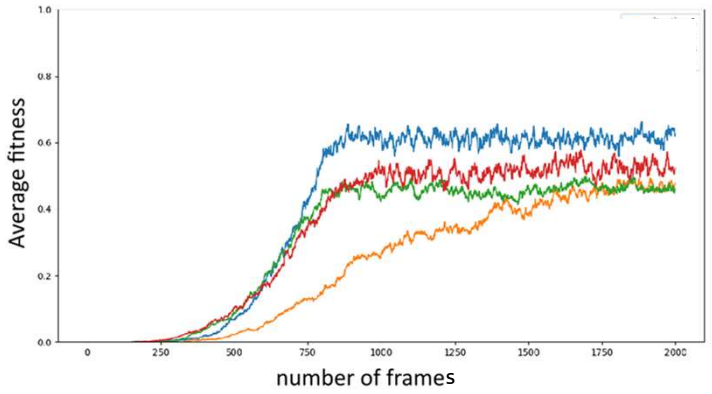
Boidance - context | problem | implementation and results | outcomes and discussion

# Flock behaviors rely on the interdependence between genetic and boids algorithms

Genetic algorithm fitness curve depends on Composite Behavior parameters

| | Alignment | Avoidance | Cohesion | Stay in Radius |
|---|---|---|---|---|
| System 1 | 1 | 50 | 1 | 1 |
| System 2 | 50 | 1 | 1 | 1 |
| System 3 | 1 | 1 | 50 | 1 |
| System 4 | 1 | 5 | 20 | 2 |

Table 1 - Figure 1.7 - 120 agents

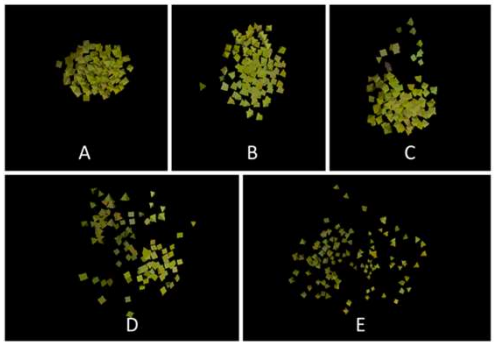



Boids equilibrium depends on Plasmid Genetic Algorithm parameters

| | Mutation Rate | Mutation Range | Insertion rate | Elitism threshold | Lerp time |
|---|---|---|---|---|---|
| Plasmid Color | 0.01 | 0.1 | 1 | 0 | 0.8 |
| Plasmid Speed | 0.01 | x | 1 | 0.6 | 0.8 |

**x = 0.01 (A); 0.1 (B); 0.2(C); 0.3 (D); 0.4 (E)**

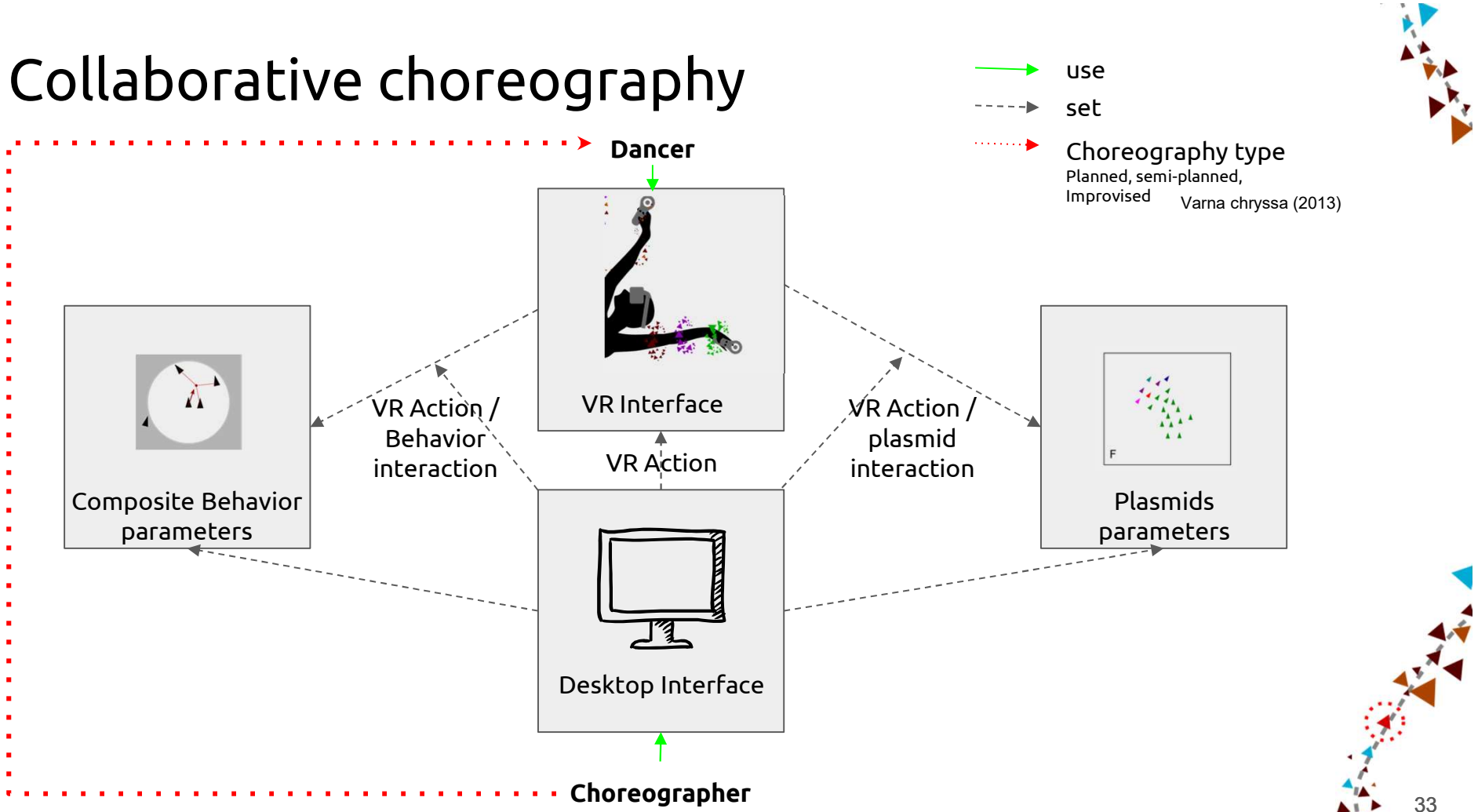
Table 2 - Figure 1.8 - 120 agents



# How to perform a dancer-boids interaction using virtual reality?

2. How to enlarge dancer movement through developing the kinesphere?

# Collaborative choreography



# Development of desktop interface

Development of a desktop and a VR user interfaces

- View parameters
- Gene panel
- Behavior panel
- Plasmid panel
- VR action panel
- Interactions panel
- Saving panel

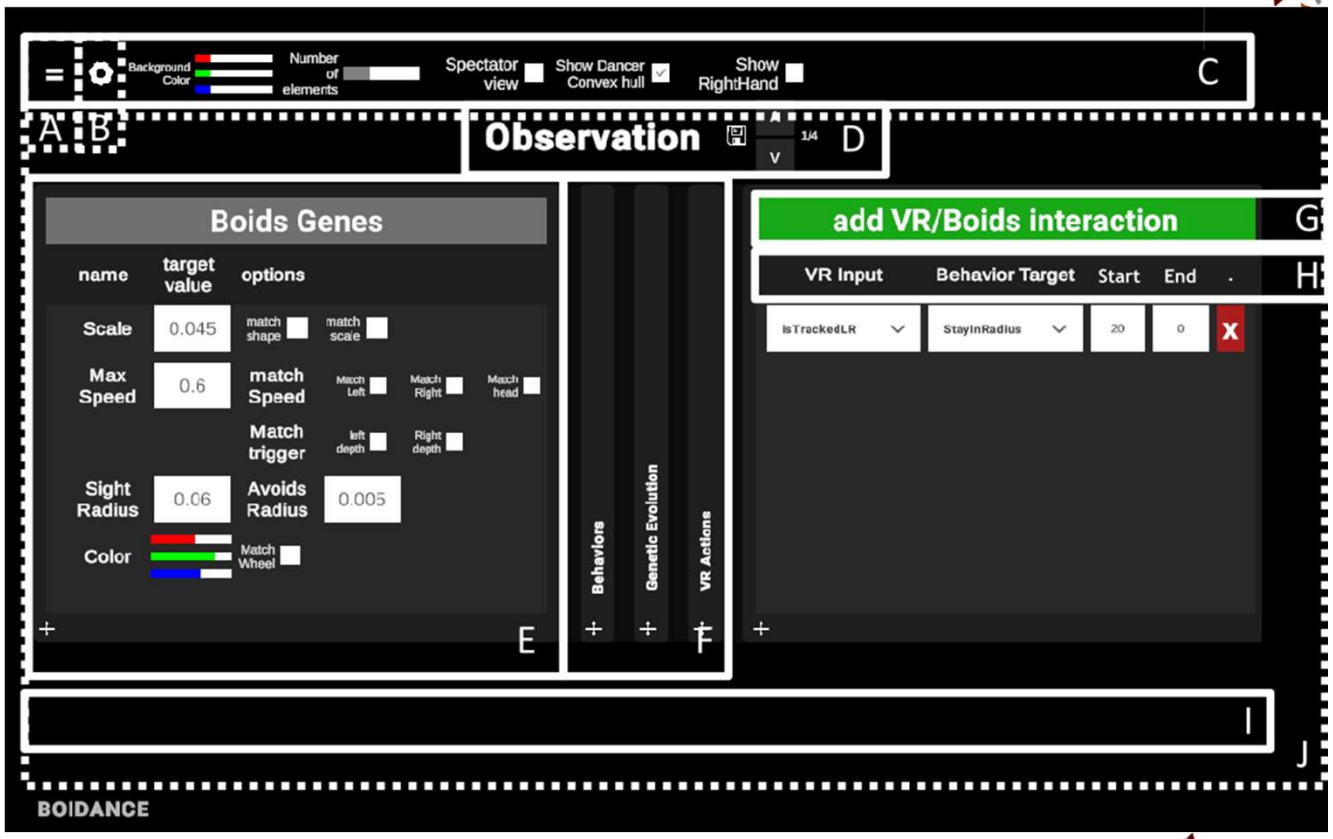



Figure 2.1 : Desktop Interface

# Desktop Interface creates VR Action to interact with the Flock in VR

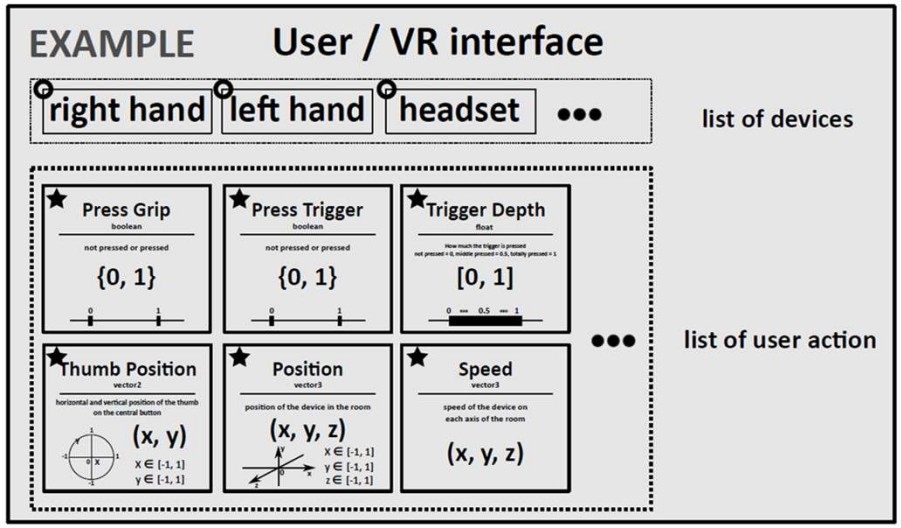



Figure 2.2: VR Action

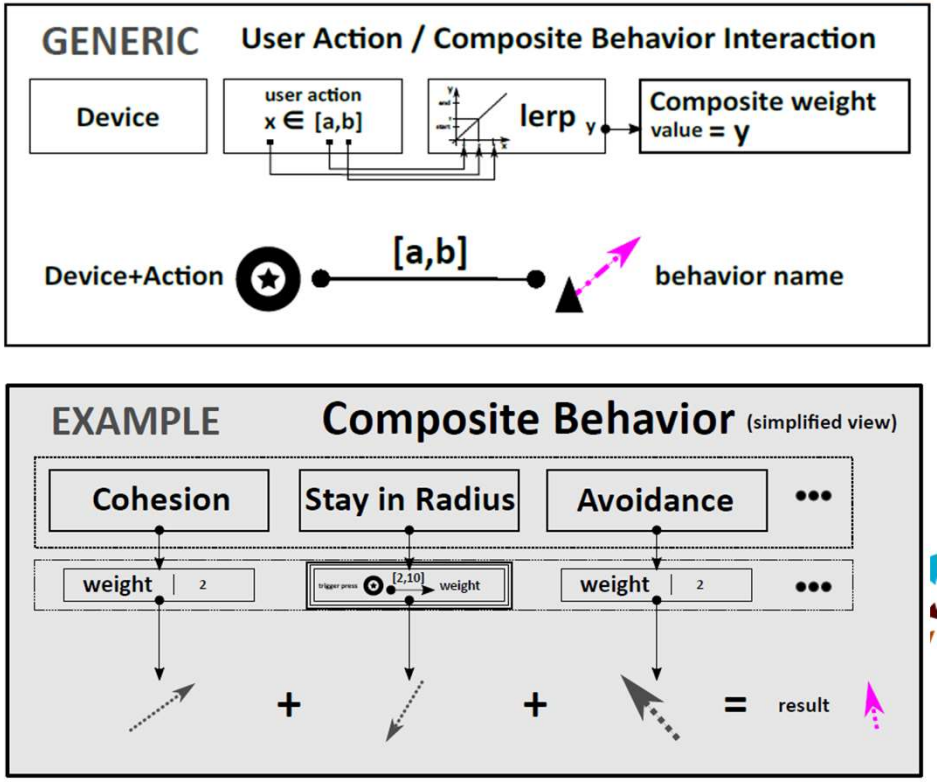



Figure 2.3 : VR Interactions

Robust and customizable

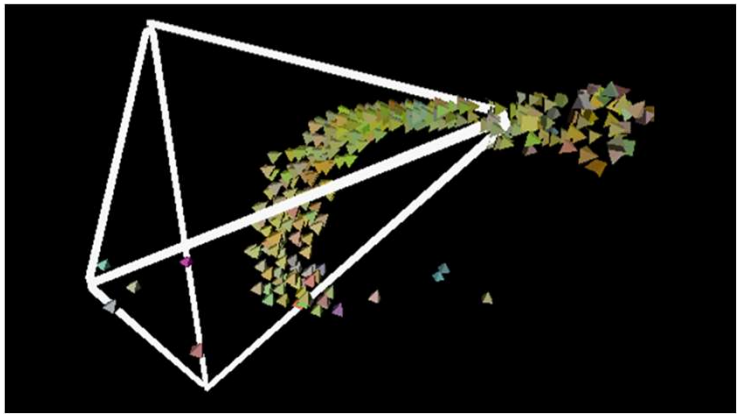
- Unity XR Input API
- Use of C# reflection
- Stored in Vector4 scale by a mask

# The software opens the field of possibilities for the choreographies and to create a unique performance

**Body extension**
Preferences

- Speed plasmid high variability
- Avoidance, Alignment, Cohesion, Follow hand (right left)
- Increase follow when pressing trigger

→ Show local Kinesphere of the dancer

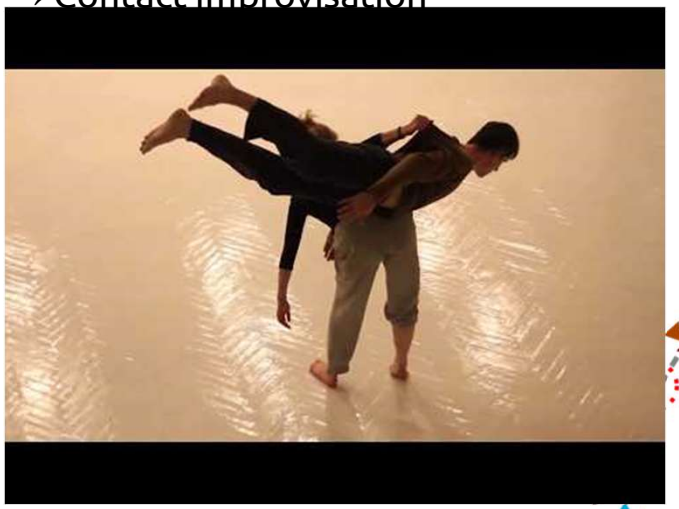


Switch preferences Save System

**Living organism**
Preferences

- Color low variability
- Avoidance, Alignment, Cohesion, Follow head, obstacle=convex hull
- Increase color variability when acceleration

→ Contact improvisation



# Conclusion

- A boid and a genetic algorithms were developed to simulate complex behaviors found in biological flocks.
- Flocks adopt behaviors that lead to equilibriums, relying on the interdependence between genetic and boids algorithms.

# Conclusion

- *Boidance* allows to enlarge the dancer kinsphere through :
  - the development of user VR/Desktop interfaces permitting two users to change initial preferences if wanted, on the fly
  - The bidirectional interactions (according to the type of choreography) between the dancer and the flocks, allowing the dancer to play with the flocks as it was a living organism or body extension
  - The number of possible choregraphies and switch between them

# Perspectives

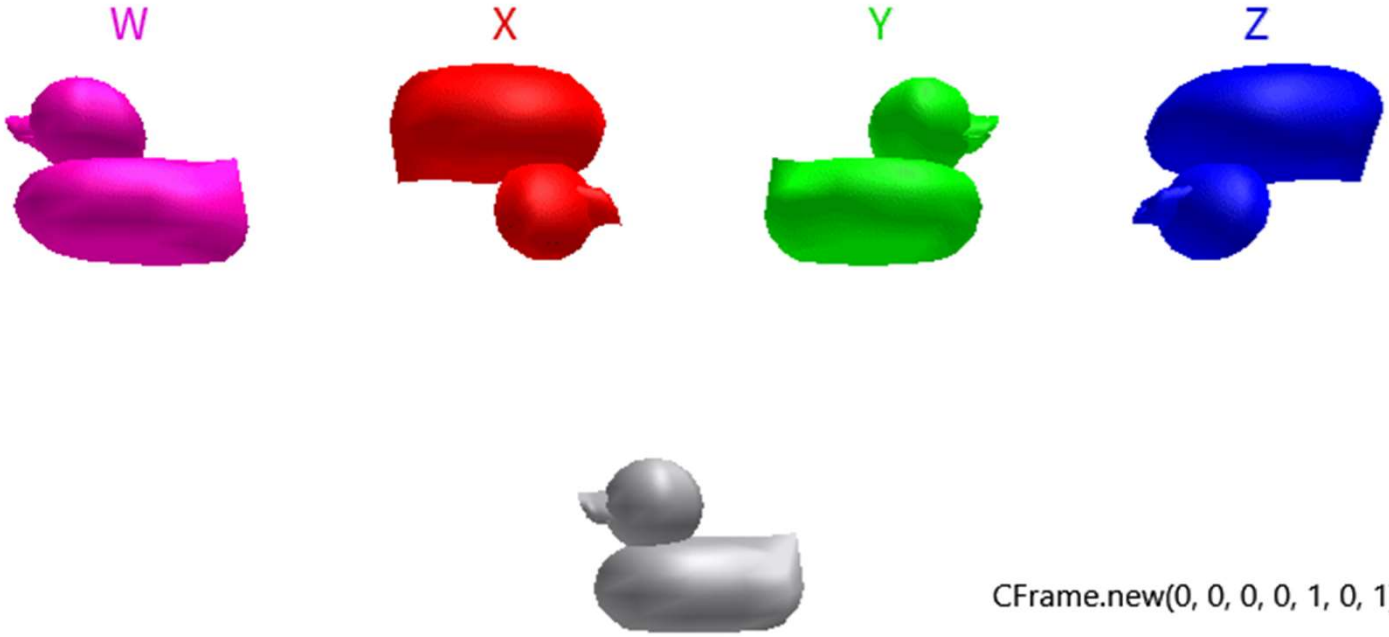
## Experimentation

- More dance theory
  - Shape, body, effort…
  - Cunningham theory
- Learning tool
- Equilibrium and Dance
- Create a flock movement analysis?

## Performances

- Audience interaction
- Virtual and Real performances
- Mixed Reality movies

# Quaternion




https://scriptinghelpers.org/blog/how-to-think-about-quaternions

# Previous exploration in Dance and VR



https://www.ceciliasweetcoll.com/anicca-vr

# Previous exploration in Dance and boids

Jean-François Le Maréchal, Eric Bertin, and Michel Hallet-Eghayan. Science and dance collective motions. page 11. (2009)

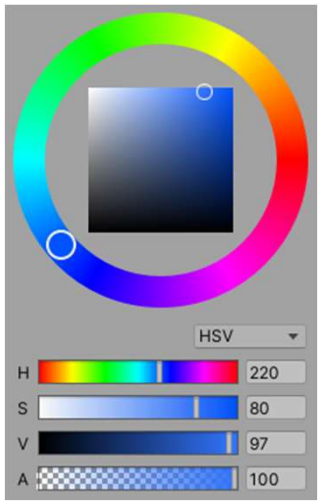
Boidance - context | problem | implementation and results | outcomes and discussion

# Choreography

Varna chryssa (2013)

| Planned choreography | Semi planned choreography | Improvised choreography |
| --- | --- | --- |
| • Automaton | • Rules as reaction to input (choreographer or other dancer) | • Open space<br>• Set of open constraints<br>• choice |

# Boids Genes


HSV
H
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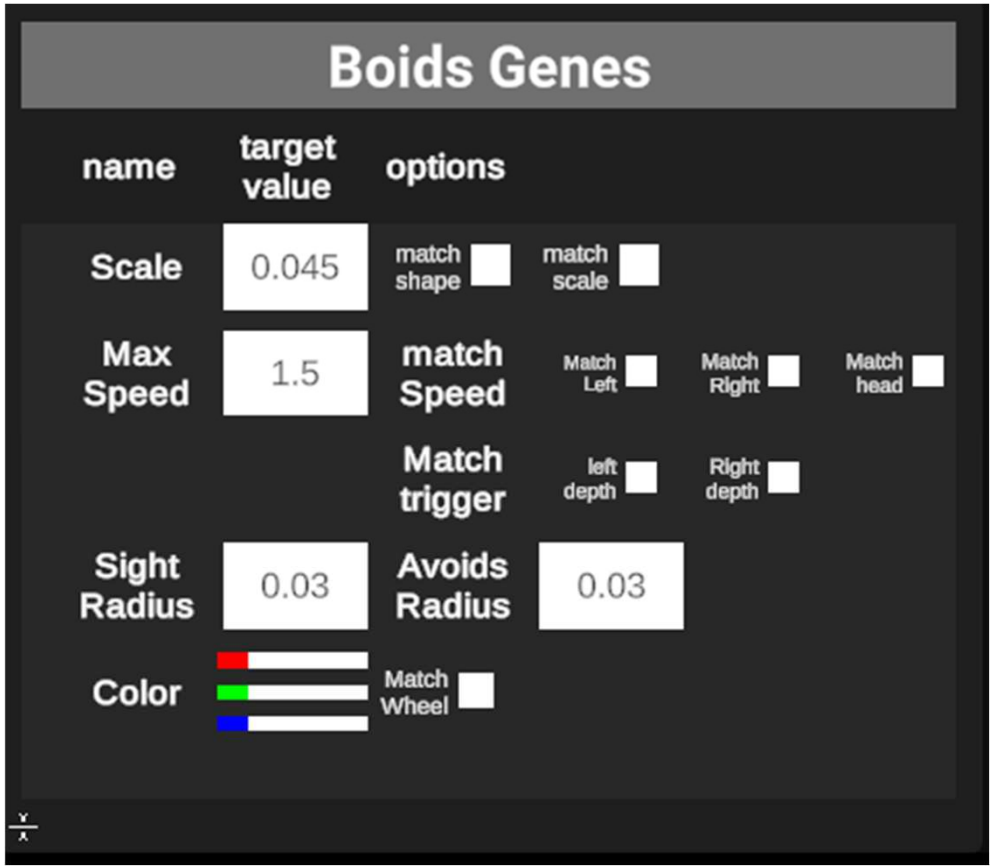
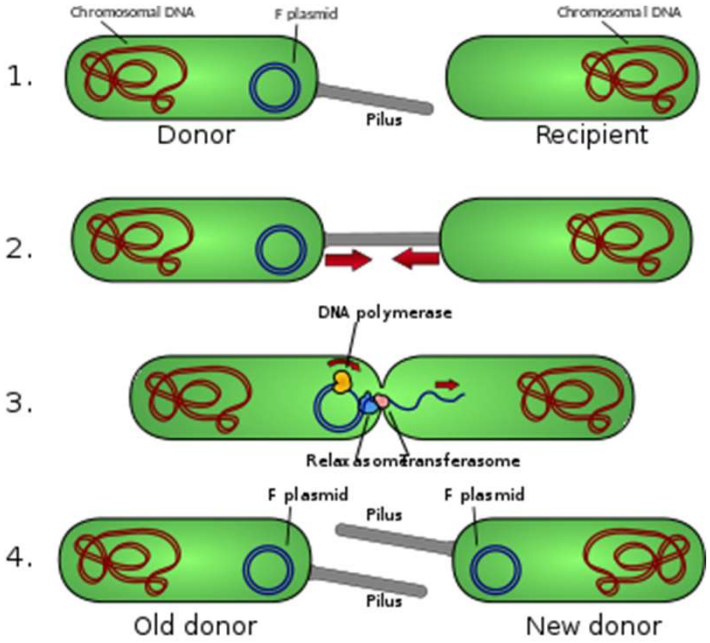
97
A
100

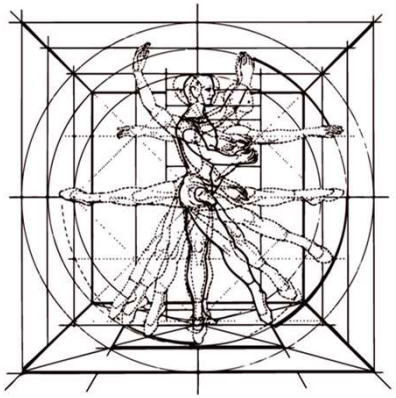

Boids Genes
name
target value
options
Scale
0.045
match shape
match scale
Max Speed
1.5
match Speed
Match Left
Match Right
Match head
Match trigger
left depth
Right depth
Sight Radius
0.03
Avoids Radius
0.03
Color
Match Wheel

# Plasmid



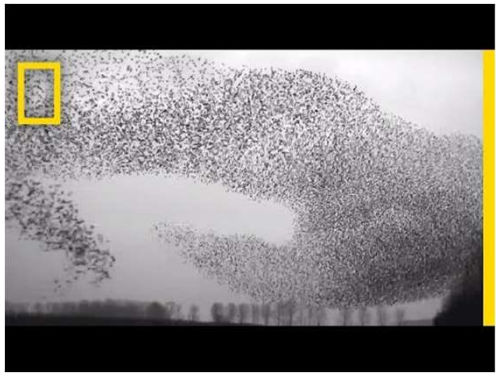

From wikipedia - Pilus

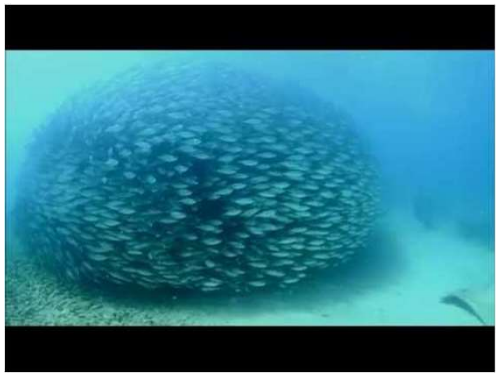
# Some Dance Theory?



Kinesphere

- Von Laban
- Gilles Jobin
  - VR theater
- Merce Cunningham
  - Art standalone in same place
  - Strategy of chance and randomness
  - Show dance through screen





https://twitter.com/biolocousb/status/1297403469096198144



Boidance - context | problem | implementation and results | outcomes and discussion

# First contact with Boidance

| Observation Equilibrium | Behavior Interaction | User Interaction | Multi-Experience Setup |
|---|---|---|---|
| Observe 150+ element group around the center of the room | Change the stay in radius weight from 1 to 0 using both trigger | Press left trigger to make the boids follow the left hand | + Match vertical left hand axis<br>+ Match speed<br>+ Match color wheel<br>+ Follow left hand<br>+ Depth speed<br>+ Match shape |





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# Unsolved problems

## Scroll wheel doesn't work with Screen Space overlay + XRUI Input Module

https://answers.unity.com/questions/1752354/scroll-wheel-doesnt-work-with-screen-space-overlay.html