ENVIRONMENTAL MODELLING
a multidimensional approach

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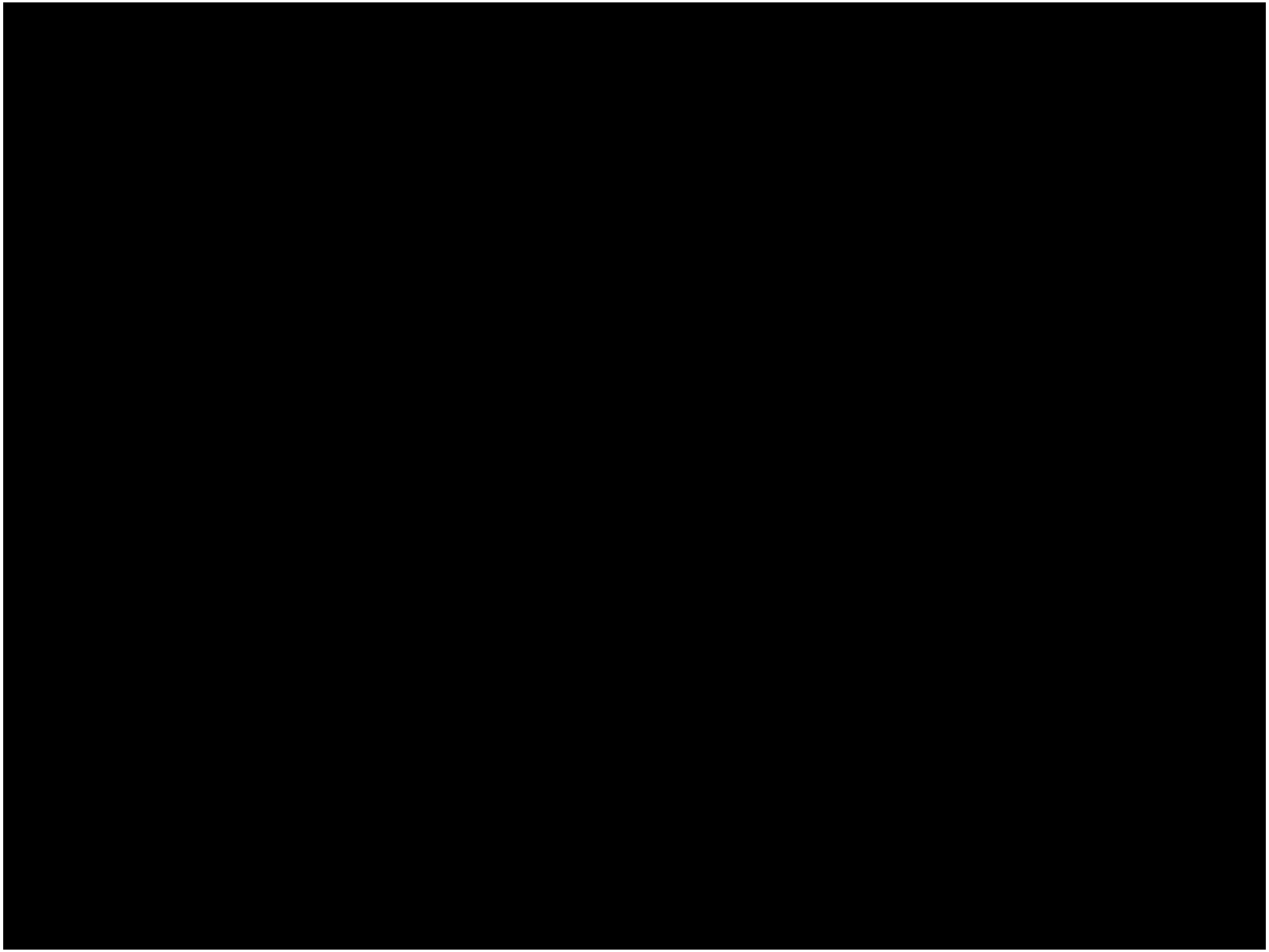
November-December, 2022



https://youtu.be/tzOgAX11vi0

Environmental modelling

a multi-dimensional approach

A bird-eye view of environmental modelling & software

Words, numbers and pictures

Real, augmented and virtual worlds

Humans, machines and Nature

A bird-eye view of environmental modelling

See slide decks on:

Environmental sensors

Environmental data sources

Environmental models

Environmental software

Words, numbers and pictures

Vannevar Bush “As we may think”

Norbert Wiener “Cybernetics”

Jay Forrester “Industrial Dynamics”

Ted Nelson, Hypertext

Will Wright, SimCity

Tim Berners Lee, World Wide Web

Mosaic and Netscape teams

Words, numbers and pictures

From causal diagrams to multi-dimensional environmental models

Pictorial models (cellular automata and unorthodox models)

Introducing artificial life, genetic programming and agent based models

Words, numbers and pictures

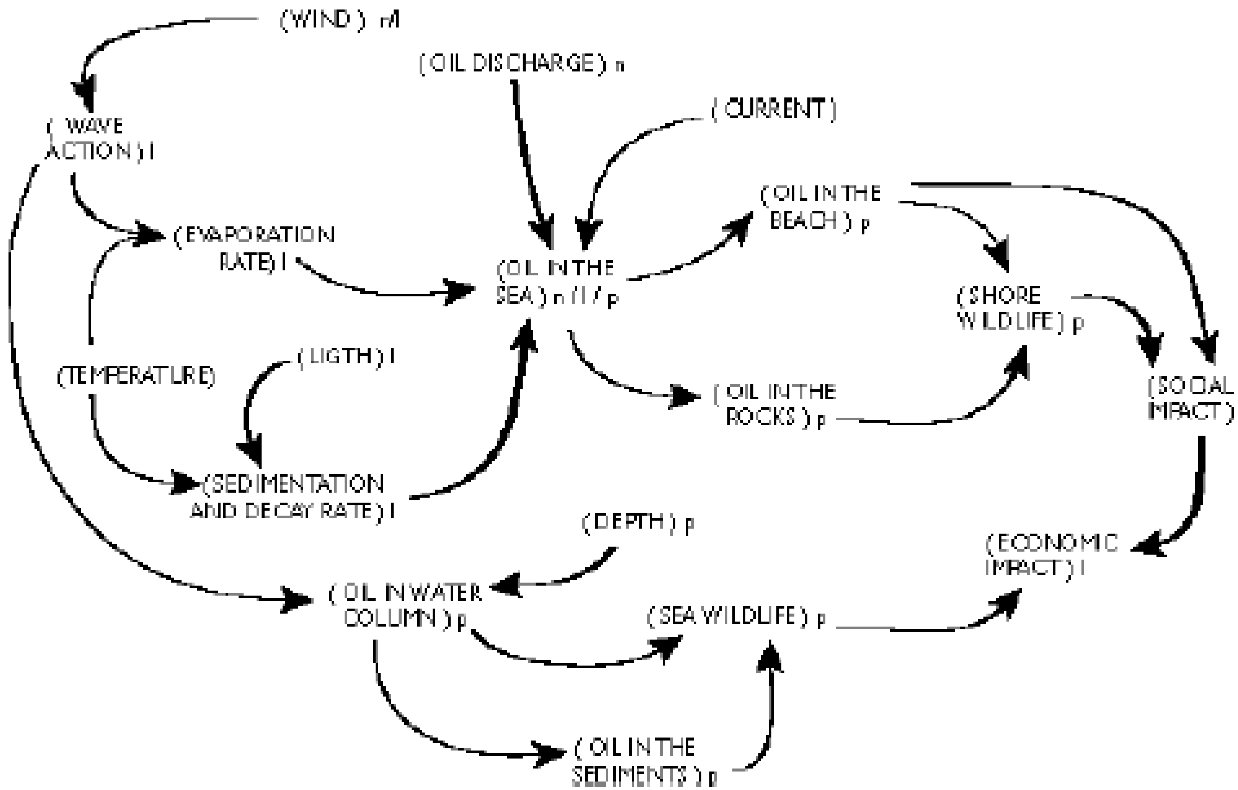
Abstract concepts can only be represented by words

Numbers provide precision

Pictures provide holistic representations

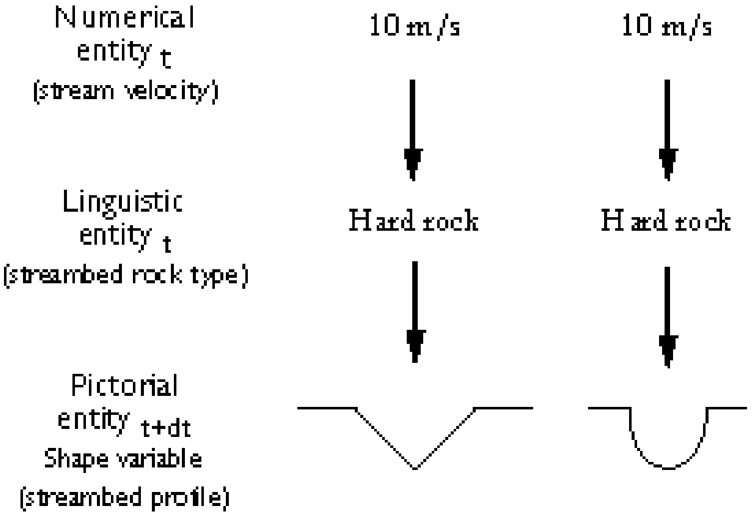
Pictures can be decoded into numbers

From a verbal description to a causal diagram

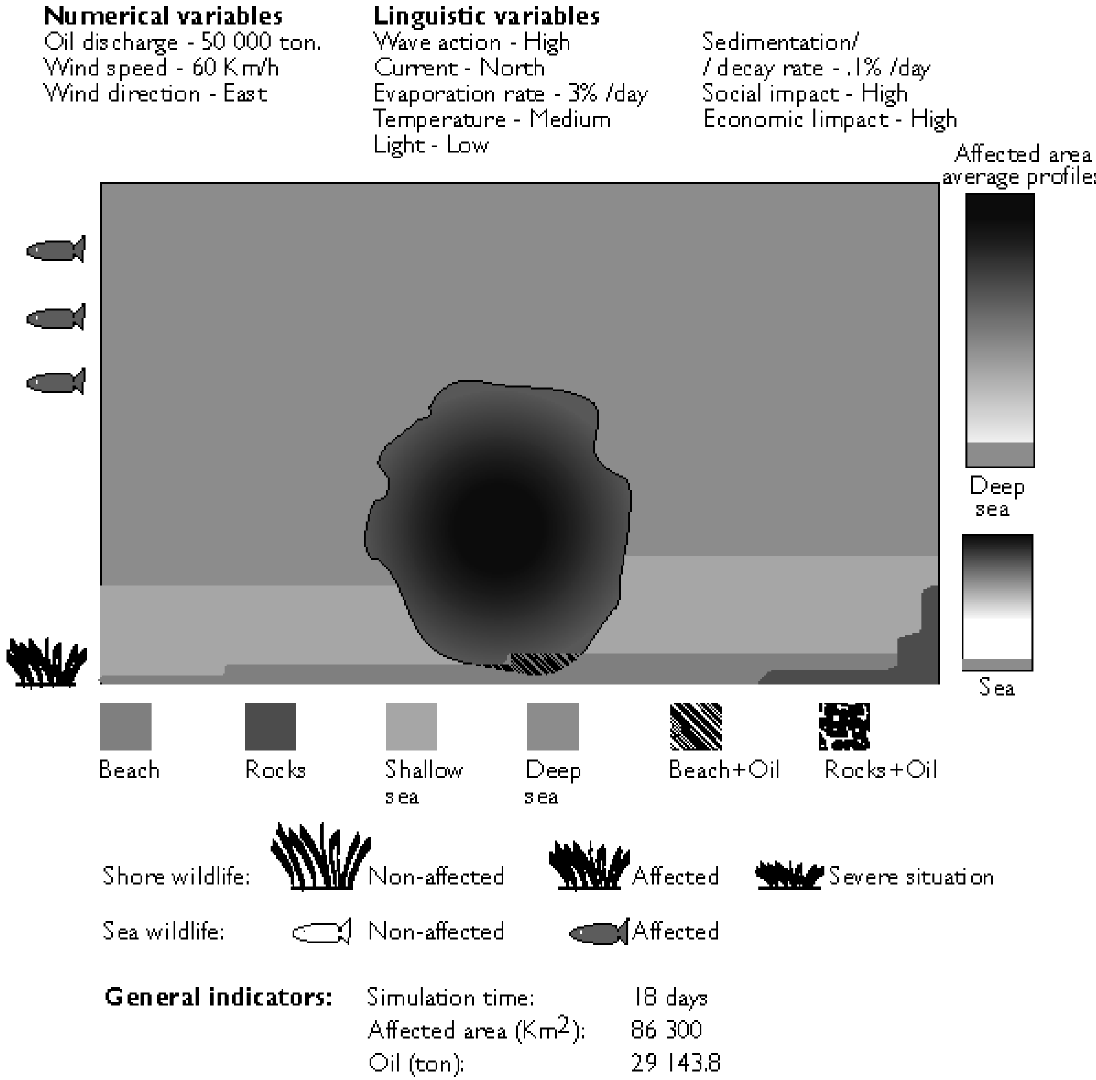


Multidimensional simulation

Numerical model as a driver complemented by qualitative relationships



Multidimensional simulation



From (partial) differential equations to cellular automata

"First (a) we stylize physics into differential equations, then (b) we force these equations into the mold of discrete space and time and truncate the resulting power series, so as to arrive to finite difference equations, and finally, in order to commit the latter to algorithms, (c) we project real valued variables on to finite computer words (round-off). At the end, we find the computer-again a physical system"

Tommaso Toffoli, 1984

Cellular Automata

Introduction

Cellular automata and differential equations

Implementation of cellular automata models

Applications

Unorthodox developments

Introduction

Uni, bi or tridimensional space divided into cells

Each cell may assume a finite set of values

The values of each cell are changed through transition rules (from t to t+dt)

Introduction

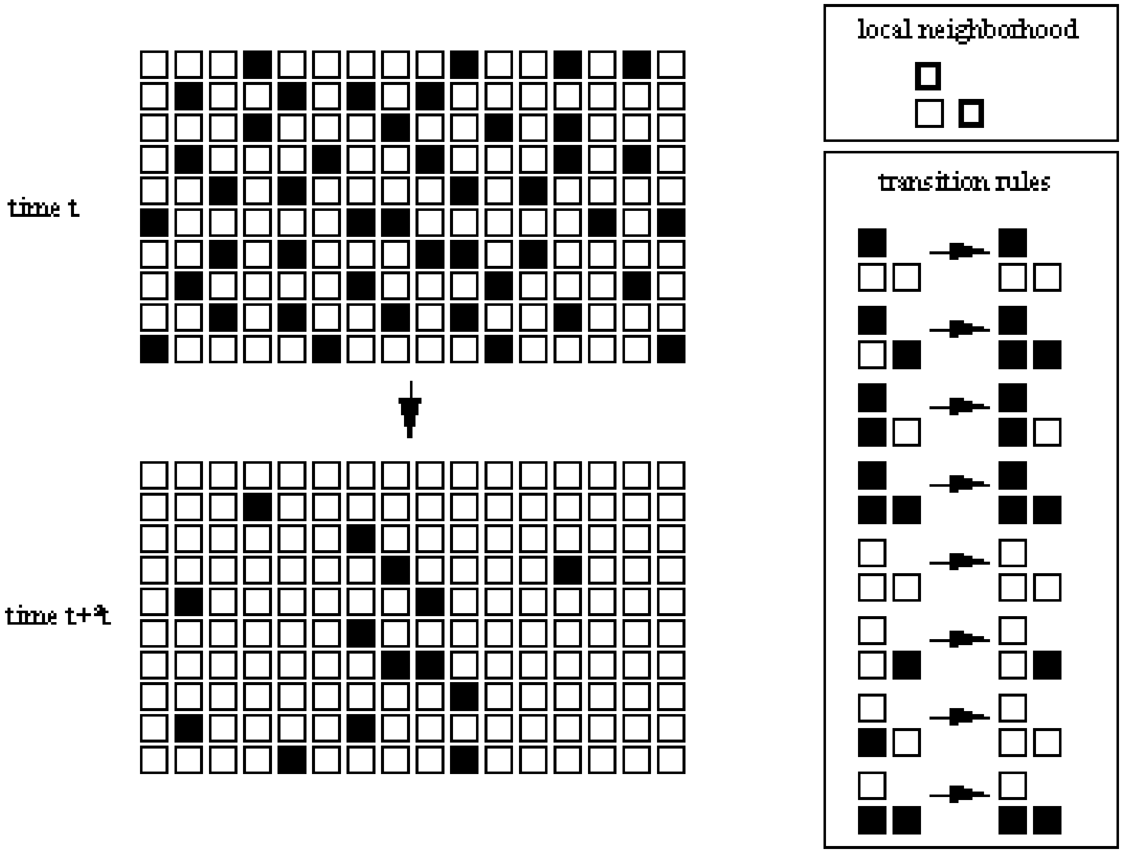
Transition rules

Local

Synchronous, but asynchronous dynamics can be considered when evaluating the cells cyclically or according to a stochastic procedure

Introduction

Examples of transition rules



Introduction

Game of life (John Conway)

Transition rules (value 0- dead cell; value 1- cell alive)

Number of live neighbors	status at t+dt
2	does not change
3	alive
0, 1, 4, 5, 6, 7, 8	dead

Introduction

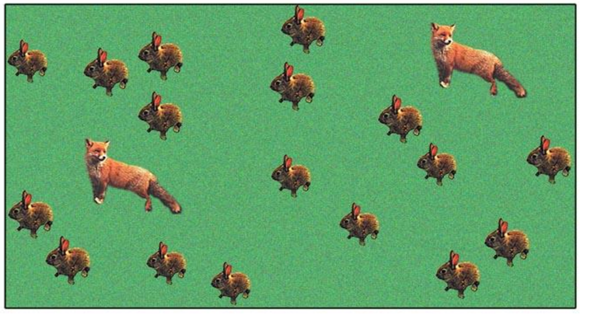
Other types of CA models:

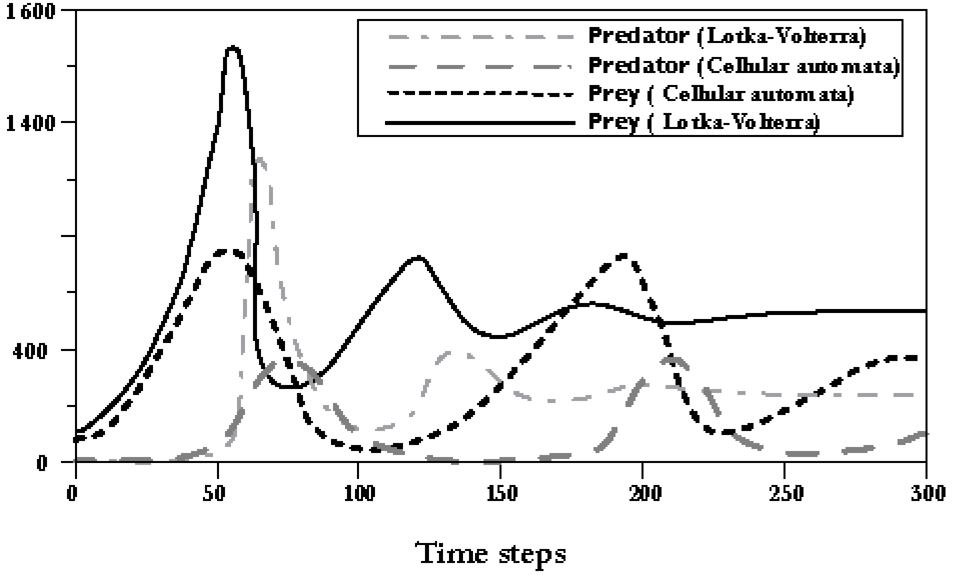
Lattice Gas system. Particles move in a medium (whether randomly or deterministically) over a discrete lattice and undergo state changes when they collide

In biology, these models are called Mobile Cellular Automata. Ant colonies have been described with such models: a ants nest is treated as a grid, with the ants occupying lattice points

Applications

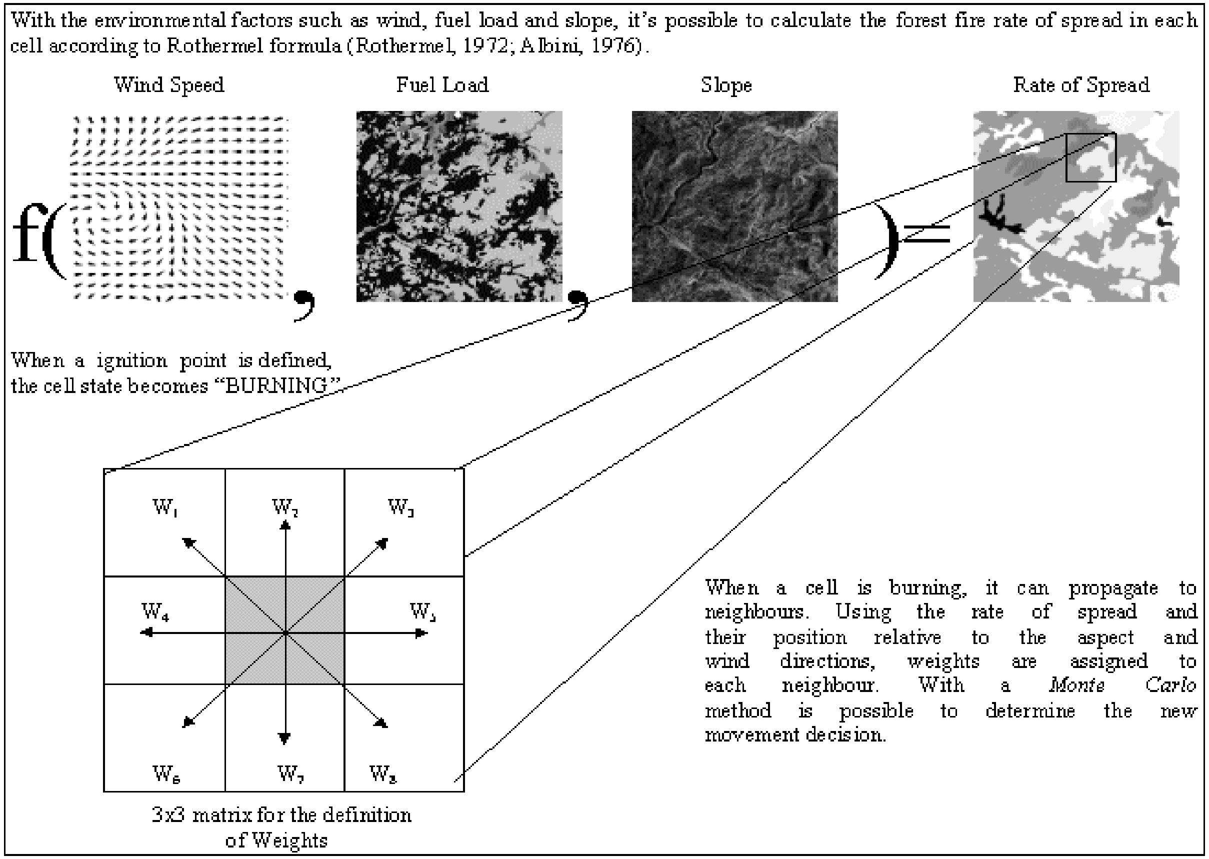
Predator-prey models





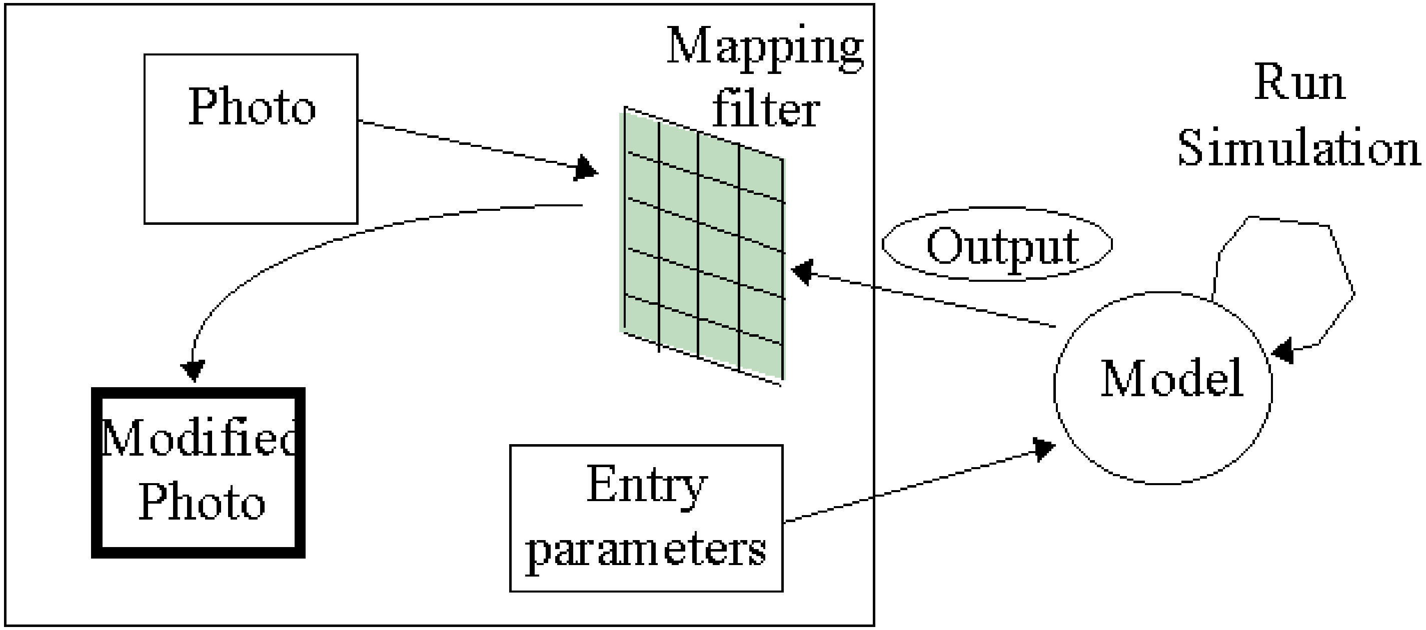
Applications

Forest fire modelling



Applications

CA models running on aerial photos (oil spills)



Unorthodox developments

Pictorial simulation

Live sketching

Programming by reproduction and interactive video

Multidimensional simulation

Pictorial simulation

Objects may be pictographs, signs or symbols

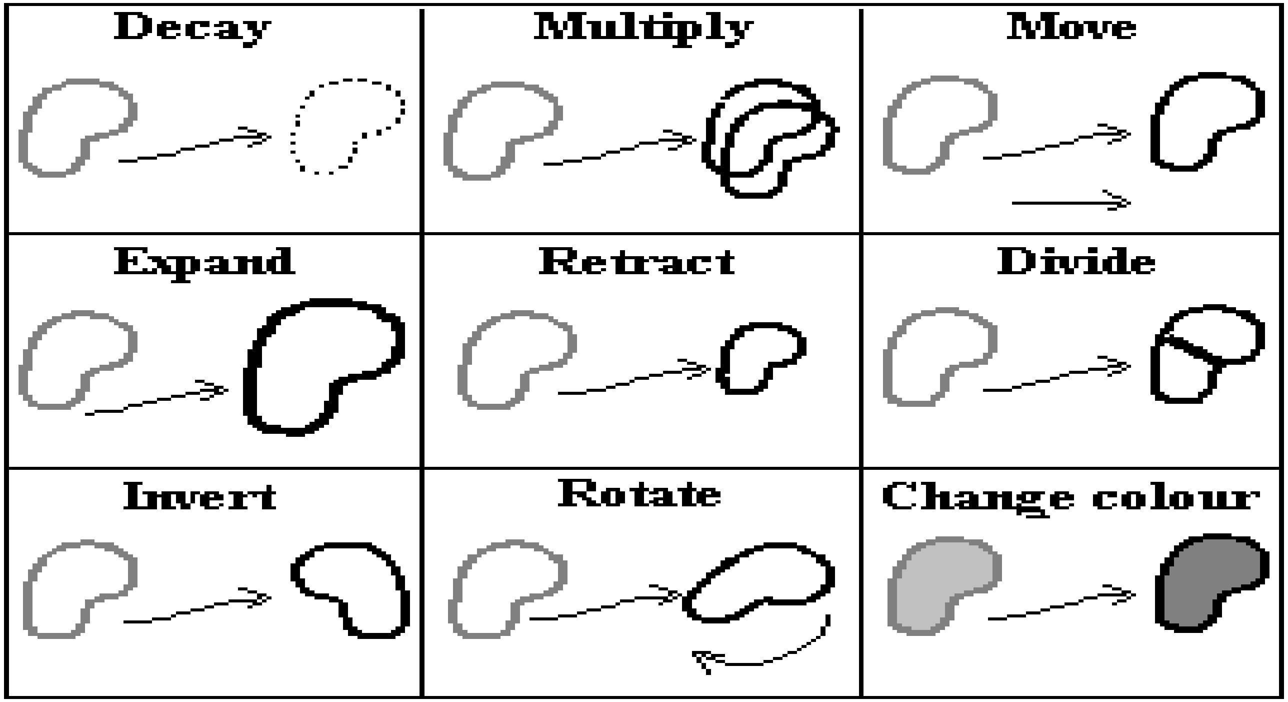
They may be described by their color, position, size and position

Transition rules may include behavior and interaction rules

Boundary conditions: donut, barrier, unlimited

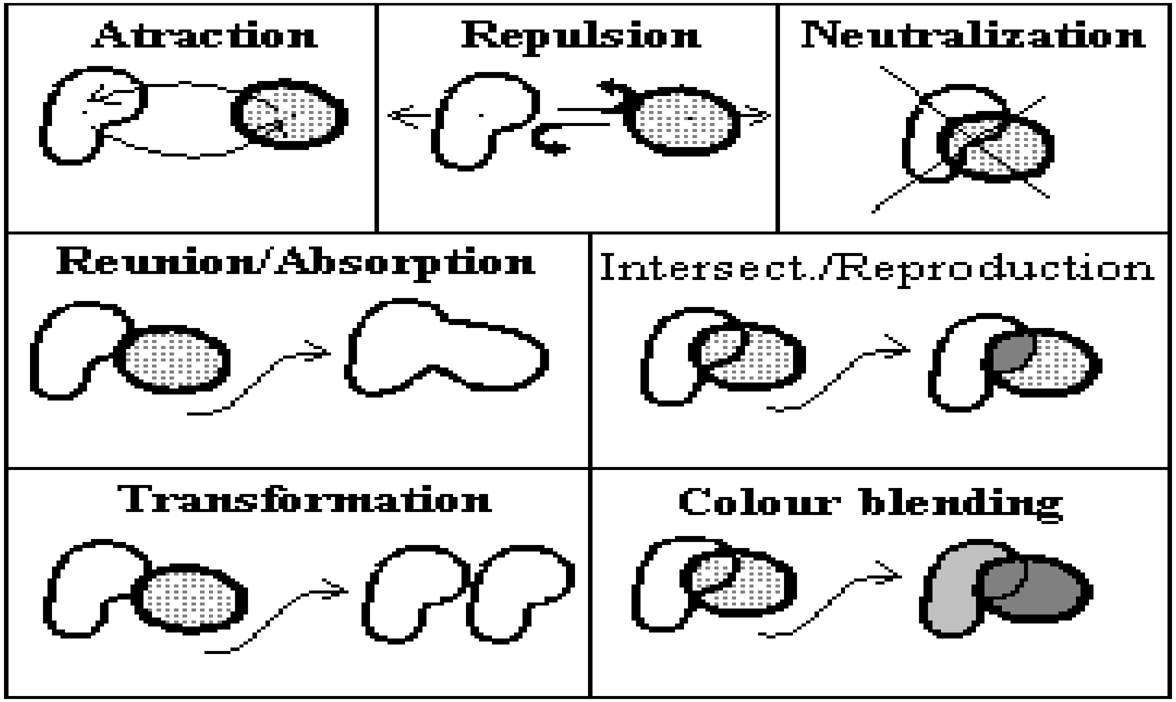
Pictorial simulation

Behavior rules

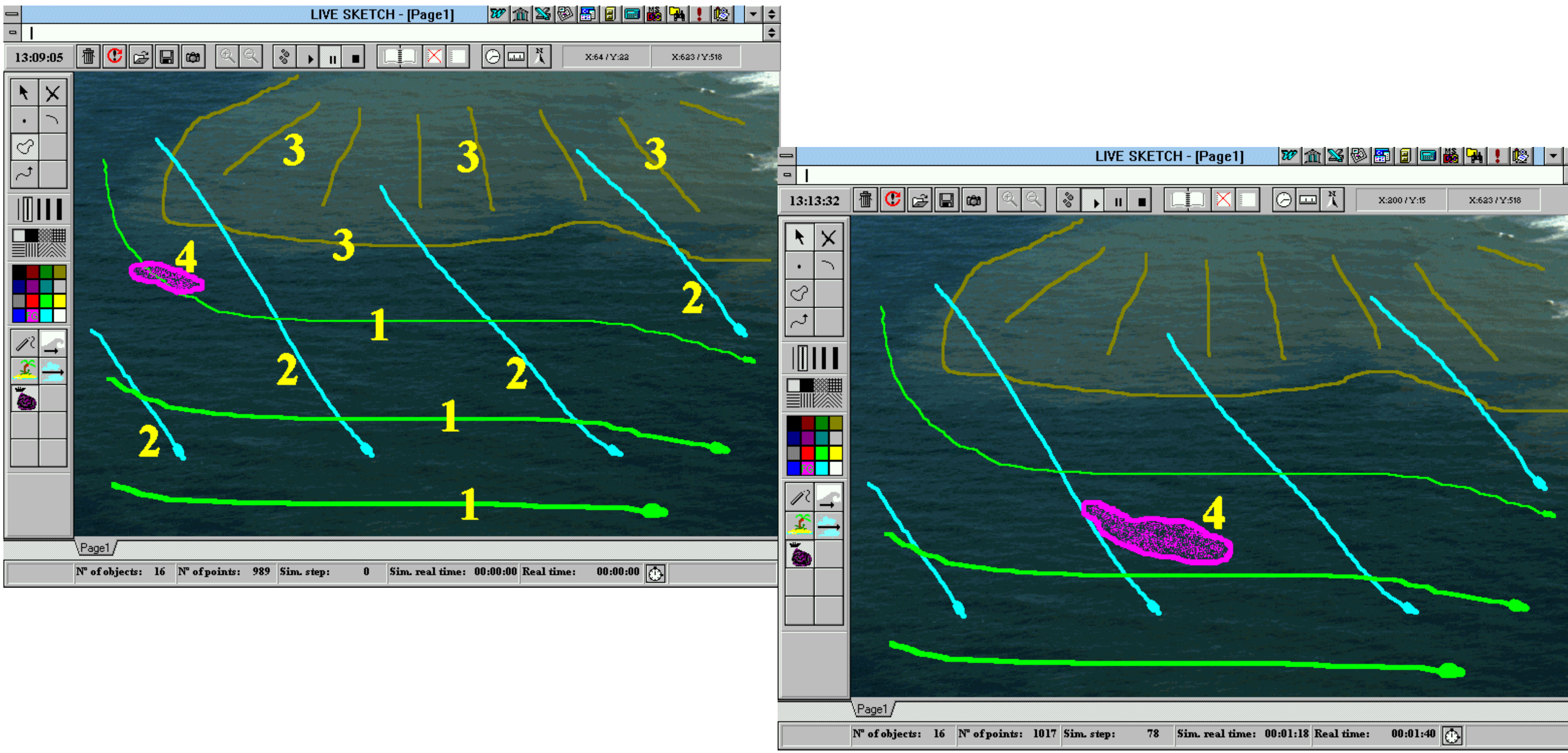


Pictorial simulation

Interaction rules



Live sketching



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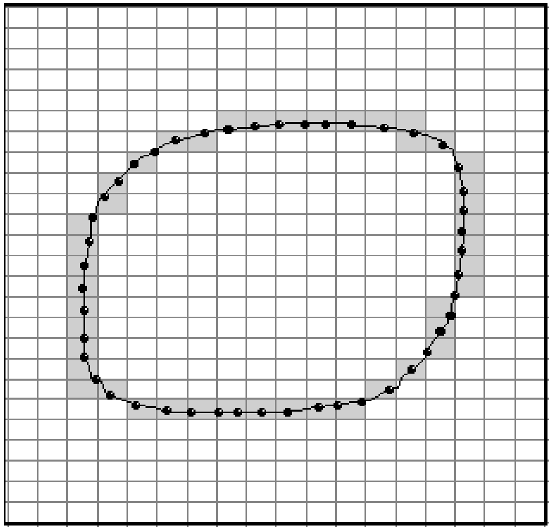

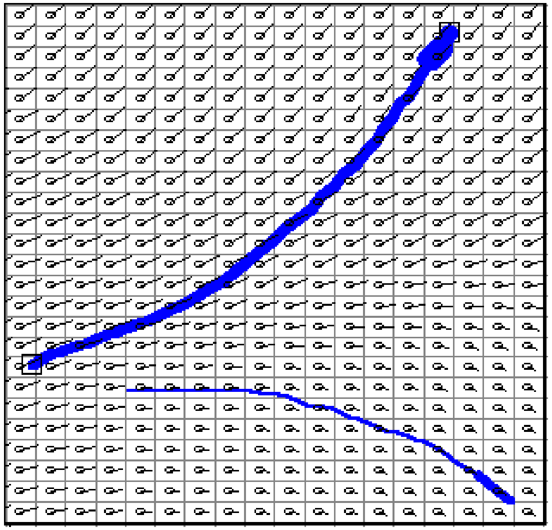

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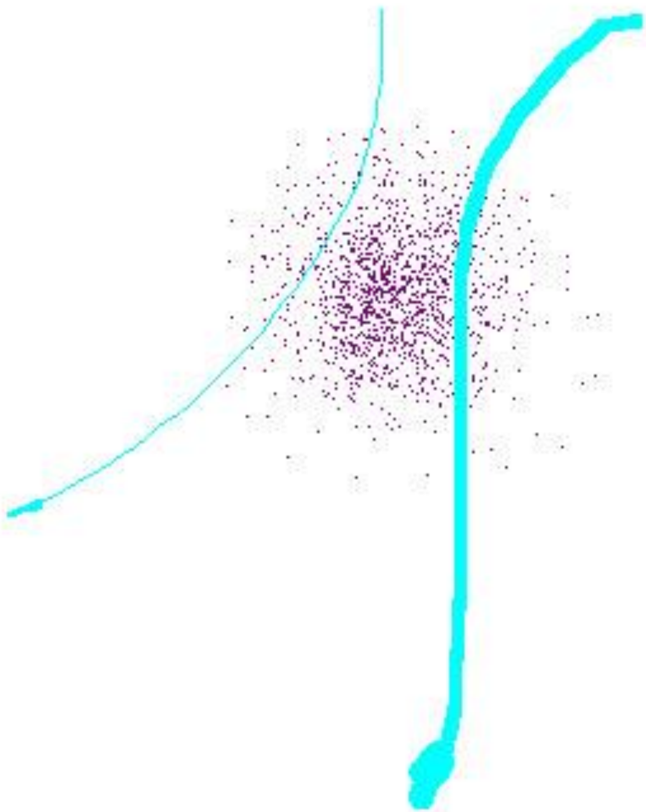
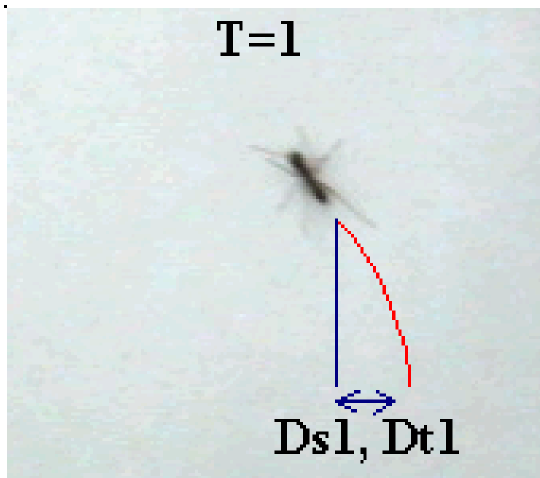
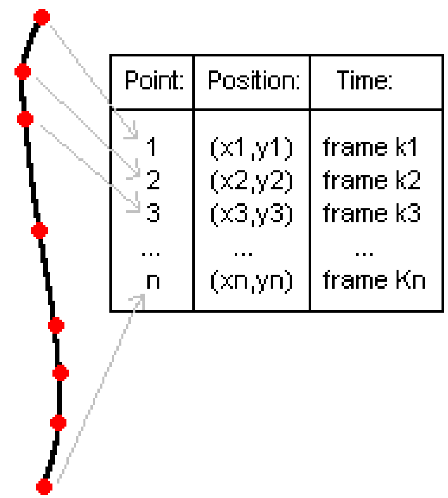


Programming by reproduction and interactive video





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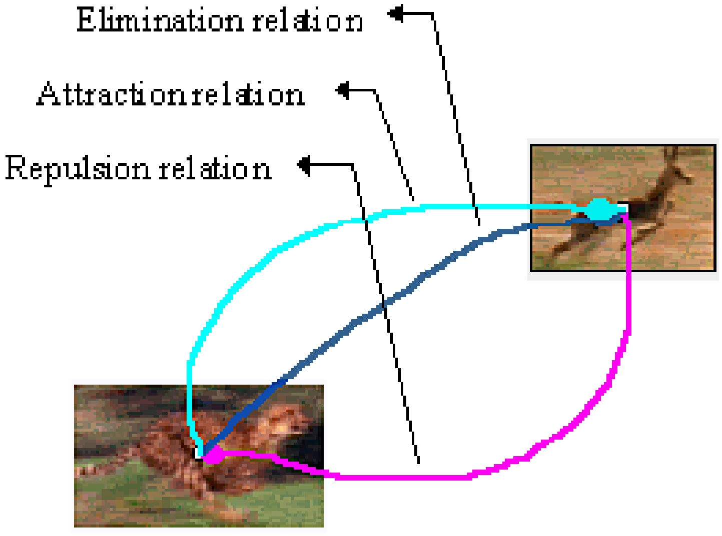

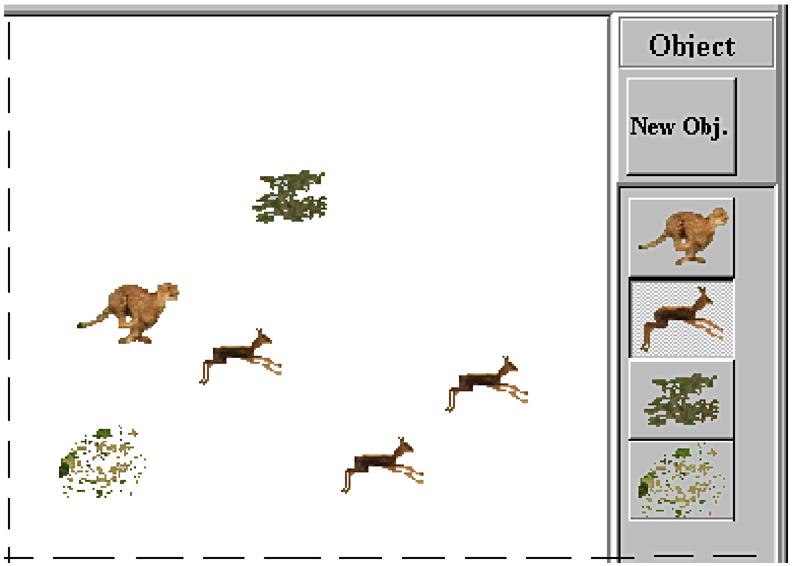

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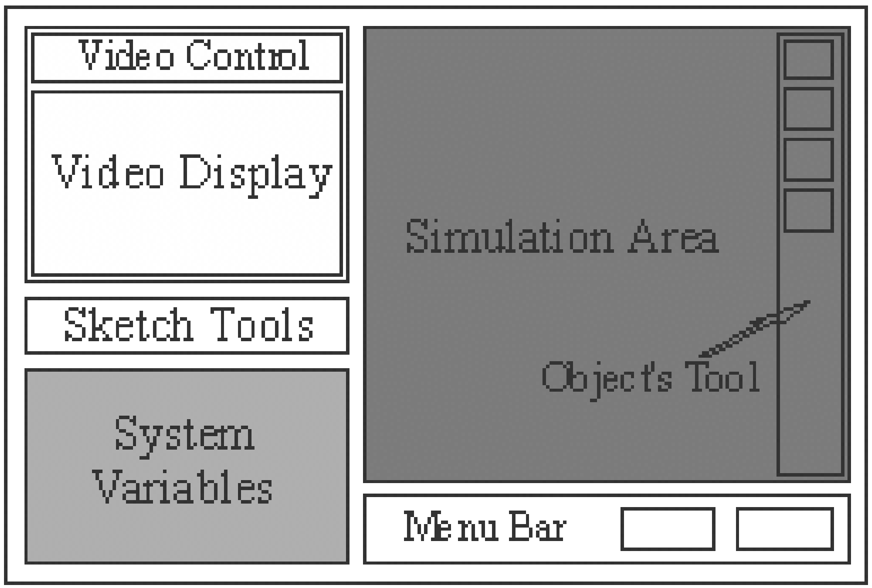

Artificial life

- Soft
  - Virus
  - Virtual Pets
  - Cellular automata
  - Genetic programming
  - Agent based modelling
- Physical objects
  - Robots

Genetic programming

Karl Sims

https://www.youtube.com/watch?v=bBt0imn77Zg

Agent based modelling

https://www.youtube.com/watch?v=UaC0UoakO7k

References

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