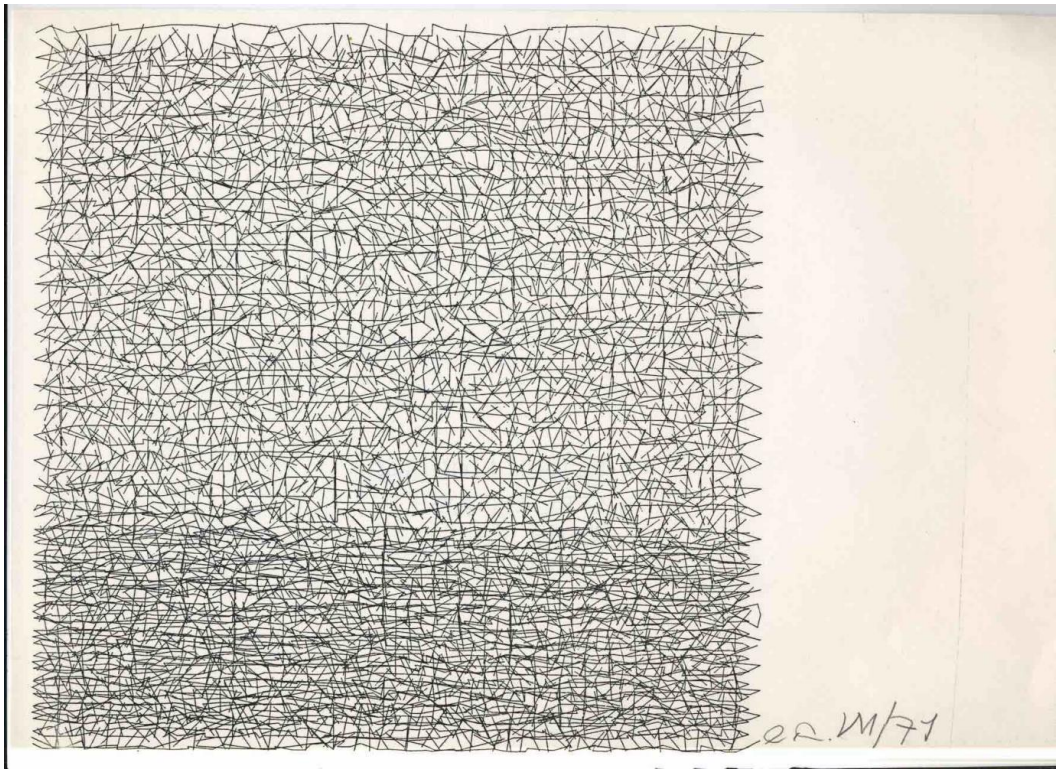
《数字艺术的先驱：AI 与计算机艺术创作的经典案例》

资料说明：

本文件汇集了多位计算机艺术与人工智能领域先锋艺术家的经典作品及其创作背景与过程。资料由伦敦大学金史密斯学院计算机系教授、“Creative Machine / 跨越六十年：人工智能的创意之火”联合策展人兼参展艺术家威廉·雷森（William Latham）和作家、翻译家赋明理（Miriam Frendo）提供，专为“2024—2025 北京中学生 AI 数字艺术挑战项目”设计使用。

资料中的作品均在泰康美术馆“Creative Machine / 跨越六十年：人工智能的创意之火”展览中展出，希望参与挑战项目的同学们来到现场，近距离观察作品，感受数字艺术的魅力。



Vera Molnar，《网络》1971，计算机印刷，19x19cm，由数字艺术博物馆提供

Vera Molnar

Vera Molnar 1924 年出生于匈牙利，是计算机艺术的早期先驱。她对基本形状着迷，曾解释说：“我的生活就是方块、三角形和线条。”

在 20 世纪 40 年代和 50 年代，她学习绘画，并创作抽象艺术。

然而，在 1960 年代，她开始发展她激进的基于系统的方法。当她创作一个系列时，她会遵循一系列指示和自我施加的限制，系统地手工处理所有可能的排列。所以说，她实质上是把自己的大脑当成了一台电脑！事实上，她将用于实现算法程序的方法称为“想象机器”。

后来，她开始使用真正的计算机和早期的编程语言 Fortran，这使她能够将无尽的算法变化输入计算机，使用 0 和 1 的语言。然后这些被输出到绘图仪，由移动的笔产生线描图。

她还探索了秩序与混乱之间的滑动，故意引入“1%的混乱”以获得一点点——但不是太多——随机性进入她的作品。

Vera 去年去世，享年 99 岁。

作品“网格”是她最早的计算机艺术作品之一，创作于 1971 年。

Vera Molnar
Born in Hungary in 1924, Vera Molnar was an early pioneer of computer art. She was fascinated by elementary forms and once explained 'My life is in squares, triangles, lines.’

Coming from a fine art background, in the 1940s and 50s she created abstract art.

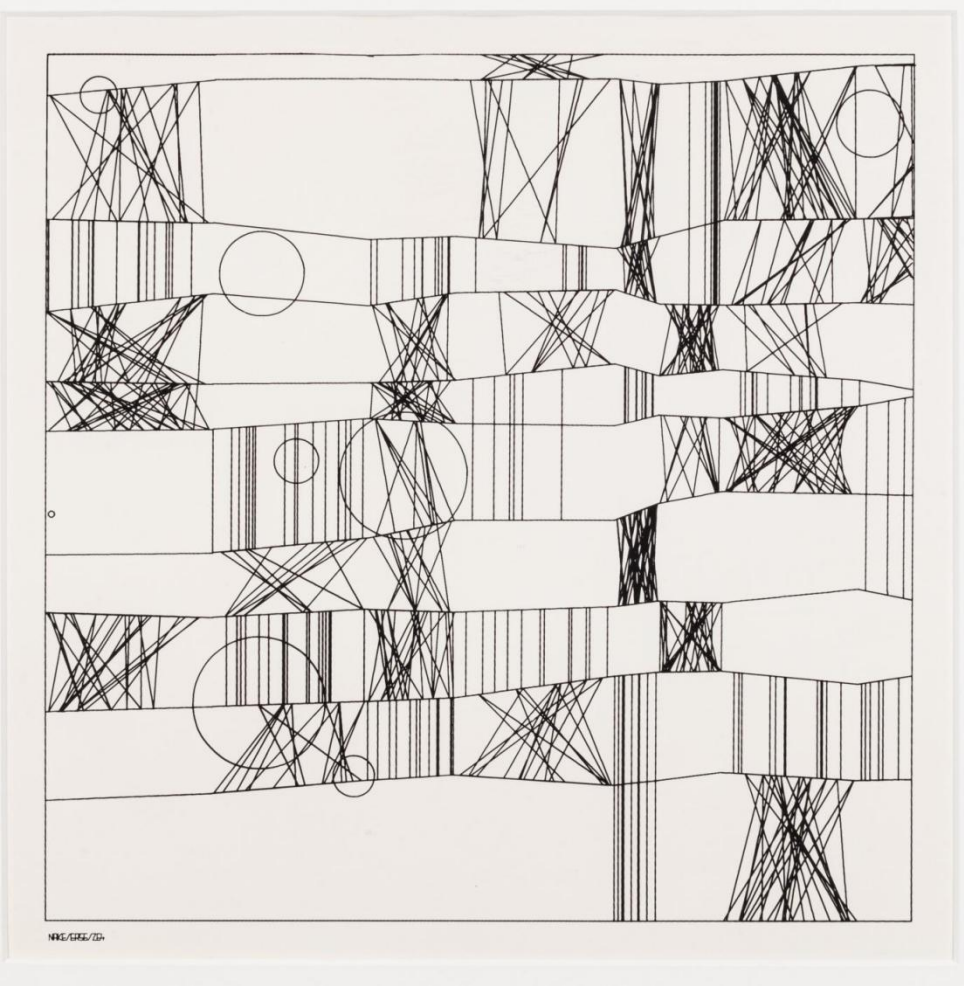
However, in the 1960’s she began to develop her radical systems-based approach. When she created a series, she would work systematically through all the possible permutations by hand, following a sequence of instructions and self-imposed limitations. Thus, she was essentially using her brain as a computer! In fact she called the method she used for implementing her algorithmic programmes her ‘imaginary machine’.

Later she began to use a real computer and the early programming language Fortran, which allowed her to input endless algorithmic variations into a computer, using a language of 0s and 1s. These were then outputted to a plotter that produced line drawings with a moving pen.

She also explored the slippages between order and chaos, deliberately introducing a '1% disorder' to get a little– but not too much – randomness into her work.

Vera died last year aged 99.

The work "Mesh" is among her earliest Computer Art works and was created in 1971.



Frieder Nake，《像保罗·克利致敬》1965，绘图仪绘画，40x40cm，由数字艺术博物馆提供

Frieder Nake

1938 年出生于德国的 Frieder Nake 也是计算机艺术的先驱。与 Vera 不同，他没有来自艺术背景，而是一位对编程感兴趣的数学家。1963 年，他为 Zuse Graphomat Z64 绘图仪开发了软件，然后使用它来创作他早期的算法艺术作品。1965 年，他在斯图加特的第一次展览标志着数字艺术的一个重要里程碑。

Nake 经常在他的作品中融入偶然元素，如他的随机多边形系列所示，其中之一在这里展示（1965 年的 25265 随机多边形绘图仪绘图）。这些作品通常由一条在随机点弯曲的单线组成，将图形简化为其基本元素。

Nake 的不对称和紧张的构图与今天“干净”的计算机美学观念形成鲜明对比。

Nake 的作品通常也很有趣。致敬克利是指德国艺术家保罗·克利，他以个人风格而闻名，其风格受到表现主义、立体主义和超现实主义的影响，以其色彩理论和将他对音乐的热爱及其音乐性融入他的艺术作品。保罗·克利对 Nake 有重大影响。克利曾将他的艺术描述为“带着一条线去散步”，而 Nake 则以此为对比，将他自己的作品称为“让计算机带着一条线去散步”。

Frieder Nake

Frieder Nake, born in 1938 in Germany is also a pioneer of computer art. Unlike Vera, he did not come from an art background but was a mathematician with an interest in programming. As a student in 1963, he developed software for the Zuse Graphomat Z64 plotter an then used it to create his early algorithmic artworks. His first exhibition in 1965 in Stuttgart marked a significant milestone in digital art.

Nake often incorporates chance elements in his compositions, as seen in his series of random polygons, one of which is shown here (**25265 Random Polygon Plotter drawing from 1965)**. These works, typically consisting of a single line that bends at random points, reduce graphics to their fundamental elements. Nake's asymmetrical and tense compositions stand in stark contrast to today’s notion of a "clean" computer aesthetic.

Nake’s work is also often witty. **Hommage to Klee** refers to German artist Paul Klee, known for his individualist style which shows influences from expressionism, cubism and surrealism, for his colour theory and his incorporation of his love for music and his musicality into his artworks. Paul Klee was a major influence on Nake. Klee has once described his art as “*taking a line for a walk”* and, by contrast, Nake described his own work as “*the computer taking a line for a walk*”.

Desmond Paul Henry，《634 号无题》1962，纸本绘画，49x53cm，由计算机艺术档案馆提供

Desmond Paul Henry

1952 年，Desmond Paul Henry 购买了一台 Sperry Bombsight 模拟计算机，二战期间的轰炸机使用它来计算准确投放炸弹的目标。当时他是曼彻斯特大学（英国）的哲学讲师，同时也是一位业余艺术家，他对机器一直有很浓厚的兴趣。他被计算机内部机械部件的优雅协同工作所吸引。1961 年，他将 Bombsight 计算机改造成 1960 年代建造的三台机电绘图机中的第一台。今天，只有他的第二台绘图机的残余部分保留下来，由伦敦科学博物馆收藏。

Henry 利用 Bombsight 计算机机构的旋转能力来创建绘图机。一个持有笔的绘图臂在移动的绘图桌上移动。Henry 计划并设置机器在某些参数内工作，但对这些不可预测的绘图机只有一般的整体控制，因为它们部分依赖于机械的偶然性来生产高度复杂、抽象、曲线的线描图。他将根据机器的创造行为进一步调整，并决定何时完成过程，然后他将手工修饰机器的绘图，这里用粉色粉笔般的阴影。

Henry 计划并设置机器在某些参数内工作，根据机器的创造行为进一步调整，决定何时完成过程，后来，Henry 会手工给机器的绘图上色和修饰，比如这里用类似粉彩的粉色阴影进行点缀。

Desmond Paul Henry

In 1952 Desmond Paul Henry, purchased a Sperry Bombsight analogue computer used by World War Two bombers to calculate the accurate release of bombs onto their targets. He was a philosophy lecturer at the time at Manchester University (UK) but was also an amateur artist and had a lifelong interest in machines. He was captivated by the graceful movements of the computer’s inner mechanical parts. In 1961 he converted the Bombsight computer into the first of three electromechanical drawing machines constructed during the 1960s. Today only the remnants of his second drawing machine remain and are held by the London Science Museum.

Henry harnessed the rotational capabilities of the Bombsight computer’s mechanisms to create drawing machines. A drawing arm holding pen(s)

travelled over a moving drawing table. Henry planned and set the machine up to work within certain parameters but had only general, overall control of these unpredictable drawing machines, since they relied partly upon a mechanics of chance for the production of highly complex, abstract, curvilinear line drawings. He would make further adjustments in response to the machine's act of creation and decided when the process was complete, then afterwards he embellished he the machine's drawings by hand, here with pink pastel-like shading.
Henry planned and set up the machine to work within certain parameters, made further adjustments in response to the machine's act of creation, decided when the process was complete and later on, Henry would colour and embellish the machine's drawings by hand, here with pink pastel-like shading.

Harold Cohen，《伦敦，在泰特美术馆展出（HC0052）》，1983，纸本水墨，55.9x76.2cm，由伦敦 Gazelli Art House 提供

Harold Cohen

作为计算机艺术和机器人技术的先驱，英国艺术家 Harold Cohen 发明了 AARON，这是最早的程序人工智能程序用于艺术创作。

AARON 软件最初构思于 1973 年，尽管它可以用于在显示器上创建视觉效果或作为投影，但它主要通过 Cohen 建造的绘图仪和绘画机工作。这些解释来自计算机的命令，在纸上制作线描图，这就是我们将这项工作归入机器人技术范畴的含义。

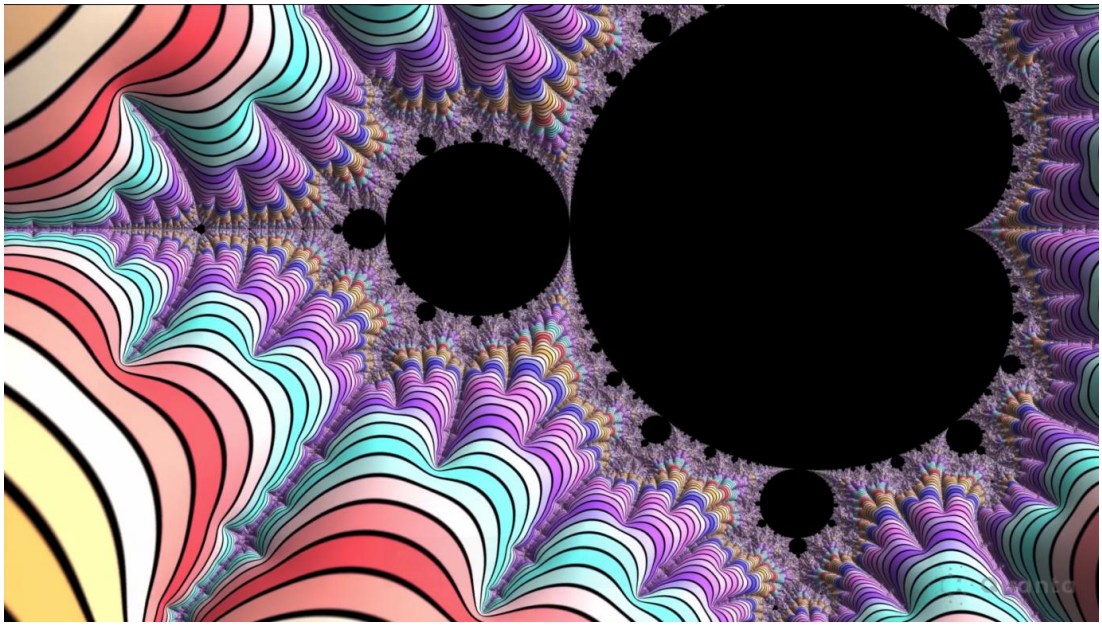
Cohen 本人是一位——非常成功的——画家，几十年来他都会手工给机器人绘图上色。1995 年，他开发了一个版本的 AARON，不仅可以绘制形状，还可以给它们的作品上色。

在泰康美术馆的展览中我们展示的 AARON 机器人的作品可以追溯到 1982-84 年，源自当时独特的人/机器合作。前两个是黑白绘图，而后两个由 Cohen 手工上色。

Cohen 将计算机提升到了“合作者”的地位，赋予其不仅仅是执行指令的能力，还具备自主做出艺术决策的能力。他一直强调 AARON 的独立创造性。除了机器人绘图外，你还将有机会在泰康美术馆展览的“教育”板块中看到 AARON 的作画过程。

Harold Cohen

Computer Art and Robotics pioneer, British artist **Harold Cohen** invented AARON, the earliest program artificial intelligence program for artmaking.
The AARON software was first conceived in 1973 and although it can be used to create visuals for displays on monitors or as projections, it chiefly works via the plotters and painting machines that Cohen built. These interpret commands from a computer to make line drawings on paper, and this is what we mean when we put the work under the heading of robotics.
Cohen himself was a – highly successful – painter and for several decades he would colour the robot drawings by hand. In 1995 he developed a version of AARON that not only drew the forms but could colour them as well.
The images we are showing here date from 1982-84, and stem from what was at the time a unique human/machine collaboration. The first two are black and white drawings while the second two have been hand-coloured by Cohen.
Cohen elevated the computer to the status of collaborator capable not only of following instructions but also of taking autonomous artistic decisions and constantly emphasised AARON’s independent creativity.
As well as the robot drawings, you will have the opportunity, on Video Player 5 in the Education Room, to see AARON in action.



Benoît Mandelbrot，《走进数学中著名的分形：曼德勃罗集》，视频，作者：量子杂志（Quanta Magazine）

Benoît Mandelbrot

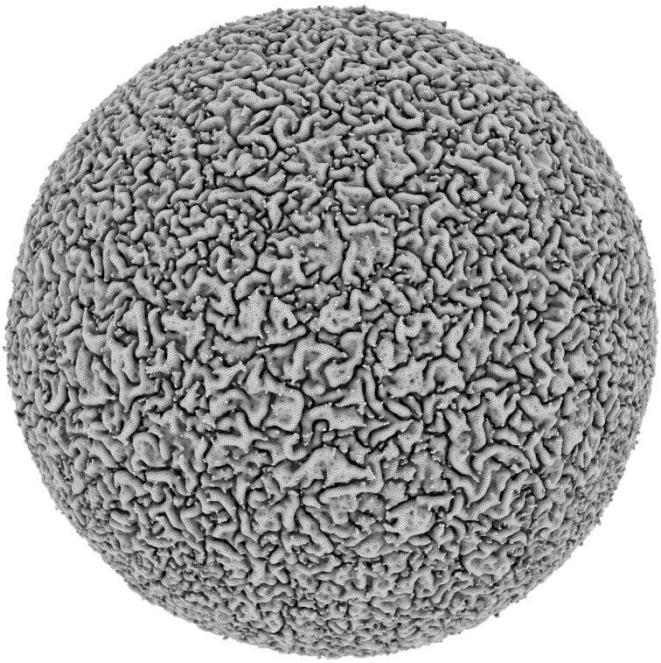
他是使用计算机图形来说明分形几何的先驱。事实上，他在 1975 年创造了“分形”这个术语，用来指在所有尺度上显示自相似性的复杂几何形状。它们是通过在持续的反馈循环中重复一个简单的过程而创建的。这意味着一个步骤的输出成为下一个步骤的输入，这使得分形呈现出“动态”的特性。你将在泰康美术馆的展览的教育室看到一些美丽的递归形式爆炸图案。分形是由递归驱动的，是动态系统的图像。

《走进数学中著名的分形：曼德勃罗集》是探索分形原理的经典纪录片。曼德勃罗集是一个二维集，定义相对简单。然而，它显示出巨大的复杂性，特别是当它被放大时。

Benoît Mandelbrot

Benoît Mandelbrot was a pioneer in using computer graphics to illustrate fractal geometry. In fact, he coined the term ‘fractal’ in 1975 to refer to complex geometric shapes that displays self-similarity at all scales. They are created by repeating a simple process over and over in an ongoing feedback loop. This means that the output at one step becomes the input at the next step and this makes fractals ‘dynamic.’ You will see

some beautiful explosions of recursive forms in our Education Room. Driven by recursion, fractals are images of dynamic systems.
A great place to start your exploration of fractals is with the Mandelbrot set (shown here) as is a two-dimensional set with a relatively simple definition. Yet, it shows great complexity, especially as it is magnified.



Andy Lomas《细胞形态 14 0016 0016》2013，数字印刷，100x100cm，由计算机艺术档案馆提供

Andy Lomas
是一位数学家与计算机艺术家，同时还是计算机生成特效领域的总监，并凭借这些荣获过艾美奖。他的艺术探索了如何通过模拟生物过程来紧急创建动态雕塑形式。

《细胞形态》使用了一个简化的形态发生生物学模型。形态发生是一个生物学术语，指的是组织和器官通过发育过程获得与其功能密切相关的形状。一个简单的例子是叶子的设计和形状的多样性，以便每棵树都有完全适合其特性和需求的叶子。

在 Lomas 的艺术中，三维结构是由粒子的相互连接系统创建的。他引入了各种参数和力量，但产生的复杂结构不是由自然规则如“适者生存”来优化的，而是由美学——换句话说，由看起来好看的——来优化的。这些作品并非旨在模拟任何具体的过程，但自然生成的形态却让人强烈联想到植

物、珊瑚、内脏和微生物。Lomas 的艺术是 A-Life 的一个例子，其中使用人工生命系统来创造艺术。

Lomas 使用 C++和 CUDA 编程语言设计所有用于运行模拟和渲染结果图像的软件。

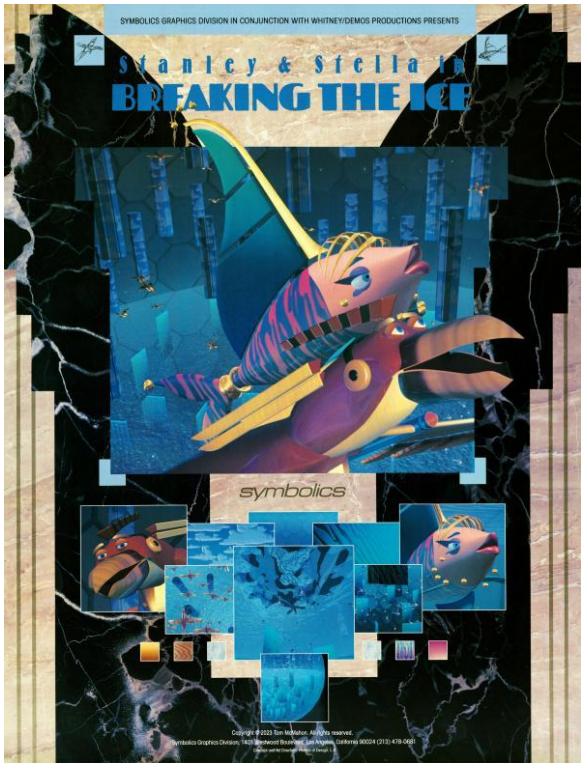
Andy Lomas

Andy Lomas (UK) trained as a mathematician and also worked as a supervisor of computer generated effects, for which he won an Emmy award. His art explores how dynamic sculptural forms can be created emergently by simulating biological processes.

Cellular Forms uses a simplified biological model of morphogenesis. Morphogenesis is primarily a biological term and is a developmental process by which tissues and organs acquire the shape that is critical to their function. One simple example is the diversity in the design and shape of leaves, so that each tree has exactly the right leaves for its characteristics and needs.

In Lomas' art, three-dimensional structures are created out of interconnected systems of particles. He introduces various parameters and forces but the complex structures produced are optimized not by the rules of nature such as 'survival of the fittest' but by aesthetics – in other words by what looks good. They are not intended to simulate any specific process, although forms naturally emerge with strong reminiscences of plants, corals, internal organs and micro-organisms. Lomas' art is an example of A-Life in which artificial life systems are used to create art.

Lomas uses the programming languages C++ and CUDA to design all the software used to run the simulations and render the resulting images.



Craig Reynolds 《斯坦利和斯黛拉：破冰》 1987，视频，3'06"

Craig Reynolds

泰康美术馆展览的“教育”板块的视频中，你会发现 Craig Reynolds 的两个视频连续播放并循环：它们是：1986 年 Boids 模拟和斯坦利和斯特拉在“破冰”——原始符号学。

Craig Reynolds 是一位研究员和软件开发者。他最著名的是他的人工生命程序，最初开发于 1986 年，模拟鸟类的群体行为。事实上，“boid”这个名字是“bird-oid object”的缩写，指的是类似鸟类的对象。你看的许多电影和玩的游戏都将有特色 boids 的动画的应用。

在最基本的 Boid 世界里，boids 必须遵守一些简单规则，比如转向以避免撞到其他 boids，对齐意味着与其他 boids 朝同一方向前进，凝聚意味着向平均位置或中心移动，以便 boids 保持在一个群体中。Reynolds 本人和许多其他软件开发者在基础模型的之上，添加了更复杂的规则，如避开障碍物和寻求目标~~，来构建基本模型。~~

Craig Reynolds 曾参与各种短片（如 1981 年的《杂技演员》和 1987 年的《斯坦利和斯特拉：破冰》）的工作，后者你会在展览中看见。他也参与过长片电影的制作，如科幻电影《创战记》（1982 年）和蒂姆·伯顿的《蝙蝠侠》（1992 年），其中计算机生成的在哥谭市的街道上行进的蝙蝠群和企鹅军团。

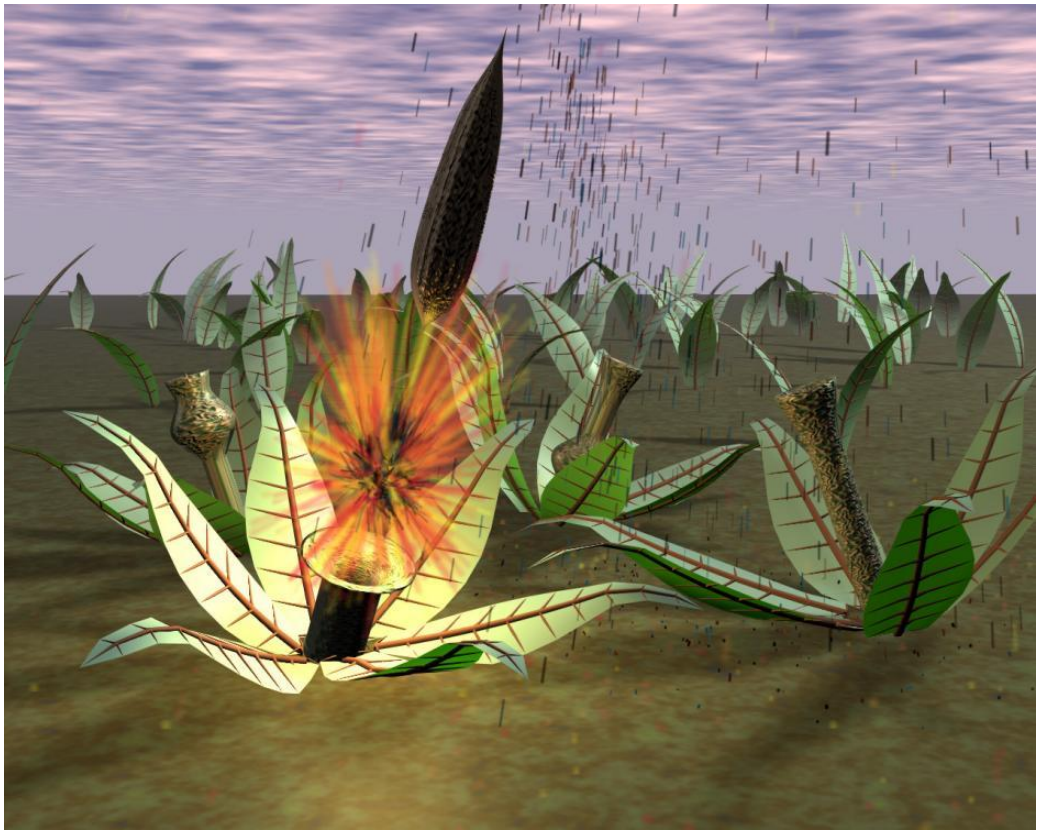
Craig Reynolds

On Video Player 3 you will find two videos by Craig Reynolds played in sequence and looped: They are 1) Original 1986 Boids simulation (Boids Demo Reel 1987 — Part B) and 2) Stanley and Stella in “BREAKING THE ICE” - Original Symbolics

Craig Reynolds is a researcher and software developer. He is best known his artificial life program, first developed in 1986, which simulates the flocking behaviour of birds. In fact, the name “boid’ is a shortened version of "bird-oid object", which refers to a bird-like objects. Many of the films you watch and games you play will have animations featuring boids.

In the most basic Boid world, the boids have to adhere to some simple rules like steering to avoid bumping into the other boids, alignment which means going in the same direction as the others and cohesion, which means moving towards the average position or centre so that the boids stay in a group. Reynolds himself and many other software developers have built on the basic model by adding more complex rules such as avoiding obstacles and seeking goals.

Craig Reynolds has worked on various shorts (like The Juggler (1981) and Stanley and Stella in: Breaking the Ice (1987), which is shown here a well as full-length feature films like the science-fiction movie Tron (1982) and Tim Burton’s *Batman Returns* (1992) where computer-generated bat swarms and armies of penguins march through the streets of Gotham City.



Karl Sims 《泛种论》1990 年，录像，2'08"

Karl Sims

是一位来自美国的开创性的数字媒体艺术家和视觉特效软件开发者。在展览中你可以尝试使用他的“反应 - 扩散探索器”（RD 工具），这是一个交互式网络应用程序，并在泰康美术馆展览的“教育”板块观看它制作的影片。

“反应 - 扩散探索器”（2022 年）通过模拟两种在 2D 网格上反应和扩散的虚拟化学物质来生成动态形状和模式，化学 A 在整个网格上以给定的“喂养”率添加。化学 B 通过消耗 A 复制，但在给定的“杀戮”率下死亡。

当您使用不同的喂养和杀戮率值时，会出现不同类型的模式。

泰康美术馆展览的“教育”板块中有 Karl Sims 的三个视频。

1. 程序动画的七个实验，2018 年（动画）

在这里，您将看到看起来“生物学”的移动图像，因为它们类似于海洋生物、神经元或其他微观结构。但这些变换的图像纯粹由数学定义。定制代码使用分形算法、程序噪声和反应-扩散技术。

2. 《泛种论》是指生命以细菌或孢子的形式存在于整个宇宙中，并在其中传播的理论。这部动画将观众置于一个积极繁殖的星系间生命形式的虚拟世界中。
3.《粒子之梦》使用 3D 粒子系统技术创作了一系列梦境序列。行为规则被应用于成千上万的单个粒子，以模拟爆炸、暴风雪和瀑布等复杂现象。

Karl Sims

Karl Sims, from the US, is a groundbreaking digital media artist and visual effects software developer. You will be able to try out his RD Tool, which is an interactive web application and watch some of his art films in the Education Room.
RD Tool (2022) generates dynamic shapes and patterns by simulating two virtual chemicals that react and diffuse on a 2D grid, Chemical A is added throughout the grid at a given "feed" rate. Chemical B replicates by consuming A, but dies off at a given "kill" rate.
When you use different values for the feed and kill rates, you get different types of patters emerging.
We are showing three of his videos.

Seven Experiments in Procedural Animation，2018 (animation)
Here you will see moving images that look “biological” in that they resemble sea creatures, neurons or other microscopic structures. But these transforming images are purely defined by mathematics. The custom code uses fractal algorithms, procedural noise, and reaction-diffusion techniques.

Panspermia 1990 (video) is the name for the theory that life exists and is distributed throughout the universe in the form of germs or spores. This animation places the viewer in the middle of a virtual world of an aggressively reproducing inter-galactic life form.

In Particle Dreams 1988 (video) a collection of dream sequences created using 3D particle systems techniques. Behaviour rules are applied to thousands of individual particles to model complex phenomena such as explosions, snowstorms and a waterfall.