# 第三类智能
# A THIRD INTELLIGENCE

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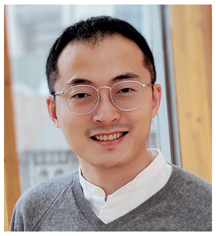

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**摘要**

将人工智能应用于景观设计学科所面临的首要挑战在于当前人工智能的定义不适用于系统性的景观框架。一般的人工智能定义不关注复杂的生态关系，而是倾向于强调个体智能，忽视了人类和非人类智能体相结合而产生的智能。我们认为，在将人工智能充分应用于景观设计领域之前，针对景观设计学科制定一个切实的“智能”的定义非常必要。我们采用智能体－环境框架来定义景观中的智能，并认为这一定义必须具体而明晰：在探讨智能时，明确智能体、环境和首要目标是十分必要的。从智能的角度来看，设计师通过精心设计分布在环境中的各种智能体来创造景观。而在将人工智能引入景观设计学科的过程中，我们提出了与人类及非人类智能体共同演进的“第三类智能”。而这些智能形式间的相互作用与对话也将为景观设计学科带来新的机遇。

**关键词**
人工智能；景观设计学；智能体－环境框架；广义智能；第三类智能

**ABSTRACT**

The fundamental challenge in the application of Artificial Intelligence to the discipline of Landscape Architecture is that current definitions of Artificial Intelligence do not fit within systemic landscape frameworks. Rather than focusing on complex ecological relationships, general definitions of Artificial Intelligence tend to emphasize the intelligence of individual entities and overlook the emergent intelligence of assemblages of human and non-human agents. We argue that it is important to develop a working definition of "intelligence" specific to Landscape Architecture before seriously considering the fruitful use of Artificial Intelligence in the production of environments. We adopt the agent-environment framework for defining intelligence in the context of landscape and assert that the definition has to be specific and situated: when discussing intelligence, it is necessary to clarify the agents, the environments, and the overarching goals. Taking intelligence as a lens, designers choreograph the intelligence distributed among human and non-human agents in the environment to produce landscapes. Introducing Artificial Intelligence to Landscape Architecture proposes a "third intelligence," co-evolving with human and non-human actors. For Landscape Architecture, opportunity lies in the interactions and dialogues between these forms of intelligence.

**KEY WORDS**
Artificial Intelligence; Landscape Architecture; Agent-Environment Framework; Universal Intelligence; Third Intelligence

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## 前沿技术概况

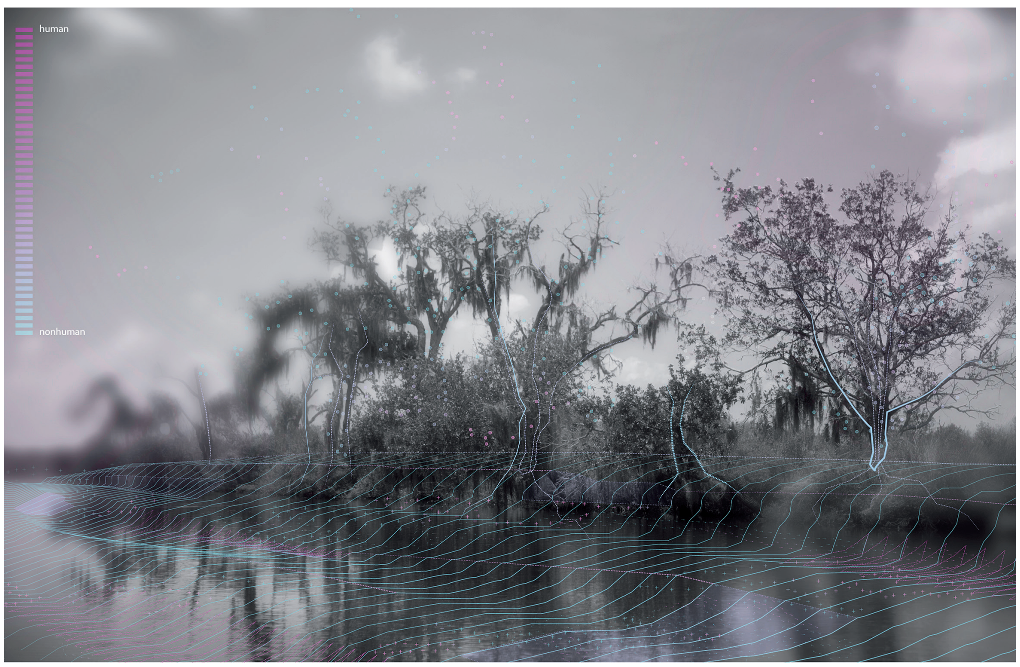
近年来，人工智能（AI）领域取得了诸多进展，拓宽了相关工具、方法和理论的应用和获取途径。下文所述案例呈现了近年来AI研究的重大突破，其中有很多AI系统在特定方面的表现优于人类，其制定策略的方式亦超出了人类的理解范围，以上种种挑战着人们对智能的定义。2012年，在被视为计算机图像识别领域标杆的ImageNet大规模视觉识别挑战赛中，研究人员见证了AI误码率的显著下降，当时的获胜算法是卷积神经网络（CNN）[1]。之后，CNN在AI领域被广泛应用，随着大量更深层次研究的陆续展开，其仅用了4年便将误码率降至3%，而彼时人类的平均误码率为5%。2016年，基于AI的深度强化学习（DRL）模型“阿尔法狗”（AlphaGo）击败了世界顶级围棋选手之一——李世石。一年之后，谷歌旗下“深度思维”公司宣布“阿尔法狗－零”（AlphaGo-Zero）能够在“不需要围棋规则之外的人类数据、指导和专业知识”[2]的情况下击败其前辈“阿尔法狗”。同样，经过DRL模型训练的AI在雅达利公司制作的系列游戏中的表现也优于最优秀的人类玩家[3]。AI技术的另一项最新进展是对抗性神经网络，又被称为生成式对抗网络（GAN），它是由麻省理工学院（MIT）发布的“2018

1. 作为一种基于DRL的人工智能系统概念设计，“荒野创造者”能够提出超出人类理解范围的环境管理策略。它通过增强来自非人类的影响来抗衡各种形式的人类影响，从而维持荒野生态系统平衡。

1. "Wildness creator," a conceptual design for a DRL-based AI, could come up with environmental management strategies beyond human comprehension and sustain wildness by enhancing non-human influences while countering all forms of human influence.

年十大突破性技术”之一。通过同步训练两个神经网络，GAN能够渲染出如实景照片般逼真的图像[4]。作为一项重大技术革新，GAN“赋予机器类似于想象力的特质，以帮助它们减少对人类的依赖，并将它们变为用于数字化模拟的超级强大的工具。”[5]此外，AI研究人员还致力于使计算机能够自主编写代码[6]、优化算法[7]，以及探索“学习”的概念[8]。

与此同时，在OpenAI，TensorFlow和ConvNet.js等机器学习库的帮助下，非专业人士也能够通过Javascript和Python等编程语言更容易地运用这些AI技术。例如，由Topos公司开发的机器学习应用程序可以分析纽约市5个行政区的城市结构，将其之间的关联可视化，并对其进行重新架构[9]。景观设计师们也开始探讨运用这些技术来管理环境的可能性及将会面临的挑战。在一项思维实验中，耿百利等人设想出一个基于DRL的AI系统“荒野创造者”，它能够提出超出人类理解范围的环境管理策略，并激发景观设计师、生态学家和环境保护人士思考这些策略对于构建荒野的意义[10]。我们相信，在不久的将来，会涌现出更多应用AI技术的自动化工具，以帮助设计人员在设计过程中对景观格局进行可视化、分析和预测。同时，景观设计领域也将会出现更多应用AI技术对环境现象进行感知和回应的响应系统，以使环境可以更好地应对人为扰动。这些技术的发展如此迅猛，以致上述很多AI系统都在冲击我们对于智能的理解。因此，在本文中，我们提出如下根本性问题：在景观设计学科中，我们应当如何定义“智能”，又该如何在这一学科中纳入对AI的考量？



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## 广义智能

“作为景观设计师，我们誓将为所有人类和物种创造更能体现社会公平和生态公平的场所。”[11]

景观设计学科认可并尊重环境中人类和非人类智能体（“智能体”另译为“行动主体”或“能动主体”）的自主性。随着景观学者和从业者对生态学的理解逐渐深入和全面，由人类和非人类智能体共同创造景观的行业意愿愈发强烈。这一景观框架形成了景观学科视角下对“智能”的独特理解：**景观设计本质上假定生态系统中的人类和非人类智能体都具有智能，而且这种智能足以使他们去感知环境并采取相应行动**。这种对智能的理解可能不同于其他学科。例如，大多数人不会认为树木是智能的。但植物学研究表明，植物可以表现出智能性，只是其与人类和动物所具有的机制不同，且时间跨度更长[12]。生态学家还发现，同一片森林中的树木可以通过由成片生长的真菌形成的菌根网络实现沟通[13][14]。此外，我们还可以在哲学、心理学、神经科学、计算机科学等一系列不同学科中找到对于智能的其他定义。

研究所有智能的定义既不现实也非必要。深度思维科技公司联合创始人谢恩·列格和他的同事马库斯·赫特曾罗列出一系列由研究团体及组织、心理学家和AI研究人员对智能所下的定义[15]，并在这些定义中找到了一个共同点，即它们都涉及智能体与其所处环境的相互作用。基于这一观察，以及为

了更好地研究机器智能，他们提出了**“广义智能”的概念，用以衡量智能体在各种环境中达成目标的能力**[16]。广义智能这一定义的提出使得人们可以利用数学模型将AI公式化，以使之可被计算和量化。我们发现这一定义值得深思，因为“智能体—环境”框架本质上是一个神经控制论模型，它与当代景观实践中的系统性思考相吻合。然而，我们认为在景观语境下讨论这一定义仍绕不开一些主要问题，即人类中心主义和个体主义。在本文中，我们运用景观设计师的感性思维对这一定义进行建设性批判，并借助其他哲学体系来修正这一定义，以使其符合系统性景观框架。

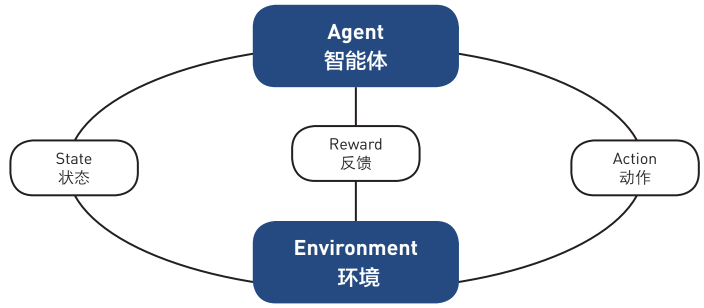
人类中心主义，即以人类的视角来理解环境，是理解广义智能概念时需要讨论的首要问题。尽管列格和赫特将智能体的范围扩展到人类、动物和机器，但在使用广义智能作为**衡量标准**去思考什么属于智能行为时，我们仍会不自觉地将人类智能标准强加于非人类智能体之上。这种以人类为中心，认为会移动、能思考才称得上智能的观点从本质上妨碍了人们对于树木智能性的认知。但是，非人类智能体对于其所处环境的认知是有别于人类的。蝙蝠通过超声波“看”世界，狗通过嗅觉“看”世界，计算机通过数字“看”世界，即使是惰性非生命体，比如一块金属，也可以智能地吸收和传导来自太阳的热量。非人类智能体感知环境、处理信息，以及响应输入的方式与人类大相径庭，所以作为人类，我们很难真正理解非人类智能体如何认知环境——正如我们无法像蝙蝠一样思考。因此，我们没有必要也不可能去比较哪些“智能”更高级或更接近于人类智能。

有关广义智能概念的第二个问题是个体主义。我们可以通过一个简单的问题来对此进行分析：在衡量蚂蚁的智能时，我们该考虑一只蚂蚁的智能还是一个蚁群的智能？定义中的“智能体”被假定为一个独立的智能个体，因此该定义忽视了由组成群体的个体间相互作用产生的群体智能，这种群体智能只存在于个体的集合中，而不见于某一个体中[17]。例如，一只蚂蚁无法智能地实施任何对环境有影响的行动，而蚁群则能够智能地构筑供其生存的地下生态系统。我们将这一现象称为集体智能或群体智能。更为重要的是，一个群体可以包含多样化的组成部分：它们可以是人类，也可以是机器。例如，通过构建社会文化生态位[18]，人类通力协作，并借由机器的技术支持，从而形成了不断壮大的社会—技术复合体，其智能程度之高，使得人类这一物种得以延续下去。

## 第三类智能？

智能体—环境框架帮助我们厘清了AI涵盖的三个部分：智能体、环境和目标。于此，我们认识到对于AI的探讨应该更为具体、更具针对性：智能体由什么构成？处于何种环境之中？意在实现什么目标？上述问题对于在景观设计学科中开发AI系统具有建设性意义。一方面，AI的安全性和伦理性虽不在本文探讨范围之内，但它们是开发AI过程中无法回避的议题[19]~[21]，我们相信，这类问题的提出能够帮助设计师培养自我反思意识，以使他们在使用AI技术的过程中守住道德底线，并秉持责任感。另一方面，提出这些问题有利于明确AI系统在景观设计及管理过程中的角色，以及它们与设计师、其他人类和非人类智能体之间的关系。

我们采用智能体—环境框架并摒除了其中的人类中心主义和个体主义。虽然这样会使AI这一议题更加复杂，但这为我们思考景观设计学科中的AI或机器智能构建了扎实的理论基础。通过摒除人类中心主义，我们可以平等地看待人类和非人类智能体，并明确景观设计中的三种智能类型：材料智能，生物物理智能（人类、动物和植物智能）和机器智能。在此，机器智能或AI，形成了可以与材料智能和生物物理智能类比探讨的第三类智能。同时，消除个体主义使得我们发现了在景观设计学科中开发AI系统的新机遇。在景观设计和管理中，AI不仅仅是一种自动化的优化工具，也是能够与其他形式的智能体共同演进的活跃参与者。通过与多元化智




2 © 张子豪

2. 在广义智能的定义下，智能体与其所处环境的关系。
3. 自动化机械系统通过不断改变河流景观、促进非静态的生态演进建构等一系列实时传感与响应式操作来使河流与周边地貌重新和谐统一。

2. The relationship between agent and its environment in the definition of universal intelligence.
3. A robotic machine attunes the fluvial morphology through a series of real-time sensing and responsive manipulations — constantly altering and modifying the riverine landscape, and privileging the evolution of ecological processes over static constructions.

能体的相互作用更是会激发新的可能。这让我们可以进一步设想会随时间推移而不断学习和演进的混合景观系统。AI能够与其所接触的环境和智能体共同演进，并形成新的关系。从某种程度上讲，我们应对在景观管理中采用AI策略秉持审慎而积极的态度，而研究这些策略将有助于我们从多个角度更好地理解景观的动态变化。此外，通过与各种形式的AI建立更深层次的关系，设计师也许可以更好地理解其他物种的智能。

最为重要的是，将AI引入景观设计学科需要摒弃以人类为中心的视角并承认智能形式的多样性。人类智能只是共同创造景观的众多智能形式中的一种，而设计师的能动性是通过编排调动众多智能实现的，其中也包含AI。新唯物主义哲学家简·班纳特认为，“在任何一个时期，所谓的人类能动性无非是人类和非人类相互交错的网络而已”[22]。材料智能、生物物理智能和机器智能的相互作用将为景观设计领域创造新的机遇。

第三类智能的概念可使AI更好地应用于景观设计学科。一方面，通过这一概念，我们将AI置于能够体现设计师能动性的交错网络中，使我们避免限于AI具有引发社会变革的能力的技术决定论。另一方面，这一概念不再聚焦于机器和具有智慧的人类之间的相似性这一以人类为中心的智能概念，而是承认了机器智能与景观中其他类型智能的区别。第三类智能的概念探索了AI未来发展的可能性，它不会替代人类智能，而会与其他类型的智能共同演进。

这一共同演进过程具体可体现在新的分析形式、生成设计和信息—物理系统上。借助无监督学习算法，AI能从数据中发现人类无法探究出的规律。第三类智能概念并不会将这些规律视作干扰，而是鼓励设计师反思机器分析决策方式，并从此前可能被忽略的数据和领域中获得新的见解。从这个层面上来讲，数据分析依靠的是人类直觉与机器智能的结合。AI和生态系统中其他生物智能共同演进是一种生成设计的新途径。

机器学习算法可以嵌入不同层级的信息—物理系统中。耿百利和贾斯汀·霍尔兹曼策划了多种将响应技术（例如传感技术和机器人技术）融入景观设计的方法，并畅想未来通过AI可使响应式景观具有学习和探索能力[23]。景观媒介（如水体、土壤和植物）与大量传感网络之间的交互为AI进行大规模学习提供了充满活力的媒介。通过研究响应式景观框架，笔者之一的张子豪强调了人类智能体及其智能在信息—物理景观系统中的重要性[24]。与期待开发强大机器的AI研究人员不同，作为景观设计师，我们的目标应该是致力于形成一个满足自然、人类和科技间的无缝衔接的网络，其中不同形式的智能能够共同演进，而不存在一种智能类型宰制其他智能的现象。

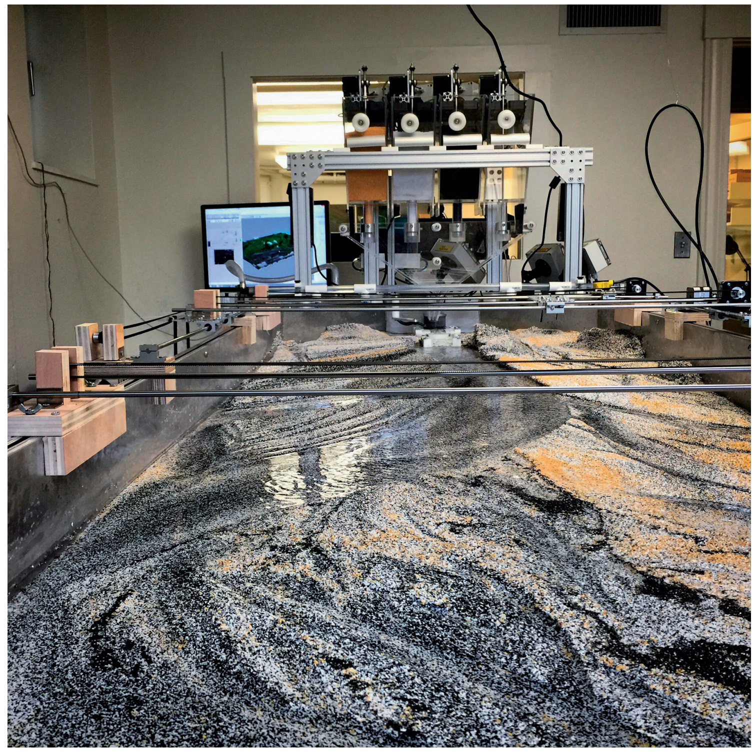
这些发展亟待新工具和新方法的支持，它们不局限于优化景观系统，而是设想材料智能、生物物理智能和机器智能的共同演进。景观设计师的重要作用便在于通过一个有利于植物、动物和地球地貌共生关系的清晰框架来运用这些工具。最重要的是，景观设计师由此获得了一种新的工作方法，这一方法否定了分析和解决问题的静态框架，反之鼓励多元参与者之间的共生发展。**LAF**

3 © Leif Estrada

### State of the Art

There have been a significant number of advances in Artificial Intelligence (AI) that have broadened the application and accessibility of tools, methods, and theories. The examples below highlight major breakthroughs in AI research in recent years. Many of these AI systems perform better than humans in certain aspects and their devise strategies are beyond human comprehension, thus challenging the definition of intelligence. In 2012's ImageNet Large Scale Visual Recognition Challenge, a benchmark for computer image recognition, the AI community saw a significant drop in error rate. The winning algorithm was a Convolutional Neural Network (CNN)[1]. CNN quickly became popular in the AI community spawning deeper research and the error rate dropped to 3% within only 4 years, while the average error rate for humans was 5%. In 2016, AlphaGo, a Deep Reinforcement Learning (DRL)-based AI, beat one of the top ranked Go players, Lee Sedol. One year later, DeepMind, a Google subsidiary, announced that AlphaGo-Zero was able to beat its predecessor "without human data, guidance or domain knowledge beyond game rules"[2]. Similarly, DRL-based AIs were also trained to play Atari games better than the best human players[3]. Another example of these recent advancements is Dueling Neural Networks, or Generative Adversarial Network (GAN), which was on the list of "10 breakthrough technologies 2018" put out by Massachusetts Institute of Technology (MIT). By training two neural nets together, GAN is able to render original photo-realistic images[4]. GAN is revolutionary as "this gives machines something akin to a sense of imagination, which may help them become less reliant on humans — but also turns them into alarmingly powerful tools for digital fakery."[5] AI researchers are also interested in the algorithms that enable computers to write code[6], to optimize algorithms[7], and to learn the concept of learning[8].

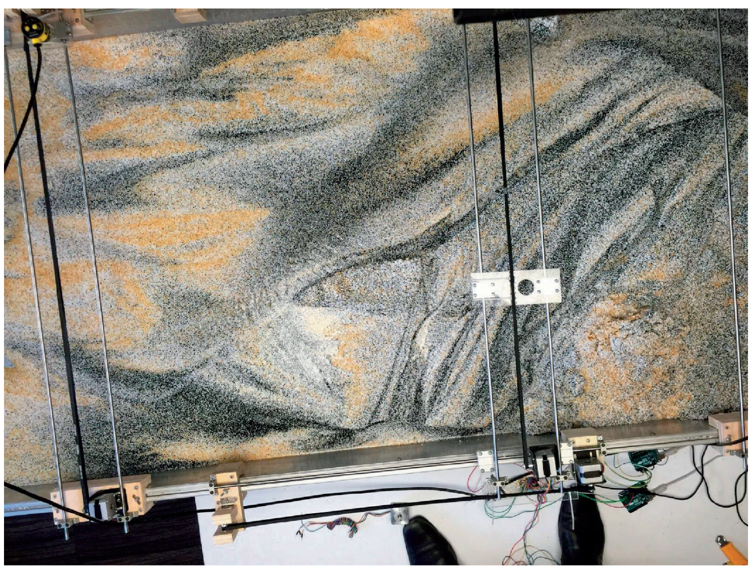
At the same time, it is easier for non-experts to access these technologies through programming languages such as Javascript and Python, by using Machine Learning (ML) libraries such as OpenAI, TensorFlow, and ConvNet.js, among others. For example, the company Topos has developed ML applications that analyze urban patterns, visualizing the connections and reorganizing the five boroughs of New York City.[9] Landscape architects also start to discuss possibilities and challenges to apply these technologies to manage the environments. In a thought experiment, Bradley Cantrell et al. imagined a DRL-based AI "wildness creator" that could come up with environmental management strategies that are beyond human comprehension and challenge landscape architects, ecologists, and environmental activists to consider what that means to construct wilderness[10]. We believe that, in the near future, there will be more automated tools empowered by AI for designers to visualize, analyze, and predict landscape patterns in design processes. We also believe that, in the near future, there will be more responsive systems that sense and respond to environmental phenomena enabled by AI to respond to disturbances. Because all of these technologies are evolving quickly, and many of the aforementioned AI



4 © Bradley Cantrell

4. 由传感阵列、介质给料器，以及控制系统组成的河流地貌模拟系统。通过运用机器智能和图像分析技术可对沉积结构进行分析。
5. 借助沉积材料所具备的智能，沉积物经不同流速的水流分类沉淀，形成特定的沉积结构。

4. Fluvial geomorphology table with sensing array, media feeders, and control systems. Sediment patterning analyzed by using machine intelligence and image analysis.
5. Sediment patterning via material intelligence, sorted via water velocity.



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systems challenge our understanding of intelligence. In this paper, we ask a fundamental question: what is a working definition of "intelligence" and how do we speculate on AI in the discipline of Landscape Architecture?

## Universal Intelligence

"As landscape architects, we vow to create places that serve the higher purpose of social and ecological justice for all peoples and all species."[11]

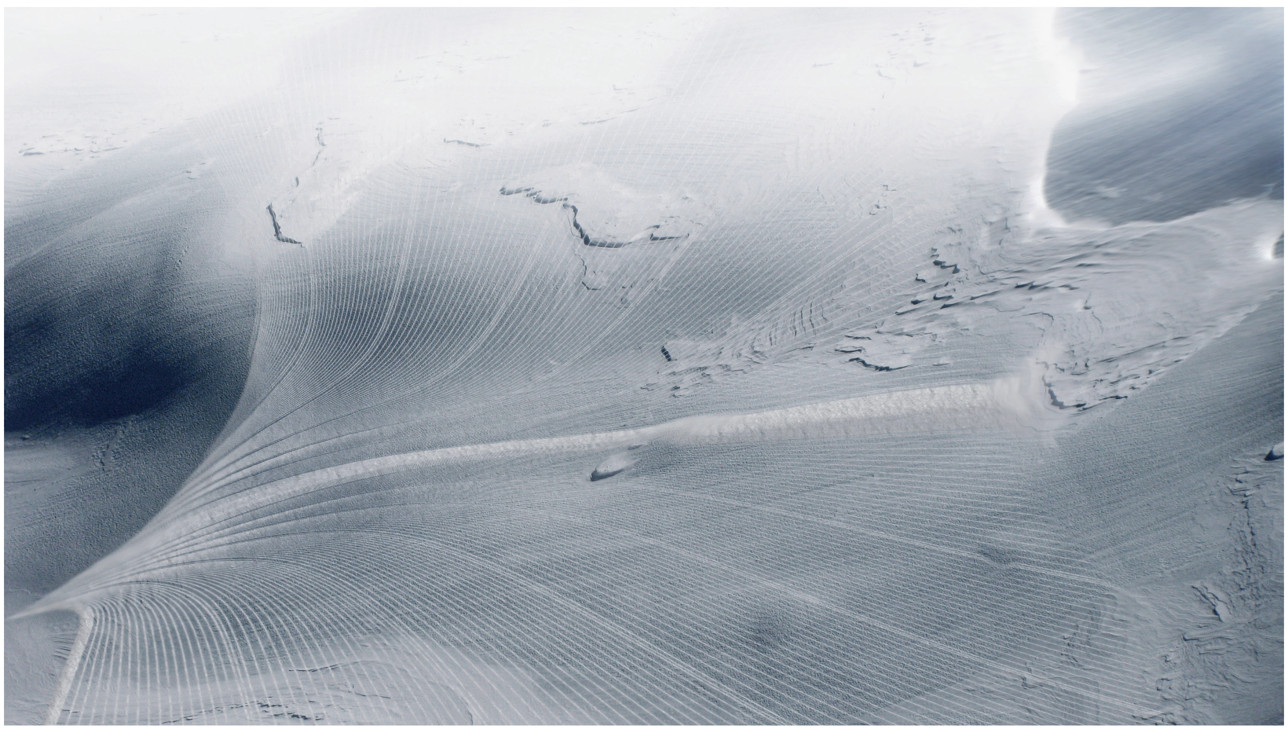
As a discipline, Landscape Architecture recognizes and respects the autonomy of human and non-human agents in the environment. With a deeper and more complex understanding of the subject of ecology among landscape scholars and practitioners, there is a growing interest to map and choreograph human and non-human agents to co-produce landscapes. This framework of co-production forms a unique understanding of *Intelligence in* Landscape Architecture: *designing landscape essentially assumes that human and non-human agents in ecosystems possess intelligence, and they are intelligent enough to sense their environments and take actions*. This understanding of intelligence may be different from other fields. For example, most people would not think trees are intelligent. But researches in botany show that plants can act intelligently, using a mechanism that is different from human beings and animals and in a longer time-span[12]. Ecologists also find that trees in the same forest can communicate with each other through mycorrhizal network formed by interconnected fungi[13][14]. Besides, it is possible to find definitions of intelligence within a range of different disciplines such as philosophy, psychology, neurosciences, and computer sciences.

It is impossible and unnecessary to survey all the definitions of intelligence. Shane Legg, a co-founder of DeepMind Technologies, and his colleague Marcus Hutter have listed a collection of definitions of intelligence from research groups and organizations, psychologists, and AI researchers[15]. Legg and Hutter found a common thread in these definitions, which always involve the interaction of an agent with its environment. Based on this observation and their goal to measure machine intelligence, they have proposed their own working definition for *Universal Intelligence: intelligence measures an agent's ability to achieve goals in a wide range of environments*[16]. This definition allows them to formalize intelligence with mathematical functions defining the values of universal intelligence, making it computable and measurable. We find this definition worth pondering because the "agent-environment" framework is a cybernetic model, aligning systems thinking in contemporary landscape practices. However, we do find this definition contains some major problems when discussed within the landscape context: anthropocentrism and individualism. Our approach is to use sensibility of landscape architects to constructively critique this definition, providing other philosophical models to modify this definition so that it fits within a systemic landscape framework.

Anthropocentrism, or understanding the world from a human-centered perspective, is the first issue when using universal intelligence. Even though Legg and

Hutter expanded the agent to include human, animals, and machines, the fact that universal intelligence working as a *measurement* unwittingly imposes a human standard on non-human agents when considering what action is intelligent. And this human-centered view prevents people from understanding that a tree is intelligent because trees cannot move or think. However, non-humans relate to their environment very differently from humans. A bat “sees” the world through ultrasonic waves, a dog “sees” the world through scent, and a computer is designed to crunch numbers, even inert non-living things, such as a piece of metal, perform intelligently in absorbing and conducting heat from the sun. Non-humans sense the environment, process information, and respond to inputs very differently from human beings, and it is impossible for us as humans to really understand how non-human relate to their world: How can we think like a bat? As a consequence, there is no necessity and it is also impossible to compare which “intelligence” is more intelligent or more similar to human intelligence.

The second problem we want to point out in universal intelligence is individualism. This problem is easier to analyze by posing one simple question: Do we consider the intelligence of an ant or a colony of ants? The “agent” in the definition assumes an individual intelligent being, thus overlooking group intelligence emerged from the interactions of individuals forming an assemblage, and this group intelligence only exists in the assemblage of the individuals and is irreducible to any individual itself[17]. For example, an ant is not capable in taking actions intelligently to impact the environments at a meaningful scale, whereas a colony of ants are able to act intelligently and



6 © Ricardo Jnani Gonzalez

6. 应用由机器人智能体构成的响应式和迭代式组织系统来改变冰冻圈的地形和生态环境。

6. A responsive and iterative organizational system formed by robotic agents and applied to change the terrain and ecological environment of cryosphere.

construct an underground ecosystem that supports their lives. We call this hive intelligence or swarm intelligence. More importantly, an assemblage can consist of heterogeneous components: they can be humans or machines. For example, through socio-cultural niche construction[18], human beings work with each other and work with technical machines to form an ever-expanding socio-technical assemblage that is intelligent enough to survive for thousands of years.

## A Third Intelligence?

The agent-environment framework helps us identify three components in AI: agent, environment, and goal. It suggests that discussion of AI should be specific: What constitutes an agent in which environment, and for what purpose? Asking these questions is constructive for developing AI system in Landscape Architecture. On one hand, AI safety and ethics, which lie outside the scope of this paper, should be a topic that we cannot avoid when developing AI[19]–[21], and we believe that asking these questions helps us as designers build a sense of self-reflexivity, so that developing AI technology in the landscape profession aims to be ethical and responsible. On the other hand, asking these questions helps to clarify the role of AI systems and their relationship with designers and other human and non-human agents in designing and managing landscapes.

We adopt the agent-environment framework and remove its anthropocentrism and individualism. In a way, we complicate the subject of AI, but we construct a solid theoretical foundation to consider AI, or machine intelligence, in Landscape Architecture. By removing the anthropocentrism, we posit an equal treatment of humans and non-humans for intelligences and identify three types of intelligences in landscapes: material intelligence, biophysical intelligence (human, animal, and plant intelligences), and machine intelligence. Then, AI, or machine intelligence forms a third intelligence that can be compared to material and biophysical intelligences. By removing the individualism, we open up new possibilities for developing AI systems in Landscape Architecture. AI is not simply a tool for automation and optimization, but an active player that co-evolves with other forms of intelligences in designing and managing landscapes. Coupled with multiple intelligences, new possibilities emerge from interactions. This asks us to imagine hybridized landscape systems that can learn over time and evolve. AI has the ability to form new relationships that co-evolve with the environments and agents they are in contact with. In a way, we should be cautious but curious to machine strategies in managing landscapes, and studying these strategies which can help us better understand landscape dynamics from multiple perspectives. Developing a deeper relationship with forms of AI may also help designers better understand the intelligence of other species.

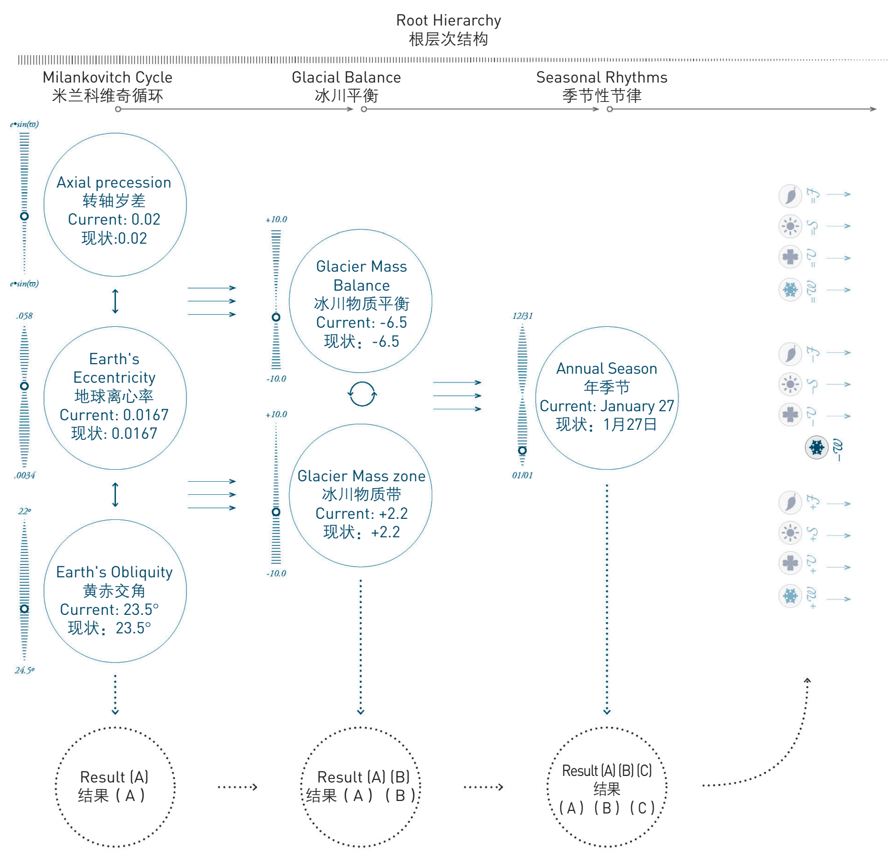
Most importantly, introducing AI in Landscape Architecture requires a recalibration of human-centric views and an acknowledgment of multiple forms of intelligence. Human intelligence is only one of many forms of intelligences that co-produce landscapes, and a designer's agency is exerted through the choreography of processes across these intelligences, including AI. New materialism philosopher Jane Bennet argues that "there was never a time when human agency was anything other than an interfolding network of humanity and non-humanity"[22]. New opportunities for Landscape Architecture lie in the interaction of these intelligences.

Conceptually, a third intelligence allows for speculation on the application of AI in Landscape Architecture in more meaningful ways. On the one hand, with this concept, we situate AI in the interfolding network of a designer's distributive agency, avoiding a technological determinism that assumes AI possesses inherent power to initiate societal change. On the other hand, the concept moves away from a human-centric definition of intelligence that focuses on the resemblance of a machine to an intelligent person, thus acknowledging differences between machine intelligence and other types of intelligence in landscapes. The concept probes the possibilities of AI, not to replace human intelligence, but to co-evolve with other types of intelligence.

This co-evolution manifests in new forms of analysis, generative design, and cyber-physical systems. With unsupervised learning algorithms, AI can find patterns in data that are outside of human comprehension. Instead of treating these patterns as noise, the concept of a third intelligence encourages designers to reflect on these machine strategies of analysis and gain new insights into the data and areas that may have been overlooked by humans. Data analysis in this sense would rely on human intuition in dialogue with machine intelligence. It is a new way of generative design that AI is co-evolving with other biological intelligences in ecosystems.

Machine Learning algorithms may be embedded in different levels of cyber-physical systems. Cantrell and Holzman have strategized ways to incorporate responsive technologies, such as sensing technologies and robotics, envisioning a future in which responsive landscapes have a heuristic ability enabled by AI[23]. The interaction between landscape media such as water, soil, and plants and extensive sensing networks provides a living medium for AI to productively learn from. Studying the responsive landscape framework, Zihao Zhang has emphasized the importance of human agents and their intelligence in the cyber-physical landscape systems[24]. Different from the goal of AI researchers — to develop powerful machines, our goal as landscape architects should be working to form a seamless web of nature, human, and technology, in which different forms of intelligence can co-evolve without one type of intelligence dominating the others.

These developments point to new tools and methodologies that go beyond optimizing landscape systems and instead imagine a co-evolution of biophysical, material, and machine intelligence. It is important that landscape architects approach these tools through a clear framework that favors synthetic relationships between flora, fauna, and geomorphology. For landscape architects this provides an approach that most importantly denies the static framework of analysis and solution, instead proposing a symbiosis between multiple actors. **LAF**

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7. A responsive and iterative organizational system formed by robotic agents and applied to change the terrain and ecological environment of cryosphere.

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