景观测知
——新自然的诞生

SENSING LANDSCAPES
— A NEO-*NATURAL* INCARNATE

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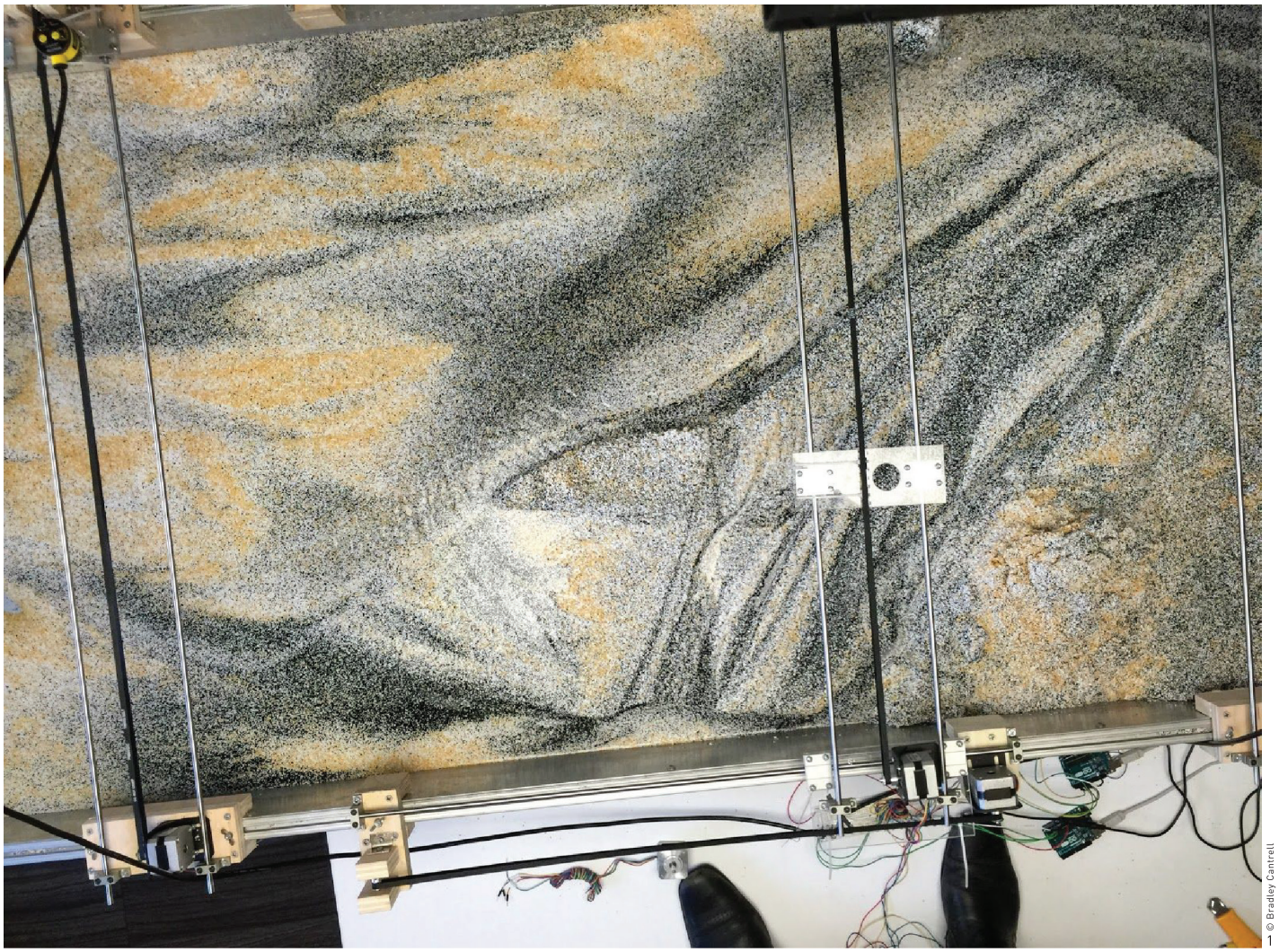

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1. 地貌具形台，可以作为不同实验的干预场地。

1. Image of the geomorphology table — utilized as the site of intervention for multiple experiments.

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摘要

作为景观设计师，在应对具形现象时，我们面临着众多复杂和不确定的因素。人类世的到来只会进一步增加这样的景观转变，其中尤以那些直接受水文形态影响的转变为甚。虽然工程技术已使如上情况有所缓解，但本文试图探讨一种基于响应技术的替代方案，以实现实时的自适管理。该方案倾向于将生态过程而非静态建构作为一种设计方法。在进行大量的实验来验证相关理论表述的过程中，我们关注响应系统所具有的不一致性和自发性，接纳其与景观的融合，以促成一种“新自然”的诞生。

关键词
知觉景观；感知；自发性；机器人科学；自然

ABSTRACT

As landscape designers, we face complexities and indeterminacies when dealing with morphological phenomena. The advent of the Anthropocene only but increased such landscape transformations, most especially those that are directly affected by hydrological morphologies. Though engineering technologies alleviate such problématique, this paper seeks to present an alternative methodology in the use of responsive technologies, enabling real-time adaptive management, which favors ecological processes over static constructions as a design methodology. Experimentations were conducted to ground such theoretical assertions, while addressing the inconsistencies and spontaneity produced by responsive systems and accepting their integration into the landscape as part of its new *Nature*.

KEY WORDS
Sentient Landscapes; Sensing; Autonomy; Robotics; Nature

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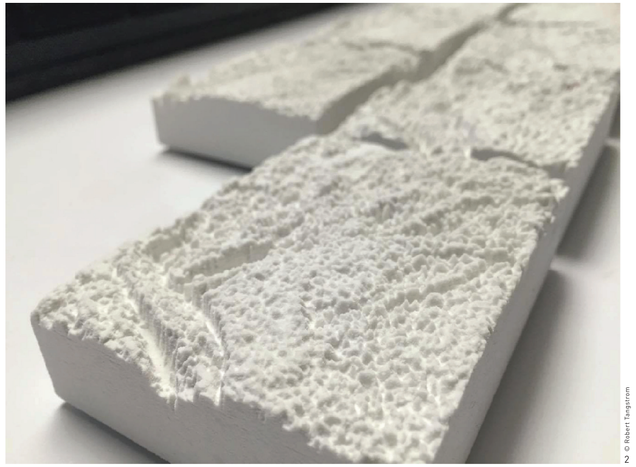

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2. 扫描地貌具形台后，3D打印而成的一次性土壤样品。其在极短时间内便创造出了一个新自然。（模型由列夫•埃斯特拉达制作）

2. Temporal 3D-printed soil samplings scanned from the geomorphology table, which were produced at an instant creating a neo-*Nature*. (Models by Leif Estrada)

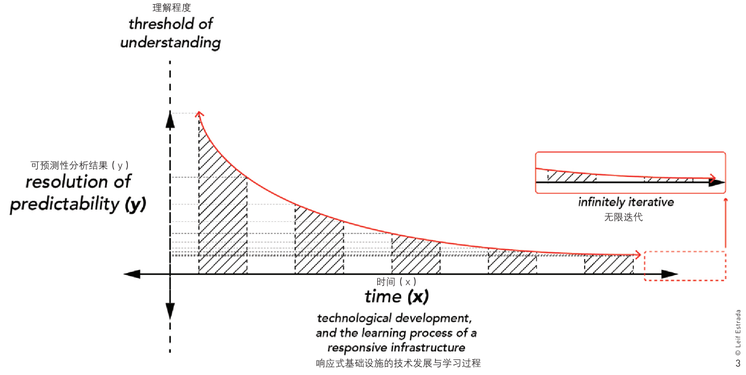
概述——应对复杂性

复杂性和不确定性是我们处理景观现象时必须面对的问题，更是在探讨影响景观地貌的流体动力学时关注的重点。虽然这样的景观可借由基础设施及干预措施的应用加以改变，但响应技术却使一种实时的自适管理方案的建立成为可能，以创建用于管理和引导不断变化的生态系统的方法。此种设计方法将生态与人造基础设施之间的不一致性和自发性视作机遇，因而不再需要无休止地追求预测的精准性，甚至不再需要更多的数据。

在历史上，当汉斯•爱因斯坦告诉提出了相对论的父亲自己想要放弃结构工程学，转而研究泥沙输移时，父亲对他加以劝阻。阿尔伯特•爱因斯坦认为，泥沙输移的研究过于棘手，汉斯应该去做一些不那么复杂的研究[1]。

“寻向测知”是由哈佛大学设计学院的响应式环境和人工品实验室（REAL）资助展开的项目。在该议题下，我个人的毕业设计以及其他多个研究实验，融合了响应系统的设计，以一个地貌具形台为干预场地进行实境增强实验（图1）。这些实验测试的目的，是探究响应式基础设施用以调整河流景观行为及其流体形态的潜在能力，其中主要涉及陆地拓展、植被增衍及物种栖殖等方面。

就当前人类掌握的科学知识来看，我们还无法保证流体动力学现象测知的精度。然而，我们可以借助水文模型捕捉河流冲积过程的行为本质。这其中不包括基于数学算法的繁复的数值模型，因为这种模型忽略了变化的环境变量所带来的不确定性，从而导致数字模拟缺乏准确性。在这一项目中，通过利用由实时测知所获得的直接讯息，传统预测方法中因信息多变造成的不可预知性非但不再是缺陷，而且能够转变为可予以利用的资源——实时变化借由测知技术的介入融入系统之中，其先以生态变量示人，并最终化身为自然本身（图2）。



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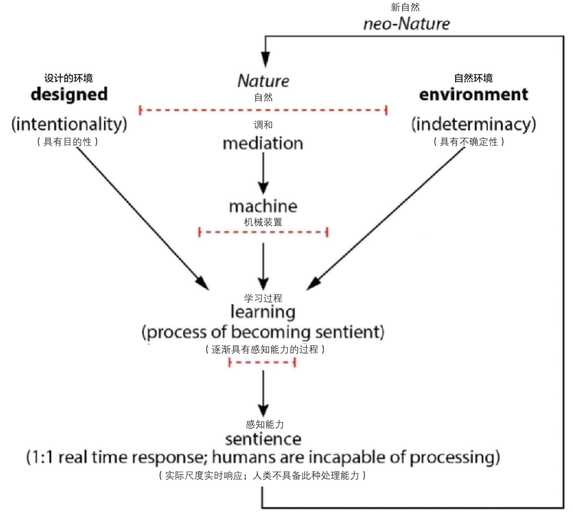
3. 以渐近值为理论基础的概念图，展示了与时间相关的现象测知结果（包括技术精度的提高及响应式基础设施对于所处环境的理解）。

4. 反馈回路示意图：展现了机械装置的学习能力，同时缩小具有目的性的设计环境与具有不确定性的自然环境之间的差距。

3. A conceptual diagram, based upon the idea of an asymptote; showing the resolution of phenomenal predictability in relation to time (the development of technological precision and a responsive infrastructure's understanding of its context).

4. Feedback loop diagram showing the machine's learning; narrowing the gap between intentionality and indeterminacy.



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实时测知和响应创建出新层面的知识及信息。这类信息因其即刻获取、即刻理解的特性，能够与某一发生转换或变化的特定时刻相对应。然而，实时测知仅仅可以帮助我们理解信息，若考虑到每一时刻产生的无限迭代及渐进演变对河流景观的影响，对其预展形态进行精准预知仍具有困难（图3）。尽管如此，本研究中所采用的超真实反馈回路所具备的复杂性（图4），仍促生了我们对其所处的即时环境的全新理解。例如，我们在名为“沉积体”的早期研究模型中（图5），观察到了新的水流方向，而在另一个名为“协调者”的模型，即“寻向测知”项目的响应模型中，则观察到不断变化的临时地形（图6）。通常情况下，这些具形现象或存在于人类的感知之外，或因后期处理分析滞后的特性而被隐藏。反之，滞后的分析亦可被视作将那些肉眼难见的地形和地貌特征以具形呈现的阻碍。

尽管缺乏精准数据的支撑，但实时测知和监测使捕捉不断变迁的景观，特别是河流系统景观中出现的新形态成为可能。实时捕捉景观具形现象的尝试，也会受到人类活动进程，以及我们所处的似乎已经存在的由技术性拓增造就的超实境的深刻影响。

理论依据——自然与技术的融合

机器的感知过程不同于人类。对前者而言，其“感知”过程借由测知和驱动响应，将捕捉到的自然范畴中的现象转译至虚拟环境中（图7）。这一无限迭代过程最终被重新应用于自然的初始状态中，以创建其新的化身。

这一融合的过程如下：

自然（现实）→虚拟→新自然→虚拟→（更新的）新自然……

对保守人士而言，这一变革过程似乎描绘出一幅环境退化的景象，并使人产生“自

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然是由于技术的增强而处于危险境地”的观念意识。这样的先入之见掩盖和低估了这种基于自然与技术融合而生的“新自然”的潜在价值。此外，这种想法过度简化了由生态过程和技术共同产生的复杂性——人们草率地消极看待生态与技术的融合及拓增，而忽视了其存在本身便代表着一种丰产可续的系统。

我们可以认为，技术进步与自然一直存在着辩证关系。若透过马克思主义的视角描述自然过程，我们可将“生产”视作人类借助技术改变自然形态的持续过程。因此，“生产者只能像自然一样工作，即在改变物质形态的过程中……他不断地得到自然力量的帮助……生产者改变了由自然所供应的材料的形态，使之成为对其有用的物件……”[2]。人类通过劳动改变自然界中的物体，制作出有用的东西以促进和满足其作为物种的生存需求——不论我们是否意识到这一过程所造成的生态影响。这种转变伴随我们不断探求新的技术、改造景观以为己所用的过程而持续存在。

5. “沉积体”是一个实验阶段的实时响应模型，其在程序指导下可阻断水流以瞬时改变水的流向，并形成新的冲击方向，进而影响地形。（模型由列夫•埃斯特拉达制作）

5. Depositor, an experimental real-time and responsive model programmed to interrupt the flow of water. It instantaneously re-directs it to percolate down a new fluvial direction, affecting its geomorphology. (Model by Leif Estrada)

6. 实时的响应模型“协调者”，可监控并调节水流冲击影响下沉积物的冲积形态，最终拓展土地。通过反馈回路，该模型可以不断从环境及所处背景中获取信息。（模型由列夫•埃斯特拉达制作）

6. Attuner, a real-time responsive model that monitors and modifies the alluvial morphology of sedimentation based on the fluvial flux of water, resulting in land accretion. It constantly learns from its environment and context through a feedback loop. (Model by Leif Estrada)

如今，新技术，尤其是那些通过与虚拟环境相融合来增强实境的新技术，已经成为我们所处环境的延伸。与数字化环境的关联逐渐成为我们自身新自然的一部分。与这种现象性和响应式基础设施的分离，带来一种新的可能会使我们失能的焦虑感[3]。虽然由人类所创造，但当这些创造物变得不受控制时，便会带来不安全感，也会促生逾越预定规范的情况发生。“人类无法驾驭自己的创造物”这一情况的出现，使我们将这些新自然视作“非自然的”，并将他们的存在异化为“他者”[4]。

实验与预展——寻向新自然

“寻向测知”项目结合了响应式基础设施模型的设计，其通过一系列实时测知和响应操控来调节地貌具形台的预展冲积形态，将之作为一种调整沉积物积累的方式。这一调整过程将不断地变换和改造河流景观，且更加关注动态的生态过程而非静态建构。

当应用于实际尺度的景观之中，模型中机器获取信息的来源，既包括典型的退化中的工程水渠（例如作为我的毕业设计研究对象的洛杉矶河）的初始场地状况，亦包括测知装置独立产生及与测知内容共同产生的变动。响应式基础设施试图通过从其所处的环境中学习并反复调适特定操作流程的过程展开测知，从而成为一种具有适机性的生态原动力，其能够行使如下效力：

将通过侵蚀现有的混凝土河道衬砌所获得的新材料视为河流沉积过程的一部分（图8，9）；

通过减缓河水和沉积物的流动促生新的临时地形；

通过渗入地下景观，补给现有地下水并创建新的含水层（图10，11）；

为这类河岸构设可以维系预展新自然的演替性植被（图12）。

借由测知性，响应式基础设施将得以调适河流景观；其测知程度超越人类的处理能力，可确保实时地响应和改造景观。借由预展性，由景观设计师所创建的响应式基础设施，将协助人类解决那些极为复杂的、与环境进行实时交涉时力不能及的问题；这类复杂情况具有实时性，因而需要立即做出响应。这些必要的响应通常会为控制着景观过程的主观政策所减缓和阻碍。实时响应的能力也使人类能够以“远距创造者”的身份，在所有地景中与非人类的主体建立关系[5]。

随着构想的新测知工具的引入，景观中新形式的出现也成为了可能——这些形式在机器的感官新维度出现之前是难以想象的。这种通过新自然的复合过程创造出来的表现形式，将使曾经“自然的”的概念变得更富争议。这些现象将推翻现有的二元分裂，即所谓的“人造”技术和所谓的未经碰触的“理想化”自然过程的分裂。

我们所拥有的构想以及创造生物和非生物混生系统的能力，促进着新自然的演变。一直以来，技术性设计总是被用作人类“驯服”生物系统以使其遵循人之意志的方法。为了使这些干预合法化，人类想方设法地寻找并榨取任何可利用的经济和实用能力。然而，即使人类的控制水平再高，这种操控系统总会在某一时刻达到极限。而同样的，对这些极限的认知将触发我们对自然的新的理解。

那在我们眼中，关于生态学和自然的普遍存在的真理，终将迎来不可避免的转变。**LAF**

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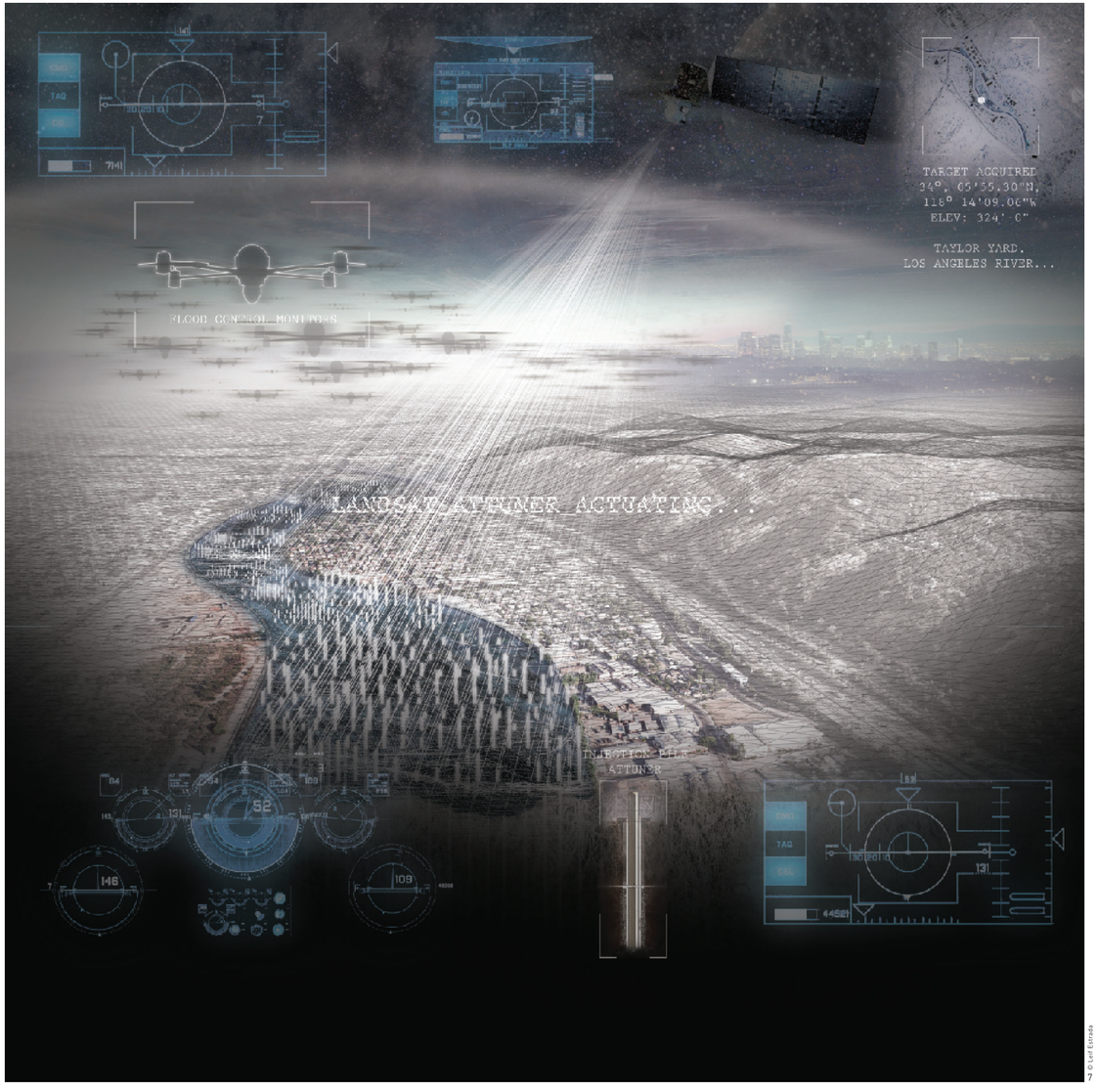

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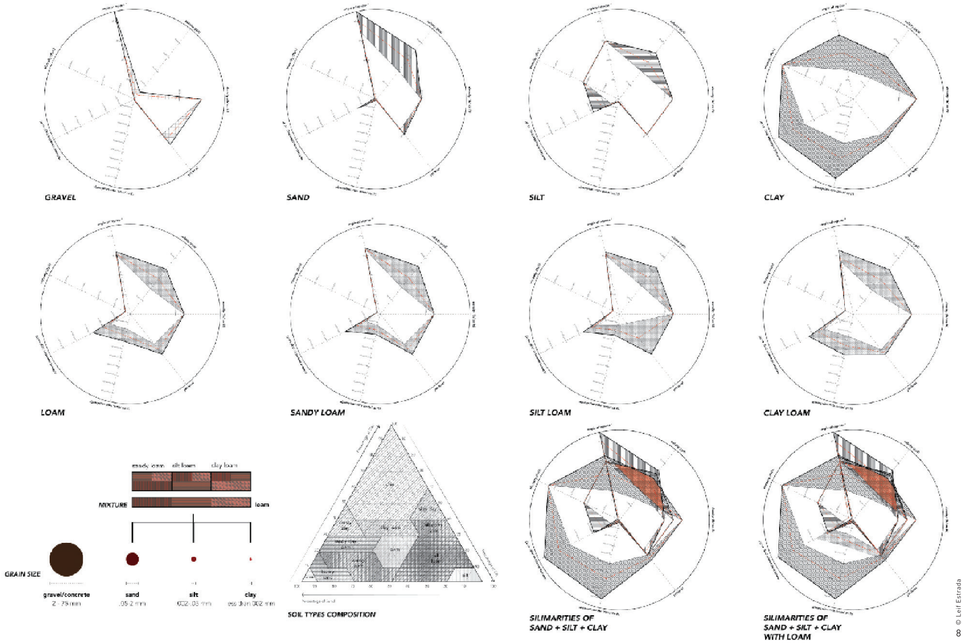
7. 构想中的“协调者”的机械感官。其将捕捉到的自然范畴中的现象转译至虚拟环境中。
8. 以矩阵形式呈现的土壤分析。其分析了当混凝土基质降解后，可能在洛杉矶河预展的演替过程中共存的不同的土壤成分。
9. 工程土壤样品：这些沉积物被应用于河流系统水流形态的动态模拟中，以对砾石、沙子、淤泥、粘土、壤土、砂壤土、粉砂壤土和粘壤土等不同类型土壤中相应成分所占比重的分析为前提。（土壤混合物由列夫•埃斯特拉达制作）

7. An imagined machinic-sensory of the Attuner. Modulated by the translation of the perceived phenomena happening in the natural realm of reality into the realm of the virtual.
8. Soil Analyses presented as an attribute matrix, analyzing the varying soil compositions that would potentially accrete in the projective succession of the LA River as the concrete substrate is degraded.
9. Engineered soil samples: The following "sediments" were used in the live-modeling of the fluvial morphology of riverine systems, which are based upon the weights of the corresponding compositions of varying soils that were analyzed: gravel, sand, silt, clay, loam, sandy loam, silt loam, and clay loam. (Soil mixtures by Leif Estrada)



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Introduction — Addressing Complexities

Complexities and indeterminacies are some of the issues one must confront when dealing with landscape phenomena — and the foremost concerns when engaging with fluid dynamics that affect the landscape's geomorphology. While it is possible to design infrastructures and interventions that alter such landscapes, responsive technologies provide a method of real-time adaptive management, creating methods that tend to curate and choreograph evolving ecological systems. The result is a design methodology that favors inconsistency and spontaneity between ecology and anthropogenic infrastructure that does not require an unending quest for precision in predictability, or even more data.

Historically, when the son of the father of relativity, Hans Einstein, approached his father about his keen interest in leaving structural engineering to study and research sediment transports, he was dissuaded, citing the very study as intractable and that he should do something less complex[1].

Towards Sentience, a graduate design thesis and other various research experiments, sponsored by the Responsive

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Environments and Artifacts Lab (REAL) at Harvard University's Graduate School of Design, incorporate the design of responsive systems, augmenting a geomorphology table, which stands as a site of intervention (Fig. 1). These experimental tests aim to simulate the potentiality of responsive infrastructures to modify the behaviors of riverine landscapes and their fluvial morphologies — including land accretion, vegetal proliferation, and species colonization.

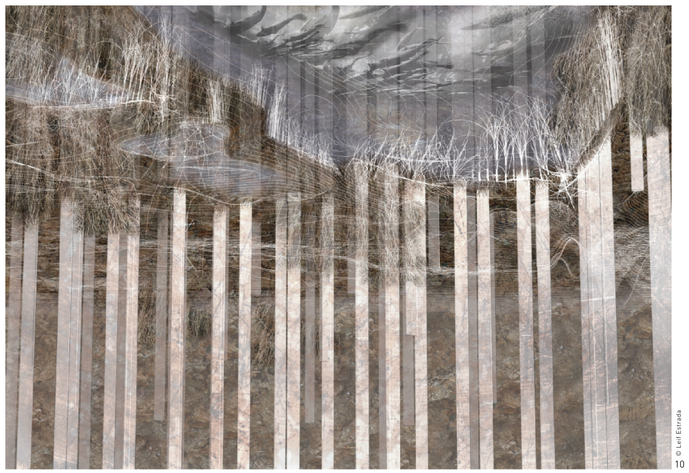
The precision of phenomenal predictability of fluid dynamics may, at the moment, be outside the full grasp of scientific knowledge; however the utilization of a hydrology model captures the behavioral essence of a river's alluvial processes. These exclude the belaboring mathematical algorithm derived from numerical modeling, which are imprecise, as it does not take into account such indeterminacies, caused by the changing environment's variance. Using the immediate knowledge acquired through real-time sensing, the indeterminate inconsistencies become latent and are taken advantage of as it becomes enmeshed through the introduction of technology as a new form of ecology, and eventually *Nature*, itself (Fig. 2).

The addition of real-time sensing and response creates new layers of knowledge that is immediately acquired and understood in relation to a specific moment of shift or occurrence of change. However, despite the level of understanding, such sensory is limited to fully predict the projective morphology of riverine landscapes, as every moment is infinitely iterative, as it is asymptotic (Fig. 3). Despite of this, however, the complexities of a hyper-real feedback loop (Fig. 4) produce new understandings of its immediate context, such as new directions of water flow as observed in an early study model, the "Depositor" (Fig. 5) or the emergence of temporal landforms that is in constant flux with the "Attuner" (responsive model of *Towards Sentience*) (Fig. 6). These manifested forms are usually latent to human understanding or even through the nature of delayed analyses brought upon by post-processing. In turn, delayed understanding becomes a hindrance to the potential manifestation of unseen landforms and land types.

Though lacking the precision of data, real-time sensing and monitoring enables the facilitation of the emergence of new morphological forms across the constantly shifting landscapes, specifically those of riverine systems, which at the same time is brought upon by the epoch of anthropogenic processes and the already-seemingly technology-augmented hyper-reality we are in.

10. "协调者"，可以被想象为实时响应的粉喷桩，可用于管理已有的及新的蓄水层。图中为从交错矩阵的视角观察到的水下情形。
11. "协调者"中不同条件下的粉喷桩细节图。

10. Attuner, imagined as real-time responsive injection piles charging existing and new aquifers seen from below the water table as a swaziometric perspective.
11. Attuner, injection piles detail shown in multiple conditions.



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Theoretical — Mergence of *Nature* and Technology

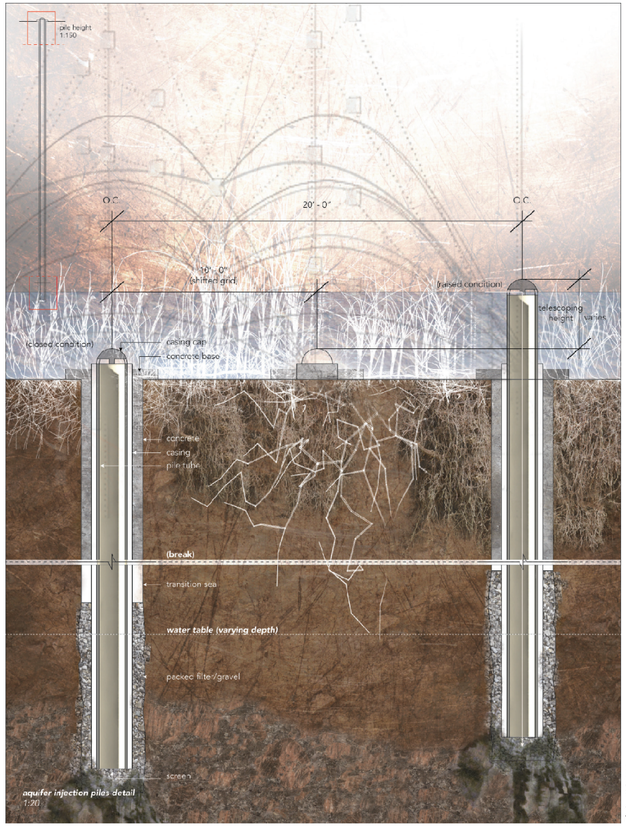
As the machine's senses are different in that of a human, its perception is modulated by the translation of such perceived phenomena happening in the *Natural* realm of reality into the realm of the virtual through sensing and actuated response (Fig. 7). The infinitely iterative process is eventually re-applied back into the initial state of *Nature* to create a neo-incarnate.

The compounding process is as follows:

Nature (Reality) → Virtual → Neo-*Nature* → Virtual → (Neo) Neo-*Nature*...

Though to conservatives, this transformative process creates an image of a degrading environment and produces the perceived notion that *Nature* is in danger due to technological augmentations. This problematizes and undermines the undiscovered value of such emerging neo-*Natures*, produced as a hybrid with technology. It further oversimplifies the complexities produced co-dependently by ecological processes and technology — where the proliferating ubiquity is immediately deemed bad, without consideration that its existence is an indication of a productive and sustaining system.

However, one can argue that technological advancements have always been in dialectic with *Nature*. Framing the processes of *Nature* through a Marxian perspective, it can be deduced that production is a continuing process, which alters the forms of *Nature* by humans along with technology's aide. As such, "the producer can work only as *Nature* does, that is by changing the form of the matter... he is constantly helped by natural forces... the producer changes the forms of the materials furnished by *Nature*, in such a way as to make them useful to him..."[2]. Humans have altered objects from *Nature* through labor to produce useful things in order to



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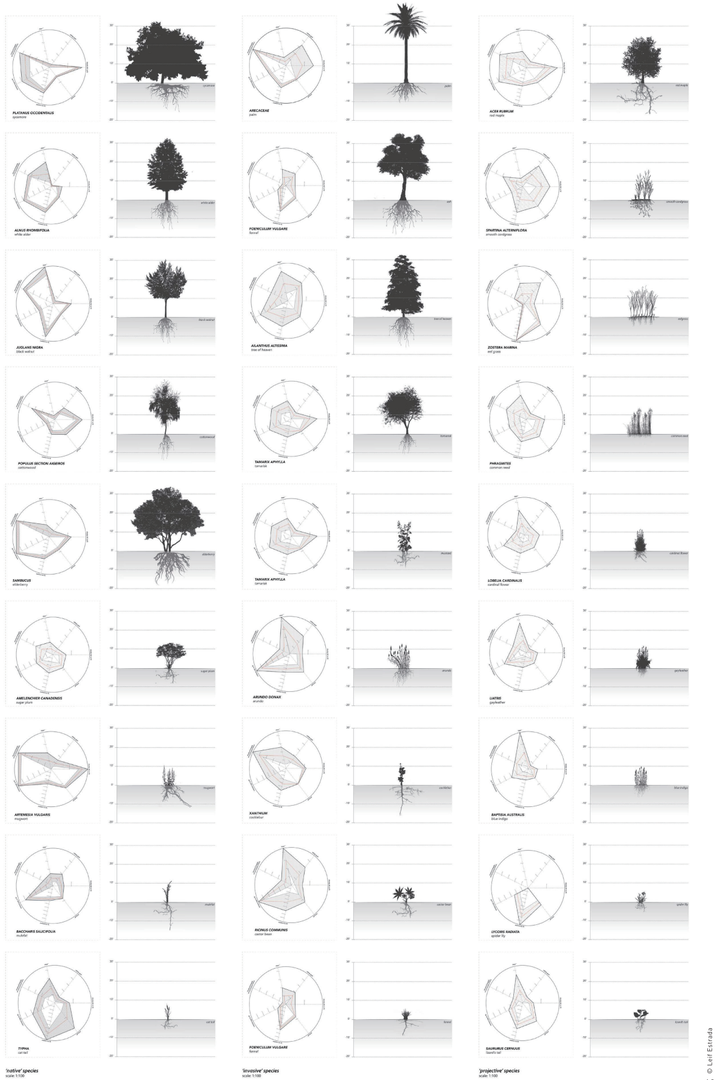

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12. 物种分析展示了每种植物的理想性能分布，可与土壤分析相结合。

12. Species Analyses, showing each plant's ideal attribute, which can be overlaid with the soils analyses.

facilitate and fulfill our needs to thrive as species, whether or not we are conscious of the ecological impact we are causing and altering. The shift is inevitable, as we continue to create new technologies in order to mitigate landscape phenomena for our benefit.

Today, new technologies, specifically those that augment the environment with its mergence with the virtual realm have become an extension of our being. Digital connectivity is more and more becoming a part of our own neo-*Nature*. A disconnection from this phenomenological and responsive infrastructure brings upon a new sense of anxiety, which can be disabling[3]. Though created by man, it can be unsettling when these creations become uncontrolled, and informalities begin to occur. The idea of man's inability to tame his own creation reverts our perception of these neo-*Natures* as "unnatural," and exoticizes their existence as being the "other."[4]

Experimentation and Projection — Towards Neo-*Nature*

Towards Sentience incorporates the design of a responsive infrastructural model, which attunes the projective alluvium of the geomorphology table through a series of real-time sensing and responsive manipulations as a way to curate the successions of sediment accretion — constantly altering and modifying the riverine landscape, privileging the evolution of ecological processes over static constructions.

When deployed in the one-to-one landscape, the machine intends to learn from initial site conditions of typically degrading engineered channels (the Los Angeles River, as explored in the thesis), but also from the modifications it will produce independently with its sensories, and co-dependently with what is being sensed. The responsive infrastructure aims to become sentient, through learning from its environments, iteratively honing on specific operational processes, as an opportunistic ecological agent, which strives to:

erode existing concrete lining, and understand the new material as part of the sedimentation process (Fig. 8, 9);

attenuate flows of water and sediment in order to accrete new temporal landforms;

infiltrate the subterranean landscape to potentially recharge existing, and create new aquifers (Fig. 10, 11);

and predict the potential successive planting that would endure the projective new *Nature* of such channels (Fig. 12).

Sentient-*ly*, it will attune the fluvial landscape — to a level of degree that man is incapable of processing in order to respond and modify the landscape in real-time. Projective-*ly*, responsive infrastructures would be created by landscape architects and designers to aid themselves and address human incapability in negotiating complexities that occur in real-time, which necessitates immediate responses. These necessitated responses are usually slowed down or hindered by subjective policies that govern landscape processes. This new ability also enables our relationships with non-human agents throughout all terrestrial landscapes in the form of a "distant author."[5]

Through the introduction of new imagined sensories, emergence of new forms within the landscapes are enabled, which has never been possible without the machine's new dimensions of sentience. Such manifested forms created by the compounding process of the neo-*Nature* would further bring upon disorientation as to what was once *Natural*. These phenomena would cause for the rejection of the current dichotomy created by "man-made" technologies and "idealized" notions of untouched natural processes.

Our ability to conceptualize and create hybrids of biotic and abiotic systems facilitates the evolution of neo-*Natures*. Technological design is consistently introduced to "tame" biologic systems to human will. To legitimize these interventions, humans find and extract any economic and practical capacities. However, despite levels of human control, there is always a moment in which a system will reach its limitations. As such, these limitations will produce our new perceptions of *Nature*.

A shift concerning ecology and *Nature* in what has been the accepted norm is inevitably upon us. **LAF**

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