Narrating global emerging issues with complexity-inspired installations

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Abstract

The global emerging issues outlined in the United Nation 2030 Agenda profoundly impact humanity and the environment. These multifaceted issues exhibit characteristics typical of complex systems. In this paper, we present an innovative approach to raise public awareness of these global challenges through complexity-inspired new media installations. These installations are derived from scientific models in the field of complex science, manifesting self-organized criticality. We illustrate how these installations can effectively communicate issues such as food insecurity due to climate change, antimicrobial resistance, and human-induced seismicity. Furthermore, we briefly discuss the merits associated with employing such systems for storytelling.

Keywords

Practice-based research, Artsci, earthquake, new media art, sound installation, interactive art, human-computer interaction, Anthropocene, climate change, sustainability.

Introduction

Art and culture play pivotal roles in achieving the Sustainable Development Goals (SDGs), functioning as catalysts for sustainable development. [1] Art fosters creativity and diverse forms of expression, which are indispensable for effectively conveying the SDGs in various cultural contexts. Moreover, it can also raise the awareness and catalyze actions about sustainability and climate change. [2] Designing public awareness campaign is a crucial first step in instigating behavioral changes of people.

Artistic expression holds distinct advantages over conventional media as a means of communication. Artworks have the capacity to deliver engaging sensory experiences that are simultaneously thought-provoking. Digital and new media art opens up new and novel pathways for intricate storytelling. [3] Narrative-centric approach in addressing sustainability issues through digital and new media gives rise to the conceptualization of non-media art. [4]

Narrating Complex Issues with Complexity

The global emerging issues can be conceptualized as emergent phenomena from a complex system. [5] A complex system comprises essentially a network of interacting agents. [6] The nature and the society therefore form a large complex ecosystem containing countless variables such as climate, industry, economy, and human behavior. The emerging issues manifest as abrupt shifts in environmental states resulting from incremental alterations in various parameters accumulated over time. These critical transitions share analogies with more readily comprehensible occurrences in nature, such as avalanches or earthquakes.

In a recent review article, Koentiz *et al.* addressed the need for new narrative representations of complexity and elucidated the associated challenges. [3] They also pointed out the advantages of interactive digital media, wherein the computer serves as a means for data storage and processing data, facilitating viewer participation and exploration of artwork from diverse perspectives. The affordances of digital media as defined by Janet Murray (procedural, participatory, spatial, encyclopedic) present distinct advantages over traditional media. [7]

We propose to use the inherent physical mechanisms in complex systems to captivate viewers and assist them in acquiring some form of emotional weight towards the underlying science. This approach is likely to evoke curiosity, and, consequently, motivate viewers to gain insight about the background concerning the emerging issue.

Biodiversity

Studies found that climate change has profound and direct impact on agriculture and food systems. Global warming, declining and more unpredictable rainfall, more frequent extreme weather and higher severity of pest and disease are among the drastic changes that could impact food production. [8] With climatic uncertainty and extremes projected to increase in the future, agriculture and food production are more vulnerable than ever. This instability poses risks to livelihoods, farmer incomes and ecosystems. It is estimated that by 2050, climate change will reduce agricultural production by 2% per decade, while food demand is anticipated to increase by 14% per decade. Additionally, major crops are expected to experience an average decline of 8% in yields, particularly for regions such as Africa and South Asia. [9]

The regions most significantly impacted are concentrated in the tropical and subtropical zones. The climate change effect the ecosystem, and the farmers will have fewer options in their system to grow. Compounded by political and economic instabilities, farmers in these areas face additional challenges, as the lack of resources, tools, and technology hinders their ability to effectively address

the issues arising from climate change.

Research showed that diversity farming is the single most important modern technology to achieve food security in a changing climate. [8, 10] The large number of different species or varieties present within a given region or ecosystem enables some of these species to endure and thrive amidst shifting environmental conditions.

Figure 1. The *Rice-Pile Model: Diversity for A Resilient Future* contains seeds from a variety of crop species to highlight the importance of bio-diversification in tackling the food-insecurity caused by climate change.

The artwork *The Rice-Pile Model: Diversity for A Resilient Future* (2019) (shown in Fig.1) attempts to raise the public awareness regarding the global food insecurity stemming from climate change. This kinetic installation features a pile of seeds within a thin, transparent container, generating avalanche events. Avalanche events are self-organizing events in the complex system when its state deviates from equilibrium. [6] The seeds employed encompass a variety of species to highlight the narrative. A mechanical device was devised to release particles from the top into the container. Upon reaching a critical slope, further particle accumulation may trigger an avalanche event. Figure 2 shows the information flow of the interactive system. The movement of sliding particles is captured through a camera and processed in a computer to synthesize sound. To achieve a natural sound resembling a real-time avalanche, concatenative granular synthesis techniques developed by D. Schwarz *et al.* [11] are employed, utilizing the sound of falling rocks as the input sample.

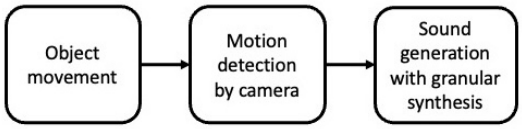

Figure 2. The data flow of the *The Rice-Pile Model: Diversity for A Resilient Future*, and *The Rice-Pile Model: SPill.*

Antimicrobial Resistance

Antimicrobial resistance (AMR) has emerged as one of the leading global public health threats in the 21st century. [12] It occurs when bacteria develop resistance to the drug diminishing its effectiveness. A study conducted in 2019 showed that 1.27 million deaths were attributed to bacterial AMR, with an additional 4.95 million deaths associated with the same cause. [13] A 2014 study commissioned by the UK government showed that if AMR remains unaddressed, the annual death toll could reach 10 million people by 2050, surpassing fatalities attributed to cancer. [14]

The mechanism of antimicrobials involves inhibiting or interfering with bacterial cell wall synthesis or protein synthesis, essential for bacterial survival. However, resistance to antimicrobials arises in bacteria through natural selection and mutation. Over time, certain bacteria can acquire genes that encode enzymes capable of breaking down antimicrobial agents before they can be effectively eliminated. [15]

Antibiotics can enter the environment through various pathways, including animal waste, human waste, and manufacturing waste. A notable contributor is the unwarranted use of antibiotics, wherein patients may insist on these medications from healthcare providers or acquire them over the counter without a comprehensive understanding of the implications or necessity. Additionally, improper disposal practices, such as flushing antibiotics down the toilet, further exacerbate the issue. Addressing pharmaceutical waste typically involves incineration, yet in many countries, the incineration temperature for regular household waste falls significantly below the necessary temperature (1100 °C) required for the effective breakdown of pharmaceutical wastes.

In order to raise the awareness about the AMR issue, we employed the same kinetic installation described in the preceding section. However, this time instead of seeds, it contains 10 kg of recycled waste pills, donated by the public whom we reached through digital social flatforms such as Facebook and Instagram (Fig. 3). This new iteration of the installation was renamed as *The Rice-Pile Model: SPill.* Beyond the description of our project, the social media posts disseminated pertinent information on the proper disposal of pharmaceutical waste. This practical and valuable guidance, coupled with genuine intentions, motivated viewers to share the posts more willingly than usual. Notably, we observed a substantial increase of approximately 400% in the number of shares and likes.

Figure 3. Left: The mechanical system used in transporting particles to the top of the container initiating avalanche events. Right: The recycled pills are collected and unpackaged.

Human-induced seismicity

Anthropogenic activities are known to induce earthquakes. These activities include the injection of wastewater into disposal wells, the erection of tall building, and practices such as fracking, as extensively documented in a global study by Fougler *et al.* [16] Induced seismicity resulting from these activities has the potential to cause significant destruction to communities in the affected regions, posing a threat to the safety of inhabitants. It is imperative to raise awareness about these issues among the public to foster a greater understanding and ensure the establishment of sustainable environments for future habitation.

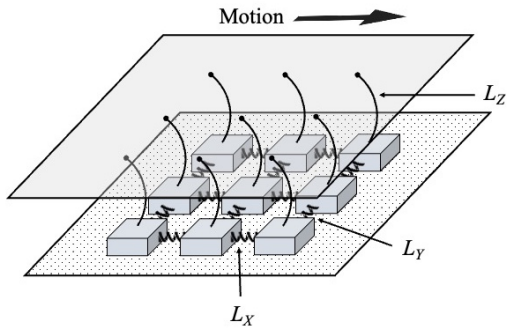

Figure 4. The spring-block model for simulation of the earthquake recurrence proposed by Brown *et al*. [17]

Figure 5. The adapted 5 x 5 spring-block system in the installation work *Echoes of the Land*. An enclosing frame provides an interface for human-interaction.

Scientists have investigated earthquake recurrence using the spring-block model, as illustrated in Figure 4. This model simulates the dynamics of earthquakes and comprises 2D arrays of blocks interconnected by springs on a rough surface. Each block is again connected to a suspended plate at the top through a spring, facilitating horizontal movement. [17] The earthquake recurrence is initiated by moving the top plate in a horizontal direction. The springs, L_Z's, pull the blocks along with the plate. However, owing to friction between the blocks and the bottom surface, the majority remains stationary until the pulling force reaches a critical threshold, causing one block to slip. The slippage subsequently triggers a cascade of sequential movements propagating throughout the network of blocks via the springs L_X's and L_Y's.

We created the artwork Echoes of the Land based on the spring-block model. To ensure an engaging sound effect while retaining a good visibility, we modified the model by transforming the top plate into an enclosing frame housing 25 blocks arranged in a 5 x 5 array, as depicted in Fig. 5. This alteration eliminates visual obstructions, allowing the audience to directly observe the movement of the blocks (see Fig. 6). The primary distinction introduced by this modification is that the central nine blocks are not directly attached to the frame, resulting in a slower propagation of motion towards the center. Despite this simplification, the ensuing dynamics closely mirror the original setup, presenting an impressive visual and auditory experience.

Similar to *The Rice-Pile Model*, we use the granular synthesis technique to map the slipping motion of the blocks onto the descriptor space to generate sounds in real-time (Fig. 2). An additional effect is the illumination of the top of the blocks while in motion, enhancing the visual impact.

The human interaction of this artwork serves as an intuitive metaphor for narrating an anthropogenic event. A comprehensive technical description and further analysis of the emergent aesthetics will be incorporated in forthcoming publications.

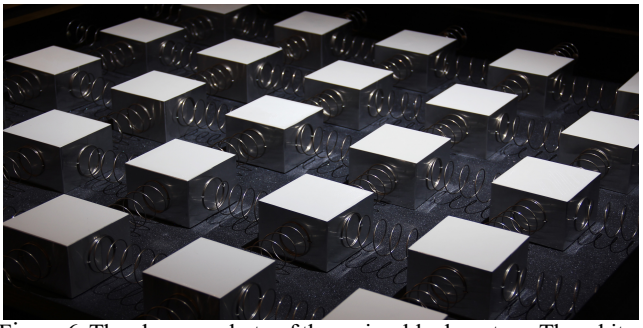

Figure 6. The close-up photo of the spring-block system. The white part of a block illuminates when it moves (not shown in this photo).

Discussion and Conclusion

In summary, we have introduced innovative approaches to convey global emerging issues through new media art installations rooted in complex science. These installations produce captivating sound and visual effects resulting from the non-equilibrium motion of self-organizing systems. Our exploration has specifically delved into three prominent emerging issues—food insecurity, antimicrobial resistance, and human-induced seismicity—and elucidated how these challenges are narrated through our artworks. The public display of the installation can actively engage viewers in a discourse regarding the emerging issues, as well as fostering discussions about the interplay between art and science.

The participation of the public by donating waste pills not only recycles wastes, but also helps to disseminate the awareness of the emerging issue via social media platforms. The donors act as agents who are likely to share the

information to their friends since they affirm the project goal. This strategy enhances the public impact of the artwork. The interactive mechanism of the *Echoes of the Land* brought clear advantage of engaging the audience, particularly the children. From our observation with the audience whiling showing the work, even though children might not have understood the science or the context behind, they spent a long time playing the installation presumably entertained by the interactive effects. Subsequently, they turned around and asked their parents to explain the meaning and how it worked. Studies supported that play is a powerful engagement process in learning especially for children. It is easier to engage the children in activities when playing is their motivation. [18, 19]

While considerable attention has been devoted to exploring aesthetic values in computational complexity [20], there remains a relative scarcity of analyses on tangible installation works. This scarcity may be attributed to the technical intricacies involved in realizing such works, resulting in a limited number of examples for study. Consequently, there is a potential avenue for investigating the aesthetic values and quantifying the complexity inherent in the systems we have created. It is noteworthy that the visual and audio aesthetics inherently embody emergence, as they stem from complexity models. A comprehensive discussion on the interconnection between complexity and our artworks, along with technical details, will be presented in forthcoming publications. Moreover, *Echoes of the Land* can be viewed not only as a means of artistic expression but also as a novel form of musical instrument or a device for performance art. Further exploration along this trajectory holds promise for additional insights and creative possibilities.

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Author Biography

Ivan is an artist and a researcher. He studied physics at Imperial College London, and subsequently obtained his PhD from Max-Planck Institute for the Physics of Complex Systems in Germany. He worked as an independent artist for 10 years before becoming a full-time faculty member at the National Yang Ming Chiao Tung University in Taiwan, where he founded the Future Narratives Lab. His current works explore new ways to narrate contemporary issues with science-inspired artistic representations. He enjoys engaging the public and make them wonder about the internal mechanism of our world and how all things are connected by simple and elegant ideas.