I Light U Up: Exploring a New Emergent Narrative Paradigm through Physical Data Participation in AI Generative Experiences

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Figure 1: "I Light U Up" - An Emergent Narrative Installation. Left: A participant interacts with the physical installation using light, where the light value is parsed into the generative algorithm. Right: One of the virtual agents, responsive to the physical inputs, narrates to the audience - with subtitled text appearing on the screen. (©Zhen Wu)

ABSTRACT

This paper introduces "I Light U Up", an interactive installation that explores the use of light as input for emergent narrative powered by LLM. Through an installation with light sensors, the audience uses light to communicate with the parallel digital beings, generating a narrative experience that emerges from the interaction. This work serves as a proof-of-concept, supporting a conceptual framework that aims to open new perspectives on the participation of physical data in emergent narrative experiences. It seeks to develop a new dimension in contrast to the text-centric one-way relationship between reader and story by including agency beyond human interactivity.

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CCS CONCEPTS

• **Applied computing → Media arts**; • **Computing methodologies → Natural language generation**; • **Human-centered computing → Interaction design**.

KEYWORDS

Emergent Narrative, Large-Language-Model(LLM), Emergent Art

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1 INTRODUCTION

In interactive art, emergence is the process where interactions between discrete elements create complexity and novelty greater than the sum of its parts [Seevinck 2017]. It embodies the Taoist philosophical concept of 'One begets two, two begets three, three begets all things'. Although interactive narrative can rely on the author's pre-scripted content, emergent narrative systems create stories during the program's run based on open-ended rules to create narratives that can unfold in unpredictable ways [Ryan 2009]. It also provides an alternative paradigm that replaces the omnipotent story creator with multiple agents - the author(s), the players, or the digital system itself - each share relative freedom and autonomy to the forming of the final narrative [Green 2020; Walsh 2011]. Physical data, captured by sensors plays an important part in emergent art. Artwork such as *Autopoiesis* [Rinaldo 2000], *Constellaction* [panGenerator 2013] and *Swamp Orchestra* [Petkovic 2016], use sensors to create complex and poetic interaction. In this work, we aim to bring emergence to an interactive narrative experience by speculating, how physical data can contribute to the unpredictable and generative qualities that emerge from the interplay of human, digital, and physical elements.

Meanwhile, Large Language Model (LLM) technology is opening up new possibilities for interactive artistic experiences [Bhardwaj and Sra 2023; Sun et al. 2023b], providing novel examples of generative narrative, though not a narrative experience akin to a complete story. The core advantage of LLM in these examples lies in the unpredictable and open-ended nature of outputs, which require active audience participation to shape the narrative, linking to the quality of emergence. Furthermore, LLMs increasingly leverage multimodal input, such as GPT-4o [OpenAI 2024b] and Hume AI [AI 2024], presenting the scenario of incorporating physical input beyond text in human-AI interactions. Considering these, LLMs can facilitate emergent narratives, serving as a medium to process complex physical data into emergent and unpredictable interactive outputs.

This paper presents "I Light U Up" (Figure 1), an installation that links emergent narrative, physical data, and LLM. It explores a new interactive framework that leverages physical data as the main input to interact with AI agents. The artwork uses light captured by photoresistors as physical data. Together with user interaction and AI-driven characters, it weaves an overall narrative experience. Besides light directed by the audience, the virtual characters' behavior is also affected by the ambient light, forging a unique synergy between the physical and virtual realms. "I Light U Up" explores the following aspects: (1) An emergent narrative framework that fuses the recursive audience-author-story loop with physical data. (2) Reflections on the text-centric human-LLM interactions by introducing the agency of physical data. (3) Non-verbal AI agents interaction and an algorithmic framework supporting it.

2 RELATED WORK

2.1 Physical data in Emergent Interactive Art

Emergence is a topic in interactive art, that stresses rich possibilities for dynamic digital experiences that transcend the simple sum of their constituent elements. The emergent interactive systems cultivate unexpected, complex behaviors that arise not directly from the explicit context or programming from which they originate [Seevinck 2017]. Physical data is important in this context. For example, *CONTACT/SENSE* introduced in [Morita and Kakehi 2023], applying data from plants in generative artwork, stressing the unpredictable and iterative processes behind plant-generated data. In *Autopoiesis* [Rinaldo 2000], the self-organizing robotic sculptures respond to the physical installation environment, with behaviors akin to those from the the natural world. In emergent a/v installation *Constellaction*[panGenerator 2013], light sensors situated throughout the environment invite audiences to manipulate the light, triggering "light domino" effects that simulate the flocking behavior of birds. In *LightSense* [Rieger et al. 2023], physical data are applied in a neural network trained on sixty thousand poems, allowing the physical structure to lead unpredictable conversations with the visitors.

2.2 AI in Emergent Narrative

Emergent narrative (EN), introduced in the late 20th century [Aylett 1999], is a storytelling approach where the narrative forms spontaneously through dynamic interactions, rather than being prewritten. EN relies on underlying behaviors and events, with complex narrative patterns arising from the interaction of simple components and rules. EN is widely used in interactive media, particularly games such as *RimWorld* [Ludeon Studios 2018] to create engaging, participatory, and unpredictable narratives [Koenitz et al. 2015]. The application of artificial intelligence (AI) related technology has gained significant attention in narrative experience. AI-generated content introduces uncertainty and randomness, offering players greater freedom compared with fixed scripts. For instance, *Façade*[Mateas and Stern 2005] uses AI with natural language processing. Characters' behaviors and dialogues dynamically adjust based on player interactions and relationships, creating a nonlinear, interactive drama experience. In *Ad Verbum*, Nick Montfort [Montfort 2000] developed a program that simulates a world, understands natural language from a participant, and provides a textual reply based on events in this world. Recently, advancements in Large Language Models (LLMs) like ChatGPT[OpenAI 2024a] enable AI to understand and respond to complex natural language inputs.*1001 Nights* [Sun et al. 2023a] showcases emergent gameplay by leveraging generative AI technologies for narrative generation.

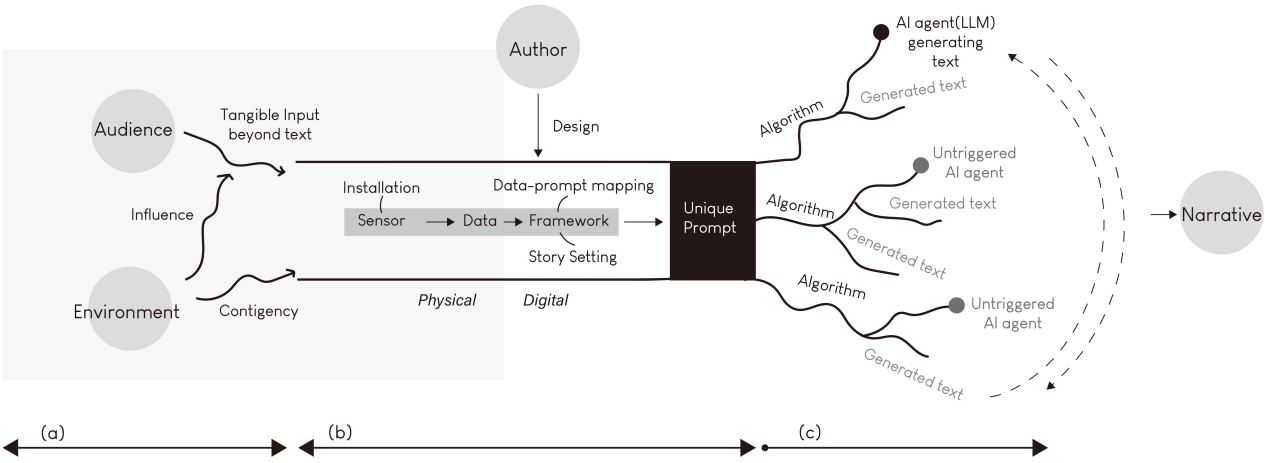

Figure 2: Conceptual Framework for the Emergent Narrative Paradigm in "I Light U Up". (a) Data is collected from the environment and author's interactive input. (b) An algorithmic generative framework defined by the author processes the data. (c) The recursive process composes the emergent narrative through each iterative loop of LLM-driven generation.(©Zhen Wu)

Players interact with an AI-driven character to co-create stories, dynamically materializing narrative elements into game objects.

2.3 Tangible Narrative

Tangible narrative systems use physical objects to augment storytelling, combining physical items with digital content to trigger multimedia experiences through user interaction [Harley et al. 2016]. This form emphasizes user interaction, with objects representing or metaphorically conveying story elements. Users explore, reconstruct, or influence the story by manipulating these objects. For instance, PuzzleTale [Shen and Mazalek 2010] integrates tangible puzzle pieces with an interactive table, allowing users to influence digital characters and storylines through physical manipulation. Architales [Mazalek et al. 2009] employs an interactive story table to merge physical and digital storytelling in public spaces, inviting users to engage with narratives through touch and tangible objects. Narrative integration in alternative reality mobile games, such as *Ingress*, also presents the possibility of linking digital stories to real-world data [Chess 2014]. In artwork, *The Garden of Unearthly Delights* [Yip 2023] invites the audience to interact with the system, forming a branching narrative blending the physical and digital.

3 CONCEPTUAL FRAMEWORK

Based on the related work discussed above, we propose a new conceptual framework for emergent narrative experience in "I Light U Up". This framework consists of three primary steps involving the author, audience, and environment as the three main actors, as shown in Figure 2. In step (a) the audience and environment both produce data, captured and processed by sensors embedded in the physical installation. These sensors forge a direct connection between physical and virtual ensuring that all elements of the physical environment affect the behavior of the virtual characters. In step (b), the received physical data is encoded into authored prompts and parsed into LLMs for a live narrative generation. While the story setting can follow traditional authoring, the algorithmic framework for data processing is open-ended, considering how physical inputs dynamically interact with and shape the evolving narrative. Under the algorithmic framework designed by the author, the audience has agency by directly interacting with the narrative. Concurrently, the environment has agency in directing the story by placing contingency upon the main content. Finally, step (c) is a recursive process. After one generation loop is finished, the algorithm waits for the next iteration of input from the physical sensors. Through this iterative interaction loop of inputs and outputs, individual narrative fragments are procedurally generated and collectively form a unified, emergent narrative whole.

Our conceptual framework aims to raise the thinking of how incorporating non-human elements, such as environmental factors, can cumulatively shape and influence the narrative. By blurring the boundaries between audience, story, and external stimuli, this conceptual framework transcends traditional notions of authorship and narrative linearity, embracing an emergent, contingent storytelling model.

4 DESIGN AND INTERACTION

This section explains this artwork's detailed interaction design, following the conceptual framework described in Section 3. Figure 3 demonstrates the system design of this artwork, and how the audiences interact with different agents within different environment conditions. The system consists of a physical installation, linked to the digital content displayed on the screen, with an LLM backend to support the narrative generation.

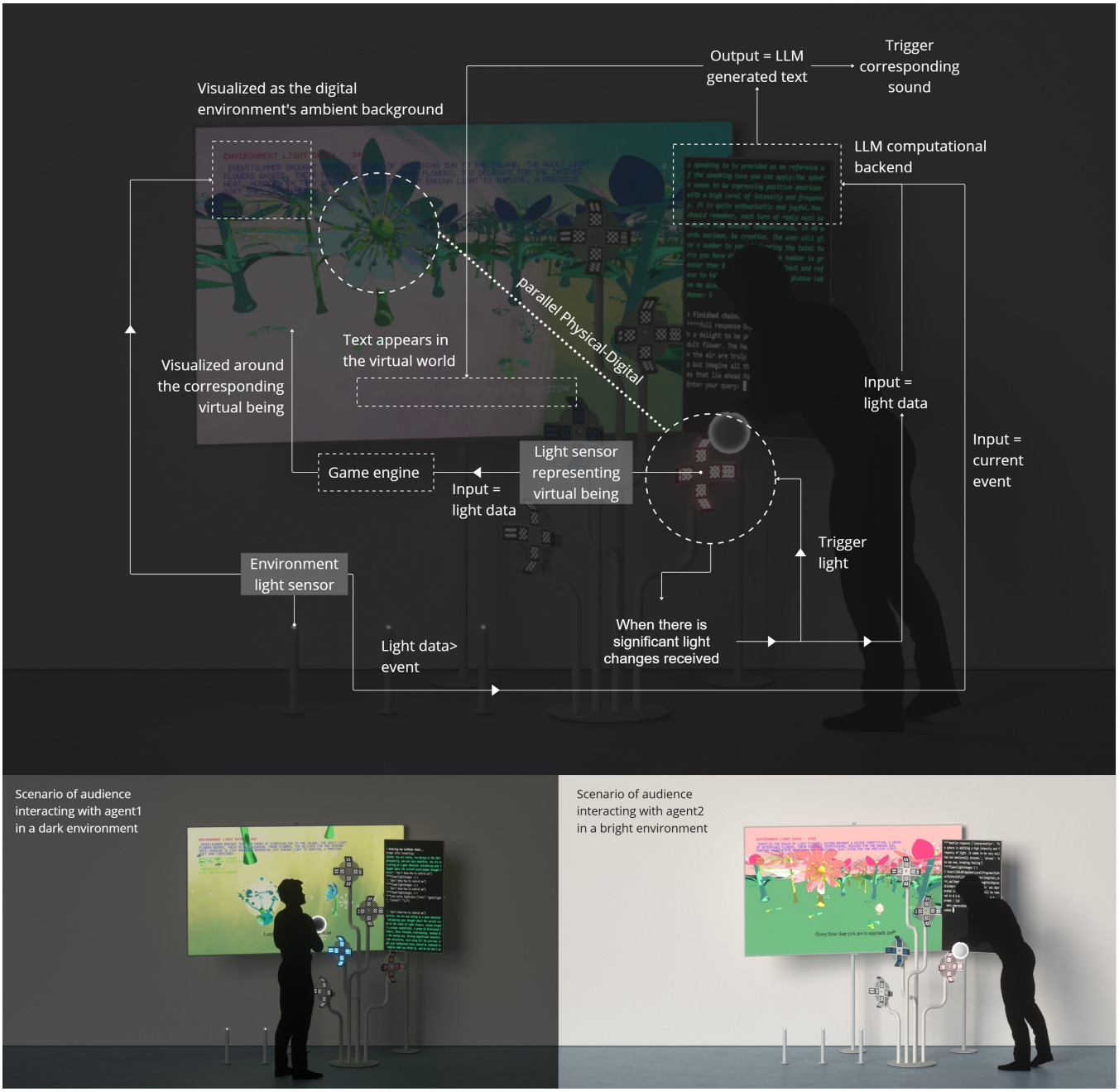

Figure 3: System Design Overview for the 'I Light U Up' Interactive Installation. (Top) The workflow of the interactive system illustrates how the different components - including sensors, user inputs, and the backend algorithm - communicate and integrate to drive the experience. (Bottom) Two interactive scenarios depicting the installation in different environmental lighting conditions.

4.1 Story Design and Interactive Narrative Mechanisms

Inspired by the idea of Alternate Reality [Szulborski 2005], we set our story in an artificial world where the virtual creatures, depicted as flowers, serve as avatars of tangible sensors in the physical world. Audiences enter a flower-filled island as outsiders, where the communication language is light-interacting with the sensors by delivering light, which means communicating with flowers from the virtual world. This project aims to simulate real-world human communication. A noisy environment prevents the speaker's message

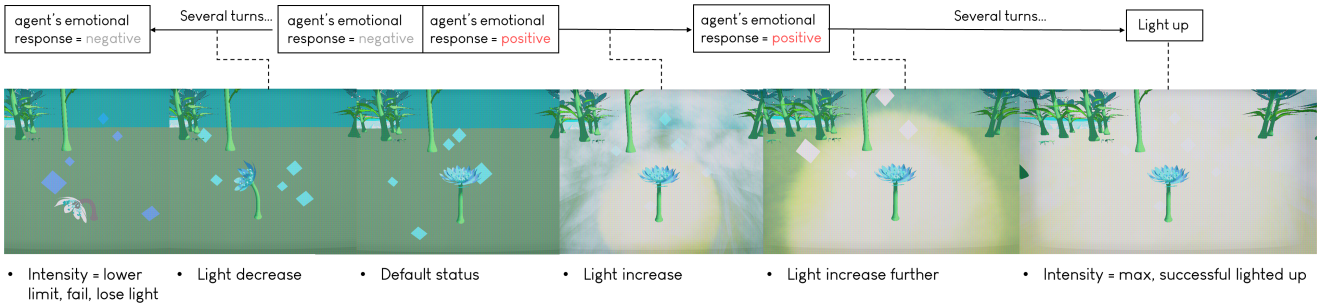

Figure 4: The reward mechanism of the narrative experience. If the virtual entities are satisfied with the current conversation, they will emit light, increasing in intensity until the maximum brightness is reached, signifying the audience's successful illumination. Conversely, if the light diminishes, it symbolizes a failure.(©Zhen Wu)

from being fully and accurately conveyed to the listener. Similarly, in our artwork, although the audience can deliver different types of light as input, the actual information received by the virtual flowers is the data captured by the sensors, affected by the ambient light "noise". We designed four interactive flowers as characters with distinct personalities and backstories, leading their response to the audience's light. For instance, some flowers prefer high-frequency, high-intensity light, indicating their outgoing and enthusiastic nature. If these flowers receive low-frequency, low-intensity light to communicate with them, they will feel disappointed and refuse to talk. Besides, we designed a positive feedback reward system [Wang and Sun 2011] as shown in Figure 4. As players learn more about each flower, they can better communicate by providing the appropriate light, leading to a more positive narrative.

4.2 LLM Generative Framework Design

Figure 5 demonstrates the generative framework. It consists of two main parts. The first part contains a prompt library with knowledge bases and dynamic prompt assignment functions. The setting of the entire narrative world is stored in a shared knowledge base, and the background story of each agent is stored individually. When an agent is activated, the shared world setting and the agent's background are applied as a Retrieval Augmented Generation (RAG) mechanism [1] within the generation loop. The second part of the framework focuses on the LLM generative process, containing a dynamic prompt-formatting framework that determines how the input light data can be processed as the prompts for LLM generation. The following describes the framework in detail, combined with the related interactive behaviors.

4.2.1 Light Interaction of the Environment. The proposed system uses the light data sensed by the environment light sensors to control the events of the narrative world. A predefined set of 16 event sentences is designed, each associated with a specific range of light intensity values between 0-4095. This light-event dictionary maps the darker values to events in colder seasons and the brighter ones to the warmer seasons. For example, an environment light data of 1295 corresponds to the event *"Autumn leaves the island bare and desolate. The once vibrant Light Flowers lie scattered, decaying, their withered forms a reminder of life's fleeting beauty"*. The current event influences the AI agents' focus in the narrative generation. Figure 6 demonstrates how the virtual environment varies from different physical environment conditions.

4.2.2 Light Interaction of the Audience. Light data is converted into emotional phrases, creating a novel form of character-driven narrative communication supported by a light-emotion dictionary (see Figure 5) that serves as a shared knowledge base for the agents' emotional expression and narration. Referring to the Circumplex Model of Affect [Russell 1980], the light data is modeled into four quadrants based on two factors: light intensity as emotion valence and light frequency as emotion arousal. For each quadrant. We collect words, phrases, and sentences representing the emotional situation. Audience actions trigger the narrative generation, with the sensor detecting light changes that are parsed into the generative algorithm. Two LLMs work in this process. The first LLM is for interpreting the received light based on the shared light-emotion dictionary and reporting an emotional response representing the NPC agent's feeling towards this interpretation. For example, when the audience uses a bright light to interact with Lumina, a sensitive agent who becomes anxious under intensive light, the flower will interpret the light information as positive valence. Influenced by the flower's characteristic of detesting intensive light, but understanding the audience's positive intent, the flower may output a low valence, low arousal emotional phrase, such as "complex soreness". The system then performs a semantic search within the agent's story base using RAG, picking a story fragment relevant to "complex soreness". The story fragment, interpretation, and emotional phrase are used in the second LLM for generating the final narrative reply as shown in Figure 5. Then, the reply is sent to the Unity interface for visual display. The reply length and the emotional response type are also sent to Unity to handle sound playback, as well as shaping how the agent's light changes in the virtual world.

4.3 Sound Design

The sound design for the alternate reality we create with the interactive installation is twofold. For one, sound is used to establish, define, and realize an environment – if even a fictional one. For two, the sound design comprises a sound-based, musicalized, and

[1] https://python.langchain.com/v0.2/docs/tutorials/rag/

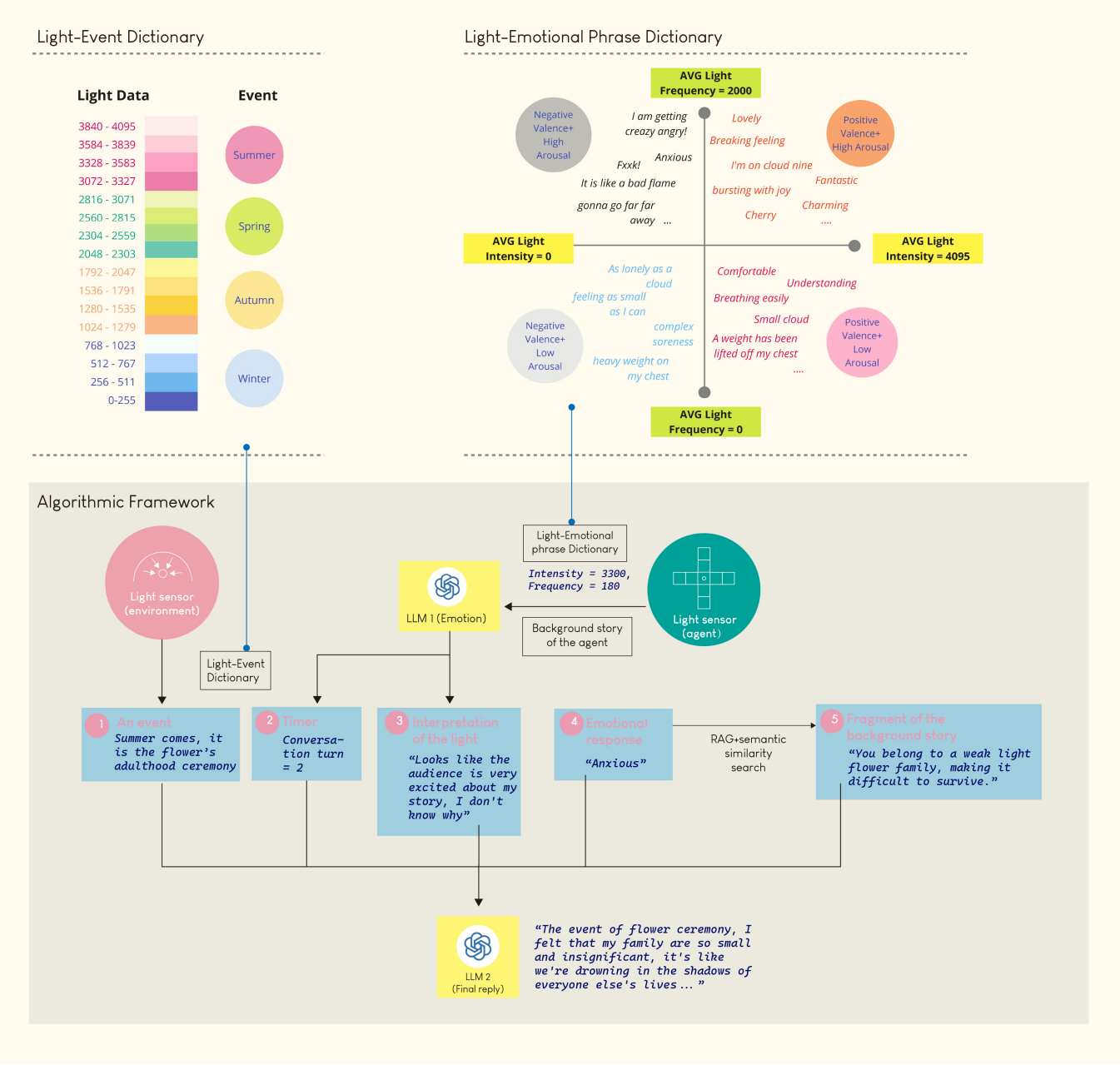

Figure 5: Architectural Overview of the program. (Top) The two core components of the light dictionary framework, map light inputs to corresponding generative prompts. (Bottom) The high-level structure of algorithm for narrative generation.

non-semantic language that is the flowers' way of "speaking" to the audience, syncing the LLM-generated text output.

4.3.1 Sonic World Building. The environmental sound design in "I Light U Up" is used to establish a world in the sense of a "sonic world-building" – establishing, creating, and realizing a fictional world by way of creating its sonic characteristics [White 2021]. It utilizes ambient sounds from open-source libraries, including recordings of nature, such as forests with wind, leaves, and insects to establish a sense of a synthetic natural environment. Additionally, the soundtrack features a series of five electronic music tracks composed by a team member, which are played in a random, looping sequence.

4.3.2 The Flowers' Sonic "Language". Sound is often used as a medium for the user to interact with a virtual world [Geronazzo and Serafin 2023]. In "I Light U Up", in addition to the LLM-based text outputs of the flower-shaped avatars, sounds are used as a

Figure 6: The installation within different environment light conditions. (©Zhen Wu)

Figure 7: Interaction process within two different environment conditions, light (upper) and dark(lower). From left to right: From not being activated, to audience interacts with the installation using light, and the corresponding virtual agent generates a reply.(©Zhen Wu)

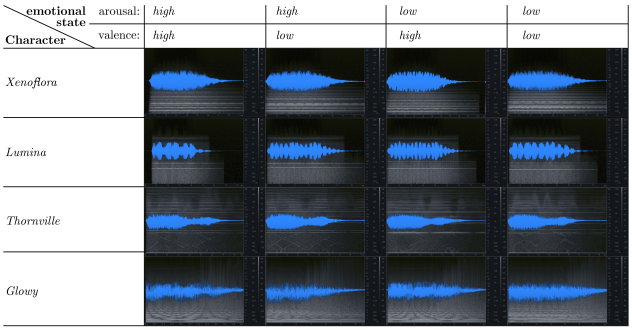

Figure 8: Table with combined spectrograms and waveforms of 16 'speaking' sounds of the flowers, organized by flower name and emotional state. They all show a similar length and overall envelope, yet are different in their timbre and their harmony ratio.

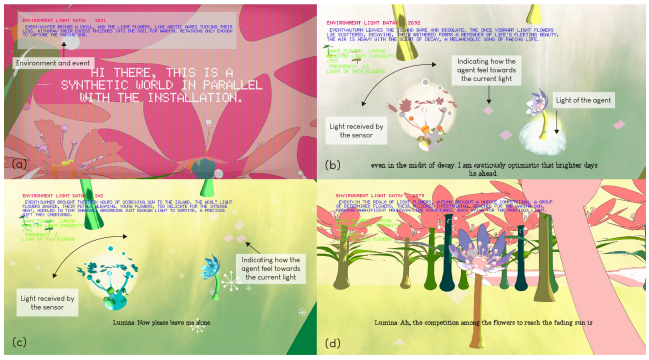

Figure 9: The digital visual of "I Light U Up": (a) When no agents are awakened for conversation, the camera travels through the virtual world. (b) and (c) When one agent is awakened, particles represent the flower's preferences, and the emitted light reflects the reward mechanism. The narratives generated by LLMs are placed at the bottom of the screen. (d) The camera focuses on the agent at the start of their narration.(©Zhen Wu)

key means of communication between the avatars and the audience. An original sound-design-based non-semantic language has been developed and implemented, which is organized around the four avatars, each of which can respond in four different emotional modalities based on arousal and valaence; therefore, a total number of 16 sound files have been created (see Figure 8). These sound files contain chords generated using a software synthesizer with a complex, semi-harmonic, and semi-inharmonic timbre. Each sound file has a slow attack (200ms) and a longer release and decay time (500ms), looping every 5 to 10 seconds, depending on the length of the generative text.

4.4 Digital Visual design

The digital visual aesthetic is designed to be dreamlike yet synthetic, with a stylized, non-realistic "toon-like" quality. As shown in Figure 9, when no agents are active, the camera travels through the virtual world, with the current environmental light data displayed in the top left. Once an agent is awakened, the camera shifts to a conversation mode. The light received by the sensors is visualized as the ambient light within the conversation loop. Particles are designed to represent the agent's preferences, and the light emitted by the agent reflects the reward mechanism (see (b) and (c) in Figure 9). The narratives generated by LLMs are placed at the bottom of the screen, as subtitles.

4.5 Physical Installation Design

In contrast to the stylised and colorful aesthetics of the digital content, the installation design purposefully retains a synthetic, "robotic" aesthetic. We used grid-like LED panels to create an artificial aesthetic, while the floral arrangement of the panels, centered around light sensors, introduces a natural counterpoint. The supporting structure is made of inexpensive PVC tubes, further reinforcing the overall plastic, synthetic feel of the piece. Through

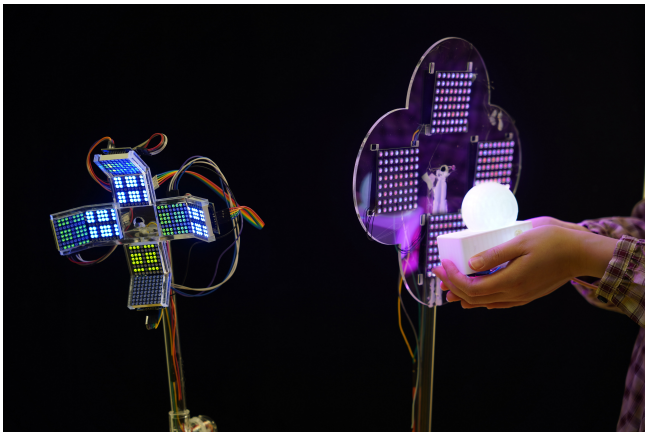

Figure 10: The physical installation with two installation units as an example. A participant is sending light data to one of the installation units. (©Zhen Wu)

these design choices, a juxtaposition is established between the serious, mechanical installation and the playful qualities of the digital visual.

5 TECHNICAL IMPLEMENTATION

We use Unity to interface all aspects of the artwork. The content generated through the LLM is sent to Unity via a socket-based JSON communication protocol. Figure 5 demonstrates the program's architecture for narrative generation. The LLM-related part uses the LangChain v0.2 [2] for implementing RAG and dynamic prompt formatting. We use the GPT-3.5 model as the LLM for generating text, and text-embedding-ada-002 for RAG, both from OpenAI [3]. The program is coded in Python, including handling LLM model requests and assigning the dynamic prompt as a query to the LLM. The sound composition is produced in Ableton Live. The physical installation uses several ESP32 chips as the processor, wirelessly sending light data to the LLM program. 8x8 LED panels are connected in series. when a response is generated, the LED panels may display a specific lighting pattern to indicate the audience.

6 REFLECTION AND DISCUSSION

The "I Light U Up" installation has been showcased once privately at a small scale. We interviewed six audience members to gather their perceptions of this installation, and we got some key points from their feedback.

(1) **Light interaction is visually captivating but requires exploration to understand fully.** Almost every participant (5/6) mentioned the interaction experience was "inspiring". They found the light interaction visually captivating and artistically engaging, especially suitable for a darker environment. However, it requires time to interpret the mechanism.
(2) **Simplify LLM-generated content to improve interaction clarity.** The audiences (4/6) stated that the text content responded to by the agents could be too complex or overwhelming compared to the general style of the installation, making interactions feel less natural and harder to understand. For instance, one audience reported, "*The overall process is quite poetic and romantic, but having text pop up directly disrupts this romantic feeling.*" They suggested simplifying the text to lower the interpretation burden.
(3) **Incorporate diverse feedback mechanisms to enhance immersion.** The audiences recommended integrating more diverse feedback methods, such as mechanical movements and more interactive light patterns on the installation, to make the interaction more immersive (3/6). They emphasized the importance of players being able to see their presence in the virtual world, for instance, through a camera mapping their position or projecting their silhouette. This would help players feel more connected and aware of their role in both the virtual and physical aspects of the installation.

The art practice of "I Light U Up" has raised questions about balancing the different sensory channels and interaction modes in designing LLM-powered artistic experiences. For the input mechanism, the non-textual interaction with LLMs in our work is worth further exploration, as they may bring artistic experiences but sacrifice intuitiveness. On the output side, the question arises whether textual narration is necessary for delivering the LLM outputs, or if alternative modalities such as sound and visuals can completely replace the texts to achieve more poetic and sensual forms of expression. Moreover, the use of dictionaries and prompt formatting framework in this work helped maintain the author's voice and literary expression, which we aim to further develop in future creations. In future work, experimenting with different input modalities beyond light, and how they impact the authoring process and prompting strategies is an interesting area for exploration.

In summary, "I Light U Up" provides an interesting case for exploring the application of AI language models in creative practices beyond textual input, and serves as a proof-of-concept of the conceptual framework for considering the interplay between technology, emergent narrative, and environment/human interactivity.

[2]https://python.langchain.com/
[3]https://platform.openai.com/docs

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