Contemporary Visual Culture and Art
https://journals.zycentre.com/cvca

REVIEW

A New Type of Technology Art Performance—Historical Research and Diverse Presentations of Drone Stage Performance

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ABSTRACT

Technology art performance is an emergent interdisciplinary form that integrates visual art, performing arts, and digital technologies. This paper examines how unmanned aerial vehicles (UAVs), first developed in the early twentieth century, have been adopted within technology art performances in the early twenty-first century. With rapid advancements in UAV technology and the miniaturization of hardware, drones began to appear in both outdoor and indoor stage productions in the early 2010s. Contemporary drone-based performances can be broadly divided into two categories: small-scale indoor stage drone shows and large-scale outdoor swarm formations. This study investigates the global and Taiwanese development of UAV-based stage performances and exhibition formats, while also exploring the potential of drones as a medium for technology art. In Taiwan, drone performances have become increasingly popular in festival contexts. Artists Helin Luo and I-Chun Chen are among the earliest contemporary Taiwanese practitioners to integrate UAVs into technological performance art. Their works—*Prisoners under the Torch*, *Child (L'ENFANT)*, *Child 2.0 (L'ENFANT 2.0)*, and *Beams of Weighted Light*—open new possibilities for theatrical creation, automated and semi-automated drone choreography, aerial

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ARTICLE INFO
Received: 24 October 2025 | Revised: 12 December 2025 | Accepted: 19 December 2025 | Published Online: 26 December 2025
DOI: https://doi.org/10.63385/cvca.v1i2.414

CITATION
Hsieh, H.-C., Chen, I.-C., Luo, H.-L., 2025. A New Type of Technology Art Performance—Historical Research and Diverse Presentations of Drone Stage Performance. Contemporary Visual Culture and Art. 1(2): 44–65. DOI: https://doi.org/10.63385/cvca.v1i2.414

cinematography, and the incorporation of augmented reality (AR). These performances expand the vocabulary of contemporary stagecraft and open new directions for interactive, immersive, and technologically mediated theatrical creation.
Keywords: Drone; Drone Show; Drone Stage Performance; Technology Art; New Media Art

1. Introduction

Technology art performance is an interdisciplinary form of artistic presentation that brings together visual arts, performing arts, and digital technologies. In contemporary practice, many groups engage with audiences, experiment with emerging technological media, and integrate the real and the virtual to create innovative audiovisual experiences. As technologies continue to evolve, an increasing range of technological media has been incorporated into technology-based performances [1]. This paper focuses specifically on how unmanned aerial vehicles (UAVs), which first appeared in the early twentieth century, have been adapted and repurposed within technology art performances in the early twenty-first century.

The English word "drone" originally referred to a male honeybee whose sole function was to mate with the queen, and later developed into a verb associated with a buzzing sound. UAVs—also commonly referred to as "drones"—are aircraft without onboard human pilots, typically operated remotely by human controllers or autonomously by onboard computers [2].

Early development and deployment of UAVs were primarily driven by military objectives, particularly during World War I and World War II. From the late 1910s through the Second World War, drones were used extensively in aviation, national defense, and reconnaissance. In recent decades, they have also been widely adopted in commercial, agricultural, and logistical sectors. During the two World Wars, UAVs appeared in diverse forms, including airplane-type and helicopter-type models. However, the quadcopter—equipped with four rotors—has become the most popular configuration in recent years due to its affordability and ease of operation [3, 4].

With continuous technological advancement and the miniaturization of drone hardware, UAVs have expanded far beyond military use to include personal, recreational, and commercial applications. Since the early 2010s, drones have increasingly been introduced into both outdoor and indoor stage performances. Large-scale swarm drone shows involving thousands of units have rapidly developed in recent years and have become a major highlight at festivals worldwide [5–7]. Today's drone performances can generally be divided into two categories: small-scale indoor stage shows and large-scale outdoor swarm formations. This paper conducts a historical study of drone-based stage performances and formats, with a particular focus on their development in Taiwan, and explores the diverse possibilities of drones as a medium for technology art performance.

This study adopts a qualitative review-based methodology to analyze the development and transformation of drone-based stage performances and contemporary art practices from the early 2010s to the early 2020s. The selection of case studies is based on their historical significance in the evolution of drone performance, the degree of integration between technology and performance, and the availability of relevant academic literature, project documentation, and audiovisual materials. The scope of the review encompasses both international and Taiwanese practices, enabling comparative analysis across different cultural contexts and production conditions. To establish a coherent and analytically effective framework, the selected cases are categorized into three main types—large-scale outdoor drone swarm performances, small-scale indoor stage works, and experimental practices in contemporary art—according to performance scale, spatial setting, and the functional role of drones within the works. This categorization serves as the basis for subsequent comparative and theoretical discussions.

The primary contribution of this study lies in its systematic review of the development of drone-based performances from early technical applications to their incorporation into stage performance and contemporary art contexts, using a qualitative review-based approach. While existing scholarship has largely focused on engineering aspects, swarm control, or large-scale commercial spectacles, this article situates drone performances within the theoretical frameworks of performance studies and technology art, conceptualizing drones not merely as technical tools but as performative agents. Moreover, this study is among the earliest schol-

arly efforts to provide a comprehensive review of drone performance practices and constitutes the first academic examination of drone performance art in Taiwan. By bringing Taiwanese practices into dialogue with international cases, the article addresses a notable gap in the literature concerning non-Western and localized contexts of drone performance.

2. Outdoor Drone Swarm Performances

Among the earliest documented instances of drone-based performance, the first work formally recognized as a "drone performance" can be traced to *49 Quadrocopter in Outdoor Formation Flight* (2012), presented by the Ars Electronica Futurelab in Linz, Austria. This project represents a pivotal moment in the history of technology art, marking the transition of quadrotor drones from engineering research tools to autonomous artistic performers (**Figure 1**)[8].

The presentation employed 49 quadrocopters, each equipped with RGB LED (Red, Green, Blue light-emitting diode) light sources and controlled through Futurelab's proprietary multi-vehicle positioning and synchronization system. As the music began, the drones ascended from the ground and slowly rose into the night sky. Through sequential formation changes, geometric rearrangements, and coordinated spatial transformations, the swarm produced dynamic aerial light patterns across three-dimensional space. The flowing and rotational movement of the illuminated points created a visual rhythm reminiscent of an elegant waltz in the sky. Throughout the performance, the color, intensity, and luminosity of the LEDs shifted in conjunction with the musical progression, generating an immersive synthesis of sound and light. The presentation concluded with the controlled descent of all drones, each returning precisely to its designated landing position. The significance of this work lies not only in its technical achievements—such as multi-drone coordination, outdoor RTK/optical positioning, and airspace safety management—but also in its conceptual innovation. It was one of the first projects to establish the drone swarm as a legitimate stage performer rather than a technical demonstration. This performance laid the foundational framework for the subsequent global development of large-scale drone formations, citywide light shows, and drone-based technology art. Ars Electronica Futurelab thus emerged as an early pioneer in shaping the aesthetic and performative language of drone choreography[8].

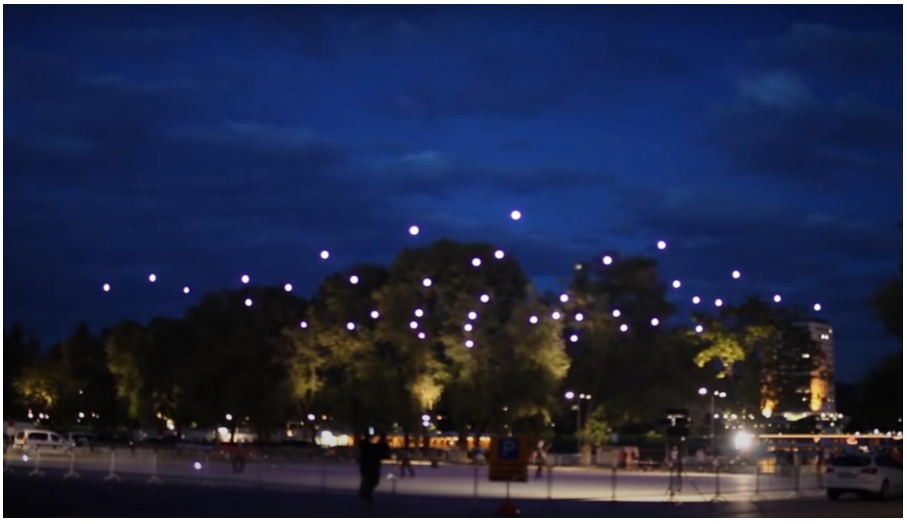

Figure 1. 49 quadrocopters in outdoor-formation-flight in 2012 at the Ars Electronica Futurelab in Linz, Austria.

Source: Ars Electronica Futurelab official YouTube channel[8].

From the earlier formations of several dozen or several hundred drones, large-scale configurations involving more than a thousand units have become common. Performances featuring several thousand drones have gradually become central elements in national festivals and major urban cultural events. In 2021, the Chinese technology company HighGreat Innovation conducted an outdoor swarm performance of 5200 drones in Shenzhen, setting a world record at

the time[9, 10]. Cities worldwide have continued to invest in technological upgrades and the expansion of application scenarios, positioning drone swarms as increasingly influential components of public visual culture. On 17 June 2025, the city of Chongqing, China, set a new Guinness World Record by simultaneously launching 11,787 multirotor drones, marking the largest outdoor drone performance to date. The performance took place above the riverbanks at the confluence of the Yangtze and Jialing Rivers, using the city's mountainous nighttime landscape as a visual backdrop (**Figure 2**). Technically, the drone formations were programmed to display a sequence of visual segments, including urban skylines, floral motifs, and landscape symbols[11, 12].

In recent years, Taiwan has also developed its own software and hardware systems for drone-swarm performances, enabling locally produced large-scale aerial shows. Taiwan's Hope Innovation Co. was commissioned by the Southern Branch of the National Palace Museum to execute the 2021 National Day holiday drone performance *Sky Light*. Using 300 drones equipped with domestically developed software and hardware, the company presented a narrative symbolizing the emergence of "a dawn of hope after the darkness brought by the COVID-19 pandemic." The project later received the first prize in the category of "Best Drone Show under 1000 Units" at the second International Drone Formation Competition[13, 14].

Figure 2. 1 Large-scale outdoor drone swarm performance in Chongqing, China (2025), featuring 11,787 multirotor drones. Source: iChongqing[11].

While large-scale outdoor drone swarm performances emphasize spectacle and collective movement, the following section shifts focus to indoor stage works, where drones increasingly engage in direct interaction with human performers.

3. Diverse Forms of Drone Stage Performances

In the early 2010s, beyond outdoor swarm performances, drone-based stage presentations also began to flourish globally, giving rise to a wide range of innovative performance formats. In stage contexts, drones initially served functional roles such as aerial cinematography, aerial projection, or lighting effects. Over time, however, they gradually evolved into integral components of stage productions—equipped with lighting or pyrotechnics, modified into various forms, interacting with dancers, or performing as independent stage actors. In other words, drones have progressively shifted from supporting tools and secondary elements to central features or even protagonists within performance settings[15].

In 2012, *Meet Your Creator—Quadrotor Show*, created by Saatchi & Saatchi, was presented as a stage performance without any human dancers. Instead, the performance featured sixteen quadrotor drones equipped with mirrors and LED lights performing on stage. By positioning multiple drones as the primary performers, the work signaled a shift

in which drones assumed the role of on-stage actors. The projected white light beams were reflected by the mirrors, and the flickering reflections generated a distinctive visual composition of light and shadow (**Figure 3**)[16, 17].

Figure 3. *Meet Your Creator—Quadrotor Show* (2012), by Saatchi and Saatchi.

Source: Metalocus et al.[17].

In the performance, the aerial vehicles emitted and reflected white light beams through the combined use of mirrors and lighting, accompanied by an electronic music soundtrack. The quadrotor robots were assigned the role of "performers": rather than functioning merely as hovering tools, they became choreographable, mobile, responsive "mechanical dancers" capable of producing dynamic light-and-shadow effects. According to the creative team, the project was conceived to "create the sensation of humans dancing with machines," while paying homage to creativity and technological innovation. By situating the audience within a quasi-ritualistic context described as a "religion of the creator," the performance invited reflection on the relationship between humans and the tools they invent. This performance holds three major significances. First, it stands as an early exemplar of drones functioning as on-stage performers rather than as auxiliary lighting devices. Second, it expanded the potential applications of drones beyond military or purely technical uses toward artistic creation and public sensory experience. Third, it marked an early point of departure for drone swarm choreography, light-beam control, and computer-based aerial performance design, establishing a precedent for subsequent large-scale outdoor drone formations and indoor choreographed performances. Taken together, *Meet Your Creator* can be regarded as a milestone experimental work in the field of drone-based performance art.

In December 2014, the Association for Unmanned Vehicle Systems International (AUVSI)—the world's largest nonprofit organization dedicated to advancing unmanned systems and robotics—together with the Academy of Model Aeronautics (AMA), launched an educational campaign titled *Know before You Fly* in partnership with the U.S. Federal Aviation Administration (FAA). The initiative aimed to educate the public and provide information and guidelines on responsible drone use. It explained and illustrated examples of both commercial and recreational applications of drones, followed by safety instructions intended to enable users to operate unmanned aircraft systems responsibly (Unmanned Aircraft Systems, 2015). In February 2015, the FAA also announced the U.S. regulatory framework for drone operations. These standards and safety regulations were not only applied in the United States but also began to be adopted internationally. In Canada, Transport Canada and the Office of the Privacy Commissioner of Canada (2013) conducted research on UAVs and issued safety guidelines in Novem-

ber 2014 concerning the procedures for obtaining a Special Flight Operations Certificate for unmanned aircraft (The Review and Processing of an Application for a Special Flight Operations Certificate for the Operation of an Unmanned Air Vehicle (UAV), 2014)[18]. Following the widespread dissemination of UAV regulations and safety guidelines across various countries between 2014 and 2015, drone-based stage performances expanded rapidly, and an increasing diversity of creative expressions emerged.

In 2014, Cirque du Soleil collaborated with ETH Zürich and its spin-off company Verity Studios to produce *SPARKED: A Live Interaction between Humans and Quadcopters*, a hybrid stage and video experiment. The project employed ten quadcopters, each concealed inside a lampshade-shaped outer shell. The drones were equipped with LED lighting systems, allowing them to function within the performance as "light fixtures brought to life," transforming from static bulbs into animated flying objects[19] (**Figure 4**).

Figure 4. *SPARKED: A Live Interaction between Humans and Quadcopters* (2014), by Cirque du Soleil, ETH Zürich, and Verity Studios. Source: S + T + ARTS Prize official website[19].

The narrative portrays a lamp repairman who, late at night, discovers that all the lampshades in his workshop have suddenly come alive. The lampshades—powered by the drones—flutter, hover, and swirl around him, engaging in interactive movement. The piece was filmed inside ETH Zürich's Flying Machine Arena, a research environment equipped with high-speed motion-capture systems, such as VICON and multi-camera arrays, as well as integrated drone-tracking, communication, and flight-control platforms[20].

From a technical perspective, the project confronted multiple challenges: coordinated multi-drone flight control, wireless communication interference, stable infrared and optical tracking, the seamless integration of drone hardware with the lampshade shells, and precise synchronization between drone trajectories and stage lighting or cinematography. As reported by *New Atlas*, each drone was also assigned a distinct "personality," expressed through variations in flight rhythm, movement pattern, and behavioral response.

In 2016, the drone technology team brought the ten lampshade-equipped quadcopters into the live stage performance of *Paramour* on Broadway, adding a new technological dimension to Cirque du Soleil's production at the Lyric Theatre in New York. The drones, each disguised as a circular lampshade, hovered and circled above the two lead performers, becoming a central component of the production's visual and kinetic design[21] (**Figure 5**).

These lampshade drones were developed and operated by Verity Studios as part of the "Stage Flyer" system, designed specifically for use in theater environments. Unlike conventional outdoor drone demonstrations, this system had to meet strict indoor performance-grade safety standards. It combined visual-based localization, collision-avoidance algorithms, and fault-tolerant control mechanisms, enabling the drones to perform safely in a packed theater of approximately 2000 audience members for multiple shows each week, up to eight performances weekly. During *Paramour*, the drones functioned not only as lighting devices but also as stage "performers," executing finely choreographed flight paths that interacted with the singers, acrobats, and dynamic lighting effects on stage[22, 23].

Figure 5. *Paramour* (2016), a Broadway production by Cirque du Soleil, was developed by Verity Studios.

Source: Verity Studios official website [22].

The production demonstrated how drones can coexist with human performers in a physical theater space, moving beyond their role as tools or visual background elements. Moreover, the underlying localization technologies, swarm-control systems, and safety protocols provided a model for cross-disciplinary integration between robotics and theatrical production. Overall, the lampshade drone sequence in *Paramour* became an important milestone in the collaboration between technology and theater, laying both the technical and aesthetic groundwork for the future use of drones in stage performance.

During Muse's *Drones: The Drones World Tour* in 2015–2016, the band incorporated drones as part of the stage performance. Small drones were embedded within transparent spherical structures and flew above the stage or around the performers. Equipped with lighting and other special effects, these small drones enhanced the overall visual impact of the concert [24] (**Figure 6**).

Figure 6. *Muse: Drones World Tour* (2015–2016), stage performance by Muse.

Source: Music Wiki [24].

Muse also employed a large drone during the tour. This larger aircraft featured expansive wings and integrated lighting effects, enabling it to fly above the stage or within the surrounding performance space. Functioning as a distinct theatrical character, the large drone introduced a unique visual presence and became one of the standout elements of the tour[25] (**Figure 7**).

The 2019 production *2047 Apologue*, directed by Zhang Yimou and co-produced by the National Centre for the Performing Arts (China) and the Paris Opera, represents an innovative attempt to integrate traditional Chinese performance with modern technologies. In one segment of the production, sixty-six Lucie micro-drones were deployed, each disguised as a white plastic bag. Through carefully designed lighting, the black drone bodies were visually concealed, allowing the floating white bags to dominate the stage imagery. The plastic bags drifted and rotated around a large tree-like stage prop, forming a "cloud of plastic" that descended from above, guided with precision by the flying drones[26]. The spectacle of plastic bags filling the sky metaphorically referenced the global crisis of plastic pollution (**Figure 8**). Through coordinated swarm formation and shifting light color, the scene constructed a fluid, almost poetic aerial landscape. Each Lucie micro-drone weighs only about 58 g and is engineered by Verity Studios for safe operation in theatrical and crowded environments[27].

Figure 7. Drone stage effect for *Muse: Drones World Tour (2015–2016)*, designed by Moment Factory.

Source: Moment Factory official website[25].

Figure 8. *2047 Apologue* (2019), directed by Zhang Yimou.

Source: *China Daily*[27].

Technically, the piece employed an indoor and semi-outdoor drone positioning system combined with RGBW (red, green, blue, and white) lighting modules, with all drone flight paths pre-programmed in advance. The lighting cues were synchronized with the choreography, enabling precise coordination between the drone swarm's movement and the

illumination changes so that the falling plastic bags became integral to the narrative structure of the performance. In terms of visual design, the work transformed plastic bags—objects conventionally associated with waste and pollution—into the primary aesthetic and choreographic elements of a robotic aerial ensemble, creating an image of "pollution aestheticized." Furthermore, the drone swarm served not merely as a set of flying light sources but as an aerial medium for expressing environmental concerns through performative action. The production ultimately demonstrated how micro-drone technologies, swarm choreography, and sculptural modification can be effectively integrated into large-scale theatrical contexts.

In August 2020, the Southern Branch of the National Palace Museum presented *A Midsummer Night's Starry Fantasy* on Zhishan Lake, featuring a floating stage constructed on the water. This production marked the first interdisciplinary performance in Taiwan to integrate stage performance art with drone technology. The event combined a drone-swarm show with live stage acting. In the night sky, 400 drones formed images of eight iconic National Palace Museum artifacts, including the *Jadeite Cabbage* and the *Meat-Shaped Stone*.

On the floating stage, the performance featured Hanuman—the official mascot of the Southern Branch—who appears to protect the museum's national treasure, the *Jadeite Cabbage*. Hanuman engages in an aerial battle with the demon king Ravana, represented through coordinated drone movements[28]. The production incorporated contemporary dance, water choreography, and drone technology to create a hybrid human–machine theatrical performance (**Figure 9**).

Figure 9. "Playing in the South—Midsummer Night's Star Fantasy" in 2020, Taiwan.

Source: Courtesy of Lo Ho-Lin.

Beyond variations in lighting and form, drones have increasingly been developed to carry additional effects such as pyrotechnics and lasers. SKYMAGIC, in collaboration with the fireworks company Grucci, created a new generation of pyrotechnic-equipped drones known as PYRODRONES™, which have been used internationally in drone-swarm performances featuring onboard fireworks. In 2020, a formation of 173 such pyrodrones set the Guinness World Record for "the most unmanned aerial vehicles (UAVs) launching fireworks simultaneously."[29] (**Figure 10**).

In Taiwan, Professor Helin Luo's team at the Tainan National University of the Arts has been developing laser-equipped drones. In late 2023, the team presented a small-scale drone-and-laser stage performance titled *Beams of Weighted Light* at the Kaohsiung Museum of Fine Arts. This work will be discussed in detail in a later section.

Figure 10. S *PYRODRONES*™ (2020), by SKYMAGIC in collaboration with Grucci.

Source: SKYMAGIC official website [29].

4. Experiments with Drones in Contemporary Art

Drones, in addition to being widely used in large-scale swarm performances for festivals, commercial advertisements, and the entertainment industry, have also increasingly become a medium for small-scale and experimental creations by contemporary artists and engineering practitioners. Although these works do not rely on large drone formations, they often introduce new performance modes through refined concepts, customized forms, and narrative imagery. Their innovative approaches demonstrate a high degree of creativity. In such projects, drones are frequently viewed as "performative agents" situated between machine and body, with their very movements becoming integral elements of the visual and narrative composition.

One early representative example is the *Superman Drone* flight test conducted in 2013 in San Diego, California, by aircraft designer Otto Dieffenbach. Dieffenbach's company, CoolFlyingToys, has long specialized in developing remote-controlled flying devices modeled after cartoon characters, superheroes, and fantasy figures. For this project, he used Superman as the design template, constructing a "flying Superman" using foam, lightweight composite materials, and the core components of an RC drone. The propeller was positioned on the character's chest, while the battery and flight-control system were concealed within the head and torso, enabling the drone to appear fully like a superhero soaring through the air. When the Superman model flew along the coastline, its posture closely resembled the iconic flight pose seen in comic books, leading many bystanders to believe they had witnessed "Superman" in real life [30]. Although the flight duration was limited by battery capacity, this project successfully demonstrated—through its strong entertainment value and visual impact—the potential of "characterized and stylized" drone design (**Figure 11**).

Figure 11. *Superman Drone* flight test (2013), by Otto Dieffenbach.

Source: *China Daily* [30].

From the perspective of technology art, the *Superman Drone* represents an early attempt to shift drones from functional tools to narrative characters. It was not merely a flight experiment but an act of creative intervention into cultural iconography: translating the popular-cultural imagination of Superman into real space through aeronautical engineering, allowing a fictional character to "momentarily materialize" within the urban skyline. Such projects opened new visual vocabularies for subsequent drone applications in film special effects, public art, and immersive performance.

Contemporary Japanese artist Daito Manabe has collaborated with the dance company Elevenplay since the early 2010s, developing a series of stage experiments that integrate drones, choreography, and projection technologies. Among these works, the drone-dance performances presented in 2014 and 2016 stand as significant examples of cross-disciplinary collaboration between technological art and contemporary choreography. The 2014 performance, presented at Spiral Hall in Tokyo, featured three dancers performing alongside multiple drones equipped with white, pyramid-shaped sculptural attachments (**Figure 12**). The staging incorporated projection imagery and lighting design, producing a highly graphic and visually striking composition. Motion-capture systems and feedback-control technologies were employed on site, enabling the real-time tracking of dancers' positions and gestures. As a result, certain drone trajectories dynamically responded to the dancers' movements, while others followed pre-programmed flight paths, forming a hybrid system in which "human-motion-driven" and "algorithm-driven" modes coexisted.

Figure 12. Drone-dance performance by Daito Manabe and Elevenplay (2014).

Source: Daito Manabe official website [31].

In 2016, Manabe and Elevenplay brought this technological and aesthetic approach to a wider global audience through their appearance on *America's Got Talent*. Supported by Rhizomatiks Research, the team deployed twenty-four drones equipped with color-changing LED light spheres, performing above both the stage and the audience. The piece featured five dancers interacting with the aerial formations, with the drones hovering above the performers, shifting formations, and extending their trajectories into the judges' area and audience space. This choreography emphasized the verticality and spatial layering of the three-dimensional performance environment while simultaneously increasing the complexity of real-time risk management and flight-control precision (**Figure 13**). Through refined programming and control design, the drones achieved a high degree of synchronization with the dancers' gestures and musical rhythm, generating a unique stage experience and a visually stunning effect [31, 32].

Viewed within the broader context of Manabe and Elevenplay's collaborative practice, these two drone-dance works elevate drones from simple stage props or lighting devices to "mechanical dancers" with their own temporal rhythm and spatial logic. Through precise software design, motion tracking, and flight-control systems, the drones align closely with human movement and sound, producing performances that are visually compelling while also prompting reflection on the evolving relationship between the human body and technological systems [33, 34]. By merging dance,

technology, and music, these works demonstrate Manabe's distinctive creative vision and technical ingenuity, offering audiences an innovative and captivating form of technologically mediated performance.

Figure 13. Drone-dance performance by Daito Manabe and Elevenplay on *America's Got Talent (2016)*, a televised stage performance with drones.

Source: Daito Manabe official website [31].

In 2016, Hong Kong artist Alan Kwan developed an artwork titled *Flying Umbrella Project* with support from the University of Applied Arts Vienna. Beginning with the idea of transforming an umbrella into a floating, jellyfish-like organism, Kwan combined drones with umbrella structures so that the drones would function not merely as algorithmically controlled machines, but as aerial entities endowed with quasi-organic qualities. In the project, lightweight quadcopters were mounted beneath black umbrellas, their surfaces illuminated to create the visual impression of two umbrellas slowly drifting, rotating, and descending through the air [35, 36] (**Figure 14**). Although the resulting forms did not fully resemble jellyfish—with trailing tentacles or gliding motions—their buoyant movement, gentle rotation, and suspended presence within an artificial environment endowed these "flying umbrellas" with a poetic form of biomimicry.

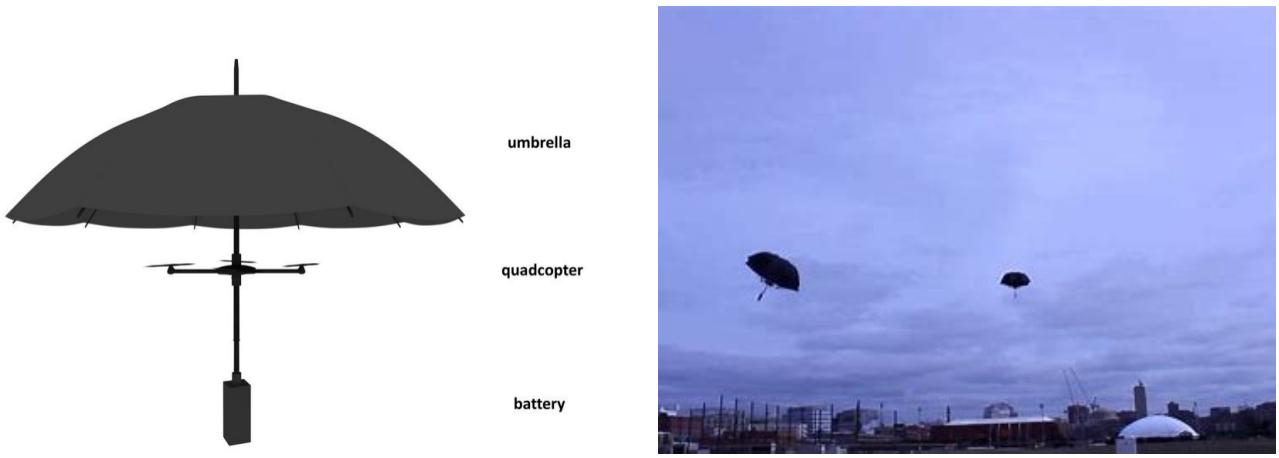

Figure 14. *Flying Umbrella Project* (2016), by Alan Kwan.

Source: Alan Kwan's official website [35].

Technically, Kwan integrated lightweight quadcopter mechanisms, drone flight-control systems, and umbrella-based sculptural design. He noted that flying robots "embody our fascination with non-physical objects floating in the air." During production, however, the team faced a number of engineering challenges, including the aerodynamically

unfavorable shape of the umbrella, reduced flight stability, and the difficulty of achieving accurate flight control and positional tracking in semi-outdoor environments. Despite these constraints, the work combined lighting, mechanical flight, and object transformation to create an uncanny scene of "umbrellas drifting in midair," prompting viewers to reconsider the familiar everyday object as a hybrid form—part artificial, part biomimetic, and entirely airborne. Rather than relying on large-scale formations, the *Flying Umbrella Project* demonstrates how drone technology can be applied to small-scale, experimental artistic practices. Through the use of only a few aerial units paired with sculptural ingenuity and atmospheric staging, the work expands the creative vocabulary of drones within contemporary art.

In the 2020 Venice Biennale, DRIFT, Drone Stories, and SKYMAGIC jointly presented an indoor aerial drone performance titled *Social Sacrifice*. The work featured one hundred drones, which collectively enacted a scenario in which a swarm of "artificial intelligence" fish encounters a predator (**Figure 15**). The performance took place inside the historic Chiesa di San Lorenzo [37]. In this staging, the majority of drones equipped with white lights represented the original fish school, while a smaller number of drones with red lights signified the intruding predator. The luminosity of the drones intensified when the "fish" moved closer together and dimmed when they dispersed. Over time, the initially stark contrast between the white and red lights—emphasizing confrontation and separation—gradually dissolved as the red lights blended into the larger white swarm. The intertwining and eventual merging of the two light groups metaphorically suggested a process of transformation from hostility to coexistence among different species.

Figure 15. *Social Sacrifice* (2020), by DRIFT in collaboration with Drone Stories and SKYMAGIC.

Source: Studio DRIFT official website [37].

This performance demonstrated the growing potential of drones within the field of contemporary art. Beyond serving as a novel artistic medium, drones function as performative instruments capable of transcending conventional spatial constraints. Through dynamic lighting, spatial movement, and narrative construction, the work delivered a visually and sensorially compelling experience while simultaneously eliciting emotional resonance and critical reflection from its audience.

Large-scale outdoor drone swarm performances are typically characterized by coordinated formations composed of hundreds or even thousands of drones, with their aesthetic impact relying heavily on scale, synchronization, and the legibility of visual imagery. Such performances most often take place during festivals, national celebrations, or large public events, where drones function as highly programmable and precisely controlled visual units. Their value lies in the spectacular effects generated through collective movement and the immediate readability of symbolic images. Within this context, individual differences and technical characteristics of drones are largely minimized in favor of overall formation and visual narrative,

and audiences experience these performances from a distance as a form of collective, public-oriented technological spectacle.

In contrast, small-scale indoor drone stage works and experimental practices in contemporary art place greater emphasis on real-time interaction and co-performance between drones and human performers. Due to spatial constraints, the number of drones involved is usually limited, making flight paths, speed, and spatial positioning more perceptible and introducing a higher degree of uncertainty and risk. In such works, drones are often treated as co-performers or performative agents that share the stage with dancers or actors, with their movements directly shaping stage dynamics, visual narration, and performance rhythm. Compared to the collective spectacle of large-scale swarm performances, these practices prioritize conceptual design, physical modification, and dynamic visual storytelling, transforming drone flight itself into a central component of the performative structure and meaning-making process.

In contemporary art contexts, drone-based practices further detach drones from purely performative functions and reposition them as media for critical and conceptual inquiry. Such works do not necessarily pursue precise control or visual spectacle; instead, they foreground the power relations, surveillance mechanisms, technological governance, and socio-political implications embedded in drone technologies. Artists may deliberately preserve technical instability, even incorporating failure, noise, and risk into the structure of the work, thereby transforming drones into instruments that expose the limitations of technology and human dependence on it. Within these practices, drones are often anthropomorphized, objectified, or symbolized, and their performative actions are no longer oriented toward entertainment or narrative progression, but function instead as devices and agents that provoke critical reflection.

Taken together, these three modes of drone-based performance and creation delineate a developmental trajectory that moves from "collective visual spectacle" to "human–machine co-performance," and further toward "conceptual and critical practice." Through comparative analysis, it becomes evident that the roles and aesthetic meanings of drones are not fixed across cultural and creative contexts, but are continually renegotiated among technological control, embodied experience, and social imagination.

5. The Emergence of Drone Practices in Contemporary Art in Taiwan

From the evolution of artistic forms, the development of technological art in Taiwan can be broadly divided into several stages: In the early 1980s, artistic practices were primarily centered on experimentation with new media such as video art and laser art, responding to the historical moment when imaging technologies first entered the artistic field. Around the turn of the millennium, with the widespread adoption of digital imaging technologies, computer animation, and interactive software, the focus of artistic creation gradually shifted toward digital art, interactive installations, and multimedia imagery, accompanied by the emergence of more clearly articulated narrative structures and aesthetic discourses. From the mid to late 2000s onward, supported by museum institutions, art festival platforms, and cultural policies, creative forms further expanded to include large-scale immersive installations, public-space projections, sound art, and technology-based performance art, emphasizing audience participation, embodied perception, and site-specific experience. Over the past decade, development has increasingly moved toward cross-disciplinary integration, incorporating artificial intelligence, robotics, sensing systems, data visualization, biotechnology, and networked systems, resulting in highly experimental modes of practice characterized by intensive interdisciplinary collaboration. Overall, technological art in Taiwan has evolved from early single-medium experimentation into composite creative practices that integrate technology, the body, space, and social issues, demonstrating a high degree of diversity and ongoing transformation. The introduction of drones into contemporary technological art practices in Taiwan, by contrast, did not occur until the latter half of the 2010s[1]. The following discussion examines the various forms of expression through which drones are employed in contemporary art. The following discussion examines the various forms of expression through which drones are employed.

In contemporary art practices in Taiwan, the use of drones has taken multiple forms. Early applications often involved employing drones to suspend or transport objects, while many contemporary artists have incorporated aerial drone footage as a creative method. For instance, in 2018, artist Hung Yu-Hao produced *Floating Blocks*, a work that

utilized drone aerial photography to document the urban landscape of Wanhua[38]. In the same year, artist Tsui Kuang-Yu created the performance piece *Exercise Living: Flying Chicken*, in which a chicken drumstick was suspended beneath a drone, generating an absurd yet incisive critique through the juxtaposition of the flying object and everyday life[39]. In 2020, artist Chang Cheng-Chun presented *This Place: NT$300,000 for One Aerial Shot*, a work in which he stood at the entrance of a CPC Corporation facility with a drone in hand. While the ground-level area was accessible to the public, the airspace above was designated as a no-fly zone (**Figure 16**). This industrial zone was the only area in the region where drone flight was prohibited, and launching a drone there would incur a fine of NT$300,000. By staging this action, Chang's performance challenged the logic of authority and highlighted the contradictions embedded in restrictive regulatory frameworks.

Taiwanese artists began incorporating drones into stage performance—and positioning them as central agents rather than mere tools—through the pioneering works of contemporary artists Lo Ho-Lin and Chen Yi-Chun. In their practice, the drone functions not as a secondary prop but as a performative entity endowed with symbolic significance. *Prisoner under the Torch* (2016) is recognized as the first theatrical production in Taiwan to integrate a drone into live performance. In this work, a dancer on stage interacts with a hovering drone whose movements evoke the presence of an extraterrestrial or technologically othered being[40] (**Figure 17**). The encounter raises questions regarding companionship, dependence, constraint, and psychological burden: does the drone serve as an extension of human agency, or does it operate as an oppressive technological weight? The performance foregrounds the tension between human reliance on technological devices and the potential pitfalls of overdependence.

At the same time, the drone in *Prisoner under the Torch* also functions as an imaging apparatus. Equipped with a camera, it assumes the role of an observer, possessing its own "cinematic" capacity. The performance further incorporates a high-speed motion-capture camera to track the drone's spatial position and assist in its navigation. This multi-layered system—comprising the dancer, the drone, the motion-capture camera, and the audience—complicates conventional visual hierarchies. The work ultimately raises the question: who, within this constellation, is observing whom? Through this interrogation of seeing and being seen, *Prisoner under the Torch* probes the dynamics of surveillance, spectatorship, and mediated perception within contemporary performance.

Figure 16. *This Place: NT$300,000 for One Aerial Shot* (2018), by Chang Cheng-Chun.

Source: Courtesy of Zhang Chengjun.

Figure 17. *Prisoners under the Torch* (2016), by Lo Ho-Lin and Chen Yi-Chun.

Source: Courtesy of Lo Ho-Lin.

In 2017, Lo Ho-Lin and Chen Yi-Chun created their second drone-based performance, *L'Enfant*, which was presented as part of the opening program of the Ars Electronica Festival in Linz, Austria. In response to the contemporary refugee crisis in Europe, the artists chose not to collaborate with professional dancers; instead, they invited members of the audience to participate directly [41]. In this configuration, the drone became the only moving performer on stage. *L'Enfant* invited the audience to enter an enclosed world constructed by the artists, beginning with the act of listening to a spoken childhood memory. Throughout the performance, the drone operated in conjunction with a tracking-camera system that captured real-time images of the participants. These images were then projected onto a large screen, where algorithmic computation enabled interactive visual responses (**Figure 18**).

Figure 18. *L'ENFANT* (2017), by Lo Ho-Lin and Chen Yi-Chun.

Source: Courtesy of Lo Ho-Lin.

L'Enfant 2.0 was subsequently invited to the 2018 Click Festival in Denmark. Continuing the thematic focus on the refugee crisis, the work employed a high-speed motion-capture system for indoor positioning, enabling the drone to be controlled through a combination of automated and semi-automated movements. The drone's onboard aerial camera, integrated with augmented reality (AR) imagery, expanded the possibilities of theatrical composition by introducing real-time, hybrid visual layers into the performance environment (**Figure 19**).

Figure 19. *L'ENFANT 2.0* (2018), by Lo Ho-Lin and Chen Yi-Chun.

Source: Courtesy of Lo Ho-Lin.

On stage, a dancer dressed in red moves through smoke, embodying states of anxiety and fear. She then raises a gun and fires toward the large projection screen. When the drone enters the space, the footage captured by its camera—merged with AR-generated imagery—is projected onto the screen, creating a perceptual ambiguity between what is real and what is virtual. As the dancer walks into the audience, the projected drone-mediated image renders her presence uncanny, as if a spectral or virtual double were occupying the stage. This virtual figure appears to symbolize death, and the performance ultimately unfolds into a sequence of farewell and rebirth, interweaving corporeal movement with mediated representation to interrogate themes of loss, displacement, and transformation.

Through this mechanism, every participant was able to "dance" within the work, becoming a child in the imagined memories of another. At the conclusion of the experience, participants discovered that their own projected silhouettes had been algorithmically altered to grow angel wings. The drone, meanwhile, hovered and navigated around the space, serving simultaneously as an inspecting and policing figure—monitoring and detecting the faces and movements of the audience (**Figure 18**). In this way, *L'Enfant* explored the dynamics of participation, surveillance, and mediated identity within an immersive, algorithmically responsive performance environment.

The Beam with Weight was created as the culminating presentation of the Ministry of Science and Technology–funded project "5G Drone Theatre: A Full-Spectrum Research on Human–Machine Interactive Performance in Technology Art." The work represents a cross-institutional and interdisciplinary collaboration led by Lo Ho-Lin in partnership with National Tainan University of the Arts and several of Taiwan's most advanced drone-technology research teams. It constitutes a technology art performance in which drones and dancers co-choreograph movement within a shared performative environment. The production employed newly developed drones equipped with laser modules and real-time lighting control systems, marking the world's first public presentation of a human–drone co-performance utilizing laser-equipped UAVs.

The Beam with Weight was performed twice: first in November 2023 at the NTUA anniversary celebration, presented at the Bronze Mirror Plaza in front of the Library

and Information Building (**Figure 20**); and again in February 2024 at the Kaohsiung Museum of Fine Arts during the "Diffusive Coupling" technology art exhibition, where it was staged in the museum's outdoor plaza [42]. The performance consisted of two parts. It opened with a dancer dressed in white, moving through a haze-filled plaza while interacting with a single laser-equipped drone. The drone projected shifting, mobile laser beams, which the dancer navigated and responded to choreographically.

In the second part of the performance, seventeen drones equipped with laser modules ascended slowly into the air, producing a dense matrix of luminous beams that intertwined into a mesmerizing "forest" of light. As the drones maneuvered through the space, their laser trajectories formed a dynamic aerial landscape. The dancer's movements interacted with these beams, creating a reciprocal choreography between the human body and laser-based drone motion.

Figure 20. *Beams of Weighted Light* (2023), by Lo Ho-Lin, performance at the Bronze Mirror Square in front of the Library and Information Building, Nanjing University of the Arts, November 2023.
Source: Courtesy of Lo Ho-Lin.

The conceptual foundation for employing laser-equipped drones originated from the 2019 anti–extradition bill protests in Hong Kong. Conventionally, light is perceived as intangible, weightless, and immaterial. Yet during the protests, demonstrators used laser pointers as a means of expressing resistance and dissent toward state authority; the mere possession of a laser pointer even became grounds for arrest by the police. Consequently, the laser beam emerged as both an expressive instrument and a symbolic gesture within the social movement—an optical signifier that carried the weight of collective resistance. Light, in this context, became "heavy" with political meaning.

The Beam with Weight draws upon this symbolic transformation by deploying drones equipped with laser modules to inscribe a shifting "forest" of laser patterns across the plaza. These intersecting beams metaphorically represent the public's freedom to voice their beliefs and assert their agency. The dancer's interaction with the laser field becomes emblematic of citizens' participation in social movements, embodying the gestures of protest, expression, and political presence through the intertwined motions of the human body and laser-illuminated airspace.

Prisoner under the Torch, the *L'Enfant* series, and *The Beam with Weight* together mark a critical shift in Taiwanese drone-based stage performance from technological intervention to the subjectification of performance. As the first theatrical work in Taiwan to incorporate a drone into live performance, *Prisoner under the Torch* positions the drone as a performative agent endowed with both symbolic and functional significance. Through its hovering movements alongside the dancer, the drone assumes an ambivalent role—at once resembling a companion and a burdensome or oppressive presence—thereby metaphorically articulating human dependence on technology and the psychological tensions it produces. At the same time, through the integration of an onboard camera and a high-speed motion-capture system, the work constructs a multi-layered visual apparatus composed of the dancer, the drone, imaging technologies, and the audience. This configuration destabilizes the conventional visual hierarchy of theatrical spectatorship and transforms

the performance into a critical inquiry into gaze, surveillance, and mediated perception.

The *L'Enfant* series and its subsequent iterations further expand this structure of viewing and surveillance into a participatory and algorithm-driven performance mechanism. By deliberately removing professional dancers, the works position the drone as the only continuously moving performer on stage. Through real-time tracking, image projection, algorithmic computation, and augmented reality technologies, the audience's bodies are incorporated into the core of performance generation. Spectators are no longer mere observers but become captured, translated, and recomposed as datafied bodies, whose stage presence constantly oscillates between the real and the virtual. Within this configuration, the drone simultaneously functions as observer, performer, and governance apparatus, rendering performance a technological field concerned with participation, surveillance, and the mediated production of identity—while also resonating with issues of mobility, visibility, and power embedded in the refugee crisis.

By contrast, *The Beam with Weight* deliberately departs from image- and surveillance-centered performance paradigms, redirecting attention toward the redefinition of embodiment, perception, and materiality. Through the use of laser-equipped drones, the work transforms light—traditionally perceived as immaterial and weightless—into a performative condition that can be bodily sensed and responded to. Air, laser beams, and the dancer's movements collectively constitute a performative environment charged with material tension. Conceptually rooted in the political weight carried by laser light during Hong Kong's anti–extradition bill protests, light in this work ceases to function merely as a visual effect and instead becomes a medium symbolizing public action and collective will. In this context, the drone no longer primarily operates as a device of observation or surveillance, but rather as a perceptual medium that weaves spatial relations and guides embodied movement. While the former two works reveal how technology reorganizes regimes of vision and governance, *The Beam with Weight* advances technological performance toward a perceptual event grounded in embodied experience and political symbolism, thereby expanding the theoretical possibilities of drones as performative agents within contemporary technology art.

6. Conclusions

The use of drones as a medium for technology art performance emerged in the 2010s, a period marked by the miniaturization of drone hardware and significant advances in flight-control technologies. After 2012, both large-scale outdoor drone-swarm performances and smaller-scale stage productions involving multiple drones began to proliferate globally, giving rise to a wide array of artistic and commercial applications. Drones are frequently combined with lighting systems, pyrotechnics, or modified into alternative sculptural forms. For instance, in the rock band MUSE's *Drones Tour*, drones were configured as floating luminous spheres, while in Cirque du Soleil's *SPARK*, developed in collaboration with ETH Zurich and Verity Studios, drones were outfitted as autonomous lampshades.

In most such productions, drone trajectories are preprogrammed, enabling the synchronized movement of multiple drones in choreographed sequence with dancers or performers. The integration of drones into performance thus relies on the orchestration of coordinated flight paths, creating a hybrid choreographic field in which aerial devices and human bodies inhabit the same spatial and temporal framework.

Unlike images projected on a screen, drones are physical objects capable of purposeful, spatially directed movement. Sharing the same environment as human performers, they are able to interact through light, motion, sound, or even direct physical proximity. Drones can also enter the audience's space, breaking the conventional "fourth wall" of the stage and producing encounters that are immediate and unexpectedly affective [43].

Within performance settings, drones can be deployed in multiple capacities. They may function as three-dimensional scenic elements or as aerial lighting units, providing distinctive illumination effects. They can also be employed to enhance stage atmospherics—for instance, by dispersing confetti, artificial snow, or smoke. Equipped with cameras, mirrors, laser modules, or spotlights, drones can serve as mobile apparatuses that extend the sensory and visual vocabulary of a performance. Moreover, drones can be customized or sculpturally modified to enact specific roles, dancing with and interacting alongside human performers. A taxonomy of drone-based stage performance types is presented in **Table 1** [44].

Table 1. Categories of Drone-Based Performances.

Type of Drone Performance	Outdoor Drone Performance	Indoor Drone Performances
Existing Applications	1. Swarm formations such as honeycomb, flocking, or grid-based matrix displays 2. Pyrotechnic-like displays (firework-style aerial effects) 3. Light-based aerial performances	1. Use as stage props or three-dimensional scenic elements 2. Use as stage lighting units or mobile illumination sources 3. Use as surveillance devices, video-recording tools, or real-time broadcast cameras 4. Use as performers or instrumental agents within the choreography

Drone performance systems employ advanced control technologies to coordinate the movement of multiple drones, producing visually striking and highly distinctive aerial displays. Through autonomous navigation and precise motion-control capabilities, drones are able to execute intricate aerial choreography that synchronizes with music, lighting, and other stage effects. Nevertheless, safety and reliability remain critical considerations in the design and operation of any drone-based performance system, particularly when performances occur in proximity to human performers or audiences [44].

Drone performance systems employ advanced control technologies to coordinate the movement of multiple unmanned aerial vehicles, producing highly precise and dynamically evolving visual spectacles. Their capabilities in autonomous navigation and accurate motion control enable drones to execute complex aerial choreographies while interacting in real time with music, lighting, and other stage elements. Nevertheless, as the scale and technical complexity of drone performances continue to increase, safety and system reliability remain central concerns that must be carefully addressed in both design and operation.

Looking ahead, the aesthetic forms and narrative structures of drone performances are likely to develop toward greater adaptability, responsiveness, and openness—a shift closely linked to the integration of artificial intelligence. As AI is increasingly applied to autonomous drone control, capabilities such as real-time sensing, environmental interpretation, path planning, and collective decision-making allow drones to move beyond pre-programmed flight sequences and dynamically adjust their behavior in response to on-site conditions and human actions. This technological transition not only expands creative possibilities for real-time interaction and generative choreography, but also raises new issues concerning control, responsibility, and performance safety, positioning AI-driven drone autonomy as a key topic in future research on technology art and human–machine co-performance.

As an emerging branch of technology-based performance, drone stage works rely heavily on the support of specialized technical teams in practical implementation. From spatial positioning, flight-path planning, and collision-avoidance mechanisms to multi-drone formation control and AI-integrated human–machine sensing and interaction systems, their realization requires close collaboration between engineering and artistic expertise. Although some contemporary artists have begun to adopt drones as creative media, the broader dissemination and maturation of such practices will depend on sustained institutional support and cross-sector collaboration among governmental agencies, research institutions, and professional technical teams. Through the integration of these interdisciplinary resources, drone performance can continue to expand its potential as a form of human–machine co-performance situated at the intersection of art, technology, and society.

Author Contributions

Conceptualization, H.-C.H., I.-C.C., and H.-L.L.; methodology, H.-C.H. and H.-L.L.; investigation, H.-C.H., I.-C.C., and H.-L.L.; writing—original draft preparation, H.-C.H.; writing—review and editing, H.-C.H. and H.-L.L.; funding acquisition, H.-L.L. All authors have read and agreed to the published version of the manuscript.

Funding

This work was supported by the National Science and Technology Council (NSTC), Taiwan, under the project titled "The Practice of Multi-UAV Heavy-Lift and Smoke-Pulling for a Giant Puppet Light-and-Shadow Theatre" (NSTC 114-2811-H-002-027) and (NSTC 114-2420-H-002-011).

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data used in this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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