EasyChair Preprint

№ 1068

Twinkle: A Flying Lighting Companion for Urban Safety

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May 30, 2019

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Abstract

Today's urban lighting system still lacks coverage for many walkways, inducing feelings of insecurity and promoting the probability of crime. Ubiquitous surveillance is an intrusion on privacy and does not allow real-time action. The cold, lifeless light shines in the dark, trapping people in the solitude of silence. These absences motivated us to create Twinkle—a luminous transformative creature which inhabits on light posts. They are curious, aerial animals attracted by human activity. During the day, they rest on urban light posts, expanding their solar panels for charging. At night, they react to pedestrians on the street based on various distinct personalities. Twinkle is an indirect solution to urban security without the need for surveillance. We envision a future where technology goes beyond its form and becomes a companion to us.

Keywords

Affective computing; UAV; Urban Lighting; Autonomous Aircraft; Interactive; Play.

Figure 1a. Twinkles can lead people's way back home.

Introduction

Imagine a city with flying light: as night falls and darkness creeps in, all of the sudden a bright sparkle appears, and then another–one-by-one lighting up the city street. Soon, the sullen city comes alive, orchestrated with the natural rhythm of "Twinkle".

Lighting is a major part of urban infrastructure, providing visibility to pedestrians and contributing significantly to feelings of safety [1, 2]. Farrington et al. suggested that crime can be prevented by environmental measures that directly affect offenders' perceptions of increased risk and decreased reward [3]. However, the current urban lighting system leaves many areas uncovered. Especially in remote regions with less population, sparse and dim street lights can lead to feelings of insecurity and increased criminal activity. One way urban environment can be improved is through closed-circuit television (CCTV) cameras. However, these surveillance systems invade people's privacy, and do not promote real-time action, as most of them become evidence to crimes that had already occurred in the past.

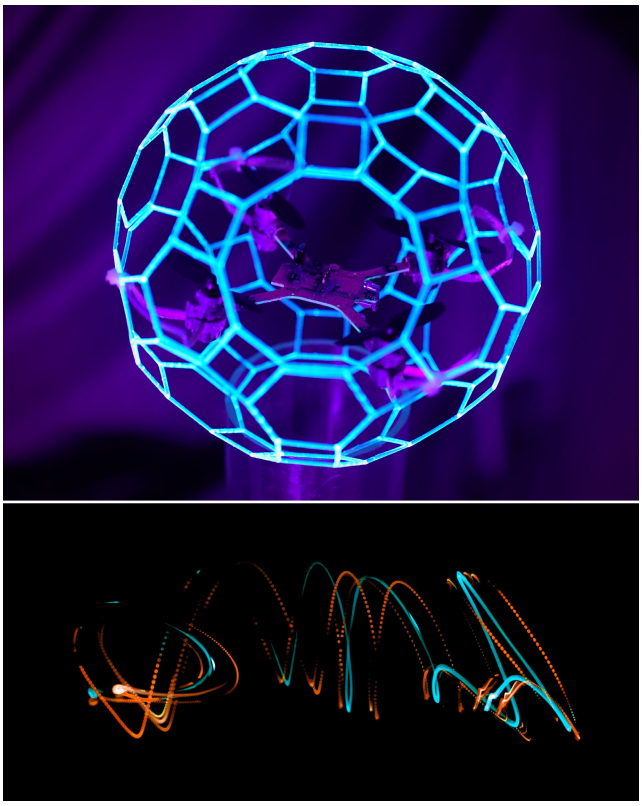

Figure 1b. "Puppy" Twinkle prototype and its flight trajectory.

These absences motivated us to create Twinkle–a dynamic lighting companion that light up areas on demand and prevent crime (fig 1). Twinkles are luminous transformative creatures inhabit on light posts. They are aerial animals, like fireflies, and are curious, playful and alerted by human activity. During the daytime, they rest on urban light posts, expanding their solar panels for charging, which double as shade for pedestrians. At night, they fly to each passing individual to offer increased visibility for their pathway ahead. Twinkle is an indirect solution for improving urban safety without the need for surveillance. Twinkle's behavior helps each nearby pedestrian achieve a better view of their surroundings. At the same time, their presence prevents crime by dazzling light and revealing the identity of individuals who attempt to misbehave.

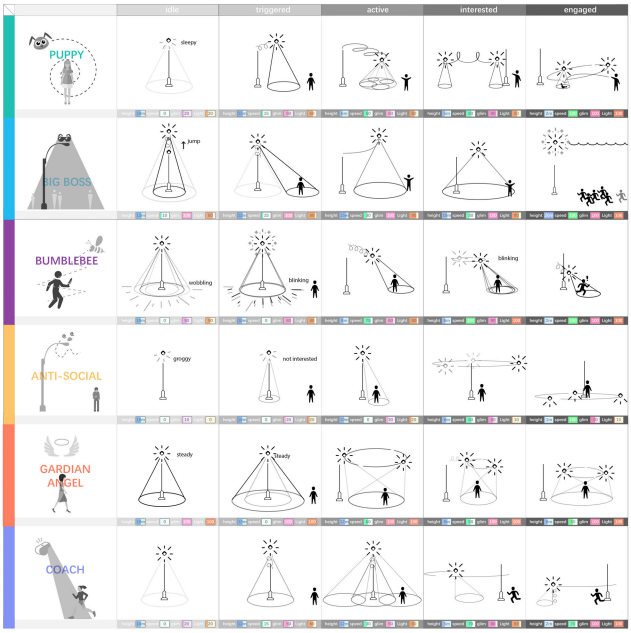

Figure 2. Twinkles embody a personality based on their surroundings. Personalities are quantified by height, speed, glim, and light. The five states are: idle, triggered, active, interested, and engaged.

Personality

Twinkles are living creatures sharing the same space with humans. Like humans, they express various emotions and personalities.

We selected speed, reaction time, altitude, power and consistency as key characteristic factors for each drone (fig. 2). These physical properties result in the drone's distinct behaviors and hence lead to their unique personalities.

From friendly to annoying, and active to inactive, these flying creatures interact with people in distinct ways: "Puppy", with trusting and affectionate characteristic, is interested in playing with children. It feels comfortable when getting close to people. It flies around with intermediate motions moving altitude up and down without a consistent, predictable path. It's naughty and curious, turning the night into a playground. "Big Boss", embracing confidence and discipline, sits at high altitude to maintain awareness of its territory. During an emergency, it quickly reacts to lead people away from danger by projecting evacuation directions with its light skin. Its powerful light reflects high visibility even in smoky and foggy areas. It can turn into an alarm or light up in dark areas for smoother evacuation. Its consistent, fast, and strong. "Bumblebee" is sensitive to suspected misbehavior and acts accordingly. Being suspicious and nervous, it looks around for danger all the time. Once detected, it attacks the criminal with dazzling light and at full speed. By exposing the potential criminal, it performs pre-crime preventions. "Antisocial Guy" is not interested in anything happening around. It's reserved, insensitive, and buried in its own world. When a person comes into view, it wobbles a little (and may bump into things) and returns to its original position, keeping a distance from people. Sporadic light appears indistinctly depending on its mood. "Coach" guides people in training and helps optimize training routes. During outdoor workouts, it keeps a steady distance ahead of the person, and illuminates the pathway ahead. It cheers trainees up when they are tired and sets the pace fit for their health.

Figure 3. Twinkle's skin helps convey emotion, protect the propellers, and change its shape and function.

Skin

The outer polyhedron skeleton is Twinkle's skin. It serves three roles: (1) convey Twinkle's emotion, (2) prevent direct contact to its propellers, and (3) change Twinkle's shape and function (fig. 3). When Twinkle expresses an emotional state, the LED lights in the node will display colors, frequencies, and rhythms specific to the personality. The light travels through the optical fiber to the entire skin (fig. 4).

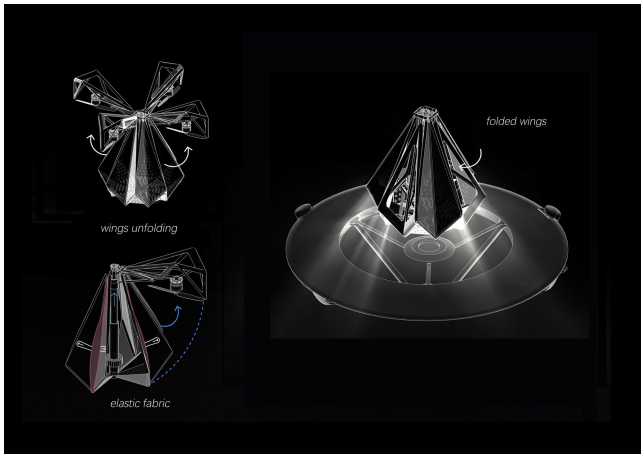

Figure 4. Twinkle's skin is made of translucent, flexible waterproof fabric. Under its wing, a near-invisible seam allows the fabric to unfold when Twinkle spreads its wings. When contracted, the wings gather into the main structure through an open seam.

Light

The light attaches to the quadcopter body via a three-axis gimbal for maximum degree of freedom (fig. 5). Equipped with a 100w LED omnidirectional flood light, each Twinkle has the capability of a wide range of light intensity and directional control. Combined with the Glimmer on Twinkle's skin, the two systems make it possible for Twinkle's personalities and versatile applications to shine through.

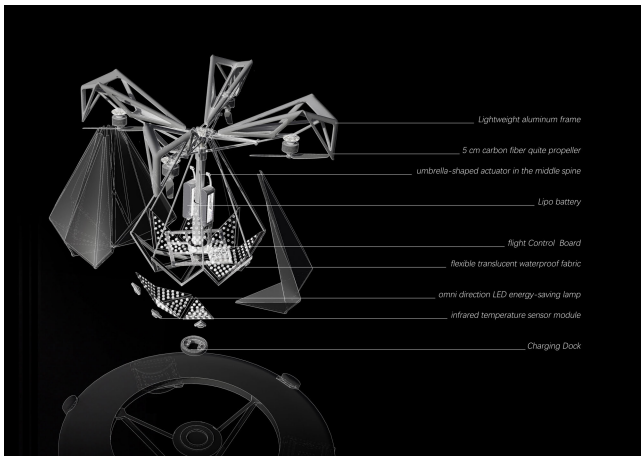

Figure 5. The anatomy of a Twinkle: optical fiber skeleton, flood light, solar panel film, quadcopter, actuator, and LED's. Twinkle's nest consists of a charging dock and behavior sensor.

For example, Bumblebee blinks a cautionary yellow at rapid pace on their skin when suspicious people are nearby. The blink frequency gradually increases when the suspect gets closer. Certain behaviors, like screaming, triggers Twinkle's flood light to maximum brightness without buffer time. Bumblebee sheds intense light directly on people, unlike other personalities. When the suspect moves closer, the light beam will steadily focus on the suspect's face through parabolic reflectors, leaving an unpleasant flash. These lighting features encourage people to flee the scene, much like people's reaction to real-life bees. On the other hand, Anti-social Guy blinks with a sleepy rhythm, like he's in a constant state of grogginess. He hardly gets triggered by surrounding activity. And when he is, his reaction is so slow in intensity that he dims down just before reaching full brightness, because he loses interest. Twinkle's various light functions can play a key role in promoting safety and security to the urban lifestyle through a multitude of scenarios (fig. 6).

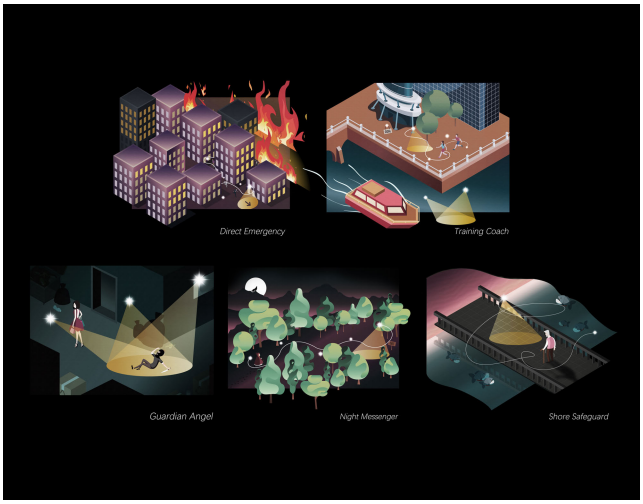

Figure 6. Example scenarios where Twinkles plays a key role.

Nest

The base nest station (fig. 7) offers multiple twigs to host more than one Twinkle. During the daytime, when Twinkle expands its solar sail to charge, the nest stores excessive electricity. In case of insufficient sunlight, it transmits power to Twinkle through a wireless charging dock. At night, it serves as the data hub for signal collection and analysis. Whenever someone enters the responsive range, it captures and analyzes the location information of pedestrians to guide Twinkle's flight path.

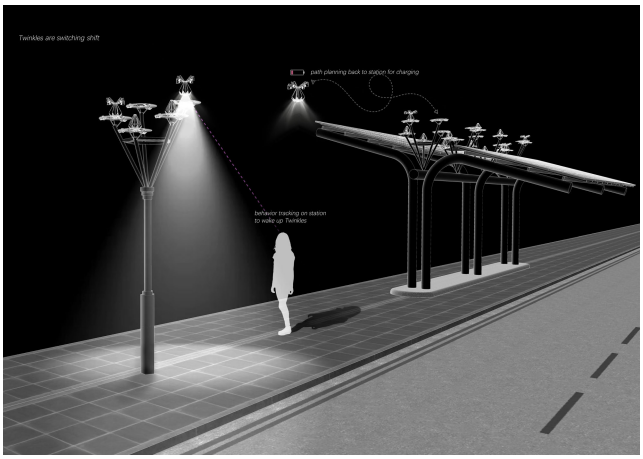

Figure 7. Nest stations analyzes pedestrian behavior and position and sends data to Twinkles.

Transformative Elytron

We also explored a transformative structure to make Twinkle more expressive. Its skeleton is based off the octahedron-cuboctahedron jitterbug transformation (fig. 8).

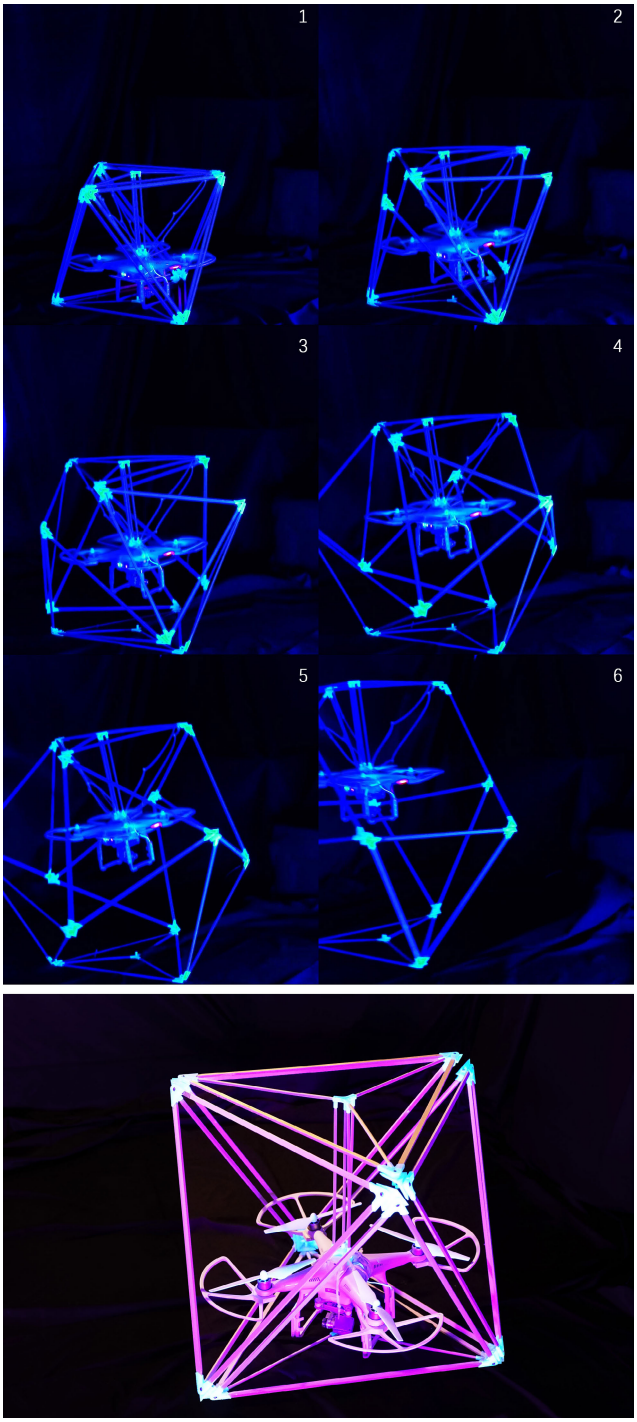

Figure 8. Twinkle's skeleton mimics the octahedron-cuboctahedron jitterbug structure.

At night, the triangle frames are compressed into a smaller-profile octahedron shape to minimize the impact on the center quadcopter aerodynamics (fig. 8). During the day, an actuator pushes the bottom and top triangle frames to trigger the symmetry rotation of each triangle frame on the rotation nodes. This transformation gradually reveals the thin-film solar cell folded in quadrangle gap between the isosceles triangle structures. When the actuator extends the structural height to twice as the original, the skin is fully expanded to a cuboctahedron skeleton, covered with six square solar panels. This design provides solar absorbance to a size as large as the original octahedron surface area and supplies shade protection for pedestrians from the sun. The structure is wrapped back to its octahedron form to improve mobility and prevent solar cells from blocking light after sunset.

Impact on Human Lives

Urban lighting is no longer a cold, immutable infrastructure, but a new form of companionship with personality and feedback. Community-wise, Twinkle's habitual nature promotes public security, and therefore improves city environments. Flying with pedestrians indirectly obstructs crime, reshaping a dangerous neighborhood to a safe neighborhood. The companionship reduces not only crimes but also misbehavior, like public graffiti and littering. As a result of Twinkle's personality, an unsafe neighborhood would attract more Bumblebee's and Guardian Angel's. Twinkle will be able to transform its personality in accordance with city development and ultimately form a dynamic autonomous lighting solution (fig. 9). Communities will steadily be reshaped by Twinkles and soon discover a new vitality in people's lives both at day and at night.

Figure 9. Twinkle as a flying companion to guide people in the dark.

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Author Biographies

Honghao Deng is a computational designer and artist. He holds a Master of Design Studies with distinction at Harvard GSD and has served as a research fellow in the City Science Group at MIT Media Lab. Recognition gained in the design and interaction community include: Golden A' Design Award, iF Design Award, Fast Company World Changing Ide-as Award, 1st Place Future Cities Contest, Ubicomp/ISWC Design Award. His work has been covered by Domus, CCTV, ArchDaily, Designboom, Milan Design Week, The National, and Metropolis Magazine.

Jiabao Li works at the intersection of emerging technology, art and design. Her work opens questions about technology's influence on human perception, identity, and emotion. Her research-based projects range from wearables, projections, drones, installations to scientific experiments. She holds a Master of Design in Technology degree with Distinction from Harvard GSD. Jiabao's work has been featured in Domus, TechCrunch, Yahoo, CCTV, Yanko Design, and The National. Her work has been shown in Milan Design Week, Dubai De-sign Week, SIGGRAPH, CHI, AR in Action, and PRIMER. She is the winner of iF Design Award, Fast Company World Changing Ideas Award, Future Cities Contest, ISWC Design Award, and Harvard Best Thesis Award.