Creative Media + The Internet of Things = Media Multiplicities

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Creative Media + the Internet of Things = Media Multiplicities

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Abstract

This paper proposes the term "media multiplicities" to describe contemporary media artworks that create multiples of "internet of things" devices. It discusses the properties that distinguish media multiplicities from other forms of media artwork, provides parameters for categorizing media multiplicities, and discusses aesthetic and creative factors in the production of media multiplicities.

Media multiplicities are networks of independent media entities that work together to form a single media entity. We posit that such a tongue-twister is needed to capture the qualities of an emerging form of media technology that is set to become ubiquitous in the near future (we can also talk of the companion term "multiplicitous media" as the general field of activity involving media multiplicities).

Media multiplicities involve multiple digital media devices—such as lights, speakers, screens, physical movement or other forms of actuation—working in some kind of coordinated manner. Recent examples include the Spaxels [1], AudioCubes [2], Radical Atoms [3], PixelBots [4], Siftables [5], our own work with Distributed Interactive Audio Devices [6,7], Squidsoup's *Bloom* installation [8] (Fig. 1) and many other forms of networked music and art, as well as of media architecture [9].

The Spaxels project [10], for example, creates large-scale outdoor spectacles using powerful lights carried by a swarm of drones. A precisely choreographed air display with the potential to act as a dynamic low-resolution screen, the Spaxels makes a natural extension to existing public outdoor spectacles such as fireworks displays and projection mapping.

A series of underlying technological transformations is feeding this evolution. The key ingredients are those of the wider world of the internet of things (IoT) in general: the miniaturization of high-performance computing devices, open-source hardware, battery power, wireless communication technologies, cloud computing, affordable and interoperable sensing and actuating components with common general-purpose input/output (GPIO) protocols and rapid prototyping [11].

In media technologies we observe a simultaneous convergence and divergence. Media technologies are converging around computational technologies; they all have a central, programmable computational brain that can run software and communicate over a network. They are also diverging as it becomes increasingly easy to produce custom products, strange hybrids or domain-specific devices that remain interoperable because of their common computational core and networking capabilities.

A theory of the structures, dynamics and affordances of media multiplicities is needed that can guide both end-user interaction design and digital creativity. Such a theory should enable categorization of media multiplicities according to relevant properties. In this paper, we propose a number of ways to describe and categorize media multiplicities to kick-start this process.

Fig. 1. Squidsoup, *Bloom,* a multiplicitous media artwork consisting of 1,000 wifi-networked computational devices. (© Anthony Rowe/Squidsoup.org)

Beyond Pixels: Substrate versus Object

We have described media multiplicities as multiplicities of digital media devices. But do screens made of pixels and multi-speaker sound systems count as examples of media multiplicities? We believe this points to a key issue. Screens and multi-speaker arrays act as substrates that render an image. We do not focus on the individual pixels, nor on the individual speakers. But in all of the examples given above, we see that each object in the multiplicity is identifiable as an object in its own right. Sometimes the objectness of these objects disappears into the background so that the attention is directed toward the overall image. But as these examples each convey, it is the flexibility to shift focus back and forth between substrate and object that is novel. Our spatial relations to screens and speaker arrays are constrained by the demands of the image. Media multiplicities explore a richer set of spatial relations between person and technology. This is achieved in different ways—often through the portability (the ability to touch and move objects) or even motility (where drones and robots are concerned) of the component objects. But it can also be achieved simply through use of scale, as in media architecture. This new affordance goes hand in hand with a new demand for systems highly adaptive to contexts and spatial relations.

Properties: Spatial, Scatterable, Sensing, Scalable

We continue by noting properties that help distinguish old media such as screens and speaker arrays from multiplicitous media. The first is common to old and new; the other three are largely novel properties. We say that multiplicitous media are:

- **Spatial:** Multiple speakers and multiple pixels can produce spatial effects in a variety of ways, and can easily afford immersive experiences, especially in multiuser cases [12]. Spatial effects can be produced at close proximity, as in headphones and VR headsets, or they can be embedded in environments, as in media facades.
- **Scatterable:** More novel is the idea of "scatterability," which involves both spatiality and portability or motility: Scatterable media can be rapidly reconfigured spatially without interrupting the media experience—possibly even enhancing it.
- **Sensing:** Multiples of sensing devices working together have been described as sensor network interfaces [13]. Together, these devices can build complex distributed representations of their environment and share this information. They can be readily employed for complex data display, as in data sonification [14].
- **Scalable:** Although TV screens of many different sizes can be created out of the same basic pixels, TV screens are not readily scalable. But we can build TV walls, tiled from individual screens. Increasingly, multiplicitous media aggregates will have no fixed size and may dynamically scale depending on available resources or need.

Orders of Magnitude

How many elements make up a typical media multiplicity? We believe that the correct question is, instead: How can we analyze different affordances of multiplicitous objects at different scales? These affordances are sometimes associated with different innate human cognitive factors and, at other times, are grounded in physics or mathematics. Several significant number "landmarks" are worth considering. Numbers of objects above four require counting proper; below that, we can immediately perceive how many objects are present; this is known as the subitizing threshold [15]. Seven plus or minus two is the magic number in the study of psychological memory [16]. Twelve is considered an ideal number of people for decision-making, as in juries [17]. Different musical genres—from rock to orchestral music—are attached to different ensemble sizes. Dunbar's number, 150, is the theoretical ideal number of social contacts a person has, which may influence how we experience crowds or social networks [18]. At 96 × 65, Nokia's 1101 cell phone, the most popular cell phone ever, has only 6,240 pixels, sufficient to display several lines of text, simple images and perfectly enjoyable games. Flocking behaviors in bird populations occur in the tens of thousands. Suntec Singapore's "Big Picture" video wall has a resolution of 32,051 × 7,941, or 254,516,991 pixels, covering an area 15 × 60 m [19]. In Ishii's vision of the future, smart, dynamic actuated environments would consist of similar numbers of components [20].

Heterogeneous and Self-Organized Multiplicities

Two other axes along which to look at media multiplicities are (1) heterogeneous versus homogeneous and (2) self-organized versus composed. The divergence of media objects enables the creation of heterogeneous media multiplicities, just as an orchestra of heterogeneous instruments come together to form a whole. Speaker or light arrays can be adapted to spaces in creative ways. Equally, homogeneous hardware components can assume heterogeneous roles in media experiences. Related to this, we might compose content for heterogeneous or homogenous multiplicitous media experiences as if composing a symphony for an orchestra, thinking about the way a multiplicity of voices come together to form a whole. Alternatively, we might implement self-organizing systems from which a top-level structure emerges. This old issue in the creation of artistic work takes on new meaning in the context of a platform of disparate interacting elements, especially when those elements are active, interactive and motile agents. Interactivity demands emergent outcomes, as there is no single creative agent, and the creative relationship between top-down and bottom-up compositional processes becomes necessarily more entangled.

Advanced Media Multiplicities

In summary, we claim that advanced media multiplicities mark a clear departure from existing forms of media experience. While hard to precisely define, these mix in some combination the potential to be spatial, scatterable (at least portable, perhaps motile), sensing and scalable. They can readily adapt to interactive relations with their users, particularly in terms of the fluid interplay between presenting individual *objects* or multiplicitous *substrates*. They may be able to function from heterogeneous components and readily embody the emergent properties of self-organizing systems.

Creative Challenges

This vision of an emerging creative media revolution points to two great challenges for multiplicitous media designers. The first is to build the kind of adaptive intelligence we see in nature into dynamic, scalable systems. Adaptive behavior in the biological world is relatively well understood, but what is poorly understood is how to be creative while working with such adaptive behavior. The second challenge is to build authoring environments that allow for the rich simulation of multiplicitous media outputs. Here the solution is more obvious: Create virtual creative workstations for the composition of the physical computing world, directly interoperable with IoT deployment potentials. This area also provides ways to begin to unpack the first challenge, by using the virtual world as a sandbox for experimenting with adaptive, dynamic and scalable behaviors. The emergence of media multiplicities is already beginning to point to the practical importance of nature-inspired generative processes that have been of diminishing interest in the world of digital creativity in recent years, and we might be so bold as to predict a strong merger of IoT technologies, VR and generative art to address these challenges.

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