Fluid Ontologies - For two laser-feedback instruments using Bela Gem

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1 Program Notes

In "Fluid Ontologies", Transsonic (Nicola Leonard Hein and Viola Yip) continues to expand their intermedial artistic practice in performances. For this work, they further develop their DMI "FO^2". It is a laser-feedback-instrument that uses laser modules as sound sources and solar panel as microphones, creating audiovisual feedback loops, which create images and sound, using the same optoelectrical mechanism. The work is for two performers, each using one laser-feedback instrument. FO^2 comprises two 3D-printed handheld controllers, a backpack with an embedded DSP system running on a Bela[4] Gem and programmed in SuperCollider[8], and laser drivers. The laser drivers are controlled via their modulation input, using the Bela's analog output to modulate sound signals onto the lasers, effectively operating them as opto-electrical oscillators. We use solar panels as microphones to pick up the sound that is modulated onto the lasers and feed the sound back into the Bela audio input. This enables the mediality of feedback through light connection to be explored in ways that are entirely different from feedback circuits working in the audio domain only. Fluid Ontologies, using FO^2, explores the embodiment and situatedness of musical performances through audiovisual instruments in a distinctive manner.

Furthermore, by incorporating multichannel spatialization, Transsonic extends the spatial dimensions, both sonically and visually, creating a unique audiovisual experience.

The project explores and defines new concepts of the instrumentality of light in audio circuits, putting space, body, technology[2], and instruments into one dynamic feedback system, exploring forms of cybernetic[1] and transmedial modes of listening[9], as well as the emerging dances of agency[5].

Fig. 1. The performer combines two laser beams to form two overlapping planes.

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Fig. 2. The performers move their laser instruments,
allowing the laser to fill the space and create architectural features.

2 Project Description

Transsonic develops new site-specific works that communicate the sonic fluidity in intermedial work consisting of site-specific light installations, electric guitar, multichannel live electronics, and relays working as oscillators. Transsonic is a project of sound artist/ composer and light Viola Yip as well as guitarist, electronic musician and sound artist Nicola Leonard Hein The project centers around the development of "light as musical material" and questions the ontology of music from this intermedial perspective. In light of the ongoing digital revolution, we develop translational potentials of electronic and digital media to develop our working concept of music across different media.

In "Fluid Ontologies", Transsonic continues to expand their intermedial artistic practice in performances. For this work, they further develop their DMI "FO^2". FO^2 comprises 2 handheld line-laser modules, embedded in 3D-printed handheld control devices, and 1 3D-printed backpack containing a Bela microcomputer, 2 laser drivers, 2 circuit boards (to connect analog and digital controls to the Bela), and 3 DC step-down converters per performer.
The instrument is built around a distinctive mode of audiovisual transduction in which audio signals drive laser modules, encoding sound to light. Using solar panels as microphones, we transduce light back to the audio domain. This transduction, when used within an audio circuit that generates feedback, enables us to explore the mediality of the resulting feedback. By creating an immediate coupling between the sender (line laser) and the receiver (solar panel), the audio circuit exhibits feedback dynamics different from those of a circuit using a microphone and a loudspeaker, for example. These dynamics enable us to musically explore and compose with the resulting musical affordances of the instrument, playing the instrument as a kind of string instrument, a percussion instrument, and developing many other characteristics that become accessible due to the dynamics of the feedback and the speed of the closure of the feedback system and its rapid increase in saturation, in coordination with the digital signal processing (DSP) algorithms used for this piece. Using this

opto-electrical mechanism, we can develop a close association between the sonic and the visual layers of the performance, since both are generated by the exact mechanism, leading to an audiovisual system that quickly generates material with internal consistency. Lastly, this basic assumption tightly binds body, space, and technology, making every bodily movement intended to create sound a spatial gesture, and vice versa, using the reflective properties of surfaces and other objects to influence and shape the sound by reflecting light. Every musical gesture is a spatial gesture, leading to a shift in proprioception for us as performers as we connect the spatial and musical layers of gestures in our musical thinking and performance.

To transduce sound onto the line lasers used in FO^2, the laser modules' DC power supply is modulated via its pulse-width modulation input. The PWM modulation input signal is provided by a Bela Gem microcomputer. The Bela microcomputer's audio output provides audio for performers and the audience, as well as a driver signal for PWM modulation of the laser drivers (via its 5V analog output). This allows the lasers to transduce sound into light, functioning as an oscillator and projecting sonic information into the room, inaudible yet materially present within the performance space. We intentionally use laser modules with 110° line optics to produce extended laser lines. These lines carve through the performance space, suggesting new architectures and reframing existing spaces. Working with lines (rather than laser dots) allows us to engage directly with the specific geometry and the idiosyncratic formation of the performance space.

Alongside the laser modules—which function like "opto-loudspeakers," projecting audio encoded in light into the room—FO^2 uses solar panels in the performance space to convert that light back into sound. The 5V solar panels work as photoelectric transducers excited by illumination rather than air pressure, functioning as "opto-microphones". When struck by the laser lines, they generate an electrical current that, when routed into an audio circuit and reproduced through loudspeakers, becomes audible. In this way, the light impulses produced by the laser modules are sonified.

Altering the spatial and functional relationship between the solar panels and the laser modules produces different sounds—different readings of the light. By working with indirect illumination, reflections, and materials with varying refractive indices, *Fluid Ontologies* opens a wide range of compositional options. Shifts in light intensity, reflection patterns, and panel response allow us to activate different feedback nodes, changing the behavior of the laser-feedback instruments in real time. Through the mediality of light—varying distance, angle, and the degree of reflection between lasers and panels—the feedback accentuates different overtone structures and dynamic profiles, moving between states of relative stability and instability. In combination with our DSP processes, changes in the angle of incidence become especially consequential, shaping the aesthetic character of the feedback dynamics. The immediacy of this optical feedback differs markedly from microphone–loudspeaker systems in the audio domain. When the beam hits the panel, the feedback can reach maximum intensity within a few milliseconds. The electrical signals from the solar panels are routed to two instrument units—one per performer—where they are processed using DSP algorithms.

FO^2 uses a Bela Gem microcomputer as its DSP unit. The Bela microcomputer, with its integration of several programming languages into a low-latency platform, provides analog and digital I/O and the flexibility needed for this project. FO^2 is programmed in SuperCollider. It leverages its flexibility between sclang and scsynth to maximize performance gains, running only the synthesizer and audio effect algorithms needed at a given moment on scsynth, while keeping the other algorithms available. The SuperCollider patch used for FO^2 currently uses seven different stereo feedback algorithms as sound sources for the instrument. Each laser "opto-loudspeaker" is linked to one solar panel "opto-microphone" and runs in parallel, with parallel controls for synthesis parameters. These have been

composed to allow for clearly defined musical topoi in the composition of *Fluid Ontologies*. All these algorithms define a specific kind of musical space and invite unique spatial interaction, as they react differently to input from the solar panels and lasers. Each synthesis algorithm exposes two parameters per channel, which can be controlled via the hall-sensor joysticks (x and y dimensions) on the handheld controllers (left and right hands independently). Every algorithm uses an added pink noise (or other noise) source that is modulated onto the laser but not audible through the loudspeakers, to produce light and act as a trigger to excite the feedback.
FO^2 uses 10 live electronic effects, controlled via 10 keys on the two handheld controllers. These are composed in pairs, divided between the performers' hands; each finger of the left and right hand (and palms) forms a pair of related algorithms. The pairs of related algorithms are: 1. Stutter Freeze/Freeze, 2. Comb Delay/Reverb, 3. Fuzz/Generative Feedback Reverb, 4. Forward Looper/Backwards Looper, 5. Waveset Distortion/FFT Amplitude Modulation. Furthermore, the index finger key on each hand serves as a gate for the laser and audio output of that hand, enabling the performer to control which sound is visible and audible. The SuperCollider code for the project is published on GitHub: https://github.com/NicolaLHein/FO2. A video showing the functioning of the laser feedback instrument is attached as supplementary material.

The piece *Fluid Ontologies*, along with the instrument FO^2, produces a unique form of musical composition and performance through opto-electronic feedback instruments, exploring modes of feedback musicianship[3]. They bring forth an emergent choreography, as every musical impulse and development is also bodily and spatial, letting new relationships emerge from the constellation of the "performance ecosystem"[7], as well as forms of cybernetic[1] and transmedial listening[9]. As a performer, using laser light as a musical medium offers alternative insights into how music could be mediated and perceived in a particular environment/system. With FO^2 we explore new modes of embodiment of technology[4] and the instrumentality of bodies in technology[6]. In *Fluid Ontologies*, as discussed, laser light is used as a musical medium to carry an audio signal. It affords a different kind of performativity in music and offers alternative insights on how music could be mediated and perceived in a particular environment/system. It furthermore explores the emergent agency [5] between the human performers, their bodies, the space, the sound and the different materialities involved in the performance.

Fig. 3. One 3D-printed handheld controller.

Fig. 4. 3D printed backpack and controllers.
For wearing, straps are attached through the loops of the backpack.

3 Technical Notes

The performance needs a stereo or (preferred) multichannel sound system. We can adapt to any sound system and will deliver our output accordingly.
Below is an image of our signal flow. We only need to be able to connect to the PA, either via analog out, Dante, or Madi. Spatialization is done on our computer and can be adjusted to any multichannel system.
Furthermore, we prefer the venue to have walls / a projection screen on which we can project our lasers. The walls/projection screen should ideally be white, but our lasers are sufficiently bright to work with black surfaces as well.

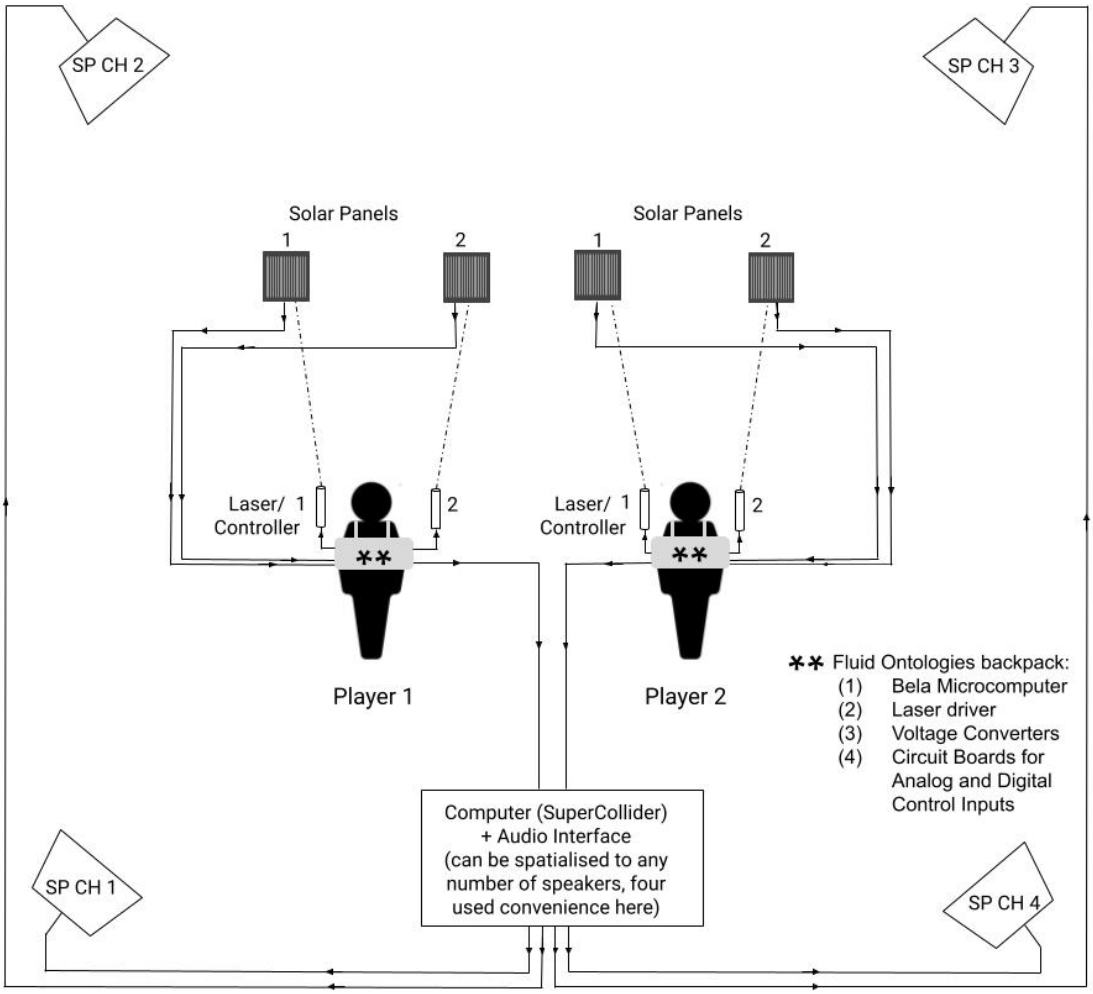

Fig. 5. Signal flow chart of performance with FO².

4 Media Link(s)

- Video demonstration of Fluid Ontologies: https://youtu.be/wUaUfmb6-i4

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Compliance with Ethical Standards

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