Institutional presentations：” Quantum Art Bridge: Superposition and Entanglement of Quantum Physics and TechArt” of NTHU

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Quantum Mechanics and Tech-Art are two distinct frontier fields. The former continually expands the boundaries of human knowledge, while the latter delves into the intrinsic structure of technology and its cultural effects, as well as probing the boundaries of human perception. Unlike most creations or curations that symbolically or metaphorically reference the characteristics of quantum mechanics, this project involves collaboration among three laboratories at National Tsing Hua University (NTHU): the Quantum Optics Laboratory of the Institute of Photonics Technologies, the Art in Action Lab, and the LumiSound XR Lab of the Graduate Institute of Art & Technology. The aim is to establish Taiwan's first practical field that combines Tech-Art with quantum experiments. As a highly experimental initiative, our primary focus is exploring potential cross-domain collaborative solutions. A key task is the creation of what we call a 'bridge' – an artistic initiative that includes both practical and theoretical methodologies for bridging these two fields.

Keywords: Tech-Art, quantum physics, quantum random numbers, artistic experiments, macroscopic quantum phenomena

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We are the "Quantum Art Bridge" project team from National Tsing Hua University, formed in June 2023. This current phase of the project is funded by the university until the end of 2024.

Quantum Mechanics and Tech-Art are two distinct frontier fields: the former continuously expands the boundaries of human knowledge, while the latter delves into the intrinsic structure of technology and its cultural effects, probing the boundaries of human perception. Although these two areas seem far apart, we believe in the potential for intersection and synergistic collaboration between them. National Tsing Hua University (NTHU), a renowned research university in Taiwan known for its science and engineering studies, became the first top university in Taiwan with an art college after merging with National Hsinchu University of Education in 2016. In 2020, it established the Institute of Technology Art. This project aims to leverage the advantages of NTHU's combined strengths in scientific research and artistic creation. It involves collaboration among three laboratories: the Quantum Optics Laboratory of the Institute of Photonics Technologies, the Art in Action Lab, and the LumiSound XR Lab of the Institute of Technology Art, to establish Taiwan's first practical field combining technology art with quantum experiments. Currently, most creations or exhibitions merely use quantum mechanics' characteristics symbolically or metaphorically. We aspire to achieve substantial collaboration with physics laboratories. Our team comprises three faculty members from different fields (contemporary art creation and theory, quantum physics, XR and sound art), one doctoral student in information technology, one doctoral student in technology art, four graduate students, and one graduate student from the Quantum Optics Laboratory.

As a highly experimental project, we view this initiative as a litmus test, initially focusing on exploring possible cross-domain collaborative solutions. Our current task is to create what we call a 'bridge' – an artistic initiative that includes both practical and theoretical methodologies for connecting these two fields, and on this foundation, proceed with technology art creation.

The "Quantum Manifesto[1]" proposed by the European Commission in 2016 mentioned that in the upcoming second quantum revolution, quantum theory will once again lead the innovation and evolution of semiconductors, chips, and components. This force, together with artificial intelligence and big data, will be a major driving force shaping the future intelligent society, highlighting the considerable impact of quantum physics on the future of civilization. We expect that the new wave of the quantum "revolution" should not only discuss the technical integration between different fields but should also include the humanistic aspects, because a so-called revolution should be a multifaceted transformation across the entire civilization. Without the contemplation of the humanities, it's challenging to assess or even foresee the impact of technology on the world (not just

[1] de Touzalin, Marcus, Heijman, Cirac, Murray, Calarco. *Quantum Manifesto, A New Era of Technology*, European Commission, 2016

human civilization but also the environment composed of other species and things). The Industrial Revolution serves as a noteworthy example in this context.

Therefore, the interaction between scientists and scholars and practitioners in the humanities (artists, philosophers, sociologists, anthropologists, etc.) should be given significant attention. This interaction enables critical and creative interventions in the humanities during the development of technology. On the other hand, practitioners in the humanities could play a more proactive role by providing dialectics, creativity, and foresight for emerging technologies, collaboratively shaping a technological progression that embodies both the uniqueness of the humanities and the universality of science. The following are the core concepts we have formulated through six months of discussion:

1. **Beyond Application**: The microscopic physical properties revealed by quantum mechanics (superposition, entanglement, tunneling, uncertainty, etc.) have a profound impact on human everyday cognition, and even on philosophical ontology. We temporarily refer to these as the 'transcendental nature' of quantum phenomena. In the development of applied technologies, there seems to be a tendency to 'normalize' these characteristics for practical use. For example, quantum computing requires strict control of quantum states to form logic gates; quantum encryption needs precise control of quantum channels to prevent collapse of quantum states; semiconductors require precise control of tunneling probabilities through temperature and material manipulation. It can be said that applied science requires maintaining quantum states within a controllable range for practical use. While the humanities and arts may lack the precise control capabilities, they are not bound by such constraints. Under the umbrella of art, exploring the uncertainties of the living world through quantum uncertainty, connecting emotional distances through entangled states, and confronting the immovable via quantum tunneling, all become possibilities. We believe that the integration of quantum mechanics with the humanities and arts may open up more pathways beyond applied science, blossoming into a vibrant array of flowers in the world of everyday life.
2. **The Bridge of Everything**: The properties revealed by quantum mechanics — being simultaneously scientific and transcendental — carve a deep abyss of possibilities and thought-provoking ideas atop the spacetime view established by classical mechanics, potentially bridging the chasm between science and humanities, and even serving as a bridge across all fields. Art, as an activity in the humanities that constantly collides with various boundaries, should naturally be the first to attempt contact with quantum science and explore potential inspirations. These inspirations may help us reconnect the lost fragments in the process of civilization's development and mend the ruptures caused by modernity. Contemporary art can play the role of a vanguard in this regard, responding swiftly as it did when the concept of the Anthropocene was introduced as a geological term, initiating deeper levels of critique, contemplation, and practice.

Current main task:

We advocate for the creation of a 'bridge', a mechanism that provides an effective channel between quantum physics and the humanities and arts, welcoming new aesthetics and ways of life. This 'bridge' should include a certain level of theoretical construction (as initiated by this document), a series of technical interfaces that translate microscopic phenomena to the macroscopic world, and artistic creations derived from these two elements as a foundation.

1 Theoretical Construction:

1.1 Establishing the "Quantum Art Bridge Statement": We have completed a preliminary draft, and the above points are excerpts from this statement. The document will continue to be revised based on our discussions and the development of our members' creative practices, with a final version planned for publication in the second half of 2024.

1.2 Continuously publishing theoretical articles regarding the API construction and members' creative practices.

2 Implementation of Hardware and Software for the Bridge:

2.1 **Quantum Random Number Generator (QRNG)**: We decided to start with the generation of quantum random numbers (true random numbers), which is technically easier to achieve, yet also carries significant meaning. We believe the difference between pseudorandom and true random numbers signifies not just new encryption technology but potentially a bridge from the empirical world to the transcendental one. In other words, the transcendent nature inherent in true randomness could challenge the boundaries between the mundane and the extraordinary, rational and emotional, and even history and myth. The QRNG we are currently designing will consist of a coherent laser light source, a fiber beam splitter, a detector, a signal processing board, and a microcomputer (Raspberry Pi), with the finished size being approximately that of a laptop.

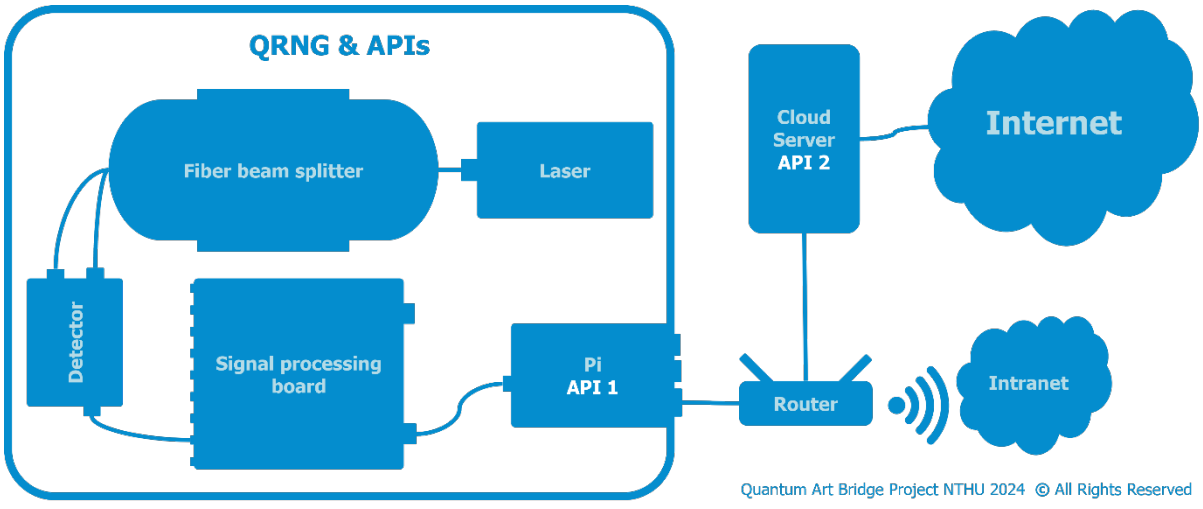

Figure 1: QRNG and API design diagram for Quantum Art Bridge project of NTHU.

2.2 **True Random Number Application Programming Interface (API)**: We are also concurrently developing the API. Unlike existing random number services, our API will focus more on providing data formats and communication protocols suited for Tech-Art creations, such as random colors, random noise (both visual and auditory), and formats like OSC (Open Sound Control) for tools such as Supercollider and Touch Designer, as well as communication protocols like TUID. This API will be built into a microcomputer for direct connection and local network use, with plans to establish the API on the cloud later on, allowing users to access it via the internet.

3 Artistic Creation:

3.1 As a demonstrative creative case of the "bridge," members of our project are currently engaging in artistic creation. There is one teacher-led project and three to five student projects underway, expected to be completed and exhibited by the end of 2024. We look forward to collaboration and exchange with various academic entities, creators, and groups, hoping to gradually expand our scale. We warmly welcome those interested to contact us.

3.2 **Observational Event Broadcasting Platform**: In our future planning, we aim to advocate for the establishment of real-time broadcasting mechanisms for observational events (such as the detection of gravitational waves, neutrinos) in major laboratories. This will enable artists to receive relevant information synchronously as events occur, allowing them to respond through artistic creation. Such an event platform will also enable the creation of art or recreational activities based on physical events, fostering collaboration and enjoyment among different laboratories.

2024 Annual Goals:

Organize international seminars, a joint exhibition, and publish several journal articles. As a preliminary attempt, we hope to continue expanding this project in the future, gradually establishing an international community of experimental creation, performance, and discourse.

Project members:

- Chien-Ming WU, Postdoctoral researcher, Institute of Photonics Technologies
- Jiahe ZHAO, Ph.D. student, International Intercollegiate Ph.D. Program – Art and Emerging Technology
- Tang-Chen CHANG, Ph.D. student, Institute of Information System and Applications
- Kai-Yu LIN, Master's student, Institute of Photonics Technologies
- Tsai-Wen LING, Master's student, Graduate Institute of Art and Technology
- Shao-En HSU, Master's student, Graduate Institute of Art and Technology
- Ming-Shan TAI, Master's student, Graduate Institute of Art and Technology
- Chun-Huang LIN, Master's student, Graduate Institute of Art and Technology

Figure 2-5: Conference and workshop in Quantum Optics Laboratory of the Institute of Photonics Technologies, July 2023. Photography: Cheng-Yu PAN