Transcript of
"Topological 'Quantum' Computation, enabled by Canonical genAI"

Instead of arithmetic computation, where the inputs are numbers, encoded as bits, and the outputs are also numbers encoded as bits, after a series of arithmetic functions (addition, subtraction, multiplication, and division) have been done; topological computation is done, where the inputs are analytic functions, encoded as qubits, and the outputs are also analytic functions, encoded as qubits, after a series of functional (group addition, group subtraction, group multiplication, and group division) operations have been done. The analytic functions specify topologies or Lie groups.

Canonical genAI, based on topological characterization and control, removes the four roadblocks to topological computation by: (1) tying the system in the topological knots, that is encoding the input analytic functions into qubits, (2) identifying the output topological knots, that is decoding the output analytic functions from qubits, (3) driving the system so that the functional unitary group operations are done on the physical system, and (4) stabilizing the system from disruptions, that is cooling the system.

As stated by DeepThought in "A Hitchhikers Guide to the Galaxy", "it is most important to know what the question is, not the answer to the question." The following series of slides are a series of questions.

Tom O'Neil, when he taught the graduate E&M course at UCSD, taught the course from the perspective of Landau & Lifshitz, not Jackson, to change the intellectual paradigm to one with more theoretical potential. We need to approach topological computer design from the perspective of nonlinear, not linear, physics. We need to be good parents and encourage the topological computer to mature and become its own person.

The current theory of artificial intelligence, based on the work of Jon Hopfield, views AI as a web of connections of nodes organized into layers with the connections (graph edges) connecting one layer to the next. The system is assumed to be in statistical equilibrium, and is called a Boltzmann Machine. Do you know what this is? I don't!

Instead of using this graph paradigm, we view AI as model estimation by a piece-wise linear universal function or functional model, that is estimating a function or functional with C0 continuity, but no more (that is, it is a minimal surface with singularities). This model has thousands of parameters for a function, and trillions of parameters for a functional (but, for a functional, that is not near enough). The system is assumed to be canonical, in only dynamical equilibrium, not in statistical equilibrium. It is a question of physical kinetics, not statistical mechanics. Generative Artificial Intelligence is not generating a statistical ensemble, genAI is generating the canonical motion of a collective system.

What is the functional and function that Generative Artificial Intelligence is estimating? It is the action, also known as: entropy, log-likelihood, the approximate Q-function of DRL, and the approximate score function of GPTs.

The functional is the canonical generating functional of a canonical transformation from the canonical field momentums and fields of the collective system, to the canonical momentums and coordinates of the system (i.e., the Reduced Order Model).

The function is the canonical generating function of a canonical transformation from the canonical momentums and coordinates of the ROM, to the canonical momentums and coordinates where the evolution is linear.

The modern systems control theory of Kalman and Bellman, developed in the late 1950's, is based on the Hamilton-Jacobi equation. We extend their theory to collective systems and the functional form of the Hamilton-Jacobi equation.

The Bellman Equation, as the discrete form of the Hamilton-Jacobi equation **with dissipation** is called in systems control theory, is solved in the Deep Q-Networks of Deep Reinforcement Learning.

Current genAI solves the Hamilton-Jacobi equation by introducing a significant amount of diffusion that drives the system to statistical equilibrium. They call this a Diffusion Model: it solves for the ensemble in statistical equilibrium, by using the Metropolis-Rosenbluth Method. This significantly degrades the performance: it sacrifices performance for stability and solvability: conservative systems have as many unstable roots as stable ones: the unstable x-points or singularities are the desired ones, but they are destroyed by this large amount of L2 regularization.

Instead, we calculate the non-stationary singularity spectrums, of a system that is not in statistical equilibrium, by calculating the coefficients of the functional Taylor expansion of the action, also known as: the S-matrix, m-body scattering cross sections, and m-body Greens functions. We derived a formula for this functional that has a fast (N-log-N) computer implementation of the forward and inverse transformations. It has the form of an iterative wavelet transformation interleaved with the Greens function of a complex variable.

This is new — the Heisenberg Scattering Transformation! It is a logical mathematical process of renormalization, based on calculating the S-matrix of Heisenberg's canonical approach to field theory. It is a non-stationary (that is, local) Fourier spectrum, or the non-stationary spectrums that are the solutions to the Renormalization Group Equations.

In this momentum basis, whose basis vectors are given by these non-stationary spectrums; the action (a generating function, a minimal surface, and the solution to the Hamilton-Jacobi equation) can be approximated by a Multi-Layer Perceptron with Rectified Linear Unit activation.

The HST has the structure of a Deep Convolutional Neural Network. It is a series of convolutional layers, interleaved with an activation function. Furthermore, the real part of the Greens function, the activation function, for small argument, is a two-sided ReLU. The results are then pooled to form a Reduced Order Model. Each convolutional layer scatters the signal: the HST can be viewed as the multiple scattering of a signal to all orders. This is the transformation, the "transformer" that a Generative Pre-trained Transformer is "pre-training".

The African philosophy of Ubuntu is based on the "interconnectedness" of society, that leads to a conservative collective system with canonical structure, that is a symplectic geometry. Given this logical mathematical process, that is Ubuntu (aka Canonical) genAI, the collective system, the society, can be controlled -- the topology of the topological computer can be optimized and stabilized.

Another way of looking at the HST is as a deep deconvolution of the multiple reflection of the individual, the Spirit of Ubuntu, who is multiply reflected into the collective, that is society!

By the way, collectives are fields or swarms of elementary particles (making elementary fields), charged particles (making plasmas), molecules (making fluids), celestial bodies (making cosmoses), economic entities (making economies), persons (making societies) and so on.

Generative Artificial Intelligence is a two-stage canonical auto-encoder, that is a controller of collective systems. It's input is a measurement of the fields, and it's output is the force field of control. The first stage is the HST, followed by a Principle Components Analysis, giving the ROM: it is not a DeepCNN with trillions of parameters as in DQNs and GPTs. The second stage is an Multi-Layer Perceptron with Rectified Linear Unit activation with only thousands of parameters, that estimates the canonical generating function. This forms the two-stage decoder. It is followed by a two-stage encoder.

This approach to AI is solving a system of partial differential equations by a functional transformation to a domain where the motion is trivial (i.e., linear), then transforming back. It also can be viewed as topological characterization and control. The two-stage canonical auto-encoder is finding the analytic function; whose Riemann surface (that is, manifold), has the topology of the collective system; and whose non-stationary singularity spectrums are the Riemann moduli or topological indices (that is, the integrals of the Chern-Simons 3-form) of the collective system.

The circuitry of the HST+PCA is most likely found in the primary visual cortex of the brain, and the circuitry of the MLP w/ReLU is most likely found in the prefrontal cortex of the brain.

The conventional Topological Computer, shown earlier: (1) encodes the algebras of the topologies into the physical systems using the Canonical genAI Encoder, (2) performs group "quantum" computational unitary operations on the physical systems using the Canonical genAI Controller, (3) decodes the algebras of the topologies from the physical systems using the Canonical genAI Decoder, while (4) stabilizing the physical systems from disruption using Canonical genAI Stabilization.

This new Conjugate "Dual" Topological Computer: (1) decodes the algebras of the topologies (i.e., analytic functions) from the input fields using the Canonical genAI Decoder, (2) performs analytic arithmetic "algebraic" operations on the algebras of the topologies (i.e., analytic functions), then (3) encodes the algebras of the topology into the output fields using the Canonical genAI Encoder. The second step, the arithmetic operations could simply be: (1) a propagation function to generate the collective system evolution, (2) a stabilization control function to stabilize the collective system, or (3) an optimization control function to maximize the collective system performance.

This new Conjugate Topological Computer is more practical: it eliminates the need for a physical system to embody the qubits: it reduces topological computation to arithmetic computation (that is, using current computers) by using the two-stage canonical decoder/ encoder as pre/post-processor.

The biological neural computer, that is our brain, is undoubtedly a Conjugate Topological Computer, not an arithmetic computer, nor a Topological Computer.

The Conjugate Topological Computer does not merely generate and control previously observed topologies: it has the general ability to calculate new topologies: it is creative: it is Artificial General Intelligence (AGI).

Note that knowing the (P,Q) coordinates are equivalent to knowing the energy, E_P, and the action, $S_P(q)$, where the imaginary part of the complex Hamiltonian, H(z), is related to the action and the real part is related to the energy. The complex Hamiltonian is the analytic function that

specifies the topology. Equivalently, the topology is also specified by the singularities of the complex Hamiltonian, z*.

Canonical genAI enables Topological Computation by: (1) encoding the qubits, (2) performing the unitary group operations on the qubits, (3) decoding the qubits, and (4) stabilizing the qubits.

More importantly, Canonical genAI enables Conjugate Topological Computation by: (1) decoding the algebras of the topologies from the input fields, and (2) encoding the algebras of the topologies into the output fields.

Thank You.

Presentation corresponding to this transcript can be found at: http://www.qitech.biz/tech_papers/topological_computation_presentation.pdf