Quantum Computing - QTM

Based off of the QTM proposed by STEFANO GUERRINI, SIMONE MARTINI , AND ANDREA MASINI

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Church-Turing Thesis

‘“Every ‘function which would naturally be regarded as computable’ can be computed by the universal Turing machine’” (D. Deutsch 3).

“Naturally regarded”

= ROOM for interpretation within physics and math

Many outliers within physics = quantum physics

ASSERTION of computability based off classical physics

“Finitely realizable physical systems” (D. Deutsch 3) (discrete physics)

NOT for CONTINUOUS physical systems (quantum)

= UTM canNOT model/simulate physical systems in nature

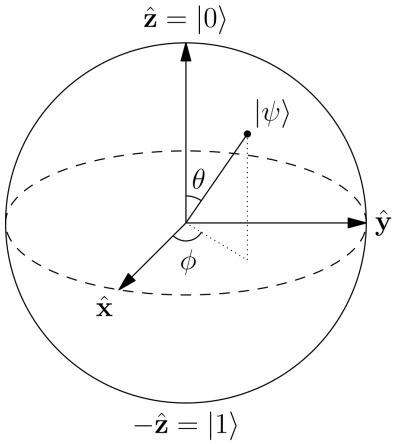
Does not address quantum physics

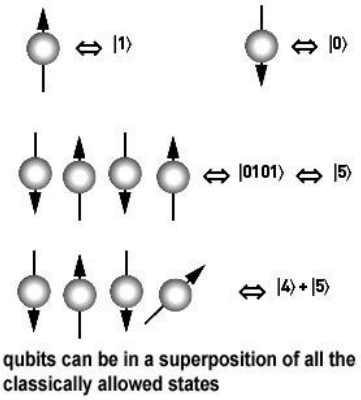
Church-Turing “Principle”:

“‘Every finitely realizable physical system can be perfectly simulated by a universal model computing machine operating by finite means”’(D. Deutsch 3). By stating “Finitely realizable physical system”, Dr. Deutsch refers directly to a classical physical object that can be tested, measured and observed.

Qubit

- Orthonormal basis states:
  - $|0\rangle$, $|1\rangle$
- Superposition:
  - $|\varphi\rangle = a_0|0\rangle + a_1|1\rangle$
- Born Rule:
  - $\sum |a_i|^2 = 1$
- Entanglement:
  - $|x\rangle \otimes |y\rangle = |xy\rangle$
- Readability, accessibility & measurability





Qubit states:

Orthonormal basis states

Span infinite dimensional Hilbert Space

Qubit:

Prob distribution of possible outputs

Reped : Block Sphere

Linear combo of quantum states

Defined by superposition equation

Outputs in classical bit form

Superposition:

= is simultaneously in BOTH states

= Quantum Parallelism

Disjointed computations running @ same time til all reach final result (like NDTM)

= less time

Born Rule:

Indicates taking norm of ai yielding probability

Entanglement

= do NOT have to physically & operationally measure qubits entangled partner's qubit value

= Save Time and operational complexities

Readability:

Collapsing of qubits

= + operational and time complexities

= limitation on QTM capabilities and functionalities

QTM M = (∑, *Q*, Q□,Q□, $\boldsymbol{\delta}$,q_i,qf)

- Quantum tape & qubits
- Quantum Computation Functions:

  f: superpositions → probability distributions of $\mathbb{N}$

  - Final result = limit of QTM computations
  - Domain : Complex Hilbert Space
    - Unitary norm and denumerable
  - Unitary, reversible, invertible, infinite
- Computations are the limit of classical UTM computations' that reach the final result
  - Quantum Parallelism

QTM:

Finite controller (∑, and *Q* finite)
Infinite memory
Quantum tape

Computations:

Function: mapping of superpositions of N to probability distributions of N
Each func is limit of infinite computation of QTM
Domain is hilbert space w/ unitary norm
Interable, untiray, invertible, infinite

Configurations are Superpositions of classical UTM

Final result: limit of parallel infinite computations of a UTM

Final result

limit of computations of parallel UTM computations that reach the final result

- Advantages:
  - Polynomial Time
  - Quantum tape
  - Superposition
  - Entanglement
  - Quantum parallelism

- Limitations:
  - Evolution operator:
    - No initial & final states
    - “Final result”?
  - Measurability
  - “Black Box”

How to address
Evolution Operator?

Solution!

- Extra Symbols Alphabet!
    a. "Trap" the configuration in source/target states!
        i. Transition function rules:
            1. If read & write marked symbol → No transitions entering/exiting non-source and non-target states.
            2. In final state: if read symbol ∈ ∑ → write extra symbol & move right
            3. In initial state: if read symbol ∈ ∑ to left of head → write extra symbol & move left
                a. If read extra symbol under head → replace with symbol ∈ ∑, move right

Extra Symbs
= manipulate initial and final configuration to "TRAP" them into source/target states
Still maintain unitarity

Read marked symb
= No transitions out of a final state when reading a marked symbol

Writing marked symb
= No transition entering initial state

Read/write marked symb
= NO transition entering nor exiting the NON-Source & NON-TARGET states