Begrifflichkeiten

## Quantum Computing

**Quantum Bits (Qubits):**

* The fundamental unit of quantum information, analogous to classical bits in classical computing. Unlike classical bits, qubits can exist in multiple states simultaneously due to the principles of superposition.

**Superposition**:

* The ability of qubits to exist in multiple states at once. This property enables quantum computers to perform parallel computations.

**Entanglement**:

* A quantum phenomenon where qubits become correlated and the state of one qubit is directly related to the state of another, even if they are physically separated.

**Quantum** **Gate**:

* The quantum equivalent of classical logic gates. Quantum gates manipulate qubits to perform quantum computations.

**Quantum** **Circuit**:

* A series of quantum gates that perform a specific quantum computation. Quantum algorithms are often expressed as quantum circuits.

**Quantum** **Parallelism**:

* The ability of quantum computers to explore multiple solutions simultaneously, providing a potential speedup for certain algorithms.

## Quantum Machine Learning

**Quantum Machine Learning (QML)**:

* The intersection of quantum computing and machine learning, where quantum algorithms and models are used to enhance classical machine learning techniques.

**Quantum Neural Networks (QNN):**

* Neural network models designed to run on quantum computers, taking advantage of quantum parallelism for certain tasks.

**Quantum Feature Space:**

* A representation of data in a quantum form, leveraging quantum entanglement and superposition to potentially enhance machine learning algorithms.

**Quantum Data**:

* Data that has been encoded or processed in a quantum form, often using quantum circuits, gates, or algorithms.

**Feature Maps:**

* Quantum circuit for encoding classical data into a quantum state
* Data can then be used for a quantum algorithm

**Ansätze:**

* Trial wavefunction or quantum circuit structure for a specific quantum algorithm
* Provides initial guess for this quantum state

**Hamiltonian:**

* Totale Energie eines Quantensystems
* describing the evolution of a quantum state over time through the Schrödinger equation
* Hamiltonian of a physical system that we are simulating on a quantum computer. For example, in quantum chemistry simulations, the Hamiltonian describes the total energy of a molecule, including kinetic and potential energy contributions from electrons and nuclei.

**Wichtige Quantum Gates:**

* **Pauli Gates:**
  + X Gate (Pauli-X, NOT Gate): Flips the state of a qubit (|0⟩ to |1⟩ and vice versa). It's the quantum equivalent of a classical NOT gate.
  + Y Gate (Pauli-Y): Performs a bit flip and a phase shift. It maps |0⟩ to i|1⟩ and |1⟩ to -i|0⟩.
  + Z Gate (Pauli-Z): Changes the phase of the qubit. It leaves |0⟩ unchanged and maps |1⟩ to -|1⟩.
* **Hadamard Gate (H Gate):**
  + Creates a superposition of |0⟩ and |1⟩. It maps |0⟩ to (|0⟩ + |1⟩)/√2 and |1⟩ to (|0⟩ - |1⟩)/√2.
* **Phase Gates:**
  + S Gate (Phase Gate): Applies a phase of π/2. It leaves |0⟩ unchanged and maps |1⟩ to i|1⟩.
  + T Gate (π/8 Gate): Similar to the S gate, but applies a π/4 phase. It maps |1⟩ to e^(iπ/4)|1⟩.
* **Controlled Gates**:
  + CNOT Gate (Controlled-NOT): Flips the state of a second qubit (target) if the first qubit (control) is |1⟩.
  + Controlled-Z (CZ Gate): Applies a Z gate to the target qubit if the control qubit is |1⟩.
  + Toffoli Gate (CCNOT): A controlled-controlled-NOT gate, flips the state of a third qubit if the first two qubits are |1⟩.
* **Rotation Gates**:
  + Rx, Ry, Rz Gates: Rotate a qubit around the x, y, and z axes of the Bloch sphere, respectively, by a given angle.