Deutsch-Jozsa Algorithm

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1 Algorithm

ref. chapter 8.2 Learn Quantum Computing w/ Python and Q# - Kaiser,Granade

Classically, to determine if a function is constant or balanced, we must learn the entire function (build its entire truth table). With this algorithm we can solve this with a single call to the oracle U_f.

1. Prepare 2 qubits labeled control and target in $|0\rangle \otimes |0\rangle$ state
2. Apply operations to control and target to prepare $|+\rangle \otimes |-\rangle$ state
3. Apply oracle U_f to this state, $U_f|x\rangle|y\rangle = |x\rangle|y \oplus f(x)\rangle$
4. Measure control in X-basis: function f is constant if 0, balanced otherwise.

[4]:
```
open Microsoft.Quantum.Intrinsic;
open Microsoft.Quantum.Diagnostics;
open Microsoft.Quantum.Measurement;

operation ApplyZeroOracle(control : Qubit, target : Qubit) : Unit {
}

operation ApplyOneOracle(control : Qubit, target : Qubit) : Unit {
    X(target);
}

operation ApplyIdOracle(control : Qubit, target : Qubit) : Unit {
    CNOT(control,target);
}

operation ApplyNotOracle(control : Qubit, target : Qubit) : Unit {
    X(control);
    CNOT(control,target);
    X(control);
}

operation CheckIfOracleIsBalanced(oracle : (( Qubit, Qubit ) => Unit)) : Bool {
    use control = Qubit();
    use target = Qubit();

    H(control);
```

```
    X(target);
    H(target);

    oracle(control, target);

    H(target);
    X(target);

    return MResetX(control) == One;
}

operation RunDeutschJozsaAlgorithm() : Unit {
    Fact(not CheckIfOracleIsBalanced(ApplyZeroOracle), "Test failed for zero␣
 ↪oracle.");
    Fact(not CheckIfOracleIsBalanced(ApplyOneOracle), "Test failed for zero␣
 ↪oracle.");
    Fact(CheckIfOracleIsBalanced(ApplyIdOracle), "Test failed for zero oracle.
 ↪");
    Fact(CheckIfOracleIsBalanced(ApplyNotOracle), "Test failed for zero oracle.
 ↪");

    Message("All tests passed.");
}
```

[4]:
```
ApplyZeroOracle, ApplyOneOracle, ApplyIdOracle, ApplyNotOracle,
CheckIfOracleIsBalanced, RunDeutschJozsaAlgorithm
```

[6]:
```
%simulate RunDeutschJozsaAlgorithm
```

```
All tests passed.
```

[6]:
```
()
```