Quantum Mechanics Enabled Genetic Programming

Abstract—**Quantum Computing (QC) has often been touted as an esoteric and terrifying field of computing research. However, the possible advantages offered by the inherent quantum fundamentals beseeches extensive additional ventures into this field. Just as QP offers exciting ideas in the field of computing, Genetic Programming (GP) offers an application oriented optimization route. GP uses Darwinian theories to maintain a set of candidate solutions, apply multiple operations on the candidates and eventually declare a global winner. In this paper, we combine QC and a flavour of GP to create a new interdisciplinary front of computational intelligence.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

Majority of the problems faced in any aspect of computer science, in one way or another, involves a catch-22 of multi-functional optimization. Entire fields have been dedicated to solving a generic version of this issue. The most common method of dealing with optimization problems is to be in collaboration with another interdisciplinary frontier acting in the capacity of a helper function.

A. Computing Methodologies

Most form of computational algorithms in the present day, are executed on a conventional computer. The fundamental notation used for differentiating classicial computing (CC) and QC is the basic unit of information. While classical computers use bits 0 and 1, quantum computers use "one of" two computational basis states. The label awarded to these states is "bra-ket" notation i.e, state $|0\rangle$ or $|1\rangle$. Bits are assigned states 0 or 1 deterministically and independently. However, qbits can exist in a superposition state of $\alpha_0|0\rangle + \alpha_1|1\rangle$, where $\alpha 0$ and $\alpha 1$ are complex numbers, such that $|\alpha_0|^2 + |\alpha_1|^2 = 1$.

B. Why go Quantum?

The field of applied quantum mechanics is still unexplored for the best part. However, there are certain applications in which QC outperforms CC. Consider Shor's algorithm and RSA, both of which are used for encryption. Basically, the encryption of any form of data transmitted over the Internet relies immensley on factorization of a huge number. This process is extremley ardous for a non-quantum computer, with the best known factoring technique requiring an amount of time proportional to $2^{n^{\frac{1}{3}} \log(n)^{\frac{2}{3}}}$, where n is the number of digits in the number to be factored. Meanwhile Shor's Quantum algorithm requires time proportional to only $n^2 log(n) log(log(n))$.

QC takes advantage of major quantum phenomena such as superposition, quantum entanglment, principle of uncertainity among others, for improving existing searchc and optimization techniques. Humans inherently stick to definitive physical concepts such as deterministic state transition, state duality and temporal static behaviour of particles.

According to Moore's Law, the size of computational units shrinks at an exponential rate as the number of transistors on a chipset increases every year. Even after accounting for physical constraints, a time will come when operations will be conducted on an atomic scale. On such a level, atomic forces overpower particle physics naturally. As a result, understanding QC and applying them in a virtual landscape to get a sense of their possibilities is a must.

C. Using Evolutionary Algorithms

Evolutionary Algorithms (EA) encompass a wide array of research ideas stemming from general principles of genetics and the theory of evolution. Models are developed to illustrate the behaviour of naturally occuring phenomena, develop these algorithms and test out the application of the corresponding theory. The general process of any EA is depicted in figure 1. In a nutshell, an initial population of candidate solutions is generated and each solution is labelled according to their performance on a set fitness function. Further down the line, these candidates are improved upon by conducting a set of operations on them for a predetermined number of generations. After some stopping criterias are achieved, the process strops and the best candidate is hypothesized as the global solution. The advantages offered by this technqiue include but not limited to resilience to noise, in-built support for parallelism and distributed learning, multi-pronged attack and handling complex problems.

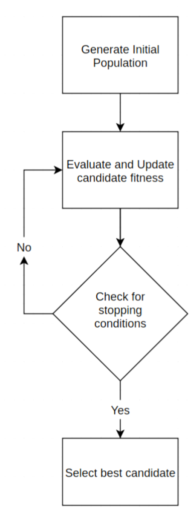

Fig. 1. General Flow of Evolutionary Algorithms

Our paper provides an insight into the ensemble of both the previously mentioned techniques and preparing algorithms for a future where quantum computers replace traditional computers as commonplace machines.