Abstract

Massive parallelism, molecular scale miniaturization, high storage density, environmental friendly mode of computing and bio-compatibility are the promising features that motivates this research work in the field of DNA computing. Functionalities desired to obtain in such unconventional computers is still very similar to traditional solid state electronics which leads to the development of several DNA computing models for simulation of logic gates and Boolean circuits as a potential building blocks. In recent past, many DNA models have been developed to simulate logic gates and circuits with their merits and drawbacks. However, on the basis of available literature some limitations are identified such as: use of different types of bio-operations leading to error in computation; non uniformity in representing logic '0' and '1'; specifically applicable for only one kind of gate (not generalized), lack of parallelism and reusability.

Referring to the above problems, the present investigation is focused on exploitation of DNA properties in a step wise advancement to develop a reusable, generalized, parallel DNA computing model preferably with new readout techniques. The research work aims at inclusion of some features like single design strategy for any logic function, uniformity in representation of logic '0' and '1' throughout the simulation process and is cost and implementation effective with parallel processing capacity.

In view of the above, in the first research work, an algorithm has been proposed to design gate strands for simulation of Boolean functions using DNA. The algorithm ensures a low cost generalized model with reusable readout technique. In general, the efficiency of molecular logic gate depends on two parts; the gate simulation operation and the readout techniques. In the proposed model, to enhance the efficiency of gate operation, the number and types of biochemical reaction involved is reduced to simple hybridization reaction with minimal use of error prone reactions such as PCR and enzyme dependent reactions.

In the second work, a model to simulate Boolean circuit using the property of DNA to induced hairpin in a G.G mismatched strand in the presence of Naphthyridine Dimer is proposed. This model ensures features such as reusability, parallelism, generalizability, flexibility and scalability. The DNA gate strand consists of two sub-sequences: loop sequence and stem sequence. The loop sequence is designed using an algorithmic approach. The stem sequence consists of simple self-complementary sequence with G.G mismatches.

In the third work, the high specificity in induction of DNA secondary structure in presence of certain ion is proposed to employ in simulation of DNA logic gate (switches). The advantage of such logic gate is its fast response time, controllability and cost effectiveness. This work depicts a simple proof-of-principle type of simulation of chemically implemented logic gate based on the structural switching of single stranded DNA from i-motif to hairpin and vice versa, triggered by regulating H^+ and Copper(II) ions.

These works are not meant to be final, optimized designs for devices, but rather demonstrations of the wide range of possibilities afforded by nucleic acid engineering and of problems that can be practically solved with dynamic nucleic acid devices in the near future.