Automation of Target Based Drug Delivery to Cancer Cells using Artificial Bee Colony and Particle Swarm Optimization Techniques

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***Abstract*-There are many ways to treat cancer ranging from Chemotherapy to immunotherapy, though each method has its own risks and side effects. A common side effect seen in these methods is the collateral damage of healthy cells. Usage of highly optimal, target based drug-delivery system will overcome this side-effect.Also, the cancerous cells may be distributed over a large area in a specific organ that demands repeated targeting of drugs to the same vicinity.Nanotechnology gives promising solutions to these problems. Nanobots are machines or robots whose components are at or close to the scale of a nanometre (10^{-9} meters).The nanobots can adopt the concepts of swarm intelligence such as particle swarm optimization and artificial bee colony, to stay together and move collectively towards a goal. Swarm intelligence (SI) introduced by Gerardo Beni and Jing Wang in 1989 is the collective behavior of decentralized, self-organized systems, natural or artificial. It is based on the principle of large number of homogeneous agents interacting among themselves locally, without central coordination to produce an emergent behavior.Examples in natural systems of SI include ant colonies, bird flocking, animal herding, bacterial growth, fish schooling and bee foraging.**

Keywords*—*Swarm, Nanobots, Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), Emergent behaviour, Swarm Intelligence,Carcinogenic

I. INTRODUCTION

It is often noticed that the cancer repeats even after effective treatment for the same. Poor detection and poor diagnosis of minimally affected secondary areas is found to be one of the reasons. Hence there is a need to enhance the method of detection of cancer cells.

Swarm of Nanobots carrying the drugis injected into the blood stream. These bots reach the target site, detect the cancerous cells with the help of receptors and deliver the requisite drug in the right amount. The mission is controlled by an on-board nano-computer that makes several decisions throughout the path taken by these bots.

As cancerous cells may be distributed over other areas nearby, apart from the small targeted main site, the bots are programmed to explore the area within specific boundary, to find secondary affected sites and destroy the cancerous cells there. A small set of bots are made to detach themselves from the swarm andreach the secondary area to destroy cancer cells. Although,the minimum requirement of bots in the main swarm is maintained.

One of the main challenges in these systems is to avoid collision of the bots with the obstacles in the blood stream and also among themselves. This is solved by adopting PSO algorithm.

PSO is a population based algorithm that harnesses the idea of individual agents with limited capabilities, in co-ordination with other agents producing low-cost, robust solutions.

Experience of each agent is continuously shared with the whole swarm leading the swarm towards the most optimal pace and direction.

Another prevailing challenge is to re-direct a set a bots to the newly discovered target area without disturbing the swarm. This is done by implementing artificial bee colony algorithm.

ABC is based on the concept of a small fraction of the colony constantly searching the environment looking for secondary affected areas, while the whole swarm is moving towards the main target area.

II. IMPLEMENTATION

A. *Particle Swarm Optimization*

PSO draws inspiration from behavioural patterns of bird flocking; birds fly large distances without collision and maintaining an optimum distance from each other.

There are three flocking rules:

- *Flock centring:* flock members attempt to stay close to nearby flock mates by flying in a direction that keeps them closer to the centroid of the nearby flock mates(cohesion)
- *Collision avoidance:* flock members avoid collisions with nearby flock mates based on their relative position(separation)

- *Velocity matching:* flock members attempt to match velocity with nearby flock mates(alignment)

Each agent is represented as a point in n-dimension. Thus PSO's solution space is typically represented as a set of n-dimensional points.

The moving particles, at each iteration, evaluate their current position with respect to the problem's fitness function to be optimized, and compare the current fitness of themselves to their historically best positions, as well as to the other individuals of the swarm.

Then, each particle updates its experience and adjusts its velocity to imitate the swarm's global best particle.

Before the end of each iteration of PSO, the index of the swarm's global best part is updated if the most recent update of the position of any particle in the entire swarm happened to be better than the current position of the swarm's global best particle.

Thus the direction of each particle is updated using a "nearest neighbour rule", a local rule which replaces the direction of each particle with the average of the particle's own direction plus the directions of its immediate neighbours.

Thus the communication among particles in PSO is rather direct without altering the environment

Memory is used to store the particle's historically best position and the swarm's global best position.Thishelps each particle to keep track of its own individual experience and also helps the most superior particle to communicate its social experience to the other particles

B. Artificial Bee Colony

The Artificial bee colony mimics the foraging strategy of honey bees to look for the best solution to an optimisation problem. Employed bees go to their food source and come back to hive and dance. Onlookers watch the dances of employed bees and choose food sources depending on dances. The employed bee whose food source has been abandoned becomes a scout and starts to search for finding a new food source.

But the algorithm is modified to have very few scouts that explore the secondary affected sites and accumulate a small portion of employed bees to that site.

Firstly, a sub-set of the swarm is determined as scouts that are allowed to explore new affected sites additional to the main target area. As soon as these scouts detect the affected sites, diagnosis of the area is done and the amount of drug required for each area is calculated and the corresponding numbers of bots from the swarm are made to change their direction to reach the new site as a swarm.

III. ALGORITHM

```
DO
        Randomly select scout-bots depending on the
        probability of number of affected sites
END
Set bots into motion in pre-defined velocity
For each scout-bot
        Randomly change the direction within the
        specified boundary
        If affected site detected
                Calculate the drug density and the
                number of bots required
                If main-swarm has excess bots
                        Signal the corresponding
                        number of bots to the site
For each bot
        If signal received
                1. Change direction
                2. Reset pBest
                3. Reset gBest
        Calculate fitness value
        If the fitness value is better than the best fitness
        value (pBest) in history
            set current value as thenew pBest
  End

Choose the particle with the best fitness value of all the
particles as the gBest
   For each particle
          Calculate particle velocity
          Update particle position
   End
Do until stop_condition=TRUE
```

IV. ADVANTAGES

Advances in nanotechnology such as nano-ram computer memory, anon-volatile random access memory based on the position of carbon nanotubes deposited on a chip-like substrate and Metallic carbon nanotubes for nano-electronic interconnects that can carry high current densities support the feasibility of usage of nanobots.

Adaptability: SI Systems respond well to rapidly changing environments, making use of their inherit autoconfiguration and self-organization capabilities. This allows them to autonomously adapt their individuals‘behaviour to the external environment dynamically on the run-time, with substantial flexibility

Collective Robustness: SI Systems are robust as they collectively work without central control, and there is no single individual crucial for the swarm to continue to function (due to the redundancy of their individuals). Hence, the fault- tolerance capability of SI systems is remarkably high, since these systems have no single point of failure.

Individual Simplicity: SI systems consist of a number of simple individuals with fairly limited capabilities on their own, yet the simple behavioural rules at the individual level are practically sufficient to cooperatively emerge sophisticated group behaviour.

V. CONCLUSION

This paper proposes the idea of using the swarm intelligence techniques such as PSO and ABC to effectively target the nanobots to cancer site and destroy the cancerous cells without affecting the healthy cells in the vicinity.

PSO implementation ensures safe movement of the nano-bot swarm in the blood stream without colliding with the obstacles as well as among themselves by maintaining an optimal velocity and distance.

ABC implementation expands the usage of the nano-bots to autonomously detect the secondary –cancer sites, deflect a subset of the swarm to these areas to destroy cancer cells.

Thus the combination of PSO and ABC will extend the reachability of nanotechnology not only to destroy carcinogenic cells in the target but also to automate the diagnosis of faintly infected areas.

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