DEPARTEMNT OF SCIENTIFIC COMPUTING
FACULTY OF COMPUTER & INFORMATION SCIENCES
AIN SHAMS UNIVERSITY

AUTONOMOUS NANO-ROBOTICS SYSTEM FOR CANCER TREATMENT

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BY

DOAA EZZAT MOHAMMAD MAHMOUD

MSc. Degree in Scientific Computing Department,
Faculty of Computer & Information sciences
Ain Shams University.

SUPERVISED BY

Prof. Dr. MOHAMMED FAHMY TOLBA

Professor in Scientific Computing Department,
Faculty of Computer & Information sciences,
Ain Shams University.

Prof. Dr. HOWIDA ABDELFATTAH SABER SHEDEED

The Head of Scientific Computing Department,
Faculty of Computer & Information sciences,
Ain Shams University.

Dr. SAFAA AMIN

Associative Professor in Scientific Computing Department,
Faculty of Computer & Information sciences
Ain Shams University.

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ABSTRACT

A significant problem in cancer treatment using chemotherapy is the strong toxic side effects of this therapy on healthy tissues. These side effects lead to dose reduction and treatment delay or discontinuity. It is so difficult to limit these side effects on healthy organs and to strength drug efficiency to cancer cells. In order to avoid these side effects, researchers have developed a lot of strategies to deliver anticancer drugs into only the tumor cells using Nano-robots.

Nano-robot is a programmable and controllable Nano scale robot, which is used to perform specific tasks in the microscopic world. Nano-robots are designed to work with precision at Nano scale dimensions. They provide many novel capabilities because of their ability to sense and act in microscopic environments.

To perform cancer treatment on a cellular level, Nano-robots are injected into the human body and then start their journey in the blood vessels. They try to reach the cancer area and then release drugs to destroy cancer cells. During their journey, they may encounter immune system cells as obstacles. So, they need an appropriate strategy for avoiding and escaping from such obstacles.

This thesis firstly proposes a modified algorithm for delivering a swarm of Nano-robots to the tumor micro-environment. This algorithm is called Directed Particle Swarm Optimization (DPSO). Simulated experiments showed the efficiency and the power of this modified algorithm. In these experiments, DPSO was compared with four other algorithms, and the results showed that DPSO can deliver 94% of

the swarm after only 10 iterations, while the other algorithms can deliver only 70% after the same number of iterations. So, when using DPSO, the number of iterations needed to deliver the whole swarm to the target area is reduced. Also, DPSO can guarantee the reachability of the target area by all Nano-robots.

The second part of this thesis introduces another modified algorithm to enable Nano-robots to avoid dynamic obstacles (such as red and white blood cells) on their way to the tumor region. This algorithm is called the Modified Multi-Stage Fuzzy (MMSF) algorithm. The simulated experiments conducted in this part showed that this modified algorithm can reduce the time needed to deliver the whole swarm of Nano-robots to the target by 80%. Also, these experiments showed that MMSF can reduce the number of collisions by 91%. A new control strategy was also proposed in this part. This strategy uses DPSO for Nano-robots delivery to cancer area and uses MMSF for avoiding dynamic obstacles.

In the third part of this thesis, DPSO is combined with a Quorum Sensing algorithm that controls the drug release rate inside the cancer area to kill cancer cells. Simulated experiments proved that this combination can speed up the process of destroying cancer cells up to twice as some other combinations do.

The fourth part proposes a new hybrid algorithm (DJaya algorithm) that presents a useful combination between the first algorithm proposed in this study (DPSO) and another recent and efficient optimization algorithm (Jaya). It was proved experimentally that the proposed hybrid algorithm achieves better performance than both original algorithms (DPSO and Jaya). This proposed algorithm can start the process of Nano-robots delivery early like Jaya and can finish this process early like DPSO. Also, it can easily aggregate the Nano-robots inside the cancer area like DPSO to facilitate the drug release process.

Finally, this study proposes a new overall control strategy constituted of three algorithms: the first one for delivering Nano-robots to cancer area (DJaya), the second one for avoiding dynamic obstacles on their way (MMSF) and the third one for controlling drug release inside the cancer area (the Quorum Sensing algorithm).

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LIST OF ABBREVIATIONS

Abbreviation	Stands for
A	Ahead
AA	Average All
ACO	Ant Colony Optimization
AI	Artificial Intelligence
Ai	Auto-inducer
AL	Ahead Left
AR	Ahead Right
B	Back
BA	Bat Algorithm
BCO	Bee Colony Optimization
BFOA	Bacterial Foraging Optimization Algorithm
BL	Back Left
BR	Back Right
CS	Cuckoo Search
DJaya	Directed Jaya
DPSO	Directed Particle Swarm Optimization
EA	Evolutionary Algorithms
F	Far
F	Fast
FA	Firefly Algorithm
FLA	Fuzzy Logic Algorithm
GA	Genetic Algorithm
gbest	Global Best Position
IBFOA	Improved Bacterial Foraging Optimization Algorithm
JA	Jaya Algorithm
L	Left
M	Medium
MMSF	Modified Multi-Stage Fuzzy
MOA	Modified Obstacle Avoidance
MPSO	Modified Particle Swarm Optimization
MSF	Multi-Stage Fuzzy
N	Near
NZ	Nearest Zone
pbest	Personal Best Position

PRM	Probabilistic Roadmap
PSO	Particle Swarm Optimization
R	Right
S	Small
SI	Swarm Intelligence
TLBO	Teaching Learning Based Optimization
TSP	Travelling Salesman's Problem