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Comparing of Routine Nano-particles for Creating Pattern Using Genetic Algorithm and Particle Swarm Optimization - Ant System in Simulation using Atomic Force Microscopy

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Abstract: Pattern creating with nano-particle is one of the best application methods in nano-scale that it will be used for new pattern creating and make micro/nano-electromechanical System (MEMS/NEMS) in future. Particle swarm optimization algorithm is one of evolutionary computation techniques and the optimization method based on population and ant algorithm, optimization algorithm is modeled based on ants. In addition explained algorithms, the genetic algorithm is adaptive methods that use to optimizing of problem. In this paper, we have created modified and combined of particle swarm optimization and genetic algorithm. Also this method has been implemented using modified in genetic algorithm. In other words, proposed algorithms have been implemented with modified in their structures and considering applied condition for creating of pattern with nano-particles. Dynamic modeling and simulation for manipulating of cantilever and probe in the liquid and vacuum environment in Mathimatica Software done. Routing of algorithms implemented in Matlab Software. The functionality of the method are: Firstly, the result is minimum of time and energy in moving of cantilever. In fact we can find the minimum of routing. Secondly, during the transport of nano-particles mustn't occur any collision, because in this case the atomic force microscope has to scan the surface again, and it will take more time. So we will get the minimum time for creating of the special pattern without any collision using the proposed algorithms.

Keywords: Routing and Simulation, Creating Pattern, Genetic Algorithm (GA), Particle Swarm Optimization-Ant System (PSO-AS), Nano-particles, Nano-manipulation, Liquid Forces, Atomic Force Microscopy (AFM).

Introduction

Capability of science in having control over materials in nano-meter dimension, exploitation from material properties and phenomena in this tiny dimension, and creating new tools and systems in this dimension, have paved the current field rapid progress. The main goal of nanotechnology is to create structures of materials which it is molecular arrangement of system elements be pre-designed, about model creation which is based on SPM, extensive biological researches has been done. Atomic force microscope has shown great usage in medical fields. Ability of atomic force microscope to measure forces in the nano-Newton range in physiological conditions and research on the reactions between drug / protein, protein / protein, cell / cell, cell / protein and many other phenomena related to intermolecular forces, has made it very effective tool in this field. Determination of molecular reactions in biological systems is the most important need of researchers and engineers.

Capability of Atomic Force Microscope in imaging of surfaces has made it a powerful tool in studying individual molecules [1]. Also capability in imaging of the surfaces and in nano-particles manipulation makes it an effective tool to be exploited in creating nano-particles patterns. AFM is used as a simple nano-manipulator for guiding nano-particles movement on surfaces.

The idea of routing algorithm in nano-environment has not been used to create models yet. For the first time the idea of routing algorithm in a vacuum and liquid. This method will be done quickly, with movement of nano-particles to create the model and without collision. This method will always be discovered best path without any collision. If a collision occurs, nano-particles will be lost in the environment (means that will get distance from its original path), therefore, to determine the location of nano-particles we are forced to re-imaging that will destroy minimum of time and energy, which this method can solve this problem [2, 3]. Routing algorithm in the environments is examined from two aspects: Step1. Minimum time to create a model: Minimum time is spending to create model. Step2. Least power consuming for a model creation: Minimum energy is Consuming to create model. In both above cases can be avoided of nano-particles collision. This presented Method in article covers both of these steps together.

Related Worked

A. *Manipulation Modeling*

In this study, we have defined nano-particles as having a radius R_P with the capability of being absorbed in substrate and ridden by an AFM probe under particular vacuum and liquid environmental conditions. In order to ride the particles, the tip of the probe must be in contact with the particle, so for the safety of this contact under particular conditions, a basic jump, Z_{P0}, should be verified through system feedback. Different steps of nano-manipulation of a particle movement are shown in (Fig. 1) [2, 3, 4].

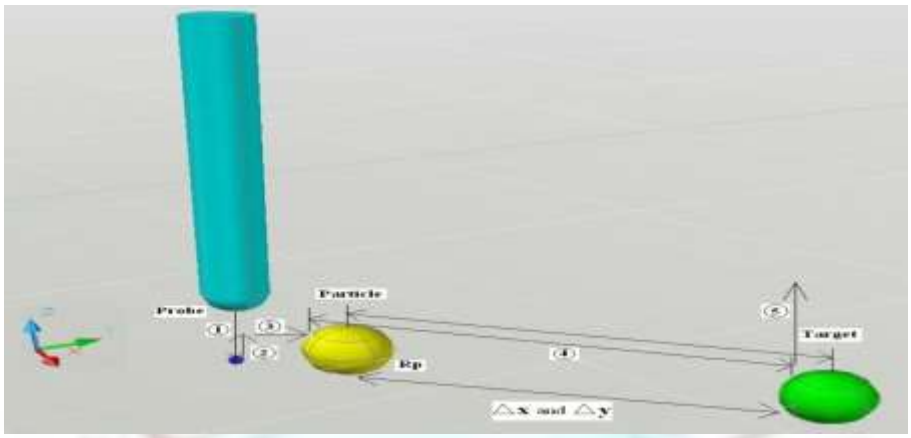

Figure 1. Nano-manipulation states in manipulation of nano-particle.

The following steps are performed in contact mode (Fig. 1) which Include:

Step 1: Head of instrument move automatically in path of Z to substrate which is specified by bending cantilever.
Step 2: Coming back to predetermined stop position.
Step 3: Head of instrument will move along the substrate until contact with the particle, which is determined by AFM and then it will stop. AFM can be determined optical methods.
Step 4: Head of instrument or substrate with a constant speed force on particle by the tool will start to increase until it become critical value for particle motion on substrate. After this time, the particles will move to desired position.
Step 5: completion of movement action of the nano-particles and head of instrument will back to the initial position.

B. *Vacuum and Liquid Forces*

We consider overall outcome of the applied forces to cantilever zero in the vacuum environment. In other words, there is not any force on cantilever and nano-particles before and after moving into the vacuum environment but the fluid force is applied on nano-particle and cantilever which will expressed below fully. In general case, forces in the fluid space that enters on objects surfaces, it can be divided into two categories: 1- Molecular interaction forces. 2- Macro forces (that are entered to the whole object).

First molecular interaction force is important in dynamics that is "Electrostatic Double Layer Force". The reason of this force creation is charge of surfaces of each other opposition. Water is a liquid with high dielectric for this reason, dissociation and absorption of charge is high in it. Joining of electrically charged surfaces and ions can create electrical Layer. This will decrease intensity force in long distance. If two surfaces be close together, The potential gradient will reduce (Fig. 2A) and consequently the charge density will decrease too [5]. Hydration Force is another force that affects in surfaces in this environment. Effective of two level Hydration, if we consider liquid environment are join, in the contact mode When the diameter of fluid between two surfaces be as low number as molecules in fluid; In this case a force will enter from 1 to 3 nano-Newton as the repulsion force between surfaces.

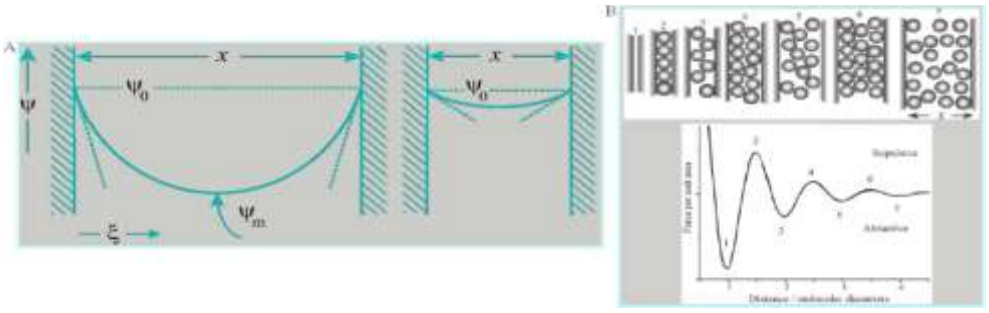

Figure 2. (A) A change in potential distribution between two surfaces during approaching each other, space between these two is filled with fluid [2, 3]. (B) The diagram of Solvation force.

In fact, this force is short range, and salt of less than 0.1 M/lit is negligible in against of electrostatic force. Except cases which surfaces is perfectly flat or salt concentration low. This force decreases exponentially with increasing distance and it is repulsion 0.001 to 10 J*square meter energy amount. This force in compare with Electrostatic force shows its effect in high concentrations of salt.

Another force is the arrangement of atoms in space (Steric Force). These forces are caused as repulsion force between two surfaces covered with a polymer, which is an appropriate soluble. Polymer molecules are stuck to the surface, the affective of these closing surfaces and increasing of entropy, repulsive force will create effective of entropy.

Next most important force is the nano-scale, which is adhesiveness or adhesion Force. In fact, this very important force is making contact of sample while during with probe and energy is needed to separate them. It has been described for high complexity of adhesion to the various theories. In most cases, they considered adhesion as combination of electrostatic force and endurance force and chemical bonding and acid-base. In this research we will use combinations of above forces, as well as surface adhesion energy. For theoretical calculations of the dynamic contacts will use Johnson–Kendall–Roberts (JKR) and considered surface adhesion energy between nano-particle / probe and nano-particle / surface as equal based on JKR theory until be proper amount for surfaces in liquid situation [6, 7].

Including other forces can be pointed to Solvation Force, usually structure of fluid is close to the wall but it is different from its volumetric mode features. For many fluid their normal density profiles close to wall has fluctuation, this fluctuation period is equal to the diameter of fluid molecules. This area can be extended to a distance of a few molecules and it can cause to making gravity- repulsion fluctuation. In this distance, molecules can be placed in different layers. When two surfaces coming close together, first layer after the other will separate and remove from between of two surfaces. Oscillatory changes between molecules decreased exponentially in the interaction. This term is called "Salvation Force". (Fig. 2B) shows a view of the fluid layer between two surfaces and graph theory in Solvation Force.

Hydrophobic Force, Hydrophobic surfaces attract each other in water. The gravitational force is called Hydrophobic Force. This phenomenon occurs in surfaces that has a 90 or more contact angle. When one of surfaces is hydrophilic and another hydrophobic, this phenomenon will not occur. Many studies have been performed in this field, but still there is not any theory for calculating of these practical results and origin of this phenomenon are still unclear. It seems this force has a short term for 2 to 6 nm distances and a long-term for up to 100 nm distances.

After a brief review of molecular interaction forces at the nano-scale, we will mention to 2 major forces in macro-scale dimension, those are influence in dynamic relationships (cantilever).

First of these forces is drag force that occurs from fluid motion on Cantilever surfaces, as we know two kinds of drag caused by fluid motion : 1- Pressure drag: that is caused on perpendicular surfaces of fluid flow (here because of a much thin thickness of Cantilever is negligible). 2- Frictional drag: that is caused because of the fluid moves in Cantilever up and down to two surfaces and making shear stress. Different methods are used to calculate the drag coefficient.

Many researchers were considered Cantilever AFM as a cylinder [8] and research on drag force caused in Cantilever form based on this consideration. In (Fig. 3A) is shown a view of Cantilever atomic force microscope.

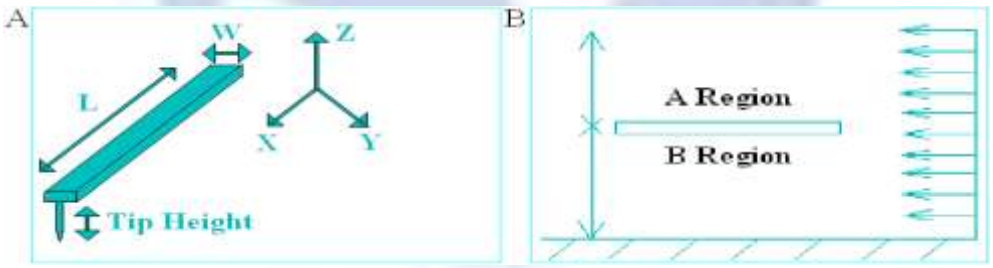

Figure 3. (A) AFM Cantilever [2, 3]. (B) Flow pass above and below AFM Cantilever [2, 3].

Dimensions and geometric properties of cantilever and particle are in Table I and II.

Table I: The Cantilever geometric constants

L(μm)	w(μm)	t(μm)	H(μm)	Rt(μm)
225	24	1	12	20

Table II: The Cantilever mechanical properties

E(GPa)	ν	G(GPa)	ρ(Kg/m3)
169	0.27	66.54	2330

In the present modeling, Cantilever moves in horizon and parallel level of base surface (Substrate), because of small thickness of Cantilever compared with the length, width, and also due to its slow flow and low Reynolds. We put amount of drag coefficient equal with a cube drag coefficient, that frictional drag is entered in two surfaces [9].

From below equation is obtained:

$$C_D = \frac{8\pi}{\mathrm{Re}_D \log(\frac{7.4}{\mathrm{Re}_D})} \tag{1}$$

Amount of drag caused by fluid is equal:

$$F_{Drag} = C_D \frac{1}{2}\rho V^2 (DL) \tag{2}$$

In fact, here we consider frictional drag that is entered on top and bottom surfaces of Cantilever (Fig. 3B). This work is usually done in calculating of drag on Cantilever.

First here we must get velocity profile for calculate drag. With the assuming steady laminar flow with low and non-compressible Reynolds movement will be equation as equation (2). Due to Cantilever low thickness (about 1 micron) we assume the flow one-dimensional and escape from effects of two-dimensional flow [10, 11]. Then movement equations are obtained as follows:

$$\nabla p = \eta \Delta \vec{u} \tag{3}$$

Because of the thin thickness of cantilever (1 µm), we assume 1-Dimensional flow:

$$\frac{\partial p}{\partial x} = \mu \frac{\partial^2 u}{\partial y^2} \Rightarrow \frac{1}{\mu}\frac{\partial p}{\partial x} = \frac{\partial^2 u}{\partial y^2} \tag{4}$$

Initial condition:

y=0 → u=0, y=H → u=U

Therefore:

$$u(y) = \frac{1}{2\mu}(\frac{\partial p}{\partial x})y^2 + \frac{1}{2\mu H}(2\mu U - (\frac{\partial p}{\partial x})H^2)y \tag{5}$$

The pressure gradient is unknown. We divided the flow in two sections, Cantilever up and down. We get flow Gradient amount with assuming of its incompressible, after it is compute, we can calculate amount of drag for flow passing from Cantilever top and down.

$$Q_{total} = Q_{top} + Q_{below} \tag{6}$$

$$Q_{below} = \frac{1}{2}hU, Q_{top} = \int_0^H u dy, \tag{7}$$

$$Q_{total} = U(H+h) \Rightarrow Q_{top} = U(H+h) - \frac{1}{2}hU \tag{8}$$

$$\underline{(6,7,8)} \rightarrow (\frac{\partial p}{\partial x}) = \frac{3\mu^2 U}{H^2} - \frac{6\mu U}{H^3}(H - \frac{h}{2}) \tag{9}$$

$$\tau = \mu \frac{\partial u}{\partial x} \tag{10}$$

$$F_{D_{Top}} = WL\left(\frac{3\mu^2 U}{H^2} - \frac{6\mu U}{H^3}(H - \frac{h}{2})\right)(y + \frac{\frac{2\mu U}{\frac{\partial p}{\partial x}} - H^2}{H}) \tag{11}$$

Below the cantilever Assume

$$(\frac{\partial p}{\partial x}) = 0 \Rightarrow F_{D_{Below}} = WL\mu\frac{U}{h} \tag{12}$$

These values should be applied until results of changes become analyzed.

Another force that here we will discuss about it is a force that happens under "Squeeze File Effect". When Cantilever comes closer to surface based on its width, Squeeze Film effect will appears. If we assume that a Thierry is parallel to surface with ratio a gap without dimension and the probe height is H, in this case the equations of flow will converted in

form of Stokes equation to a thin layer. That will apply to whole Cantilever. With increasing remarkably distance of surfaces, force caused by Squeeze film will lost its effect and only drag can be observed.

The surface tension force: when we put a curtain of fluid such as water, inside the frame so that one side of frame is movable, if we draw the moving side as a way that move and be drawn, we must work for overcoming the surface tension. This surface work is dependent on amount of curtain level increasing in frame. Due to Tension both sides of fluid curtains will be equal (b.dX). Amount of work by introducing the coefficient of surface tension will be [12]:

$$dw = \gamma . dA \qquad (13)$$

C. *Dynamic Modeling*

In nano-manipulation operation, the probe is considered as cylinder. A view of cantilever forces and probes, force contact between the probes, particles, and forces between the probes and Cantilever are shown in (Fig. 4A, B, 5A, B). These two figures express forces, from 2 aspects in two environments. Horizontal and vertical elements between the probes, Cantilever, and V are the sheer force between these [2, 3, 13].

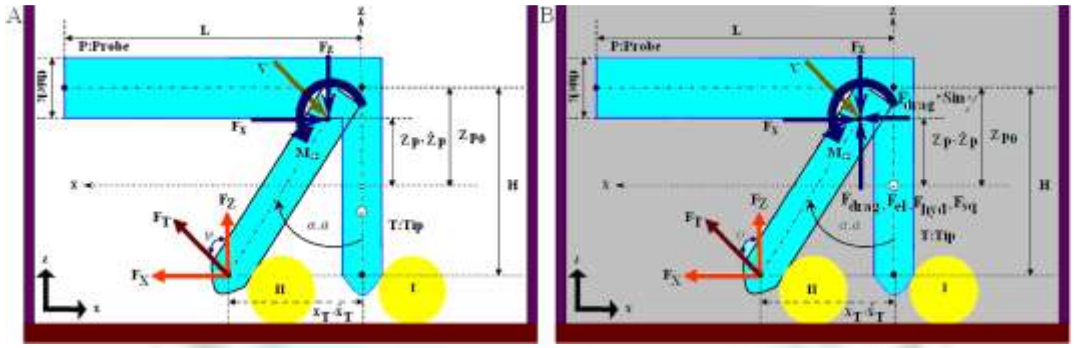

Figure 4. (A) AFM Cantilever and probe bending along x-z axes during pushing nano objects in vacuum [2, 3] (B) AFM Cantilever and probe bending along x-z axes during pushing nano objects in liquid

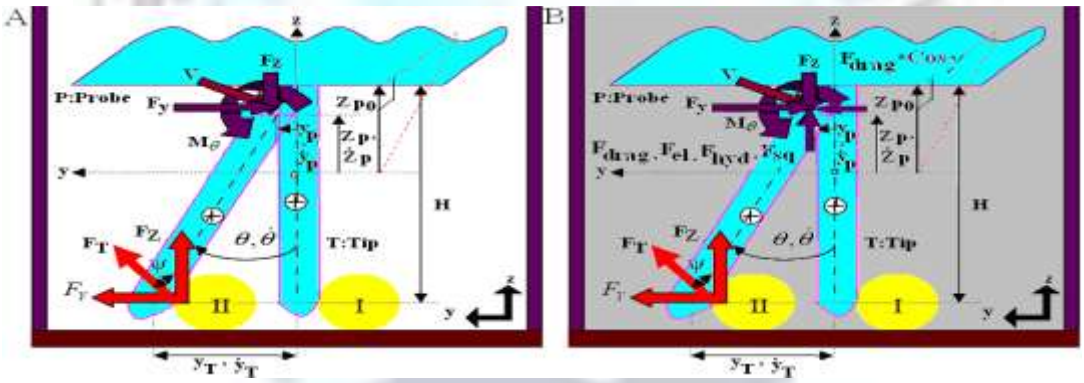

Figure 5. (A) AFM Cantilever and probe bending along y-z axes during pushing nano objects in vacuum [2, 3] (B) AFM Cantilever and probe bending along y-z axes during pushing nano objects in liquid

By considering below figure model to drive down the particles by head of atomic force microscope probe which forces enter on a particle is through probe, in order to probe force angle, contact angle of the probe head, and nano-particle. Contact angle is designed during System function remains fixed and for Manipulation will be in pushing mode (Fig. 6A). Diagram of a probe with a nano-particle, along with the forces will be entered from liquid to a head Cantilever (Fig. 6B).

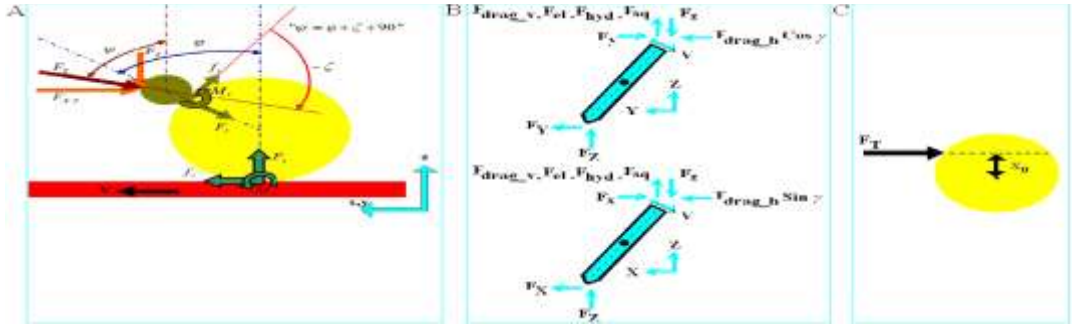

Figure 6. (A) Positioning of the nano-particle by the tip of AFM Cantilever pushing [2, 3]. (B) FOB of probe [2, 3]. (C) The Passing along the resultant of forces applied to the particles, nano-particle rotational will move internally.

Vertical and Frictional forces are achieved in quasi-static status from force and angle of the probe:

$$f_t = F_T \cos\zeta \quad (14)$$
$$F_t = -F_T \sin\zeta \quad (15)$$
$$f_s = F_T \cos\psi - F_{DP} \quad (16)$$
$$F_s = -F_T \sin\psi \quad (17)$$

Which f_s and f_t are in order sliding friction force on the probe head, the base board friction force on the real contact area, and vertical force described in JKR model are perpendicular. Then friction models for sliding, rolling, and circulation are obtained from following order:

Rolling friction:

$$\begin{cases} f_s > \mu_s F_s + \tau_s A_s \\ f_t > \mu_t F_t + \tau_t A_t \end{cases} \quad (18)$$
s:sub,t:tip

Sliding friction:

$$\begin{cases} M_{s_{max}} > \mu_{r_s} F_s + \tau_{r_s} A_s \\ M_{t_{max}} > \mu_{r_t} F_t + \tau_{r_t} A_t \\ (f_s + f_t) R_p > M_{t_{max}} + M_{s_{max}} \end{cases} \quad (19)$$
r:rolling,s:sub,t:tip, p:particle

Circular friction: will occur in order to existence of distance between particle center and point of force apply in with applying force to the center of nano-particle. Due to torsion will decrease unwanted motion possibility of the particle (Fig. 6C).

$$F_{x,y} x_0 > \mu_{s_s} F_s + \tau_{s_s} A_s \quad (20)$$
s:spinning,s:sub

In the above equations, μ = Friction coefficient, τ = strength of cutting, A = contact area between Particle with substrate and head of probe.

Particle Critical force sliding on substrate (base page):

$$F_T > \frac{F_{DP} + \tau_s A_s}{\sin\psi - \mu_s \cos\psi} \quad (21)$$

Critical Rotation Force around particle axis:

$$F_T > \frac{F_{DP}.R + \tau_{r_s} A_s + \tau_{r_t} A_t}{R_P(\sin\psi + \cos\xi) + \mu_{r_t} \sin\xi - \mu_{r_s} \cos\psi} \quad (22)$$

Kinematic equations for Cantilever deformation is obtained with considering of contact deformation between particles - particles and instruments head – base Page.

$$z_P = z_{afm} + H\cos(\theta)\cos(\alpha) + (R_P - \delta_S) + (R_t + R_P - \delta_t)\cos(\varphi)$$

$$x_P = x_{afm} - (R_t + R_P - \delta_t)\sin(\varphi) - H\sin(\alpha) \quad (23)$$
$$y_P = y_{afm} - (R_t + R_P - \delta_t)\sin(\varphi) - H\sin(\theta)$$

In dynamic equations movement in x, y, and z path, torque are obtained from balance equations:

$$\Sigma \vec{F}_y = m\vec{a}_y \Rightarrow F_Y - (F_{Dtop} + F_{Dbelow})\cos\gamma - F_y - V\cos\theta = m\left(\frac{\ddot{y}_T + \ddot{y}_P}{2}\right) \quad (24)$$

$$\Sigma \vec{F}_x = m\vec{a}_x \Rightarrow F_X - (F_{Dtop} + F_{Dbelow})\sin\gamma - F_x - V\cos\alpha = m\left(\frac{\ddot{x}_T + \ddot{x}_P}{2}\right) \quad (25)$$

$$\Sigma \vec{F}_z = m\vec{a}_z \Rightarrow F_Z - (F_z + F_{Drag} + F_{el} + F_{sq} + F_{hyd}) - V\sin\theta - V\sin\alpha = m\left(\frac{\ddot{z}_T + \ddot{z}_P}{2}\right) \quad (26)$$

$$\Sigma \vec{M}_P = I_P(\ddot{\theta} + \ddot{\alpha}) \Rightarrow M_\theta + F_z H\sin\theta\sin\alpha - F_Y H\cos\theta - M_\alpha - F_x H\cos\alpha = I_P(\ddot{\theta} + \ddot{\alpha}) \quad (27)$$

$\ddot{z}_T$, $\ddot{y}_T$, $\ddot{z}_T$ Values are equal with zero and also $\ddot{z}_P$, $\ddot{y}_P$, $\ddot{x}_P$ can be obtained from derivative of equation (23), With placement of acceleration values by above equations, with using of software based on spatial variables F_X, F_Y, F_Z. We can compute final values of y_P, x_P, θ and α. Therefore, we will have outcome of the forces:

$$F_{XY} = \sqrt{F_X^2 + F_Y^2},\ F_T = \sqrt{F_{XY}^2 + F_Z^2},\ \psi = tan^{-1}\left(\frac{F_Y}{F_Z}\right) \quad (28)$$

It is obvious that with considering of probe head speed after probe head contact with particle, specified time will take until applied forces overcome to frictional forces, this time should be accurately calculated. This work will be achieved with dynamic modeling probe head movement and consequently Particle motion.

General diagram of a nano-particle dynamic displace until reaching its original location (the transfer of a nano-particle) (Fig. 7).

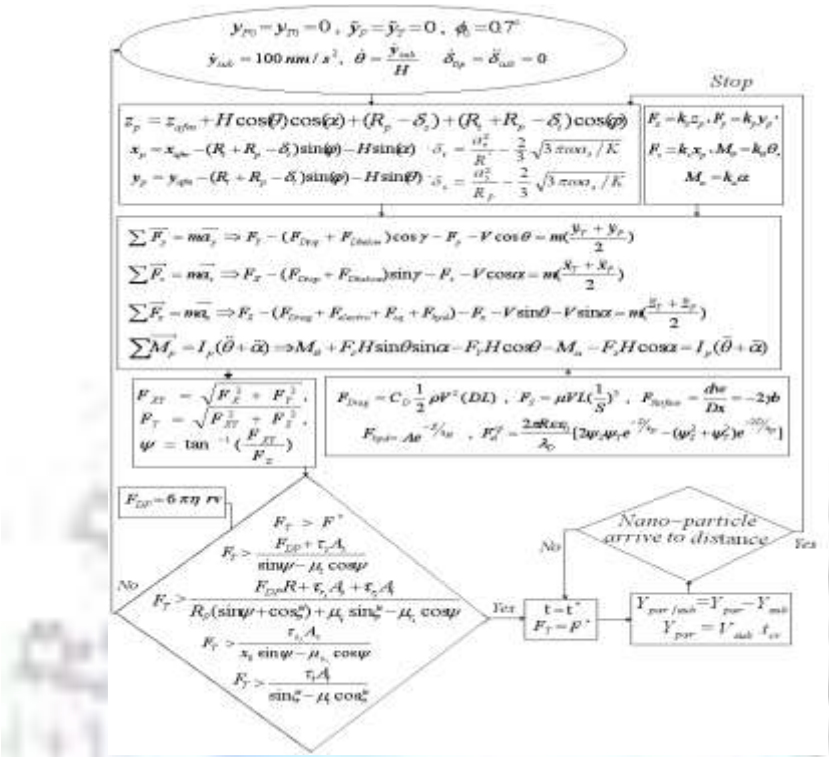

Figure 7. The flowchart dynamic modeling algorithm in pushing nano-particle.

If fluid forces be removed from nano-particles dynamic modeling displacement in fluid equations, it will change into a dynamic modeling of nano-particle displacement in the vacuum environment, so we do not show displacement diagram of the dynamic modeling of nano-particles in a vacuum environment, but we apply it in simulation. This modeling diagram is produced from removing fluid forces which removed from fluid modeling diagram.

D. Genetic Algorithm

Genetic is Comparative method that is used for optimization problems, this algorithm is based on biological processes of organ. Natural populations during several generations, according to the principles of natural selection and "survival of the appropriate test" evolves, this method was expressed in many forms clearly by the Karls Dravin. Genetic algorithms with imitation of these processes, if they properly be encoded, it will be able to evolve solutions of real world problems. For example, genetic algorithms simulate these processes in natural populations for evolution. In nature, basically people in the community to compete to obtain resources such as food, water, and shelter with together. In fact, the members of same types often compete to attract partner, people who can get a larger number for children to survive and attract partner will be successful. Genetic algorithm is use similarity of normal behavior. Based on the population of people, each of them is working for providing a possible solution to the problem, we will give a physical fitness score to each person, and depending on how good a solution to solve the problem has been allocated [14].

For example, suitable people will have more opportunities for the reproduction, cross-breeding with other populations of people. The new people are produced as offspring, and contribute some of parent characteristics. Whole new population determined from possible solutions, consequently with choosing the best people of current generation and copulation them a category of new people. In this way, more than many generations, good profile of the population are combined and modified with other good details. More interest in copulation with appropriate people, the more promising regions of search space is explored. With well-designed genetic algorithm, the population will converge to an optimal solution. Power of genetic algorithms is taken from reality. Genetic algorithm cannot always guarantee to find an optimal public solution for problem but generally is good to find solution for problems. A view Genetic Algorithm stages is shown in (Fig. 8) [14].

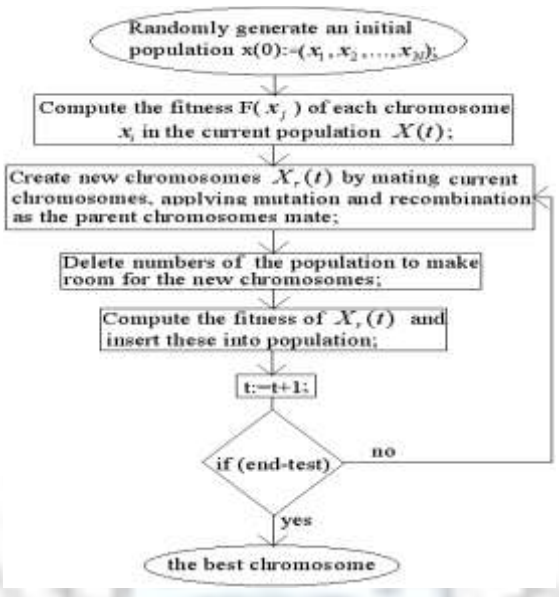

Figure 8. The flowchart of genetic algorithm.

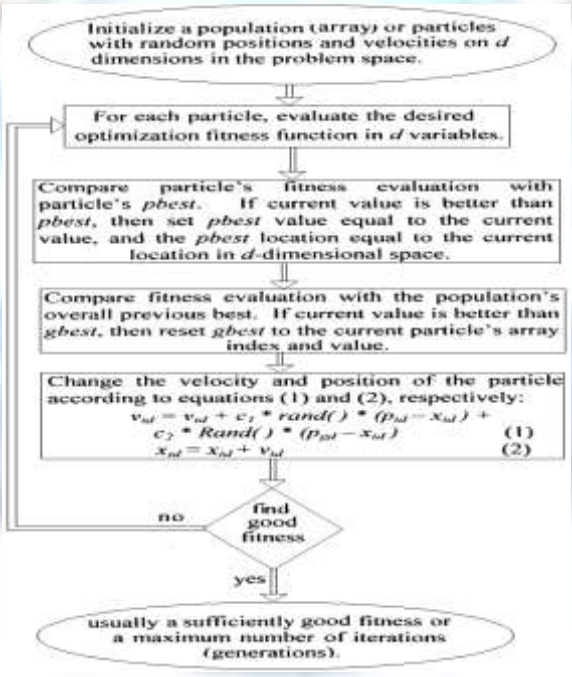

Figure 9. The flowchart of PSO algorithm.

E. Particle Swarm Optimization

PSO algorithm originally introduced by Kennedy and Eberhart in 1995, that is a evolutionary computation techniques and a population-based optimization method that has been inspired from birds and fish life. This algorithm is composed of a group members that moves in search space and try to find the optimal answer, each member of this algorithm update its speed based on own previous experience or best experienced member of the group speed. This algorithm is conceptually simple and has few parameters and easy to implement. Scientists have found that the coordination behavior of birds has directly relation with optimal distance between their members and neighbors, so speed plays an important role in adjustment with others. Also scientists simulate the scenario of birds search for food scientists with considering of their social behavior discovered, that members in order to find food for determine own speed based on the two factors: best own previous experience and best experience of all other members. This is similar to human behavior in making decision. PSO combine local search techniques (experience by members) and methods of search (by neighboring experiences) until are able to reach public optimum. In this way, members in practice tend to fly towards better search environment. PSO questions are position and speed vector that are shown in 29 and 30 relationship [15, 16, 17, 18].

$$V_{t+1} = C_1 V_t + C_2(P_{ig} - X_t) + C_3(P_{\forall g} - X_t) \quad (29)$$

$$X_{t+1} = X_t + V_{t+1} \quad (30)$$

The summary of PSO algorithm is shown in (Fig. 9).

F. Ant Algorithm (Ant System (AS)) [19]

Ant colony is taken based on the behavior of ants for food searching. Ants start search of food using routes, when they found food then decide to go to the next route. The basic idea of the ant colony optimization met heuristic is taken from the food searching behavior of real ants. When ants are on the way to search for food, they start from their nest and walk toward the food. When an ant reaches an intersection, it has to decide which branch to take next. While walking, ants deposit pheromone, which marks the route taken.

Subsequently, more ants are attracted by these pheromone trails and in turn reinforce them even more. As a result of this autocatalytic effect, the optimal solution emerges rapidly.

Proposed Methods

A. Application of PSO-AS [2, 3, 19]

When we create a node, we create nodes randomly that represent the way as a public path. In this section position of the particles shows a direction from origin to destination, so after path was created randomly. Each particle will have a special position of 36 formula are used to for updating the fitness value function for all particles. Particles will select with lowest fitness as the best public and particles will be selected in the neighborhood that has best fitness as the best local particles. P_s, P_{s-1}, P_{s+1} will be for each particle and its neighbors. When we calculate new speed for each particle, it finds a new position. Therefore you can see in 30 formula.

Speed will be displayed by using order of nodes and with the Question 31 is calculated.

$$N_a = \begin{cases} P_{\forall g,\, t} - \omega_t & \text{if} \quad \eta \le C_3 \\ P_{i\,g,\, t} - \omega_t & \text{if} \quad \eta > C_3 \;\&\; \eta \le C_2 + C_3 \\ Rand \quad Selection & \text{if} \quad \eta > C_2 + C_3 \;\&\; \eta \le C_1 + C_2 + C_3 \\ & \text{where} \quad C_1 + C_2 + C_3 = 100\% \end{cases} \quad (31)$$

$$where... \quad a = k+1, k+2$$

And speed vector will be updated by formula 30 and updating of particles Fitness, when they find a new situation they will be calculated with 32 formulas.

$$F(x) = \beta * (1/hop - count) + (1-\beta)(F_w / W) \quad (32)$$

$$where \quad \beta = \quad Algorithm \;\; parameter.$$

$$F_w = \quad Number \; of \; free \; nano - particle \; and \; distance \; available \; on \; the \; route$$

$$W = \quad total \; number \; of \; nano - particle \; distance$$

The parameters of this method are showed in the Table III [15].

According to create the pattern to specific places in the environment for the placement of nano-particles is defined and on the other hand the initial placement of particles in environment is done randomly. That means it will be distribution randomly. Therefore a member is including the nano-particles random place and other places to create pattern. Therefore characteristics of a member include path nodes that are same nano-particles places and destination data. Special nodes can be defined for members, but we consider the best, which you can see in (Fig. 10A).

(Fig. 10B) Example of used member in navigation - finding the location that is contains location nodes and destination nodes. For example, nano-particle No. 4 and No. 5 are transmitted to the destination and the rest will be to be transferred in same way. (1 to 2, 3 to 1, 2 to 5, and 5 to 3) with navigation of this choose origin and destination will change until have optimize the source and destination without colliding the nano-particles. The overall structure of the program will be performed in this way: first we select a random number, if random number is less than the C3 and the previously selected node is the global best, then we must add next node to new path. Path node shall be added to the wt. If previous node is not in the local best, it will be added in later condition, if random number is less than C2 + C3 or greater from C1 + C2 + C3 (sum of three is 100%) or in first or second condition due to reasons nodes not added to route, we will choose a node randomly which still not selected and has not any relation to previous node and will add to w_t.

Table III: Explanation of Parameters proposed method PSO-AS [15].

Parameter	Explanation
X_t	The particle's current position
X_{t+1}	The particle's new position
V_{t+1}	The particle's new velocity for the next iteration.
N_{t+1}	Are the chosen intermediate nodes, from source node to destination node
C3	A probability of selecting to use the information of the global best
C2	A probability of selecting to use the information of the local best
C1	A probability of selecting to use the information of particle's own exploration, done by random search
ω_t	Partial route from source to destination node
$P_{i\ g,t}$	Position of the local best particle
$P_{\forall\ g,t}$	Position of the particle's global best particle searched so far
$P_{i\ g,t}$ - w_t	This will give the next node in $P_{i\ g,\ t}$ from the last node in w□
$P_{\forall\ g,t}$ -w_t	This will give the next node in $P_{\forall\ g,\ t}$ from the last node in□ w□

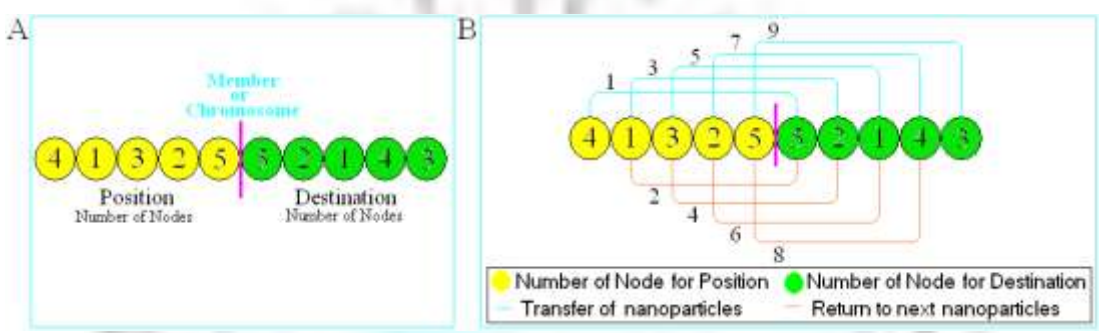

Figure 10. (A) An example of member or chromosome (including nano-particle with yellow color and place for transfer nano-particle with green color). (B) Stages of transfer nano-particle.

Selecting the best member will performing after following steps: length of path: this length will be calculated for each member and calculation will perform in this way: length will be calculated between first nano-particles origin, first nano-particles destination, and destination of the first nano-particles with origin of second nano-particles. This calculation will be performed while finishing of all particles and destinations. The entire route will be calculated for a member. For all members length of path will be calculated and stored in the fitness array and (second column) (fitness array in (Fig. 11)).

Figure 11. Select best member or chromosome of fitness in current stage.

The number of collisions: a part of program will recognize collisions if the nano-particle is near to path and its distance is less than a specified amount, collision will occur otherwise important collision will not be occur. Therefore we will check collision of first nano-particles with all nano-particles. Number of collisions for all members must be calculated and stored in fitness array (third column) (fitness array In (Fig. 11)).

Finding global best of current iteration: If two or more of members have the same number of collisions and number of collisions is the lowest among all members, we will select the route with minimum route length. But, if we have just one member with the least number of collisions, we will select it, because having fewer collisions has higher priority than low route length (Fig. 12).

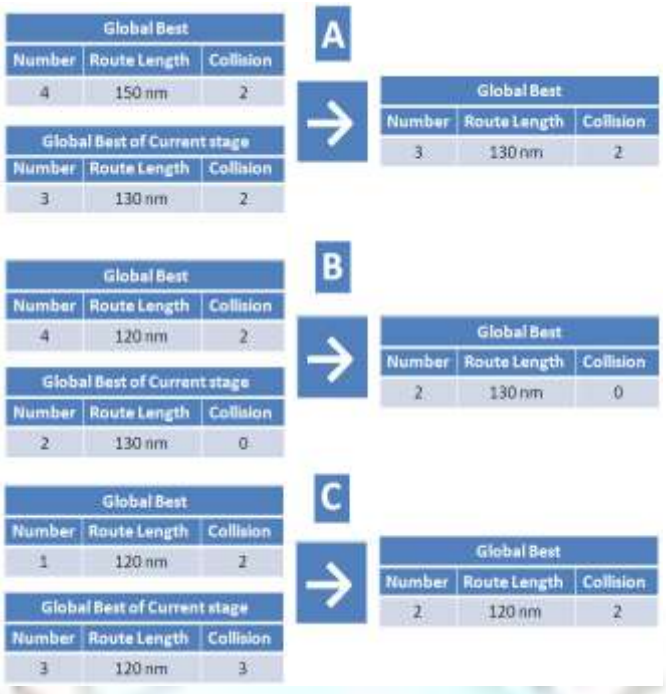

Figure 12. Cases of selection global best of old global best and best member in this stage.

Finding global best of all iterations: We have the global best that is the best member calculated from the former stage. If the best member of this stage is better than the global best, we will replace the global best with it. There are three possible cases for this replacement seen in (Fig. 12).

Finding local best: If the local best of each member is worse than the created route for each member in this stage, we will replace the local best with created route as shown in (Fig. 13).

Figure 13. Step-by-step selection of local best for each member using old local best and fitness in present stage.

B. Application of GA

Considering that, this is defined for creating specific pattern in special places for placement of nano-particles in the environment. In the other hand, the initial placement of nano-particles is performed randomly in environment, it means their distribution are randomly, so a chromosome (members) is includes nano-particles random location and model creating location. Therefore a member is including the nano-particles random places and other places to create pattern. Hence characteristics of a member include path nodes which are same nano-particles places and destination data. Specific modes can be defined for chromosomes, but we consider the best which you can see in (Fig. 10A).

(Fig. 10B) Example of used chromosome in navigation - finding the location that is contains location nodes and destination nodes. For example, nano-particle No. 4 and No. 5 is transmitted to the destination and the rest will be transferred in same way. (1to 2, 3 to 1, 2 to 5, and 5 to 3) with Navigation of this choose origin and destination will change until optimize the source and destination without colliding the nano-particles. The overall structure of the program will be performed in this way:

Crossover: this combination is done in this way. We select a random number that will be larger or smaller than a constant. If it be smaller in the left side or if it be larger in the right side, the crossover will occur. If open combination

happens in right side during creation of two chromosomes, the parents' genes that are in left side will not re-appear in the right side. Only genes that are in right side will be exchanged (Fig. 14A).

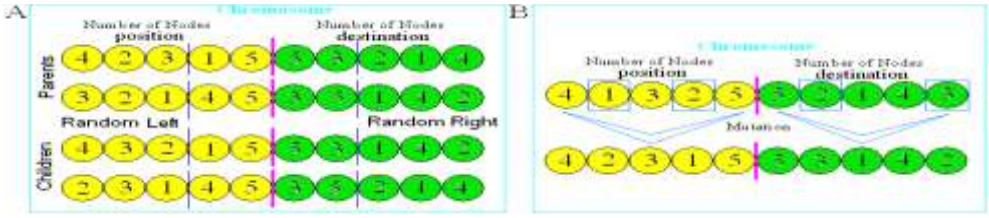

Figure 14. (A) Crossover of self-left chromosome (Nodes of yellow color (nano-particle)) and self-right chromosome (Nodes of green color (pattern)). (B) Mutation does in a chromosome (in position and destination) stage.

Jump: first, we select a random number if it is less than a fixed percentage, the mutation will occurs. In Jump we select two numbers and replace them together. Jump is performed separately for source and destination. Twice, one for source and one for destination, it can be performed (Fig. 14B). Its function is as follows:

Selecting the best chromosome will perform after following steps: length of path: this length will be calculated for each chromosome, calculation will perform in this way: length between first nano-particles origin, first nano-particles destination, and destination of the first nano-particles with origin of second nano-particles will be calculated. And this calculation will be performed while finishing of all particles and destinations. The entire route will be calculated for a chromosome (Fig. 11). For all chromosomes length of path will be calculated and stored the in fitness array (second column) (fitness array In (Fig. 11). The chromosome of collisions: a part of program that will recognize collisions. If the nano-particle is near to path and its distance is less than a specified amount, collision will occur. Otherwise important collision will not occur. Therefore we will check collision of first nano-particles with all nano-particles. Chromosome of collisions for all chromosomes must be calculated and stored in fitness array (third column) (fitness array In (Fig. 11)).

Selecting best chromosome of the global best after performing the above two parameters can be done as follows:

First, between lowest collisions (in the case that is more than one) the chromosome which has lowest path length will be selected as the best chromosome, but if only one chromosome has lowest collision, we will not pay attention to its path length and we will select it as the best member. Because of the lack of collision, it has high priority than path length (Fig. 12). Collision detection: After calculating the shortest path between 2 nano-particles, we calculate distance between other ones and calculated path, if distance was less than specified value then collision will be occurred.

C. Pseudo Codes of algorithm

In this section we will describe the pseudo code of the two algorithms. First, the genetic algorithm pseudo-code that is used in this paper will be expressed and then will express birds - ants algorithm. First you can see the pseudo-code for birds - ants algorithm that is used for this article (Fig. 15A), then you can see pseudo-code for genetic algorithm used in this article (Fig. 15B). At the end of this section, you see a pattern general diagram of dynamic navigation with its steps expression (Fig. 16).

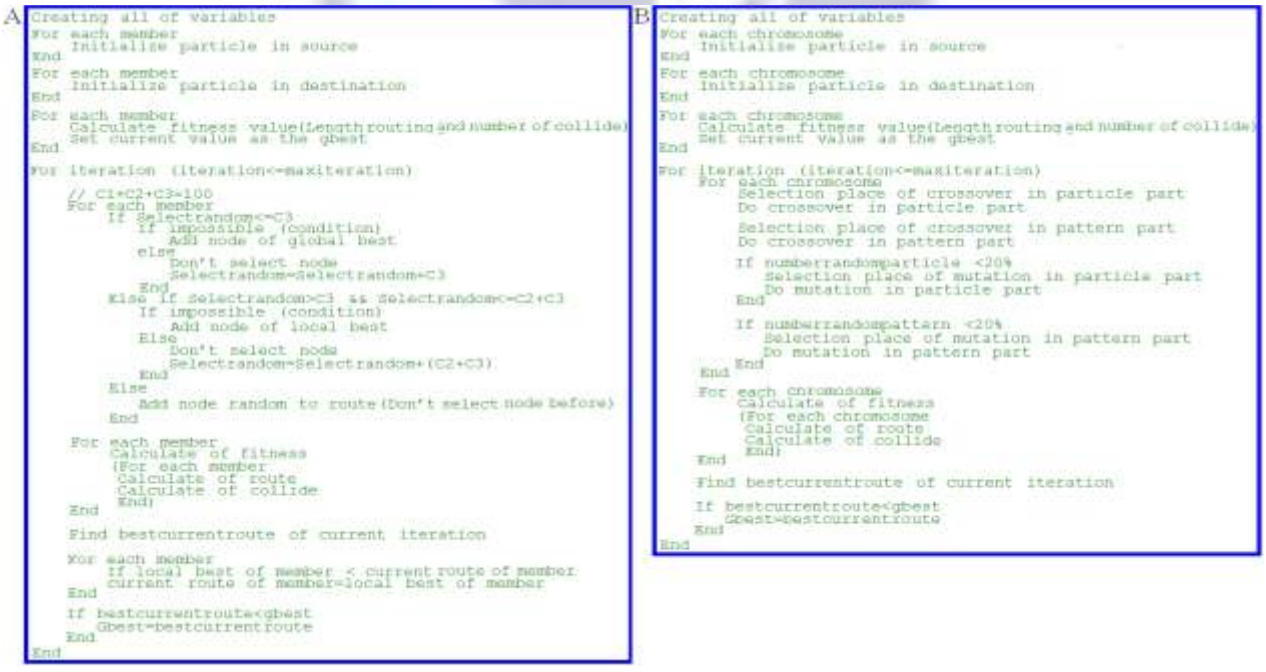

Figure 15. (A) The pseudo-code of PSO-AS algorithm. (B) The pseudo-code of Genetic algorithm.

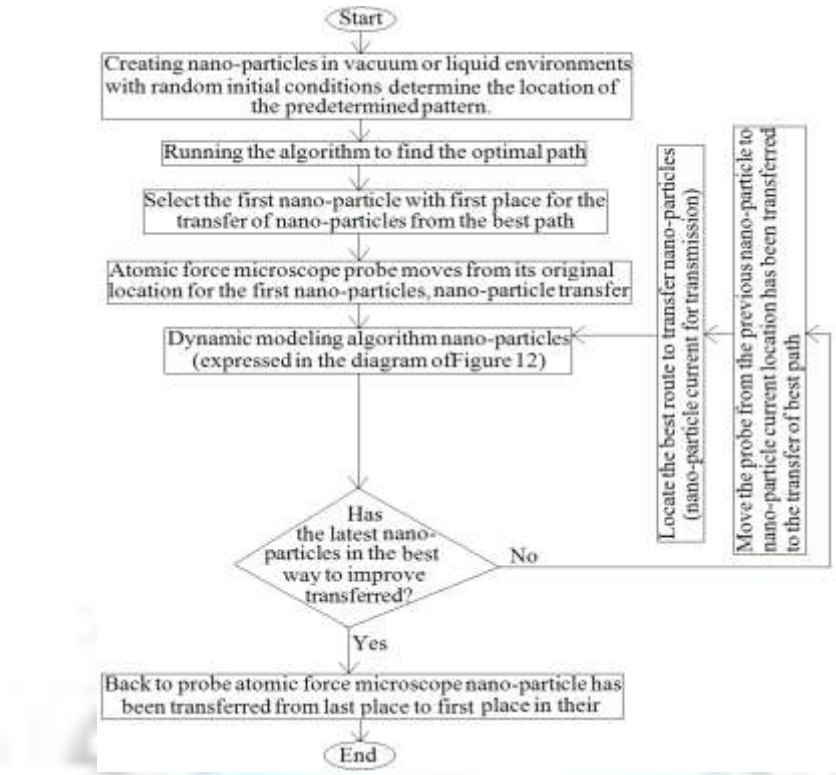

Figure 16. The diagram of stages of creating pattern in nano-manipulation.

Modeling and Results

A. Describing Force of Angle Nano-manipulation

Often majority of the forces applied on the nano-particles from cantilever and probe in nano-scale are different angles and environments (although the amount of applied force at the nano-scale is low).

For better expression of this enforcement forces, in the two vacuum and liquid environments, you can see below table that is used to routing model for creating nano-particles to calculate the total time of the applied force or displacement.

These forces in below table are applied forces in different angles and environments. Meaning of average applied forces to overcome the friction forces are average of applied forces from earliest moment of force apply to nano-particles until overcome moment between these two operating. Force starting from a fixed amount and reaches a constant value which nano can start to move, so average value of these two forces are considered for calculations (Table IV).

Table IV: Forces acting at a different angle to over coming in the force of sliding motion in both liquid and vacuum environments

Angles	Environment	Medium Apply Force for beat on friction(μN)	Force Nano-manipulation (During) (μN)
0, 180, 360	Vacuum	0.56655	0.61309
0, 180, 360	Water	0.56999	0.61680
22.5, 157.5, 202.5, 337.5	Vacuum	0.56628	0.61267
22.5, 157.5, 202.5, 337.5	Water	0.56972	0.61638
45, 135, 225, 315	Vacuum	0.56601	0.61224
45, 135, 225, 315	Water	0.56944	0.61594
67.5, 112.5, 247.5, 292.5	Vacuum	0.56575	0.61183
67.5, 112.5, 247.5, 292.5	Water	0.56916	0.61551
90-270	Vacuum	0.56562	0.61163
90-270	Water	0.56889	0.61509

B. Force of Aspects Energy and Time

Making patterns with nano-particles can be studied in viewpoint of energy and time. This is the time view, since the probe began to move from its original location as long as the building all patterns and return to its original location. This is calculated according formula 33. The parameters explain in Table V.

$$T_{total}=T_{TimetofirstParticle}+T_{routing}+T_{backtofirstplacel} \quad (33)$$

View of energy point a little bit different, because the transmission uses different energy particles at different angles. This may be very little difference that we brought in the previous section. The overall calculation is according formula 34. The parameters explain in Table VI.

$$E_{total}=E_{TimetofirstParticle}+E_{routing}+E_{backtofirstplacel} \quad (34)$$

The formulas above are two views, energy and time.

Table V: The Parameters of Total Movement Time.

Parameter	Details
T_{total}	Total movement time
$T_{TimetofirstParticle}$	The movement time towards the first nano-particle to the point where the probe and cantilever
$T_{routing}$	The time of shift patterns to create nano-particle (Route+ Least twice during the peak)
$T_{backtofirstplacel}$	The movement time of come back from the last place to the place initial probe and cantilever

Table VI: The Parameters of Total Movement Energy.

Parameter	Details
E_{total}	Total movement Energy
$E_{TimetofirstParticle}$	The movement energy towards the first nano-particle to the point where the probe and cantilever
$E_{routing}$	The energy of shift patterns to create nano-particle (Route+ Least twice during the peak)
$E_{backtofirstplacel}$	The movement energy of come back from the last place to the place initial probe and cantilever

These three views are expressed in this research, with 1000×1000 nm, 2000×2000 nm and 3000×3000 nm scales are used to create patterns. Different patterns of expression are created in two scales with different numbers of particles, which has been calculated above. We have used two types of algorithms, in a separate table for each method, so we can compare them easier. We have certain pattern for any number of nano-particles, for creating of the correct pattern; we distributed nano-particles randomly with the same number. The tables VII, VIII, IX, X, XI and XII shows you and you will discover the fact that the algorithm is a combination of all the best and it maintains the energy and time minimally. It keeps these two factors, minimally and no collision of nano-partials in good condition.

Table VII: Create patterns using algorithms based on PSO-AS number of nano-particles in the environment dimension (1000×1000 nm)

Algorithm	No. Nano particle	Pattern	Environment	Total –Length (µm)	Length-Routing (µm)	Full-Time (Sec)	Full-Energy (µN)
PSO-AS	5	+	Vacuum	11.000	3.990	111	27.320
PSO-AS	5	+	Liquid	11.000	3.990	111	713.460
PSO-AS	7	^	Vacuum	13.134	6.124	133	41.921
PSO-AS	7	^	Liquid	13.134	6.124	133	728.149
PSO-AS	9	B	Vacuum	15.584	8.574	157	57.747
PSO-AS	9	B	Liquid	15.584	8.574	157	744.071
PSO-AS	11	P	Vacuum	16.225	9.215	164	63.164
PSO-AS	11	P	Liquid	16.225	9.215	164	749.521
PSO-AS	13	E	Vacuum	18.841	11.831	190	80.215
PSO-AS	13	E	Liquid	18.841	11.831	190	766.675
PSO-AS	15	8	Vacuum	21.138	14.128	213	95.428
PSO-AS	15	8	Liquid	21.138	14.128	213	781.980

Table VIII: Create patterns using algorithms based on GA number of nano-particles in the environment dimension (1000×1000 nm)

Algorithm	No. Nano particle	Pattern	Environment	Total –Length (µm)	Length-Routing (µm)	Full-Time (Sec)	Full-Energy (µN)
GA	5	+	Vacuum	11.000	3.990	111	27.320
GA	5	+	Liquid	11.000	3.990	111	713.460
GA	7	^	Vacuum	13.134	6.124	133	41.921
GA	7	^	Liquid	13.134	6.124	133	728.149
GA	9	B	Vacuum	15.584	8.574	157	57.747
GA	9	B	Liquid	15.584	8.574	157	744.071
GA	11	P	Vacuum	16.515	9.505	167	65.001
GA	11	P	Liquid	16.515	9.505	167	751.369
GA	13	E	Vacuum	19.441	12.431	196	83.888
GA	13	E	Liquid	19.441	12.431	196	770.370
GA	15	8	Vacuum	21.776	14.766	219	99.102
GA	15	8	Liquid	21.776	14.766	219	785.676

Table IX: Create patterns using algorithms based on PSO-AS number of nano-particles in the environment dimension (2000×2000 nm)

Algorithm	No. Nano particle	Pattern	Environment	Total –Length (µm)	Length-Routing (µm)	Full-Time (Sec)	Full-Energy (µN)
PSO-AS	10		Vacuum	16.257	10.247	164	68.721
PSO-AS	10		Liquid	16.257	10.247	164	755.111
PSO-AS	15		Vacuum	21.734	15.724	219	105.224
PSO-AS	15		Liquid	21.734	15.724	219	791.835
PSO-AS	20		Vacuum	25.967	19.957	261	133.768
PSO-AS	20		Liquid	25.967	19.957	261	820.552
PSO-AS	25		Vacuum	29.846	23.836	300	160.476
PSO-AS	25		Liquid	29.846	23.836	300	847.421
PSO-AS	30		Vacuum	34.933	28.923	351	194.530
PSO-AS	30		Liquid	34.933	28.923	351	881.681
PSO-AS	35	ALi	Vacuum	40.804	34.794	410	232.870
PSO-AS	35	ALi	Liquid	40.804	34.794	410	920.253

Table X: Create patterns using algorithms based on GA number of nano-particles in the environment dimension (2000×2000 nm)

Algorithm	No. Nano particle	Pattern	Environment	Total –Length (µm)	Length-Routing (µm)	Full-Time (Sec)	Full-Energy (µN)
GA	10		Vacuum	16.257	10.247	164	68.721
GA	10		Liquid	16.257	10.247	164	755.111
GA	15		Vacuum	22.297	16.287	224	108.285
GA	15		Liquid	22.297	16.287	224	794.915
GA	20		Vacuum	26.483	20.473	266	136.829
GA	20		Liquid	26.483	20.473	266	823.631
GA	25		Vacuum	31.155	25.145	313	168.435
GA	25		Liquid	31.155	25.145	313	855.428
GA	30		Vacuum	36.077	30.067	362	201.265
GA	30		Liquid	36.077	30.067	362	888.456
GA	35	ALi	Vacuum	42.852	36.842	430	245.727
GA	35	ALi	Liquid	42.852	36.842	430	933.187

Table XI: Create patterns using algorithms based on PSO-AS number of nano-particles in the environment dimension (3000×3000 nm)

Algorithm	No. Nano particle	Pattern	Environment	Total –Length (µm)	Length-Routing (µm)	Full-Time (Sec)	Full-Energy (µN)
PSO-AS	20	Random	Vacuum	40.641	35.641	408	229.890
PSO-AS	20	Random	Liquid	40.641	35.641	408	917.254
PSO-AS	30	Random	Vacuum	59.965	54.965	601	353.712
PSO-AS	30	Random	Liquid	59.965	54.965	601	1041.825
PSO-AS	40	Random	Vacuum	80.995	75.995	811	487.943
PSO-AS	40	Random	Liquid	80.995	75.995	811	1176.867
PSO-AS	50	Random	Vacuum	94.785	89.785	949	578.092
PSO-AS	50	Random	Liquid	94.785	89.785	949	1267.561
PSO-AS	60	Random	Vacuum	126.549	121.549	1267	778.444
PSO-AS	60	Random	Liquid	126.549	121.549	1267	1469.124

Table XII: Create patterns using algorithms based on GA number of nano-particles in the environment dimension (3000×3000 nm)

Algorithm	No. Nano particle	Pattern	Environment	Total –Length (µm)	Length-Routing (µm)	Full-Time (Sec)	Full-Energy (µN)
GA	20	Random	Vacuum	40.651	35.641	408	229.890
GA	20	Random	Liquid	40.651	35.641	408	917.254
GA	30	Random	Vacuum	61.381	56.371	615	362.284
GA	30	Random	Liquid	61.381	56.371	615	1050.448
GA	40	Random	Vacuum	77.134	72.124	773	464.678
GA	40	Random	Liquid	77.134	72.124	773	1153.461
GA	50	Random	Vacuum	100.617	95.607	1008	614.214
GA	50	Random	Liquid	100.617	95.607	1008	1303.902
GA	60	Random	Vacuum	134.390	129.380	1345	826.199
GA	60	Random	Liquid	134.390	129.380	1345	1517.168

C. Result of Converge of Algorithms

In fact, in this paper we expressed how to create patterns, using atomic force microscopy modeling algorithms in liquid and the vacuum environments. The results show that the shortest path algorithm have found based on the conditions mentioned above (non-colliding particles). Algorithm of birds maybe will converge faster, but may fall in local minimum, but genetic algorithm won't converge faster, but it is not trapped in local minimum.

In (Fig. 17A) are shown 5 nano-particle pattern with the red line,7 nano-particles with the green line, 9 nano-particles with the dark blue line, 11 nano-particle with the light blue line, 13 nano-particle with the yellow blue line, and 15 nano-particle with light violet line. Each line with a color chart shows convergence in certain intervals (Fig. 17B, 18A, B). The red line first finds the fast convergence and to follow that the convergence gets slower. After a while it finds fast convergence and gets into its final results. These patterns have been established with this number of particles in three scales of nanometers. It is better to know there are restrictions in creating the number of particles with the specific radius and specific scale. Overview of the charts in the end came to the conclusion. The overall convergence graph algorithm combines the best convergence performance than other algorithm show various scales of them. The study will seek to reality.

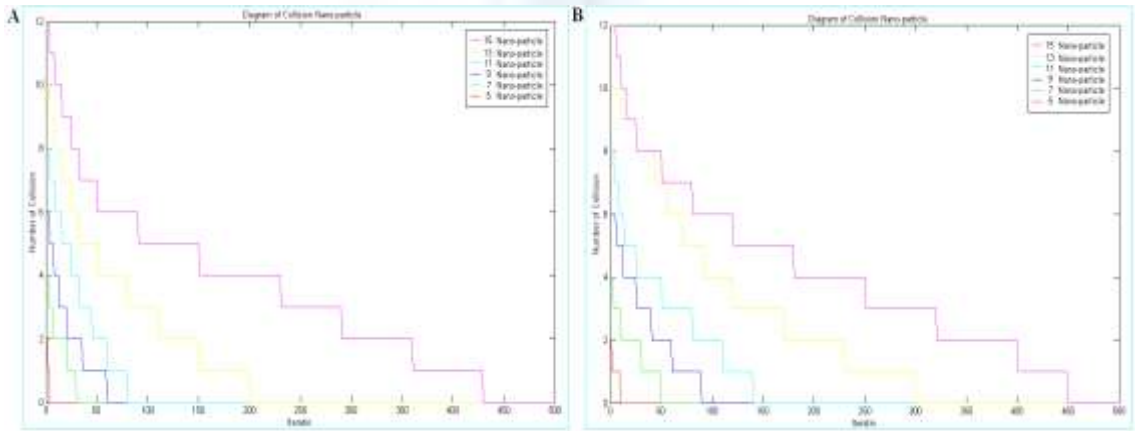

Figure 17. (A) Graph algorithms PSO-AS Convergence Nano-particles for the lack of scale (1000×1000 nm) (B) Graph algorithms GA Convergence Nano-particles for the lack of scale (1000×1000 nm)

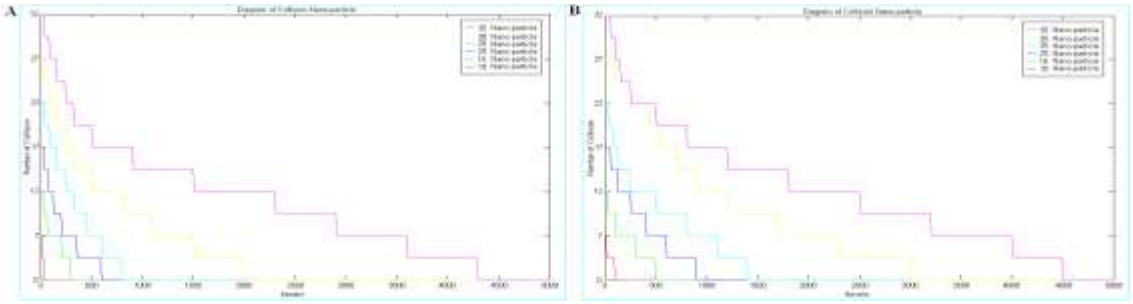

Figure 18. (A) Graph algorithms PSO-AS Convergence Nano-particles for the lack of scale (2000×2000 nm) (B) Graph algorithms GA Convergence Nano-particles for the lack of scale (2000×2000 nm)

D. Simulation Experiment

First randomly, we distribute number of Nano-particles in thousands of nanometers in thousands of nanometers (Nano-particles within the Mathematical). Location of information together (the location of particles to create a pattern) will be stored in Excel files. With this information is performed in call routing algorithm for the pattern of expression. When the algorithm finds the best path, it is stored in another file and run other files Mathematical. The data can be read and we will deliver nano-particles to specific locations. This transfer is done in the simulation. Particles are moved to specified locations and the pattern is made. We have shown our model for the simulation of several examples to better understand routing and routing tables in the previous section for the model.

Top 15 distributed randomly in the form of nano-particles in thousands of nanometers in place that we have the model A with the nano-particles (Fig. 19A). Routing nano-particles with nano-particles which came to the conclusion to which location is transmitted to the model. B with the same pattern with 10 nanometer particles associated with the routing pattern for the bottom you can see in (Fig. 19B).

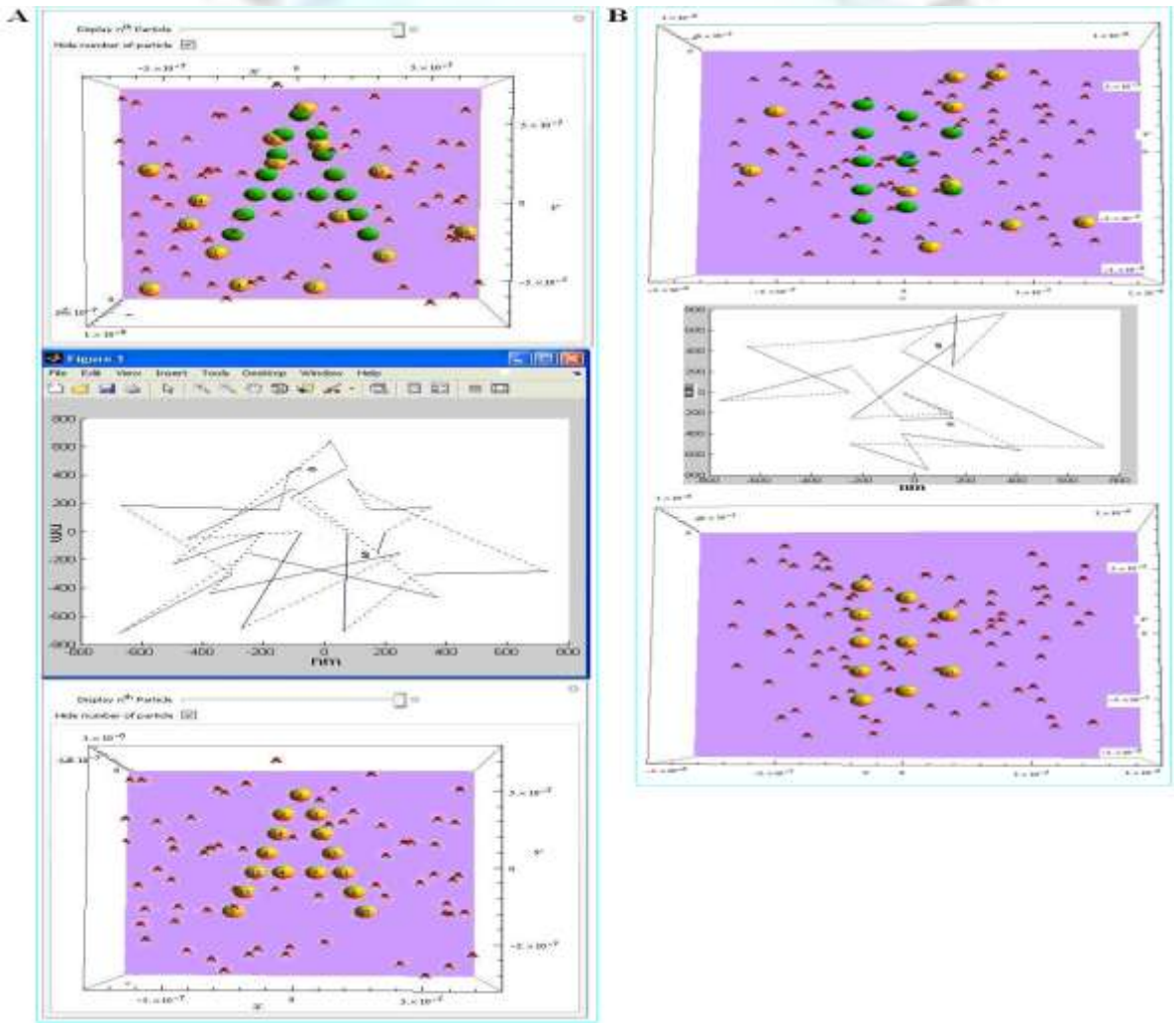

Figure 19. (A) Manipulation of 15 nano-particles for creating pattern A (B) Manipulation of 10 nano-particles for creating pattern B

Condition Parameters

A. Liquid Condition

From the powers of Water, Vander Waals force is negligible in comparison with the Electrostatic force. The electrostatic force between the probes and particle is ignored, because the particle's surface is assumed Gold. Also due to cantilever being non-polar, the force of the arrangement of atoms in space, the Hydrophobic force and the solvent coating force are negligible and close to zero. And also the cantilever force is negligible. Due to the negligible effect of hydrogen bond, we do not consider it as well, but this bond affects other forces. Also assuming that the cantilever is completely immersed in a fluid environment, the Capillarity force is also ignored due to the lack of separator layer between the liquid and the air. In addition, because cantilever moves in the vertical direction, the Drag force, and the Electrostatic force acts in the vertical direction .The Compression force from the surface and also the hydration force are negligible, but they are put in calculations to show they are ineffective (with the statement that all forces are considered, some of which the force of the arrangement of atoms in space, the Hydrophobic force, the Solvent coating with zero value, and some (the Hydration force and the compression force) value are very low. The Drag force on cantilever in the horizontal direction is also considered. In the end about the act of Drag on the particle also in equations, because it is assumed that even before the particle motions by probes, the particle is stuck to substrate. Therefore, before the particle motions (which we have done up to this stage of the model) is considered equal to zero.

Electrostatic Force Formula:

$$F_{el}^{cp} = \frac{2\pi R\varepsilon\varepsilon_0}{\lambda_D}[2\psi_S\psi_T e^{-D/\lambda_D} - (\psi_S^2 + \psi_T^2)e^{-2D/\lambda_D}] \quad (33)$$

Hydration Force Formula:

$$U = Ae^{-x/\lambda_H} \quad (34)$$

Steric Force Formula:

$$f(x) = K_B T T^{3/2}[(\frac{2L_0}{x})^{9/4} - (\frac{x}{2L_0})^{3/4}] \quad (35)$$

Adhesion Force Formula:

$$\omega = \frac{H}{24\pi D_o} \quad (36)$$

Salvation Force Formula:

$$f = f\,\mathrm{Cos}(\frac{2\pi x}{\sigma})e^{-x/\lambda} \quad (37)$$

Drag Force Formula:

$$F_{Drag} = \frac{8\pi}{\mathrm{Re}_D \log(\frac{7.4}{\mathrm{Re}_D})}\frac{1}{2}\rho V^2(DL) \quad (38)$$

Squeeze Force Formula:

$$F_S = \mu VL(\frac{1}{S})^3 \quad (39)$$

Surface Force Formula:

$$F = \frac{dW}{Dx} = -2\gamma b \quad (40)$$

The parameters of liquid force are explained in table XIII.

Table XIII: The parameters of liquid force

Parameter	Value
$\lambda_{electrostatic}$	9.6×10^{-9}
$€_{electrostatic0}$	1×10^{-9}
$€_{electrostatic}$	150×10^{-9}
φ_{es}	80×10^{-3}
φ_{es}	50×10^{-3}
$\nu_{surface}$	74.23×10^{-3}
$A_{hydration}$	10.8×10^{-9}
$\lambda_{hydration}$	225000×10^{-9}
μ_{water}	0.015
η_{water}	0.015
ρ_{water}	1000
$V_{cantilevertip}$	100×10^{-9}

B. PSO-AS

We explain some parameters of PSO-AS and Genetic algorithms that know condition of algorithm are used. Important parameters of PSO-AS and Genetic algorithms are explained in table XIV.

Table XIV: The Parameters of Particle Swarm Optimization-Ant System and Genetic algorithms

Type Algorithm	Parameter	Environment (Nano-meter)	Value
PSO-AS	Iteration	(1000×1000)	1000
PSO-AS	Population	(1000×1000)	50
PSO-AS	Iteration	(2000×2000)	5000
PSO-AS	Population	(2000×2000)	200
PSO-AS	Iteration	(3000×3000)	10000
PSO-AS	Population	(3000×3000)	500
PSO-AS	C1	ALL	40
PSO-AS	C2	ALL	35
PSO-AS	C3	ALL	25
GA	Iteration	(1000×1000)	1000
GA	Population	(1000×1000)	50
GA	Mutation	(1000×1000)	5%
GA	Iteration	(2000×2000)	5000
GA	Population	(2000×2000)	200
GA	Mutation	(2000×2000)	5%
GA	Iteration	(3000×3000)	10000
GA	Population	(3000×3000)	500
GA	Mutation	(3000×3000)	5%

C. Predict Possible

When the algorithms are fail to find the answer that means there are no conditions without any collision. Two possible approaches to solving this problem (problem solving) as follows: a) Change the location of the particles (re-broadcast will be random). b) Shift pattern (placement of nano-particles can be moved to create a pattern). Considering the feasibility of the first method is not possible (if the player or the player may be placed in locations not specified). We use our second approach, shift pattern. It is easily to do.

Conclusion

In fact, in this paper we expressed how to create patterns using atomic force microscopy modeling algorithms in liquid and the vacuum environment. The results show that the shortest path algorithm have found based on the conditions mentioned above (non-colliding particles). Algorithm of birds maybe will converge faster, but may fall in local minimum, but genetic algorithm will converge later, but not be trapped in local minimum. The conditions for the two algorithms mentioned above. Scale test was conducted in 1000×1000 nm, 2000×2000 nm, 3000×3000 nm has shown good performance of both algorithms. The PSO-AS algorithm is shown regard less of the local minimum path length better than genetic algorithm (according to the conditions that had been expressed). Using the method described in this study, the particles move faster to create a model has been carried out using the optimal route for nano-particles. The advantages of our approach by stating that the nano-particles can be re-imaging or not imaging, because this requires more time and energy. Using the algorithm, reduce the required time and energy to create models and will find the best place for transmission of the particles. We can test models for high-speed devices without any damage done. Also for the nano-devices can be prevented from unwanted chemical reactions.

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