The Genetic algorithm simulation of liquid crystal cells

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The liquid crystals and their non-isotropic property made them interesting for wide range of industrial application such as displayers, filters and sensors. The phenomenon that appears in micro structure liquid crystal devices should be numerically simulated by CAD tools. Several approaches have been proposed for numerical simulation methods. Minimization of energy function by different methods such as Newton's method, global optimization, relaxation method and finite element method are used frequently. Genetic algorithm is an optimization technique based on evolution selection. This technique can be applied to determine the orientation of liquid crystals. It is more general and can solve more complex structures.

Keywords: Liquid crystal; Genetic Algorithm; Numerical Simulation; Energy Function; Optimization

Introduction

Making an optical device based on liquid crystals (LCs) requires a Compiled simulation of LC behaviour includes spatial variations director (tilt and twist angles), under applied voltage, boundary conditions in the LC cell. Hence, several approaches have been proposed to minimize the free energy function. Such as Newton method [1], global optimization method [2], relaxation method [3], are well known and popularly used in the research into LCD modelling. Also finite element method [4], is an analytical method can be used to obtain accurate results.

Among the reasons that we need to design a simulator that can set, is Lack of resources and the high costs of testing, trial and error. The contribution of numerical methods and results of practical electro-optic experiments could lead to design of an appropriate simulator. Be useful in many different modes.

In this paper we're going to use genetic algorithms to deal with this matter.

The genetic algorithm (GA)

Genetic algorithm as an optimization technique, which aims to identify all the genes, sequencing and analysis of system components based on the evolution selection. One advantage of this method is ease of use and a more general nature of the procedure. GA generally consists of three basic steps: ranking, reproduction and mutation. In this three-step process will result in the storage, data development and collection issues. This model helps us to identify and evaluate the relationships between genes. To do this we must first seek to determine the validity of each gene so an initial randomly generated population (Parents) is ranked for fitness by a particular cost function. Now we can choose the best genes with a specific plan, so the initial populations allowed to reproducing according to the principle of survival of the fittest.

After reproduction, mutations are introduced. Which leads to the development of relationships and data verification? This process will continue as a full cycle to get the best data. The results obtained are as children of a new generation of their parents, and have their own rank. The significant point here is that the children belongs to their parents.

Actually LCs are interest to have an orientation under the boundary conditions, electric field, etc. Here we use our GA model to simulate LCs. We consider the set of molecules within a cell as the LCs family. Families in addition to their internal order are partners in shaping the social system.

Consider the first case in which bulks randomly placed together. Then the boundary conditions, electric field, etc. are applied. We expect each of them to find the new situation neatly. The simulation must first determine the Rank of each bulk and put it in place their own. Note that this step does not make any change in the genome. This is shown in Figure 1.

Step I:

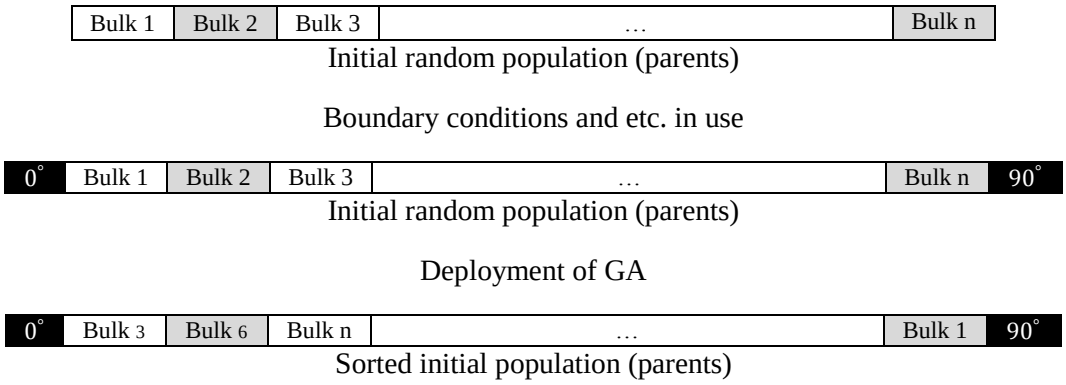


Figure 1

After the bulks were in place, it turns out to controlling relationship bulk members between each other and between family members nearby. So this time simulator with system microscopic examination and determine the rank and fitness of members, according to the principle of ‘‘survival of the fittest" will start reconstruction. This is shown in Figure 2.

Step II:

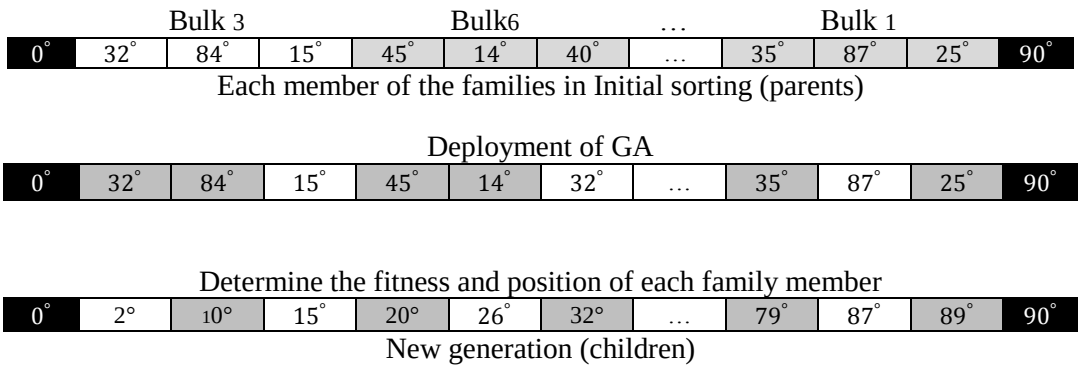
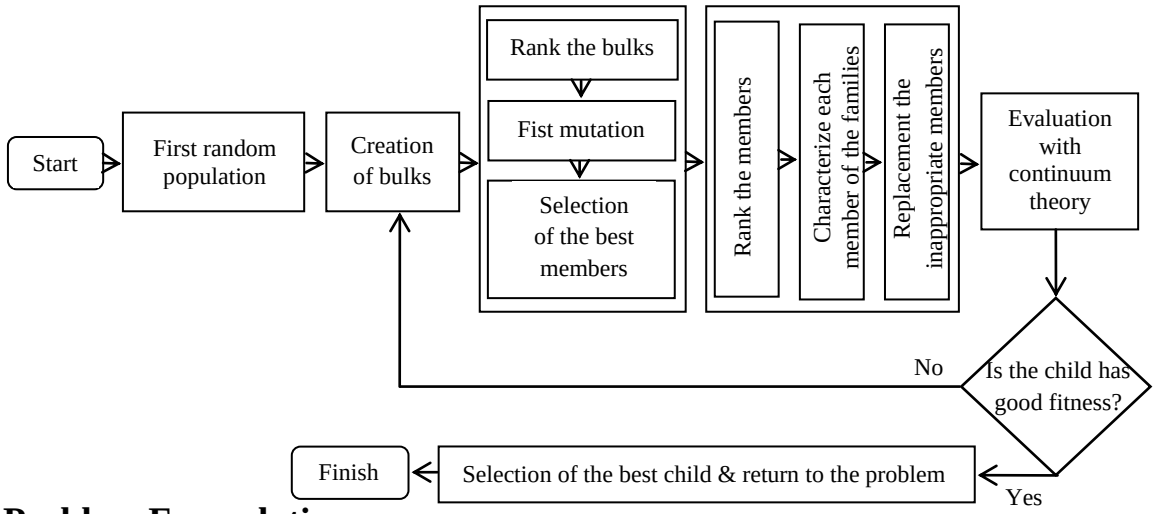


Figure 2

At each stage of this process is that the new generation has a higher fitness level than their parents. According to what we know of the Continuum theory, we can say that what relationship the bulks will have together, is very important. Therefore, simulator is forced to consider this matter and increase its accuracy on every step to ensure the best results. Flowchart program is defined as follows:



Problem Formulation:

In the present paper, we consider a two-dimensional model, the horizontal and vertical electrode of each pixel in the liquid crystal cell is assumed to be finitely large. Furthermore, we assume that the surface free energy can be ignored in the strong anchoring case, and we have the pretilt angle θ is fixed on the cell surfaces. We choose the z axis along the direction perpendicular to the horizontal surface of a nematic LC. The Ossen-Frank free-energy density *F* is given by the following expression:

$$F = \frac{1}{2}K_1(\nabla.\bar{n})^2 + \frac{1}{2}K_2[(\bar{n}.\nabla\times\bar{n}) + q]^2 + \frac{1}{2}K_3(\bar{n}\times\nabla\times\bar{n})^2$$

Here we can use the Euler–Lagrange method to minimize the total free energy. So the following equations must be satisfied at the minimal value:

$$\frac{\delta f}{\delta\theta} = \frac{\partial f}{\partial\theta} - \frac{d}{dz}\left(\frac{\partial f}{\partial\theta'}\right) = 0$$

To obtain a numerical algorithm, we discredited the above equation by central finite differences and calculate θ_i in an iterative way. The values of θ_i at the nth iteration are denoted by$\theta^n(i)$. Thus, we obtain

$$\theta'^n(i) = \frac{\theta^n(i+1) - \theta'(i-1)}{2\Delta z} \qquad \theta''^n(i) = \frac{\theta^n(i+1) + \theta'(i-1) - 2\theta^n(i)}{(\Delta z)^2}$$

Numerical Results

To illustrate the present method, we give a numerical example in this section for various types of conditions on a nematic liquid crystal with an asymmetric pretilt. We consider the square cells with dimensions of 10μm × 10μm. In this cell, the electric field does not apply and rotation of the liquid crystals is based on the boundary conditions. The boundary conditions are defined as pretilt at the left, right, bottom and the top alignment layer. We choose E7 LC with the following elastic parameters: $K_{11}=12\times10^{-12}$ N, $K_{22}=9\times10^{-12}$N, $K_{33}=19.5\times10^{-12}$N.

Example: In the first step, the boundary conditions are defined as follows:

```
Pretilt-L = (90)*pi/180;        % pretilt at left alignment layer
Pretilt-R = (0)*pi/180;         % pretilt at right alignment layer
Pretilt-B = (90)*pi/180;        % pretilt at bottom alignment layer
Pretilt-T = (0)*pi/180;         % pretilt at top alignment layer
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The calculated profiles as functions of position for the tilt angle for the E7 liquid crystal under different possibilities is shown in Fig.3-a and Fig.3-b, respectively.

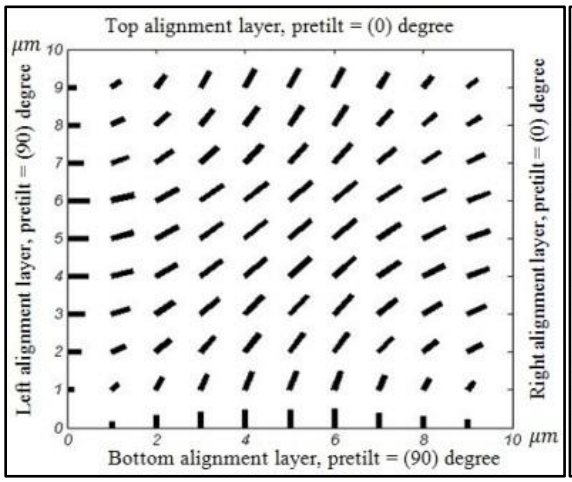

Fig.3-a

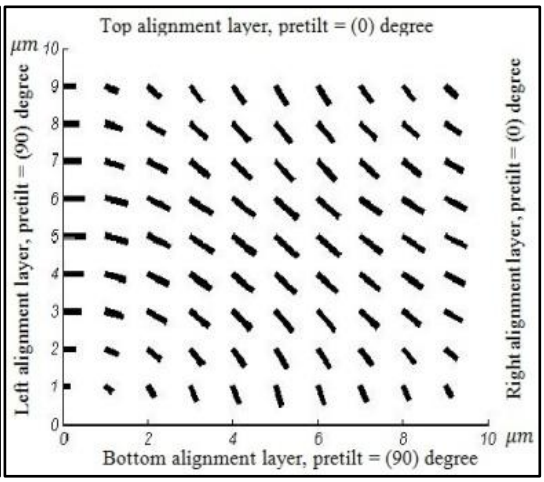

Fig.3-b

Anticipation 1: As can be seen in Fig.3-a, LCs are rotated from the bottom layer to right layer, same as the left layer to the top layer. In the corner of the junction of the two left and bottom layers same as the junction of the two right and top layers, liquid crystals are formed 45-degree angle. In the bottom left corner same as the top right corner two similar rotations in the opposite direction are came together, thus, formation of LCs in the cell along the cell diameter is the result of the superposition of these two rotations.
Anticipation 2: As can be seen in Fig.3-b, LCs are rotated from the left layer to the bottom layer, same as the right layer to the top layer. In the corner of the junction of the two right and bottom layers same as the junction of the two left and top layers, liquid crystals are formed nearly 45-degree angle. In the bottom right corner same as the top left corner two similar rotations in the opposite direction are came together, thus, formation of LCs in the cell along the cell diameter is the result of the superposition of these two rotations.

Conclusion

In the present paper, we have presented The Genetic algorithm simulation of liquid crystal cells. Numerical results have been presented for a symmetric LC cell, a nematic cell with symmetric pretilts. The present iterative finite-difference method is stable, simple, and fast. The method works well for various types of LC cell. The present numerical method can be extended to the three-dimensional case easily.

References

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