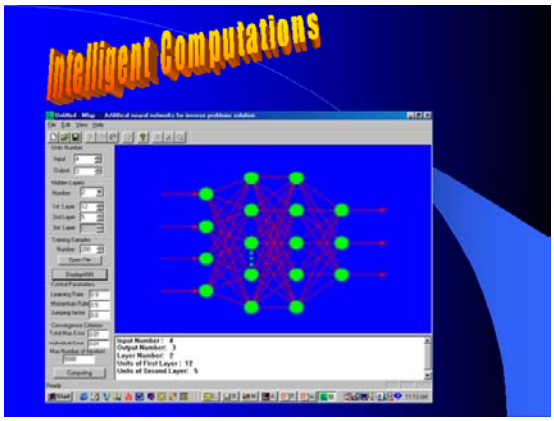
ARTIFICIAL NEURAL NETWORKS
FOR DETECTION OF CRACKS AND FLAWS

Codes Developed

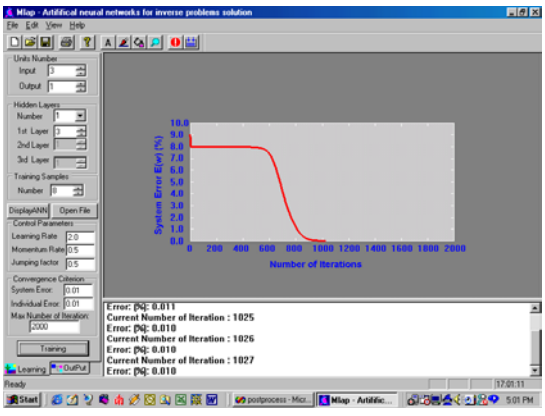
- **Mlap** Adaptive artificial neural networks package for detection of cracks and flaws in composite materials
- **FlawDec** Analysis of time-harmonic response and flaw detection for anisotropic sandwich plates

Application Non-destructive detection of cracks and flaws in composite materials

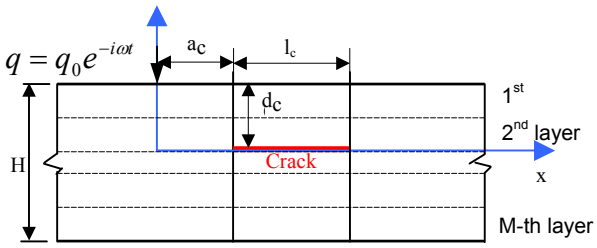
Artificial neural networks is one of the most popular intelligent techniques widely applied in engineering. Excellent properties in modeling non-linear problems and the robustness for noise environment make neural networks an ideal choice for the detection of cracks and flaws contained in composite materials. Application of neural networks is generally divided into two stages. The first stage is to train the neural networks with specified architecture by using the sample data that are obtained *a priori* from the forward solver. The second stage is to use the well-trained neural networks to generate the corresponding output by feeding in the measured signs. If necessary, the output can be improved by re-training the neural networks with adjusted sample data. Numerical examples on the detection of cracks in an anisotropic laminated plate are investigated, and the influence of noise in input signs on the detection result is also examined. This study shows the neural networks are very effective for the detection of cracks and flaws in composite materials.



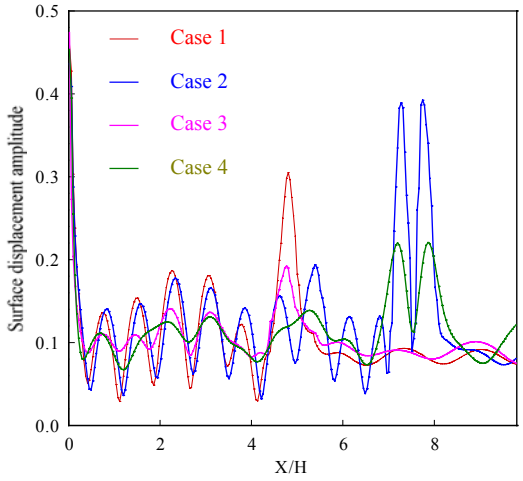
Intelligent computation – Neural networks technique



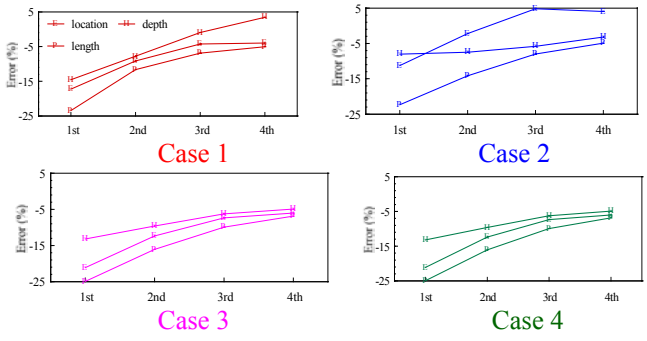
Convergence of neural networks in training



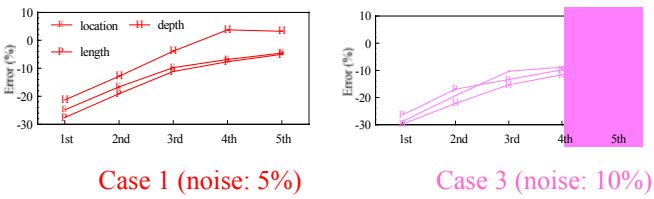
A M-layers anisotropic laminated plate with a horizontal crack



Surface displacement amplitudes used as the input of neural networks



Errors of crack parameters detected by neural networks when no noise involved in the response data



Errors of crack parameters detected by neural networks when noise involved in the response data

ADVANCED PHASE TRANSITION

Methods development: Improved Molecular Dynamics (MD) and Monte Carlo (MC)
Application : Magnetofluidic separators, sealing and damping devices, etc.

The relationship between the nature of the molecular interactions and the resulting **phase diagram** is the central theme of equilibrium statistical mechanics. Recent computations have provided new insight into the structural and orientating behavior of strongly interacting dipolar hard and soft spheres. The interactions are an isotropic Lennard-Jones (LJ) potential, which favors the condensation when the temperature decreases and an anisotropic dipole-dipole interaction potential, which tends to have a chain formation, i.e.

$$v(\mathbf{r}_{ij}, \boldsymbol{\mu}_i, \boldsymbol{\mu}_j)=4\varepsilon\{(\sigma/r_{ij})^{12}-(\sigma/r_{ij})^{6}] -3(\boldsymbol{\mu}_i\cdot\mathbf{r}_{ij})\,(\boldsymbol{\mu}_j\cdot\mathbf{r}_{ij})/r_{ij}^{5}+\boldsymbol{\mu}_i\cdot\boldsymbol{\mu}_j/\mathbf{r}_{ij}^{3}$$

where ε is the LJ well depth, σ is the LJ diameter, $\boldsymbol{\mu}_i$ is the dipole moment of particle i, and $\mathbf{r}_{ij}$ is the vector joining particles I and j. The first term on the right hand of the equation is the isotropic LJ potential and the second term is the anisotropic dipole-dipole interaction potential.
The main conclusions of the numerical investigation can be summarized as the follows.

(1) At sufficiently low temperatures a dense system of dipolar hard spheres (or soft spheres) can spontaneously break its symmetry and order into a ferroelectric state. Polarized domains (Fig.1) form in the presence of a depolarizing field.

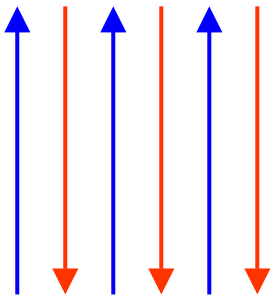


Fig1 Polarized domains. The arrows show the direction of the polarization.

(2) No evidence is observed for the existence of a gas-liquid transition (Fig.2) in a broad density-temperature range in contrast with general belief and a variety of theoretical predictions

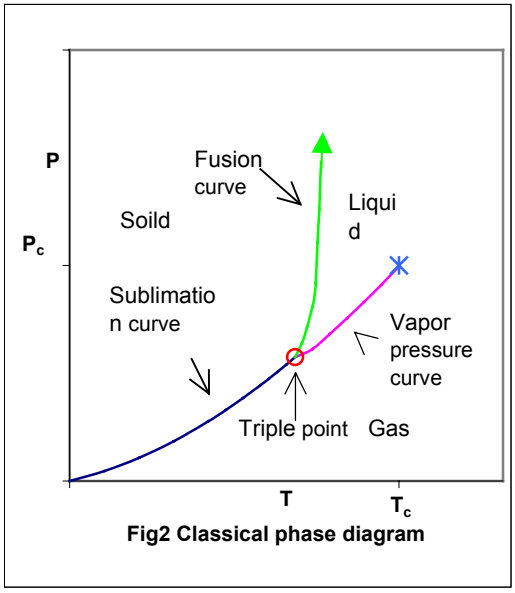


Fig2 Classical phase diagram

(3) Instead, the particles are found to be associated with the chainlike structures (Fig3) at its near contact of the hard spheres and head-to-tail alignment of the dipole moments.

Fig.3 Polymer like chain structures

However, it has been argued that the Gibbs ensemble Monte Carlo (GEMC) method used in some of these simulations is unreliable in the relevant regime of temperature and density. Thus, it is still a problem whether a condensation or a formation of polymer like chain structure is dominant at the low temperatures and densities.