The rotor of a magnetic bearing is suspended in the air gap by using permanent magnets or currents in the coils to generate magnetic force, which has the advantages of no friction, long life, high speed and high precision and so on. So magnetic bearings have been widely used in aerospace, medical instruments, rail transit and other fields. In traditional magnetic bearings, displacement sensors are often used to detect rotor displacements, which provide some problems such as high price, occupying space and increasing system structural complexity. To solve above problems, the self-sensing method is proposed to predict rotor displacements.

## Six-pole radial Hybrid Magnetic Bearing

- The six-pole radial hybrid magnetic bearing is mainly composed of a permanent magnet, two pieces of stator, radial control coils and rotor.

- Radial control coils on the corresponding two magnetic poles are connected in series and the winding directions are opposite, so that the six control coils can be driven by a three-phase inverter.

- The magnetic flux consists of bias flux and control flux, which are generated by the permanent magnet and the magnetization of the control coil, respectively.

### Displacement Prediction Model

- **FSVM**

  According to KTT condition and the Mercer condition, the prediction model of the SVM can be expressed as follows:

  \[
  y(x) = \sum_{i=1}^{N} \alpha_i K(x_i, x) + b
  \]

  Kernel fuzzy clustering (KFC) algorithm is used to blur the input training samples. And the objective function expression of KFC algorithm in high dimensional space is as follows:

  \[
  J(x, y)^{KFC} = \sum_{i=1}^{N} \mu_{x_i} d^2(x_i, y_i)
  \]

- **Mixed-kernel Function**

  \[
  K_\alpha = \frac{1}{K_1 + (1 - \lambda)K_2}
  \]

  where \( K_1 \) is the radial basis kernel function, \( K_2 = \exp(-\|x_1 - x_2\|^2/2\sigma^2) \), \( K_3 \) is the polynomial kernel function, \( K_3 = (\alpha x_1 + 1)^2 \), \( \lambda \) is the mixing coefficient, \( 0 < \lambda < 1 \).

- **Self-sensing Modeling**

  1. Acquisition and preprocessing of sample data for input and output variables.
  2. Initialize parameters.
  3. Determine if the particles meet the requirements.
  4. Produce the next generation population.
  5. Retrain and test the FSVM model.
  6. Output the predicted values.

### Experimental Results

- The initial displacements of magnetic bearing rotor is \( x=0.3 \text{mm}, y=0.4 \text{mm} \).

- In the floating period, the predicted values is closer to the actual values.

- So the prediction performance of the method proposed in this paper is good.

### Conclusions

- A self-sensing method using the mixed-kernel function FSVM is proposed to establish the rotor displacement prediction model of six-pole radial HMB.

- The prediction model between the currents of the control coil and the displacement of the rotor is established, which realizes the self-sensing control of the rotor.

- The predicted values is nearly equal to the actual values, which proves that the method can accurately detect the displacements of the rotor and realize the stable suspension of the magnetic bearing system.