Next, we calculate the sample entropy of each sample data set. Figure 3 shows the calculating values of sample entropy from different fault pattern. We can see that different fault pattern correspondence with different sample entropy. So we can diagnosis rotor fault by such feature.

Here, "·" denotes sample entropy of normal signal, "O" denotes sample entropy of unbalanced signal, "*" denotes sample entropy of misalignment signal, "+" denotes sample entropy of oil-film whirl signal and "x" denotes sample entropy of rubbing signal .

Figure 4 shows the sample entropy of original signal, we know that sample entropy from non-denoised signal can not distinguish different fault pattern. It is improved the importance of de-noising.

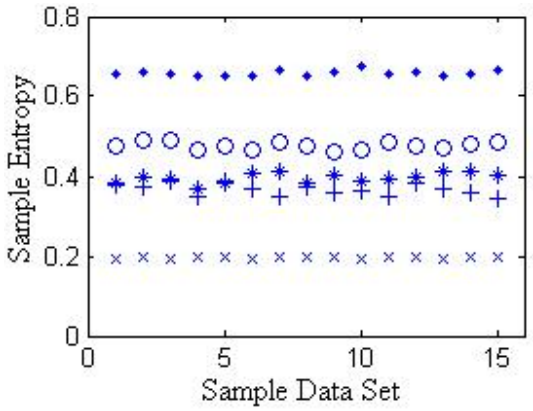

Figure 4. Sample entropy of five fault patterns before rank-morphological filter de-noising

VI. CONCLUSION

In this paper, we propose a new fault extraction method by using rank-order morphological filter and sample entropy. The rank-order morphological filter could eliminate noise interference before the further process of the sample data. And the sample entropy could serve as a good feature parameter for different rotor fault. Practical results show the good performance of the proposed method in feature extraction of rotor fault. It will supply a new method for fault diagnosis of rotating machinery.

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