§48. Analysis of MHD Stability Using Data Mining Technique in LHD Plasmas

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Data mining technique based on statistics, pattern recognition, artificial intelligence and information technology have been used in the areas of distribution and finance for business, and bio-informatics, astronomy and geology for science. Data mining techniques can extract new information because they are able to automatically pick out patterns in large amounts of high-dimensional data. We applied a data mining technique to analyze the fluctuation signals within a large database in order to identify MHD instabilities on Large Helical Device (LHD) plasmas. Moreover, the entry of information about MHD instability classifications into a database enables us to exactly and quickly investigates the characteristics of MHD stability through parameter studies. We successfully classified and identified the MHD instabilities in H-1[1,2] and Heliotron J plasmas[3] by the data mining technique. In this report, we will introduce the initial result of data mining for LHD plasmas.

We apply the data mining technique to magnetic probe signals with high sampling frequency, which can measure the Alfvénic MHD instabilities. We analyzed 117 discharges (shots) and use six magnetic probes belonging toroidal array. We use 1024 data points, which were used for the short time segments (Δt~1 ms). Figure 1 shows the phase differences of each magnetic probe. There are six clear different clusters (physically distinct modes with different poloidal and toroidal mode number m, n). The largest number of distinct modes, we have seen in one clustering before is five, on LHD dataset including both directions of magnetic field. Therefore there are only three physically distinct modes in that case. The catchall cluster of red which is all modes that are not clustered is relatively small (147 modes) about half of which are probably a separate modes, so less than 70 out of 1200 data points are not successfully clustered. This is also the highest success rate. The spreads in the phase within each cluster are quite small. The time evolution of clustered modes are shown in Fig. 2 for NBI heated LHD plasmas. The color in Fig. 2 corresponds to that of Fig. 1. The data mining found what appear to n = 2 MHD instability like energetic particle mode (EPM) of which frequency sometime chirps up and/or down because of nonlinear effect. The black dots, which do not stand out at all on the frequency time diagram. Figure 3 shows the time evolution of n=2 modes having strong frequency chirping down.

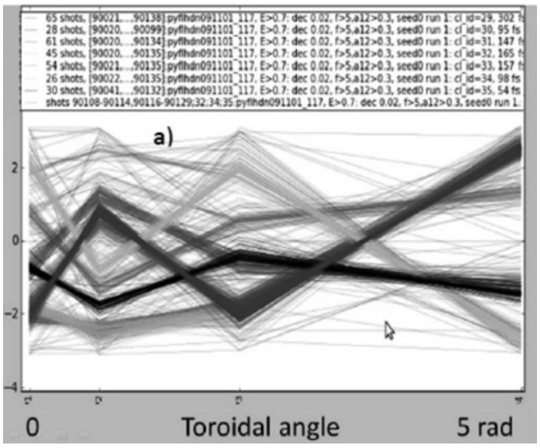

Fig. 1. Phase differences of each magnetic probe belonging toroidal array.

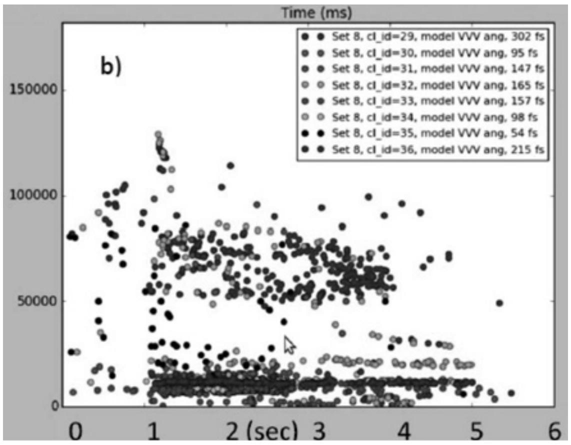

Fig. 2. The result of clustering of observed MHD instabilities based on singular value decomposition in LHD NBI heated plasmas.

We recently made a breakthrough with von Mises clustering of phase difference like Gaussian but allows for the angle to periodic in 2π. We can be identified using likelihood of multivariate von Mises distributions. We will apply this new technique to LHD data mining and construct data set including several kinds of plasma parameters for parameter study of MHD instability.

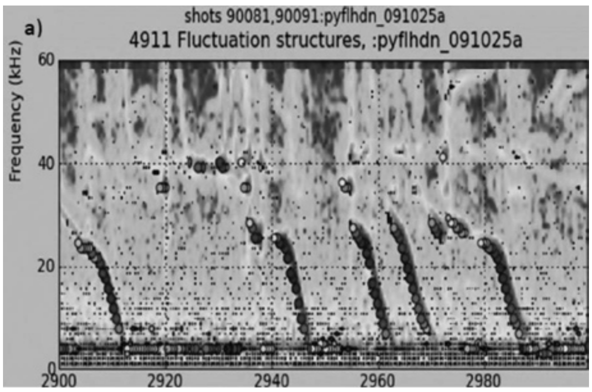

Fig. 3. The time evolution of clustered MHD instability with n=2 and strong frequency chirping down.

1) Pretty, D., and Blackwell, B., Comput. Physics Comm **180** (2009) 1768
2) Pretty, D., Ph.D. thesis, Australian National University, (2007).
3) Yamamoto, S., et al., to be published in Plasma Fusion Research (2010).