§36. Long-Time Real-Time Measurement of Plasma Parameters with Neural Networks

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In a long time discharge, real time measurement of plasma parameters and real time control are indispensable. Accordingly fast data acquisition, high-speed data processing, and rapid control output are necessary. As a method of the high-speed data processing, neural network is a best selection, since it may induce the results in a speed higher than the normal nonlinear processing.

The neural network is trained with teacher data of output raw signal (A) from a plasma parameter diagnostics and the processed results (B). The neural network may output (B) in real time during discharge from the input of (A). And we can bring up the neural network by adding teacher data pairs and training it again shot by shot. The training may be possible during the discharges in the long-time case. By adding (A) various data from other diagnostics, we can also make clear the correlations with the data (B). Namely scaling law of plasma parameters may be deduced.

First as a test we applied the neural network system to magnetic measurement in a long time discharge of circular configuration by 2.45 GHz LHCD on TRIAM-1M. In Fig. 1 is shown an on-line hard copy from a data processing system in TRIAM-1M, where delay time due to eddy current in the vacuum chamber is taken into account. In Fig. 2 is shown a off-line hard copy of a display in long-time real-time acquisition, calculation and display system of plasma parameters with neural networks. The network had been trained without taking the eddy current into account. It is a reason why the initial horizontal position does not coincide with the one in Fig. 1. The time resolution is not high since the sampling time is 10 ms, while it is 0.2 ms and the processing time is 0.8 ms in Fig. 1.

The operating system of the data acquisition and the signal output device is Windows NT and that of neural network training device (VT-α) is UNIX. AD and DA convertors can manipulate data at one point in time to take a real time system into consideration.

The magnetic data from magnetic coils for poloidal field, Rogowskii coil for plasma current, DCCT for poloidal field coil current are input via insulating amplifier, and the magnetic surfaces are calculated and shown on the display in real time. Instead of drawing contour lines of flux function, contour belts are painted for fast (real time) processing. Via 100BaseT, the data are transferred from the NT system to the UNIX system for data storage and real time training in case of long-time discharge.

A real time measuring and display program is coded with visual basic or C++, since the AD and DA convertors can be driven by the language and the language is good at drawing the results on the display. A training program is coded with Fortran or C, since the α-based languages without emulator are available. The real time measurement system may be applied not only to the magnetic data processing but also to the Langmuir probe data analysis, plasma cross-section image processing, etc.

Finally this system is applied to the long-time real-time measurement of the plasma parameters on LHD. In order to apply to fluctuation and correlation measurement, we have got fast AD convertor, which can input data at not one point but plural temporal points. In order to try deduction of scaling law, we have increased the number of slow but multi-channel AD convertors. In order to prepare shortening of cycle time, we have got a starter's kit of DSP (Digital Signal Processor), since AD, CPU and DA are installed on the same board and the cycle time is shorter.

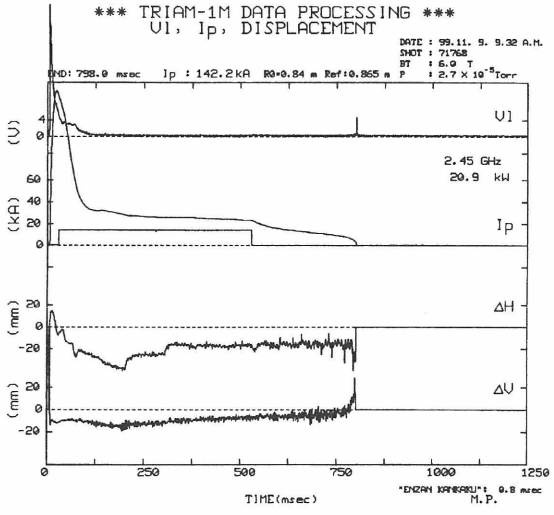

Fig. 1. An on-line hard copy from a data processing system in TRIAM-1M.

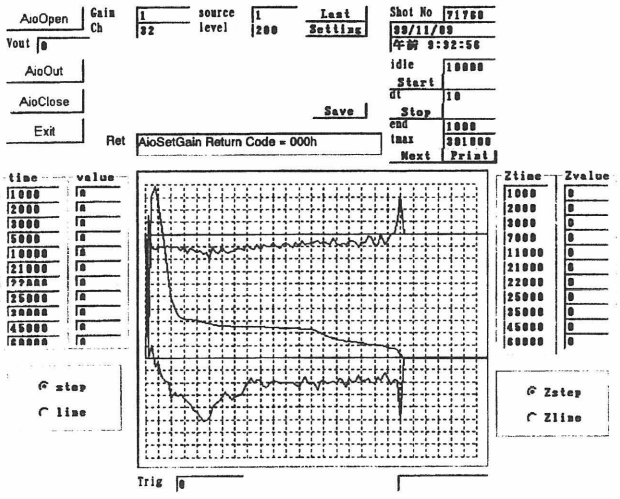

Fig. 2. An off-line hard copy of a display in neural network system.