DATA ACQUISITION AND REAL TIME TOMOGRAPHY DIAGNOSTIC USING LABVIEW REAL-TIME AND MULTICORE TECHNOLOGY

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The currently available multi-core PCI Express systems running LabVIEW RT (Real-Time) and FPGA cards greatly shorten the design and implementation cycles of large scale, real-time data acquisition and control systems. This paper details a data acquisition and real-time tomography diagnostic system using LabVIEW RT for plasma diagnostic in an existing tokamak (Max Planck Institute for Plasma Physics, Garching).

The temperature rise of the bolometer foil, due to radiated power from the plasma heating the 4 micron thick platinum absorber, is measured as a voltage difference on a Wheatstone bridge [1]. Using an AD 7730 (Analog Devices) for the measurement of each bolometer bridge voltage and a 19-inch rack with 32 channels, the digitized signals of up to 128 channels can be transferred serially to a single PXI 7813R FPGA card with 4 x 40 DIO connectors. The absorbed power of the bolometer foil, which is a weighted sum of the raw data and its filtered time derivative, is calculated in real time on the FPGA. The fixed-point differentiator filter for the FPGA was generated using the LabVIEW Digital Filter Design Toolkit. The incident power to the measurement foil is then given by [2]:

$$P_{rad} = \frac{2}{U}(R_{OH} + 2R_C)\kappa\left[\tau\frac{du_d}{dt} + u_d\left(1 - \frac{U^2}{4\kappa(R_{OH} + R_C)^2}\right)\right] \quad (1)$$

where u_d is the amplitude of the measured signal. During the discharge the raw data is processed using Equation 1 to calculate the power flux to each of the 128 bolometer foil absorbers in real time. The radiation peaking factor is also calculated in real time and is used for feedback control of the discharge. The real time soft X-ray tomography is performed with LabVIEW RT. The transformation matrix is pre-computed based on the geometry of distributed X-ray sources and sensors (Fig. 1). A parallelized iterative algorithm is adapted to solve a constrained linear system for plasma reconstruction diagnostic.

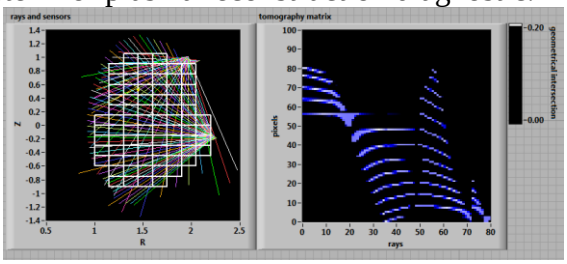

Figure 1: The design of tomography transformation matrix (right)

We report performance numbers for an X-ray tomography system based on the order of 100 rays and an equal number of pixels (plasma densities). Using multi-core machines the entire cycle time is well below 1 ms.

[1] K.F.Mast, J.C.Vallet, C.Andelfinger, P.Betzler, H.Kraus, G.Schramm, A low noise highly integrated bolometer array for absolute measurement of VUV and soft X-ray radiation, Rev. Sci. Instrum, Vol. 52, 1991, pp. 744.
[2] L.Giannone, K.F.Mast, M.Schubert, Derivation of bolometer equations relevant to operation in fusion experiments, Rev. Sci. Instrum, Vol. 73, 2002, pp. 3205.