JET Facilities

Protection of the ITER-like Wall

Development of an algorithm to eliminate neutron hits from a raw image

Neutron hits typically present themselves as a saturated single pixel. The standard algorithm to deal with such kind of noise in images is the median filter. This filter replaces the pixel under test with the median of a window, typically, with 3x3 pixels and the test pixel in the middle. This yields a relatively blurred image, but effectively clears the noise.

The proposed algorithm is a modification of the median filter. The 3x3 pixels are sorted according to their intensity, forming an array. In the standard median filter, the value at the middle of this array is put in the image. In this new filter, only if the original center pixel is at one of the edges of the array, is the median value taken. If not, then the pixel remains with its original value.

The advantage of this algorithm is that most of the image data remains untouched. Only where the pixel under test is the brightest or darkest of its vicinity does it suffer a change.

Practical tests reveal that the proposed algorithm handles single pixel neutron hits as well as the median filter, while preserving image detail on other areas. However, it has been found that this algorithm fails to remove neutron hits that affect two or more pixels. In this case, the median filter, being more aggressive, is more suitable.

Intershot CSI program

The Intershot Camera Status Information program was developed to provide information about the camera status in between JET pulses.

This program has several functionalities:

- Provide new alpha matrices, if they are required
- Provide new dead-pixel maps, if required.
- Provide information for the VSO (Visual Systems Operator) to decide if the new matrices/maps are to be implemented.
- All data is displayed on a GUI

Each pixel's digital value (DL) is modeled by a simple linear relation:

$$DL = \beta I + \alpha$$

where I is the light intensity in arbitrary units, β is assumed to be 1 and α is the electronic noise obtained when the sensor is not illuminated. For each camera, one has a matrix of α values.
Over time, the sensor degradates which is mainly noticed as an increase in the α values. For this reason, they have to be monitored and, when the alpha matrix is significantly different from the previous, it must be updated.

With the degradation of the sensor, some pixels become dead, or non-responsive.If they are non-responsive and stuck at low DL, their contribution should be masked by the α matrix. If they are stuck with a high DL, they must be removed. This is the role of the dead-pixel map.
If the average α value for a given camera is above half the 8-bit DL range, the camera is flagged as bad and requires replacement.
The program does not update the files with the α matrices automatically. The VSO is responsible for monitoring the flags as they appear and take appropriate action.
This program provides a tool to display the previous α matrix as well as the proposed one from the new data and their difference between both. It can also save the proposed α matrix as a file to be copied to the camera server.

A wiki page detailing how to use the program was also developed for the VSO's reference and can be found at http://users.jet.efda.org/openwiki/index.php/Intershot_CSI.

PIW Camera Calibration

Camera calibration consists on producing a map that converts the digital level (DL) values of the camera pixels into surface temperatures of the materials to monitor.

The PIW cameras are to monitor the new ITER-like wall at JET which has tiles of 3 different materials: bulk tungsten (W), tungsten-coated Carbon (WcC) and Beryllium (Be).

In the Lab, a black body source was used to provide the relation between temperature and DL for a few temperatures, on each camera, for the two filters which are to be used in JET, 1016nm with 10nm bandpass and 980nm with 60nm bandpass.

For each set of temperature, filter and lens F#, a 100 frame movie was produced.

The program developed takes these movies, detects the hotspot region caused by the black-body source and also detects the background region. Taking the average of the 100 frames in each of the regions, and removing the background value from the hotspot value, the relation between temperature and DL is found. Using Planck's Law, the relation between DL and Planck radiation is found to be linear.

For the lab measured temperatures converted to Planck radiation values and video signals, a linear fit is then performed. The applied fit imposes crossing the origin. It is performed on all the available data for each camera and filter, since the F# is normalized. Due to video signal saturation, some points have been removed from the fitting procedure.

For a set of temperatures from 400 to 3510 K, the expected video signal is calculated, based on this fit. This calculation also takes into account the 3 different materials.
It is known from other sources that W requires a temperature dependent calibration, while the Be and WcC have a fixed relation.

This relation from temperature to DL is then inverted, using interpolation to obtain temperature as a function of video signal. Wherever the video signal value would go below the minimum on the initial set of temperatures, it was truncated to the nearest valid value. Wherever it would go beyond the maximum, it was linearly extrapolated from the last two points. Due to VTM (Vessel Thermal Map) restrictions, the temperatures are rounded to the nearest multiple of 4.

ITER FPSC

MARTe interconnectivity via SDN

Using a IOGAM which was developed for communication via SDN, two MARTes were connected and data sent from one to the other and back again.

One MARTe running on the FPSC-PSH computer simulated data acquisition, by loading a data file with magnetic data from the last C27 JET pulse. This data was then sent over the SDN to the FPSC-HPC computer where the Felix algorithm is running as a MARTe GAM. This algorithm takes raw magnetic data and determines the distance of the last closed flux surface (LCFS) to each of the magnetic probes, called gaps. It also determines if an X-point is present, its location and the 4 strike points on the divertor.

All this data is transmitted back via SDN to the FPSC-PSH computer. It can be acquired by MARTe and then stored, or acquired by an EPICS IOC which converts the gaps into coordinates which were then used as a PV to plot the LCFS on a CSS panel.

The FPSC-PSH sends one data packet every 50us. The FPSC-HPC, takes about 150us to run the Felix algorithm, which makes it lose every 3 in 4 packets, but is still more than enough for human monitoring.

MARTe ATCA-IOP IOGAM

Assistance was provided in the development of the GAQCM for the new ATCA acquisition boards. This module is providing timing data and all 48 channels with error to MARTe.

In polled mode, it can provide a new data packet every 50us, with a jitter of 10us. In triggered mode, only one every 4 packets is received and sometimes it even misses more. This is a strange behavior, but it may be due to a mismatch between MARTe's trigger and the hardware trigger.

Given that the device driver for these ATCA boards always runs in triggered mode, this difference from polling to triggering inside MARTe is only a software problem. It should be solved early in 2012.