YUI and HANA: control and visualization programs for HRC in J-PARC

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Abstract. We developed control and visualization programs, YUI and HANA, for High-Resolution Chopper spectrometer (HRC). YUI is a comprehensive program to control DAQ-middleware, the accessories, and sample environment devices. HANA is a program for the data transformation and visualization of inelastic neutron scattering spectra. We describe the basic system structures and unique functions of these programs from the viewpoint of users.

1. Introduction

High Resolution Chopper spectrometer (HRC) is an inelastic neutron chopper spectrometer to investigate elementary excitations of spin and orbital fluctuations in strongly correlated electron systems with high energy resolution. Recently it is used also for the study of hydrogen atoms in a solid. HRC is installed at BL12, in Materials and Life Science Experimental Facility (MLF), J-PARC [1, 2]. Basic accessories including vacuum chamber, T0 chopper, Fermi chopper and Soller collimator, and minimal sample-environmental devices had been prepared until 2010, and then we have constructed computing system and developed software environment to control these devices and to handle neutron signals obtained from detectors. Comprehensive-control program YUI and visualization program HANA have central roles in the software environment. In this paper, we firstly explain the configuration of the computing-system which underlies the two programs. Next, we explain basic constructs and unique and characteristic functions in YUI and HANA.

2. System configuration

The HRC computing system consists of six Linux-based machines (PC), three network-attached storage (NAS) machines, and four switching (SW) hubs, as shown in figure 1. For every PC

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except the FL-net gateway, which is only communicated with the vacuum-chamber controller, DAQ-middleware (DAQ-MW) [3] was installed.

The roles of these machines are as follows. Two DAQ-CPU machines collect the event data generated from the position-sensitive detectors (PSD) via the NeuNET modules [4]. The number of the machines is determined by taking into account the total number of PSDs (324 PSDs as in Mar. 2017). The obtained event data are stored to one NAS machine. This sequent process is controlled by the DAQ-operator machine, on which the program YUI simultaneously runs. The versatile server machine aggregates and logs statuses from the devices. Its communication mechanism is described in the following section. The analysis server machine behaves as a CPU of the program HANA.

These machines are linked via the three independent HRC-intranet networks, i.e., storage LAN, control LAN, and analysis LAN, and the other J-PARC network infrastructure, called JLAN. They play roles in handling the obtained event data, intervening between the computing system and all the controllable devices, processing the data visualization, and connecting to the internet, respectively.

In our computing system, a client-server model is adopted for the convenience of users. YUI and HANA are respectively available as the terminal in two iMac PCs in the user’s room of the HRC cabin. Users do not need to operate the Linux machines directly.

![Diagram](image)

**Figure 1.** Schematic diagram of the computing system in HRC. Open and hatched round-squares denote common-use accessories and sample-environment devices, respectively.

### 3. YUI

The comprehensive control program YUI is the abbreviation of *Yasashii* or *Yoku-dekita* User Interface. Here, these italic words are Japanese which means friendly or easy, and well-constructed, respectively. YUI allows users to perform the measurement by sequential operation
of DAQ-MW, to control the devices, and to log their status. The main window of YUI is shown in figure 2.

The most basic function is a measurement by DAQ-MW, so-called “DAQ Run”. By sending “begin” and “end” commands to DAQ-MW, one measurement is completed. On YUI, DAQ Run is implemented as the built-in macro, called “user-command”. Other than DAQ Run, several user-commands to control the accessories such as the Fermi Chopper have been prepared. Users can perform their experiment by editing and executing a sequence of appropriate user-commands.

To control the accessories, of which their communication protocols are different, we developed a “device server,” a virtual machine which intervenes between YUI and the corresponding device. The installed device servers work for DAQ-MW, MLF server, Fermi chopper, Soller collimator, oscillating radial collimator, goniometer and temperature controller. Here, the MLF server is regarded as the accessory, to obtain the number of protons injected to the neutron production target between the beginning and completion times of DAQ Run. The number of protons is used to normalize the observed neutron intensity on HANA, as below. The device servers of the last two are prepared for each set of sample-environment devices, such as the GM-type refrigerator and the $^3$He circulation-type refrigerator [5]. Users activate and connect their required device servers on the device-server list subwindow as shown in figure 2.

Set and current values of the devices are continuously monitored and recorded to the log files every 5 seconds. The obtained log data can be graphically displayed on a browser page named “Log-visualizer”. This helps users to check the time variation of the current values of the devices, such as stability of the phase of the Fermi chopper. The details are described elsewhere [6].

Figure 2. The main window of YUI. It consists of three subwindows: list of activated device servers (top-left), sequence edited by users and its progress status (top-right), and messages communicated with devices, called system log (bottom).

4. HANA

HANA (HRC ANAlyzer) is a data-reduction program for the initial data handling and the data visualization. The basic flow is creation of intensity-histogram data from the event data,
sequent reduction of the histogram data, and visualization of the dynamical structure factor in four-dimensional space.

One detected neutron is treated as a data set labeled with three parameters of \((d, p, t)\), where \(d\), \(p\), and \(t\) denote the PSD number, position on the PSD, and time of flight (ToF) of the neutron, respectively. Here, \(p\) is given from the ratio of the electrical pulse heights at the upper and lower ends \([3]\). The parameters \((d, p)\) can be regarded as the geometric coordinate on the PSD array. From the data set \((d, p, t)\) and the incident energy \(E_i\), the energy transfer \(\omega\) is calculated. This calculation is executed for each neutron and then the intensity-histogram data of \(I(d, p, \omega)\) is created. Here, the observed value of \(E_i\) can be determined by a simple fitting procedure on HANA.

The dynamical structure factor in four-dimensional space can be visualized in two patterns. One is for a single-crystal. The momentum transfer \(Q\) has the reciprocal-lattice coordinates of \((Q_a, Q_b, Q_c)\). Their directions are defined from the given lattice parameters. Users can visualize a two-dimensional intensity map, on which two of the four parameters \(Q_a, Q_b, Q_c\), and \(\omega\) are selected as vertical and horizontal directions. The other pattern is for a powder sample. The momentum transfer is simply regarded as \(|Q| = Q\). Users can visualize an intensity map of the \(Q-\omega\) plane.

As unique functions of HANA, the histogram data can be transformed to a data format of the visualization program DAVE MSlice \([7]\). The alignment support function is convenient and indispensable in the beginning of single crystalline experiments. From a Laue profile measured by a white beam, users can obtain the information of the relation between the coordinate of the crystal and that of the spectrometer with an easy procedure. The details of the procedures are described elsewhere \([6]\).

5. Summary
We have developed the control program YUI and the data-analysis program HANA for HRC spectrometer. They have been improved day-by-day for convenience of users and instrument staff members. The hardware of HRC is always updated; for example a new Soller collimator has been installed for more neutron flux, and a new device for sample environment will be installed in future. YUI also evolves with the progress of the hardware. On the other hand in HANA, we are planning to implement a functions of the analysis for four-dimensional data obtained from the continuously rotation scan of a single crystal.

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