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DIAGNOSIS APPLICATION BY GREAT AMOUNT OPERATION DATA ANALYSIS PROGRAM FOR TAIWAN PHOTON SOURCE

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Abstract

To find out abnormal situations of the machine for preventive maintenance or machine trip tracking or instability source diagnosis, a large amount of operating data in an accelerator is thus can be used to build a series data analysis program. When the archived data is classified accordingly, the standard deviation (STD), peak-to-peak value and other statistic indexes within the inspection time zone by the belonging families can be used to point out the especially abnormal signals. The analysis program adopts the techniques of parallel calculation and memory optimization to greatly reduce the time for data transmission and analysis and also displays the correlation signals to operators for deeper analysis. This paper illustrated a simple yet effective method for quickly identifying a not-so-obscure hardware issue by simply using a personal computer (PC).

INTRODUCTION

TPS has officially opened to users since Sep. 2015 and there are still many machine trips or unstable problems that are difficult to be completely analysed or solved. Adopting new method to find out the problem source is always the working target of the operators.

The data storage of TPS is mainly in RDB (Relational Data-Base) SQL database by using PostgreSQL [1] and the typical text type data stored in ASCII format. The frequently used data browsers in NSRRC are CSS (Control System Studio) [2], Archive Viewer [3], History [4]. These tools are not only used to compare the correlation with certain signals but also employed for multi-channels plotting generally, such as 7-20 channels data acquiring at once. For much more data acquisition like tens to hundreds of channels, that would take large time consuming and manual build channel-correlations difficultly.

The storage ring of TPS is a complex machine which composed with 174 Beam Position Monitors(BPMs), 249 quadrupole magnets, 168 sextuple magnets, 168 skew quadrupoles, 336 slow correctors and 192 fast correctors, respectively. . Currently, all similar magnets be turned off within a transient time, using the diagnosis tools in operation would consume huge amount of time to find out the problem.

Reducing the time of diagnosis can prevent the repeated events of beam trips, and make sure the availability and reliability of the accelerator. Hence, the fast and automatic diagnosis tool is developed and reported.

SOFTWARE FUNCTIONS

To find out abnormal points from numerous signals, the "TPS distributed signal checker" equipped sub-programs with four kinds of signal groups for the checking of machine events:

1. BPM Checker
2. QPS/SPS (quadrupole and sextuple power supplies) Checker
3. Fast Corrector Checker
4. Slow Corrector Checker

For BPM Checker, the program will be executed as follow steps: 1. select the time interval, 2. select the data base (1-Hz or 0.1-Hz sample rate), 3. press "Take data" button then the program acquires the close-beam orbit from 172 horizontal and vertical BPMs and plots the orbits with the stored beam current. After the procedure, the average value, standard deviation error bar, STD and peak-to-peak value for all BPMs would be plotted with the corresponding BPM positions of the beamlines. The PV name (name of Epics Process Variable) of the characteristics BPM can be symbolled by clicking the marked function. The time trend of these BPMs would be plotted at bottom graph, and the abnormal pattern is displayed. The graphical interface is shown in Figure 1.

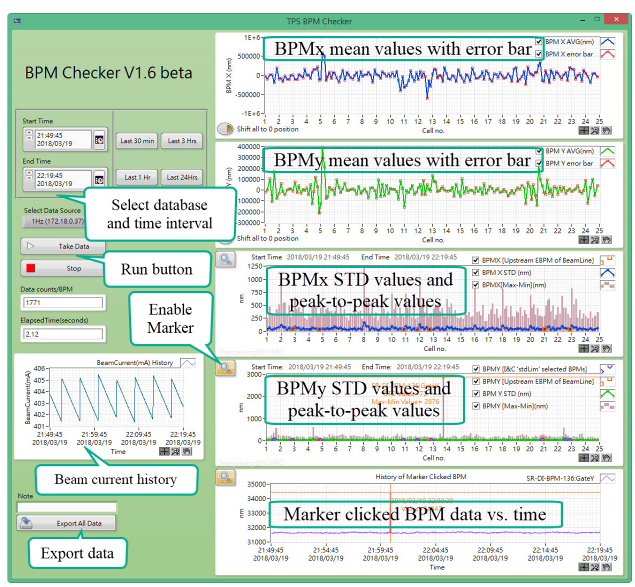

Figure 1: The graphical interface of BPM checking software.

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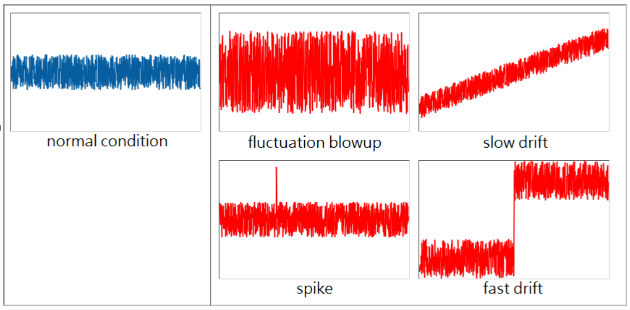

Figure 2: Display of signals in the TPS SR when abnormal conditions.

The triggered points of the statistical data are usually causing by below four kinds of variations as shown in Figure 2:

1. Spike
2. Slow drift
3. Fast drift
4. Fluctuation blow-up

These variations would cause the increasing of the STD value. The peak-to-peak value mainly indicates the behavior of the spikes. If the selected time interval is longer in statistic view, the single spike would not be observed easily.

The stored beam current would always be displayed as executing the program to ensure the fixed condition. The progress bar showed the required executing time and the proceeding could be cancelled and froze anytime. After acquiring data, the data would be saved in the memory temporarily for marking and displaying the history data of the characteristic channel rapidly. At the history data of the specified channel, the cursor can check the time and the value. Moreover, the BPM acquirements are blocked during beam injection due to the serious beam perturbations. The beamline users avoid to collect data during beam injection.

CONSTRUCTION CONCEPT AND PROGRAMMING SKILL

Parallelized data acquisition is the most significant characteristic in this scheme which can greatly reduce the total time of data query. In the general codes of SQL, “union” can accomplish the function of connection by query various instructions at once but it cannot apply systematic sequential sorting. The processing time would be extended when the data of each channel is acquired by sequential commands. The developed program adopts the unique “For loop iteration parallelism” configuration of LabVIEW and the setting is shown in Figure 3 where sets “Number of generated parallel loop instances” as the number of execution in PC. For example, the value can be applied value “8” into the PC which means multi-thread 4 cores CPU for calculation. The executing speed can be improved significantly comparing with single execution thread. The result of processing time for 345-channels acquiring is listed in Table 1.

The actual block diagram of parallelized data under LabVIEW is shown in Figure 4.

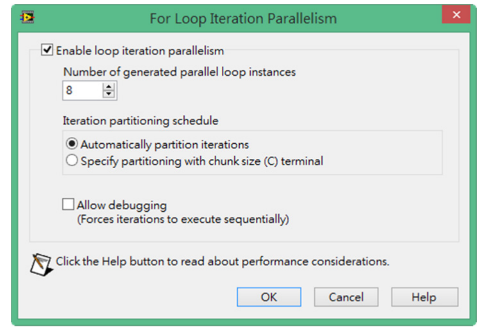

Figure 3: The key setup page for setting parallelism execution in LabVIEW.

Table 1: Time Consumption Bench Mark

data interval	8 threads elapsed time	1 thread elapsed time
30min	2.3s	25.4s
1hr	3.8s	35.8s
3hrs	9.2s	73.7s
8hrs	22s	135.5

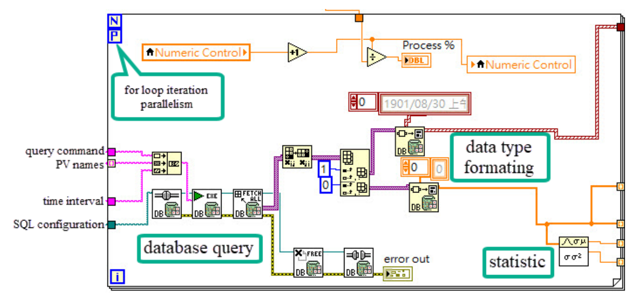

Figure 4: Parallel database query in LabVIEW.

CASE STUDY

There is a real machine event at the day of 2018/3/6, TPS fast orbit interlock (FOFB) triggered to cause abnormal action and beam tripped. In this event, several beam correctors outputted the maximum current 10A rapidly for the beam orbit compensations. Then, the serious orbit deviation over the limit of orbit interlock to lead the whole system trip. By using the inspection of “TPS QPS/SPS Checker”, the output of QS5-0705 power supply showed a different current comparing with the output current of other quadrupoles. A 0.15-A peak current from QS5-0705 power supply was observed as shown in Figure 5. This event is sufficient to shift the tune of the normal users operation mode in the TPS. After confirmed by Archive Viewer program as shown in Figure 6, the estimated machine trip sequences should be described as below: QS5-0705 had spike → the variation of tune in Y-axis, orbit changing→ FOFB react but resulting in divergent due to too much changing instantly → fast corrector output grew up gradually with large orbit drift→ orbit interlock activated and beam trip.

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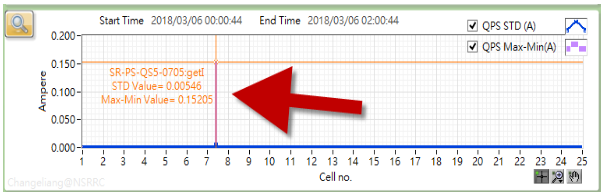

Figure 5: Find out the problem by "TPS QPS/SPS Checker".

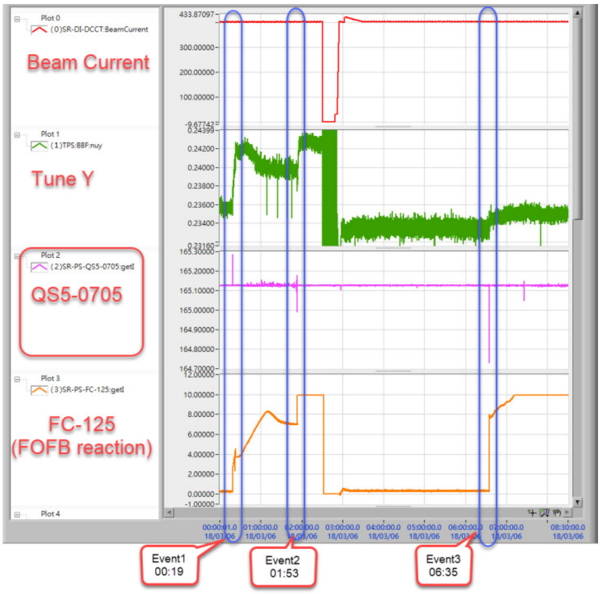

Figure 6: Confirming the trip history by Archive Viewer.

After mechanical inspections, the event was caused by the power cable connector burning between power supply and the quadrupole magnet. Figure 7 shows a photo of the damage status in this cable connector. In this case, although the FOFB system can lock the beam orbit, it still cannot suppress the faults from hardware. For finding the sources in actual issues, FOFB perhaps makes a misjudgment to cause the abnormal output current into fast correctors. Nerveless, we presented this program, the actual problem can be diagnosed quickly to shorten the diagnostic time, and prevent the repeated problems for improving the availability and reliability of the accelerator.

Figure 7: The burn out of the cable terminal of QS5-0705 causing spikes.

CONCLUSION

The program is mainly focused on a short-term-faulty diagnosis. The algorithm of decision tree would be implemented as machine learning for the development of a long -term diagnosis tool for accelerator in the future.

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