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Pixelman: a multi-platform data acquisition and processing software package for Medipix2, Timepix and Medipix3 detectors

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ABSTRACT: The semiconductor pixel detectors Medipix2, Timepix and Medipix3 (256x256 square pixels, 55x55 μm each) are superior imaging devices in terms of spatial resolution, linearity and dynamic range. This makes them suitable for various applications such as radiography, neutronography, micro-tomography and X-ray dynamic defectoscopy. In order to control and manage such complex measurements a multi-platform software package for acquisition and data processing with a Java graphical user interface has been developed. The functionality of the original version of Pixelman package has been upgraded and extended to include the new medipix devices. The software package can be run on Microsoft Windows, Linux and Mac OS X operating systems. The architecture is very flexible and the functionality can be extended by plugins in C++, Java or combinations of both. The software package may be used as a distributed acquisition system using computers with different operating systems over a local network or the Internet.

KEYWORDS: Detector control systems (detector and experiment monitoring and slow-control systems, architecture, hardware, algorithms, databases); Data acquisition concepts

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Contents

1 Introduction

The detectors Medipix2 [1], Timepix [2] and Medipix3 [3] are semiconductor single photon counting ASIC chips of the Medipix family which have developed in the frame of the Medipix collaboration [4]. These hybrid silicon pixel detectors consist of a sensor chip with 256 x 256 square pixels of 55 μm size each and a read out chip containing an amplifier, discriminators and counters for each pixel.

Both the arrival of Medipix3 chip and of new readout interfaces such as FITPix and Flatpanel give the need for a significant upgrade of the current data acquisition software, Pixelman [5]. Moreover, increased complexity of experiments involving the use of various devices and different equipment, as well as different software platforms requires that the data acquisition (DAQ) software tool be used on different operating systems. Also, the possibility of controlling the software remotely plays an important role in specific experiments.

This paper describes the upgrade and extensions made to the software in order to support new hardware, improve user interface compatibilities, and to make the software multi-platform and controllable from distance over network.

2 Software architecture

The Pixelman software package is designed to control complex experiments (data acquisition, stepper motor, online data analysis, tomography, . . .) with radiation imaging devices, mainly with the Medipix and Timepix chips. The package has a very flexible modular architecture (see figure 1) that can be extended by plugins (i.e. additional software that extends functionality).

Hardware Libraries communicate through a variety of readout interfaces (USB [6], MUROS, FITPix, FlatPanel, . . .) with Medipix, Timepix and other devices. Each hardware library creates a common interface which allows the *Control Library* (see below) to access the devices in a readout interface independent way.

Medipix Control Library handles all connected Medipix and Timepix devices through the hardware libraries. This library provides synchronised access to these devices, including acquisition control, data buffer handling and configuration management. The library also provides event notification of the acquisition progress.

Pixelman Manager handles all C++ plugins management, enables plugins to access the *Control Library* and provides synchronisation and communication required between plugins. The manager also maintains registered functions, events and filter chains.

C++ Plugins can control experiment specific hardware (e.g. stepper motor, X-ray tube, etc) and can perform data processing or even to control the entire experiment. They have access to Control Library functions as well as other plugins functions. The plugins can register events or be notified about the events. Multi platform plugins extend or enhance software functionality but provide no user interface. The windows plugins can provide a user interface that is only compatible with the Microsoft Windows operating system.

Java Wrapper loads the Pixelman C++ core (the manager) and creates an interface between C++ core and the Java based part. This tool allows Java plugins to use the same functions as the C++ counterparts.

Java Manager takes care of loading and initializing the Java plugins as well as registering and propagating events to the Java plugins.

Java Plugins can extend Pixelman functionality in the same way as C++ plugins. However, in contrast to C++ plugins these can offer multi-platform user interface compatibility in Java.

3 Medipix3 support

In comparison to Timepix and Medipix2 detectors, the Medipix3 chip is a more complex, feature-rich and highly configurable chip. Consequently, this imposes new requirements on acquisition and control software. In order to meet these new requirements significant changes had to be made in the Pixelman software.

Firstly, unlike Timepix or Medipix2 chips, the counter depth of each pixel in the Medipix3 chip is configurable from 1 bit up to 24 bits which required a change in inner representation of data in the software. Secondly, instead of a single counter for each pixel, Medipix3 contains two counters working either separately or as one counter of 24 bit depth. Lastly, each group of 4 pixels has up to 8 configurable thresholds with appropriate counters (colour mode). In order to visualise these new modes, a support for sub-frames has been added. Each frame can contain several sub-frames which can represent either two separate counters as well as difference between the two counters or also the 8 thresholds in colour mode or other custom data.

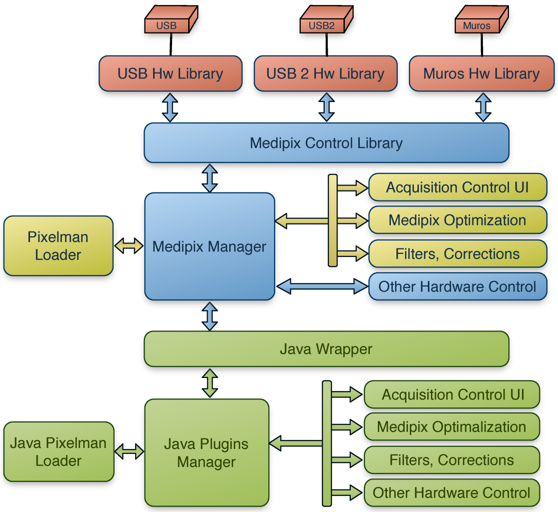


Figure 1. Scheme of the software architecture: Hardware libraries (red), multi-platform C++ core and plugins (blue), windows plugins (yellow), multi-platform Java core and plugins (green).

Furthemore, Medipix3 adds 3 new acquisition modes: continuous read-write, charge summing and colour mode. These modes are reflected in Graphical User Interface as well as in the Pixelman core. To support Medipix3, a completly new hardware library for USB readout interface has been developed.

4 Multi-platform software

Previous versions of Pixelman were compatible only with the Microsoft Windows platform and thus was not possible to use the software on other operating systems. Therefore the core of Pixelman has been modified to be compatible with Linux and Mac OS X systems.

4.1 Java Graphical User Interface

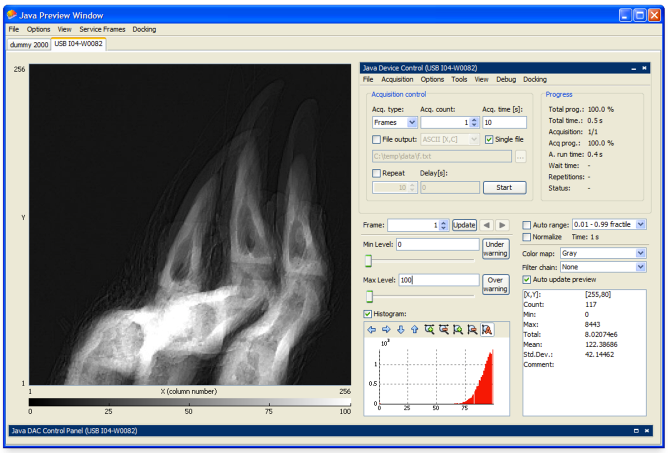
Since the MFC (Microsoft Foundation Class) Graphical User Interface (GUI) is dependent on the Microsoft Windows operating system, and it is not compatible with other platforms, it has been replaced by a new Java interface (see figure 2) that allows users to employ the software on multiple platforms while keeping the same graphical outlay, level of visualization and operation.

In addition the new Java GUI adds new features that make the software more user friendly. Here are few examples of the new features:

Window docking allows to dock separate windows into one window. This is very helpful when using the software with several detectors connected.

Preview overview visualises all the images from all connected detectors as well as the progress of measurement in one window.

Subframes visualisation allows sub-frames of one frame to be shonw in different tabs in one preview window.



Java Preview Window
File Options View Service Frames Docking
dummy 2000
USB I04-W0082
256
Y
1
1
X (column number)
256
0
25
50
75
100
Java Device Control (USB I04-W0082)
File Acquisition Options Tools View Debug Docking
Acquisition control
Progress
Start
Update
Under warning
Over warning
10^3
1
0.5
0
0
25
50
75
Java DAC Control Panel (USB I04-W0082)

Acq. type: Frames
Acq. count: 1
Acq. time [s]: 10
□ File output: ASCII [X,C] ☑ Single file
C:\temp\data\f.txt
□ Repeat 10 Delay[s]: 0

Total prog.: 100.0 %
Total time.: 0.5 s
Acquisition: 1/1
Acq prog.: 100.0 %
A. run time: 0.4 s
Wait time: -
Repetitions: -
Status: -

Frame: 1
Min Level: 0
Max Level: 100
☑ Histogram:

□ Auto range: 0.01 - 0.99 fractile
□ Normalize Time: 1 s
Color map: Gray
Filter chain: None
☑ Auto update preview

[X,Y]:	[255,80]
Count:	117
Min:	0
Max:	8443
Total:	8.02074e6
Mean:	122.38686
Std.Dev.:	42.14462
Comment:	

Figure 2. Java GUI: Pixelman control and preview window.

4.2 Java development

In order to incorporate the new Java GUI into Pixelman a special bridge interface (the Java Wrapper) between the native C++ core and the Java interface had to be produced (see figure 1). The Java Wrapper translates all the functions from C++ to Java that the core of Pixelman offers to plugins. Thanks to this it is now possible to create Java plugins for the software. This allows users to create multi-platform plugins with the user interface more easily than before. The use of Java means that the same code can be used on all the platforms unaltered.

Nevertheless, it is still possible to create multi-platform C++ plugins for faster data processing or for controlling of experiment-specific hardware. All the Windows-only plugins created for older version of Pixelman can be still used on Microsoft Windows.

5 Distributable acquisition software

Thanks to its modular extendable architecture the Pixelman functionality can be enhanced by different custom made plugins. One of these plugins is the Remote Control Plugin that adds a network interface with a simple text protocol to Pixelman. This interface allows for control of acquisition and of the entire measurement remotely over a network (see figure 3) via a terminal such as telnet. In order to simplify the control of Pixelman through this interface a Java Remote Control Application with a web interface has been developed [7].

By using a Remote Control Plugin, Pixelman can become a client of a distributed acquisition system. Because of its multi-platform nature each, Pixelman distributable client can run on a different operating system and thus can use specific hardware that is bound to an individual operating systems. The whole system can be controlled by a Java Remote Control Application with web interface, which can also be used on different platforms.

An example of such a distributable system with Pixelman software is the ATLAS-MPX network [8], which consists of a network of 16 Medipix detectors placed within the ATLAS detector cavern at CERN. The whole network is controlled from one computer running Linux with the Java Remote Control Application installed.

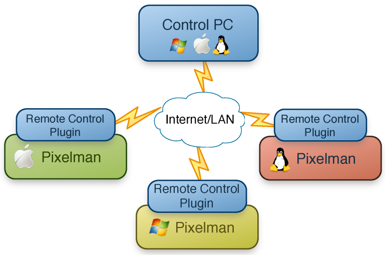


Figure 3. Scheme of a distributed acquisition system.

6 Conclusions

The Pixelman software package is widely used in many scientific institutions worldwide for the control and DAQ of pixel detectors of the Medipix family. A significant upgrade has been made to the software that improves its functionality. Pixelman now fully supports the latest detector from Medipix family — the Medipix3 chip. This allows users to carry out new types of measurements.

The new Java GUI brings platform independence and enhanced user friendly operation. Support for Java plugins speeds up the development of Pixelman enhancements. The combination of C++ and Java platform allows to connect Pixelman to a large range of hardware as well as software systems.

The multi-platform nature of Pixelman makes it possible to control complex experiments with different operating systems and using the platform specific hardware involved. Thanks to Remote Control Plugin, one can create a distributable acquisition system with several computers running different operating systems and different equipments controllable from one place over a LAN or the internet.

Acknowledgments

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