User-defined Instrument

Weidong Ye, Yongwei Du*

Beihang University, China

Beihang University, China

ywd57@buaa.edu.cn, duyongwei@buaa.edu.cn

Keywords: Software-defined Instrument; User-defined Instrument; User experience design

Abstract. Research of traditional measurement instruments has been focused on improving the performance, ignoring the importance of interaction. With the deepening of the concept of "software-defined", the problems of the traditional instrument in the user experience(UE) become more and more obvious. Driven by the boom of mobile terminal device interaction design, there will be a revolution launched on design of UE and ease of use in measuring instrument industry. Based on software-defined instrument and synthetic instrument technology, this paper proposes the concept of user-defined instrument. That is, to emphasize the User-centered Design(UCD) philosophy, on the basis of "software-defined", and to solve the problem of the unsuitability between traditional general instrument and user's requirements, under the precondition of meeting the requirements of individual users.

1 Introduction

All along, research of traditional measuring instruments is focused on how to improve the measurement accuracy, pursuing superior performance and comprehensive functions. Rarely considering the actual needs and measuring instrument manufactures provide stereotyped instruments and functions in face of vastly different walks of life with various measurement requirements. In result, traditional instruments are surrounding with many UE problems such as complex operation, complicated configuration, gaps between provided functions and user's requirements. These problems partly caused by no optimizing design for UE and ease of use. Besides, "vendor-defined" design mode makes functions of traditional instruments' hardware fixed.

With electronic Science and Technology highly developed, fixed-function hardware era has ended in many areas. Just like the emergence of smart phones subvert the entire mobile phone industry, electronic measuring instrument users also want to control their device more in some way. Emerged in recent years, concept of "Software Defined Instrument" (SDI) is one of the products in this development. SDI learns from the ideas of Software Defined Radio(SDR), allowing users to customize functions of the radio devices through a dedicated programming interface, and uses digital components as much as possible replacing analog ones [1]. Using this design, the instruments can meet users' measuring requirements more, but software development of SDI must be done by professional programmers. Therefore, in order to meet the requirements of instrument users, the best solution is to achieve their desired functions by themselves with a simple method.

On the basis of Synthesis Instrument(SI) and SDI, we propose the concept of User-defined Instrument(UDI), which basically means users can customize the user interface(UI) and measuring functions of their measuring instruments according to their unique requirements, in the way of assembling and configuring the modular hardware and software provided by manufacturers.

2 User-defined Instrument

2.1 Basic Concept. UDI is an electronic device based on embedded technology, equipped with the front-end measuring circuits in the area which users focus on. It can achieve measuring task in assigned area by a simple configuration. Measuring and operating method, display and processing algorithms of UDI can be customized by users, with great UE.

© 2016. The authors - Published by Atlantis Press

Since virtual instrument technology emerged in the 1980s, the concept of “software is the instrument” has been leading the development of instruments. With this software-centric ecosystem established, thinking of user-mode changed. National Instrument(NI) proposed that instrument design mode changed from “vendor-defined” to “software-defined” in SDI design.NI believes that what previous users consider is how to use factory preset functions but now users concern more about how to use instruments to achieve their desired functions [2]. This view is consistent with the idea of UDI proposed in this paper. As “software-defined” is only a method, “user-defined” is the read goal of the development of measuring instruments. In order to improve UE of measuring instruments fundamentally, the design of a UDI must contain interaction, hardware and software architecture, construction method and so on.

2.2 Interactive Mode. Interactive mode is of great importance for UE. As the development of touch technology, such as smart phones and tablets, buttons and knobs are giving way to touch-screens in the machine panels of new instruments. Because of the superiority and convenience of touch technology, there will be brand new UE of touch operation.

The most important advantage of using touch-screens is to change the interactive mode, which has been validated on smart phones. Users can touch or slip fingers on the screens to complete every operation they want. For example, users will only need few seconds to set the trigger of oscilloscope instead of a set of complex operations. This disruptive design of operation will bring unprecedented convenience and usability.

Apart from this, there are many other advantages of touch-screens that traditional interfaces do not have. Firstly, full color and high contrast screens can display richer content and more various figures. In this way, poor display effect such as darkness and simple numerical format will not be a problem. Secondly, operation mode with touch-screens can avoid problems of instrument damage under long term usage. Finally, with touch-screens, the traditional multiple levels of nesting menus can be changed to graphical menus which are intuitive and easily understandable and can ensure users a quick study.

To fully improve UE of instrument, UCD should be strengthened, which can be solved by some advanced interface design ideas and technological measures.

2.3 Basic Types. According to the complexity of application scenarios, the implementation of user-defined instruments can be divided into two types: parameters configuration type and smart type.

Parameters Configuration Type. Parameters configuration type is suitable for lower level of customization. To use such a UDI, users only need to add one or several customizable buttons on the existing instruments and make the parameters configurable and can be saved, and then the UDI can be configured by one button. In this way, users can make simple adjustment to measurement, data processing and display mode, and the output of measurement result will be more intuitive and can meet the requirements of different projects.

For example, digital display voltmeter can allow users to turn voltage output and current output to project units using parameters configuration. Thus, users can get actual physical parameters directly when they measure a convertor of 4-20mA. In this way, the computation of counter is not needed, which greatly enhances UE.

Oscilloscope is the same. In actual measurement, users need to make complex adjustment to different signals. If parameters configuration can be saved to different user-defined customizable buttons, then when changing measurement signals, all configuration will be done at once when users just push a button.

Smart Type. Most users only use a small part of functions of standard instruments. That is, usually quite a bit part of purchase cost is wasted. But instrument manufacturers are unable to meet all the requirements of different and complex application scenarios. Thus, the need of custom-made instruments is generated. These custom-made instruments are various and special but in small demand, so may be relatively more expensive. In this case, the best way to develop this kind of products is UDI. Instrument manufacturers only need to provide professional hardware modules and software modules, then users can assemble the parts they need according to actual requirements. In this way, the quality of instruments can be guaranteed, and the requirements of users can also be meet.

To solve this problem, we propose a concept of smart UDI. Smart UDI will make software and hardware highly modular, and allow users to achieve different functions by assembling different modules. Hardware modules are mainly constituted by signal conditioning extended modules for different application scenarios. Software modules include various algorithms, hardware drivers, display drivers, measure process and custom algorithms. UI is also modular design, users can customize the UI in the way of WYSIWYG (What You See Is What You Get), just by assembling different display modules which have been configured before.

2.4 Hardware Architecture. The underlying hardware architecture must be designed with reconfigurable and programmable embedded chip. In order to allow users to combine different functions through software, each functional hardware part should be modular, such as DAC, ADC, filters, oscillators, attenuators, DSP and so on. Each hardware module provides digital interface, replacing analog circuits with digital circuits and algorithm.

General hardware architecture of UDI is shown as Fig.1, including three main parts: the main board, the displayer with touch screen and extended module interfaces. The main board have a high-performance MCU and multiple basic analog input channels. It is also preloaded with RS232/RS485, CAN bus, USB interface, Ethernet interface and other communication interfaces commonly used in industry. UDI uses SD card as external memory for storing measuring data and programs. Reserving extended module interfaces can be used to extend hardware functions for specific requirements.

2.5 Software Architecture. Considering that most of users are not professional at programming, who are very familiar with their measuring tasks, software architecture of UDI should be designed to reduce the complexity of configuration. UDI can achieve a variety of users' requirements in graphical interface method, sheet-like configuration for parameters, equation editor for input algorithms, based on commonly used software algorithm modules provided by manufactures.

Software architecture of UDI includes Hardware Driver Layer(HDL), Data Control Layer(DCL) and Display Feedback Layer(DFL). Functions of each layer are shown in Fig. 1.

The main task of HDL is to obtain the original data and transmit the data to DCL. The raw data is derived from the onboard analog input channels, serial interfaces or extended modules. How the data is collected in HDL is depending on the control information generated in DCL. Apart from generating control information for HDL, DCL can process format the data from HDL, and will be packaged in specific format and sent to DFL later. After DFL received the final data, the data will be displayed on the LCD screen. Meanwhile, DFL is monitoring the touch screen. Once there is input data, it will be sent to DCL to parse.

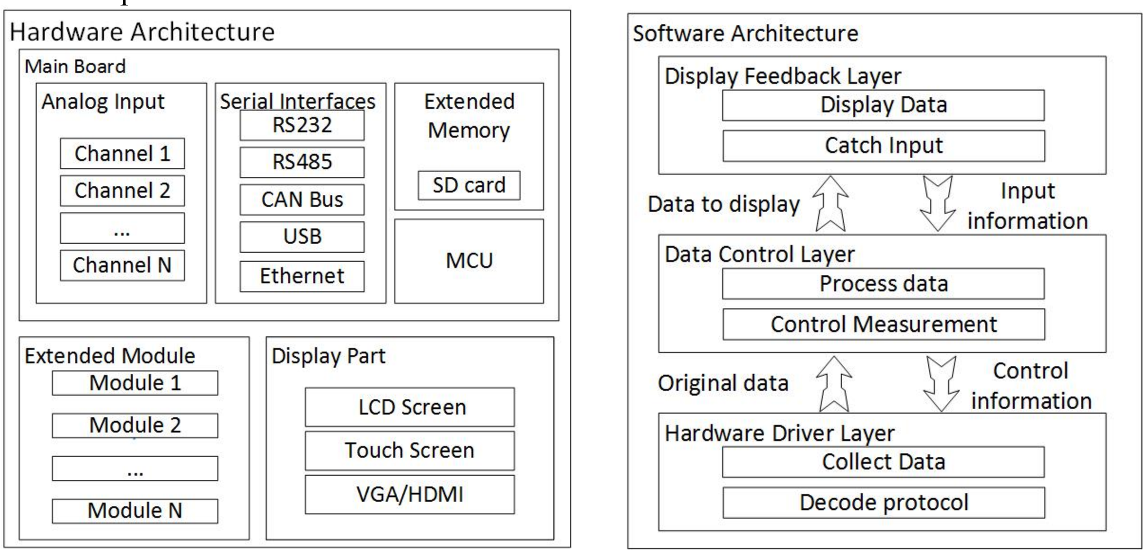

Fig.1. Hardware and Software Architecture of User-defined Instrument

2.6 User Interface Design. On the basis of touch-screen technology, a good UI design will give a better experience for users of instruments. Human-computer interface must be designed based on the principles of UE as follows:

Simple interface style, rationally layout. Contents and functions should be laid out rationally, so that users can find relevant information quickly. Important information should be highlighted and others should be reduced. Too many parameters and settings will confuse users, so the most concerned information should be placed in eye-catching positions. Thanks to the convenience of touch-screens, many functions of traditional instruments can be removed, such as to resize or drag curves, to ensure a simple interface.

Easy and fast operations. One of the evaluation standards of UE is whether users could get any information they want in 3 operations. Instrument software interface design should also follow this principle. This idea is a guarantee of UE of operation. Therefore, the design of settings of menu should be flat and graphical, and avoid deep nested structure.

Be considerate of different operation habits. While touch-screens have brought a lot of new ways of instrument operation, more styles of UI should also be provided, so that the instrument can fit in with the needs of different users. At least two styles of interface should be provided. One is a brand new graphical interface and a brand new operation experience, which provides an operation mode similar with tablets and mobile phones. The other is like traditional instrument interface, with buttons on screens, which can ensure users accustomed to traditional interface a quick study.

3 Conclusions

As the emergence of smart phones has twisted the industry of mobile phones, UDI will be the major topic of measurement instruments. Therefore, the design of measurement system should carry on the transition from fixed hardware to programmable and commonly used hardware platform. Meanwhile, more flexible interfaces of software should be provided, to get more integrated and complicated functions. Multifunctional and intellectualized instrument is an inevitable trend. As instrument becomes smart enough, only a good UE can take the advantage of instrument intellectualization to its fullest.

In conclusion, as the establishment of software-centered measurement ecosystem, instrument designer should pay more attention to the requirements and interaction of users, to carry on the transition from software-defined to user-defined.

References

[1] Ling Lin, Lijun Zhang, Gang Li. Software Defined Instrument[J]. Electronic Engineering & Product World, 2007, (11):54-54.

[2] Charles Schroeder. Construction of the New Instrument: Software-defined Instrument [J]. Foreign Electronic Measurement Technology, 2012, (9).

[3] Starkloff E. Creating a Synthetic Instrument with Virtual Instrumentation Technology[J]. Rf Design, 2006, (Aug, 01).

[4] Agilent N8241A Arbitrary Function Generator［EB/OL］.
http://literature.cdn.keysight.com/litweb/pdf/5989-2595CHCN.pdf?id=824123

[5] Xiangru Shan. Agilent 4000X Oscilloscope-Completely Subvert the Traditional User Experience [J]. China Electronic Market, 2012, (12):30-31.

[6] Jinsong Yu, Xingshan Li. Architecture and Key Technologies of Next Generation Automatic Test System [J]. Computer Measurement & Control, 2005, 13(1):1-3.