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An embedded lightweight GUI component library and the ergonomics optimization method for industry process monitoring

Key words: Embedded lightweight graphic user interface (GUI); Quasar technology embedded (Qt/E); Industry process monitoring; Multi thread; Ergonomics performance

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Motivations

1. Embedded GUIs such as embedded Wizard, μGFX, Android-GUI, or IOS-GUI have been applied on mobile phones or panel computers, but they are rarely used in industrial devices.

2. Developing an efficient and robust lightweight GUI for industry process monitoring is always a challenging task.

3. Current methods for embedded GUIs are with the matters of real-time processing and ergonomics performance.

4. A new embedded lightweight GUI component library that can improve the real-time processing and ergonomics performance is needed.

Main ideas

1. To meet the requirements of industry process monitoring, an entity-relationship (E-R) model for the GUI library is developed to define the functional framework and data coupling relations.

2. Considering the differences of embedded target systems, a cross-compilation environment is constructed, and the Qt/E shared library files are tailored to satisfy the requirements of different embedded target systems.

Methods

1. By the signal-slot interfaces, a message mapping method that does not require a call-back pointer is proposed, and the context switching performance is increased.

2. Referring to multi-thread method, the parallel task processing capabilities for data collection, calculation, and display are enhanced, and the real-time performance and robustness are guaranteed.

3. The human computer interaction process is optimized by a scrolling page method, and the ergonomic performance is verified by the industrial psychology methods.

Major results

1. The proposed embedded GUI component library can adapt different embedded target systems.

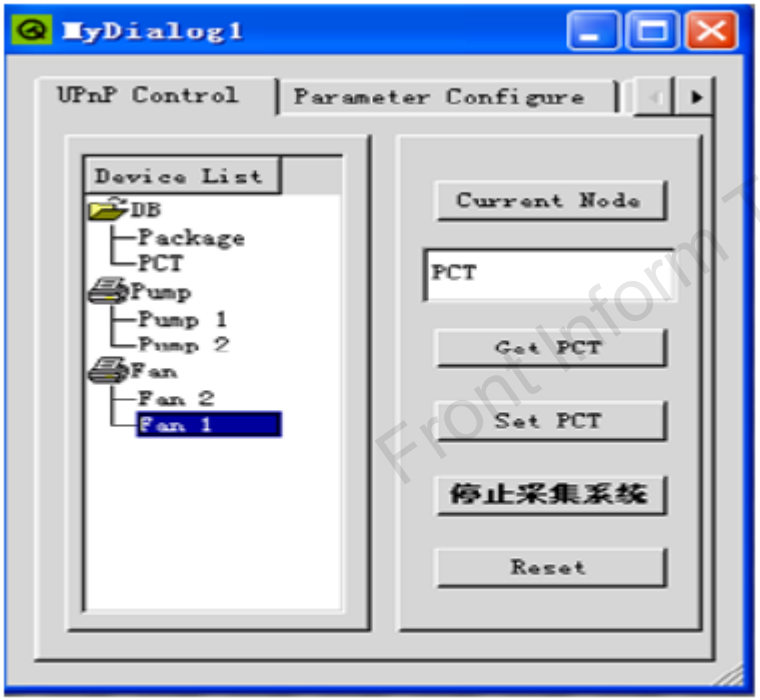

Fig. 12 Chinese information interface in embedded system environments

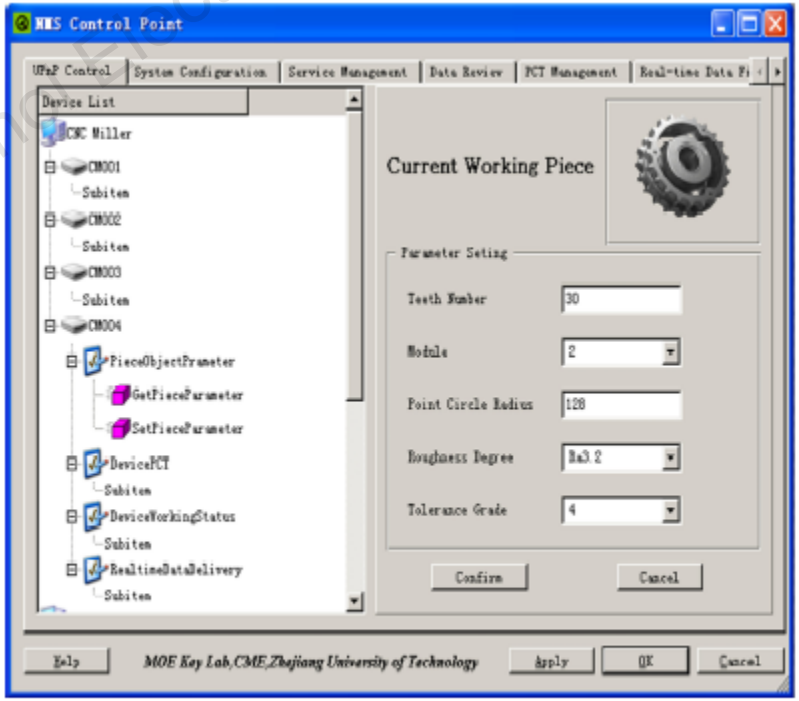

Fig. 14 Embedded IPMS interface developed by the component library in Windows-CE

Major results

2. The message mapping method can increase real-time read-write correction ratios more than 26% and 29%, compared with Windows-CE-GUI and Android-GUI.

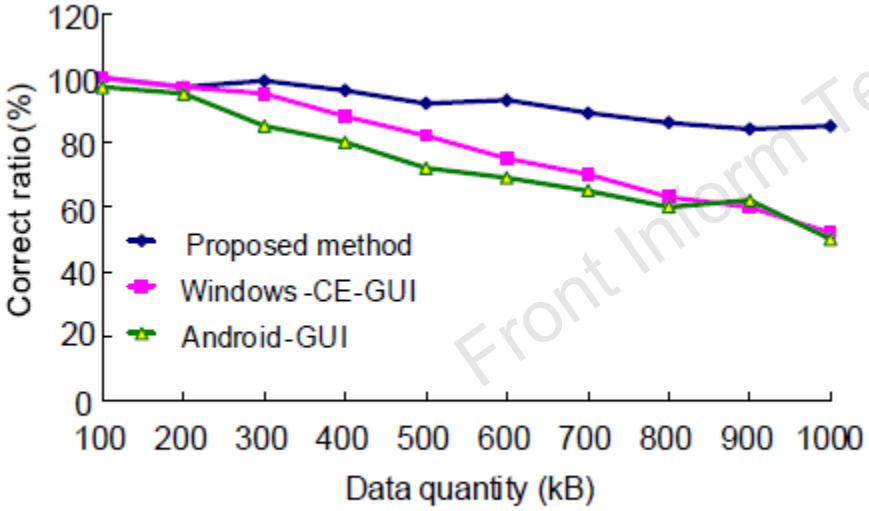

Fig. 19 Audio data read-write experiment results

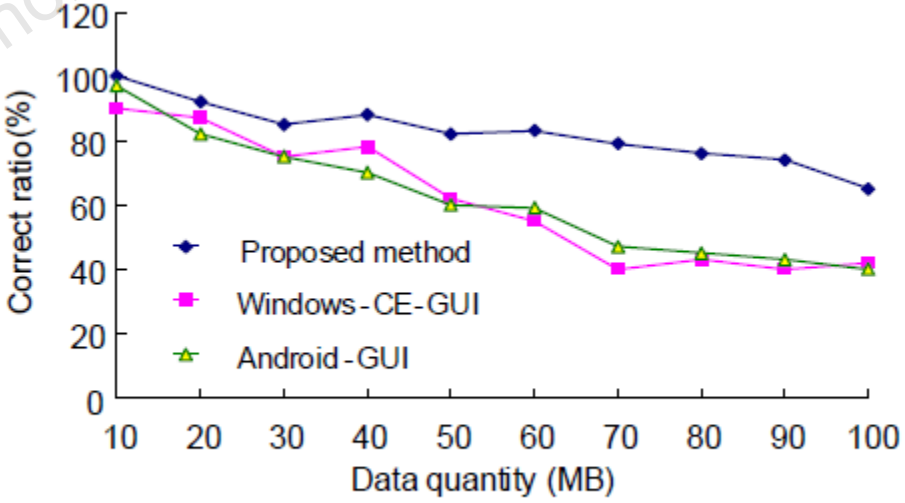

Fig. 20 Video data read-write experiment results

Major results

3. Industrial experiments have been performed in four large-scale enterprises: WISCO, BSG, SLOF, and SPF.

Fig. 21 Industrial field experiment scenarios in four large-scale enterprises

Major results

4. The average session switch time can be controlled less than 0.6 s, and six key indexes for ergonomics are verified by different industrial applications.

Table 3 Working performance comparative experiment results with Mini-GUI and Windows-CE-GUI

GUI	Least library space (KB)	Maximum parallel process number	Average session switch time (s)	Number of compatible software platforms	Number of compatible hardware platforms
Mini-GUI	1024	8	0.82	12	8
Windows-CE-GUI	>1024	32	0.53	1	8
IPMS-GUI	900	32	0.55	18	12

Table 4 User appraisement results of industrial field experiments

Index	SPF-handheld	SLOF-handheld	WISCO-fixed	SLOF-fixed	BSG-fixed
NSP	0.94	0.92	0.85	0.88	0.87
NAP	0.94	0.90	0.90	0.82	0.80
NUP	0.98	0.96	0.95	0.93	0.90
NCDO	0.97	0.91	0.88	0.90	0.85
TES	3.83	3.69	3.58	3.53	3.42
Satisfaction ratio	95%	97%	90%	93%	87%

Conclusions

1. To adapt different embedded systems, a cross-compilation environment that could hold multiple embedded targets was constructed. A QVFB platform was developed to improve the development efficiency.

2. The total memory use of the GUI library including the Chinese fonts was less than 900 kB, which could satisfy the running requirements of currently popular embedded target environments.

Conclusions

3. By the signal-slot communication interfaces, a message mapping mechanism that did not require a call-back pointer was realized, and the context switching speed was improved by 26% and 29%, compared with Windows-CE-GUI and Android-GUI, respectively.

4. Industrial experiments in four large-scale enterprises proved that the embedded IPMS-GUI achieved good user appraisals. The average satisfaction ratio could reach more than 90%, and the effects of the handheld GUI were better than the fixed GUI.