An Intelligent Wearable Computer Environment

János Nacsa [*#], Géza Bognár [#]

[*] CIM Laboratory, MTA SZTAKI (Computer and Automation Research Institute), Kende u. 13, H-1111 Budapest, Hungary, e-mail: nacsa@sztaki.hu

[#] Department of System Analyses and Design and Application Technology, Gabor Dennis College, Etele út 68, H-1115 Budapest, Hungary, e-mail: bognarg@szamalk.hu

Abstract: Recent years the mobile computing got more and more importance in almost every field of life. Typical mobile computing devices are the so called wearable computers, that provides PC like resources in a miniature format including keyboard and screen I/O-s and wireless network connections. The first part of the paper introduces wearable computers especially a simple prototype built in our laboratory.

Even if these computers are available the intelligent applications are very limited by now. In the second part of the paper the so-called KSC (knowledge server for controllers) concept will be extended to allow knowledge processing for the wearable computers.

The third part of the paper shows how these tools are able to support the reengineering process of different expensive workpieces. The idea will be illustrated in a prototype application where the designers can remotely examine the different high value waste pieces and decide about the further usage and processing of them.

The fourth part will introduce the special interfaces among the KSC and the wearable computers.

Keywords: wearable computer, knowledge server, XML

1 Introduction

Information technology developments have given faith to system designers to plan for a new generation of manufacturing environment. Some experts tend to call this new era as digital revolution in manufacturing, and foresee a time in the near future, when the “paper-less office” will be replacing the present workplaces. In a similar process as the design and planning, also the execution and control of the

[*] The work was supported by the Bolyai János Grant of the Hungarian Academy of Sciences (2002-2005).

manufacturing processes in a factory will (or could) run in a paper-less style, and this vision has led to the birth of a new topic: “running a digital factory”. The main idea behind our research is to provide for our applications the features of the multimedia and the artificial intelligence together in a harmonized way.

Multimedia provides rich views of content. Beyond the classical textual and audiovisual media, VR models, data visualization images and increasing number of media types forms “multimedia”. We consider multimedia much more human centric as pure media solutions. In a real multimedia presentation we can show the same thing from different aspects. Additionally, most people are visual, they not just prefer images, they think visual. Consequently, extending the simple views of resources with multimedia capabilities, we provide a more comprehensive, more sophisticated and more understandable views of resources.

In the same time many people benefit from the advantages offered by artificial intelligence and some modern techniques, which include fuzzy concepts, and a lot of friendly tools is intended to help them to understand one of the powerful techniques behind them.

2 Wearable Computers

During the evolution of the computer systems the room-sized equipment became handy or pocketsize devices. The next step of the miniaturisation may be the computers that are somehow parts of the clothes. They are not only small in space and weight, but they are robust and they have interfaces that give dynamic possibilities of their users.

According to the widely accepted terminology the first generation of the wearable computers have wireless LAN connection and they have standard PC-like architecture and interfaces. It is possible to define some basic features of the wearable computers [7]:

- always “on” (working) and “online” for other computers,
- user and application oriented functionality,
- small, ‘easy’ to wear,
- application specific input and output devices,
- electric touch protection.

While the research projects are growing especially in health applications, there is a lack of real applications of wearable computers in manufacturing.

If the worker have wearable computer, he remains both hands free while his computer reaches all the necessary information (text, graphic, video) he needs for his duty (e.g. repair work). It is very easy to pick up his following task from the central database of the company. When he is walking to the next workplace, he can order a new workpiece in oral, then he can check the filled ordering form through his HMD.

The complex machines and electronic devices have thousands of pages of maintenance manuals and guides (e.g. aircrafts, nuclear power plans). If the information provision not only includes production and maintenance information, but also incorporates design, quality, and standards, the stored documentation can become significant. The workers need on-line help to navigate through the information and find the appropriate ones. There are cases that are unexpected, and it was not possible to practice previously how to solve them. Only the huge amount of materials can help, but it is not possible to read these books in the workplace. With wearable computer, maintenance worker have constant access to required information and can get real-time advice from special experts initiating a video-conference session. Documents are on-line and the newest revisions are available.

The main direction in the current research is the so-called Augmented Reality (AR), that applications are developed and tested where the real and the virtual views are mixed to support the users [11]. Our research presently do not deal with AR problems, but we focus on those manufacturing applications where the users of simple wearable computers need special data and knowledge processing resources.

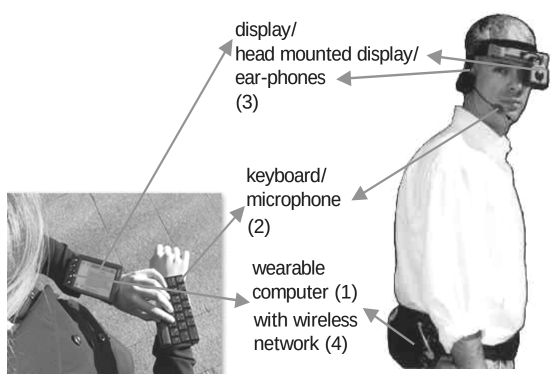

Figure 1
Basic elements of a wearable computer

Fig. 1 shows some examples to the four main functional parts of a typical wearable computers: (1) computer itself, (2) input device, (3) output device; (4) wireless network. The following two parts are also important optional parts of the wearable computers in several applications: (5) video camera, (6) equipment to determine the position and/or orientation of the user.

2.1 Experimental Wearable Computer

In our laboratory an experimental wearable computer (Fig. 2) was built with the simplest parts available.

This experimental system can work as a wearable computer, it is capable to transfer and process multimedia data and it can act as a client of more sophisticated (e.g. knowledge processing) applications. Presently there is no equipment to determine the local position and the orientation, so the experimental wearable computer is unable for augmented reality applications.

Figure 2
Wearable computer built from simple elements

The main aims were: to give the feeling of the wearable computer to the user and to have it with low-cost parts. So it has no parts that were developed directly for the wearable computers.

3 Knowledge Server for Controllers (KSC)

In the last years a new framework was defined to serve intelligent data processing.

The features of World Wide Web led Eriksson [4] to introduce Knowledge Server to easier solve the installation and version control problems, distributed and remote access issues of expert systems and to provide a web based interface of the knowledge base for the different users. Some advanced knowledge based systems are based on this concept (e.g Cyc system, Istar). There are also some applications of knowledge servers in manufacturing (e.g. in our institute Váncza at al. [5] uses it in a robotic inspection planning system). These systems basically keep the original concept of Eriksson.

3.1 Concept of KSC

Knowledge Server for Controllers [1] is a little bit different while it was defined as a server providing capability of intelligent data processing for other external systems. KSC allows the client systems to reach its intelligent processing resources, so it enhances the intelligence behaviour within these systems, albeit they do not have such capabilities. The KSC contains (Fig. 3) a high performance reasoning tool, and different knowledge based modules. All the modules have their special rule and procedure sets. The client system calls these modules, passes them specific data if necessary. Then the KSC module executes the intelligent data processing and sends the results to the clients. It is also possible, that KSC can collect data if the activated knowledge processing requires.

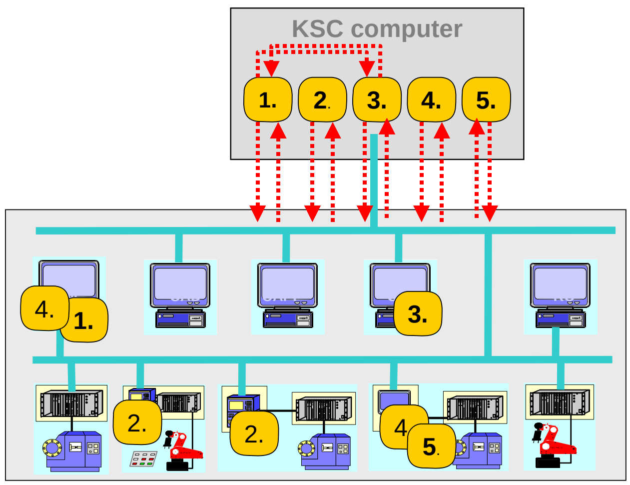

Figure 3
A KSC solving different clients in a whole workshop

Generally the resources of the KSC can use more clients (controllers or SCADA systems) simultaneously. It leads to a cost effective AI solution, because one costly AI environment can solve more problems parallel. So all the intelligent problems in a distributed environment are grouped in a single server. The overhead of the KSC (network connection, one more computer, some delay etc.) is much less than the advantages (AI environment licensing, less computing power in the clients/controllers etc.). It is also possible that the same KSC service is used by more clients, e.g. when same type (or similar) machines/controllers are working in a workshop. Fig. 3 shows a sample KSC architecture in a discrete manufacturing environment (e.g. CNCs, robot controllers, quality assurance stations). Figure 3. shows 5 different different knowledge based modules. Module 2 and 4 is used in two equipment (e.g. KB quality checking). The structure also allows that the KB modules uses the results of each other (e.g. Module 1 and 3).

3.2 KSC Serving Wearable Applications

If the wearable computers must process complex data processing, this requirement is opposite that they should be as small and simple as possible. While the transmission speed is big enough in the current applications, a client – serve structure can be used to help the wearable computer to perform its tasks. If the necessary information processing is knowledge based then the KSC architecture can be used. The wearable computer calls the KSC for a given KB task, and when it is done the KSC sends back the result/solution to the wearable computer. Of course similar to older applications, the KSC can solve more then one wireless client – wearable computer – and more then one problem in parallel.

The capabilities of the KSC can be used either the application programs running on the wearable computer, or the human user itself who is wearing the computer and need some help that requires intelligent data processing (e.g. decision support). This second case is close to the original concept of Knowledge Server introduced by Eriksson.

The multimedia data connections are managed and processed with the MUMUS system [10].

4 Wearable Computer Application to Utilize Rejected Workpieces

As a part of a big national research project [9] an interactive multimedia framework (IMUTA) was developed at a workshop of an industrial partner.

4.1 IMUTA

IMUTA is a Framework of Resource Integration and Multimedia. In this framework we extended Enterprise Resources with multimedia information and functionality. The Extended Resource model provides a richer and more human oriented view of resources and processes, for example:

- Machining might visually observe real time and remotely, process data, product drawings, technology plans, quality reports can be chosen and shown according the needs.
- Documentation of value products might be extended with multimedia attachments to ensure the customers satisfaction.
- Customers observe the production flow of a product.

The framework features as follows:

- Multimedia Document Management
- Media Stream and Process Management
- Semantic Resource Model
- Resource Adapter Architecture

We considered semantic information management as a key issue of the resource integration. In our approach, semantic features makes possible to identify the nature and behavior of the entity. The applied semantics model is flexible and extendible, so we may feed more and more “knowledge” into the system.

Since enterprise resources do not form a well defined and closed set of entities, the framework provides adapter architecture easy to implement for different types of resources.

4.2 Utilization of Rejected Workpieces

The IMUTA was tested and introduced in a big industial company in different places. Among others they are manufacturing extremely expensive workpieces, so the rejected parts should be reused. Within this repository it is possible to collect all the production information of a given part including the description of the problem why it was selected as waste. Good quality pictures and – optional – videos can be added as well. The potential customers can examine through a web interface the stock and find some waste parts that are interesting to them. Also within the system a video-conference session can be started between the customer and the quality expert who wants to sell the rejected workpiece.

To support these activities wearable computers were suggested. Fig. 4 shows the way how the customer can get on-line information about the interesting workpieces. He/she reaches the multimedia data of the given part, has a voice communication with the quality expert, and can see on-line video about the workpiece. The quality engineer has a wearable computer while he/she is walking in the inventory to show the potential pieces and discuss with the customer via the mobile system. The wearable computer is connected to the Internet through a wireless network.

After the first tests it became clear that the existing USB based video cameras did not provide as good quality pictures as the customers wants. So the pictures for the multimedia database are taken by a digital camera offline, and the quality engineer downloads the selected pictures into the database when he sets the folder of the new rejected workpiece.

Special signal/noise experiments were needed to determine whether the wireless network connection of the wearable computer is good enough in the noise workshop. The tests proved that the user can walk anywhere in the hall, the performance of the network is still acceptable.

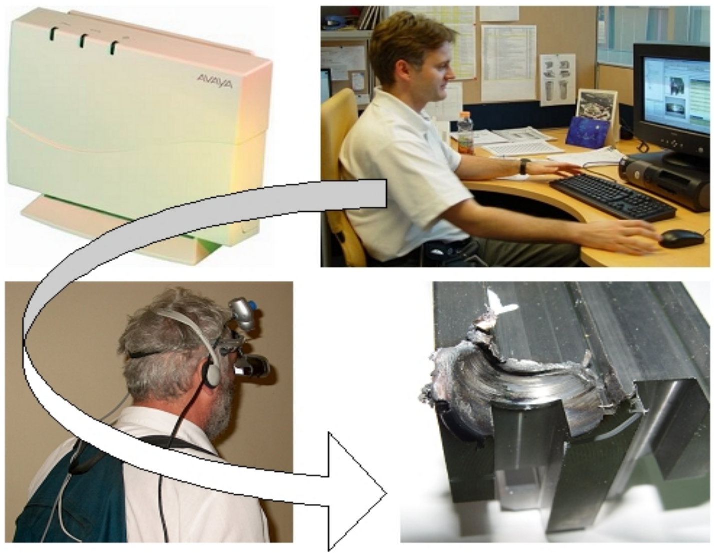

Figure 4
Wearable computer to support the utilisation of rejected parts

4.3 First Prototype of an Intelligent Wearable Computer Application

Based on this concept and a previous CNC Axis tester [3] the architecture of the experiment can be seen on Fig. 5. A Java based test of different measurements is running on the wearable computer with a browser based HMI. If the intelligent evaluation of the measurement results is needed, the Java application as client calls the G2 [2] based KSC module. The normal arrows show the simple test logic, while the dotted ones illustrate the usage of the KSC resource.

In this prototype the session described in the previous subchapter has som efurther features. The user – holding the wearable computer - can measure some geometric values of the waste workpiece. The “test” boxes reperesents these activities on Fig. 5. The KSC server is able to provide some intelligent evaluation using the measured values A simple decision could be the following: “The workpiece X can be remaked to workpieces Y or not?” It is possible to have more complex decision: “Which workpiece (Y, W or Z) is rewarding to remake from workpiece X?”

In the prototype mainly the plattform and the interfaces were set up to solve such problems. The KSC modules are only acts as decision support agents, the real knowledge processing is missing from them at the present level.

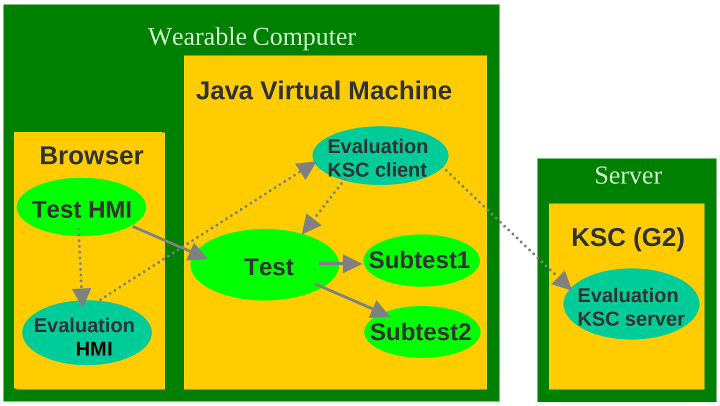

Figure 5
Prototype test measurement application on a wearable computer supported by a KSC

5 The XML Based Interface of Intelligent Wearable Computer

Interfacing the wearable computer client with the KSC server requires a platform independent but widely accepted solution. The data is defined in XML [8], so the message handler should easily support XML (eXtensible Markup Language) based protocol. Two possible solution were examined: SOAP (Simple Object Access Protocol) and XML-RPC (Remote Procedure Call). Other protocols as CORBA, DCOM, Java RMI are not fully XML based. The first one is more complex and grows up very quickly, the second one is more simple. Finally because of the limited human resources the XML-RPC was chosen.

The data model of XML-RPC is enough to describe the inputs and outputs of the KSC services. The following types of XML-RPC requests/responses were defined:

- To check if an intelligent service is free/available in KSC
- To reserve a KSC service
- To load the parameter data of a service
- To start a service
- To check if the service is done
- To load the result data of the service
- To free the service

Conclusions

An intelligent wearable computer environment and some prototype applications were introduced. The KSC server concept were used to add knowkedge processing features to the wearable applications. The XML based interface of the system was shortly described.

References

[1] Nacsa J., Kovács G. L., Haidegger G.: Intelligent, Open Architecture Controller Using Knowledge Server, in Sensors and Controls for Intelligent Manufacturing II, Proc. of SPIE Vol. 4563, pp. 25-33 (2001)

[2] Gensym Corporation: G2: A powerful platform for wide range of operational expert-system applications, Brochure, 2002

[3] Nacsa J.: Intelligent Open CNC System Based on the Knowledge Server Concept, In: Digital Enterprise Challenges - IFIP Prolamat, Budapest, 7-10 Nov. 2001, pp. 360-368

[4] Eriksson H: Expert Systems as Knowledge Servers (1996) IEEE Expert, Vol. 11, No. 3

[5] Váncza J., Horváth M., Stankóczi Z.: Robotic Inspection Plan Optimization by Case-Based Reasoning, Proc. of the 2nd World Congress on Intelligent Manufacturing Systems and Processes, June 1997, Budapest, Hungary, pp. 509-515

[6] Drozdik Sz.: IMUTA - a framework for integration, Proc. of ISDA 2004 Conference, Budapest, Hungary

[7] B. Rhodes (1997), A brief history of wearable computing, 1997; www.media.mit.edu/wearables/lizzy/timeline.html

[8] Tibor Gottdank, Webservices, XML based communication on the Internet, Computerworks, 2003 (in Hungarian)

[9] G. Haidegger, S. Drozdik, B. Bámer, G. L. Kovács, F. Sárközy, J. Nacsa, Zs. Bíró, S. Kopácsi, Zs. Bori, T. Szalay, A. Anufriev: Interactive multi-media test scenarios in digital factory projects, Proc. Of 37th CIRP International Seminar on Manufacturing Systems, May 19-21, 2004, Budapest, Hungary

[10] B. Bámer, Design and operation of a Java based distributed media processing system, Proc. of ISDA 2004 Conference, Budapest, Hungary

[11] Augmented reality portal; www.augmented-reality.org