Intelligent wearable computer application using a knowledge server

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Abstract – **Recent years the mobile computing got more and more importance in the every field of life. One of the types of these devices are the so called wearable computers, that provides PC like resources in a miniature format including keyboard and screen I/O-s and – optionally – wireless network connections. The first part of the paper introduces wearable computers especially a simple prototype built in our laboratory. Even these computers are available; the intelligent applications are very limited by now. In the second part of the paper the so-called KSC concept will be extended to allow knowledge processing for the wearable computers.**

I. INTRODUCTION

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.

Wearable computers

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.

In the recent years a new generation of wearable computers are appearing (e.g. MIThril [8]). The goal of the MIThril project is the development and prototyping of new techniques of human-computer interaction for body-worn applications.

Potential manufacturing applications

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

In quality assurance applications or in open air workplaces where the workers have to check and/or to measure things the wearable computers could have many advances. E.g. in a Norwegian centre the quality guards of ships and oil-derricks can compare the previous and the reference data with the present values. Some workers of Bell Canada use wearable computers during the open-air telephone line maintenance.

A wearable video camera mounted on the head of the wearable computer user allows sharing the view with others via the network (e.g. running a NetMeeting application). So remotely other people (e.g. experts) can give advices or commands to the user because they know what he/she is seeing.

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). 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.

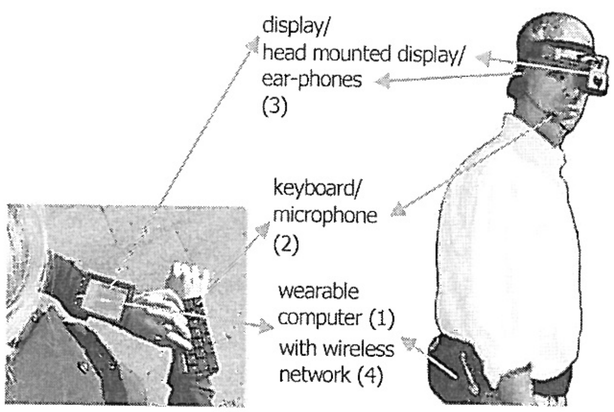

Fig. 1 . Basic elements of a wearable computer

Architecture of wearable computers

Fig. 1 shows some examples to the four main functional parts of the 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 local/global position and/or orientation of the user.

II. EXPERIMENTAL WEARABLE COMPUTER

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

Fig. 2 . Wearable computer built from simple elements

1. A Dell Latitude notebook is the wearable computer that is worn in a rucksack. It is light enough for the experiments.
2. A Sony Personal LCD Monitor S700E is the head mounted display that is connected through a battery module to the VGA output of the notebook. Normally the battery box is also in the rucksack.
3. A general Genius mouse with the net-scroll feature is the input device. During walking only its buttons and the scrolling can be used.
4. An Avaya Wireless PCMCIA network card in the notebook communicates with a wireless HUB, so the experiment wearable computer can reach the LAN of the institute with 11 Mbit/sec, that is quick enough to run e.g. simple video conferencing applications.
5. A TerraCAM USB video camera was fixed to the top of the HMD and was connected to the USB port of the notebook.
6. A microphone and earphones built together are connected to the standard audio in and out plug of the computer.

Presently there is no equipment to determine the local position and the orientation, so the experimental wearable computer is unable for augmented reality applications.

Different pieces of software were tested with the pilot set:

- NetMeeting between a desktop computer and the pilot wearable computer;
- Photo Express for making snapshots;
- JMF (Java Multimedia Framework) based video and voice transmission using the first version of SZTAKI's IMUTA system [6].

First positive experiences with the pilot wearable computer in the industry demos were the following:

- The full duplex video transmission was working properly while the user was walking around the whole level of our office building or in a noise workshop.
- It gives a personal feeling for the users inspiriting ideas about possible applications and further developments. It proved for some of our industrial partners that it is more than a "toy".

Based on the first experiences further tuning will be done with the pilot wearable computer (e.g. more powerful notebook, new input device, better mechanical integration of the HMD and the video camera). The augmented reality problems will be also targeted.

III. WEARABLE COMPUTER APPLICATION TO UTILIZE REJECTED WORKPIECES

As a part of a big national research project [9] an interactive multimedia repository was developed at a workshop of an industrial partner. 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. 3 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 commercial digital camera offline, and the quality engineer downloads the selected pictures into the database when he sets the folder of the new rejected workpiece.

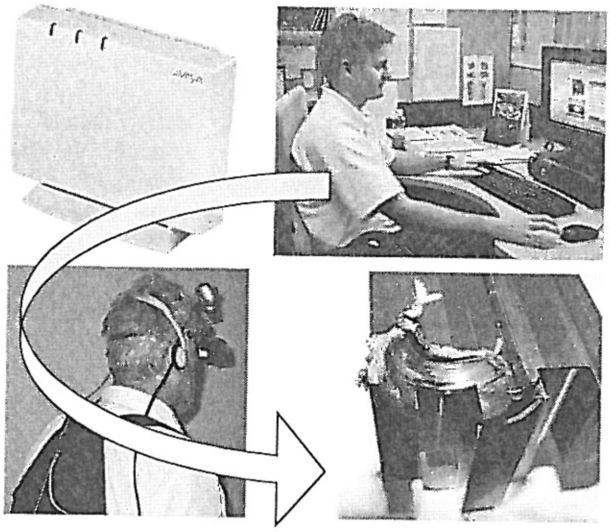

Fig. 3 . Wearable computer to support the utilisation of rejected parts

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.

IV. CONCEPT OF KNOWLEDGE SERVER FOR CONTROLLERS

In the last years a new framework was defined to serve intelligent data processing. The pilot wearable computer introduced in the previous chapter was tested within this logical frame.

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.

Knowledge Server for Controllers (KSC) [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. 4) 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.

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. 1 shows a sample KSC architecture in a discrete manufacturing environment (e.g. CNCs, robot controllers, quality assurance stations)

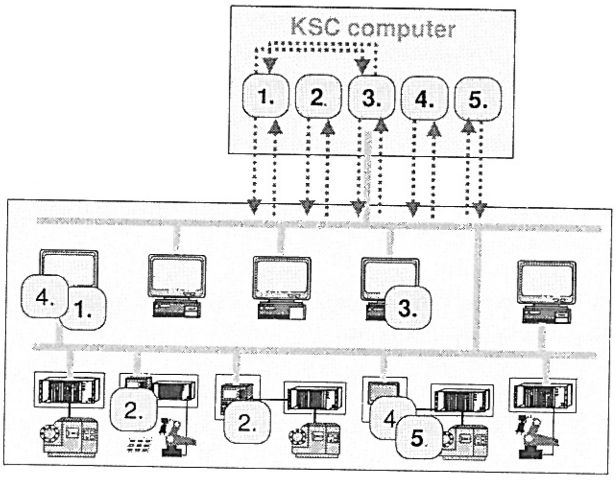

Fig. 4 A KSC solving different clients in a whole workshop

It should be stated that KSC does not deal with fuzzy and neural net based AI modules. The computing power and the necessary software costs and complexity of these methods are less than the rule- or model-based ones. (In the case of the neural nets it is true only if the net is not trained on-line.) Another important comment is that the KSC concept and the idea of the intelligent agents are different. Fig. 5 shows the KSC in the world of distributed AI. In the figure it can be seen that the KSC based systems basically belong to the world of distributed AI, but it is also possible that:

1. The client systems using the same KSC are local AI applications.
2. The KSC modules act as intelligent agents.

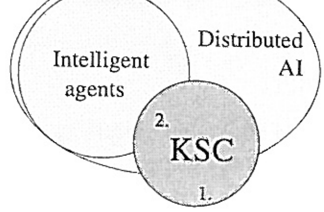

Fig. 5 KSC in the distributed AI world

V. KSC SERVING WEARABLE APPLICATIONS

In many cases the wearable computers may need intelligent data processing. On the other hand they should be as small and simple as possible. It led to the idea to support the wearable computer applications with KSC.

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.

Interfacing the wearable computer client with the KSC server requires a platform independent but widely accepted solution. So the usage of XML was evident. The protocol defines the following:

- How a client can require a service from the KSC.
- The transfer of the necessary variables and actual parameters for the knowledge processing.
- Optionally the client can define response time if the KSC implementation can support it. The most commercial knowledge processing environments does it.

Similar to the other clients, KSC can solve more then one wireless client parallel.

VI. 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. 6. A Java based test of a fictive device is running on the wearable computer with a browser based HMI. If the intelligent evaluation of the test results is needed, the Java application as client calls the G2 [2] based KSC module.

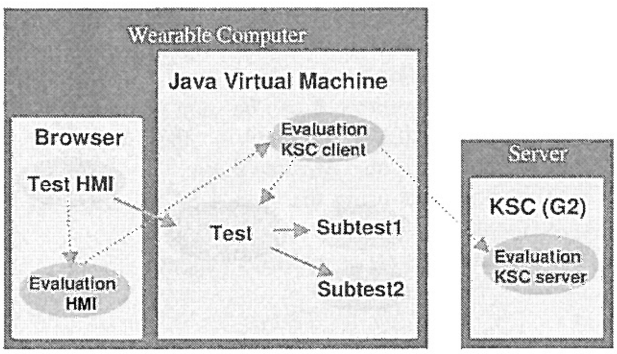

Fig. 2 Prototype tester application on a wearable computer supported by a KSC

The normal arrows show the simple test logic, while the dotted ones illustrate the usage of the KSC resource.

The problem of utilisation of rejected parts described in Chapter III. is under investigation how to

VII. CONCLUSION

The wearable computers were shortly introduced, together with the pilot wearable computer of CIM Laboratory, SZTAKI. It was noted, that for research purposes a wearable computer can be built from standard parts.

The Knowledge Server for Controllers concept was extended in wearable computer environment. Some possible manufacturing applications were also shown. Among them an experimental tester was shortly described.

VIII. ACKNOWLEDGEMENT

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