TELEASSISTANCE FOR ELECTRONIC COMPONENTS IN REHABILITATION TECHNOLOGY

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INTRODUCTION:

The synergisms of control and telecommunication systems have paved the road towards increasingly interesting fields such as teleassistance and telemedicine, and one other interesting application of these technologies may be in the field of prostheses. Nowadays, we are used to high-tech prostheses whose sensors or microprocessors, on one hand, enhance the performance of the prosthesis itself, while, on the other, can also cause problems which require the intervention of a specialised technician. The numerous benefits provided by telecommunication for prosthesis wearers are obvious for those patients who would otherwise have big problems in getting to the specialised centers, even just for a simple check-up. It is also important to consider the savings in money and time, since many patients bear not only travelling expenses, but are sometimes required to stay for days at a time at the specialised centers. The ideal solution would be to carry out as many telematic operations as possible through audio-video-data connection, which entails a much lower cost and much less inconvenience, even when considering a trip of only a few kilometres. This project originates from the necessity of INAIL, which has numerous centers spread out throughout the entire Italian territory, to concentrate specific technical services in a limited number of centers to which reference is made for each clinical case. By going to the closest INAIL Center, equipped with video-communication apparatus, the patient will be able to carry out operations that he normally would have had to carry out at the Prosthesis Center, ranging from the periodic check-up of the condition of the prosthesis, such as: the status of the batteries, the condition of the cosmetic sleeve, a control of the sensors and their calibration, to more complex cases of calibration or modifications in the function of the prosthesis itself, by means of the variation of specific parameters. Even the analysis of the electromyographic signal can be carried out at a distance, thus allowing the technical-rehabilitative crew to evaluate various solutions before asking the patient to return to the Prosthesis Center.

A fundamental partner in this activity is the OttoBock company, who has fully participated in all the objectives of the project for the purpose of providing both the patient and the orthopaedic technician all the instruments necessary in order to allow the patient to have increasingly advanced and reliable devices and the technician to carry out his job more quickly and efficiently. Various solutions were examined during the project, all of which were fully workable with different levels of quality and costs.

The only choice made and maintained from the initial phase of the project was that of utilising point to point connections though digital ISDN telephonic lines. In any case, this choice is not binding, although it is highly advisable, particularly in view of the fact that this service is available in almost every city, at increasingly economic prices. The reliability of this network in comparison to the telephone network and the availability of a larger band of transmission, allows for an efficient transmission of not only the audio signal, but also the video signal and a data channel.

The operations of calibration and monitoring made possible locally, by connecting the prosthesis with a PC, can be carried out between two local and remote locations that communicate through the ISDN network.

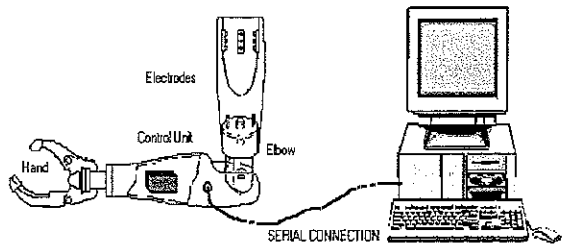

Fig. 1a Control software for prostheses with microprocessor

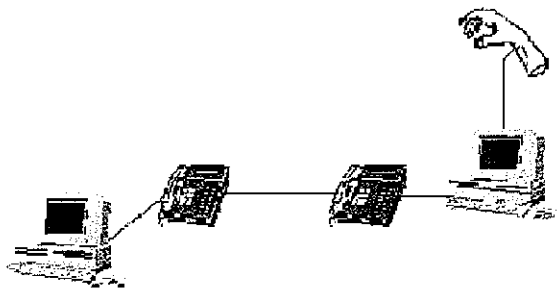

Fig. 1b Connection diagram between local and remote locations

POSSIBLE SOLUTIONS FOR VIDEOCOMMUNICATION

The analysis of the problem and the evaluations carried out during its development, have allowed for identifying two groups of solutions which will be examined further ahead.

In any case, problems exist that are common to all the solutions, particularly in relation to the temporal synchronisation of the events between the local and remote locations and the delays caused by the width of the video signal band to be transmitted. In addition, in view of the need to communicate with the prosthesis, a synchronism is necessary between the images: for example, the hand that moves with the data that are transmitted or received during that action. This is the only way a diagnosis of the prosthesis itself can be carried out.

The elimination of the video surely simplifies the problem, but in the thirty-year experience of the Prosthesis Center, human contact between the technician and the patient has definitely proven to be one of the main prerogatives for a correct prosthetic treatment and the possibility of seeing each other favours this human approach.

The two groups of solutions identified for the problem are illustrated in fig. 2.

The first choice that has to be made for videocommunication is between the "Consumer" type systems, with the characteristic of low prices and typically medium-low performance and the "professional" type systems, characterised by a better performance and considerably higher costs (in our case, videocon Aethrakits were utilised).

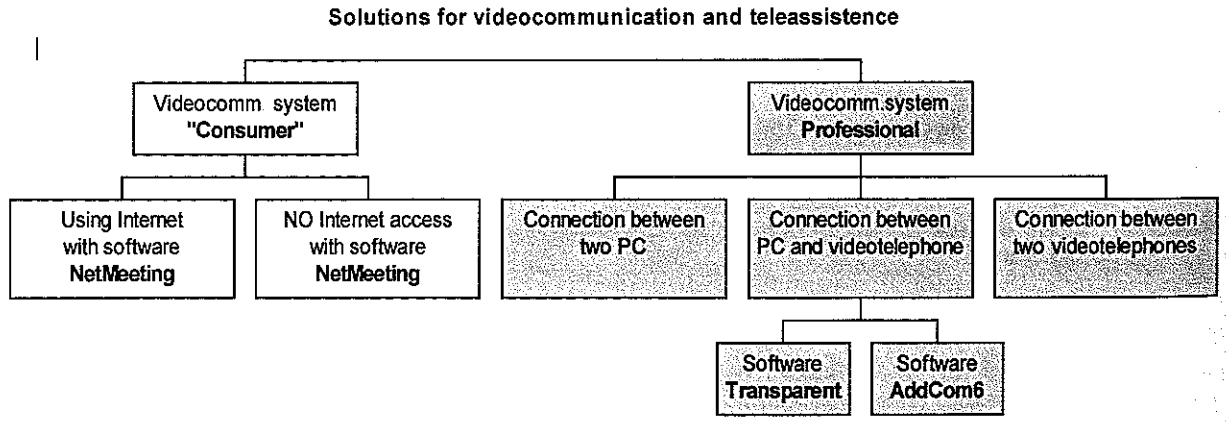

Fig. 2 Analysed solutions for video teleassistance

CONSUMER SOLUTIONS BY MEANS OF APPLICATION SHARING

For this group of solutions, the concept of Application Sharing, which consists in the utilisation of an instrument that allows the operator to act and manipulate on the prosthesis control Software at a distance, takes on fundamental importance. Substantially, the patient who goes to a peripheral center connects his own prosthesis to a PC containing the control/monitoring software, which is remotely shared with another PC on which the expert technician, who is capable of correctly interpreting the meaning of the gathered data, is operating.

The expert operator, from the main center, shares this application just as though it were directly present in his own terminal.

Different types of software are presently available that have similar features and in this study, it was decided to use NetMeeting Microsoft, also in view of the fact that it is distributed without charge.

NetMeeting is a *Microsoft* program that is very easy to use for video communication which allows connection through the local network (LAN), via Internet or by directly utilising a modem. If the connection is made through LAN or Internet, the calls can be carried out by specifying the name of the network or the TCP/IP address of a specific computer. If a connection is made to a computer that carries out a USL (User Location Server) via Internet, it is also possible to call and specify the name of a User in the file managed by the User Location Server. Once the call is made, NetMeeting allows both to dialogue by means of written messages (even with more than one User at a time) and to share the applications, which is the essential characteristic of the teleassistance project. Another important feature that this software offers is the audio-video remote connection with the User, according to current standards.

This solution requires that the software relative to prosthesis management be distributed to all the peripheral locations and run locally from the PC, with the patient's prosthesis connected by means of serial gate. The operator, from the main center, can share this application just as though it were available on his own terminal.

Therefore, on both sides, the system requires NetMeeting software and a videocommunication kit[1] and, on the user's side, the addition of the application package relative to the prosthesis worn by the patient

The advantages of this solution are fundamentally linked to its low cost, since both the required hardware and software are products that are easily found at low prices in any computer store. The above solution may foresee, as a further development, prosthesis monitoring directly from the home of the patient and no longer in the centers equipped with sophisticated (and costly) professional systems.

The disadvantages of this solution, on the other hand, are due to extremely long delays in results caused by the lack of hardware codifiers and de-codifiers for video and audio in these video communication kits. With the solution that foresees the connection via Internet, it is also important to keep in mind that the TCP/IP protocol does not guarantee a fixed delay in the transmission of the packages, first of all because they aren't transmitted in a group and therefore arrive at destination with very different speeds and secondly because the delays depend on the amount of traffic on the network. Another limit regards the quality of the picture: such devices guarantee a quality that is sufficient for seeing a person, but certainly not sufficient for examining details. The suggested window format for these devices is 160 x 120; when increasing in size, the detail of the image worsens. Although personal computers are used daily by an increasing number of people and their easy utilisation makes them accessible to people who would have never used them up until a few years ago, there is still a category of elderly people that finds that this instrument makes everything more complicated.

Furthermore, the enormous flexibility representing one of the strong points of the PC, may also turn out to be the weak point of the solution in the case one desires to use the computer for other tasks, from which the unavoidable problem of software viruses or instability could arise.

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[1] For testing, the multi-media Digicom Galileo kit was utilised, consisting in: video camera, headphones and microphone, integrated with a SoundBlaster 32W card

PROFESSIONAL VIDEOCOMMUNICATION SYSTEMS

The videocommunication apparatus utilised in the tests are systems manufactured by the AETHRA company in Ancona (Italy), a European and world-wide Leader as far as systems of videocommunication and teleconferences are concerned. Solutions are possible for various operative requirements (Fig. 3a, 3b, 3c) which utilise from the simple but practical video telephone for instalment at the patient's home, to the more sophisticated systems of videoconference, for use by businesses.

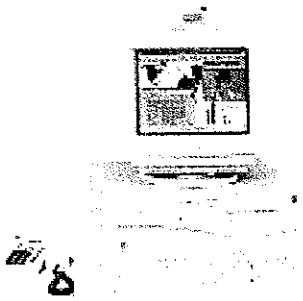

Fig. 3a Videocom system PC based

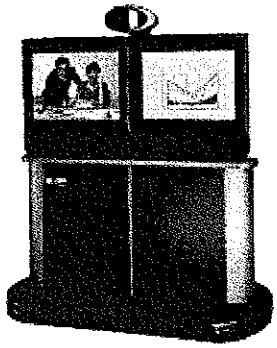

Fig. 3b High quality video conf. system

Fig. 3c Videotelephone

In this analysis, the PC Based systems will be considered, i.e. those consisting in a PC with a HW dedicated to systems based on videotelephones.

By adopting these types of solutions, one may benefit from a complete system consisting in hardware and software the allow for management of remote connection via ISDN network. Typically, these kinds of systems include a PC card that encodes and decodes the audio video signal, also permitting the utilisation of professional monitors and video cameras for those cases where high quality is required. The systems are capable of utilising 1 to 3 digital lines, associated in such a way as to have a useful transmission band up to 384Kbit/sec. One important characteristic of the system is the availability of a *remote serial,* called *Com6,* which allows to receive and transmit the data without having the serial gate physically present on the PC, although present on the remote video communication apparatus to which one is connected. Thanks to a low-level software interface, the data transiting on a physical serial (com1 or com2) are transferred to the data channel of the ISDN network and, vice-versa, the ones arriving from the network are directed to the PC bus as though they were being received from a physical serial. In a totally transparent manner, the expert operator who has the task of tuning up the prosthesis, selects a remote serial (com6) by means of the options provided by the prosthesis management software and elaborates the signals of the remote patient's prosthesis just as though they were directly connected to a serial gate of his PC. For this additional serial gate (defined as a remote or virtual serial) provided by the software application, the characteristics of the communication protocol, such as the speed of transmission, the start and stop bits, the equality bits, etc., may be fixed.

This type of solution avoids the network transportation of video maps which characterise Application Sharing, thus limiting the flow of data from and to the prosthesis, which, in the worst of cases, is 19200, while obtaining a distinct improvement in the speed and quality of the image and a drastic decrease in the delays between the audio visual reception and the data relative to the prosthesis.

Two PCs are present in this solution: one at the patient's home and one used by the technician who manages the video communication and the data transfer and elaboration.

The software layer (Caronte.vxd) delegated to detecting the data of the physical serial connected to the prosthesis for transfer on the ISDN network, and the relative PC with the video communication apparatus at the

patient's home, may be replaced by a special video telephone which is entirely and automatically occupied with the management of the data channel, with the same features of the Caronte application. In this case, the apparatus found at the patient's home consists in a video telephone that can also be used as a normal telephone and which is no doubt more useful for people that aren't familiar with computer systems. The only flaw in this solution is the high cost of these devices when compared to a normal telephone.

In the hypothesis of the use of a PC and a videotelephone, two alternative software solutions have been developed for the purpose of making the system more flexible. In fact, with the previous structure (Fig. 4a), a software layer exists that provides access to the com6 serial (Addcom6) at an operative system level, although, in turn, the prosthesis software application must foresee a com6 serial gate in its configuration options in order to be able to activate the teleassistance. This forces the producers of prostheses to have to modify the existing software, already distributed. The reason for this is that the PC managing the videocommunication is the same one working with the prosthesis software. One solution to the problem (Fig. 4b) may be to separate the two functions of prosthesis management and videoconference/data transmission, by leaving an application called "Transparent" on the PC delegated to the videocommunication carrying out the function of recopying the data arriving from the com6 virtual serial to a physical serial of the same PC: com1 or com2. At this point, the physical serial can be connected to the physical serial of the PC in which the prosthesis management software is installed.

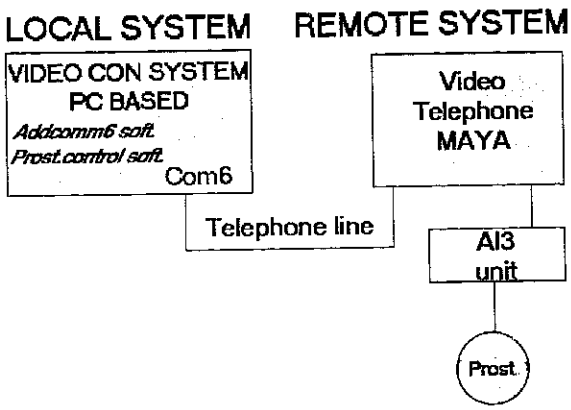

Fig 4a Solution with AddComm6 software

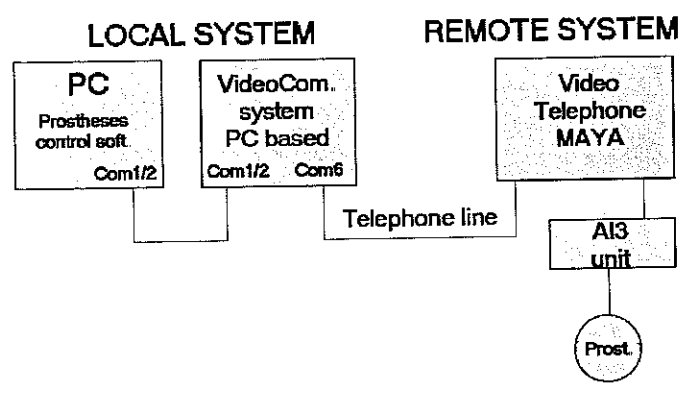

Fig. 4b Solution with Trasparent software

As described in the following Table, by using a second PC, the same software can be utilised without any modifications.

Remote Connection Application	Local Hardward Required	Necessary Software Modifications
Transparent	**2** PCs with Pentium 133 Mhz or more, one of which equipped with Aethra kit	**None**
AddCom6	**1** PC with Pentium 133 Mhz or more, equipped with Aethra kit	An additional serial gate is necessary: *Com6*

As a last solution, one could foresee the connection of two videotelephones that carry out all the functions of videocommunication and opening of the data channels for the virtual serial. With such a solution, however, the

problem remains that no intervention on the communication protocol is allowed and therefore it is impossible to carry out an optimal synchronisation of the video with the data.

RESULTS AND FUTURE DEVELOPMENTS

The various teleassistance systems based on professional equipment or on typically "low cost" equipment, with different solutions, have surely proven to be capable of carrying out an important role in the remote management of myoelectric prostheses.

The following Table lists the essential information concerning the various solutions, including economical aspects. Each solution requires the identification of certain hardware and software requirements for the local system and remote system and emphasise should be made that one absolutely preferable solution does not exist: in fact, the choice is based on a compromise between performance, costs and the typology of the patient. For example, in the case a choice must be made for an elderly patient, at home, who is not at all interested in purchasing a PC, the solution with the Maya telephone is surely the best, even though the costs are still fairly high.

ADOPTED SOLUTION	COST	NOTES
Low cost PC-based system	LOW	Ideal for patients having good familiarity with computers.
Professional system with HW PC (SDV8000) 128 KB	MEDIUM	Ideal for Assistance Centers
Professional system with MAYA 128KB videotelephone	HIGH	Ideal for elderly patients or other people with very little familiarity with computers.

The tests were carried out by connecting both an Inail center with the Prosthesis Center and the Prosthesis Center with the OttoBock Austria headquarters in Vienna, Austria. During these experiments, a test of the sensors installed on the SensorHand and their calibration was carried out. Verification was also made of the possibility of remotely diagnosing malfunctions due to the batteries or to a bad electrode contact. Another very interesting test, giving truly excellent results, was relative to an electromyographic examination of the patient at a distance.

One other important field in which this system could be extended is that of electronic wheelchairs, which may undergo functionality tests by means of special dedicated switchboards or software that can be personalised as far as maximum speed and acceleration, etc. are concerned. In this case too, teleassistance will make it possible to solve some of the wheelchair problems directly at the patient's home and offer him a series of additional services to make its utilisation and management more simple. Just think how much it would cost to ship an entire wheelchair in comparison to replacing only the broken part that has been identified by means of remote connection.

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