INTERNATIONAL SYMPOSIUM ON THE APPLICATION OF AUTOMATIC CONTROL IN PROSTHETICS DESIGN
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SESSION V - F R I D A Y MORNING, August 31, 1962.

CHAIRMAN of the Session Mr. Miklos ORBAN - from the Automation Laboratory of the Hungarian Academy of Science

CHAIRMAN: I should like to open this morning's session informing you about the program. We shall listen first to Mr. Mancini's and Roncaglia's paper about an ELECTRONICALLY CONTROLLED SERVOMANIPULATOR and after that we shall have the closing session. Now, Mr. Tomović would like to say a few words about minutes.

MR. TOMOVIĆ. I would like to ask the participants to give us their corrections to the minutes as well as any additional material that was not taken down on the tape. Please do this immediately or please send us back by the end of September so that we can publish the minutes.

CHAIRMAN: Now, I call upon Mr. Mancini from the Atomic Energy Committee of Italy to present his paper.

Mr. MANCINI: Mr. Chairman, Ladies and Gnetlemen, as you have already hear we are working for the CNEN which is the Italian Atomic Energy Committee and during the last years we have been particularly concerned with remote handling problems. Mr. Roncaglia who is sitting on my left has been in charge of the mechanical design of the Manipulator we are going to present to you this morning.
During the days we have spent at this Convention we have learnt from you many interesting things and I am more convinced now that there are many common problems in Remote handling and Prosthetics design, and that a deeper insight on what you do and on what we do may help both of us.
I would like to point out, however, ane important difference between prosthetics and Remote Handling devices. In fact

we design equipment suitable for healthy operators and it is therefore obvious that we have input data different from yours. For example, we never considered the existence of electric potentials in muscles as a source of signal which would actuate some mouvements of our equipment since we can use directly the movements of the operator's arm and hand.

Before describing the Manipulator we have realised in our Laboratory, I would like to give you a general idea of the Remote Handling problems in Nuclear applications. As you all know Remote Handling Devices are employed by us in order to extend the human activity to those working areas where men cannot work directly with his hands on account of the high radiation levels present there. As a matter of fact all Nuclear Plants are equipped with some kind of Remote Handling Devices.

A typical application, for instance, is what we call Hot Laboratories which generally are, small rooms very radioactive inside with large walls all around made in heavy concrete where all the tests and research work are carried out which are usually performed in conventional chemical, metallurgical or engineering laboratories. These Hot Laboratories are essentially made to study the influence of high radiations on the physical and chemical properties of materials which will be employed in the construction of reactors and nuclear facilities.

Naturally, these laboratories are completely operated by men in the safe area which is outside the walls. At the very beginning of the nuclear age technicians solved their remote handling problems, by designing each time a special equipment for the particular remote operation they had to perform, By this way couldn't obviously be followed any longer when the problems were increasing in variety and complexity.

The idea of the Manipulator was then conceived which had to be a general purpose handling tool capable to carry, by an operational point of view, the hands of the operator

besides a large wall.
I think that many of you have seen these mechanical manipulators and I will not waste time to describe them.
When maintenance problems of large nuclear plants, such as fuel element reprocessing plants and power stations, were more seriously taken into account, people started thinking that mechanical manipulators couldn't completely solve the problem.
The maintenance of a plant is something which cannot easily be foreseen and it is not feasible to provide so many mechanical manipulators around a large nuclear plant in order to repair or substitute equipment and components where a fault occurs.
The most outstanding disadvantage of mechanical manipulators is due to mechanical linkages between master and slave, master stations when operator works. These mechanical linkages do not allow any mobility of the slave station. As a consequence the working volume covered by the manipulator is limited.
(PAPER DISTRIBUTED)

We are going to show you a short film illustrating the operating capabilities of our manipulator.
Before concluding I would like to make a few considerations on the future design development. I think we can now look at the film.

CHAIRMAN: I wish to thank the authors for this very interesting paper and now I open the discussion. Are there any questions or remarks? Mr. Tomović.

Mr. TOMOVIĆ: My points can be divided into two groups. First of all I completely agree with Mr. Mancini that the field of prosthetics has certain connections with the problem of remote handling. So far these problems have been considered completely separately and I think that by trying to apply some of the advances in prosthetics and reversely we can achieve better equipment. To be more specific, I think that

certain theoretical principles which I explained in my paper relate also to remote handling. Now, I mean remote handling by radio links where you have a problem of reduced channel capacity. By applying the theoretical proposition which I call the minimum of information from the central place we can design equipment for remote handling by radio links where most of information would be derived from the local spot, using the least possible information from the central place. Secondly, the point where these two problems meet is, I think, the problem of functional design so that the operator of the servo-manipulator does not need to learn too much, in other words he should not be especially trained. I am not a specialist in remote handling and I would like to have Mr. Mancini's comment. It seems to me that remote handling equipment should be designed as aprosthesis so that the man uses his normal functional habits for control. This perhaps can bring us much nearer to better manipulation and I think that you have made important advance in this field. I have seen various projects in other countries but your seems to be most advanced in that it does not require too much specialised training to use the robot. I personally believe that in the future it will be possible to build even more functionally designed robots. Now, as regards the second point, I have some specific questions to ask. First, every additional degree of freedom, as you have said, increases the cost of the remote handling equipment. Now, the hand we have shown here is commanded by very simple on-off signals and it can handle objects of various shapes without requiring additional extension of the central control system. What is your opinion about the application of such equipment to remote handling, specifically to the type you are using? Secondly, while visiting MIT I saw a project for remote handling and for some reasons they are interested in sending back information about the object not by television channels but by other means. They are interested in

recognising the object by its roughness. Is there any need for this, I mean, to know whether the object is rough or not, so I would like to have your opinion. And there is a third point which we are considering in my group for further prosthetics work. We have developed a very small device using pressure sensitive elements which we put here at the neck. Now, as you know, the man normally positions his hand by his eyes. We are experimenting in positioning the hand by turning the neck. We have also used electrooculographic signals for this purpose. This is still at a very early stage of development so I cannot say much about successes, but I would like to know your opinion whether this can be used for manipulators.

Mr. MANCINI: Thank you dr. Tomović for your appreciation of our work. I think that your hand can be very usefully employed in our manipulator and I think that it could be also employed in on-off type of control we have now. I am not quite sure, but may be we should need some force reflection too. I do not know whether the mechanical chain connecting the input pulley in your hand and the movements of the fingers are reversible or not. If they are not reversible we can not have any force reflection of the fingers to the fingers of the operator. Otherwise this can be done.

Mr. TOMOVIĆ: The movements are not reversible but we can obtain force reflection by measuring the pressure electrically.

Mr. MANCINI: Yes, that is right. With the signals obtained from this transducer you can actuate motors which then give you the force. This could be done of course. I think your hand should be designed for more heavy duty operation than it is now. As regards the roughness or smoothness of objects I do not know actually what is the reason for their use. May be to simplify the problem of feedback. I think this electrooculographic signals could be very usefully employed not only for moving the arms of the manipulator but also for moving the TV camera. So when the operator is moving his head, as he naturally would do in

in order to move to one side or the other, the camera would follow the movements of the operator and could be automatically focussed on the object.

Mr. TOMOVIC: Thank you.

Mr. WIENER: I would like to point out that what you are doing and what the people with the prostheses are doing is so similar that you might practically call what you are doing prostheses for senses that we do not have and for actions that we can not ordinarily make. I mean the notion of the prostheses is only for senses that we have lost prostheses may be for actions and sesnses that we do not have and never will have. But I want to make one suggestion. What you have done might have a great medical application what you can call the counterpart of endoscopy. Endoscopy is putting devices into the body to see the inside of cavities which you can not ordinarily see. That can then also be the manipulation of the inside. It seems to me that by the combining endoscopical interior sensory devices with this sort of the thing on a small scale, it might be possible to do very valuable surgery inside the body without opening a good many cavities. I just wanted to make this little suggestion.

Mr. MANCINI: I do not know actually how manipulators could be applied in this field but there are many other fields where they can be applied. For instance underwater ...

Mr. WIENER: Oh, yes.

Mr. MANCINI: ... and there are many others.

Mr. BOTTOMLEY: I noticed that when your device was operating, when it was turning things it had to letthem go and get hold of them again like an ordinary hand does whereas I do not see any reason of the need of this limitation. I was wondering whether you thought of having all movements go round through 180 degrees or whether you have devised anything of controlling that.

Mr. MANCINI: You mean why we did not turn the tongue through 180 degrees?

Mr. BOTTOMLEY: Why it could not continue to rotate?

Mr. MANCINI: We could continue it on for + or - 180 degrees but it is not so comfortable for the operator in certain position to turn his hand 180 degrees.

Mr. BOTTOMLEY: Oh, yes, he could get go his handle and get hold of it roundways without letting it go if nothing is holding to it. There would not be anyopportunity of dropping. You see what I mean?

Mr. MANCINI: Hmm, I see it now. I see what you mean. Yes, of course it could be done. I do not know why the operator preferred to do it this way.

CHAIRMAN: Are there any other questions or remarks?

Mr. NIGHTINGALE: I am interested in the use of this on a much smaller scale for the same purpose, in hospitals where we are dealing with 50 milicuries on 100 mc of radium, radioactive gold and so on. We are only very short distance away from doing very fine manipulations and this is giving us trouble in handling. Many people are finding this problem in many hospitals. I think all over the world there are few attempts being made to use remote control manipulators of the mechanical linkage type but these take rather long time to use. We just have not time to spend over at the job. Is there any possibility of your system being adapted for fine movements? We do not need television, because we can give ourselves a glass barrier and look directly. The point is in providing a device that can be controlled in an easier way. It would of course be more difficult to build because you are demanding rather finer movements.

Mr. MANCINI: Yes, we started designing a few months ago a new type of manipulator which is much smaller in size than the one we described here. This new one, which we call micro manipulator, will be used in very small hot cells for

plutonium manipulation. As you know plutonium is very toxic material and we need a completely sealed container in these hot laboratories. This type of manipulator I think, could be suitable for application you mentioned. Itwill also be much more economic, much less expensive than the one we have made. The one we made now, apart from the research which is not included in the price, costs us 100.000 dollars.

Mr. RESWICK: There is another kind of system or system of devices which are similar to the prostheses and remote handling and which have aroused considerable interest in the United States. This is the concept of the return servo soldier It reminds to something like medievial suit of armour but with all of the joints externally powered and controlled. The idea is that, perhaps in the device like Mr. Mancini's, the man sits within the device and as he moves his arms the servosystem follows the movements and provides for tremendeous amplifications in force and weight carrying possibilities. There is an interesting problem that comes about here if one visualises the structure, perhaps like the one that we are working on at CASE, where the arm of a person lies inside a moving servo device, but the arm is very weak, as in the case of paralysis, and must rest upon the device all the time. This is rather a straightforward thing to do but one might say why not put a position sensor or force sensor between the arm and the structure and then move the arm of a normal person and then as the errors are developed within the structure have the structure follow the arm. The problem here, as in the case of a paralysed person who may have some residual function, is that which is bound up in the problem of gravity. In other words, if the person is strong enough to create a small movement so that a signal might be developed, but not strong enough to support his arm in the gravity field, then it is almost impossible tobalance the device in three dimensional spece so that an error signal can be developed. I have mixed up the two points here. The servo soldier idea of couree is

built around a normal person who can support his arm in a gravity field and therefore quite easily can cause the error signals to be developed so that the structure will follow his arm. The possibility of applying a similar structure to paralysis or weakness involved in muscular distrophy for example is very, very much more difficult. There is another point I would like to make. In our own work we are trying to build a device to support only five pounds and have realized the kinds of mechanical design problems that are necessary to make any structure which is stiff and free to move in all directions and how big the parts have to be. I am rather sceptical that it will be simple to design a structure which is not much bigger in size but which will support say 500 lbs, the way some of our artistic designers who draw pictures for our magazines show these devices.

CHAIRMAN: If there are no other questions I would like to thank the authors for their interesting paper, and all the participants in the discussion for their contribution. After ten minutes break Mr. Tomović will take over the chair for the closing session.

E N D morning session FRIDAY, August, 31.