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Proposal for the Application of Nanotechnology in Microsurgery

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Abstract

Microsurgery allows you to perform tasks that are closed to medicine without adequate instruments. Incredible advances have been made, but at a very high cost in personnel and resources. Not everyone can deploy it. That is why it can be affordable by personnel who cannot carry it out, for example, in countries without expert micro-surgeons, or in isolated places, or situations of lack of means, such as catastrophes. The technology can be simple, straightforward, and robust. Why develop advances in robotics and nanotechnology in microsurgery.

Keywords: Nanotechnology, Microsurgery, Communication, instruments

Introduction

According to statements from a surgeon in microsurgery, it takes 50 sessions of it to have optimal success capabilities. Many times there is not enough material or personnel to do it, so microsurgery must be affordable for professionals who cannot do it [1].

- Microsurgery is art nowadays, fully available for the task of the person performing it, something that is not always possible.
- There are always human errors in its execution by a single person.
- It has a very small actuation range, sewing 0.5mm diameter capillaries.
- Vision with microscopes and perfect view and contrast is required.
- Many times there is no time available to ask for a specialist.
- Many training sessions are required to acquire the skill.
- It is very expensive, both in the media and in preparation.
- It is desirable to intervene in the smallest possible area, to prevent infections and
- promote postoperative recovery.

Thus, the following proposal for an automatic device to perform microsurgery in operating room conditions, with connection to a presentation equipment such as a screen, is presented.

It consists of the following elements:

- Recognition
- Acting
- Communication

The recognition would be done with a 3D micro scanner using a camera, with the front and back of the area to be joined. It has been assumed that, based on existing technology (for example, at the INFAIMON company, with recognition of fat spots in pig tissue), it is possible to recognize living tissue, with its nerves and capillaries. All the technology shown is very reminiscent of that existing for Google Maps, so a route reading has been planned to unite the two faces, as if route algorithms were used, to connect the nerves and capillaries. All this would be done with multispectral cameras, which would guarantee adequate contrast to distinguish fine details. It would be shown, with the appropriate artificial vision and augmented reality program, on the screen that would remain outside the operating room, allowing more specialized and training personnel to attend the operation and make comments.

Besides, broadcasting in a video format with VR/AR would allow, later, to edit the operation, save it for examination and analysis (such as a soccer game), as well as the training of professionals. Being a video format, it can also be broadcast via streaming to other locations. The performance has been planned using 3 actuators painted in vivid colors, to facilitate the contrast of the vision cameras. One of them would carry the suture needle and the other two would make the necessary knots to get the sutures well done. Each actuator has 6 axes of freedom. Except for the base, which is Cartesian, with movements in x and y, the other axes have an adjustable tripod format, made of titanium, a biocompatible and economical material, machined into its shape using laser ablation. The shape of each axis is special, to house the three actuators and their corresponding wiring [2].

The actuator is a DEMA (Distributed Electrostatic Micro Actuator) model, made by lithography, very easy to manufacture and control, with the simplicity to be cleaned with ozone in the operating room before the operation. The actuator control would be carried out with electronic assemblies type BUCK- BOOST, with PID type control of the voltage. Very simple, robust, and proven circuits that would provide control over the three actuators on each axis, providing the necessary degrees of freedom to perform the complex suture movements of the operation. The control of the actuators would be carried out with a microprocessor external to the actuators, since they are protected, to facilitate cleaning tasks. Vision cameras would record the position of the actuators and, by machine vision and shape recognition, could provide the necessary position feedback to close the reading loop. That is, the cameras would act as position sensors, just as a human eye would do concerning manual sewing of tissues [3].

The whole set should be manufactured and assembled with nanotechnology techniques, such as lithography and MEMS assembly, by specialized companies. However, except for the actuator microprocessors and machine vision, they are simple assemblies to implement. The actuators can be welded in a particular position to the titanium shafts employing etching, to be able to conveniently weld the cables to the places indicated in the DEMA. The third section, communication, is very important. It has been divided into two concepts: electric charging and data transport [4].

Because the equipment must be mobile and must be able to move between operating rooms, wireless communication has been chosen, to facilitate both transportation and ozone cleaning of instruments. The charge would be carried out using RFID, as if it were a mobile phone, at the precise site of the operation. It has been assumed that, due to energy consumption, it will not go beyond the consumption of a mobile battery. Currently, the charging of mobiles using RFID allows, in the latest models, to reach 60W at a reasonable time. The power demanded by the microsurgery mechanism will not go further. Thus, it is assumed that the equipment will have a graphene battery, powerful enough to provide power without supply for 4 or 5 hours, which is normally the duration of a microsurgical operation of these characteristics. External communication with presentation equipment must be very fluid and with a large capacity for transmitted data. The 5G standard has been chosen, since it already has proven technology indoors, and it is planned that there will be no significant interference at a distance from an operating room. It has been assumed that inside the operating room there will be a small cell, with which communication with the outside will be kept indoors [5].

Conclusion

The latency allows the retransmission in the streaming of the operation, thanks to the fact that it is of the order of 1 millisecond, for a flow of 20 Gbytes / s. The Keysight company has the necessary hardware models for the transmission, so it would not be a problem to be able to video streaming the sutures and to send the appropriate orders to the microprocessor responsible for controlling the actuators. The software required for this microsurgery device is currently available in various forms; it would only have to adapt to the actuators, carry out the 3D scan and the mapping of the path of the nerves and capillaries, perform the necessary feedback during the operation, and ensure communications during artificial vision and augmented reality. This proposal aims to make the device easily sterilizable by ozone, with hardly any cables or complex MEMS mechanisms where bacteria and viruses can lodge. Hence the simplicity of its mechanism. The instruments can be cleaned with ozone. It is considered the best option, since it has the widest range of cleaning, both in instruments and in operating room areas. With this approach, it would only be necessary to build a prototype to establish an action protocol. To be able to prove it, since it is a system already implemented separately in its different parts. The feasibility of the components has been checked separately. Thus, only the necessary investment would remain to carry out the concept tests with the prototype and be able to offer an affordable product to hospitals that cannot have microsurgery.

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