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Active catheters prototyping: application for neuroradiology

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ABSTRACT

Clinicians performing endovascular surgery (interventional cardiology or neuroradiology) are increasingly demanding in terms of improvement of their operating tools and more specifically of their catheters. Conventional catheters appear significantly limited with respect to commandability, precision and stability when introduced and positioned into the arterial frame. Active catheters in which the tip move actively using shape memory alloy (SMA) actuators that are activated using the Joule effect presents a promising approach[2-3-4] .

In this work, a new low-cost active catheter (see Fig.1(a)) concept is proposed [1] for endovascular surgery in general and for the treatment of brain aneurysms in particular. The limitations imposed on the device by the in vivo operating conditions have been considered, and a specific shape memory alloy has been selected that is able to operate in a narrow temperature range.

From a technological and structural point of view, our approach relies on (i) the use of a composite-like structure obtained by thermoassembly and whose fibres can have various functionalities: rigidity control, actuation, position sensing, connection. (ii) a precise theoretical modelling of the behaviour of such a structure submitted to large deformations.

As far as the thermal control is concerned, experiments have been conducted in-vitro using an angiographic model of the circle of Willis (see Fig.1(b)) and temperature elevations caused by the Joule effect measured with sensors. Furthermore, we constructed a numerical simulation model suited for prediction of temperature distribution and subsequent optimization. Results obtained for different electical pulse are presented and time duration to reach the temperature limit are determined.

Insights from the finite element results and in-vitro experiments permit us to present a number of directions for further improvement of the present active catheter design, such as cooling possibilities.

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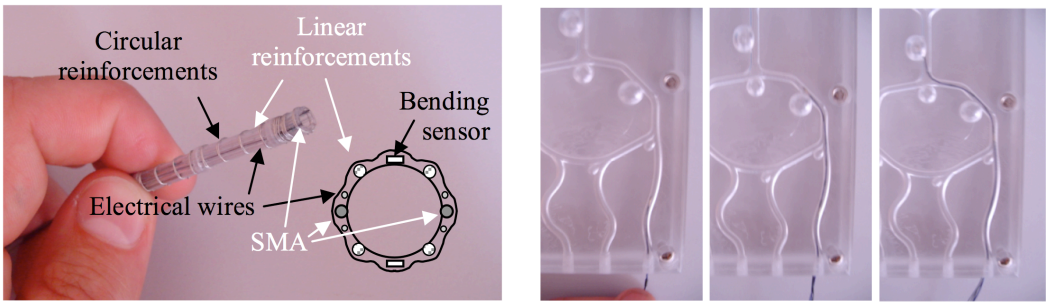

(a) (b)

Figure 1: Active catheter of neuroradiology: (a) Details of the catheter (diameter=4mm), (b) Experiments performed in a simplified in-vitro model of the circle of Willis presenting aneurysms.

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