Towards Optimized Neural Stimulation in a Device for Urinary Incontinence

Arsam N. Shiraz[1], Andreas Demosthenous[1]
[1]UCL Department of Electronic & Electrical Engineering, Torrington Place, London, WC1E 7JE, UK

Introduction: Periodic storage and elimination of urine depend on coordinated signalling of the peripheral nervous system, organized in the brain and spinal cord. After spinal cord injury (SCI), functions of the lower urinary tract are often disrupted which may have fatal consequences. Using the probe shown in Figure 1, Craggs *et al.* [1] in their study on 6 SCI patients, suffering from relevant conditions, demonstrated that by conditional trans-rectal stimulation of the pudendal nerve upon sensing an EMG signal from the external anal sphincter, it was possible to suppress hyperreflexia and increase the bladder capacity in all the subjects.

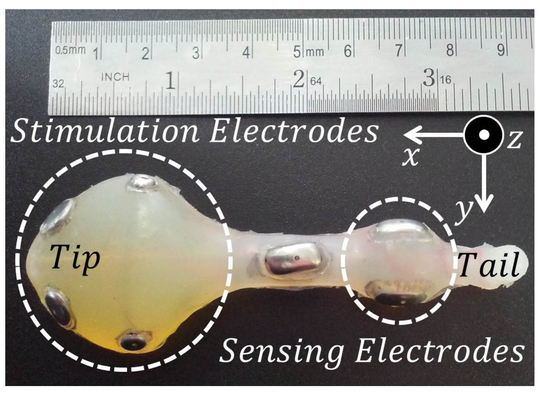


Figure 1. Trans-rectal probe used in initial studies.

Objectives & Constraints:

- Embed battery operated μelectronics in the probe shown in Figure 1.

However, as the stimulation of the nerve is trans-rectal, a high level of current is required to excite the nerve. Thus,

- Design should be optimised to minimise power consumption.

MRI Studies:

- To find the trajectory of the target nerve with the device *in situ*.

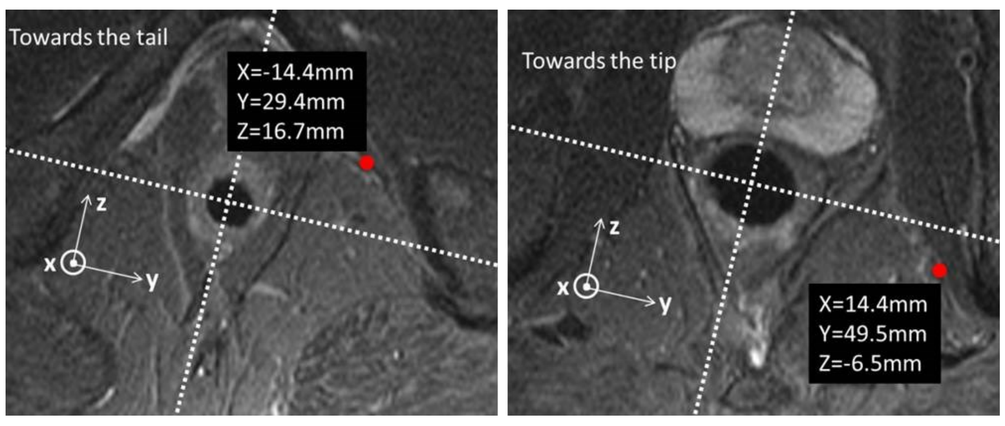


Figure 2. Transverse planes of the MRI . Origin defined inside the probe and the position of the nerve is marked in red.

Modeling: The probe shown in Figure 1 was modeled assuming a double layer surrounding and devising extra electrodes on the probe. Activating function [2], defined as the second spatial derivative of the electric potential, should be maximized to achieve a better excitation of the nerve.

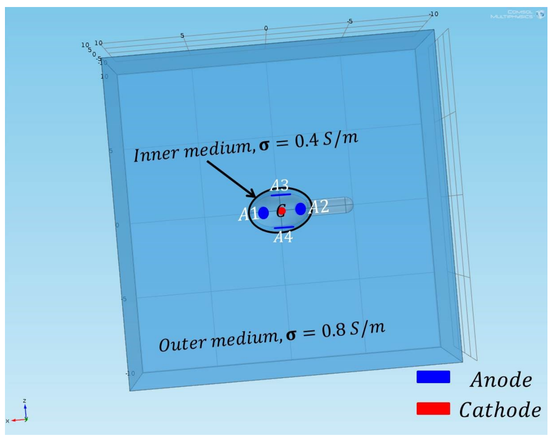
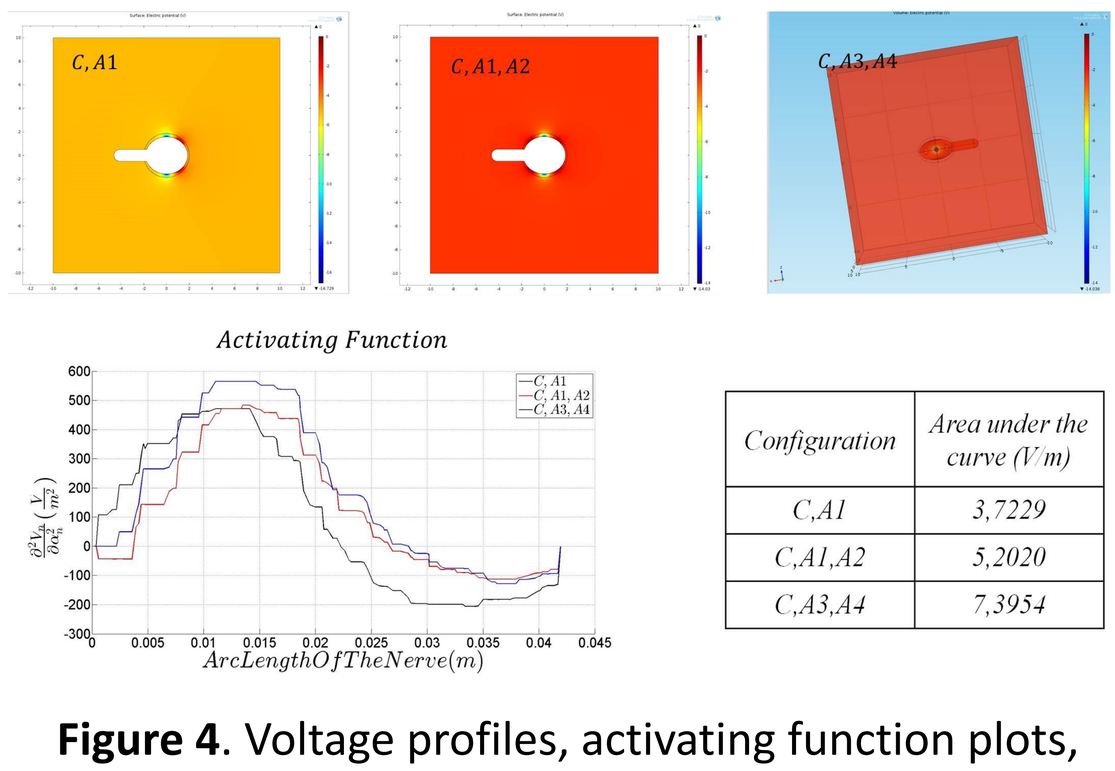


Figure 3. 3D model of the probe with extra electrodes on the surface of the probe and a double layer surrounding medium.

Results: Having defined the approximate trajectory of the nerve as a *Cut Line 3D*, passing through the points defined in Figure 2, the activating function along the line was calculated using different electrodes.



Configuration	Area under the curve (V/m)
C,A1	3,7229
C,A1,A2	5,2020
C,A3,A4	7,3954

Figure 4. Voltage profiles, activating function plots, and area under each curve for different configurations

Conclusion: Results show that C,A_3,A_4 is the optimized stimulation configuration.

References:

[1] M. Craggs *et al.*, Conditional neuromodulation using trans-rectal stimulation in spinal cord injury, Neurology and Urodynamics, 28, 836-837 (2009)
[2] F. Ratay, Analysis of models for external stimulation of axons, IEEE transactions on biomedical engineering, 33, 974-977, (1986)

Excerpt from the Proceedings of the 2013 COMSOL Conference in Rotterdam