(1) Presentation Title: Expanding Comprehensive Optimization Problem Solutions for a Wider Range of Concentric Ring Electrodes

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(8) Abstract:

Comprehensive optimization problem for dimensions (width/radius of recording surfaces and distances between them) of a concentric ring electrode (CRE) based on its finite dimensions model has been previously solved in [1]. It targeted maximizing the accuracy of the Laplacian (second spatial derivative of the surface potential) estimation and analytic results were confirmed by finite element method modeling [1]. However, that study had several limitations: all the results were obtained for a very limited number of finite dimensions model segments (6 and 9 only) and a single (tripolar) CRE configuration while other configurations were just mentioned in passing as consistent with the proposed five general principles that defined optimal CRE geometries in terms of the accuracy of the surface Laplacian estimation.

This study addressed all of the aforementioned limitations greatly expanding the mathematical analysis performed in [1]. In particular, it added three more CRE configurations (quadripolar, pentapolar, and sextapolar) along with a range of the numbers of segments (covering every feasible number up to 25 for each configuration) to illustrate how several characteristics including the number of possible different geometries for each CRE configuration change with respect to the number of segments.

Some of the obtained results were to be expected. This includes the increase in the number of possible different CRE geometries associated with the increase in the number of segments that its finite dimensions model has been subdivided into and respective growth in the maximum increase of the minimum absolute value (worst to best case scenario) of the lowest order truncation term coefficient of Taylor series expansion. Despite of that these results are still useful for practical applications like drawing direct comparisons between the number of possible different geometries corresponding to different CRE configurations for a specific number of finite dimensions model segments. Moreover, other obtained results were harder to predict. This includes the minimum absolute value of the lowest order truncation term coefficients being

lower for CRE configurations with higher numbers of rings or their increase with the increase in the number of finite dimensions model segments. With this result it is important to note that those coefficients correspond to different lowest remaining truncation terms orders: sixth for tripolar, eight for quadripolar, tenth for pentapolar, and twelfth for sextapolar CRE configuration respectively. Since “higher-order terms usually contribute negligibly to the final sum and can be justifiably discarded” [2] most likely the CRE configuration and hence the truncation term order was the determining factor in the decrease of coefficients associated with the increase in lowest remaining truncation terms order. Otherwise obtained results are consistent across different CRE configurations and different numbers of finite dimensions model segments.

[1] O. Makeyev, Y. Ye-Lin, G. Prats-Boluda, and J. Garcia-Casado, “Comprehensive Optimization of the Tripolar Concentric Ring Electrode Based on Its Finite Dimensions Model and Confirmed by Finite Element Method Modeling,” *Sensors*, vol. 21, no. 17, p. 5881, Aug. 2021, doi: 10.3390/s21175881.

[2] M. R. King and N. A. Mody, *Numerical and statistical methods for bioengineering: applications in MATLAB*. Cambridge University Press, 2010.