A new methodology for RF-EMF exposure assessment based on sequential surrogate modeling

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The World Health Organization (WHO) recently listed in its Research Agenda the need for the quantification of the exposure to widespread as well as emerging radio frequency (RF) sources, which is valuable information for both epidemiological research and governmental risk communication towards the general public. However, robust assessment of RF electromagnetic fields is not yet possible in real-world situations, because only a limited set of measurement data can be gathered given a certain amount of time. The objective of our study is to conceptualize a new and efficient methodology that, despite an incomplete set of measurements and limited accuracy, makes it possible to accurately map the exposure to RF electromagnetic fields (RF-EMF) in a certain area.

Our procedure begins by characterizing the area under study, i.e., determining the two-dimensional geo-coordinates and the dominant signals, followed by calculating a Latin hypercube distribution of the initial measurement locations. From then on, all measurements are performed iteratively: based on the knowledge from previous measurements, a sequential sampling algorithm "learns" the EMF exposure on the fly, and sequentially proposes optimal locations for the following measurements.

After the initial batch of measurements, a first surrogate model can be built by interpolation. This model is then updated after each subsequent batch of measurements. And by calculating the change of the model compared to the previous version, a certain stopping criterion can be defined for our procedure.

We have validated this procedure in a small suburban area in Ghent, Belgium (for GSM900 downlink only), and the results were very satisfactory. Measurements of the electric-field strength were performed in ten batches of ten, using an EME-SPY120 exposimeter. We found that 50 measurements were sufficient to obtain a valuable map of the GSM900 electric-field distribution in this area. Validation of the resulting model with 30 independent measurements resulted in a mean relative error of 1.5 dB, and a correlation coefficient of 0.7.

In short, we present a new, efficient measurement and modeling approach for the assessment of RF exposure, based on surrogate modeling and sequential design. It is applicable in real-time and without a priori knowledge, making it interesting for epidemiologists, authorities and dosimetry research. Currently, we are also applying this procedure to the fast and efficient characterization of RF-EMF hotspots in a large urban area.