EMF exposure assessment in 5G scenario by deterministic and stochastic approaches

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The upcoming development of the 5th generation mobile networks (5G) will see the evolution and expansion of existing 4G networks and the introduction of new radio access networks in the millimeter wave bands (30 - 300 GHz). 5G networks will be designed in order to meet the new users' needs such as low transmission latency and data rate transmission increase and, in the end, will lead to a new world of connectivity, which will develop the concept of future smart cities, factories and roads and Internet of things (IoT) with billions of connected devices. As a result of these innovations, the future 5G networks will be different than the previous ones. In particular, the use of much higher frequency ranges will increase the number of base stations, including smaller cell deployments and advanced antenna technologies. Among these, the most innovative are the use of 'massive' MIMO antennas and the beamforming technique, which will permit to send and receive more data simultaneously and to obtain a very narrow beams that will follow the user with an impact for the surrounding exposure level different from that of current systems [Larsson et al., 2014].

This heterogeneous network will consequently drastically modify the users' exposure to RF EMF in the next years and may raise questions from general public [ITU-T, 2017]. This fact underlines the need of conducting promptly an appropriate exposure assessment considering these highly variable exposure scenarios, in order to verify that the EMF exposure limits reported in the guidelines will be respected around these new radiocommunication infrastructures.

The purpose of the present work is to introduce the use of both determinist and stochastic dosimetry approaches as methods to analyze the level of exposure of these new upcoming EMF exposure scenarios [Chiaramello et al., 2019], characterized by high complexity and variability, which cannot be addressed by a deterministic approach only.

Indeed, even if the use of deterministic methods represents a fundamental step in evaluating the users' exposure, it still counts some limitations. In particular, the deterministic methods could have problems in handle all the factors that will characterize the highly variable 5G scenario. Indeed, despite the progress in high performance computing, the classical computational electromagnetic techniques will still require highly time-consuming simulations for every single new specific case in order to evaluate the exposure level. For this reason, the deterministic methods will also be supported by the use of stochastic dosimetry approaches. Stochastic techniques are methods that combines the classical electromagnetic computational techniques and statistics to build surrogate models for obtaining the distribution of the quantity of interest with low computational effort. Stochastic dosimetry was successfully used in previous works both at low and high frequency cases and seems promising for dealing with the complexity of the emerging 5G scenarios. In particular, these methods could permit to take account of all the multitude of factors that characterize the highly variable 5G scenario.

The work will mainly focus on some downlink exposure cases, characterizing the exposure level changes that will occur with the introduction of the massive MIMO antennas and the beamforming technique. In particular, firstly a MIMO antenna will be accurately modelled and the exposure levels of a user in this realistic exposure scenario will be analyzed with deterministic dosimetry. The stochastic approach will then be used to evaluate the exposure variability that is caused by the use of the beamforming techniques. In this way, the specific exposure scenario to a MIMO antenna will be generalized to a multitude of different cases that characterize the heterogeneous 5G scenario.

Therefore, this mix of deterministic and statistical approach will allow providing an accurate description of the exposure assessment considering both realistic and typical exposures scenarios and use cases that the new 5G networks will bring in the immediate future.

References

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