Machine learning-assisted antenna modelling for realistic assessment of human exposure reference levels at frequencies above 6 GHz

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Abstract:
Oversaturation of frequency spectrum, increased need for higher data rates, transmission security and connection reliability have all led to the development of the fifth generation (5G) mobile telecommunication technology, currently in the deployment phase world-wide. Given the fact that operating frequencies of 5G hand-held communication devices often fall into the mmWave frequency range, hitherto poorly researched from the perspective of human exposure to radio-frequency (RF) non-ionizing radiation (Hirata et al. 2021), it is necessary to reevaluate the interaction with the human body and define appropriate dose metrics. The only prominent negative effect of this type of radiation is manifested through the surface heating of the exposed surface of the skin, thus, through standards and/or guidelines, various international bodies have defined dosimetric reference limits and corresponding exposure reference levels, correlated with the increase in tissue temperature (Foster et al. 2018).
This study is based on the assessment of the incident power density - exposure reference level for frequencies above 6 GHz (Hashimoto et al. 2017), through an illustrative example of the near-field exposure of a simple human skin model to high frequency RF radiation. Machine learning and associated techniques such as automatic differentiation have been utilized to improve the overall accuracy of the simulation by eliminating the numerical artifacts inevitable in the standard modelling of a realistic antenna. The discussion on the current state and future directions of differentiable computing in computational electromagnetic dosimetry is outlined.

Foster, K.R. et al. 2018. Modeling tissue heating from exposure to radiofrequency energy and relevance of tissue heating to exposure limits: Heating factor. Health Phys. 115(2), 295-307.
Hashimoto, Y. et al. 2017. On the averaging area for incident power density for human exposure limits at frequencies over 6 GHz. Phys. Med. Biol. 62, 3124-3138.
Hirata, A. et al. 2021. Assessment of human exposure to electromagnetic fields: Review and future directions. IEEE Trans. Electromagn. Compat. 63(5), 1619-1630.