Antenna System Diagnostics using Radiation Pattern Data and Machine Learning

Large antenna systems are responsible for distributing terrestrial broadcasts such as FM and DVB-T over large areas. To achieve the desired coverage and radiation pattern, the antenna systems are usually placed at higher altitudes and such placement exposes the antennas to severe weather conditions which can, over time, cause faults. Faulty antennas cause various unwanted effects that can impact the overall performance of the antenna system. One parameter influenced by the faulty antenna is the VSWR (Voltage Standing Wave Ratio) at the transmitter. However, diagnostic and identification of the faulty antenna using VSWR measurements is lengthy and requires a complete shutdown of the transmitter while the qualified personnel work at the antenna system. The other parameter determining the function of the antenna system is its radiation pattern, specifically its shape which can be measured using UAVs (Unmanned Aerial Vehicles). The advantages of diagnostics using the radiation pattern measurement lie in:

- the possibility to perform the measurements during the full operation of the antenna system (eliminating the necessity for a complete shutdown),
- not requiring the qualified personnel being present at the antenna system during the measurements,
- the speed of obtaining the required data and subsequent evaluation and the antenna identification process.

The faulty antenna can then be identified by comparing the measured radiation pattern with the radiation pattern obtained from the numeric calculations which can offer a radiation pattern shape prediction for various single faulty antennas. The main drawback of using radiation pattern measurements for antenna system diagnostic is the influence of real environment and parameters of the real antenna system. These can cause slight deviations from the predicted radiation patterns and can in some cases lead to inaccurate identification of the faulty antenna. Therefore, a simple comparison by correlation coefficient may not be suitable for use in some cases and a more robust method for determining the similarities and differences of the radiation patterns from calculation (prediction) and measurement should be created.

One such method can be dynamic machine learning and neural networks which can create predictions, taking into account the calculations and real environment measurements. These predictions could, with high probability, represent the behavior of the real antenna system containing the faulty (not radiating) antenna.

The goal of this project is to test various machine learning algorithms utilizing calculated and measured radiation patterns as training datasets. Subsequently, the best performing one can be selected. Afterwards a database based on the chosen algorithm can be created for an easy and effective implementation for scientific/industrial purposes. Furthermore, upon a successful testing, the system based on machine (Deep) learning for identification of faulty antennas can be implemented even beyond the terrestrial antenna systems, for example for satellite communications or base stations for 5G broadcasting, which utilize extensive antenna arrays.