Compact MIMO Antennas for Localization and PHY-layer Security in Wrist-Worn IoT Devices

Abel Zandamela, Nicola Marchetti, Max J. Ammann and Adam Narbudowicz
{zandamea, nicola.marchetti, narbudoa}@tcd.ie; max.ammann@tudublin.ie

ABSTRACT: On-body IoT technology, like wrist-worn devices, are becoming a key enabler of many cutting-edge applications such as connected healthcare systems (e.g., patient monitoring, in-hospital localization, sports fitness and tracking). However, miniaturization, improved antenna efficiency, advanced beamforming performance, and low energy consumption are still critical design requirements in such systems. Therefore, in wearable IoT scenarios, implementing traditional security methods and localization using classical antenna arrays are challenging. This research advances the above limitations by exploiting novel multimode MIMO antennas to enhance security aspects of wearable devices via emerging physical layer security methods and their capabilities to enable angle of arrival AoA-based localization.

Challenges and limitations

- Compact designs suitable for integration into wrist-worn devices.
- Challenge: Performance deterioration due to coupling with the human body.
- Beamsteering capabilities to allow localization and PHY-security.

Multimode MIMO Antennas

- Multiple-Input Multiple-Output (MIMO) structures.
- Excitation of different orthogonal omnidirectional radiating spherical modes.
- The modes exhibit different phase variations around the horizontal plane.

Antenna Configuration and Simulation Setup

- Size: $0.65\lambda \times 0.65\lambda \times 0.19\lambda$.
- MIMO structure comprising stacked patches.
- Excitation of 5 spherical modes using 5 ports.
- Unidirectional beamsteering across the entire horizontal plane ($xy$-plane).
- Antenna performance tested in free space and using a four-layer forearm phantom.

PHY-layer Security and AoA Performance

- Isolation $< 16.7$ dB, IBW ($\pm 10$ dB) of 23.5 MHz.
- Unique secure steerable direction with bit error rate of $10^{-5}$.
- Beamwidth with bit error rate $< 10^{-3}$ of 44°.
- MUSIC performance for single impinging signal AoA errors $< 0.45°$.
- SAR below FCC/EU limits (0.49 W/kg and 1.42 W/kg).

This work is supported by SFI Starting Investigator Grant no. 18/SIRG/5612.