MS Thesis Topic: Direction-of-Arrival Estimation with Hardware Impairments in beyond 5G/6G Systems

April 2021

1 Main Goal

The goal of this thesis study is to investigate effect of hardware impairments on angle-based localization performance in beyond 5G/6G systems. The thesis work will be carried out within the **Communication Systems Group**, which is a part of Chalmers E2, **Communication, Antennas and Optical Networks Division**.

2 Background

The demand for systems that have both communication and radar detection capabilities has increased with emerging platforms such as unmanned aerial vehicles and smart cars. Joint communication and radar sensing (JCAS) solutions have emerged as an attractive solution for integrating communication and sensing into one system. In multiple-input multiple-output (MIMO) JCAS systems, **direction-of-arrival (DoA) estimation** has a direct impact on localization and sensing accuracy, and therefore is an essential problem. Several methods are available for estimating the DoAs of the incoming radar/communications signals, such as the MUltiple SIgnal Classification (MUSIC) algorithm. While most of these methods work well in ideal scenarios, in practice **hardware impairments** can severely degrade their performance. Examples of such impairments include mutual coupling, amplifier nonlinearities, phase noise, and carrier frequency offset.

Massive MIMO systems are key to next-generation wireless networks such as 6G, and with hundreds of antennas deployed on base stations, the distance between adjacent antennas becomes small, generally less than half a wavelength. When two antennas are close together, some of the energy that is actually intended for one antenna ends up with the other. This electromagnetic interaction between the antennas in an antenna array is called **mutual coupling**. An important challenge in DoA estimation is that in practice, antenna arrays have directional beampatterns and accordingly, the mutual coupling effect varies with the incoming signal direction. This effect is referred to as **direction-dependent mutual coupling**.

The focus of this thesis is to investigate the effect of direction-dependent mutual coupling and to estimate DoAs under this effect. Thesis study will involve literature review on mutual coupling effect in MIMO systems, and algorithm development and implementation for DoA estimation. The study can be extended to cover adaptive array calibration methods.

3 Scope

- Literature study on mutual coupling effect and its modeling (direction-dependent vs. direction-independent)
- Implementing standard DoA estimation methods in the presence of mutual coupling
- Developing and implementing new DoA estimation methods that are robust to or can exploit mutual coupling
- Literature search on imperfect array calibration and adaptive calibration methods

- Depending on the outcome of the work, write a conference or journal paper

4 Profile

- Master's degree students in MPCOM, MPSYS, MPCAS, etc.
- Solid math background is needed.
- Knowledge in statistical signal processing or array signal processing is a benefit.

5 Duration

- For 2 students: 1 semester, 30 ECTS points
- For 1 student: 2 semesters, 60 ECTS points (outstanding academic track record needed)

6 Application

- Attach your resume, transcript, and cover letter (stating your interests and thoughts within the given area).
- Send your application by email to sinar@chalmers.se and furkan@chalmers.se

7 Questions

In case of questions, please contact

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