VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Adnan Al Baba**

The public defense will take place on **Monday 23rd June 2025 at 4pm** in room **I.2.02** (Building I, VUB Main Campus)

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# MM-WAVE IMAGING WITH FORWARD-LOOKING SAR: ALGORITHMS AND SYSTEM OPTIMIZATION

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## Abstract of the PhD research

This doctoral thesis explores millimeter-wave (mm-wave) imaging for forward-looking synthetic aperture radar (FL-SAR), focusing on advancing algorithms and system design to meet the demands of autonomous applications. The research addresses critical challenges in achieving high angular resolution with FL-SAR for autonomous ground vehicles by leveraging platform motion to synthesize larger apertures and enhance imaging performance. Key contributions include novel methodologies for signal modeling, SAR image reconstruction, and computational complexity reduction. The thesis examines advanced aspects such as multiple-input, multiple-output FL-SAR (FL-MIMO-SAR), theoretical angular resolution limits, radar-network odometry integration, motion parameter estimation, and SAR autofocus algorithms. Innovative solutions are proposed to mitigate common imaging artifacts such as sidelobes, grating lobes, and Doppler left-right ambiguities. Additionally, advanced SAR processing techniques, including sequential spatial masking and decimated backprojection, are introduced to enhance image quality and computational efficiency. The proposed methodologies are quantitatively evaluated using simulation scenarios, controlled experimental data from an anechoic chamber, and real-world test data from robotics and automotive applications. These evaluations demonstrate the effectiveness of FL-SAR imaging with sparse MIMO arrays in delivering high-resolution radar images while relaxing constraints on synthetic aperture length. This thesis significantly contributes to the practical realization of mm-wave FL-SAR imaging systems, paving the way for their adoption in diverse fields such as automotive, robotics, aviation, security, and industrial applications.