Popular Science Summary
- Exploring Near-Field SAR with mmWave Pulsed Coherent Radar

The word *radar* was originally an acronym for *radio detection and ranging*. Today, the word describes a whole field of technology where radiofrequency electromagnetic waves are transmitted towards a region of interest. The fundamental idea of radar is that these waves are reflected by objects in the region to later be received by the radar system. By transmitting and receiving these waves, the distance to the objects can be determined.

There exist many different types of radar systems, however, this thesis will utilize a *pulsed coherent radar* (PCR) system. A PCR system transmits the electromagnetic waves in short pulses, where the distance to the object is determined by the time it takes for the pulse to return to the sensor. The term *coherent* means that the returned signal contains both amplitude and phase information, which is useful in many applications. The phase information can, for example, be utilized to detect very small movements.

Radars can also have different numbers of antennas which affect the information present in the received data. A so called single-channeled system, which have one transmit antenna and one receive antenna, only provides information about the object's distance but not its angle. However, by moving the system and measuring from different positions in space, an additional dimension of information is introduced. By utilizing this additional information radar images can be generated, which is the fundamental idea of *Synthetic Aperture Radar* (SAR). The movement of the sensor mimics a much larger antenna and thus creates a synthetic aperture.

The technique was introduced during the 1950s to image ground targets at far ranges, regardless of light and bad weather. These radars had a longer wavelength, often between a couple of centimeters up to a meter. In these scenarios the radar is often placed on a space or aircraft to introduce movement. However, this thesis aims to explore the use of the same imaging methods for close targets using a PCR system with a shorter wavelength, in the range of a few millimeters. *Near-field SAR*, as this is called, has applications in object detection, concealed weapons detection and non-invasive medical imaging.

There are two main categories of image formation algorithms which are used within SAR: frequency domain-based algorithms and time domain-based algorithms. This thesis will focus on two algorithms that can be seen as the extremes in each category: *Doppler Beam Sharpening* (frequency-based) and *Global Backprojection* (time-based). The thesis thoroughly explains the theory and approximations behind each of the algorithms. These are later quantified via simulations to demonstrate the difference between the algorithms and show the effect of noise and errors in the measurements. The algorithms are also applied to real data to generate images of everyday objects. The data is collected using an Acconeer A121 sensor, which is a single-channel PCR system designed in Malmö, Sweden. Two-dimensional and three-dimensional images are created to showcase the potential of near-field SAR and demonstrate the achievable image resolution. The results indicate that it is possible to produce detailed and high-resolution images using the same algorithms employed for far-range situations, but with certain exceptions at very close distances. The images also highlight different scenarios where each algorithm is most suitable.