Effective cancer management requires adequate diagnostic means, and imaging plays a central role in this process. One essential limitation is that the most promising modalities are largely based on highly expensive magnetic resonance imaging (MRI). The growing burden of healthcare costs on our society motivates the use of more sustainable modalities. While a pivotal role of ultrasound would represent an excellent cost-effective and widely accessible alternative, the accuracy of ultrasound-based methods typically falls behind those of novel MRI strategies.

The ultimate goal of this thesis was therefore to advance and extend today’s ultrasound imaging to such a level that it allows accurate cancer diagnosis based on ultrasound alone, providing timely and accurate assessment of both tumor location and aggressiveness. To achieve this, ultrasound imaging should be exploited to its full potential. This dissertation aims to pave the way in this direction, by providing a holistic ultrasound imaging solution through novel and dedicated signal processing methods that permit measurement of those characteristics that are typical for cancer. Assessment of such a broad spectrum of features, both vascular- and tissue-related, ultimately enables reliable detection and comprehensive phenotyping of malignant tumors, while retaining the high cost-effectiveness that makes ultrasound so appealing.

Figure 1: An example of estimated microvascular flow fields in prostate cancer (A, zoom B), as well as the parametric maps resulting from the flow characterization using entropy (C) and conditional Entropy (D). Tumor lesions are marked in red (E).

Figure 2: 3D ultrasound tractography and quantification of vascular tortuosity of different human prostates, and their correspondence with cancer identified by histopathology.