

Abstract

Advances in Objective Assessment of Image Quality for Computed Tomography Applications

Juan Pablo Cruz Bastida

X-ray computed tomography (CT) is a fundamental component of diagnosis and treatment in many modern medical applications. Therefore, a successful outcome of patient healthcare often depends on the image quality provided by CT systems. However, when pushing the boundaries of CT imaging, several missing pieces in our current understanding of image quality become evident. It is the objective of this work to scientifically study those missing pieces, particularly in the following four cases: (i) CT imaging in peripheral regions of the scan field of view. (ii) Increased spatial resolution CT imaging. (iii) Radiation dose reduction in single-energy CT. (iv) Radiation dose reduction in dual-energy CT (DECT). As we will see, the study of case (i) unveils an incomplete understanding of the noise properties of CT systems. Case (ii) challenges the use of observer models for high contrast and high spatial resolution imaging tasks. In cases (iii) and (iv), potential limitations in the quantification accuracy will be the main focus. The contributions of this Thesis work to the current state of knowledge can be summarized in three key results: (i) The noise power spectrum of clinical multi-detector CT systems is strongly influenced by the use of the bowtie filter and how well it matches with the image object. (ii) A modified ideal observer model was developed and validated to predict human observer performance for high contrast and high spatial resolution CT imaging tasks. (iii) The CT number bias of filtered backprojection based CT systems is inversely proportional to the exposure level. This limitation can be mitigated with the help of noise-reduction strategies. Interestingly, limited quantification performance at low dose levels does not extend to image-based DECT.