

AbstractID: 9805 Title: Relationship of DQE to visual signal detection

Over the past decade, developers of novel medical imaging systems routinely report to their scientific colleagues, to users, and to the FDA, the noise equivalent quanta (NEQ) and its close cousin, the detective quantum efficiency (DQE), as measures of imaging performance. In one sense, one can think of DQE as an empirical characterization of imaging performance in the same manner as other physical measurements such as image uniformity and pixel size. However, the use of DQE in imaging system characterization is grounded in statistical decision theory. Using this framework, one can determine upper bounds on the diagnostic accuracy obtainable from an imaging system for a specified imaging task. Such upper bounds describe the performance of a special observer known as the ideal-observer, defined as an observer that makes optimal use of the detected data in performing the specified task. The performance of human observers can be compared to that of the ideal observer to determine when the human's ability to extract relevant information from the displayed data is efficient in terms of task performance.

When the task is the detection of an exactly-specified signal (signal-known-exactly (SKE)) in additive, stationary Gaussian correlated measurement noise (background-known-exactly (BKE)), the ideal-observer signal-to-noise-ratio (SNR) takes on a particularly elegant form for linear, shift-invariant imaging systems. In this special case, it can be shown that the ideal-observer SNR can be written as a product of the power spectrum of the signal to be detected and the noise equivalent quanta (NEQ). Many imaging phantoms incorporate SKE imaging tasks and provide homogeneous BKE noise backgrounds. So, one can show a direct connection between human observers using these imaging phantoms and the empirical characterization of the imaging system in terms of the NEQ.

Yet, we should recall the assumptions for the imaging system and noise, i.e., linear, shift-invariant imaging and stationary noise, that led to the privileged position of the NEQ descriptor for the assessment of imaging systems as described above. If NEQ is to be associated with signal detection, one has to be cognizant of the breakdown of any assumptions and the impact of the breakdown on characterizing imaging performance. First, the structure in realistic images is not stationary; the covariance of the data is location-dependent due to correlations in the object structure as well as non-uniformities in the detection device. Second, the assumption of shift-invariance is violated by discrete detector devices. When there are image features on the order of the pixel size, the detected data are quite dependent on signal location and are not shift-invariant. The connection of NEQ and DQE to visual signal detection under a lack of noise stationarity and shift-variant imaging remains the subject of current research. We will provide a review of recent results addressing this topic.

Educational Objective:

1. To understand the connection between DQE and statistical decision theory.