The medical diagnosis process starts with an interview with the patient, and continues with the physical exam. In practice, the medical professional may require additional screenings to precisely diagnose. Medical imaging is one of the most frequently used non-invasive screening methods to acquire insight of human body. Medical imaging is not only essential for accurate diagnosis, but also it can enable early prevention. Medical data visualization refers to projecting the medical data into a human understandable format at mediums such as 2D or head-mounted displays without causing any interpretation which may lead to clinical intervention. In contrast to the medical visualization, quantification refers to extracting the information in the medical scan to enable the clinicians to make fast and accurate decisions. Despite the extraordinary process both in medical visualization and quantitative radiology, efforts to improve these two complementary fields are often performed independently and synergistic combination is under-studied. Existing image-based software platforms mostly fail to be used in routine clinics due to lack of a unified strategy that guides clinicians both visually and quantitatively. Hence, there is an urgent need for a bridge connecting the medical visualization and automatic quantification algorithms in the same software platform. In this thesis, we aim to fill this research gap by visualizing medical images interactively from anywhere, and performing a fast, accurate and fully-automatic quantification of the medical imaging data. To end this, we propose several innovative and novel methods. Specifically, we solve the following sub-problems of the ultimate goal: (1) direct web-based out-of-core volume rendering, (2) robust, accurate, and efficient learning based algorithms to segment highly pathological medical data, (3) automatic landmarking for aiding diagnosis and surgical planning and (4) novel artificial intelligence algorithms to determine the sufficient and necessary data to derive large-scale problems.

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The public is welcome to attend.