

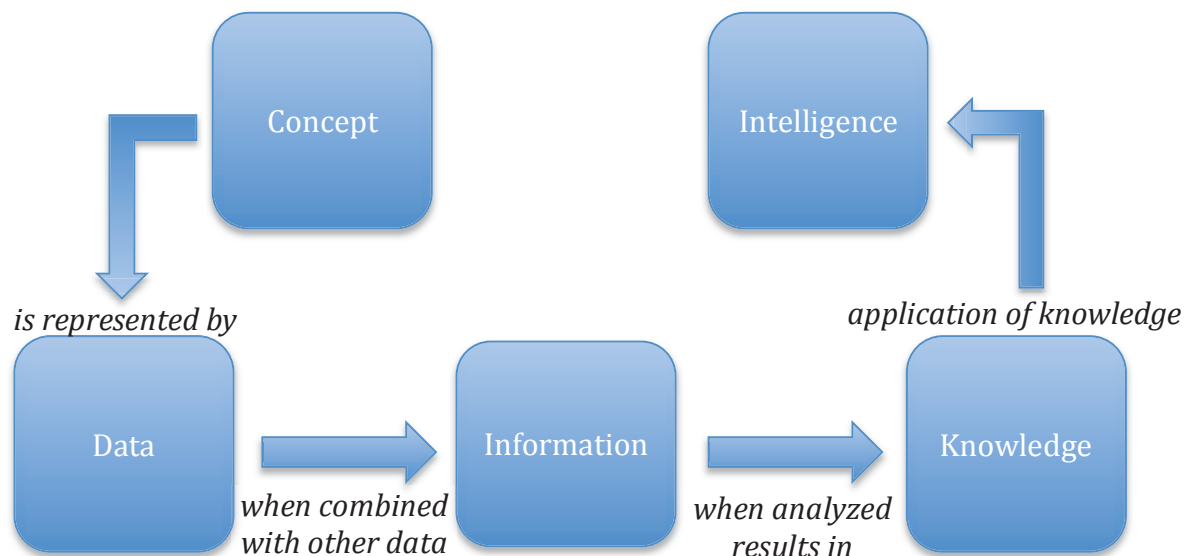
Re-imagining the Microscope to Facilitate Collaboration and Integration of Big Data in Medicine

Big Data and Medicine

There are many healthcare institutions and providers talking about big data and its importance to the future of medicine. Big data is defined by its number of “V”s. The first 3 V’s were in Doug Laney’s 2001 classic definition of big data, which has been expanded over the years.

Volume	The enormous quantity of data
Velocity	The speed at which data is created, stored, analyzed...
Variety	The many different types of data (structured/unstructured, numerical/text, image, sound, video...)
Veracity	The truthfulness and accuracy of data
Variability	The changing of the meaning of the data
Visualization	The organization of the data to facilitate analysis and understanding
Value	The conversion of data into usable intelligence

How do we get from a simple concept and data to intelligence? The expression of a concept requires detail to ensure clarity and enable others to make use of the concept. Data are facts used as a basis for reasoning, discussion or calculation. Information is data that is interpreted, organized and structured. Knowledge is information that has been synthesized so that interrelationships are identified and formalized. The application of that knowledge to the specific instance leads to intelligence.



Whole-Slide Imaging

Whole-slide imaging (WSI) has matured to the point where it is technically feasible to reliably produce high quality digital microscopic images in a timely and efficient manner. Yet it still remains underutilized in pathology today for a multitude of reasons; including technical, workflow, financial, and regulatory. Disruptive technologies change workflows in ways that drives adoption of these new systems.

Most WSI viewing programs, and therefore the ways that we are utilizing these digital slides, do not vary significantly from the use of glass slides on a microscope. If digital slides are subject to the same limited uses as glass slides, pathologists will continue to choose to keep their microscopes, and WSI will remain limited to the niche applications in which they are being utilized today. However, if we take advantage of the digital nature of WSI and use them in new and novel ways that were not possible with physical slides, then we will make significant progress to convince pathologists to embrace this technology.

The Drive for Collaboration in Medicine

The need for collaboration in patient care, medical education, and translational research continues to grow, driven by a demand for fast and accurate diagnoses to support patient care in an environment of increasing amounts of knowledge and sub specialization. Clinicians require enhanced interdepartmental conferences to help them understand disease and treatment options for their patients. Medical education is evolving from the Flexner model, embracing newer teaching methods while struggling to deliver increasing quantities of content. Medical research is becoming multi-centered, primarily due to the strong preferences by government and private funding agencies for multiple site collaborations in medical research.

The physical nature of the glass slide makes true collaboration difficult, inefficient and expensive. One of the promises of WSI is to facilitate collaboration in medicine. While many of the digital pathology tools currently being utilized have made the logistics of sharing microscopic images somewhat easier, it has not yet fundamentally changed the nature of these interactions. Taking maximal advantage of the potential of digital microscopic images means that we must go beyond a simple conversion of the physical workflow into a virtual environment to look at re-imagining the “microscope” in the age of cloud computing with a specific emphasis on meaningful and efficient collaboration.

Scalable Adaptive Graphics Environment

The Scalable Adaptive Graphics Environment (SAGE) is an open-source collaborative windowing environment that runs in a web browser and the cloud, taking advantage of HTML5 and the high-performance graphics and networking

capabilities contained in modern web browsers. SAGE enables users to share big data, including digital-cinema quality video, very high resolution images, high-definition video-teleconferences, presentation slides, documents, spreadsheets and shared computer screens, in a collaborative environment. SAGE goes beyond the commonly recognized web-based collaboration systems, such as WebEx, GoToMeeting, Google Hangouts and Skype.

SAGE and WSI

An app to view WSI within the SAGE environment was created. This app is agnostic to the WSI file format. Through this app users can add WSIs, move them, manipulate them and analyze them. Multiple users can interact with the same instance of a WSI simultaneously, and all users instantly see any changes made by any other user. This interaction is not dependent on the users being in the same physical space. With a web browser and access to the Internet, location becomes irrelevant. The app was then utilized in a variety of scenarios covering the areas of patient care, medical education and medical research. Specific examples include:

Consultation: Consultations across distances, whether down the hall or around the world, are fully interactive and informal.

Multidisciplinary Conferences: Multiple different types of data (medical records, radiology, gross and microscopic images, and other medical data) can be displayed and presented simultaneously side-by-side.

Multi-institutional Conferences: Medical conferences for education, patient care or research can be held across multiple institutions while maintaining a high level of interaction between parties.

Medical Education: Pathology sessions for undergraduate medical students and pathology residents can utilize this technology to help adapt to modern teaching techniques, such as the flipped classroom and team-based learning.

