Exploring Clinically-relevant Image Retrieval for Diabetic Retinopathy Diagnosis

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Summary: Diabetic retinopathy (DR) is the leading cause of new blindness in adults aged 20-74. Among diabetics, the prevalence of DR is 28.5 percent. Despite advances in diabetes care, visual impairment is still a devastating complication. Studies show that timely DR diagnosis and treatment can significantly reduce the risk of severe vision loss. Although digital retinal imaging has quickly become an alternative to traditional face-to-face evaluation, it is laborious and prone to error and reviewer fatigue. For this reason, researchers are exploring automated detection and evaluation of diabetic retinal lesions. Potential benefits of automated DR diagnosis include improved consistency and speed over human review. However, clinicians remain superior in detecting and assessing the severity of DR over computer-based systems, which fail to incorporate the experience and variables that clinicians apply to their assessments. Therefore, more effort is required to improve the performance of such systems.

This research project explores an innovative way to retrieve clinically relevant images for facilitating timely and accurate evaluation of DR. Images are considered clinically relevant if they contain the same types of lesions with similar severity levels. Dr. Li and his team have extensive experience in acquisition and deployment of computer-assisted evaluation of DR. Building on their experience, the team is designing a machine learning-based algorithm for retrieving images of clinical relevance to contribute to building automated DR detection and evaluation systems. Additionally, the team plans to develop a prototypical DR image management system to improve reviewers' diagnostic performance. A direct outcome of the proposed research is a system that can provide a reviewer with instant reference to annotated images from a database. Maximizing the efficiency and accuracy of assessing DR could help prevent vision disabilities and their resulting high cost to the health care system.

Specific Aims:

- Develop a content-based retrieval system for referencing diabetic retinal images to improve diagnosis. **(Ongoing)**
- Develop a prototypical DR image management system to improve reviewers' diagnostic performance. **(Ongoing)**

2012 Activities: The initial focus of the project was to collect a sufficient number of DR images to support the development of the machine learning algorithm, which requires large amounts of data to diagnose different stages of DR. These stages include non-proliferative retinopathy (mild, moderate, and severe) characterized by microaneurysms, and proliferative retinopathy, characterized by neovascularization. Initially, Dr. Li planned to use images from a researcher with a large database of images, but the researcher

retired. As a result, Dr. Li contacted alternative potential collaborators around the country. To date, he has amassed approximately 1,000 images.

Dr. Li began work on the algorithm using the available images. Currently there are five well-known algorithms to process DR Images. These existing algorithms do not sufficiently distinguish between shades of red, the dominant color in DR images. Dr. Li's team focused on color contrast when developing their algorithm to address this weakness. To do this, the existing algorithms are being applied to each of the images in Dr. Li's collection. The algorithms work by extracting several hundred data points from each image and analyzing them. These results will serve as the benchmark for the newly-developed algorithm.

Dr. Li and his team developed the first version of the user interface (UI) used by clinicians to upload new DR images and see the results produced by the algorithm. The team solicited feedback from an ophthalmologist to learn about the end-user's experience with the system. This ophthalmologist provided advice for improving system usability, including incorporating Web-based access so that clinicians may use the system outside the office. The other recommendation was to adjust the UI to fit a wide screen computer monitor to provide more space to display information. The team is in the process of incorporating these recommendations. Significant effort will be required to adapt the system to provide end-user Web-based access.

As last self-reported in the AHRQ Research Reporting System, project progress is on track in some respects but not others, and project budget funds are slightly underspent. Project delays are due to the additional time required to incorporate Web-based access to the system. Dr. Li and his team are conserving funds for a no-cost extension.

Preliminary Impact and Findings: Classification accuracy is the performance measure used to assess the machine-learning algorithm. Dr. Li reports that the classification accuracy for his algorithm is 87 percent. The highest classification accuracy reported in the literature is 75 percent, and most are closer to 50 percent.

Target Population: Adults, Chronic Care*, Diabetes, Other Conditions: Diabetic Retinopathy

Strategic Goal: Develop and disseminate health IT evidence and evidence-based tools to improve health care decisionmaking through the use of integrated data and knowledge management.

Business Goal: Knowledge and Creation
