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Visual knowledge plays an important role in many highly skilled applications, such as medical diagnosis, geospatial image analysis and pathology diagnosis. Medical practitioners are able to interpret and reason about diagnostic images based on not only primitive-level image features such as color, texture, and spatial distribution but also their experience and tacit knowledge which are seldom articulated explicitly. This reasoning process is dynamic and closely related to real-time human cognition. Due to a lack of visual knowledge management and sharing tools, it is difficult to capture and transfer such tacit and hard-won expertise to novices. Moreover, many mission-critical applications require the ability to process such tacit visual knowledge in real time. Precisely how to index this visual knowledge computationally and systematically still poses a challenge to the computing community.
My dissertation research results in novel computational approaches for high-throughput visual knowledge analysis and retrieval from large-scale databases using latest technologies in big data ecosystems. To provide a better understanding of visual reasoning, human gaze patterns are qualitatively measured spatially and temporally to model observers' cognitive process. These gaze patterns are then indexed in a NoSQL distributed database as a visual knowledge repository, which is accessed using various unique retrieval methods developed through this dissertation work. To provide meaningful retrievals in real time, deep-learning methods for automatic annotation of visual activities and streaming similarity comparisons are developed under a gaze-streaming framework using Apache Spark.
This research has several potential applications that offer a broader impact among the scientific community and in the practical world. First, the proposed framework can be adapted for different domains, such as fine arts, life sciences, etc. with minimal effort to capture human reasoning processes. Second, with its real-time visual knowledge search function, this framework can be used for training novices in the interpretation of domain images, by helping them learn experts' reasoning processes. Third, by helping researchers to understand human visual reasoning, it may shed light on human semantics modeling. Finally, integrating reasoning process with multimedia data, future retrieval of media could embed human perceptual reasoning for database search beyond traditional content-based media retrievals.