# Content-Based Image Visualization

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## Abstract

*The proliferation of content-based image retrieval techniques has highlighted the need to understand the relationship between image clustering based on low-level image features and image clustering made by human users. In conventional image retrieval systems, images are typically characterized by a range of features such as color, texture, and shape. However, little is known to what extent these low-level features can be effectively combined with information visualization techniques such that users may explore images in a digital library according to visual similarities. In this article, we compared and analyzed a number of Pathfinder networks of images generated based on such features. Salient structures of images are visualized according to features extracted from color, texture, and shape orientation. Implications for visualizing and constructing hypermedia systems are discussed.*

## 1. Introduction

Content-based image retrieval has been a highly active field of research [1, 2]. A number of widely known image retrieval systems have been developed over the last few years, notably, IBM's QBIC [3], PhotoBook [4], ImageRover [5], and Webseek [6]. In these systems, images are typically characterised by attributes known as features, ranging from simple, low-level ones such as color and texture, to more complex, relatively higher-level ones such as shape and other semantically rich query classes.

Ultimately, feature-extraction techniques, combined with other techniques, are expected to narrow down the gap between relatively primitive features extracted from images and high-level, semantically-rich perceptions by humans so that users will be able to find the right images more easily and intuitively.

The advances of information visualization and data mining techniques now allow users to explore an information space organized through a variety of metaphors, such as an information landscape or an information galaxy [7, 8]. Many of these visualizations are based on interrelationships derived from textual information, typically using classic information retrieval models such as the vector space model [9], Latent Semantic Indexing (LSI) [10], or other variants. There has been a steadily increased interest in a variety of layout and visualization techniques that tend to place similar objects near to each other and separate dissimilar objects far apart in the visualization space.

The work described in this article extends our earlier work in structuring and analyzing the design of various information visualization displays. We have gathered computer-generated images of a variety of information visualizations [11]. In particular, we have visualized image networks based on similarity measures produced by IBM's QBIC system [12], including color, layout, and texture.

Researchers and practitioners in information visualization often need to find an optimal way to arrange various visualization images so that design patterns and trends will become apparent. Ideally, images of similar layouts, spatial properties, or overall shapes should be closely grouped together. Users should be able to explore and compare images within such structures.

Generalised Similarity Analysis (GSA) is a generic framework developed for structuring and visualizing information spaces [13, 14]. Applications of GSA include visualization of university websites, online conference proceedings, and journals in digital libraries according to a variety of similarity measures, such as term-frequences, hypertext reference links, author co-citation profiles, and browsing trails of users. A key element in GSA is the use of Pathfinder network scaling technique to extract the most salient links and eliminate redundant or counter-intuitive links [15]. Pathfinder has some desirable features over techniques such as multidimensional scaling (MDS), for example, Pathfinder networks present a more accurate local structure. In this article, our aim is to explore a synergy



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