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Visual segmentation based on the luminance and chromaticity statistics of natural scenes

The luminance (brightness) and chromaticity (color) of surfaces in natural scenes have been shown to be relatively statistically independent. The luminance of a surface provides little information about the chromaticity of that surface, and vice versa. However, differences in luminance between two locations in a natural scene are strongly associated with differences in chromaticity.

We used the statistics of these luminance and chromatic differences to construct a Bayesian model that predicts whether or not two points within an image belong to the same surface. For a given separation between two points, the probability that the two points fall on the same surface can be expressed as $p(\text{same}/(dL, dRG, dBY)) = [p(\text{same})p((dL, dRG, dBY)/\text{same})]/p(dL, dRG, dBY)$, where dL , dRG and dBY represent the difference in luminance, red-green and blue-yellow chromaticity between the two points respectively. We made the simplifying assumption that the joint distribution of luminance and chromatic differences given that both points fall on the same surface, $p((dL, dRG, dBY)/\text{same})$, is independent of the separation of the two points, i.e. color values for pixels belonging to a single surface are identically and independently distributed. $p(dL, dRG, dBY)$ is the joint probability distribution of luminance and chromatic differences for two points given the separation between them.

This model provides an algorithm for surface segmentation that matches segmentations made by observers. One common difficulty with using Bayesian models to predict behavior is that estimating observers' priors often requires ad hoc assumptions, or choosing those priors that best predict observers' performance. In this case the spatio-chromatic structure of natural scenes allowed us to estimate a reasonable prior that was independent of human performance, making our model a good test of using Bayesian algorithms to model behavior.

Supported by EY-13149, EY-01711, NSF SBR-9870897 and a LJIS fellowship.