Generating Saccades for a Biologically-Inspired Irregularly Tessellated Retinal Sensor

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There is an interest in biologically-inspired vision models because of the undisputed success of these models in nature. Biological vision systems have evolved over millions of years into efficient and extremely robust entities with a level of perception and understanding that greatly surpasses the creations of modern machine vision. Vision systems found in nature are quite different from those developed in conventional machine vision. Space-variant visual processing reduces the dimensionality of visual information, exhaustively processing information in the central (foveal) region of our field-of-view while constraining the processing resources dedicated to peripheral regions. Eyes fixate only on regions of the visual scene which that are deemed salient or interesting, and change the point of fixation using ballistic or sudden eye movement called saccades.

Biological and artificial systems that use a space-variant strategy to extract visual information from a scene using a retina face the problem of targeting their sensor so that the central high acuity foveal region inspects salient regions in the scene. At the same time the coarse peripheral region of the retina must extract visual information over a wide field of view to find new interesting locations for future detailed examination with the fovea. We present a model for the saccadic exploration of an image using an artificial retina with a space-variant irregular receptive field tessellation. The retina's receptive field density is uniform in the central foveal region and seamlessly reduces in the space-variant periphery of the retina. The irregular retinal receptive field tessellation forced us to concede geometric regularity in the retinal mosaic but enabled seamless continuity in the retina's receptive field density from the fovea to the periphery. This irregular tessellation resembles that from empirical data gathered from biological experiments on human and animal retinae.

Feature extraction using the irregular retinal tessellation necessitated the pre-computing of unique filter coefficients for each receptive field position. Biologically-inspired circularly symmetric receptive fields sampled chromatic opponent information from the image using these filters. The responses from these were analysed for edge information by chromatic opponent orientated Gabor filters which were once again defined on the irregular tessellation.

We decided to designate areas in the image with chromatic opponent corners as salient or interesting. Detecting corners identifies specific regions in the image which are salient to humans and at the same time easily detected by a computational system. Corners were detected by using the Harris corner detector on the responses from the chromatic opponent Gabor filters. A saliency map was constructed assuming a spatial Gaussian uncertainty in the saliency values generated from the Gabor filters. The Gaussian standard deviation was equal to the corresponding orientated filter's support region. The retina was fixated upon the region with the highest saliency value. This region was then suppressed using an inhibition-of-return mechanism so the retina would examine other salient parts of the image.

The aim of this research is to test the space-variant irregularly tessellated retina on tasks such as visual search for an object in a scene and recognising an unknown object given a limited object training database. To efficiently perform the saccadic examination of an image for these tasks the system will have to combine the bottom-up feature information we currently extract from the retina with top-down task biased information.