LIST OF FIGURES

2.1 Information flow in the human visual system ....................... 13
2.2 The human visual pathway - cellular representation of the retina 14
2.3 The retinal signal processing using Center - surround receptive fields ................................................................. 15
2.4 Typical classical receptive fields of neurons in the visual pathway........................................................................... 16
2.5 Arrangement of rods and cones in the eye.............................. 16
2.6 Schematic representation of BCS........................................... 17
2.7 Dynamic compression and image edge enhancement............. 19
2.8 Centre on-off surround kernel of radial symmetry................. 20
2.9 Images obtained by Convolution with center surround kernel which shows image enhancement................................. 20
2.10 Effect of the stage 2 kernel on the image with different orientations................................................................................. 22
2.11 Tessellation schemes (a) Square (b) Triangle (c) Hexagon..... 23
2.12 (a) A rectangular sampling raster (b) A hexagonal sampling raster................................................................. 25
2.13 (a) A rectangular band region (b) A hexagonal band region... 26
2.14 A circular band region imbedded in a (a) Rectangular region and (b) Hexagonal band region................................. 26
2.15 (a) A possible uniform sampling on the Euclidean plane (b) A Frequency domain sampling lattice......................... 28
2.16 Optimum sampling lattice for two dimensional isotropic functions................................................................................. 29
2.17 Hexagonal sampling lattice and its Fourier Transform........... 32
2.18 Spectral packing for (a) Rectangular sampling (b) Hexagonal sampling................................................................. 32
2.19 Neighborhood relationships in Square grid and Hexagonal Grid ... 33
2.20 Connectivity on (a) Square grid and (b) Hexagonal grid ....... 33
2.21 Distance in (a) Square grid and (b) Hexagonal grid
2.22 Curved figure represented in (a) Hexagonal grid and (b) Square grid
2.23 Super CCD by Fuji Co.
2.24 Complete HIP system
2.25 Mixed system approach
2.26 Hexagonal lattice and triangular pixels
2.27 Hexagonal scheme of Watson
2.28 Hexagonal scheme of Horn
2.29 Hexagonal data structure with a rectangular shape
2.30 Pseudo hexagonal pixel (a) Square (b) Hexagonal
2.31 Quincunx sampling
2.32 Spiral Architecture and Spiral addressing
2.33 A square grid and hexagonal grid which has the same area
2.34 (a) One virtual hexagonal grid and its four connected square pixels
   (b) One square grid and its three connected virtual hexagonal grids
2.35 Virtual Hexagonal Architecture
2.36 (a) Rectangular Pixel Grid (b) Simulated Hexagonal Grid
2.37 Conversion of a regular square grid to a hexagonal grid
2.38 Addressing points on a hexagonal lattice using two skewed axes
2.39 Symmetrical hexagonal frame \( R^2 \)
2.40 Relation between frames \( R^3 \) and \( R^3 \)
2.41 Spiral rotating direction
3.1 Implementation of resampling
3.2 Ideal interpolation (a) Kernel plotted for \( |x| < 3 \) (b) Magnitude of Fourier transform
3.3 One dimensional decomposition of the 2-D, N x N interpolation of the point \((x, y)\)
<table>
<thead>
<tr>
<th>Section</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4</td>
<td>(a) The regular hexagonal lattice and its Voronoi cell (b) The dual lattice</td>
</tr>
<tr>
<td>3.5</td>
<td>(a) Generating functions ((X_j)_0) and ((X_j)_0) (b) Creation of horizontal edges</td>
</tr>
<tr>
<td>3.6</td>
<td>Formation of edges (a) Formation of right-hand edges (b) Compensation of dark</td>
</tr>
<tr>
<td>3.7</td>
<td>Interpolation functions in (a),(c),(e) spatial domain and (b),(d),(f) Frequency domain using nearest neighbor, linear and cubic B-spline respectively</td>
</tr>
<tr>
<td>3.8</td>
<td>Effect of interpolation kernels (a) Original image (b) - (d) Images after convolution with nearest neighbor, linear interpolation and cubic B-spline respectively</td>
</tr>
<tr>
<td>3.9</td>
<td>Performance measures of the interpolation kernels (Nearest neighbor, linear and cubic spline) (a) Mean Squared Error (b) Peak Signal-to-Noise Ratio (c) Computation time (in seconds)</td>
</tr>
<tr>
<td>3.10</td>
<td>(a),(c),(e) Hex splines in spatial domain (b),(d),(f) Hex splines in frequency domain for first, second and third order respectively</td>
</tr>
<tr>
<td>3.11</td>
<td>(a) Original Image (b) Tiling/Image representation by the hex spline (c) - (e) Interpolated image with hex splines of order (p = 1, 2) and (3) respectively (f) Part of the image (Figure 3.8) to highlight the tiling of hex – splines</td>
</tr>
<tr>
<td>3.12</td>
<td>Five parameters defining each filter in the frequency domain</td>
</tr>
<tr>
<td>3.13</td>
<td>Hex Gabor kernels at different sigma values</td>
</tr>
<tr>
<td>3.14</td>
<td>Hex-Gabor kernel with details of absolute values at sigma = (2/\pi)</td>
</tr>
<tr>
<td>3.15</td>
<td>Comparison of Hex-Gabor data and cubic B-spline data</td>
</tr>
<tr>
<td>3.16</td>
<td>Computation of gradient with respect to pixel distance</td>
</tr>
<tr>
<td>3.17</td>
<td>Plot of Hex-Gabor kernel at different sigma values</td>
</tr>
<tr>
<td>3.18</td>
<td>Hex-Gabor kernel surface at (a) sigma = (100/\pi) (b) sigma = (500/\pi)</td>
</tr>
</tbody>
</table>
3.19 (a),(c),(e),(g) original images Lena, Barbara, Peppers and Cat respectively. (b),(d),(f),(h) Enhanced images using Hex-Gabor

3.20 Plot of sigma vs PSNR for the Barbara image using Hex-Gabor

3.21 Comparative study of Hex-spline and Hex-Gabor (a) Original Image (b) Tiling using Hex-spline (c) Enhanced image using Hex-spline (d) Enhanced image using Hex-Gabor

3.22 (a), (c), (e), (g) Original images of chestxray.tif, thumb.jpg, X-ray1.jpg and X-ray2.jpg respectively (b), (d), (f) and (h) Enhanced images using Hex-Gabor

3.23 Nonlinear windowed function \(1.1781/(1 + \left(\frac{x}{25}\right)^2)\) and Hex-Gabor kernel plotted on the same figure

3.24 (a) Original image (b) Enhanced images using the approaches (b) Kramer PDE model (c) Hex-Gabor

4.1 The masks used in the Prewitt edge detector implementation (a) square (b) hexagonal [9]

4.2 The Convex Polygon with top-left corner pixel removed

4.3 The Basis Structures over the 3 x 3 Rectangular grid

4.4 Lattice formed by 16 convex polygons

4.5 The pixel and its 7-neighborhood structure in a hexagonal lattice

4.6 The Basis Structures over the 7-neighbourhood Hexagonal lattice

4.7 Lattices formed by 18 convex polygon

4.8 (a) Neighborhood of pixels in the rectangular sub sampled image and (b) Neighborhood of pixels in the Hexagonal sub sampled image

4.9 Cyclone II 2C20 FPGA

4.10 General block diagram of the proposed Architecture

4.11 Proposed architecture for the edge detection using hexagonal structure
4.12 (a) Pixel addressing in hexagonal grid (b) S-block Group of registers (b) Operation of S_block registers

4.13 Status of S_block registers after first three clock cycle

4.14 Status of S_block registers after second three clock cycles

4.15 Demultiplexer and selection counter

4.16 Multichannel Gabor system

4.17 Verilog simulation results of CLAP algorithm (a), (d) Original images (b), (e) Edge detected images on rectangular structure (c),(f) Edge detected images on hexagonal structure

4.18 UC Berkely Benchmarking of Segmentations dataset results

4.19 FPGA results using ALTERA DE-1 board (a) Original Image (b) Edge detection on hexagonal structure (c) Edge detection on rectangular structure

4.20 Edge detection using Hex-Gabor on hexagonal grid (a), (d), (g), (j) Original images: Image.1, Image.2, image.3, image 4 respectively. (b), (e), (h), (k) Edge detection using canny operator (c), (f), (i), (l) Edge detection using Hex-Gabor Filter

4.21 Performance comparison on rectangular grid and hexagonal grid (a), (d), (g), (j) Original images: Image.1, Image.2, image.3 , image 4 respectively. (b), (e), (h), (k) Edge detection using canny operator on rectangular grid (c), (f), (i), (l) Edge detection using Hex-Gabor filter

4.22 Comparison results of Hex-Gabor and canny operator for UC Berkeley Segmentation dataset images

4.23 (a) Original image (Lena) (b) Edge map using the spiral architecture [128], (c) Edge map using proposed CLAP algorithm based architecture (Hardware based) and (d) Edge map using proposed Hex-Gabor

5.1 Examples of skeleton images

5.2 Classification of thinning algorithms

5.3 Local hexagonal PE neighborhood $N(\Pi_j)$
5.4 Algorithm for Skeletonization
5.5 Architecture of Rectangular Processing Element
5.6 (a) Rectangular Processor Array (b) Hexagonal Processor
5.7 Overall architecture (a) Rectangular processor array
(b) Hexagonal Processor Array
5.8 (a) Original Image (b) Skeleton Image after 40 ns (c) Skeleton Image after 120 ns
5.9 (a) Original Image (Finger print image) (b) Skeleton Image after
after 120 ns
5.10 (a) Original image (Edge detected image) (b) Skeleton image after
120 ns
5.11 (a) Original image (b) Skeleton image using rectangular processing element (c) Skeleton image using hexagonal processing element
5.12 (a) Character image (b) skeleton using hexagonal processor array (c) skeleton using rectangular processor array
5.13 (a) Skeleton image obtained on rectangular grid (b) and (c) Reconstructed images during different iterations
5.14 (a) Skeleton image obtained on hexagonal grid (b) and (c) Reconstructed images during different iterations
5.15 (a) Skeleton image (b) Reconstructed image using hexagonal processor array (c) Reconstructed image using rectangular processor array (d) original image