# DIGITAL IMAGE PIXEL PROCESSING AND 2D-CONVOLUTION

**Dr. Kanaka Durga Returi[1]., Dr. Radhika, Y[2] and Dr.Vaka Murali Mohan[1*]**

1. *Principal & Professor of CSE, Malla Reddy College of Engineering for Women, Medchal, Hyderabad, Telangana, India.*
   *Ph. No: +91- 9885477515, 9966023477*
   *E- Mail: durga1210@gmail.com*
2. *Director Academic Affairs & Professor of CSE, GITAM University, Rushikonda, Visakhapatnam, Andhra Pradesh, India.*

**ABSTRACT**

Digital Image Pixel Processing and 2D convolution have been presented in this paper. Digital image exists as collection of pixels in network taking sparkle which stands as utility of rows and columns. Digital image is considered as 2-D signal with luminance principles stands as utility of pixel state on hydroplane. A digital image is a two-dimensional array or two-dimensional sequence of pixels. The simplest and efficient way to represent the above equation into graphical form is convolution. The convolution summation can exist as multiplying two classifications $x(k_1, k_2)$ and $h(n_1 - k_1, n_2 - k_2)$ which exist variables of the functions $k_1$ *and* $k_2$ and summing the product over altogether integers values of $k_1$ *and* $k_2$.

## 1. DIGITAL IMAGE PROCESSING

Digital image stands as an experimented illustration of correspondent image. Therefore it signifies as image by means of a predictable gathering of illustrations. Image is collected as essential unit named as *Pixel.* A Digital image is 2D sequence of pixels and collection of pixels organized in a significant order expresses an image. The recognition of conventional appearances in pictures is a shared constraint in the appreciation of various patterns. Image processing is well known as processing of a multi-dimensional indication that is utilized to improve, transform, extract data, wrapping and convert images into signals of multivariate. Generally image can remain preserved such as signal of spatial or two dimensional. The conventional technique in signal processing like clarifying, mitigating, etc is stretched to copy appearance in the arrangement of processing of an image. The latest technology with mechanism of visualization comprehensively depends on processing of digital image for extracting data designed for directing the automaton process.

## 2. Literature Review:

Numerous methods must exist since various years in image processing, then again are computationally demanding. Some of them are Hakan Cevikalp et al [1] introduced a strong technique for semi-supervised research on neural networks designed for multi-label image grouping. Rizwan Qureshi et al [2] reported the performance for pattern appreciation to predictable 3 channel images in RGB. Ji Zhang et al [3] suggested visual semantic tree successfully establish significant image classifications and accuracy rates. Jianqiang Song et al [4] recommended a great design 'multi-layer discriminative dictionary learning (MDDL)" through section limitation in classification of an image. Douglas C.Yoon et al [5] presented the digital Radiographic Image Processing and Investigation. Lei Wang et al [6] introduced an extraordinary structure of photography in 3D motion. Hamilton, P, W [7] described "process of digital images in histopathology, cytopathology and pathology-centric research". Yohan, T et al [8] recommended a technique for procurement of lower and upper limits of acceptable spin approaches by means of centre angles in digital images. Lin, P, L et al [9] described a well-organized and operative scheme of digital watermarking used for appearance interfere recognition and retrieval. Franck Xia [10] stated straight in 2D images and utilized for dump recognition to several flattening process. Rosenfeld, A et al [11] specified the image topology of pixel pair of neighbouring, opposite in a 2D digital image. Hemd, J, F [12] existing a modest procedure which usage of "fast fourier transformer (FFT)" for quick division to identify straight lines of a stated measurement. Biswas, S et al [13] designated set of rules for execution several responsibilities and reducing dissimilarities in image processing.

**3. DIGITAL IMAGE PIXELS**

Image can described as longitudinal scattering on a plane. Statistically longitudinal glow scattering is labelled as constant utility of 2 dimensional images. Processors cannot switch constant imaginings but then again single array of numbers in digital. Therefore a numerical appearance characterises as 2 dimensional collections of pixels. Two-dimensional array illustration of digital image pixels are shown in figure 1.

The spot of a pixel stands specified in the standard symbolisation used for matrices. The first index $m$ symbolized the place of row, second $n$ symbolized the place of column. Suppose digital image comprises $M \, x \, N$ pixels, i.e., is symbolized as $M \, x \, N$ matrix, the key $n \; runs \; from \; 0 \; to \, N-1$ and key $m \; runs \; from \; 0 \; to \, M-1$. Every pixel symbolizes not objective of a point in the image then again somewhat a rectangular section, the fundamental compartment of the setting selection. The significance related by means of the pixel requirement represents the normal glow in the consistent chamber in a suitable technique. Using big pixel (cells) dimensions the spatial determination reduced however similarly the gray significance breaks at the pixel edges seem as troubling the image. By way of the pixels converted into less significant, the influence develops a smaller amount marked up to the impression of a spatially incessant image. The pixels converted into less significant than the longitudinal determination of photographic structure. A rectangular network remains individual the modest geometry in lieu of a digital image and additional measures of the pixels are also potential and shown in figure 2.

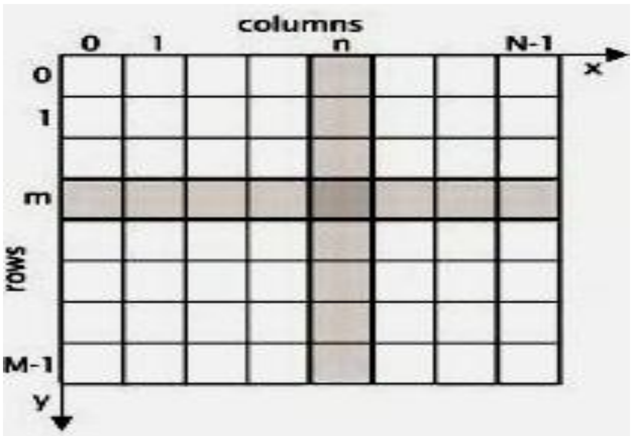
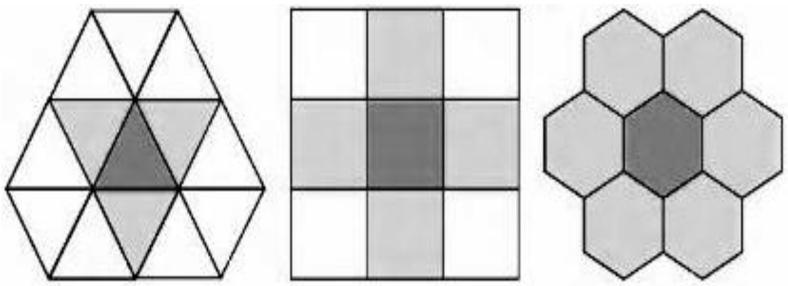



Figure 1: Two-dimensional array illustration of digital image pixels



(a) (b) (c)

Figure 2: Arrangements of pixels:

(a) triangular, (b) rectangular and (c) hexagonal grids

## 4. TWO-DIMENSIONAL SIGNAL ANALYSIS

Digital image exists as collection of pixels in network taking sparkle which stands as utility of rows and columns. Digital image is considered as 2-D signal with luminance principles stands as utility of pixel state on hydroplane. The mandate of image process is essential to recognize 2-D indications. A scalar 2-D signal $s(n_1, n_2)$ is statistically a compound bi-sequence and it is utilized to plotting the 2-D figures into the compound hydroplane. The main resolution is signal $s$ is distinct used for completely determinate principles of the situation digit influences $n_1$, $n_2$ by means of zero lining as essential. The simplified period categorization is adopted completed further accurate bi-sequence.

### 4.1 Two-dimensional Signals

**Unit Impulse**

A simple example of a 2 – D signal is the impulse defined as follows:

$$\delta(n_1, n_2) = \begin{cases} 1 \ \ for(n_1, n_2) = (0,0) \\ 0 \ \ for(n_1, n_2) \neq (0,0) \end{cases}$$

Figure 3 shows the plot of 2-D impulse function. This pot has been obtained using MATLAB signal processing tools.

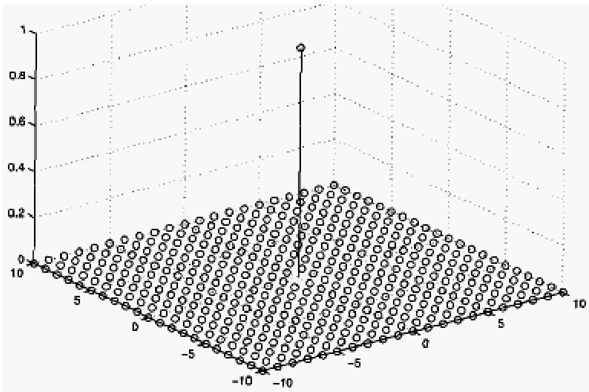


Figure 3: A plot of a 2-D spatial impulse signal

2-D signal can exist by means of immeasurable summation completed with cleaned impulses and specified as:

$$x(n_1, n_2) = \sum_{k_1, k_2} x\,(n_1, n_2)\ \delta(n_1, n_2)$$

The abstract exists as digit pairs $(k_1, k_2)$. By means of 2-D impulse definition every point $(n_1, n_2)$ is accurately unique duration arranged at right side with nonzero, the term $x(n_1, n_2)*1$ and therefore the prior equality is right. This equation is known as shifting illustration of signal x.

**Unit Step**

Impulses are separately from a elementary 2-D indication period is step function, probably greatest common of first quadrant element phase function $u(n_1, n_2)$ is as follows:

$$u(n_1, n_2) = \begin{cases} 1, \ for \, n_1 \geq 0, \ n_2 \geq 0 \\ 0 \ \ for \, elsewhere \end{cases}$$

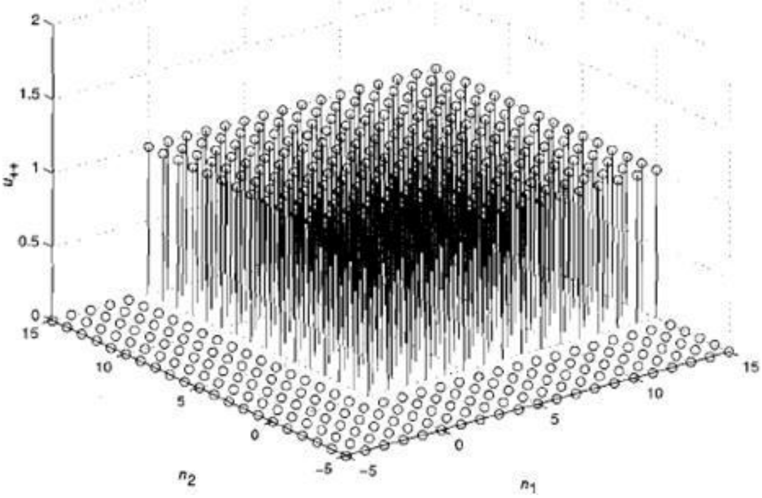
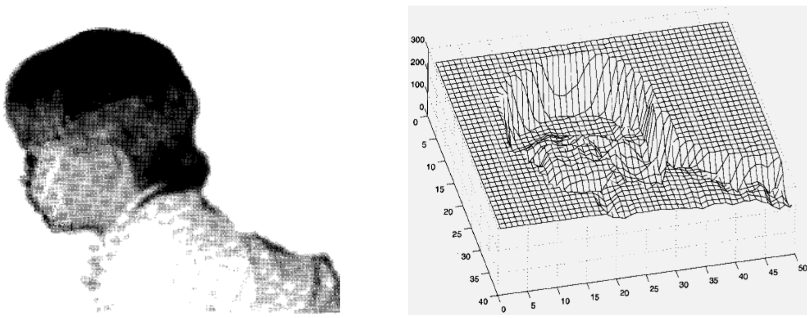



Figure 4: Plot of a unit step bi-sequence $u(n_1, n_2)$

In two dimensions here numerous phase functions of attention and known as first quadrant element stage function and represented as $u_{++}(n_1, n_2)$. The remaining three element phase functions are represented in remaining three quadrants those are represented as $u_{-+}, u_{+-}$ *and* $u_{--}$ these are in 2nd , 4th and 3rd quadrants correspondingly. A actual illustration of a determinate 2-D classification is a digital image and shown in Figure 5.



(a) (b)

Figure 5: Different plots for 2d signals:

(a) Intensity Plot and (b) Mesh plot

Figure 5(a) represented an 8 bit (256) gray scale image and named as strength plot it is a bi-sequence with different co-ordinates. Figure 5(b) represented the mesh plot for (a).

**Separable signals**

A separable signal $(\text{sequence})$ satisfies the equ.

$$x(n_1, n_2) = x(n_1), \ x(n_2),$$

$$for \, all \ n_1 \ and \ n_2$$

$$for \, some \ 1D \, signals$$

$$x(n_1) \, and \ x(n_2)$$

In the finite support case $x(n_1, n_2)$ is denoted as a matrix, $x(n_1)$ *and* $x(n_2)$ is denoted as vectors of column and row. The distinguishable similarity of the corresponding matrix $x$ denoted as the outer invention $x = x_1 x_2^T$. It is also called as singular value decomposition (SVD). Note that though an $N \ x \ N$ matrix $x$ has $N^2$ units in multidimensional signal processing.

A 2-D system is represented as a common mathematical operator T that plots every signal input $x(n_1, n_2)$ into a distinctive output $y(n_1, n_2)$.

$$y(n_1, n_2) = T[x(n_1, n_2)]$$

T is the general system operator and it make available a unique mapping for each input arrangement x and output sequence y.

**4.2 Two-dimensional convolution**

Shift – invariant linear systems can be represented by convolution.

Shift invariance of a 2 – D system is given by:

$T[x(n-m)] = y(n-m)$ *for shift vector m*

If a system is linear shift – invariant (LSI),

then we can write, using the shift representation

$$y(n_1, n_2) = L\left|\sum_{k_1, k_2} x(k_1, k_2)\,\delta(n_1 - k_1,\ n_2 - k_2)\right|$$

where L is a linear operator.

$$y(n_1, n_2) = \sum_{k_1, k_2} x(k_1, k_2)\, L[\delta(n_1 - k_1, n_2 - k_2)]^2$$

And

$$y(n_1, n_2) = \sum_{k_1, k_2} x(k_1, k_2)\, h(n_1 - k_1, n_2 - k_2)$$

where the sequence h is called the impulse response,

defined as

$h(n_1, n_2) = L[\delta(n_1, n_2)$

It then follows for a 2 – D LSI (Linear Shift Invariant) system,

we haveIt then follows for a 2 – D LSI (Linear Shift Invariant) system,

we have

It then follows for a 2 – D LSI (Linear Shift Invariant) system,

we have

$$y(n_1, n_2) = (x * h)(n_1, n_2)$$
$$= (h * x)(n_1, n_2)$$

**Example of 2D convolution:**

The simplest and efficient way to represent the above equation into graphical form is convolution. The convolution summation can exist as multiplying two classifications $x(k_1, k_2)$ and $h(n_1 - k_1,\, n_2 - k_2)$ which exist variables of the functions $k_1 \; and \; k_2$ and summing the product over altogether integers values of $k_1 \; and \; k_2$. The output is a function of $n_1 \; and \; n_2$, is the result of convolving $x(n_1, n_2) \; and \; h(n_1, n_2)$ and its illustrations are shon in figure 6(a) and (b).

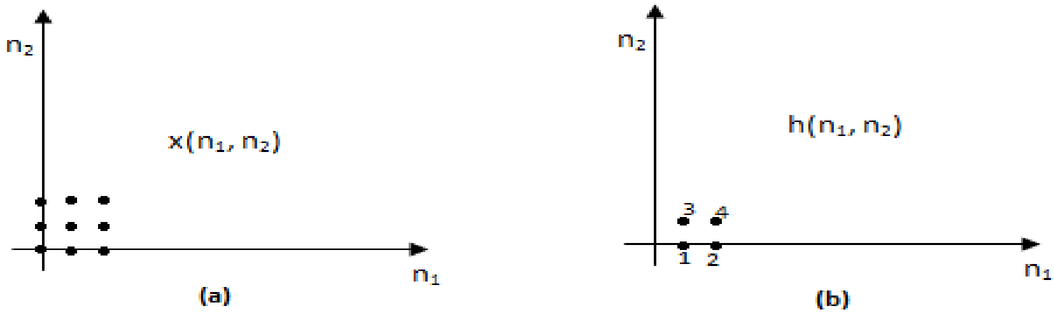



Figure 6 (a, b): Convolving two sequences

Convolution from $x(n_1, n_2) \; and \; h(n_1, n_2)$, $x(k_1, k_2)$ and $h(n_1 - k_1,\, n_2 - k_2)$ are the functions of $k_1 \; and \; k_2$ and represented as figures 6(c) to 6(f).

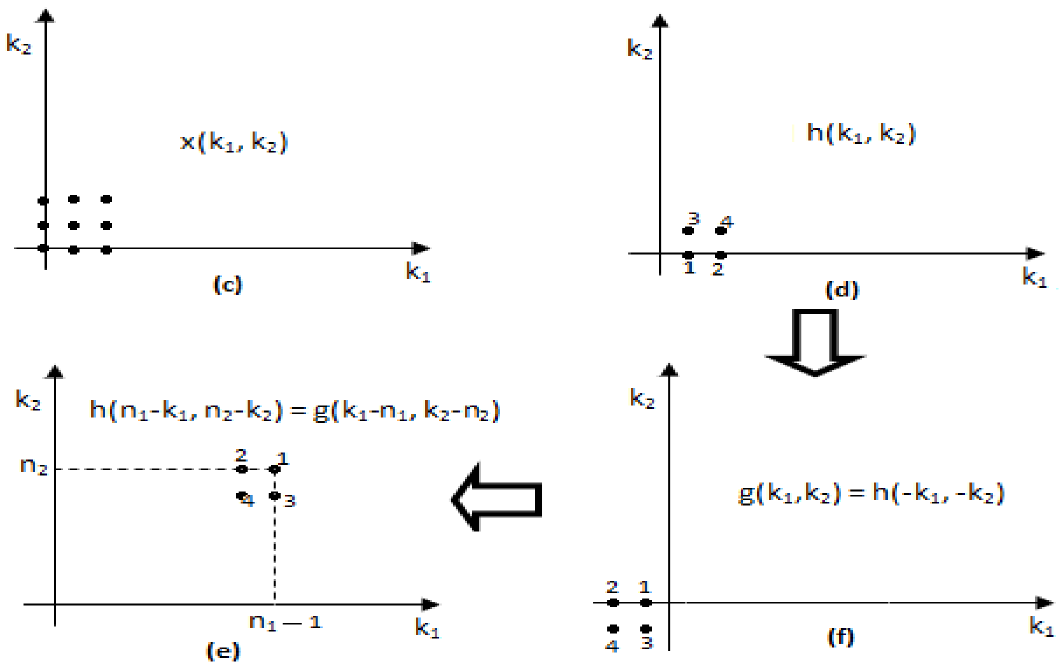



Figure 6 (c, d, e, f): Convolving two sequences

Note that $g(n_1 - k_2,\, n_2 - k_2)$ is the $g(k_1, k_2)$ shifted in the positive $k_1 \; and \; k_2$ directions by $n_1 \; and \; n_2$, respectively. Figures 6(d) to 6(f), show how to obtain $h(n_1 - k_1,\, n_2 - k_2)$ as a function of $k_1 \; and \; k_2$ from $h(n_1, n_2)$ in three steps. It is suitable to remember how to attain $h(n_1 - k_1,\, n_2 - k_2)$ directly from $h(n_1, n_2)$. One simple way is to first change the variables $n_1 \; and \; n_2$ to $k_1 \; and \; k_2$, flip the sequence with respect to the origin, and then shift the result in the positive $k_1\, and\, k_2$ directions by $n_1\, and\, n_2$ points correspondingly. Once $x(k_1, k_2)$ and $h(n_1 - k_1,\, n_2 - k_2)$ are obtained, they can be multiplied and summed ended $k_1\, and\, k_2$ to produce the output at each different value of $n_1\, and\, n_2$ and represented as figure 6(g).

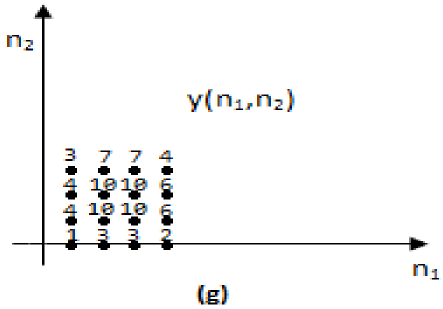



Figure 6 (g): Convolving two sequences

## 5. CONCLUSION

A simple method of digital Image Pixel Processing and 2D convolution is presented in this paper. Digital image exists as collection of pixels in network taking sparkle which stands as utility of rows and columns. Digital image is considered as 2-D signal with luminance principles stands as utility of pixel state on hydroplane. A digital image is a two-dimensional array or two-dimensional sequence of pixels. The simplest and efficient way to represent the above equation into graphical form is convolution. The convolution summation can exist as multiplying two classifications $x(k_1, k_2)$ and $h(n_1 - k_1,\, n_2 - k_2)$ which exist variables of the functions $k_1\, and\, k_2$ and summing the product over altogether integers values of $k_1\, and\, k_2$.

## 6. REFERENCES

[1]. Hakan Cevikalp., Burak Benligiray., Omer Nezih Gerek "Semi-supervised robust deep neural networks for multi-label image classification" Pattern Recognition, Volume 100, April 2020, pp 107-164.

[2] Rizwan Qureshia., Muhammad Uzairc., Khurram Khurshid., Hong Yan "Hyperspectral document image processing: Applications, challenges and future prospects" Pattern Recognition, Volume 90, June 2019, Pages 12-22

[3] Ji Zhang., Kuizhi Mei., Yu Zheng., Jianping Fan "Learning multi-layer coarse-to-fine representations for large-scale image classification" Pattern Recognition, Volume 91, July 2019, Pages 175-189

[4] Jianqiang Song., Xuemei Xie., Guangming Shia., Weisheng Dong "Multi-layer discriminative dictionary learning with locality constraint for image classification" Pattern Recognition, Volume 91, July 2019, Pages 135-146

[5] Douglas C.Yoon "Digital Radiographic Image Processing and Analysis" Dental Clinics of North America, Volume 62, Issue 3, July 2018, Pages 341-359

[6] Lei Wang., Min Xu., Bo Liu., Kin Huat Low., Jie Yang., Shiwu Zhang "A Three-Dimensional Kinematics Analysis of a Koi Carp Pectoral Fin by Digital Image Processing" Journal of Bionic Engineering, Volume 10, Issue 2, April 2013, Pages 210-221

[7] Peter W.Hamilton "How to take and process digital images for publication" Diagnostic Histopathology, Volume 16, Issue 10, October 2010, Pages 476-483

[8] Yohan Thibault., Yukiko Kenmochi., Akihiro Sugimotoa "Computing upper and lower bounds of rotation angles from digital images" Pattern Recognition, Volume 42, Issue 8, August 2009, Pages 1708-1717

[9] Phen Lan Lin., Chung-Kai Hsieh., Po-Whei Huang "A hierarchical digital watermarking method for image tamper detection and recovery" Pattern Recognition, Volume 38, Issue 12, December 2005, Pages 2519-2529

[10] Franck Xia "Normal vector and winding number in 2D digital images with their application for hole detection" Pattern Recognition, Volume 36, Issue 6, June 2003, Pages 1383-1395

[11] Azriel Rosenfeld., Punam K.Saha., Akira Nakamura "Interchangeable pairs of pixels in two-valued digital images" Pattern Recognition, Volume 34, Issue 9, September 2001, Pages 1853-1865

[12] John F.Hemdal "One-dimensional digital processing of images for straight-line detection" Pattern Recognition, Volume 31, Issue 11, November 1998, Pages 1687-1690.

[13] S.Biswas., N.R.Pal and S.K.Pal "Smoothing of digital images using the concept of diffusion process" Pattern Recognition, Volume 29, Issue 3March 1996, Pages 497-510.