**COMPSIG NITT**

**Dear friends!** COMPSIG NITT is a monthly newsletter to share the research work done in the Pattern recognition and computational intelligence laboratory, Department of Electronics and Communication Engineering, National Institute of Technology Trichy.

Concepts, Ideas pertaining to Computational intelligence, Pattern recognition and Signal processing are also included in this newsletter.

We expect the feedback, comments and articles from you all.

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**Team members**

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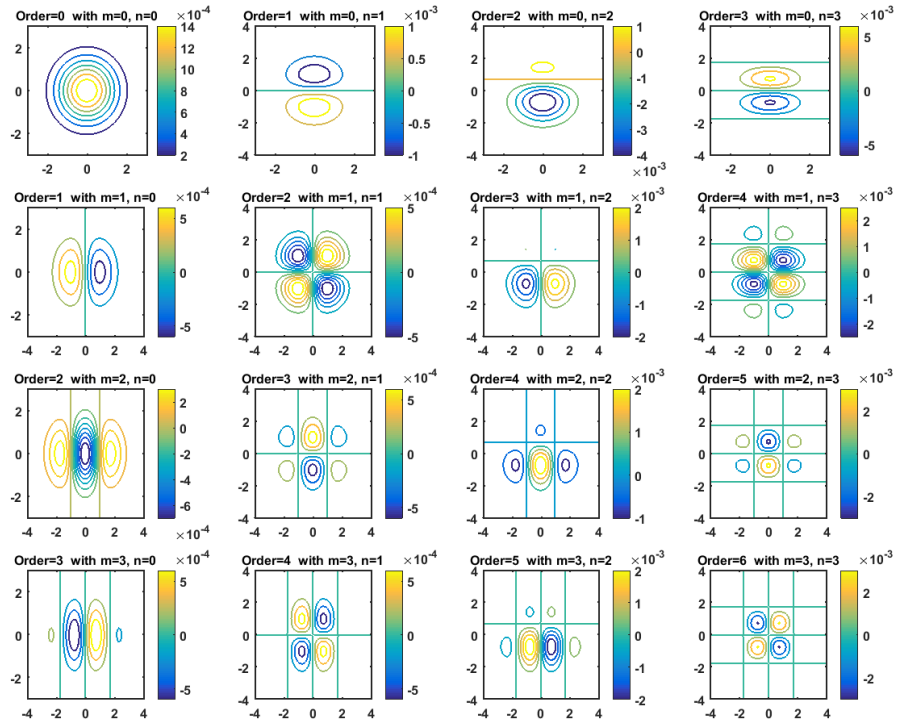6. **Shaik Mahammad, M.Tech, Communication systems.**

# Illustration



**Fig.1: Contour plots of 2-D Gaussian Derivatives**

For a Gaussian function with mean = 0 and variance $\sigma^2$, the corresponding Gaussian derivative functions are obtained by successively differentiating the Gaussian function. The $n^{th}$ order Gaussian derivative is equal to the Gaussian function multiplied by the Hermite polynomial of $n^{th}$ order. Fig.1 illustrates the contour plot of 2-D Gaussian derivatives of order $m + n \leq 6$ (refer fig.3). The Fourier transform of the $n^{th}$ order Gaussian derivative function is represented as $(jw)^n e^{-\frac{1}{2}w^2\sigma^2}$ where $w$ is the spatial frequency. Fig.2 depicts the relationship between 1-D Gaussian function, $n^{th}$ order Gaussian derivatives and their Fourier transforms. Fig.3 depicts the relationship between 2-D Gaussian function, $(m + n)^{th}$ order Gaussian derivatives and their Fourier transforms. These Gaussian derivatives can be used for feature extraction in spatial as well as Fourier domain.

For further details see to the following pdf: Refer to the pdf file

Link to the m-file: http://silver.nitt.edu/ esgopi/mfiles/gaussianderivative/

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# 1-D and 2-D Gaussian derivative functions

**1-D Gaussian function**
$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\left(-\frac{x^2}{2\sigma^2}\right)}$$

— Fourier Transform →

**Fourier Representation of 1-D Gaussian derivative function**
$$S(\omega) = \mathcal{F}\{f(x)\} = \int_{-\infty}^{\infty} f(x)e^{-j\omega x}dx$$
$$= e^{-\frac{1}{2}\omega^2\sigma^2}$$

$n^{th}$ derivative

**Hermite polynomial**
$$H_n(\alpha) = \sum_{k=0}^{[n/2]} (-2\alpha)^{n-2k}\frac{n!}{k!(n-2k)!}$$

**$n^{th}$ derivative of 1-D Gaussian function**
$$f^n(x) = \frac{1}{\sqrt{2\pi\sigma^2}}\frac{d^n}{dx^n}e^{\left(-\frac{x^2}{2\sigma^2}\right)}$$
$$= \frac{(-1)^n}{(\sqrt{2\pi\sigma^2})^n}H_n\left(\frac{x}{\sqrt{2\sigma^2}}\right)f(x)$$

— Fourier Transform →

**Fourier Representation of $n^{th}$ derivative of 1-D Gaussian function**
$$S^n(W) = \mathcal{F}\{f^n(x)\} = (jw)^n e^{-\frac{1}{2}\omega^2\sigma^2}$$
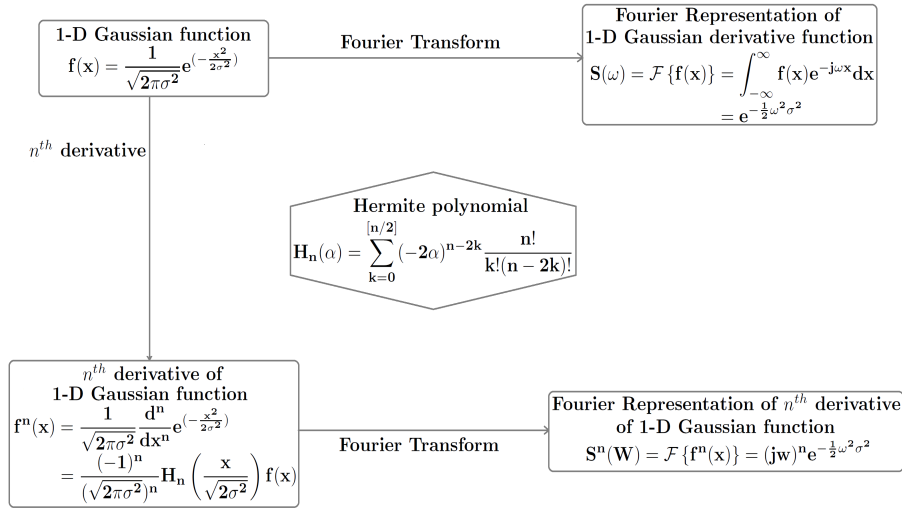
**Fig.2: Relationship between 1-D Gaussian derivatives and their Fourier transforms**

**2-D Gaussian function**
$$f(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} e^{-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}\right)}$$

— Fourier Transform →

**Fourier Representation of 2-D Gaussian derivative function**
$$S(\omega_x,\omega_y) = \mathcal{F}\{f(x,y)\}$$
$$= \int_{-\infty}^{\infty} f(x,y)e^{-j(\omega_x x+\omega_y y)}dxdy$$
$$= e^{-\frac{1}{2}(\omega_x^2\sigma_x^2+\omega_y^2\sigma_y^2)}$$

$(m+n)^{th}$ derivative

**Hermite polynomial**
$$H_n(\alpha) = \sum_{k=0}^{[n/2]} (-2\alpha)^{n-2k}\frac{n!}{k!(n-2k)!}$$

**$(m+n)^{th}$ derivative of 2-D Gaussian function**
$$f^{m,n}(x,y) = \frac{\partial^{m+n}}{\partial x^m \partial y^n}f(x,y)$$
$$= f^{(m)}(x)f^{(n)}(y)$$
$$f^{(m)}(x) = \frac{(-1)^m}{(\sqrt{2\pi\sigma_x^2})^m}H_m\left(\frac{x}{\sqrt{2\sigma_x^2}}\right)f(x)$$
$$f^{(n)}(y) = \frac{(-1)^n}{(\sqrt{2\pi\sigma_y^2})^n}H_n\left(\frac{y}{\sqrt{2\sigma_y^2}}\right)f(y)$$

— Fourier Transform →

**Fourier Representation of $(m+n)^{th}$ derivative of 2-D Gaussian function**
$$F^{(m,n)}(\omega_x,\omega_y) = \mathcal{F}\{f^{m,n}(x,y)\}$$
$$= F^{(m)}(x)F^{(n)}(y)$$
$$= (j\omega_x)^m(j\omega_y)^n e^{-\frac{1}{2}(\omega_x^2\sigma_x^2+\omega_y^2\sigma_y^2)}$$

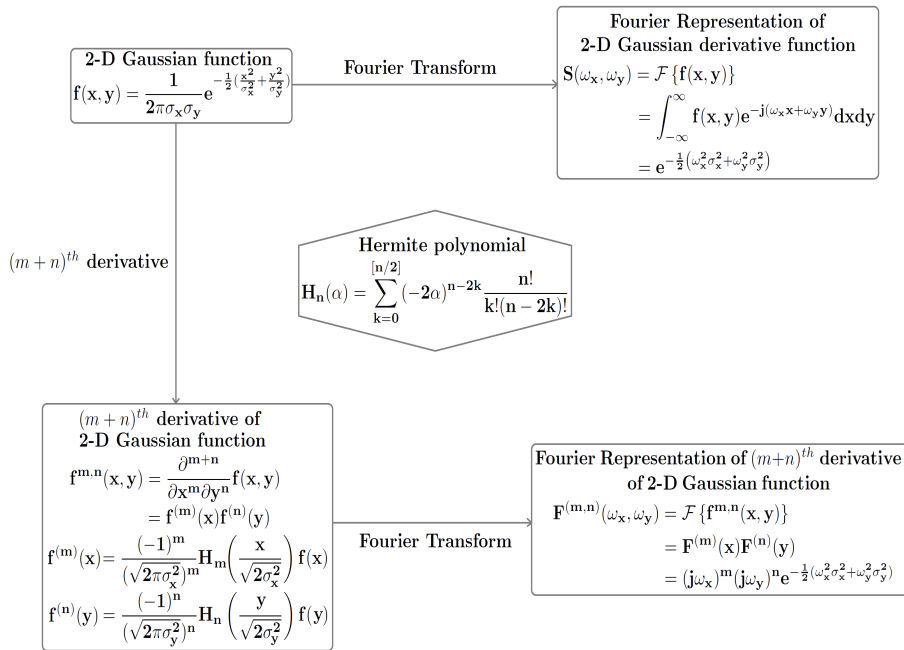**Fig.3: Relationship between 2-D Gaussian derivatives and their Fourier transforms**

## Quotes

*"Thinking is the capital, Enterprise is the way, Hard Work is the solution."* — Dr. A.P.J.Abdul Kalam

## On-going Research

- Constructing a Sunflower plant database and perform off-type identification using morphological features.
- Application of machine learning techniques in next generation wireless communication.
- Classification of Music composition styles using probabilistic generative model
- Computational intelligence for transmit power control policy of Energy Harvesting Sensors
- Estimation of Primary User Parameters in Cognitive Radio using Computational Intelligence

## Feedback

COMPSIG NITT invites articles and innovative ideas from readers for the Reader's Space column. We expect feedback and comments to monthly newsletter COMPSIG NITT . Readers can share their views in our facebook page, "COMPSIG-NITT". Those who are interested can be a part of the facebook group.

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