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The generalized continuous wavelet transform associated with fractional Fourier transform

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Abstract

The main objective of this paper is to study the fractional Fourier transform (*FrFT*) and its some basic properties. Applications of the *FrFT* in solving generalized n^{th} order linear nonhomogeneous ordinary differential equations and a generalized wave equation are given. The generalized continuous wavelet transform and its inversion formula, and the Parseval relation using the fractional Fourier transform are also studied.

Keywords: fractional Fourier transform, generalized continuous wavelet transform, generalized wave equation, Fourier transform, mother wavelet

2000 MSC: 46F12, 26A33, 46A05, 47A30, 47G05

1. Introduction

Let $L^p(\mathbb{R})$ denotes the class of measurable functions of ϕ on \mathbb{R} such that the integral $\int_{\mathbb{R}} |\phi(t)|^p dt$ is finite. Also let $L^\infty(\mathbb{R})$ be the collection of almost everywhere bounded functions. Hence endowed with norm:

$$\|\phi\|_p = \begin{cases} \left(\int_{\mathbb{R}} |\phi(t)|^p dt \right)^{1/p}, & 1 \leq p < \infty, \\ \text{ess sup}_{t \in \mathbb{R}} |\phi(t)|, & p = \infty. \end{cases}$$

The Fourier transform of a function $\phi \in L^1(\mathbb{R})$, is defined by

$$\hat{\phi}(\omega) = (\mathcal{F}\phi)(\omega) = \frac{1}{\sqrt{2\pi}} \int_{\mathbb{R}} e^{-it\omega} \phi(t) dt, \quad \omega \in \mathbb{R}, \quad (1)$$

and if $\hat{\phi} \in L^1(\mathbb{R})$, then the inverse Fourier transform is given by

$$\phi(t) = (\mathcal{F}^{-1}\hat{\phi})(t) = \frac{1}{\sqrt{2\pi}} \int_{\mathbb{R}} e^{it\omega} \hat{\phi}(\omega) d\omega, \quad t \in \mathbb{R}. \quad (2)$$

The *FrFT* is a generalization of the classical Fourier transform which depends on an angle θ , has many applications in several areas, including communications, optics, quantum physics, signal and image processing, etc. The one dimensional *FrFT* [1 – 5] with an angle θ of $\phi(t)$ denoted by $(\mathcal{F}^\theta\phi)(\omega) = \hat{\phi}^\theta(\omega)$ is given by

$$(\mathcal{F}^\theta\phi)(\omega) = \hat{\phi}^\theta(\omega) = \int_{\mathbb{R}} K^\theta(t, \omega) \phi(t) dt, \quad (3)$$

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