Advances in Engineering Software 76 (2014) 148–153

Contents lists available at ScienceDirect

Advances in Engineering Software

journal homepage: www.elsevier.com/locate/advengsoft

Survey of four models of probability density functions of wind speed and directions by adaptive neuro-fuzzy methodology

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ARTICLE INFO

Article history:
Received 31 May 2014
Received in revised form 11 June 2014
Accepted 21 June 2014
Available online 21 July 2014

Keywords:
Wind direction
Frechet distribution
Gumbel distribution
Weibull distribution
Joint probability density function (JPDF)
Adaptive neuro-fuzzy system (ANFIS)

ABSTRACT

The probabilistic distribution of wind speed is one of the discriminating wind qualities for the assessment of wind energy potential and for the execution of wind energy conversion frameworks. The wind energy spread might be obtained when wind speed probability function is known. Thusly, the probability movement of wind speed is an uncommonly huge touch of information needed in the assessment of wind energy potential. The two-parameter Weibull circulation has been normally used, recognized and endorsed in expositive interpretation to express the wind speed repeat transport for most wind regions. The Gumbel and Frechet dissemination is frequently used to model large wind speeds. The joint probability density functions (JPDF) model is advanced by minimal disseminations of wind speed and wind direction that is expected as an Extreme-Value mathematical statement. In the present study an exertion has been made to figure out the best fitting circulation of wind speed information by a soft computing methodology. We used adaptive neuro-fuzzy inference framework (ANFIS) in this paper, which is a specific kind of the neural frameworks family, to foresee the wind speed probability density dispersion. For this reason, two parameters Weibull and JPDF and three parameter Frechet and Gumbel conveyances are fitted to data and parameters for each distribution and utilized as preparing and checking information for ANFIS model. At long last, ANFIS effects are contrasted and the four introduced appropriations recommending that ANFIS conveyances are discovered to be most suitable as contrasted with the Weibull, JPDF, Frechet and Gumbel circulations.

1. Introduction

Wind is renewable source of energy and is practically the quickest developing energy asset on the planet, which is clean and offers numerous profits to people. Wind energy has been getting huge consideration in light of the fact that renewable energies have got colossal centering. Because of increment in expense of fossil fuel and the different natural issues, it is vital to like the potential of power era from nonconventional sources. The compelling utilization of wind energy is the change of wind force into profitable manifestations of power. The dissemination of wind velocity and course is vital for force generators. In this way, regionalized study as per factual view is fundamental to model wind speed conduct.

A few studies have examined the demonstrating of suitable wind speed and heading conveyance. The reason for paper [1] was to discover the most proper distribution(s) for portraying the wind speed information. It was examined Gamma, Weibull, Lognormal, Rayleigh, Burr and Frechet dispersions. In paper [2] was assessed combination of probability density works that have been proposed in the investigative written work related to renewable energies to delineate wind speed repeat movements. Weibull capacity [3] has been the most satisfactory conveyance and structures the foundation for business wind energy provisions and programming around the probability density works that have been proposed for wind speed recurrence circulation. The Weibull probability density function is a two-parameter capacity described by a dimensionless shape (k) and scale (c) parameters [4]. These two parameters focus the wind speed for best execution of a wind transformation framework and also the velocity go over which the apparatus is prone to work. It is in this way, extremely key to faultlessly assess the parameters for any applicant site for establishment of wind energy change frameworks. Wind engineering investigations the impact of wind in the regular and constructed environment and the harm because of the wind. For a structural specialist, the investment is in strong winds which may cause

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http://dx.doi.org/10.1016/j.advengsoft.2014.06.007
0965-9978/

distress. With the structures getting tall and slim the impact of wind on these structures is getting basic. The circulation of wind speed will be additionally imperative in deciding serviceability of edifices. The Gumbel dissemination is frequently used to model great wind speeds [5]. The Gumbel model has additionally been recognized in the expositive expression for the yearly most extreme wind speed weight, which is straightforwardly relative to squared wind speed [6]. Gumbel and Frechet disseminations were utilized to gauge the outline wind speed for diverse return periods [7]. In the assessment of wind assets accessible at a given site of complex territory or with some common wind directions, it is fascinating to have utilization of a joint probability density function (JPDF). That is, to have utilization of a ceaseless model of the wind rose1 that empowers examination of the variability of the energy qualities of the wind regarding velocity and direction. Information of these qualities empowers the wind turbines to be positioned in such a path as to augment the energy. It ought to be borne at the top of the priority list that it may be the case that the most extreme winds are not those which blow most hours throughout the year from a specific heading. This is a critical perspective to be considered when settling on the introduction of the wind turbines. An extremely adaptable joint probability density function of wind velocity and direction was introduced in paper [8] for wind energy investigation. A system that empowers angular–linear circulations to be gotten with specified minor appropriations has been utilized for this reason.

Despite the fact that various new scientific functions have been proposed for demonstrating wind speed probability density functions, there are many disadvantages of these functions like challenging computing time since it are strongly nonlinear functions. Artificial neural systems (ANN) could be utilized as elective to logical approach as ANN offers favorable circumstances, for example, no obliged learning of inward framework parameters, minimal answer for multi-variable issues. In this paper, four as often as possible utilized models are analyzed, Weibull, JPDF, Frechet and Gumbel distributions. Adaptive neuro-fuzzy framework (ANFIS) [9–12], which is a particular kind of the ANN family, was utilized to assess wind speed probability distribution function agreeing the four displayed models. For the right away created neural system, the effective wind velocity is utilized as data for foreseeing the probability functions. The ANFIS model is outlined dependent upon the four routines for assessing the new ANFIS probability density function. As such the ANFIS model might as well gauges normal two-parameter or three-parameter capacity of Weibull, JPDF, Frechet and Gumbel appropriations dependent upon the energizing systems.

ANFIS demonstrates quite great taking in and forecast abilities, which makes it a proficient device to manage experienced lacks of determination in any framework. ANFIS, as a mixture smart framework that improves the capacity to immediately take in and acclimate, was utilized via specialists as a part of different designing frameworks [13–19]. As such, there are numerous investigations of the requisition of ANFIS for estimation and ongoing real-time of numerous distinctive frameworks [20–28].

2. Materials and methods

2.1. Wind data

By utilizing anemometers and wind direction sensors, the wind velocity and heading information were measured and caught at a wind perception site with bounteous wind assets. The information were recorded persistently and found the middle value of over consistently to acquire the wind qualities. In the study, the hourly wind dataset of May 1, 2000 – October 21, 2005 is embraced. Fig. 1 shows percentage frequency of wind speed and direction distributions as function of effective wind speed. The effective wind speed is in range (0, 25 m/s).

With a specific end goal to portray the conduct of wind speed at a specific range, it is obliged to distinguish the dissemination (s), which best fit the information. In this study four two parameter dispersions to be specific, Weibull and JPDF and two three parameter appropriations, Frechet and Gumbel are utilized to model the circulation of wind speed and directions. A while later, the ANFIS system will be builds as potential hopeful for probability density function of wind speed and direction.

2.2. Weibull probability density function

Weibull probability density function is a numerical admiration of the scattering of wind speed over the long term. The limit gives the probability of the wind speed being in 1 m/s break, acknowledging both incidental and yearly mixtures over the period secured by the part. The Weibull allocation limit is given by:

$$f_{(x;c,k)} = \frac{k}{c}\left(\frac{x}{c}\right)^{k-1} \exp\left(-\frac{x}{c}\right)^{k}, \quad x > 0, \quad k > 0, \quad c > 0 \tag{1}$$

where $f_{(x;c,k)}$ is the probability density characterized as the frequency of event of wind velocity, c (in unit of m/s) is the scale parameter which is nearly identified with the modal wind speed for the area, and k is the dimensionless shape parameter which depicts the structure and width of the appropriation. The Weibull dispersion is in this way portrayed by the two parameters c and k.

2.3. Frechet probability density function

The probability density function for Frechet distribution is:

$$f_{(x;k,c,\gamma)} = \frac{k}{c}\left(\frac{c}{x-\gamma}\right)^{k+1} \exp\left(-\left(\frac{c}{x-\gamma}\right)^{k}\right), \quad x > 0, \quad k > 0, \quad c > 0, \quad \gamma > 0 \tag{2}$$

where k, c and γ are shape, scale and location parameters of Frechet distribution respectively.

2.4. Gumbel probability density function

The probability density function for Gumbel distribution is:

$$f_{(x;k,c,\gamma)} = \frac{1}{c}\exp\left(-\left(\frac{x-k}{c} + \exp\left(-\left(\frac{x-k}{c}\right)\right)\right)\right), \quad x > 0, \quad k > 0, \quad c > 0 \tag{3}$$

where k is the mode of the function.

2.5. Joint probability density function

The most dissimilar approach to structure the joint probability density function of wind speed and course is utilizing the data of the negligible dispersions. In wind-impelled structural exhaustion examination, case in point, the general methodology is to gap the wind direction into some subsections and apply indistinguishable probability function say Weibull dissemination for wind speed in every subsection and expect measurable autonomy around subsections. For rakish straight dissemination, the joint probability density utilizing peripheral circulation as:

$$f_{V\Theta}(v,\theta) = 2\pi g(\zeta) f_V(v) f_\Theta(\theta), \quad 0 \le \theta \le 2\pi, \quad -\infty \le v \le \infty \tag{4}$$

where $f_V(v)$, $f_\Theta(\theta)$ probability density function for mean wind and direction respectively, ζ is circular variable and $g(\zeta)$ is its probability