

Short Communication

The A_T - {Transmuted - X} Family of Distributions

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Abstract

The Exponential Transmuted Exponential distribution (ETE) appeared in and in this paper we present a new generalization of the ETE distribution based on an application of the Ampadu-G family of distributions that appeared in [1,2]. We also show the new distribution is a good fit to some real-life data, indicating practical significance. As a further development, we propose a new class of distributions based on the structure of the weight function introduced in [3].

Keywords: A_T - X(W) family of distributions; Exponential Distribution; Transmuted Distribution

Preliminaries

At first we recall the following definitions

Definition 1.1.

Let $\lambda > 0, \xi > 0$ be a parameter vector all of whose entries are positive, and $x \in \mathbb{R}$ [2]. A random variable X will be said to follow the Ampadu-G family of distributions if the CDF is given by

$$F(x; \lambda, \xi) = \frac{1 - e^{-\lambda G(x; \xi)^2}}{1 - e^{-\lambda}}$$

And the PDF is given by

$$f(x; \lambda, \xi) = \frac{2\lambda g(x; \xi) G(x; \xi) e^{-\lambda G(x; \xi)^2}}{1 - e^{-\lambda}}$$

Where the baseline distribution has CDF $G(x; \xi)$ and PDF $g(x; \xi)$

Definition 1.2.

Assume the random variable T with support $[0, \infty)$ has CDF $G(t; \xi)$ and PDF $g(t; \xi)$ [2]. We say a random variable S is A_T - X(W) distributed of type II if the CDF can be expressed as either one of the following integrals

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$$\int_0^{-\log(1-F(x;\omega))} \frac{2\lambda g(t; \xi) G(t; \xi) e^{-\lambda G(t; \xi)^2}}{1 - e^{-\lambda}} dt = \frac{1 - e^{-\lambda G(-\log(1-F(x;\omega)); \xi)^2}}{1 - e^{-\lambda}}$$

or

$$\int_0^{\frac{F(x;\omega)}{1-F(x;\omega)}} \frac{2\lambda g(t; \xi) G(t; \xi) e^{-\lambda G(t; \xi)^2}}{1 - e^{-\lambda}} dt = \frac{1 - e^{-\lambda G\left(\frac{F(x;\omega)}{1-F(x;\omega)}; \xi\right)^2}}{1 - e^{-\lambda}}$$

Where $\lambda, \xi > 0$, and the random variable X with parameter vector ω has CDF $F(x; \omega)$ and PDF $f(x; \omega)$

Application

As an application we consider the data on patients with breast cancer [1]. We assume the random variable T is exponentially distributed. So that the CDF of T is given by

$$G(t; d) = 1 - e^{-dt}$$

For $t, d > 0$ and the PDF is given by

$$g(t; d) = de^{-dt}$$

For $t, d > 0$. Now we recall the following, for some baseline distribution $K(x)$, the transmuted family of distributions has CDF given by

$$(1 + b)K(x) - bK^2(x)$$

Where $b \in [-1, 1]$. Now we assume X is transmuted exponentially distributed, so that if

$$K(x) = 1 - e^{-ax}$$

For $x, a > 0$, then the CDF of X is given by

$$F(x; a, b) = (b + 1)(1 - e^{-ax}) - b(1 - e^{-ax})^2$$

And the PDF is given by

$$f(x; a, b) = a(b + 1)e^{-ax} - 2abe^{-ax}(1 - e^{-ax})$$

Now from the first integral in 3.2 Definition, we have the following

Theorem 2.1.

The CDF of the $A_{\text{Exponential}}$ - {Transmuted Exponential} distribution is given by

$$S(x; a, b, c, d) = \frac{1 - \exp\left(-c\left(1 - \left(b(1 - e^{-ax})^2 - (b + 1)(1 - e^{-ax}) + 1\right)^d\right)\right)}{1 - e^{-c}}$$

Where $x, a, c, d > 0$ and $b \in [-1, 1]$

Remark 2.2.

If a random variable Q has CDF given by the above theorem, write

$$Q \sim \text{AETE}(a, b, c, d)$$

The PDF of the AETE distribution can be obtained by differentiating the CDF

The AETE distribution is seen to be a good fit to real life data as shown in the figure 1.

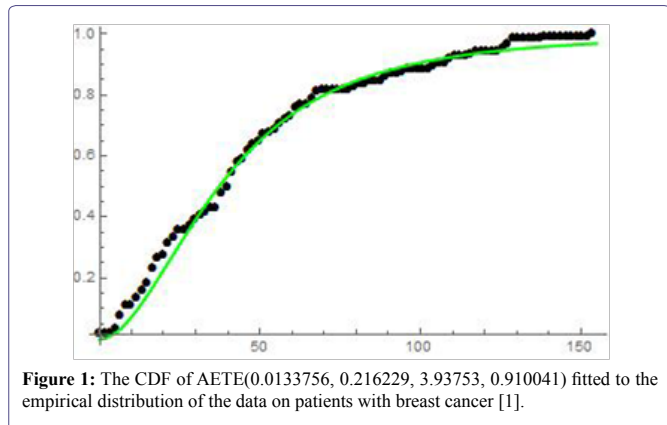


Figure 1: The CDF of AETE(0.0133756, 0.216229, 3.93753, 0.910041) fitted to the empirical distribution of the data on patients with breast cancer [1].

Further Developments

Inspired by the structure of the weight function introduced in, we ask the reader to investigate some properties and applications of a so-called $A_{(New T)} - X(W)$ family of distributions of type II [3]. We leave the reader with the following.

Definition 3.1.

Assume the random variable T with support $[0, \infty)$ has CDF $G(t; \zeta)$ and PDF $g(t; \zeta)$. We say a random variable S_{New} is $A_{(New T)} - X(W)$ distributed of type II if the CDF can be expressed as the following integral

$$\int_0^x \frac{-\log(1-F(x;\omega))}{1-F(x;\omega)} \frac{2\lambda g(t; \xi) G(t; \xi) e^{-\lambda G(t; \xi)^2}}{1 - e^{-\lambda}} dt = \frac{1 - e^{-\lambda G\left(\frac{-\log(1-F(x;\omega))}{1-F(x;\omega)}; \xi\right)^2}}{1 - e^{-\lambda}}$$

Where $\lambda, \xi > 0$, and the random variable X with parameter vector ω has CDF $F(x; \omega)$ and PDF $f(x; \omega)$

Concluding Remarks

Our hope is that the new class of distributions presented in this paper will find application in cancer modeling and forecasting

References

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