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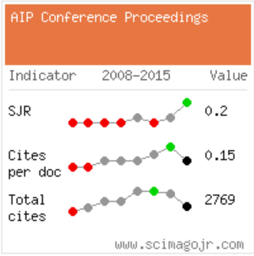

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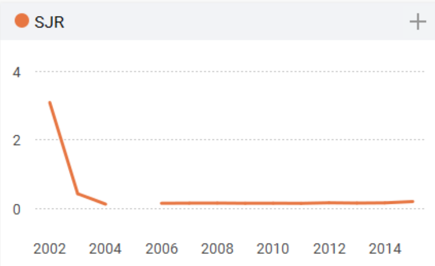

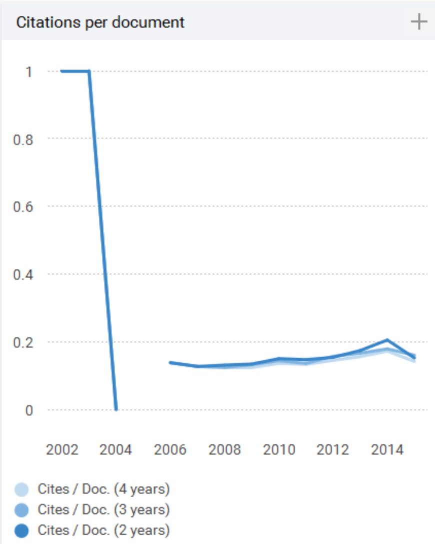

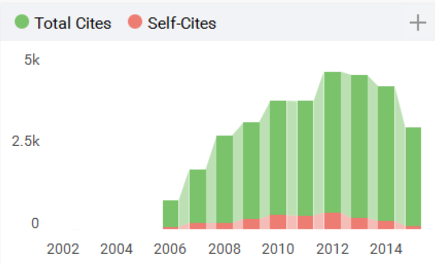

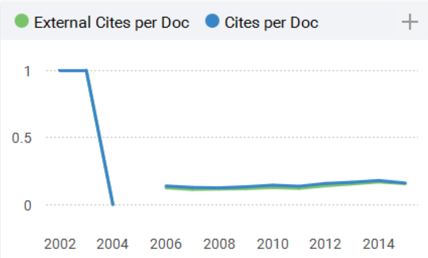

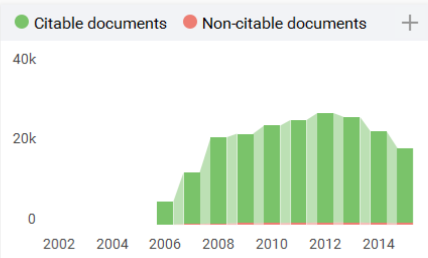

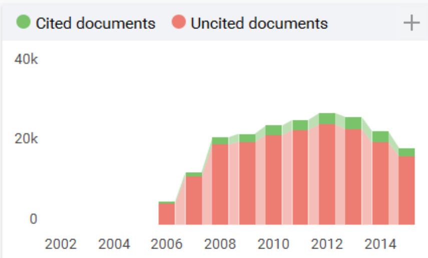

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PREFACE

First of all, we would like to thank to all participants of “The 7th SEAMS UGM 2015 International Conference on Mathematics and Its Applications” which was held on August 18-21, 2015. The conference is very important as a communication forum of the mathematicians, not only in Indonesia, but also in Southeast Asia and surrounding areas. We also thank to the steering committee members and all of the reviewers for all supports during the conference and the preparation of this proceedings.

As the scientific documentation of the conference, we provide two-types of proceedings. The first one is the AIP Proceedings which contains the high quality paper selected by blind review process. The second one is the regular proceedings, which contain the selected papers which are not published in the AIP Proceedings and the paper of our invited speakers.

We would like to say thanks to all authors who have submitted the paper to our proceedings. During the review process, we found that almost all papers has good quality. However due to the limitation number of the paper which can be published in our proceedings, we should select the submitted paper based on the reviewer recommendation and score. So, there are some papers which are not accepted to publish in this proceedings, we apologize to the authors about this inconvenience.

Lastly, we would like to say thanks for all partners and all sponsors in supporting our conference.

Warm regards,

Dr. Fajar Adi Kusumo
Editor in Chief.

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The uniform continuity of characteristic function from convoluted exponential distribution with stabilizer constant

Dodi Devianto

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The Uniform Continuity of Characteristic Function from Convoluted Exponential Distribution with Stabilizer Constant

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Abstract. It is constructed convolution of generated random variable from independent and identically exponential distribution with stabilizer constant. The characteristic function of this distribution is obtained by using Laplace-Stieltjes transform. The uniform continuity property of characteristic function from this convolution is obtained by using analytical methods as basic properties.

Keywords: convolution, exponential distribution with stabilizer constant, characteristic function, uniform continuity.
PACS: 02.50.Ng

INTRODUCTION

The characteristic function is a complex valued function which defines as Laplace-Stieltjes transform. This transformation and its properties have been introduced in formal term [1] and [4]. Furthermore, the property of characteristic function for infinite divisibility distribution has established in some well known works of Levy and Khinchine in the form of canonical representation.

This property of Laplace-Stieltjes transform as characteristic function can be used to find the distribution of convoluted random variables which are many applications in other area such as convoluted exponential random variables as service time of the quequeing or reliability model by [5]. In other hand [2] has introduced properties of the characteristic function from geometric distribution as discrete version of the exponential distribution. Furthermore, the mathematical method to obtain the convolution of exponential distribution and its variations have been introduced in some works of [6], [7], [8].

The research on characteristic functions of various kinds of exponential distribution are always interested to set their properties such as in canonical representation or its uniform continuity. Devianto et al. [3] have introduced convolution of generating random variables from exponential distribution with stabilizer constant. It is worth to give some properties of characteristic function from this new distribution. Now let us adopt the process of constructing this new introduced distribution. Let X be a random variable from exponential distribution with parameter λ. Probability density function for this random variable is given by

$$f(x;\lambda) = \lambda e^{-\lambda x} \tag{1}$$

for positive λ and all real number x. It is denoted W as random variable related to x_i which way generated from exponential distribution with values spread in form

$$w_i = \frac{x_i}{x_m} \tag{2}$$

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where it is defined $x_m = \max\{x_1, x_2, ..., x_n\}$ for $x_i \in [0, x_m]$ and $n, m \in Z^+$. Then random variable W has probability density function as follows

$$f(w;\lambda) = \theta\,\lambda\, e^{-\lambda w} \tag{3}$$

for positive λ and $0 < w \le 1$ where stabilizer constant is to maintain the nature of probability density function defined as $\theta = -(1/(e^{-\lambda} - 1))$.

Devianto et al. [3] has shown the convolution of this new intoduced distribution by setting $W_1, W_2, ..., W_n$ be n independent and identically exponential distribution with stabilizer constant where probability density function is defined as follows

$$f(w_i;\lambda) = \theta\,\lambda\, e^{-\lambda w_i} \tag{4}$$

for positive parameter λ, $0 < w_i \le 1$ and $\theta = -1/(\exp(-\lambda) - 1)$. Then the sum of random variables $S_n = W_1 + W_2 + ... + W_n$ has probability density function

$$f(s_n;\lambda) = \theta^n \frac{\lambda^n}{(n-1)!} {s_n}^{n-1} e^{-\lambda s_n} \text{ for } 0 < s_n \le n. \tag{5}$$

The properties of distribution from an exponential distribution with stabilizer constant and its convolution can be given in the form of characteristic functions. This paper gives a brief explanation of these characteristic functions and their properties of uniform continuity in Section 2 and Section 3.

THE PROPERTIES OF CHARACTERISTIC FUNCTION FROM GENERATING RANDOM VARIABLE OF EXPONENTIAL DISTRIBUTION WITH STABILIZER CONSTANT

The aim of this section is to present characteristic function of distribution from generating random variable of the exponential distribution with stabilizer constant. Furthermore, it is given property of uniform continuity from this characteristic function.

Theorem 1. Let W is generating random variable from exponential distribution with stabilier constant with probability distribution function as in (3) that is

$$f(w;\lambda) = \theta\,\lambda\, e^{-\lambda w}$$

for positive parameter λ and $0 < w \le 1$ where stabilizer constant $\theta = -(1/(e^{-\lambda} - 1))$. Then characteristic function from random variable W is

$$\phi_W(t) = \frac{-\theta\lambda}{\lambda - it}(e^{-(\lambda - it)} - 1) \text{ for } -\infty < t < \infty. \tag{6}$$

Proof. Characteristic function from random variable W is deriven by direct methods of Laplace-Stieltjes transform, that is obtained as follows

$$\phi_W(t) = E[e^{itW}] = \int_0^1 \theta\,\lambda\, e^{itw} e^{-\lambda w}\, dw \tag{7}$$

$$= \frac{-\theta\lambda}{\lambda - it}(e^{-(\lambda - it)} - 1). \;\blacksquare$$

Proposition 2. The Characteristic function of generating random variable from exponential distribution with stabilizer constant is unifomly continuous.

Proof. The uniform continuity of characteristic function from exponential distribution with stabilizer constant is showing by define for every $\varepsilon > 0$ and $\delta > 0$ such that

$$|\phi_W(s) - \phi_W(t)| < \varepsilon \text{ for } |s - t| < \delta \tag{8}$$

where δ only depends on ε. Now let us define a new function

$$\psi(w) = \frac{e^{its} - e^{itw}}{s - t}. \tag{9}$$

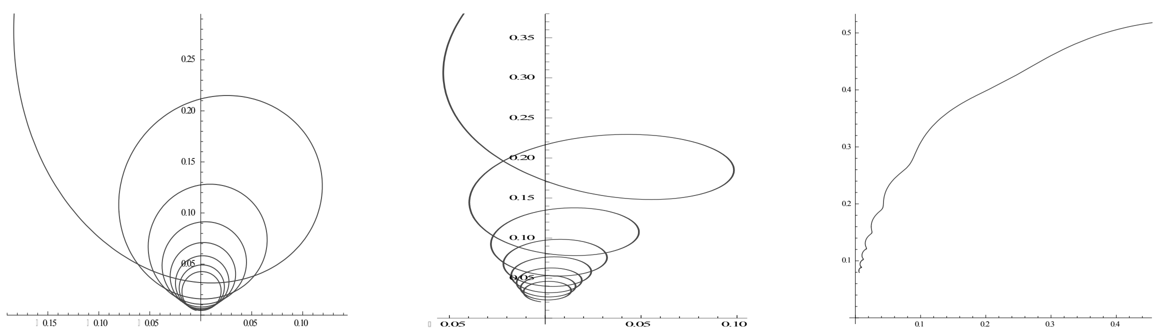
It is using Taylor expansion series to e^{isw} and e^{itw} then we have the new defined function can be rewritten as follows

$$\psi(w) = \left(-\frac{(s+t)w^2}{2!} + \frac{(s^3 + s^2 t + st^2 + t^3)w^4}{4!} + \ldots \right) + i \left(w - \frac{(s^2 + st + t^2)\, w^3}{3!} + \ldots \right). \tag{10}$$

We can establish uniform continuity of characteristic function by setting

$$\begin{aligned} |\phi_W(s) - \phi_W(t)| &= \left| \int_0^1 \theta\, \lambda\, e^{isw}\, e^{-\lambda w}\, dw - \int_0^1 \theta\, \lambda\, e^{itw}\, e^{-\lambda w}\, dw \right| \\ &= (s - t) \left| \int_0^1 \theta\, \lambda\, e^{-\lambda w}\, \psi(w)\, dw \right|, \end{aligned} \tag{11}$$

so that for every $\delta > \varepsilon$ and $|s - t| \to 0$ then we have $|\phi_W(s) - \phi_W(t)| \to 0$. This confirms the characteristic function from random variable W is uniform continuous. ■



$\lambda = 0.2$ *and* $0 \le t \le 50$ $\lambda = 1$ *and* $0 \le t \le 50$ $\lambda = 4$ *and* $0 \le t \le 50$

FIGURE 1. Parametric curves of characteristic function from random variable W with various parameter λ and variable t with $0 \le \theta \le 2\pi$.

The parametric curves of characteristic function from random variable W from Fig. 1 show smooth line and never vanish on the complex plane for all presented curves, this confirms the continuity of parametric curves by graphically.

THE PROPERTIES OF CHARACTERISTIC FUNCTION FROM CONVOLUTED EXPONENTIAL DISTRIBUTION WITH STABILIZER CONSTANT

The aim of this section is to present characteristic function of distribution from convolution of generating random variable of exponential distribution with stabilizer constant. Furthermore, it is given property of uniform continuity from this characteristic function.

Theorem 3. Let *Sn* is generating random variable from exponential distribution with stabilier constant with probability distribution function as in (5) that is

$$f(s_n;\lambda)=\theta^n \frac{\lambda^n}{(n-1)!} s_n{}^{n-1} e^{-\lambda s_n} \text{ for } 0<s_n\le n.$$

for positive λ and $0<s_n\le n$ where stabilizer constant $\theta=-(1/(e^{-\lambda}-1))$. Then characteristic function is

$$\phi_{S_n}(t)=E[e^{itS_n}]=\frac{\theta^n\lambda^n}{(n-1)!(\lambda-it)^n}\Gamma(n,n(\lambda-it)) \text{ for } 0<t<\infty. \tag{12}$$

Proof. Characteristic function is deriven by direct methods of Laplace-Stieltjes transform, that is obtained as follows

$$\phi_{S_n}(t)=E[e^{itS_n}]=\int_0^n e^{its_n}\theta^n \frac{\lambda^n}{(n-1)!} s_n{}^{n-1} e^{-\lambda s_n}\, ds_n \tag{13}$$

for $-\infty<t<\infty$ and $0<s_n\le n$. Now, by using changing variable $y=s_n(\lambda-it)$ then we have

$$\phi_{S_n}(t)=\theta^n \frac{\lambda^n}{(n-1)!}\frac{1}{(\lambda-it)^n}\int_0^{n(\lambda-it)} y^{(n+1)-1}e^{-y}dy \tag{14}$$

It is used the property of incomplete gamma function then characteristic function of random variable S_n can be written as follows

$$\phi_{S_n}(t)=\frac{\theta^n\lambda^n}{(n-1)!(\lambda-it)^n}\Gamma(n,n(\lambda-it)) \text{ for } -\infty<t<\infty, \tag{15}$$

where it is defined

$$\Gamma(n,n(\lambda-it))=\int_0^{n(\lambda-it)} y^{n-1}e^{-y}dy. \ \blacksquare \tag{16}$$

Proposition 4. The characteristic function of convoluted exponential distribution with stabilizer constant is unifomly continuous.

Proof. The uniform continuity of characteristic function from exponential distribution with stabilizer constant is showing by define for every $\varepsilon>0$ and $\delta>0$ such that

$$|\phi_{S_n}(s)-\varphi_{S_n}(t)|<\varepsilon \text{ for } |s-t|<\delta \tag{17}$$

where δ only depends on ε. Now let us define a new function

$$\psi(s_n)=\frac{e^{its}-e^{itw}}{s-t}. \tag{18}$$

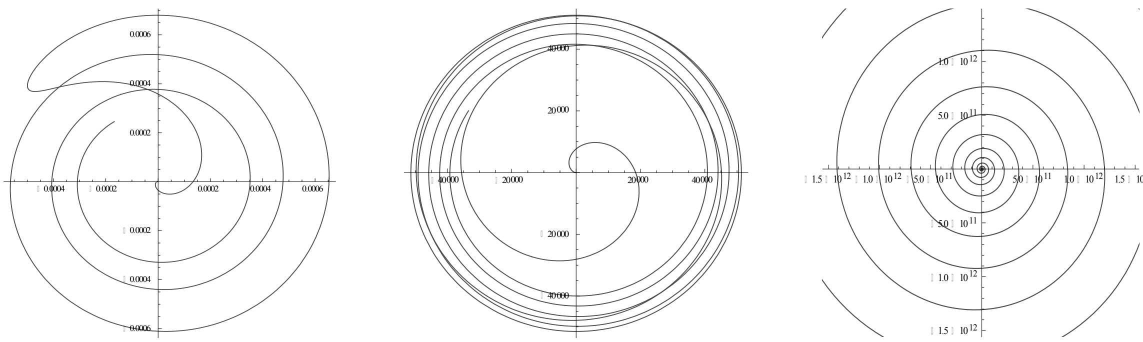
It is using Taylor expansion to e^{isw} and e^{itw} then we have the new defined function can be rewritten as follows

$$\psi(s_n)=\left(-\frac{(s+t)s_n{}^2}{2!}+\frac{(s^3+s^2t+st^2+t^3)s_n{}^4}{4!}+\ldots\right)+i\left(s_n-\frac{(s^2+st+t^2)s_n{}^3}{3!}+\ldots\right). \tag{19}$$

We can establish uniform continuity of characteristic function by setting

$$\begin{aligned}|\phi_{S_n}(s)-\phi_{S_n}(t)|&=\left|\int_0^n e^{iss_n}\theta^n\frac{\lambda^n}{(n-1)!}s_n{}^{n-1}e^{-\lambda s_n}\,ds_n-\int_0^n e^{its_n}\theta^n\frac{\lambda^n}{(n-1)!}s_n{}^{n-1}e^{-\lambda s_n}\,ds_n\right|\\&=(s-t)\left|\int_0^n\theta^n\frac{\lambda^n}{(n-1)!}s_n{}^{n-1}e^{-\lambda s_n}\,\psi(s_n)\,ds_n\right|,\end{aligned} \tag{20}$$

so that for every $\delta > \varepsilon$ and $|s-t| \to 0$ then we have $|\phi_{S_n}(s) - \phi_{S_n}(t)| \to 0$. This confirms the characteristic function from random variable S_n is uniform continuous. ■



$\lambda = 0.2$ *and* $0 \le t \le 12$ $\lambda = 1$ *and* $0 \le t \le 6$ $\lambda = 4$ *and* $0 \le t \le 4$

FIGURE 2. Parametric curves of characteristic function from random variable S_n for 10-fold convolution with various parameter λ and variabel t with $0 \le \theta \le 12\pi$.

The parametric curves of characteristic function from random variable S_n from Fig. 2 show smooth line and never vanish on the complex plane for all presented curves, this confirms the continuity of parametric curves by graphically.

CONCLUSION

The characteristic function of convolution of generated random variable from independent and identically exponential distribution with stabilizer constant is contructed by using Laplace-Stieltjes transform. The uniform continuity property of characteristic function from this convolution is obtained by using analytical methods in the complex variable as basic properties. The characteristic function of this ditribution is governed by smooth line and never vanish on the complex plane, this property confirms the uniform continuity of characteristic function by their prametric curves.

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