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FILTERING OF A DISCRETE ELECTRIC FIELD SIGNAL USING THE PREVIOUS MOVING AVERAGE

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Abstract

A filtering of a discrete signal of electric field intensity () in the frequency band from 76 MHz to 2686 MHz is proposed applying the previous moving average with n = 2. The database of temporal measurements of obtained was used. in the continuous monitoring of one day inside the ESPOCH using the NARDA SRM-3000 equipment. The vector of the mean values of the intensity of corresponding to each instant of time, is made up of 240 points because the measurements were obtained every 6 minutes, resulting in a signal of discrete intensity of . To achieve the correct smoothing (filtering) of, the previous moving average algorithm with n = 2 requires 30 passes or iterations. The result that was obtained was a smoother signal compared to the original signal, without the resulting signal losing its original shape.EEEE

Keywords: Discrete Signal, Electric Field Intensity (Ice), Moving Average (MA), Smoothing or Filtering.

I. INTRODUCTION

Since 2018 in the environmental investigation of exposure to electric fields, the moving average has been used to perform the smoothing of discrete signals. Today the moving average has become the boom for smoothing or filtering discrete signals [1].

Inside the ESPOCH located in the canton Riobamba province of Chimborazo of Ecuador, temporary measurements of the intensity of the electric field E in the frequency range of 76 MHZ to 2686 MHz were made by Eng. Pedro Infante, using the NARDA SRM-3000 equipment, the same ones that have been used in his research topic of octorate, where the information of the temporal measurements of electric field, aren stored in a database.

The main objective of this work is to use the database of the temporal measurements of the electric field strength that were obtained during the continuous monitoring of Monday, August 15, 2016 inside the ESPOCH, using the technique of the previous moving average with a window of n = 2 and with 30 passes. With these data, the smoothing or filtering of the discrete signal of electric field strength E of the indicated frequency band will be carried out, a script will be developed that allows the smoothing of the discrete signal of the electric field strength E.

This work aims to leave a great contribution to the investigation of discrete signal filtering since with this method it is possible to preserve the shape of the original signal, without loss of information.

MOBILE MEDIA (MA)

One of thealgorithms used for processing time series data isthe moving average [2].

The mobile madia algorithm is a method used in the process of smoothing discrete data, especially for time series data that aims to estimate the trend of the data [2,3]. When using the MA, the length of the order of the average to be applied must be indicated. For example, the data trend with an average of 3 points called moving average with 3 orders or 3-MA. There are 4 types of this algorithm [3]:

- Simple moving average (simple MA) algorithm does a smoothing process using an odd order.

- Centered mobile measurement algorithm(MA centered) Data smoothing can only be performed for the number of commands or observations on even and odd data.

- Double moving average algorithm (double MA) is a combination of single MA and centered MA.

- Double-weighted moving average (weighted MA) algorithm smoothsto data by giving a weight value.

In previous research, several of these moving average types have already been used in rainy time series data [4]. But the use of the MA algorithm for signal smoothing in the investigations carried out [5,6,7], the result of these is a smoothed signal with lag with respect to the original signal, which is why in this article it was proposed to improve this algorithm resulting in a smoothed signal without losing the original shape of the signal.

II. METHODOLOGY

In the first place, for this work, we took a population of 254 measurements with which we have taken a sample of 16 points of the discrete electric field strength taken at random, which are in Table I, in order to demonstrate how the algorithm that is applied for the realization of the previous moving average with a window of n = 2.

Table 1 POINTS OF THE DISCRETE SIGNAL.

Point	V/m
0	1.5
1	2.5
2	7.5
3	9.5
4	3.5
5	2.5
6	7.5
7	3.5
8	2.5
9	5.5
10	0
11	3.5
12	4.5
13	0
14	2.5
15	6.5

As a first step we proceed to conform the vector of the electric field strengthE_d for N measurement points durante a day, since this vector is Euclidean, mathematicallyand is defined by equation 1,

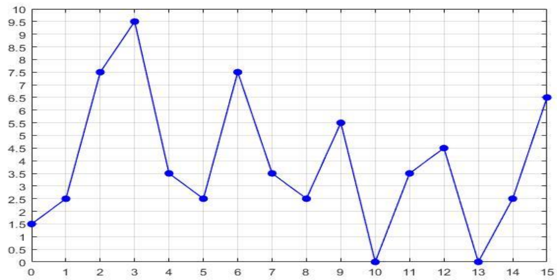
$$E_d = \{[E_d]_1 \ [E_d]_2 \dots [E_d]_N\} \quad (1)$$

$$i = 1, 2, \dots, N$$

Next, the vector is formed for the 16 points (), then $E_d N = 16(i = 1, 2, 3, 4, 5, \dots, 16)$ these samples will be used as a reference for the smoothing demonstration, therefore, the vector with the demonstration points (E_d) is made up of:

$$E_d = \{[1.5]_1 \ [2.5]_2 \ [7.5]_3 \ [9.5]_4 \ [3.5]_5 \ \dots \ [6.5]_{16}\}$$

Fig. 1. Demo signal.



Once the vector is formed, it will be registered in an Excel sheet and then imported into the script that allows smoothing, which later, through the first four passes or iterations, demonstrates how the recovery of the extreme points of the signal is performed in the passes or even iterations. For this, the signal (points) to be filtered shown in Fig.1 is first graphed, and then the first pass or iteration is obtained.

Pass 1

Taking as a starting point the graph of the discrete signal (Fig.1) we proceed to smooth the signal with the previous moving average with a window of N = 2, of two consecutive points, to each point of the original signal in order to obtain the first pass or iteration, for this equation 2 is applied, as shown below:

$$y[i] = \frac{1}{N} \sum_{j=0}^{N-1} x[i+j] \quad (2)$$

Where:

N = window number

i = number of points

$$y[0] = \frac{x[0] + x[1]}{2} = \frac{1.5 + 2.5}{2} = 2$$
$$y[1] = \frac{x[1] + x[2]}{2} = \frac{2.5 + 7.5}{2} = 5$$
$$y[2] = \frac{x[2] + x[3]}{2} = \frac{7.5 + 9.5}{2} = 8.5$$

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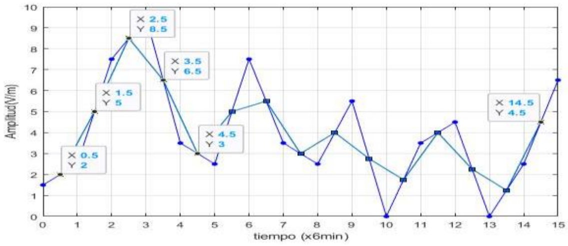
$$y[15] = \frac{x[14] + x[15]}{2} = \frac{2.5 + 6.5}{2} = 4.5$$

Once the previous moving average of all 16 points of the original signal is obtained, it results in the signal form of Fig.2, where the original signal corresponds to the blue one with a point marker , while the first pass or iteration is displayed in light blue with a square-shaped marker.

Fig.2. Smoothing the signal with the first pass or iteration



Pass 2

To continue with the smoothing of the signal, the previous moving average is calculated again, but this time it will be done to the points or values of the signal of the first pass applying equation 2, as follows:

$$y[1] = \frac{x[1] + x[2]}{2} = \frac{2 + 5}{2} = 3.5$$
$$y[2] = \frac{x[2] + x[3]}{2} = \frac{5 + 8.5}{2} = 6.75$$
$$y[3] = \frac{x[3] + x[4]}{2} = \frac{8.5 + 6.5}{2} = 7.5$$

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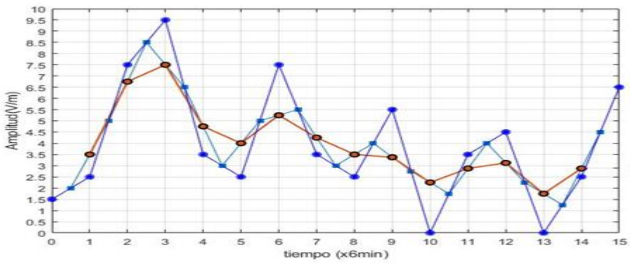
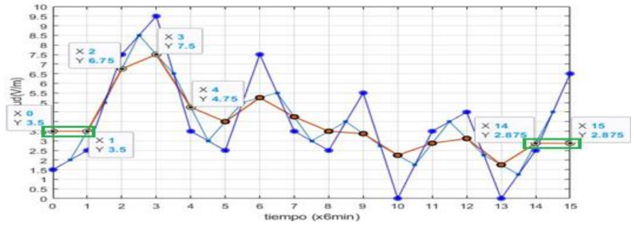
$$y[15] = \frac{x[13] + x[14]}{2} = \frac{1.25 + 4.5}{2} = 2.875$$

Fig.3. Smoothing the signal with the second pass or iteration



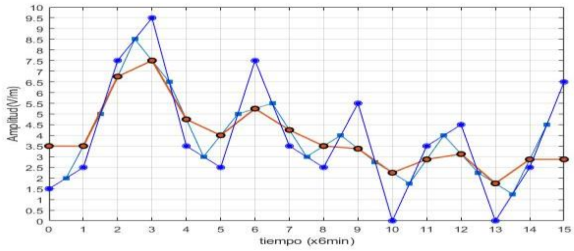
As shownin Fig.3, the moving average prior to the first light blue pass is applied, thus obtaining the second pass. Inthis part of the algorithm something particular is presented because of the calculations of the averages of the first pass, one point (0) is lost on the left side, and one point (15) on the right side, resulting in only 14 points, as shown in fig. 3 with orange dots. Torecover those lost points, proceed to take point y[1] in a straight line to the left toobtain point y[0]; and, to recover the point [15] the point y[14] is taken as a reference in a straight line to the right until intersecting with the axis of the Y obtaining the point y [15], as indicated by the green boxes of Fig. 4.

Fig.4. Recovery of the extreme points of pass 2.



Once the points mentioned to meabove have been recovered, in Fig.5, it indicates the orange signal corresponding to the smoothed signal of pass 2.

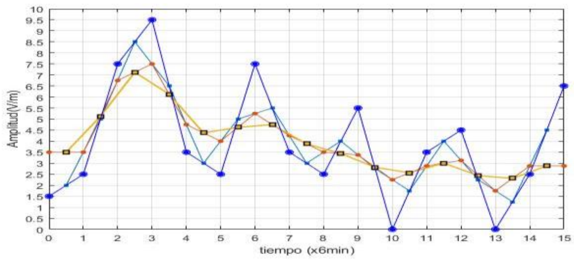
Fig.5. Smoothing of the signal of the pass 2 recovered the extreme points.



Pass 3

To make the third pass, the moving average is applied to the discrete signal of Fig.5, the resulting discrete signal is yellow in Fig.6, where it is clearly observed how this graphis smoothing, compared to the signal of pass 2.

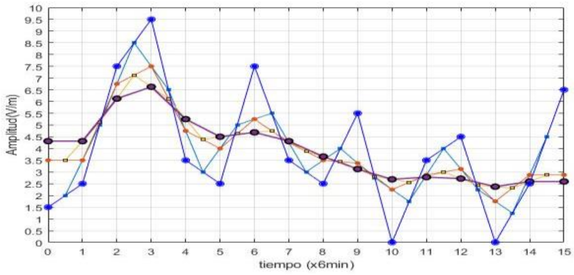
Fig.6. Smoothed with the third pass or iteration.



Pass 4

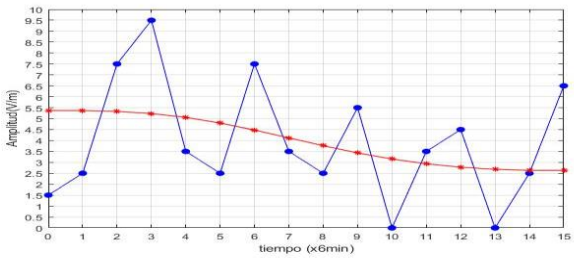
For pass 4 the same procedure is performed as in pass 2 since the points y[0], y[15] as indicated in the previous process of pass 2 must be recovered resulting in pass 4 the violet sign l represented in the Fig. 7, clearly observing that the signal is softening, compared to the original signal that is blue.

Fig.7. Smoothing the signal with the fourth pass or iteration.



For the total smoothing of the signal will be carried out until pass 30, remembering that in all even passes the recovery of points y [0] and y [15] must be performed; in addition, it is recommended not to exceed los 30 passes, because if you follow Applying more passes will obtain irrelevant values that do not show significant changes in the smoothed signal. Inl to Fig.8, it shows the red signal that will be obtained from pass 30 thus achieving that the vector E_d is softened by approximately 100%.

Fig.8. Full smoothing of the sample signal.



Secondly, taking into consideration the method of the previous moving average of 30 passes explained above to preserve the original shape of the signal, this research proposes the filtering of a discrete signal of the electric field strength in the frequency band from 76 MHz to 2686 MHz applying the previous moving average with n = 2. The database of the temporal measurements obtained in the continuous monitoring of a day inside the ESPOCH using the NARDA SRM-3000 equipment was used; Therefore, the population is EE240 discrete points obtained in the continuous measurements of the electric field strength every 6 minutes during the 24 hours of the day.

III. RESULTS.

In the previous signal of the vector, E_d explained the smoothing process of a discrete signal using the previous moving average with a window of , once verified that the script worked properly, proceeded to smooth the discrete signalN=2, of the intensity of electric field in the frequency band from 76 MHz to 2686 MHz, a signal shown in Fig. 9, which consists of 240 values or points because the electric field strength measurements were taken every 6 minutes, expressed on the horizontal axis, while the vertical axis represents the electric field strength values expressed in volts over meters (V/m).

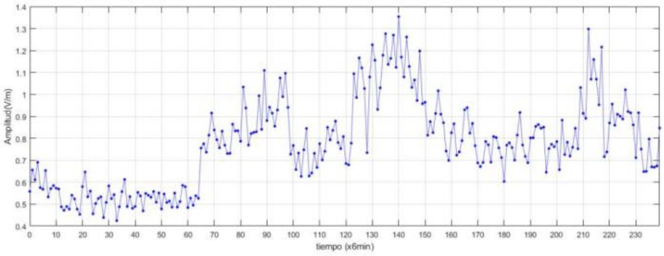
With the information extracted from the base ofdata from the electric field measurements E made inside the ESPOCH, the vector of Monday E_dlcontaining 240 daily average values of , resulting in the E vector formed by the equation:

$$E_{dl} = \{[0.55817]_1\ [0.65579]_2[0.61110]_3\ \dots\ [0.84687]_{240}\}$$

Where:

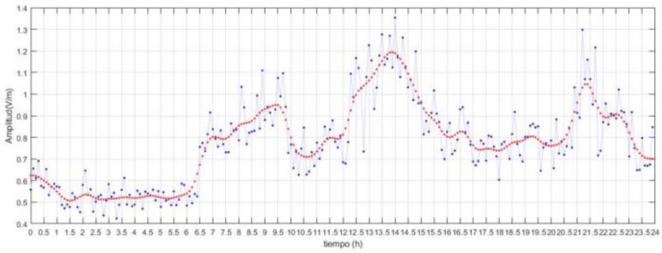
E_{dl}= Monday electric field strength

Fig.9. Discrete signal of 240 points of electric field strength



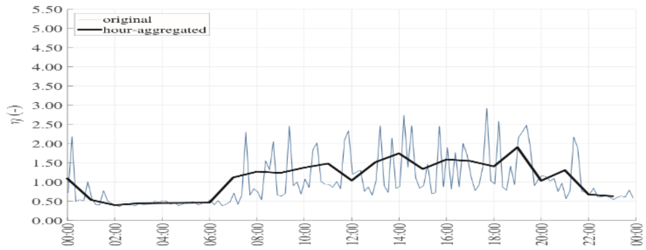
Completed the 30 passes of the moving average prior to the signal of Fig. 9, the filtered or smoothed red signal is obtained in Fig. 10, thus checking that the programmed moving average algorithm workedproperly, and can even be used to smooth other discrete signals.

Fig.10. Smoothed signal with 30 min scale.



In this work, the smoothing of the signal was performed by applying the MA with n = 2 with a time variation of 6 minutes resulting in a smoothed signal without losing the shape of the original signal, which is displayed in Fig.10, where the horizontal axis is represented by time on a scale of 30 minutes, in this half hour you have 5 points or samples of the signal as indicated in Fig.10, the vertical axis represents the value of the electric field strength in (V / m). Demonstrating in this way that the smoothing of this work is more efficient than that carried out in Wout Joseph's research in 2018 [1], in which the moving average was applied with a window of 1 hour, whose final result was a smoothed signal that loses the original shape of the signal, result shown in Fig.11.

Fig.11. Signal softened by Wout Joshep.



IV. CONCLUSIONS

This article proposes the method of the previous moving average with a window of n = 2 tosmooth a discrete signal of electric field strength, the script is used. With the intention of validating that the code created complies with the previous MA algorithm with n = 2, 16 values or points were taken at random to form a discrete signal and filter to said signal, verified that the scipt of the chosen software, complies with the correct procedure of the MA technique. Previously, it was applied to the 240 data of the discrete signal of electric field strength resulting in a smoothed signal and without losing the original signal form.

With the smoothing of the signal it was possible to better determine the behavior of the filtered electric field strengthduring the 24 hours of the day, concluding that, without exceeding the 30 passes of the signal filtering, it is more manageable and understandable compared to the original complex signal.

Bibliography

[1] AERRTS. S.; WIART, J.; MARTENS, L. & JOSEPH, S. Assessment of long-term spatio temporal radiofrecuency electromagnetic field exposure. Paris-Francia. DOI: 10.1016/j.envres.2017.11.003

[2] Raudys, A., Lenčiauskas, V. and Malčius, E.: Moving averages for smoothing financial data. Information Technology and Software (403), 34-45. Springer Berlin Heidelberg (2013) https://www.forexfactory.com/attachment/file/3794157

[3] J. Carrión.: Implementation of an artificial neural network for the prediction of short-term electricity demand. Accepted in energy magazine, (13), pages 36--42 (2016), https://revistaenergia.cenace.gob.ec/index.php/cenace/article/download/5/4

[4] Nurcahyo, S., Nhita, F., & Adiwijaya.: Precipitation prediction at Kemayoran Jakarta using hybrid genetic algorithm (GA) and connected partial feed neural network (PCFNN). International Conference on Information and Communications Technology (ICoICT), pages 166-171 (2014), https://adiwijaya.staff.telkomuniversity.ac.id/files/2013/07/JFA-b-32.pdf

[5] Y. Zhou and L. Yang, "Control Strategy to Smooth Wind Power Fluctuations of PMSG Wind Turbine based on the Secondary Exponential Moving Average Method," 2019 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC), 2019, pp. 1-5, doi: 10.1109/APPEEC45492.2019.8994429

[6] Z. Mo and H. Tao, "A Model of Oil Price Forecasting Based on Autoregressive and Moving Average," 2016 International Conference on Robots & Intelligent System (ICRIS), 2016, pp. 22-25, doi: 10.1109/ICRIS.2016.4.

[7] C.A. Glasbey, R. Jones, “Fast computation of moving average and related filters in octagonal windows”,Pattern Recognition Letters,Volume 18, Issue 6, 1997, Pages 555-565, https://doi.org/10.1016/S0167-8655(97)00045-7.