Five examples on using spreadsheet to solve engineering and mathematical problems

Victor Christianto & Florentin Smarandache

Abstract

Computer spreadsheet has been commonly used in the past few decades into very practical mathematical and problem solving tool. Here we discuss 5 examples on using spreadsheet to solve engineering and mathematical problems. We recall our story in using Lotus and Excel spreadsheet softwares since early 90s until recently. In last example we discuss more specifically on using excel spreadsheet to optimize the use of wind energy turbine in combination with solar photovoltaic. It is known in literature there are many discussions on linear programming for various cases; however there is only few discussion to take into account the uncertainties involved in the power production of PV/Wind system. In this paper, we consider integer linear programming by considering bi-level values as suggested by Pramanik and Pratim Dey. The purpose of this study is to show that it is possible to consider uncertainties in energy production in the linear programming model.

Introduction

Computer spreadsheet has been commonly used in the past few decades; its use grew from just just a special interest into ubiquitous mathematical and problem solving tool. Here we discuss 5 examples on using spreadsheet to solve engineering and mathematical problems.

We recall our story in using Lotus and Excel spreadsheet software since early 90s until recently. Hopefully what we share here will be found as useful lessons for young engineers.

Examples of using spreadsheet for solving engineering and mathematics problems

a. To find inverse of large scale matrix

Recalling one of us (VC) early years as an engineering student, during 90s he learnt how to use Lotus spreadsheet in order to find the inverse of large scale matrix. At a point he solved a 100x100 matrix in order to solve problem in matrix analysis of structures. At the time, using Lotus and IBM-compatible PC it would need no less than a few hours.

b. To calculate land filling volume

Around 1995-1996, as one of us (VC) worked in a consulting team, he often calculated landfilling volume requirement using Excel Spreadsheet. At the time, the available PC was IBM-compatible with Office 95.

c. To find optimized line of outer planets in the Solar System

Later on, around 2000-2002 he (VC) began to experimenting with PC in order to solve the problem of ordering in inner and outer planets orbits in the Solar System. At the time, he began to improve the Titius-Bode rule with quantized orbit ala Bohr's quantization rules. He succeeded to find the straight line solution of outer planets orbits by optimizing least square differences between straight line and the actual orbit data. He presented his results in a series of papers at *Apeiron*, 2003-2004 (http://redshift.vif.com)

The result has also been presented in a paper at *Progress in Physics* 2005, with Prof. Florentin Smarandache. Our result is quite simple, as shown in table below.

Object	No.	Titius	Nottale	CSV	Observ.	Δ, %
	1		0.4	0.43		
	2		1.7	1.71		
Mercury	3	4	3.9	3.85	3.87	0.52
Venus	4	7	6.8	6.84	7.32	6.50
Earth	5	10	10.7	10.70	10.00	−6.95
Mars	6	16	15.4	15.4	15.24	−1.05
Hungarias	7		21.0	20.96	20.99	0.14
Asteroid	8		27.4	27.38	27.0	1.40
Camilla	9		34.7	34.6	31.5	−10.00
Jupiter	2	52		45.52	52.03	12.51
Saturn	3	100		102.4	95.39	−7.38
Uranus	4	196		182.1	191.9	5.11
Neptune	5			284.5	301	5.48
Pluto	6	388		409.7	395	−3.72
2003EL61	7			557.7	520	−7.24
Sedna	8	722		728.4	760	4.16
2003UB31	9			921.8	970	4.96
Unobserv.	10			1138.1		
Unobserv.	11			1377.1		

Table 1: Comparison of prediction and observed orbit distance of planets in Solar system (in 0.1AU unit) [28].

Table 1. Evidence of quantized orbits of inner and outer planets in the Solar System (After V. Christianto, *Apeiron*, 2004)

d. Solving Fermat's last theorem in graphical way

More recently, he tried to find a simpler proof of Fermat's last theorem using Excel Spreadsheet. After some days figuring out the problem, finally he found out how to solve it graphically. See the Appendix section.

e. Analysis of PV/Wind systems by integer linear programming with Neutrosophic numbers by taking into account intermittency of energy production

Hybrid renewable energetic systems are systems that integrate more than one renewable energy sources. As they are time, environment and site dependant, one expects that their judicious and complementary combination may overcome some limitations which are inherent to every

individual system used alone. Hybrid systems may also reduce the need for energy storage which is very costly and space consuming.[1]

In real cases, sometimes it is of need to consider integrating renewable energy sources in order to build up economical hybrid energetic systems in the case where each type of energy are only available as specific units. For instance, we may need to combine photovoltaic panels and wind turbines with specific capacities to meet an energetic demand in a specific site with a lowest cost. Therefore, determining the optimal energy to be installed leads of determining the number of units from each source. This problem is formulated as an integer linear programming where the objective function to be minimized is the initial capital investment and where the decision variables are the numbers of units which should be pure integer numbers.

While this problem has been discussed in Zaatri and Allab [1], there is only few discussion in the literature on how to take into account the uncertainties involved in the power production of PV/Wind system. As it is known, PV and Wind energy production involves a certain level of intermittency, which makes the power production rather uncertain.

In a recent paper, we discussed possible use of quadruple Neutrosophic Numbers in order to expand the definition of statistical standard deviation in uncertainty modeling of various engineering systems and elsewhere [8]. It is known, that
intermittency, intermittence, irregularity, unregularity, uncertainty are part of Indeterminacy, which is in between: interruption and non-interruption. Therefore we can express an expanded model statistical standard deviation to include the notion of intermittency, as follows:

$$X = x' \pm \sigma.k = x' \pm \sigma(\mathrm{T} + \mathrm{I} + \mathrm{F}),$$

 Where T,I,F each represents truth value, indeterminacy, and falsehood. That is one of possible interpretations of quadruple Neutrosophic Numbers in the sense of expanded standard deviation, see for instance [8-10].

In this paper, we consider integer linear programming by considering bi-level values as suggested by Pramanik and Pratim Dey [3]. The purpose of this study is to show that it is possible to consider uncertainties in energy production in the linear programming model. So the results will be expressed in upper bound and lower bound limits.

Basics of Linear Programming

Linear programming deals with problems such as maximising profits, minimising costs or ensuring you make the best use of available resources. From an applications perspective, mathematical (and therefore, linear) programming is an optimisation tool, which allows the rationalisation of many managerial and/or technological decisions. An important factor for the applicability of the mathematical programming methodology in various contexts, is the computational difficulty of the analytical models. With the advent of modern computing technology, effective and efficient algorithmic procedures can provide a systematic and fast solution to these models.

A Linear Programming problem is a special case of a Mathematical Programming problem. From an analytical perspective, a mathematical program tries to identify an extreme (i.e., minimum or maximum) point of a function, which furthermore satisfies a set of constraints. Linear programming is the specialisation of mathematical programming to the case where both, function f, called the objective function, and the problem constraints are linear. Mathematical (and therefore, linear) programming is an optimisation tool, which allows the rationalisation of many managerial and/or technological decisions required by contemporary applications. An important factor for the applicability of the mathematical programming methodology in various contexts, is the computational tractability of the resulting analytical models.

Discussion on the problem in question

In this paper, we consider the same scenario of estimates of annual power production by PV and wind systems as discussed by Zaatri and Allab [1].

The two equations of constraints in integer linear programming can be expressed as follows [1]:

```
N1, N2 = integers
Constraint 1
min=130 x N1 + 100 x
N2

Constraint 2
66.N1 + 84.N2 >= 3000
```

This problem can be solved using MS Excel (goal seek/solver), and the result is shown in the following Table 2.
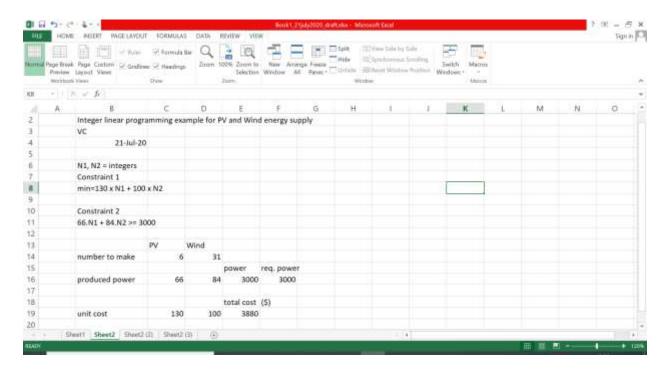

Table 2. Result of goal seek (MS Excel) for integer linear programming

The result is : it is found that optimal number of PV cells is 6, and 31 wind systems. And the total cost is found to be $3880.

It is known, that intermittency, intermittence, irregularity, unregularity, uncertainty are part of Indeterminacy, which is in between: interruption and non-interruption. Therefore we can express an expanded model statistical standard deviation to include the notion of intermittency, as follows:

$$X = x' \pm \sigma.k = x' \pm \sigma(T+I+F),$$

Where T,I,F each represents truth value, indeterminacy, and falsehood. That is one of possible interpretations of quadruple Neutrosophic Numbers in the sense of expanded standard deviation, see for instance [8-10].

Now, by simplifying procedures in Pramanik & Pratim Dey [3], we can include uncertainty parameters due to intermittency/indeterminacy of energy production by PV/wind systems, so we will include an extension:

a.   Upper bound limit:

$(66+1.64*5).N1 + (84+1.64*7).N2 >= 3000$

Which comes from setting $X = x' + \sigma.k$

Where we take for simplicity: $\sigma=1.64$, $k = 5$ for PV systems, and $k=7$ for wind systems. Actual values of k should be determined by observations.
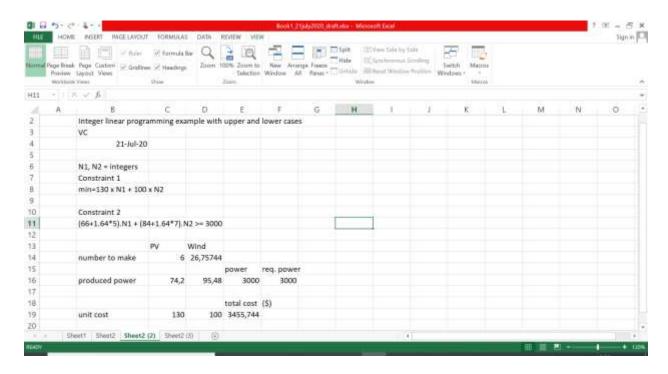
The result is shown in Table 3 as follows:

Table 3. Integer linear programming with uncertainties taken into account (upper bound limit).

The result is : it is found that optimal value is 6 PV sets, and 27 wind systems. The total cost is found to be: $3455.74

a. Lower bound limit:

(66-1.64*5).N1 + (84-1.64*7).N2 >= 3000
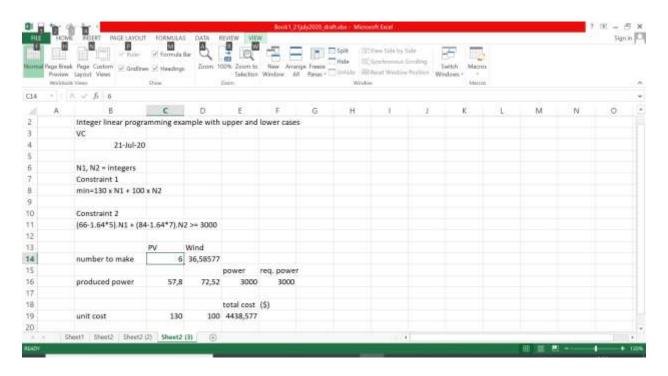
The result is as shown in Table 4.

Table 4. Integer linear programming for lower bound limit.

The result is : it is found that optimal value is 6 PV sets, and 37 wind systems. The total cost is found to be: $4438.58.

Therefore we conclude, by taking into account uncertainties due to intermittency of power production of PV/Wind systems, we come up with slightly different optimal values.

For other papers discussing MCDM/linear programming in renewable energy considerations, see [2, 4-7].

Concluding remark

In this example, we discuss some examples on how we can use computer spreadsheet to solve engineering and mathematical problems.

In the last example, by simplifying procedures in Pramanik & Pratim Dey [3], we can include uncertainty parameters due to intermittency of energy production by PV/wind systems, we will include an extension:

$(66+1.64*5).N1 + (84+1.64*7).N2 >= 3000$, which comes from setting $X = x' + \sigma.k$.

Where we take for simplicity: $\sigma=1.64$, $k = 5$ for PV systems, and $k=7$ for wind systems. Actual values of k should be determined by observations.

Similarly, we can consider the lower bound limit by setting:

$(66-1.64*5).N1 + (84-1.64*7).N2 >= 3000$, which comes from setting $X = x' - \sigma.k$.

Therefore we conclude, by taking into account uncertainties due to intermittency of power production of PV/Wind systems, we come up with a slightly different optimal values. Provided we set the PV systems to be 6, we obtain upper bound number of Wind energy system to be 27, and the lower bound number is 37.

This is where the subject of Neutrosophic Logic can be considered. Further investigation is recommended.

VC & FS

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Appendix: Graphical solution of Fermat's last theorem

Nonlinear curve as proof of Fermat's Last Theorem:

A graphical method

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Abstract

In this paper we will give an outline of proof of Fermat's Last Theorem using a graphical method. Although an exact proof can be given using differential calculus, we choose to use a more intuitive graphical method.

Introduction

Fermat's Last Theorem is one of the most difficult mathematical problems since more than 200 years ago. It can be rephrased more simply as follows:

"*The Pythagoras Theorem only works for and only for n=2, and does not work for other values of n, where the theorem can be written as* : $a^n + b^n = c^n$."

While more than hundred solutions of FLT have been proposed by eminent mathematicians, including the famous lecture by Andrew Wiles [1][2], but still many people want a simpler but intuitive argument for proving the validity of FLT. This paper is aiming to offer such an intuitive solution using graphical method.

Outline of argument

First we can write down the FLT as follows:

$$a^x + b^x = c^x,$$ (1)

Or it can be rewritten as follows:

$$\frac{a^x + b^x}{c^x} = 1,$$ (2)

The condition given by FLT is that equation (2) strictly equals 1, but let say we want to check if this condition holds for any value of x, then (2) can be written as follows:

$$\frac{a^x + b^x}{c^x} = y.$$

(3)

Now, we have a nonlinear equation in x and y. This equation can be solved at least by two methods, namely:

a. Differential calculus method, by solving dy/dx=0,
b. Graphical method.

Numerical result

In this paper we will use a simpler and intuitive graphical method, starting with an assumption that a=3, b=4, c=5, and x ranging from -10 to +10. For other values of a,b,c the readers are invited to verify themselves.
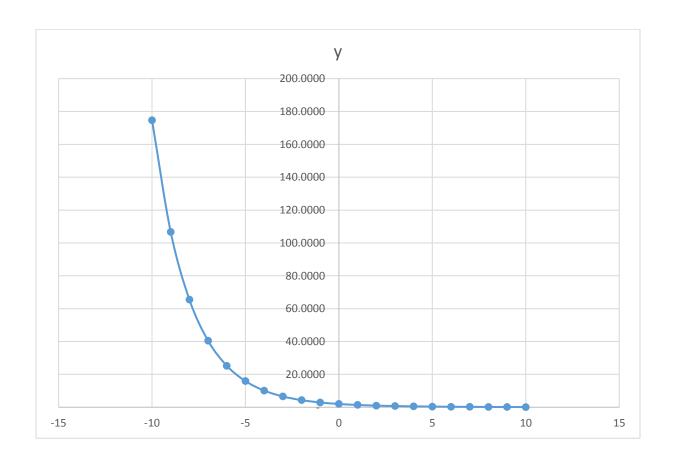
Using MS Excel, we got the following result for equation (3):

x	y
-10	174.6949
-9	106.6796
-8	65.4979
-7	40.4908
-6	25.2482
-5	15.9118
-4	10.1575
-3	6.5828
-2	4.3403
-1	2.9167
0	2.0000
1	1.4000
2	1.0000

3   0.7280

4   0.5392

5   0.4054

6   0.3088

7   0.2377

8   0.1846

9   0.1443

10   0.1134

And the graphical plot is as follows:

y

It should be clear that as x has values below 0, then y increases exponentially, but as x has values greater than 0 then y decreases approaching zero.

The only value where y=1, is where x=2.

This is a graphical method to solve FLT intuitively with equation (3).

Concluding remarks

It is possible to find a proof of validity of Fermat Last Theorem in an intuitive way using a graphical method.

Although an exact proof can be given using differential calculus, we choose to use a more intuitive graphical method.

It is our hope that such a graphical solution can be useful as teaching tool for high school mathematics teachers.

For professors in mathematics, we are aware that this graphical method for solving FLT may sound too naïve, but considering the Occam's razor principle, then the simpler solution may be closer to the truth.

Version 1.0: 27 november 2016, timestamp: 21.32

VC

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