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The Master Algorithm for Calculating n^2

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- Qasim Wani

Abstract:

Mathematics is numbers with symphony. It is civilization's greatest achievement. It is the language of the universe. Everything around us - from an infinitesimally small particle to an infinitely large object - can be represented in numbers. Once these numbers are carefully analyzed and graphed, patterns emerge. These patterns have helped us change the course of human history forever through inventions like the Turing Machine, the Internet, and Artificial Intelligence.

One such pattern can be observed in determining the squares of a number. In this research paper, the author - Qasim Wani, gives the derivation of the formula he invented in finding the square of any integer using extensive pattern and sequence recognition methods.

The Mathematical Pattern in Calculating n^2

$$(abcde \ldots x_{n-1} x_n)^2 = 2 \times \zeta\,[\,(a.bcde \ldots x_{n-1}) \times (x_n)\,] + (x_n)^2 + [10(abcde \ldots x_n)]^2$$

The derivation for the above formula to calculate the square of any real number can be found below.

A squared number is said to be the product of a number multiplied by itself. An example of this property can be seen from the following example: $13^2 = 13 \times 13 \rightarrow 169$.

Calculating the squares of larger numbers can be a strenuous challenge, if the calculations are done mentally. But this is where Mathematics dazzles Mathematicians with it's beauty.

Take the number 10, for example: $10^2 = 100$. Now, let's find the square of its consecutive number: $11^2 = 121$. The net difference between the squares of these numbers is 21.

Similarly, let's calculate the net difference between 21^2 and 20^2. $\rightarrow$ $\Delta sum = 41$. Using the same method, the calculated net difference between two consecutive terms where the first term is a multiple of 10 follows a pattern.

$31^2 - 30^2 = 61$ and $41^2 - 40^2 = 81$…

This pattern can be understood and formulated through the sequence: $\Delta sum = 20n + 1$; where n represents the first digit of the number.

Now, instead of calculating Δsum of two consecutive integers, let's use the same method to calculate Δsum between two $(n + 1)$ consecutive integers.

Let the first number n be equal to 10. So now, its $(n + 1)$ consecutive integer would be 12. Now, the Δsum between the squares of 12 and 10 are 44. Similarly, let's calculate Δsum between 20^2, 22^2 and 30^2, 32^2. The results are 84 and 124, respectively. This, too can be represented in a sequence: $\Delta sum = 40n + 4$; where n represents the first digit of the number.

Now, in order to make sense of the output produced above, let's use the same method to calculate Δsum between two $(n + 2)$ consecutive integers.

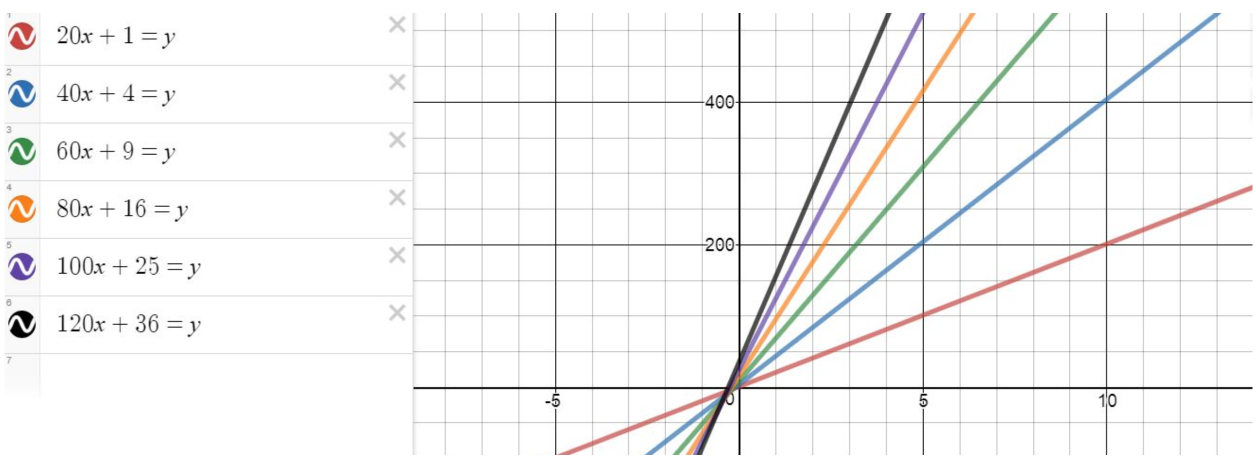
Let the first number n be equal to 10. So now, its $(n + 2)$ consecutive integer would be 13. Now, the Δsum between the squares of 13 and 10 is 69. Similarly, let's calculate Δsum between 20^2, 23^2 and 30^2, 33^2. The results are 129 and 189, respectively. The sequence produced in this series is: $\Delta sum = 60n + 9$; where n represents the first digit of the number.

There are two things which can be noticed here: **1:** The slope increments by a factor of 20 each time the distance between the two numbers increments by 1. **2:** The vertical shift of each individual sequence is the square of the last digit: $1^2 = 1$ **;** $2^2 = 4$ **;** $3^2 = 9$ **…**

In all these cases, the initial value, x_i, was taken as multiple of 10. There are two reasons for this: **1:** It is relatively easy to mentally compute the square of a number which is a multiple of 10**; 2:** It specific follows the binary expansion, $(a+b)^2 = a^2 + 2ab + b^2$.

Another formula can be created here to formulate all the sequences mentioned above:

$f(x) = (20z)q + q^2$ **,** where z represents the first digit of the number to be squared, q represents the second digit of the number to be squared, and q^2 represents the vertical increment produced by squaring the second digit of the number.



[Multiple functions following the sequence: $f(x) = (20z)q + q^2$]

Note that, $f(x) = (20z)q + q^2$ produces the net difference, Δsum, between two terms. In order to calculate the square of a number using the sequence formulated above, the square of the initial value of the integer, x_i , must be added to the result of ***f(x).*** This will result in the square of the integer and thus prove the formula. Hence, the extended version of this formula, ***g(x),*** can be calculated to be: ***g(x)*** $= (20q)z + q^2 + (x_i)^2$

Let's prove this by taking the square of a two digit number, 34. Note that *q* will represent the first digit of the integer i.e, 3 and *z* will represent the second digit of the integer i.e, 4. Also note that in order to calculate x_i , the integer must be subtracted by its terminating digit before squaring it to produce a multiple of 10. Let's demonstrate this through the equation derived above: ***g(x)*** $= (20z)q + q^2 + (x_i)^2$

$\rightarrow 34^2 = 20(3 \times 4) + 4^2 + (34 - 4)^2$

$\Rightarrow 34^2 = 240 + 16 + 900$

$\therefore 34^2 =$ **1156.**

Note that the same result can be achieved through the binary expansion of the square of the number which can be calculated as follows: $(a+b)^2 = a^2 + 2ab + b^2$ **;** where *a* and *b* are the first and second digits of the number, respectively.

$\Rightarrow (34)^2 = 30^2 + 2(30 \times 4) + 4^2$

$\therefore 34^2 =$ **1156**.

But what happens if you want to calculate the square of *n* digits? Clearly, binary expansion won't be that easy to compute. The following is another way to calculate the square of *n* digit real number whose derivation is listed below in detail.

Using the similar approach as computed in finding the square of a binary digit, let's calculate the square of a 3 digit number.

Take the number 100 for example: $100^2 = 10,000$. Now, let's find the square of its consecutive number: $101^2 = 1331$. The net difference between the squares of these numbers is 331.

Similarly, let's calculate the net difference between 111^2 and 110^2. $\rightarrow$ $\Delta sum = 221$. Using the same method, the calculated net difference between two consecutive terms where the first term is a multiple of 10 follows a pattern.

$121^2 - 120^2 = 241$, $131^2 - 130^2 = 261$ and $141^2 - 140^2 = 281\ldots$

Though this pattern seems similar to the binary one, it's formula is not. The formula for such type of a sequence can be calculated to be: $\Delta sum = 200(q.p) + 1$.

Here, q represents the first digit of the number**;** p, the second**.** Two things can be noted here: **1.** The scale factor has increased by an order of magnitude as compared to binary digits squared sequences. **2.** Two digits of the original number are involved here in which the middle digit is preceded by a decimal.

Let us try to compute and analyze the results of Δsum between two $(n + 1)$ consecutive integers.

Once again, let the first number n be equal to 100. So now, its $(n + 1)$ consecutive integer would be 102. Now, the Δsum between the squares of 102 and 100 is 404. Similarly, let's calculate Δsum between 110^2**,** 112^2 and 120^2**,** 122^2. The results are 444 and 484, respectively. This, too can be represented in a sequence: $\Delta sum = 400(q.p) + 4$**;** where q and

p represent the first and second digit of the number, respectively. Noted that b is preceded by a decimal.

Now, in order to make sense of the output produced above, let's use the same method to calculate Δsum between two $(n+2)$ consecutive integers.

Again, let the first number n be equal to 100. So now, its $(n+2)$ consecutive integer would be 103. Now, the Δsum between the squares of 103 and 100 is 609. Similarly, let's calculate Δsum between 110^2, 113^2 and 120^2, 123^2. The results are 669 and 729, respectively. The sequence produced in this series is: $\Delta sum = 600(q.p) + 9$; where q and p represent the first and the penultimate digits of the number.

There are two things which can be noticed here: **1:** The slope increments by a factor of 200 each time the distance between the two numbers increments by 1. **2:** The vertical shift of each individual sequence is the square of the last digit: $1^2 = 1$; $2^2 = 4$; $3^2 = 9$**...**

So, by combining all the results and data that were obtained above, a formula to calculate Δsum of any three digit number can be created as follows: ***f(x)*** $= (200 \times q.p)z + q^2$ **;** where q**,** p**,** and z are first, second, and third digits of an integer, respectively.

Now, based on the final model that was created from squaring a three digit number, two things can be noted: **1.** The scaling factor has increased by an order an magnitude - from 20x to 200x. **2.** Variables have been used in the same location by the same order of operation except for two things: **a.** Variable z, the middle digit, has been inserted into the second family of system of sequences. **b.** There is an insertion of a decimal point after the first unit digit, q. Using this method of analysis, two things can be understood: **1.** There must be a constant scaling factor for all kinds of families of digits - 2,3,4,5… n digit numbers must share one common scaling factor.

2. There seems to be a pattern in the multiplication of unit digits of numbers to calculate its square.

Note that, ***f(x)*** = $(200z.p)q + q^2$ produces the net difference, $\triangle sum$, between two terms. In order to calculate the square of a number using the sequence formulated above, the square of the initial value of the integer, x_i, must be added to the result of ***f(x)*.** This will result in the square of the integer and thus prove the formula. Hence, the extended version of this formula, ***g(x)*,** can be calculated to be: ***g(x)*** = $(20q.p)z + q^2 + (x_i)^2$

To further confirm whether there exists any pattern or not, let's try one last family of digits; this time, let's square a 5 digit method to prove whether the observations made above hold true for all sets of real numbers.

Take the principle 5 digit number 10,000: $10,000^2 = 100,000,000$ Now, let's find the square of its consecutive number: $10,001^2 = 100,020,001$. The net difference between the squares of these numbers is $20,001$.

Similarly, let's calculate the net difference between $10,011^2$ and $10,010^2$. $\rightarrow$ $\triangle sum = 20,021$. Using the same method, the calculated net difference between two consecutive terms where the first term is a multiple of 10 follows a pattern. The formula for such type of a sequence can be calculated to be: $\triangle sum = 20,000(q.prt) \times z + 1$.

Here, q represents the first digit of the number**;** p, the second**;** r, the third**;** t, the fourth**;** z, the fifth**.** Two things can be noted here: **1.** The scale factor has increased by 100 order of magnitudes (or by a factor of a 1000) as compared to binary digits squared sequences. **2.** Four digits of the original number are involved here in which the first digit is followed by a decimal.

Now, let us try to compute and analyze the results of Δsum between two (n + 1) consecutive integers.

Once again, let the first number n be equal to 10,000. So now, its (n + 1) consecutive integer would be 10,002. Now, the Δsum between the squares of 10,002 and 10,000 is 40,004. Similarly, let's calculate Δsum between $10,010^2$, $10,012^2$ and $10,020^2$, $10,022^2$. The results are 40044 and 40084, respectively. This, too can be represented in a sequence: $\Delta sum = 40,000(q.prt) \times z + 4$; where *q, p, r, t,* and *z* represent the first, second, third, fourth, and fifth digit of the number, respectively. Note that *p* is preceded by a decimal.

There are two things which can be noticed here: **1:** The slope increments by a factor of 200 each time the distance between the two numbers increments by 1. **2:** The vertical shift of each individual sequence is the square of the last digit: $1^2 = 1$; $2^2 = 4$; $3^2 = 9$**…**

So, by combining all the results and data that were obtained above, a formula to calculate Δsum of any three digit number can be created as follows: ***f(x)*** = (20,000 × *q.prt*)*z*+ q^2 **;** where *q***,** *p***,** *r***,** *t***,** and *z* are first, second, third, fourth, and fifth digits of an integer, respectively.

In order to calculate the square of a number using the sequence formulated above, the square of the initial value of the integer, x_i, must be added to the result of ***f(x)*.** This will result in the square of the integer and thus prove the formula. Hence, the extended version of this formula, ***g(x)*,** can be calculated to be: ***g(x)*** = ***f(x)*** + $(x_i)^2$

$\therefore$ ***g(x)*** = (20,000 × *q.prt*)*z*+ $q^2 + (x_i)^2$

There are three very important points to be noted here: 1. The scaling constant for each incremented family of digits increases by a scale factor of 10. **2.** Only the first and the last digit of the number are actually multiplied in the equation. **3.** All the digits except the last digit of a number are placed in a decimal of the first digit.

So, before calculating the master algorithm for formulating n^2, we must find out what the common scaling factor shared by all families of number really is. As mentioned above, the scaling factor increasing by one order of magnitude as one additional digit is added into the expression. Thus, it can be said that there will be (*n-1*) zeros added to the common scaling factor, 2, for *n* number of digits in an expression. To prove this, we can rewrite the binary digit sequence squared equation as follows: ***g(x)*** = $2(10z)q + q^2 + (x_i)^2$

Notice that since we are squaring a binary digit, the scaling factor 2, is followed by one just one zero. So, there are (*n-1*) zeros followed after the common constant 2 for *n* digits in a number. Let this varying constant be called as ***quintin***, represented by the letter: ζ.

Now that the derivation is complete, the final equation to compute n^2 can be formulated as shown below:

The Master Algorithm for Calculating n^2:

$$(abcde \ldots x_{n-1}x_n)^2 = 2 \times \zeta\ [\ (a.bcde \ldots x_{n-1}) \times (x_n)\ ] + (x_n)^2 + (abcde \ldots x_n - x_n)^2$$

⊗ Here, each letter represents one unit digit.

Conclusion:

In this research paper, the author, Qasim Wani, shared the formula he created to find the square of any number by finding patterns using the process of induction and sequence analysis methods. Similar models were tried to find generalized patterns of n^x but didn't prove to work for all integers. However, a clear mathematical pattern was noted in computing the cube of any real number which was very similar to that of the formula for n^2. The formula follows a similar induction based analysis approach, so writing about it's derivation can be redundant. The formula for calculating the **cube** of any real number is as follows:

$$(abcd \dots x_{n-1}x_n)^3 = 30 \times [\,(abcd \dots x_{n-1}x_n)(abcd \dots x_{n-1})(x_n)\,] + (x_n)^3 + [10(abcd \dots x_{n-1})]^3$$

⊗ **Here, each letter represents one unit digit.**

More proofs and calculations are still being conducted to find one simple, yet elegant equation to calculate n^x of any number through a similar approach used to calculate the master algorithm as formulated above. To some, the two equations above can be viewed more as a formula rather than an algorithm as an algorithm follows a sequential pattern of steps (especially done by a computer). But, the two formulas above can be treated as a mental algorithm as they both require following a series of steps to correctly compute the square or cube of any real number mentally. At the time this paper was written, no human brain emulation, nanobots, or bio-chip systems were commercialized. So, in order to mentally solve for the square/cube of any real number, this paper proves to be its bible.

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