Reliable Location of Maximum Point of Total Force due to Electric Field for a Ring-Shaped Conductor using Golden Section Search

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Abstract – The concept of electromagnetic resonance of a circular ring is widely used in the application of wideband antennas used in wearables, in order to maximize the output, the maximum field point is to be determined along the axis of ring. In this perspective I utilize the concept of Golden Section Search (GSS) to determine the maxima point along the axis. The results interpret that golden section search is capable in determination of maxima of Electric Field generated due to the ring-shaped conductor.

Keywords – ring, golden section, electric field

INTRODUCTION

In recent years, the development of wireless communications and networks is abnormal. The narrowband communication is being replaced with wideband to increase the baud rates and band rates over 1 Gbps. For on-chip fabrication large antennas cannot be accommodated, under such conditions microstrip patch antennas are modelled to serve for the purpose.

In the development of these patch antennas, scholars and researchers started utilizing the concepts of rings and metamaterials. The concept of rings is widely used due its composite structure but the range approximation is still a tough approach for researchers which led them to develop algorithms to determine the maximum point of electric field and magnetic field. Golden Section search and Parabolic Interpolation are the two methods among those techniques.

Golden Section Method:

The golden section is a method of searching for a minimum (searching for a maximum) of a unimodal function. Unlike finding a zero, where two function evaluations with opposite sign are sufficient to bracket a root, when searching for a minimum, three values are necessary. The golden-section search is an efficient way to progressively reduce the interval locating the minimum. The key is to observe that regardless of how many points have been evaluated, the minimum lies within the interval defined by the two points adjacent to the point with the least value so far evaluated.

The expression for total electric field of ring-shaped conductor is given by

$$F = \frac{kQqx}{(x^2+a^2)^{\frac{3}{2}}}$$

Where,

k	Constant - $9 * 10^9 m/F$
Q	Charge associated with the ring
q	Charge Placed along the axis
x	Distance between Q and q
a	Radius of ring

METHODOLGY

Golden Section Search:

The method starts with two initial guesses, x_l and x_u, that bracket one local extremum of $f(x)$. Next, two interior points x_1 and x_2 are chosen according to the golden ratio,

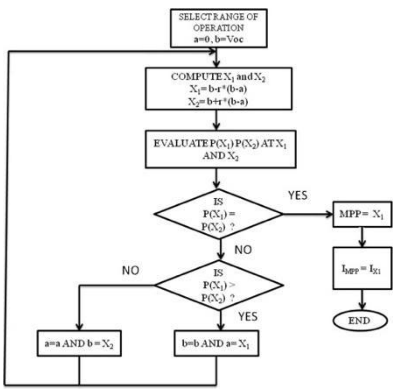
$$x_1 = x_l + d$$
$$x_2 = x_u - d$$

The function is evaluated at these two interior points. Two results can occur:

1. If $f(x_1) . f(x_2)$, then the domain of x to the left of x_2, from x_l to x_2, can be eliminated because it does not contain the maximum. For this case, x_2 becomes the new x_l for the next round.
2. If $f(x_2) . f(x_1)$, then the domain of x to the right of x_1, from x_1 to x_u would have been eliminated. In this case, x_1 becomes the new x_u for the next round.

IMPLEMENTATION USING MATLAB

Flow chart for Golden Section Search:



Algorithm for Golden Section Search:

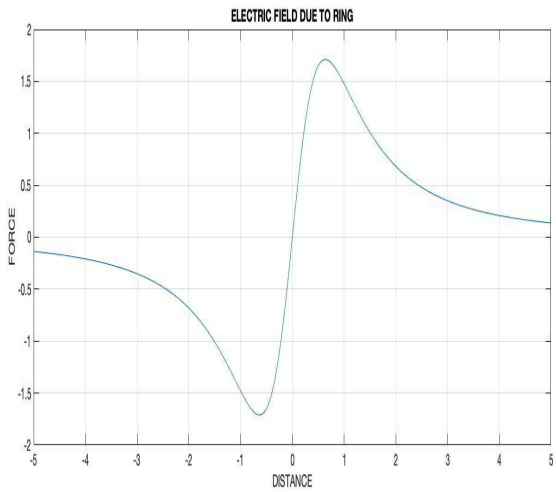
1. Specify the function to be minimized, f(x), the interval to be searched as $\{X_1,X_4\}$, and their functional values F_1 and F_4.
2. Calculate an interior point and its functional value F_2. The two interval lengths are in the ratio $c{:}r$ or $r{:}c$ where $r=1-\varphi$ and $c=1-r$, with φ being the golden ratio.
3. Using the triplet, determine if convergence criteria are fulfilled. If they are, estimate the X at the minimum from that triplet and return.
4. From the triplet, calculate the other interior point and its functional value. The three intervals will be in the ratio $c{:}cr{:}c$.
5. The three points for the next iteration will be the one where F is a minimum, and the two points closest to it in X.
6. Go to step 3

Program:

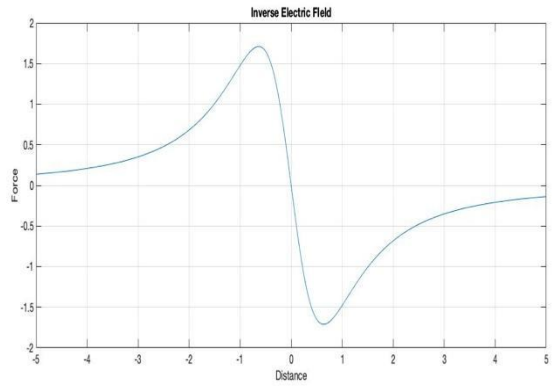
```
function [r,n] =
golden_section_user(eqn,a,b)
f = eqn;
GR = 0.618;
n=1;
x = 0:(b+a)
plot(x,f(x));
hold on;
while(1)
    d = GR*(b-a);
    x1 = a+d;
    x2 = b-d;
    if(f(x1)>f(x2))
        b=x1;
    else
        a=x2;
    end
    root(n) = (a+b)/2;
    stem(root(n),f(root(n)));
    if(n>1)
        er(n) = abs((root(n) -
root(n-1))/root(n))*100;
        if(er(n)<0.0001)
            r = root(n);
            break;
        end
    end
    n = n+1;
end
```

RESULTS AND DISCUSSIONS

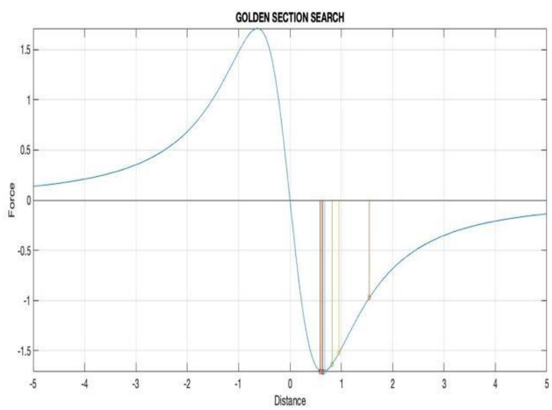
From the analysis of the electric field due to ting-shaped conductor exited by a charge placed along the axes of ring, the plot between the force and the distance is given from below Figure.



From the hypothesis of Golden Section Search (GSS) the given has to be inverted along the axes of distance. The obtained waveform is as follows:



The maxima point determined using the Golden Section Search is given by



The results are tabulated as follows:

Solution	Iterations
0.6364	31

CONCLUSIONS

The maxima point of a ring-shaped conductor is determined using the principle of golden section search. The results are provided in table and it is also interpreted from the figures. The results prove that golden section optimization is capable to determine the separation between the charges that is required to possess maximum electric field.

REFERENCES

[1] Jaime Gutierrez, Josef Schicho, Martin Weimann, " *Computer Algebra and Polynomials* ", Applications of algebra and number theory, Springer, Cham, 2015.

[2] Richard W. Hamming. 1973. "*Numerical Methods for Scientists and Engineers*". McGraw-Hill, Inc., USA.

[3] Datta, B.N. *Lecture Notes on Numerical Solution of Root Finding Problems*. 2012. Available online: www.math.niu.edu/~dattab (accessed on 15 January 2019).

[4] Calhoun, D. Available online: https://math.boisestate.edu/~calhoun/teaching/matlab-tutorials/lab_16/html/lab_16.html (accessed on 13 June 2019).

[5] Thinzar, C.; Aye, N. *Detection the storm movement by sub pixel registration approach of Newton Raphson method*. *Int. J. E Educ. E Bus. E Manag. E Learn.* **2014**, *4*, 28–31. [Google Scholar]

[6] Ali, A.J.M. *The application of numerical approximation methods upon digital images*. *Am. J. Signal Process.* **2017**, *7*, 39–43. [Google Scholar] [CrossRef]

[7] Bruck, H.A.; McNeill, S.R.; Sutton, M.A.; Peters, W.H. *Digital image correlation using Newton-Raphson method of partial differential correction*. *Exp. Mech.* **1989**, *29*, 261–267. [Google Scholar] [CrossRef]

[8] Cofaru, C.; Philips, W.; van Paepegem, W. *Pixel-level robust digital image correlation*. *Opt. Express* **2013**, *21*, 29979–29999. [Google Scholar] [CrossRef] [PubMed]

[9] Claudio Gutierreza, FlavioGutierrezb, Maria-Cecilia Rivaraa, *Complexity of the bisection method*, Theoretical Computer Science Volume 382, Issue 2, 31 August 2007, Pages 131-138

[10] Diachao Sheng, Scott W. Sloan, Andrew J. Abbo, *An Automatic Newton‑Raphson Scheme*, International Journal of Geomechanics, Vol. 2, Issue 4 (October 2002)