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Fibonacci Algorithm for Determining Minimum Value of a Unimodal Function using MATLAB Programmed Computing Software

L. N Das, Sanyam Gupta

***Abstract*: Fibonacci number sequencing process is a number generating procedure. One among the several applications of such sequencing process is to search the interval where the certain Fibonacci numbers are either at the boundary or at the position related to the Fibonacci numbered sub interval generating expressions. In this paper the author used MATLAB programed computing software to determine the local minimum of a unimodal function that's domain is not necessarily a continuous number interval and searched the values of the function using a suitable algorithm named Fibonacci algorithm for determining minimum value of a unimodal function.**

***Keywords* : Number sequencing process, Fibonacci number generator, Algorithm for minimum value of a unimodal function.**

I. INTRODUCTION

Number sequencing is a procedure in real number ordering form, and applied in generated numbers classification. Number generator is used to search a specific number or sort a disordered number. A function's numerical values are either ordered or disordered form depending on the definition of function and domain set interval. A function's minimum value selection among a disordered number is quite difficult task unless a proper algorithm with intelligent computing machine operating system executable program is implemented. Even if the computing machine is available but the domain of the function is uncertain then the number search, or line segment search are some of the techniques used by computer programmers to determine a functional value to be minimum or not.

In this paper, we review the Fibonacci sequence definition and a suitable algorithm [3] to study the MATLAB programmed computation for obtaining the minimum numeric value of a unimodal function. In the Section 2 we review the definition of Fibonacci sequence. In Section 3 we have redefined the Fibonacci algorithm for obtaining optimal numeric value of a unimodal function that's domain is uncertain but lies within a certain interval. In Section 4, we have written MATLAB codes to execute the programme through the computing machine software and hardware. The program output result is displayed in the paper after coded program execution lines.

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* Correspondence Author
Prof. L. N Das*, Department of Applied Mathematics, Delhi Technological University, New Delhi, INDIA. Email: lndas@dce.ac.in
Sanyam Gupta, Department of Applied Mathematics, Delhi Technological University, New Delhi, INDIA. Email: sanyam_phd2k18@dtu.ac.in

II. FIBONACCI SEQUENCE DEFINITION

The solution of the problem [1] "*A man put a pair of rabbits in a place surrounded on all sides by a wall. How many pairs of rabbits can be produced from that pair in a year if it is supposed that every month each pair begets a new pair which from the second month on becomes productive?" is known as the Fibonacci sequence*, or *Fibonacci numbers*. These numbers are defined as

$$F_0 = F_1 = 1$$

$$Fn = Fn-1 + Fn-2, \qquad n = 2,3,4,..$$

which yield the sequence 1,1,2,3,5,8,13,21,34,55,89,….

III. FIBONACCI ALGORITHM FOR OPTIMALITY

Fibonacci sequenced number generation algorithm can be used to find the local minimum of a unimodal function of one variable even if the function is not continuous. In case the function is not continuous and the domain interval is uncertain, for implementing the algorithm we have to define the initial interval of uncertainty, in which the local optimum lies.

Let L_1 be the initial interval of uncertainty defined by $a < x < b$ and n be the total number of experiment to be conducted. Now define $L_2^* = \frac{F_{n-2}}{F_n} L_1$ and find the two points x_1 and x_2 which are located at the distance L_2^* from each end of L_1 that is $x_1 = a + L_2^*$, $x_2 = b - L_2^*$. Discard part of the interval by using the unimodality assumption. Then there remains a smaller interval of uncertainty L_2 that is $L_2 = L_1 - L_2^*$. Now consider $L_3^* = \frac{F_{n-3}}{F_n} L_1$ and repeat the same process. This process of discarding a certain interval and placing a new experiment in the remaining interval can be continued. The ratio of the interval of uncertainty remaining after conducting *j* of the n predetermined experiments to the initial interval of uncertainty becomes

$$\frac{L_j}{L_1} = \frac{F_{n-(j-1)}}{F_n}$$

And for j = n, we obtain

$$\frac{L_n}{L_1} = \frac{F_1}{F_n} = \frac{1}{F_n}$$

The ratio $\frac{L_n}{L_1} = \frac{1}{F_n}$ will permit us to determine n, the required number of experiments, to achieve any desired accuracy in locating the optimum point.

IV. APPLICATION FOR FIBONACCI ALGORITHM

An example of determining minimum of a unimodal function, $f = 0.65 - \frac{0.75}{1+x^2} - 0.65x\tan^{-1}x$ with n experiments and uncertain interval [0, 3] is discussed in the following manner. The MATLAB code programming output yields the minimum value which is mentioned in the following lines:

```
clear
clc
% Fibonacci Algorithm for Optimality
% Written by Sanyam Gupta
format long
syms x
f = @(x)(0.65 - (0.75/(1+x^2)) - 0.65*x*atan(1/x)) % Enter the Function
N = input ('Enter number of steps\n')           % Number of the experiments
A1(1) = input('Enter the value of intial point\n')  % Left hand side of initial interval
B1(1) = input('Enter the value of final point\n')  % Right hand side of initial interval
F(1) = 1;    % First number of Fibonacci sequence
R(1) = 1;   % Redution Ratio (1/F(1)) of Fisrt number of Fibonacci sequence
F(2) = 1;    % Second number of Fibonacci sequence
R(2) = 1;   % Redution Ratio (1/F(2)) of Second number of Fibonacci sequence
k = 1;
l = 3;
for l=3:N
F(l) = F(l-1)+F(l-2);   % Fibonacci Sequence Numbers
R(l) = 1/F(l);         % Redution Ratio (1/F(l)) of Second number of Fibonacci sequence
if l == N
LL(k) = (F(:,N-2)/F(:,N))*(B1(k)-A1(k));
J = 2;
L(k) = B1(k)-A1(k);
for  J = 2:N-1
if LL(k) > L(k)/2
x1(k) = B1(k) - LL(k);
x2(k) = A1(k) + LL(k);
k = k+1;
else
x1(k) = A1(k) + LL(k);
x2(k) = B1(k) - LL(k);
k = k+1;
end
f1 = double(subs(f,x,x1));
f2 = double(subs(f,x,x2));
if f2 > f1
B1(k) = x2(k-1);
A1(k) = A1(k-1);
LL(k) = (F(:,N-J)*L(:,k-1))/F(:,(N-J+2));
elseif f2 == f1
A1(k) = x1(k-1);
B1(k) = x2(k-1);
LL(k) = (F(:,N-J)*(B1(:,k)-A1(:,k)))/F(:,(N-J+2));
else
A1(k) = x1(k-1);
B1(k) = B1(k-1);
LL(k) = (F(:,N-J)*L(:,k-1))/F(:,(N-J+2));
end
J = J+1;
if J == N
LN = B1(k) - A1(k);
else
L(k) = B1(k) - A1(k);
end
end
else
l = l+1;
end
end
L(k) = B1(k) - A1(k);

iter = 1:k+1;
Fibonacci_seq = F';
Redution_Ratio = R';
Iterations = iter';
T2 = table(Iterations,Fibonacci_seq,Redution_Ratio);
disp(T2)

Iter = 1:k;
A1_coordinate = A1';
B1_coordinate = B1';
Iterations = Iter';
LL_Value = LL';
L_Value = L';
T1 = table(Iterations,A1_coordinate,B1_coordinate,LL_Value,L_Value);
disp(T1)

Iter = 1:k-1;
X1_coordinate = x1';
X2_coordinate = x2';
Iterations = Iter';
f1_Value = f1';
f2_Value = f2';
T = table(Iterations,X1_coordinate,X2_coordinate,f1_Value,f2_Value);
disp(T)

fprintf('Final Interval of uncertanity is [A1,B1] =[%d\t%d]\n', A1(k),B1(k))
```

OUTPUT:

f =

@(x)(0.65-(0.75/(1+x^2))-0.65*x*atan(1/x))
Enter number of steps
7
N =
7
Enter the value of intial point
0
A1 =
0
Enter the value of final point
3
B1 =
3

Iterations	Fibonacci_seq	Redution_Ratio
1	1	1
2	1	1
3	2	0.5
4	3	0.333333333333333
5	5	0.2
6	8	0.125
7	13	0.0769230769230769

Iterations	A1_coordinate	B1_coordinate	LL_Value	L_Value
1	0	3	1.15384615384615	3
2	0	1.84615384615385	1.15384615384615	1.84615384615385
3	0	1.15384615384615	0.692307692307692	1.15384615384615
4	0	0.692307692307692	0.461538461538462	0.692307692307692
5	0.230769230769231	0.692307692307692	0.230769230769231	0.461538461538462
6	0.461538461538462	0.692307692307692	0.230769230769231	0.230769230769231

Iterations	X1_coordinate	X2_coordinate	f1_Value	f2_Value
1	1.15384615384615	1.84615384615385	-0.207268531573332	-0.115841532273778
2	0.692307692307692	1.15384615384615	-0.291363248435467	-0.207268531573332
3	0.461538461538461	0.692307692307692	-0.309809248294137	-0.291363248435467
4	0.230769230769231	0.461538461538462	-0.263678273496545	-0.309809248294137
5	0.461538461538462	0.461538461538462	-0.309809248294137	-0.309809248294137

Final Interval of uncertainty is
[A1,B1] =[4.615385e-01 6.923077e-01]

The final interval of uncertainty is
[A1,B1] = [.4615385, .6923077] where the optimal lies.

Application of Fibonacci algorithm another example:

If we consider the unimodal function $f(x) = x^2$ instead of $f = 0.65 - \frac{0.75}{2+x} - 0.65xtan^{-1}x$ the certain interval [1.076923e+00, 1.153846e+00] confirms the existence of minimum value in between it. This function is included in the above mentioned MATLAB program and the executed program output is mentioned below:

f =
@(x)(x^2)
Enter number of steps
7
N =
7
Enter the value of intial point
1

A1 =
1
Enter the value of final point
2
B1 =
2

Iterations Fibonacci_seq Redution_Ratio

1	1	1
2	1	1
3	2	0.5
4	3	0.333333333333333
5	5	0.2
6	8	0.125
7	13	0.0769230769230769

Iterations	A1_coordinate	B1_coordinate	LL_Value	L_Value
1	1	2	0.384615384615385	1
2	1	1.61538461538462	0.384615384615385	0.615384615384615
3	1	1.38461538461538	0.230769230769231	0.384615384615385
4	1	1.23076923076923	0.153846153846154	0.230769230769231
5	1	1.15384615384615	0.0769230769230769	0.153846153846154
6	1.07692307692308	1.15384615384615	0.0769230769230769	0.0769230769230769

Iterations	X1_coordinate	X2_coordinate	f1_Value	f2_Value
1	1.38461538461538	1.61538461538462	1.91715976331361	2.6094674556213
2	1.23076923076923	1.38461538461538	1.51479289940828	1.91715976331361
3	1.15384615384615	1.23076923076923	1.33136094674556	1.51479289940828
4	1.07692307692308	1.15384615384615	1.15976331360947	1.33136094674556
5	1.07692307692308	1.07692307692308	1.15976331360947	1.15976331360947

Final Interval of uncertainty is

[A1,B1] =[1.076923e+00   1.153846e+00]

V. CONCLUSION

The MATLAB program we have encrypted, is also suitable for any other unimodal functions whose domains are uncertain but bounded within a certain interval that's end point is fit to the Fibonacci number related arithmetic expression we have defined in Section 3. The optimal value or function's numeric value lying interval have determined from the corresponding computational programme output.

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AUTHORS PROFILE

Prof. L. N Das Dr. L N Das full name Dr. Laxminarayan Das and teaching and innovation topics is Mathematics and Computer Engineering's selective areas presently, Dr. L N Das is a professor in Department of Applied Mathematics, Delhi Technological University, India. Prior to the teaching and innovation jobs at Delhi College of Engineering since November 10, 2000, He served Synergy Institute of Engineering Technology as Assistant Professor of Mathematics since November, 1999-2000, and Orissa Engineering College as Lecturer during the year February 1994 – December 30, 1996 and January 1999 - May1999. During the year January 7, 1997 – January 13, 1999, Dr. L. N Das served as Visiting Research Associate at CSE Department Texas A & M University, College station, Texas, USA. Dr. L N Das continuing teaching profession since year 1989 as a Basic Science Postgraduate teacher to electronics at Khantapara Baleshawr Orissa Government Vocational School and in that time continued Ph.D studies at IIT Kharagpur in Mathematics Department, as a registered scholar of Utkal University, Bhunbneshaw, within supervision of Prof. S. Nanda and got award Doctor in science philosophy in the year 1995. Dr. L N Das also served Atal Behari College Basudevpur, Bhadrak Orissa during the year January1992 – Feb 1994.

Academic Qualification:

Degree	University / Institute	Year of Passing	Discipline/Specialization	Percentage of marks/CGPA
Graduate Degree (UG)B.Sc. Hons	Utkal University, BBSR, Odisha	1985	Physics, Chemistry, Mathematics (Hons)	57%
Post Graduate Degree (PG)M.Sc	Berhampur University, Odisha	1987	Mathematics (OR & Theory of Computation)	60.01%

Ph.D. degree (Mathematics)	Utkal University, BBSR, Odisha	October 1995	Operations Research (Non convex Optimization)	Supervisor Prof. S. Nanda, Maths IIT KGP Committee Chair Prof. G. Das, Maths UU, BBSR Examiner Prof M. C. Puri, Maths IIT Delhi

Publications Profile:

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Mr. Sanyam Gupta

Academic Qualification:

STANDARD	PERCENTAGE	INSTITUTE	BOARD/UNIVERSITY	YEAR
Ph.d	Pursuing	Delhi Technological University	Delhi Technological University	
M.Sc.(Mathematics)	75.00%	Hindu College.	University of Delhi	2013
B.Sc.(Mathematics)	74.11%	Acharya Narendra Dev College.	University of Delhi	2011
Intermediate	67.80%	S. Bhushan Saran J I C	Board of High School and Intermediate Education, Uttar Pradesh	2008
High School	70.33%	S. Bhushan Saran J I C	Board of High School and Intermediate Education, Uttar Pradesh	2006

Achievements:

1. Presented a research paper on "**Solvability of group**" in **"International Conference on Analysis, Geometry, Algebra and their Applications**" at Jamia Millia Islamia University, Delhi, in 2014.
2. Presented a research paper "**On Solvability of Some Special Groups**" in "**International Conference on Applicable Analysis**" organized by Department of Mathematics, Saheed Bhagat Singh College, University of Delhi, in 2017.
3. Presentation a research paper on "**Optimal Investment Decision Model Based On Simplex Algorithm With Variable Optimal Value Evaluation Process**" in "International Conference on Applied and Computational Mathematics-2018" organized by Indian Institute of Technology Kharagpur, India, in 2018.
4. Presented a research paper on "**Electrical Power System Transmission Quality and Power Supplier Micro Grid Control Functional Reliability**" in "9th International Conference on Quality, Reliability, Infocom Technology & Business Operations" organized by Department of Operational Research, University of Delhi, Society for Reliability Engineering, Quality and Operations Management (SREQOM), in 2018.

Seminar & Projects:

1. Attended **International conference** on **'The Legacy Of Shrinivasa Ramanujan"** in 2012.
2. Attended workshop **"Group theory and its application"** in 2014.
3. Attended **International Conference** on "**Current Trends in Theoretical and Computational Differential Equations with Applications**" in 2017.
4. Attended **Faculty Development program** on "**Research Methodology**" organized by Bhaskaracharya College of Applied Sciences, University of Delhi, in 2017.
5. Attended " **The 33rd Annual Conference of The Ramanujan Mathematical Society**" organized by Department of Mathematics, University of Delhi, in 2018.
6. Attended **International conference** on "**Applied and Computational Mathematics-2018**" organized by Indian Institute of Technology Kharagpur, India, in 2018.
7. Attended **International conference** on "**Quality, Reliability, Infocom Technology & Business Operations**" organized by Department of Operational Research, University of Delhi, Society for Reliability Engineering, Quality and Operations Management (SREQOM), in 2018.