FREQUENCY ANALYSIS OF NUMBERS: APPLICATIONS IN ERGONOMICS AND DIAGNOSIS OF COMPUTER KEYBOARD FAULTS

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ABSTRACT

This study explores the potentiality of decimal digits distribution to differentiate between chaotic and random numbers.

Ten thousand (10000) random and chaotic numbers each were generated using computer inbuilt random number generator and Logistic equation respectively. The random and chaotic numbers were obtained using FORTRAN codes. Logistic equation was solved for only parameters (Ks') known to exhibit chaotic behaviour with initial value of 0.3 for all cases. Graphs of decimal digits distributions were made with Microsoft Office Excel 2003.Three hundred and eighty nine (389) seed values used for this study range between 1031 and 9998 while the corresponding Logistic equation parameter (K) used range between 3.570 and 3.999. Numbers (0, 1, 2, 6, 7 and 9) recorded zero frequency at first decimal out of ten (10) thousand chaotic solutions for parameter (K=3.570). Similarly the frequency distribution for the first decimal of the chaotic solution is highly biased in favour of numbers 8, 3, 5 and 4 respectively for parameter (k=3.570).

Numbers with zero frequency range between six (6) at very low parameter and one (1) at very high parameter. In sum the first decimal digit of chaotic solution distribute drastically different from near uniform distribution observed for other cases of decimal digits.

This study has shown that a biased distribution of first decimal digits of a number set is a strong indication of chaos. In addition the results of this study can be of great advantage in diagnosing some computer keyboard faults and ergonometric problems associated with frequent use of some number keys.

Track 1: Ergonomics/Human Factors
Track 2: Maintenance

INTRODUCTION

The study of nonlinear dynamics popularly known as chaos has been hailed as the key to understanding everything from weather systems and earthquakes to traffic jams and store market. Before its discovery, chaos was inevitably confused with randomness and indeterminacy (14). Because many systems appeared random, they were actually thoughts to be random. This was true despite the fact that many of these systems seemed to display intermittent almost periodic behaviour before returning to more "random" or irregular motion. Indeed, this observation leads to one of the defining features of chaos: the superposition of a very large number of instable periodic motions. It is one thing to show that a particular phenomenon displays chaotic behaviour, it is quite another to exploit that knowledge for any useful purpose. Meteorologists employed the knowledge of chaos to forecast weather conditions with the aid of computers. Karl-Heinz and Michael (8) reported that the theoretical models for the changes in weather have been formulated. Such models, in the form of complicated mathematical equations are evaluated with the aid of the computer and used for weather predictions. In practice, weather data from the worldwide network of measuring stations such as pressure, temperature, wind direction and many other quantities are entered into the computer system which forecasts the resulting weather with the aid of the underlying model. The latest fields to embrace the idea of chaos and randomness are medicine, electronics, information and communication technology, manufacturing and maintenance industries.

Specialists in non-linear dynamics are doing their best to understand the working of the brain, heart and immune system using chaos theory (7). Raima, a physicist and Robert, a neurosurgeon (10) used chaos to simulate what happens in the brain before some kinds of epileptic seizures. Based on their work, new surgery was suggested. Starting with standard nonlinear equations that describe the behaviour of individual neurons, they linked about a thousand neurons together to represent the abnormally behaving part of the brain. It is concluded that carefully designed drugs or suitably administered electrical impulses can prevent epileptic seizures. Many physicists and physiologists suspect that cardiac fibrillation (erratic beating of the heart) is chaotic, and are trying to model it in order to find ways of stabilizing the dangerous convulsions. Daniel (3) observed that the way to stabilize a chaotic heart would be to wait until it comes closer to a more periodic state and then give it a small electric shock to nudge it into the state. According to him, one prediction from models of a chaotically beating heart is the break-up of regular electrical impulses into spirals, causing uneven contractions. He concluded from his experiments that administering small electric shocks brings the chaos under control. Marios (9) research was the practical applications of chaos theory to the modulation of human ageing. According to him, several predictions of chaos theory can be applied to ageing in an attempt to study, clarify and modify its mechanics. Researches confirm that it is possible to stimulate the body and mind to work optimally and thus postpone age-related disease and disability. According to Subias (11), there are numerous applications of chaos theory in medicine. Chaos has been used in the treatment of schizophrenia, immune system, leukaemia, arrhythmia and heart related diseases.

The knowledge of randomness plays a significant role in medicine. The modern evolutionary synthesis ascribes the observed diversity of life to natural selection, in which some random genetic mutations are retained in the gene pool due to the non-random improved chance for survival and reproduction that those mutated genes confers on individuals who posses them. The characteristics of an organism arise to some extent deterministically (e.g. under the influence of genes and the environment) and to some extent randomly. For example, the density of freckles that appear on a person's skin is controlled by genes and exposure to light, whereas the exact location of individual freckles seems to be random (2). Randomness is important if an animal is to behave in a way that is unpredictable to others. For instance, insects in flight tend to move about random changes in direction, making it difficult for pursuing predators to predict their trajectories.

Andrievskii and Fradkov (1) researched extensively on the problems and methods for control of chaos. Consideration was given to their application in various scientific fields such as mechanics (control of pendulum, beams, plates and friction), mechanical systems in engineering (control of vibroformers, microcantilevers, cranes and vessels), spacecraft, electrical and electronics systems, communication and information systems. Torres (13) developed an analog-to-digital laboratory model including an electronic Chua circuit with a gyrator as the inductive element and a control computer. Studies on application of chaos to the communication systems open wide opportunities in domains such as receiver-transmitter synchronization, message masking and reconstruction, noise filtering, restoration of information signals and development of the coding-arbitrary digital message through the symbolic dynamics of chaotic systems (4).As reported by Gregory and Jerry(6),an electrical circuit with resistance(R),inductance(L) and nonlinear capacitance(C) can be driven sinusoidally into chaotic states and modelled by differential equation. According to (5), It has been suggested that the transition to chaos may be observed for parameter values A=0.1 and 9.8<B<13.4.

The pattern of occurrence of numbers 1-9 is presently attracting researchers' interest in no small measure. According to Tim Glynne-Jones (12) in the book of numbers, you might expect to find the numbers 1-9 appearing in roughly equal measure as first digit when you study a set of data. Dr. Frank Benford, an American physicist discovered this is not the case. His research showed that 1 appears as the first digit in almost a third of all cases (30.1 percent). This probability decreases as you go up to 9, which only appears as the first digit 4.6 percent of the time. Dr. Frank research also revealed that people who concoct fraudulent data tend to start their made-up numbers with 6 most commonly. These findings interestingly have inspired investigators and financial auditors to apply Benford's law when checking for fraud. His research also found that the number 1 puts ideas into people's heads. In a line-up, police omit numbering anybody 1. The reason is because findings have shown 1 to influence a witness's choice.

The objective of this work is to use statistical methods to detect whether or not there is distinct pattern of frequencies of use of number (0 to 9) to write the decimal part of chaotic and random solutions. The results of the study are recommended for diagnosing medical and ergonometric problems as well as computer faults associated with the frequent use of some number keys.

Method:

Generate very large number (10000) of random numbers between 0.0000 and 1.0000 and for different seed values with the aid of inbuilt random number generator (ran (iseed)) coded in FORTRAN.

Use Logistic equation (1) with initial value (0.3) and 100 transient solutions to generate ten thousand (10000) solutions each for all parameters (K) that exhibited chaotic behaviour. Tune parameter (K) with a constant step of 0.001 from (K=0.001) to (K=3.999), see chaotic walks.

$$X_{n+1} = K * X_n * (1.0 - X_n) \qquad (1)$$

Where X_n, and X_{n+1} represent the current value and next value of variable X respectively.
K= tuneable parameter of the Logistic equation.

Compute the frequency of use of numbers (0 to 9) as used to write the random numbers and chaotic solutions.
Compare the frequency obtained for corresponding set of random numbers and chaotic solutions and draw relevant inferences.

Results and Discussion:

Table I: List of Parameter (K) with Chaotic Behaviour

	389 Parameters (K)								
3.570	3.571	3.572	3.573	3.574	3.575	3.576	3.577	3.578	3.579
3.580	3.581	3.582	3.584	3.585	3.586	3.587	3.588	3.589	3.590
3.591	3.592	3.593	3.594	3.595	3.596	3.597	3.598	3.599	3.600
3.601	3.602	3.603	3.604	3.605	3.607	3.608	3.609	3.610	3.611
3.612	3.613	3.614	3.615	3.616	3.617	3.618	3.619	3.620	3.621
3.622	3.623	3.624	3.625	3.626	3.635	3.636	3.637	3.638	3.639
3.640	3.641	3.642	3.643	3.644	3.645	3.646	3.647	3.648	3.649
3.650	3.651	3.652	3.653	3.654	3.655	3.656	3.657	3.658	3.659
3.660	3.661	3.662	3.663	3.664	3.665	3.666	3.667	3.668	3.669
3.670	3.671	3.672	3.673	3.674	3.675	3.676	3.677	3.678	3.679
3.680	3.681	3.682	3.683	3.684	3.685	3.686	3.687	3.688	3.689
3.690	3.691	3.692	3.693	3.694	3.695	3.696	3.697	3.698	3.699
3.700	3.701	3.703	3.704	3.705	3.706	3.707	3.708	3.709	3.710
3.711	3.712	3.713	3.714	3.715	3.716	3.717	3.718	3.719	3.720
3.721	3.722	3.723	3.724	3.725	3.726	3.727	3.728	3.729	3.730
3.731	3.732	3.733	3.734	3.735	3.736	3.737	3.738	3.744	3.745
3.746	3.747	3.748	3.749	3.750	3.751	3.752	3.753	3.754	3.755
3.756	3.757	3.758	3.759	3.760	3.761	3.762	3.763	3.764	3.765
3.766	3.767	3.768	3.769	3.770	3.771	3.772	3.773	3.774	3.775
3.776	3.777	3.778	3.779	3.780	3.781	3.782	3.783	3.784	3.785
3.786	3.787	3.788	3.789	3.790	3.791	3.792	3.793	3.794	3.795
3.796	3.797	3.798	3.799	3.800	3.801	3.802	3.803	3.804	3.805
3.806	3.807	3.808	3.809	3.810	3.811	3.812	3.813	3.814	3.815
3.816	3.817	3.818	3.819	3.820	3.821	3.822	3.823	3.824	3.825
3.826	3.827	3.828	3.850	3.851	3.852	3.853	3.854	3.857	3.858
3.859	3.860	3.861	3.862	3.863	3.864	3.865	3.866	3.867	3.868
3.869	3.870	3.871	3.872	3.873	3.874	3.875	3.876	3.877	3.878
3.879	3.880	3.881	3.882	3.883	3.884	3.885	3.886	3.887	3.888
3.889	3.890	3.891	3.892	3.893	3.894	3.895	3.896	3.897	3.898
3.899	3.900	3.901	3.902	3.903	3.904	3.905	3.907	3.908	3.909
3.910	3.911	3.912	3.913	3.914	3.915	3.916	3.917	3.918	3.919
3.920	3.921	3.922	3.923	3.924	3.925	3.926	3.927	3.928	3.929
3.930	3.931	3.932	3.933	3.934	3.935	3.936	3.937	3.938	3.939
3.940	3.941	3.942	3.943	3.944	3.945	3.946	3.947	3.948	3.949
3.950	3.951	3.952	3.953	3.954	3.955	3.956	3.957	3.958	3.959
3.960	3.962	3.963	3.964	3.965	3.966	3.967	3.968	3.969	3.970
3.971	3.972	3.973	3.974	3.975	3.976	3.977	3.978	3.979	3.980
3.981	3.982	3.983	3.984	3.985	3.986	3.987	3.988	3.989	3.990
3.991	3.992	3.993	3.994	3.995	3.996	3.997	3.998	3.999	

Table II: List of Random Number Generating Seed Values

	389 Four Digits Random Number Generating Seeds								
1526	2852	5828	1489	4512	8038	1708	8699	7060	9398
4872	7573	1480	5366	4675	6289	2514	3245	4590	6898
2083	5162	8482	2361	8760	5677	1435	1577	1127	6079
5726	8471	5809	8532	6534	7911	6099	3402	2123	7815
8546	5126	5304	9099	1388	7556	7916	1869	6383	3081
9634	4490	7617	6463	8692	2629	2841	3072	4453	4048
8425	2268	2291	7647	2789	9386	5510	1706	8483	2183
2333	7713	8914	5711	5702	9892	7691	4612	6385	7545
9352	4827	2925	9980	1855	3680	7073	8862	2966	9446
2703	8380	4247	2264	9909	2125	8273	3781	2402	7650
5197	5751	2593	2565	8209	7639	8064	7968	4217	7340
7326	5509	7487	9248	7283	8964	6538	3608	4671	7681
2658	4902	2001	7449	8515	1523	1729	7295	8736	1610
7488	4070	7853	2394	2896	1222	8272	7928	7001	9229
7278	6870	6047	2983	5555	5437	5988	3229	2286	3707
1031	1319	6638	6739	2878	8048	3736	7358	6856	8318
2277	2307	8741	4448	7049	6807	1124	5024	7377	1041
2092	8396	9420	9604	3829	9252	1458	8375	6965	1960
1284	5187	8425	9797	7052	7475	6828	3429	6439	7458
7806	8599	8311	2330	8110	8886	1233	8199	7305	7581
8434	2088	7885	1654	8637	5070	4381	2354	4238	1770
8906	6472	2911	3768	9903	5246	6162	1391	5107	1147
3174	8910	8994	6657	4205	6983	7866	3074	2183	8044
3522	6279	9754	7083	4612	3889	5369	3638	2429	3500
4663	3750	8925	5324	6730	1767	9998	5580	7882	7167
1608	1045	9796	6459	7461	9918	1565	9049	6751	9885
2901	6034	7674	2209	1500	5332	2757	8178	5873	9849
9207	6736	4475	2460	4234	5722	6120	1852	5457	8820
9073	4513	2619	8265	5438	9177	2963	4916	6723	5570
8536	8481	2047	7228	4086	2249	7611	7983	2339	4811
7454	7488	1112	2415	9423	8674	4576	9043	3668	9121
8695	9085	5929	3368	4010	5405	5893	1589	4088	3449
2232	2383	9879	5259	4077	8876	4639	7057	7408	9260
9635	5675	9937	1041	2345	5011	4637	3331	4804	2730
9052	6069	1480	9373	5671	5271	6049	8883	3818	9606
1529	3311	3076	9496	4041	5558	5351	2521	6681	3974
5016	8337	9850	6165	3510	2970	5157	2467	4991	5339
3102	6076	3679	6877	4496	5598	7542	3879	7744	3419
5369	2095	5974	8178	2347	2573	7338	4536	7812	

The three hundred and eight nine (389) four digits seed values in table II were generated using random number generator with seed value of 6789.

Table III: List of Twenty Random Number and Chaotic Solution to five decimal

S/N	Generated Random Number with Seed (1526)	Chaotic Solution of Logistic at (K=3.570)
1	0.03430	0.84054
2	0.75952	0.47850
3	0.66408	0.89085
4	0.59881	0.34714
5	0.10040	0.80908
6	0.46659	0.55146
7	0.85311	0.88305
8	0.36080	0.36870
9	0.19481	0.83095
10	0.60000	0.50148
11	0.64990	0.89249
12	0.15503	0.34254
13	0.48251	0.80399
14	0.39871	0.56260
15	0.26807	0.87851
16	0.87336	0.38103
17	0.74333	0.84197
18	0.49902	0.47501
19	0.19911	0.89027
20	0.04894	0.34875

Table IV: Frequency Analysis of Random Number in Table III

Number	Frequency Out of Twenty (20)			
	1st Decimal	2nd Decimal	3rd Decimal	4th Decimal
0	2	2	3	5
1	4	0	0	2
2	1	0	1	0
3	2	1	3	3
4	3	3	3	1
5	1	3	1	3
6	3	4	1	0
7	2	1	0	1
8	2	1	4	4
9	0	5	4	1

Table V: Frequency Analysis of Chaotic Solution in Table III

Number	Frequency Out of Twenty (20)			
	1st Decimal	2nd Decimal	3rd Decimal	4th Decimal
0	0	3	4	4
1	0	0	4	1
2	0	0	3	1
3	5	1	2	0
4	2	5	0	4
5	3	1	1	3
6	0	2	0	2
7	0	3	1	1
8	10	2	4	1
9	0	3	1	3

Table VI: Frequency Analysis of Generated Random Number (Seed=1526) and Chaotic Solution (K=3.570)

Number	Frequency Out of Ten (10) Thousand							
	1st Decimal		2nd Decimal		3rd Decimal		4th Decimal	
	R. No	Chaos	R. No	Chaos	R. No	Chaos	R. No	Chaos
0	996	0	1010	1273	1009	1687	1079	1040
1	1007	0	1015	365	956	911	972	1145
2	1007	0	979	312	1002	1781	1014	1055
3	962	2500	1056	511	1029	701	991	988
4	984	862	1010	1989	1003	899	979	1366
5	1010	1638	982	313	1027	578	998	1275
6	988	0	1006	1052	959	355	987	887
7	1008	0	991	1580	1053	679	984	680
8	1036	5000	977	1118	996	1477	1000	735
9	1002	0	974	1487	966	932	996	829

Note: *R.No =Random Number.*

Table VI refers six (6) numbers (0, 1, 2, 6, 7 and 9) recorded zero frequency at first decimal out of ten (10) thousand chaotic solution. Numbers 8 and 3 recorded 5000 and 2500 frequency respectively. Indeed, the frequency distribution for the first decimal of the chaotic solution is highly biased in favour of numbers 8, 3, 5 and 4 respectively. Is this observation a coincidence? Tables VII, VIII, and IX are generated to provide an insight to this pertinent question by picking corresponding parameter arbitrarily from tables I and II.

Table VII: Frequency Analysis of Generated Random Number (Seed=2852) and Chaotic Solution (K=3.571)

Number	Frequency Out of Ten (10) Thousand							
	1st Decimal		2nd Decimal		3rd Decimal		4th Decimal	
	R. No	Chaos	R. No	Chaos	R. No	Chaos	R. No	Chaos
0	990	0	1020	1191	964	1092	995	1013
1	1044	0	1018	336	1005	1180	999	927
2	998	0	1060	226	1032	1502	976	982
3	966	2500	967	700	1006	1021	985	936
4	1040	973	999	1778	988	884	1009	889
5	965	1527	964	647	1066	1142	995	982
6	957	0	977	704	1001	716	1019	1027
7	983	0	1003	1469	1013	709	1028	1116
8	1022	5000	1037	1543	995	970	1026	1014
9	1035	0	955	1406	930	784	968	1114

Table VII refers the same observation noted as for results in table VI.

Table VIII: Frequency Analysis of Generated Random Number (Seed=7326) and Chaotic Solution (K=3.690)

Number	Frequency Out of Ten (10) Thousand							
	1st Decimal		2nd Decimal		3rd Decimal		4th Decimal	
	R. No	Chaos	R. No	Chaos	R. No	Chaos	R. No	Chaos
0	989	0	987	1120	1017	913	960	1002
1	947	0	1005	1298	954	949	995	1017
2	1040	733	1038	1240	987	1052	1035	1061
3	978	901	998	824	1053	1057	961	1018
4	1022	752	1008	884	992	1026	1012	1020
5	1017	715	983	733	1022	925	977	981
6	1003	1241	1014	1041	1016	1051	1095	962
7	1010	2632	963	972	970	981	961	970
8	971	1861	983	915	985	1050	1007	998
9	1023	1165	1021	973	1004	996	997	971

Table VIII refers zero frequency observation noted for chaotic solution at first decimal in addition to biased frequency in favour of number 7.

Table IX: Frequency Analysis of Generated Random Number (Seed=4536) and Chaotic Solution (K=3.998)

Number	Frequency Out of Ten (10) Thousand							
	1st Decimal		2nd Decimal		3rd Decimal		4th Decimal	
	R. No	Chaos	R. No	Chaos	R. No	Chaos	R. No	Chaos
0	1020	1861	1003	1096	976	947	970	967
1	1069	979	996	958	1046	926	1039	984
2	1031	736	1013	937	998	1019	1005	976
3	984	621	1026	965	990	948	985	1010
4	996	700	949	881	977	968	990	1030
5	973	674	1122	914	1002	1027	1020	974
6	995	668	941	898	1023	946	1013	1065
7	980	750	951	1000	995	1017	998	975
8	959	907	974	1016	982	1098	992	990
9	993	2104	1025	1335	1011	1104	988	1029

Table IX refers no zero frequency observation for all cases of decimal. However the frequency distribution for chaotic solution at first decimal remains significantly biased in favour of numbers 9 and 0.

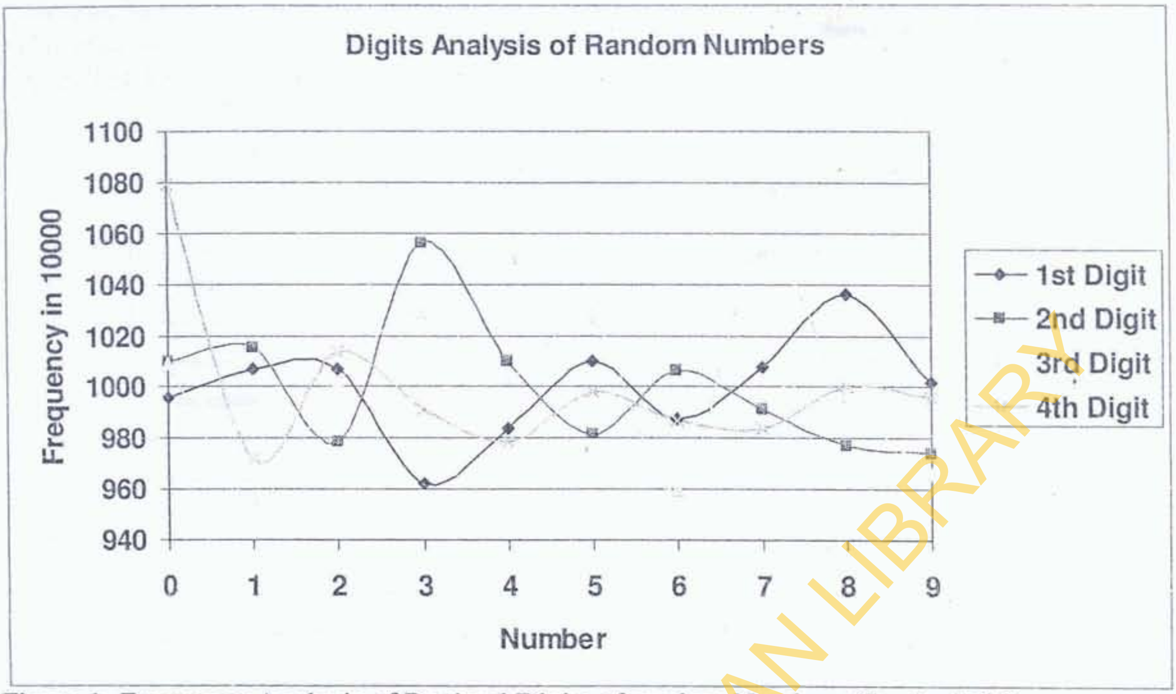

Figure 1: Frequency Analysis of Decimal Digits of random Numbers (Seed =1526)

Referring to figure 1, the minimum and maximum frequencies are 956 and 1079 respectively with very interval value of 123.

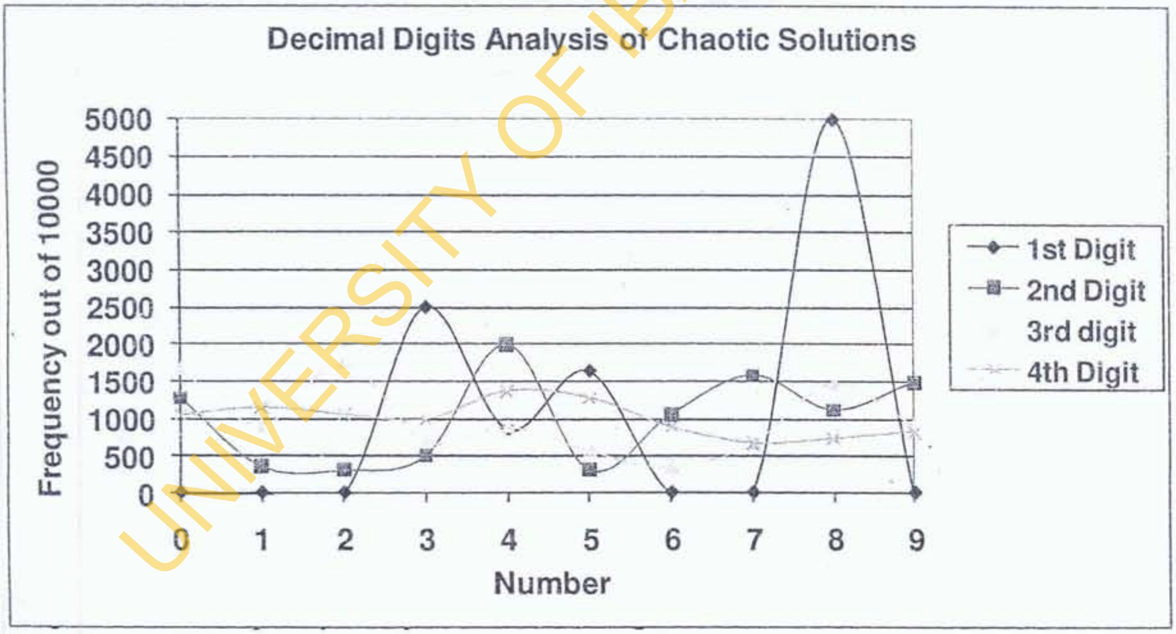

Figure 2: Frequency Analysis of Decimal Digits of Chaotic Solutions (K=3.570)

Referring to figure 2 the minimum and maximum frequencies are 0 and 5000 respectively with very large interval value of 5000. Thus the interval value for the chaotic solutions is extremely higher than its corresponding random numbers.

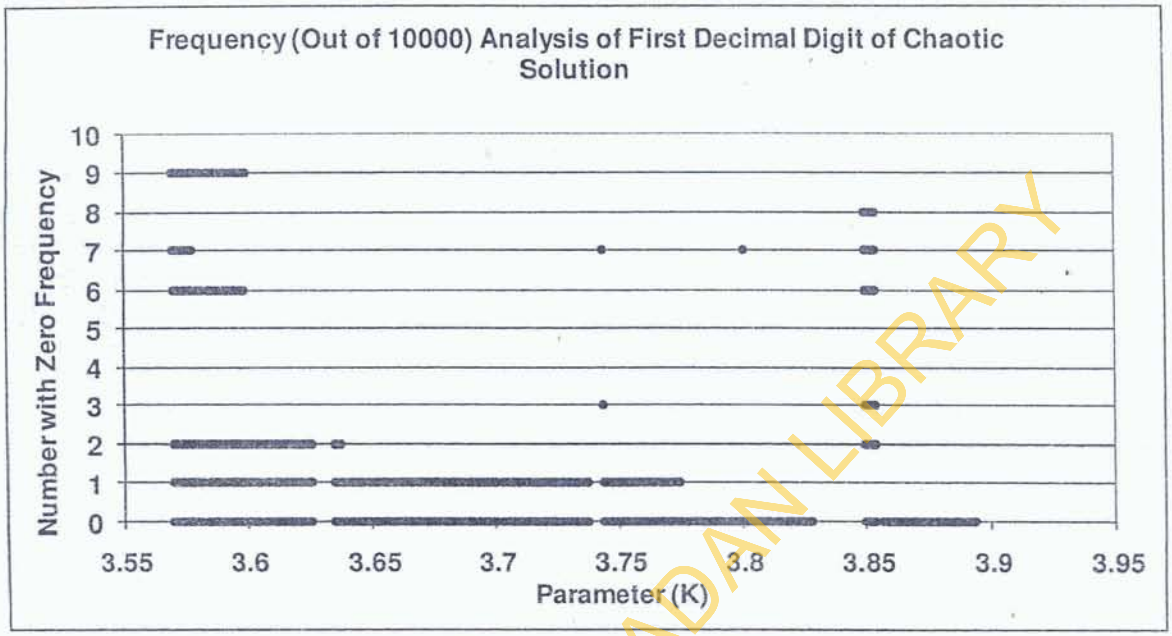

Figure 3: Frequency Analysis of First decimal Digit of Chaotic Solution

Figure 3 refers numbers 4 and 5 were only two numbers out of ten (10) that had non-zero frequency for all parameters (K) that exhibited chaotic behaviour. Parameter (K) range between 3.570 and 3.999, see table 1. Numbers with zero frequency range between six (6) at very low parameter and one (1) at very high parameter.

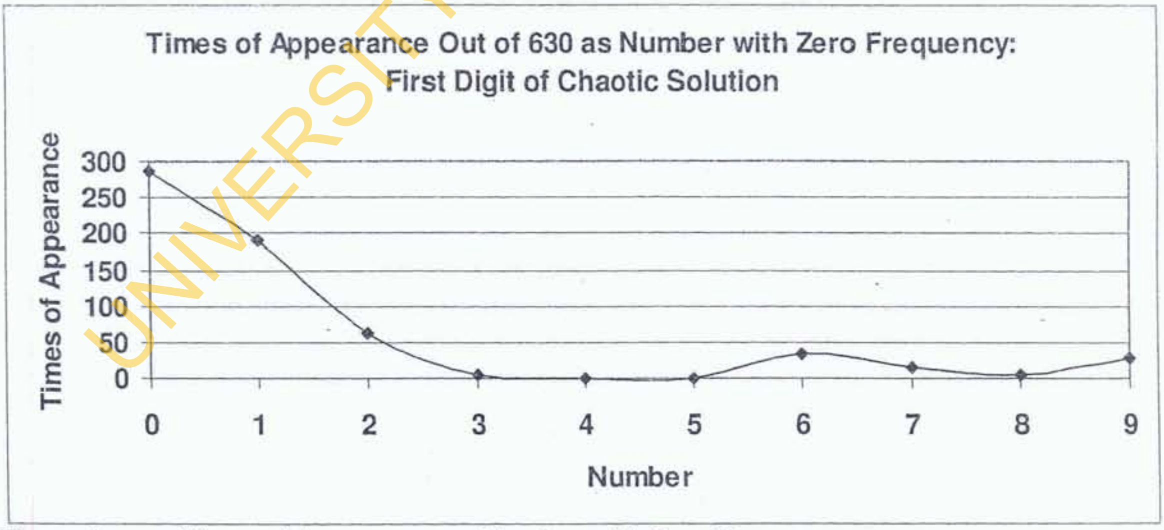

Figure 4: Times of Appearance as Number with Zero Frequency

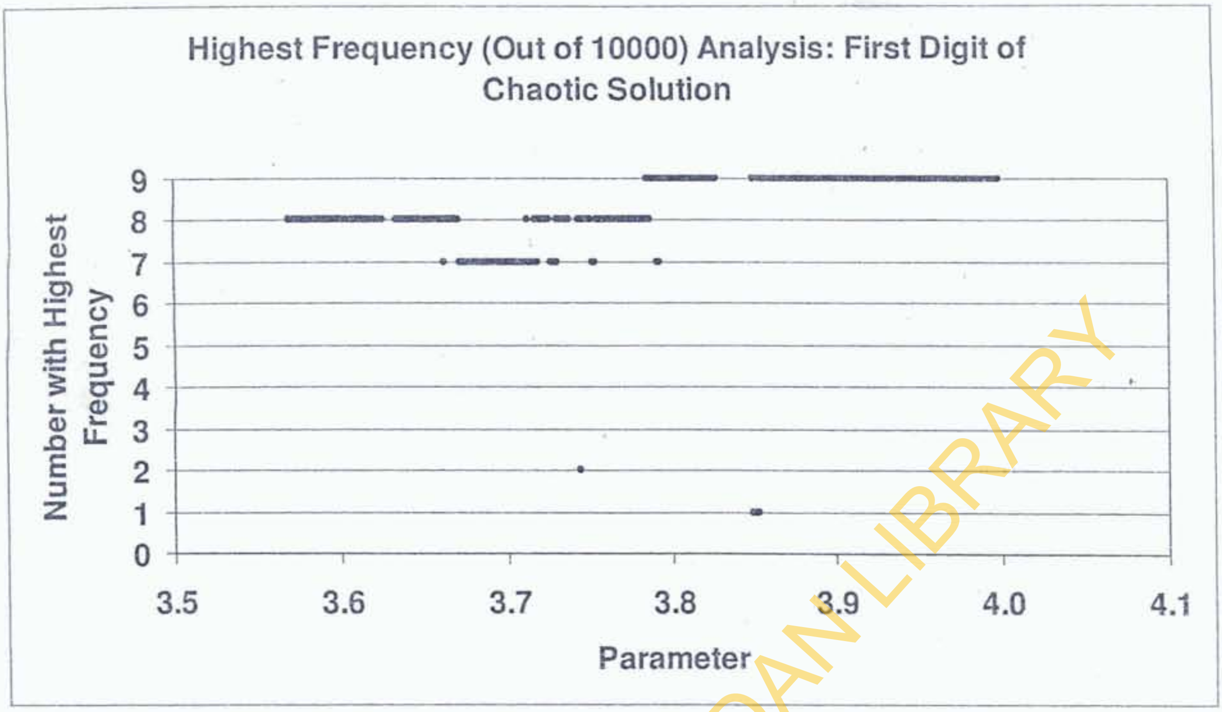

Figure 5: Highest Frequency Analysis of First Digit of Chaotic Solution

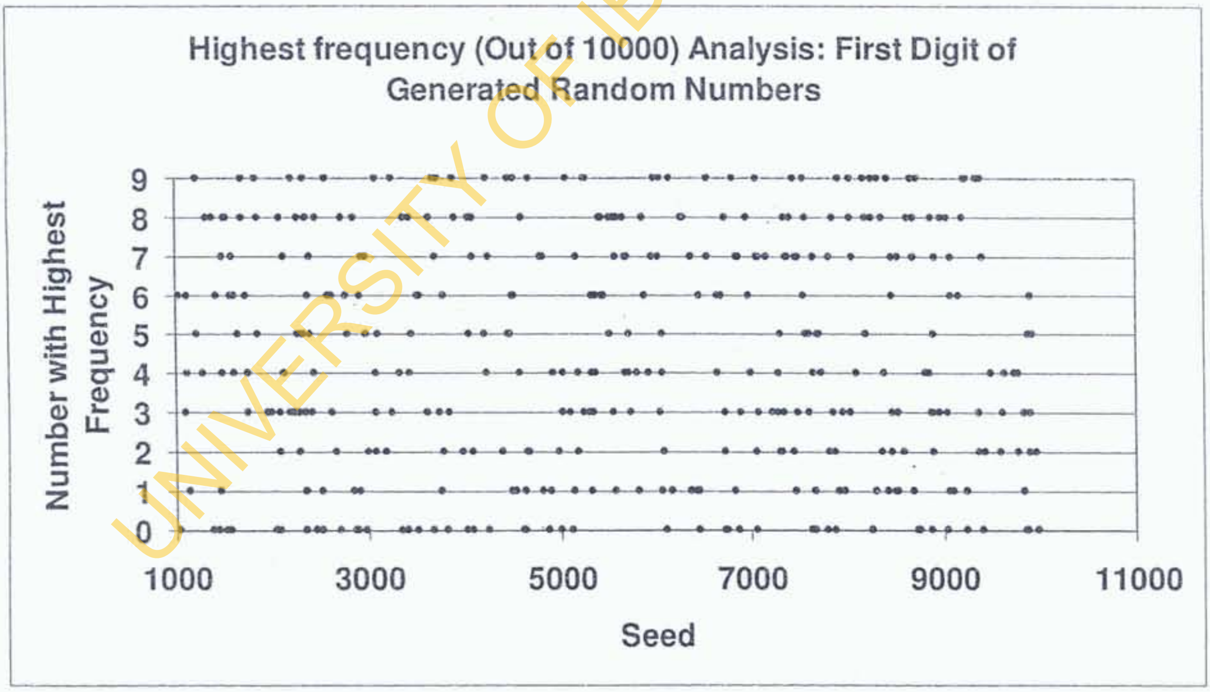

Figure 6: Highest Frequency Analysis of First Digit of Generated Random Number

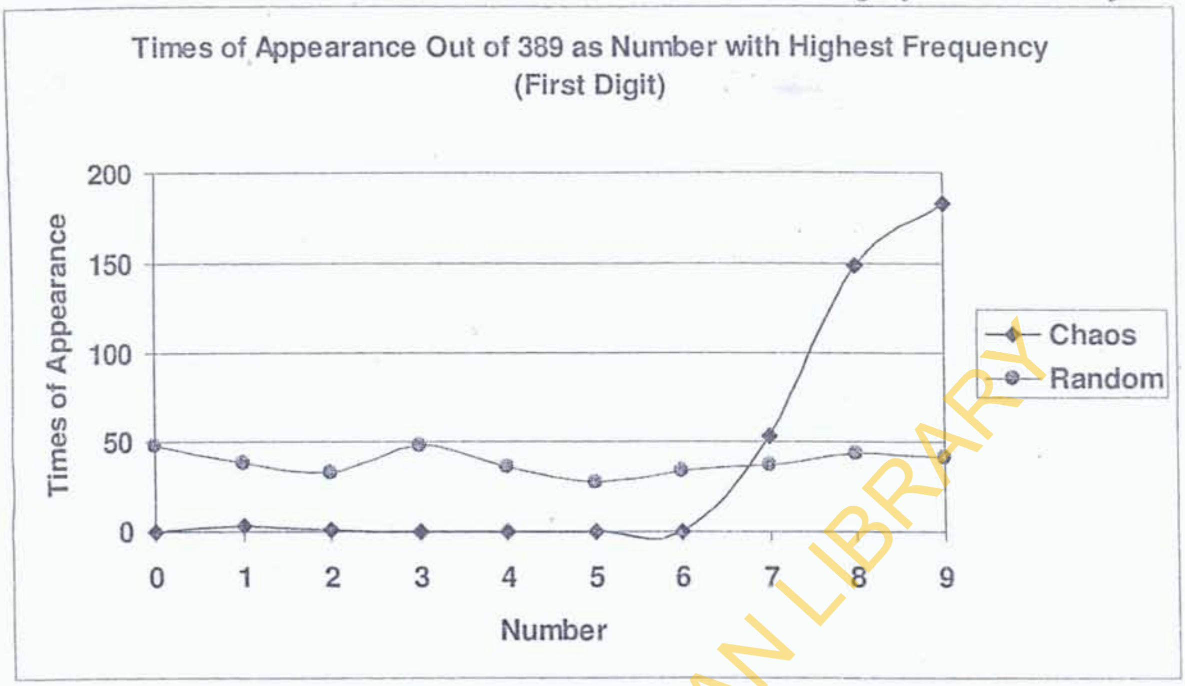

Figure 7: Times of Appearance as Number with Highest Frequency

Emerge fact referring to tables IV to IX and figures 1 to 7 is that the first decimal digit of chaotic solution distribute drastically different from near uniform distribution observed for other cases of decimal digits.

Conclusions

This study has shown that decimal digits of chaotic solution distribute like a biased die and drastically different from near uniform distribution observed for generated random number. This understanding can be used advantageously to differentiate given set of number as whether chaotic or not. Users of number keys on a computer keyboard are prone to suffer ergonometric problems associated with frequent use of number 7, 8 and 9 keys. In addition the key board life span can be drastically shortened due to overuse of number 7, 8 and 9 keys.

References

1. Andrievskii, B.R. and Fradkov, A.L. 2003. Control of Chaos: Methods and Applications. Institute of Problems of Science of Machines, Russian Academy of Sciences, St. Petersburg, Russia.

2. Breatnach, A.S. 1982. A long-term hypopigmentary effect of thorium-x on freckled skin. British Journal of Dermatology. 106(1):19-25.

3. Daniel, G. 1998. Cardiac Fibrillation is Chaotic. Daniel Ganther is a Physicist at Duke University in North Carolina, Carolina.

4. Dmitriev, A.S. and Kuz'min, L.V. 1999. Information Transmission Using Synchronous Chaotic Response in the presence of filtering in communication channel, Lett. Zh. Teorr Fiz, Vol. 25, No. 16, Pg 71-77.

5. Francis, C.Moon.1987.Chaotic Vibrations: An Introduction for Applied Scientists and Engineers, John Wiley and Sons, ISBN, 0-471-85685-1

6. Gregory, L.B and Jerry, P.G.1990.Chaotic Dynamics: An Introduction. Cambridge University Press, U.S.A.

7. http://www.economist.com. The Economist: Better Living through chaos, September, *1999*.

8. Karl-Heinz Becker, Michael Dőfler.1989.Dynamical Systems and Fractals (Translation from German language to English language done by Ian Stewart in 1989 and Reprinted in 1990).Cambridge University Press ISBN 0 521360250 hard cover and ISBN 0 52136910X Paperback.

9. Mario K. 2003. Practical Applications of Chaos Theory to the Modulation of Human Ageing: Nature Prefers chaos to regularity. The British Longevity Society, P.O. Box 71, Hemel Hempstead Hp 39DN, UK. E-mail:Kyriazis@antiageing.freeserve.uk Fax: +44-144-2216906.

10. Raima, L. and Robert W. 1999. Epileptic Seizures: Purdue University, Indianapolis. Dr. Raima and Dr. Robert are senior researchers at Purdue University, Indianapolis.

11. Subias, J.L. 1992. Applications of Chaos Theory in Medicine. Subias is a researcher at Area of Graphical Expression in Engineering, University of Zaragoza, Spain.

12. Tim Glynne-Jones.2010.The Book of numbers: From zero to infinity, an entertaining list of every number that counts. Pg. 14 (one for the Money).

13. Torres, L.A.B. and Aguirre, L.A. 1999. Extended Chaos Control Method Applied to Chua Circuit, Electr. Lett, Vol. 35, No. 10, Pg 768-770.

14. William, L.D. 1996. Chaos: The Superposition of a very large number of Unstable Periodic motions. Applied Chaos Laboratory, School of Physics, Georgia Institute of Technology, Atlanta Georgia 30332-0430.

APPENDIX-I: DIGITSTATISTIC.FOR

```
C... This programme analyse the frequency of appearance
C,,,,of digits Zero (0) to Nine (9) in First, Second,...
C....decimal place or Randomly Generated Number and
C....Chaotically Generated Number via Logistic Equation
      Implicit real *8(a-h,o-z)
      Common Cn(11000),DCS(4,10),itrade,Npt,Rate
      Dimension Rn(11000),DRS(4,10)
      Open(unit=2,file='Digitstatistic.out')
      Open(unit=4,file='Digitstatistic2.out')
      Open(unit=3,file='DigitSource.out')
C... Read Input Parameters via Screen
C.... as follow:
      Write(*,*)'Enter Rate,Itrade,Npt,and Iseed'
      Read(*,*)Rate,itrade,Npt,Iseed
      Do 10 i=1,Npt
      Rn(i)=ran(iseed)
      If(i.le.100)Write(3,15)Rn(i)
   10 Continue
   15       Format(f10.4)
      Write(3,*)
      CK=1
      KC=10
      Call Logistic
      Do 20 i=1,4
      Ck=Ck*10
C     Kc=Int(Ck)
C     If(ck.ne.10)Kc=Kc+10
      Do 20 j=1,Npt
      Nr=Int(Rn(j)*Ck)
      Nc=Int(Cn(j)*Ck)
      Ir=Mod(Nr,Kc)
      Ic=Mod(Nc,Kc)
      Ir=Ir+1
      Ic=ic+1
      DRS(i,Ir)=Drs(i,ir)+1
      DCS(i,Ic)=Dcs(i,ic)+1
   20       Continue
      Do 30 i=1,10
      Write(2,35)i-1,(Drs(j,i),j=1,4)
      Write(4,36)i-1,(Int(Drs(j,i)),Int(Dcs(j,i)),j=1,4)
   30       Continue
      Write(2,*)

      Do 40 i=1,10
```

```
 Write(2,35)i-1,(DCs(j,i),j=1,4)
40        Continue

35        Format(i1,2x,4(f10.2,2x))
36        Format(i1,2x,8(i4,2x))
 Stop
 End

 Subroutine Logistic
 Implicit real *8(a-h,o-z)
 Common Cn(11000),DCS(4,10),itrade,Npt,Rate
 Open(unit=3,file='DigitSource.out')

 Xx=0.3
 Do 10 i=1,Itrade
 Xx=rate*xx*(1-xx)
10        Continue
 Do 20 i=1,Npt
 Xx=rate*xx*(1-xx)
 If(i.le.100)write(3,25)xx
 Cn(i)=xx
20        Continue
25        Format(f10.4)
 Return
 End
```

APPENDIX-II: CHAOSSTATISTIC.FOR

```
C... This programme compute No of Zero and Number with highest Frequency
     Implicit real *8(a-h,o-z)
     Common Cn(11000),DCS(4,10),itrade,Npt,Rate
     Open(unit=1,file='Chaosparameters')
     Open(unit=2,file='Chaostatistic.out')
     Open(unit=4,file='Zerofrequncies.out')

C... Read Input Parameters via file
C.... as follow:
     Read(1,*)Npk,itrade,Npt
     KC=10
     Do 1000 K=1,Npk
     Read(1,*)Rate

     CK=1

     Call Logistic
     Do 20 i=1,1
```

```
      Ck=Ck*10
      Do 20 j=1,Npt
      Nc=Int(Cn(j)*Ck)
      Ic=Mod(Nc,Kc)
      Ic=ic+1
      DCS(i,Ic)=Dcs(i,ic)+1
20          Continue
      Count=0.0
      Fmin=0.0
      Ipk=0
      Do 30 i=1,10
      If(Dcs(1,i).gt.Fmin)then
      Fmin=Dcs(1,i)
      Ipk=i
      Else
      Endif
      If(Dcs(1,i).eq.0)then
      Count=count+1
      Write(4,31)Rate,i-1
      Endif
      Dcs(1,i)=0.0
 30 Continue
 31 Format(f10.4,2x,i2)
      Write(2,35)Rate,Count,Ipk-1,Fmin
      If(Mod(k,100).eq.0)Write(*,*)k
1000        Continue
 35         Format(2(f10.4,2x),i2,2x,f12.2)
      Stop
      End

      Subroutine Logistic
      Implicit real *8(a-h,o-z)
      Common Cn(11000),DCS(4,10),itrade,Npt,Rate
      Open(unit=3,file='DigitSource.out')

      Xx=0.3
      Do 10 i=1,Itrade
      Xx=rate*xx*(1-xx)
 10         Continue
      Do 20 i=1,Npt
      Xx=rate*xx*(1-xx)
      Cn(i)=xx
      If(i.le.100)write(3,25)xx
 20         Continue
 25         Format(f10.4)
```

```
      Return
      End
```

APPENDIX-III: RANDOMSTATISTIC.FOR

```
C... This programme compute No of Zero and Number with highest Frequency
C....for 389 Seed values picked using random number generator with seed (6789)
      Implicit real *8(a-h,o-z)
      Dimension Rn(11000),DRS(4,10)
      Open(unit=1,file='Randomparameters')
      Open(unit=2,file='Randomtatistic.out')
      Open(unit=3,file='RndZerofrequncies.out')

C... Read Input Parameters via file
C.... as follow:
      Read(1,*)Npk,Npt
      KC=10
      Do 1000 K=1,Npk
      Read(1,*)seed
      Iseed=Int(seed)
      Isd=iseed
      Do 10 i=1,Npt
      Rn(i)=ran(iseed)
   10       Continue

      CK=1

      Do 20 i=1,1
      Ck=Ck*10
      Do 20 j=1,Npt
      Nr=Int(Rn(j)*Ck)
      Ir=Mod(Nr,Kc)
      Ir=ir+1
      DRS(i,Ir)=Drs(i,ir)+1
   20       Continue
      Count=0.0
      Fmin=0.0
      Ipk=0
      Do 30 i=1,10
      If(Drs(1,i).gt.Fmin)then
      Fmin=Drs(1,i)
      Ipk=i
      Else
      Endif
      If(Drs(1,i).eq.0)then
      Count=count+1
```

```
  Write(3,31)Isd,i-1
  Endif
  Drs(1,i)=0.0
.0 Continue
31 Format(i4,2x,i2)
  Write(2,35)Isd,Count,Ipk-1,Fmin
  If(Mod(k,100).eq.0)Write(*,*)k
1000     Continue
 35      Format(i6,2x,f10.4,2x,i2,2x,f12.2)
  Stop
  End
```