Computer Program Descriptions

The Grazor Search Program for Minimax Objectives

PURPOSE: The grazor search program is a package of subroutines that optimizes the designable parameters of networks or systems to meet minimax objectives.

LANGUAGE: Fortran Version 2.3 and Scope Version 3.3 for the CDC 6400 computer; 901 cards, including comments.

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AVAILABILITY: ASIS-NAPS Document No. NAPS-01889. Listing also available from J. W. Bandler at $15.00.

DESCRIPTION: The grazor search strategy [1] is a gradient method for minimax optimization of network and system responses. Full details of the method, including mathematical flow charts and a discussion of computational experience, are available [1]. As far as possible the variables in the program correspond to those used in that paper.

The user may call the package from his own program as follows.

CALL GRAZOR(ALPHAO, ALPMIN, BETA, EPS, EPS1, ETA, PHO, PSI, K, KR, N, NR, UPHO, TERM).

The Variables

The variables in the argument list are in the following table.

Fortran Name	Variable [1]
ALPHAO	α_o
ALPMIN	$\check{\alpha}$
BETA	β
EPS	ϵ
EPS1	ϵ'
ETA	η
PHO	ϕ^o
PSI	ψ_i
K	k
KR	k_r
N	n
NR	n_r
UPHO	$U_{\phi o}$
TERM	TERM

The input variables are α_0, $\check{\alpha}$, β, ϵ, ϵ', η, ϕ^o, ψ_i, k, k_r, and n, while the output variables are α_o, ϕ^o, k_r, n_r, $U_{\phi o}$, and TERM.

It was convenient to place the following user-specified variables in

COMMON/GRZR/NCOUNT, IPRINT, UNIT, IOPT, IDATA.

NCOUNT Number of function evaluations at any stage of the iterative cycle of grazor, is initially set to zero by the user.

IPRINT Logical variable which, if ·TRUE·, enables all intermediate and final results to be printed out, and no printouts otherwise.

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For program listing, order document NAPS-01889 from ASIS National Auxiliary Publications Service, c/o CCM Information Corporation, 909 Third Avenue, New York, N. Y. 10022; $2.00 per microfiche or $5.00 per photocopy.

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C     ..................................................................
C     A TYPICAL MAIN PROGRAM FOR GRAZOR SEARCH ALGORITHM FOLLOWS--------
      DIMENSION PHO(15),PSI(11)
      LOGICAL TERM,IPRINT,IDATA
      INTEGER UNIT
      COMMON/GRZR/NCOUNT,IPRINT,UNIT,IOPT,IDATA
C     TYPICAL INPUT VALUES FOLLOW
      ALPHAO=1.
      ALPMIN=1.0E-06
      BETA=10.
      ETA=0.01
      KR=1
      NCOUNT=0
      IOPT=0
C
C     INPUT VALUES FOR THE SPECIFIC PROBLEM FOLLOW
      IPRINT=.TRUE.
      IDATA=.TRUE.
      UNIT=6
      EPS=1.0E-03
      EPS1=1.0E-06
      K=2
      N=11
      PHO(1)=1.
      PHO(2)=3.
      PSI(1)=0.5
      DO 1 I=2,N
1     PSI(I)=PSI(I-1)+0.1
C
C     MINIMAX OPTIMIZATION STARTS
      DO 2 I=1,100
      CALL GRAZOR(ALPHAO,ALPMIN,BETA,EPS,EPS1,ETA,PHO,PSI,K,KR,N,NR,UPHO
     1,TERM)
      IF(TERM) GO TO 3
2     CONTINUE
3     STOP
      END
C
C
C     ..................................................................
C     A TYPICAL ANALYSIS PROGRAM FOR GRAZOR SEARCH ALGORITHM FOLLOWS-----
      SUBROUTINE ANAL (PHO,F,DERIV,K,Y,GRADY)
      DIMENSION PHO(1),GRADY(1)
      LOGICAL DERIV
C     THE VALUE OF Y AT A GIVEN SAMPLE POINT F IS CALCULATED HERE
      IF(.NOT.DERIV) RETURN
C     THE DERIVATIVES GRADY(1),GRADY(2),.....,GRADY(K) OF THE FUNCTION Y
C     WITH RESPECT TO PARAMETERS PHO(1),PHO(2),.....,PHO(K) ARE
C     CALCULATED HERE
      RETURN
      END
```

Fig. 1. Typical main program and analysis program for the grazor search package.

UNIT Integer variable specifying the data-set reference number of the output unit.

IOPT Integer variable denoting the number of times grazor search package was called by the user, is set to zero initially by the user.

IDATA Logical variable which, if ·TRUE·, enables the input data to be printed out; otherwise not.

Fig. 1 shows a typical main program for calling the package and the form of a typical analysis program, while Fig. 2 shows typical printouts of the package.

Required Subprograms

ANAL(PHO, F, DERIV, K, Y, GRADY): This user-supplied analysis program calculates the value of function Y and its first partial derivatives GRADY(1), GRADY(2), · · · , GRADY(K) with respect to the variable parameters PHO(1), PHO(2), · · · , PHO(K), at a given sample point F. If DERIV is ·TRUE·, the GRADY are calculated, otherwise they are not calculated.

The grazor search package uses a linear-program solving routine called SIMPLE [2], which is a modified version of a program documented with the SHARE Distribution Agency, and written by R. J. Clasen (Reference No. SDA 3384). A listing is included in the package being made available.

```
THE FOLLOWING IS A LIST OF INPUT DATA
-------------------------------------

ALPHAO   =  1.00000000E+00
ALPMIN   =  1.00000000E-06
BETA     =  1.00000000E+01
EPS      =  1.00000000E-03
EPS1     =  1.00000000E-06
ETA      =  1.00000000E-02
K        =   2
KR       =   1
N        =  11
TERM     =   F

PHO(  1) =  1.00000000E+00
PHO(  2) =  3.00000000E+00

PSI(  1)=  5.00000000E-01   PSI(  2)=  6.00000000E-01   PSI(  3)=  7.00000000E-01   PSI(  4)=  8.00000000E-01
PSI(  5)=  9.00000000E-01   PSI(  6)=  1.00000000E+00   PSI(  7)=  1.10000000E+00   PSI(  8)=  1.20000000E+00
PSI(  9)=  1.30000000E+00   PSI( 10)=  1.40000000E+00   PSI( 11)=  1.50000000E+00   PSI(
```

(a)

THE GRAZOR SEARCH STRATEGY FOR MINIMAX OBJECTIVES

NUMBER OF GRAZOR CALLS IOPT	NUMBER OF FUNCTION EVALUATIONS NCOUNT	MINIMAX OBJECTIVE FUNCTION UPHO	VARIABLE PARAMETER VECTOR PHO
1	1	2.51724138E-01	1.00000000E+00 3.00000000E+00
1	12	1.23403651E-01	1.63929472E+00 3.00571067E+00
2	26	1.22711473E-01	1.63695754E+00 3.00698535E+00
2	40	9.85893848E-02	2.03206966E+00 4.16228197E+00
3	56	9.32257058E-02	2.08102554E+00 4.14559374E+00
4	72	9.22517321E-02	2.18323384E+00 4.37175240E+00
4	84	9.21606710E-02	2.21712712E+00 4.44191859E+00
4	97	9.18506526E-02	2.22026503E+00 4.44040279E+00
4	115	9.18493562E-02	2.22027815E+00 4.44039643E+00
4	132	9.18409273E-02	2.23079478E+00 4.46164347E+00
4	152	9.18381164E-02	2.23082342E+00 4.46162928E+00

```
TERM=.TRUE.,IMPROVEMENT IN OBJECTIVE FUNCTION LESS THAN EPS1=  1.00000000E-06
```

(b)

Fig. 2. (a) Typical printout if IDATA is .TRUE. (b) Typical printout if IPRINT is .TRUE.

Comments

As it stands, the package has been programmed to handle up to 15 variable parameters and 15 ripples. The choice of input parameters, including scale factors, may be critical to the efficiency of the algorithm, and the grazor search strategy should be well understood before the user attempts to use this program. The package requires roughly 20 000 octal units of computer memory.

Discussion

The grazor search algorithm has been programmed in such a way that it allows a certain amount of flexibility to the user. Thus, when GRAZOR is called once, one complete iterative step of the algorithm results, and by introducing GRAZOR in a DO loop the user has the complete freedom to make his own decision about termination subject to his own convergence criteria, or printing out intermediate results according to a preferred format, or branching out to another optimization package if desired. Appropriate diagnostic messages are provided in the program wherever necessary.

As this is a gradient strategy, it is important that the gradients as evaluated by the analysis program are correct.

Acknowledgment

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References

[1] J. W. Bandler, T. V. Srinivasan, and C. Charalambous, "Minimax optimization of networks by grazor search," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-20, pp. 596–604, Sept. 1972.
[2] Subroutine SIMPLE, Data Processing and Computing Centre, McMaster Univ., Hamilton, Ont., Canada, Library Information Sheet MILIS 5.3.130.