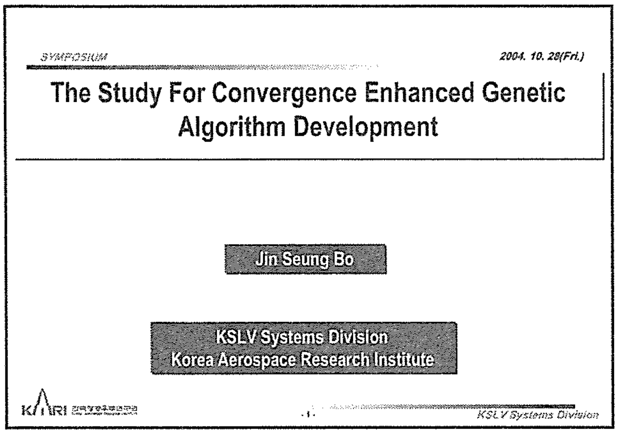
SYMPOSIUM
2004. 10. 28(Fri.)
The Study For Convergence Enhanced Genetic Algorithm Development
Jin Seung Bo
KSLV Systems Division
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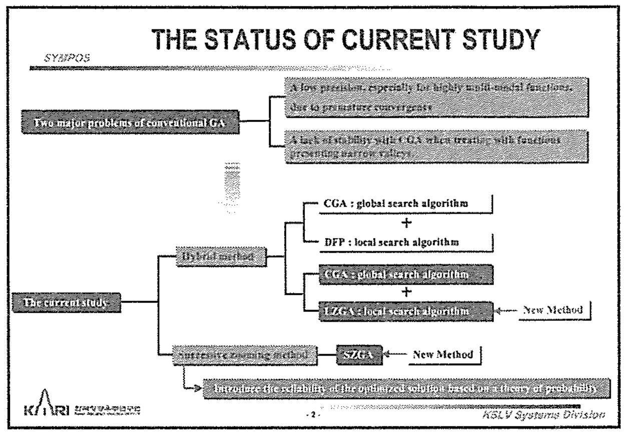
THE STATUS OF CURRENT STUDY
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Two major problems of conventional GA
A low precision, especially for highly multi-modal functions, due to premature convergence
A lack of stability with CGA when treating with functions presenting narrow valleys.
The current study
Hybrid method
CGA : global search algorithm
+
DFP : local search algorithm
CGA : global search algorithm
+
LZGA : local search algorithm
New Method
Successive zooming method
SZGA
New Method
Introduce the reliability of the optimized solution based on a theory of probability
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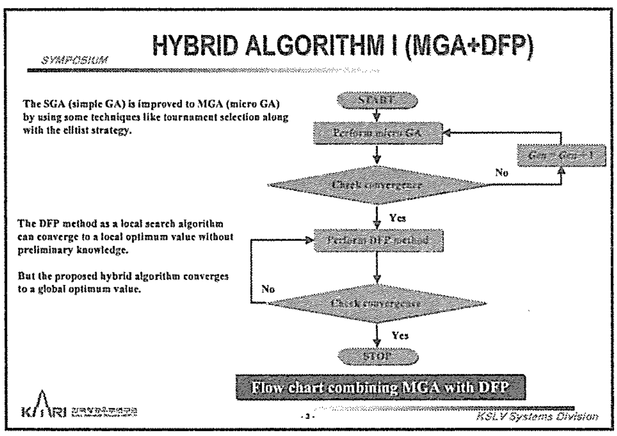
HYBRID ALGORITHM I (MGA+DFP)
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The SGA (simple GA) is improved to MGA (micro GA) by using some techniques like tournament selection along with the elitist strategy.
The DFP method as a local search algorithm can converge to a local optimum value without preliminary knowledge.
But the proposed hybrid algorithm converges to a global optimum value.
START
Perform micro GA
Gen = Gen + 1
No
Check convergence
Yes
Perform DFP method
No
Check convergence
Yes
STOP
Flow chart combining MGA with DFP
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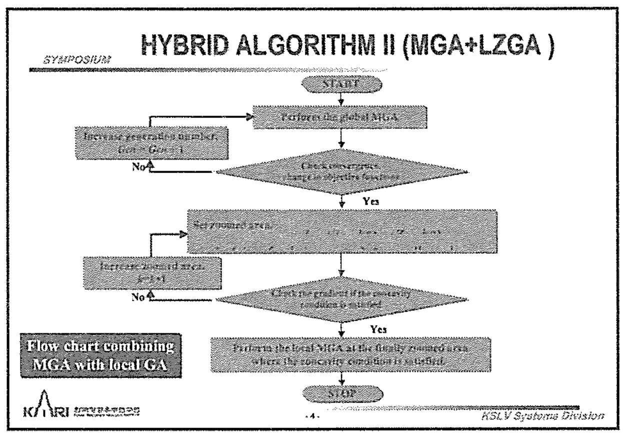
HYBRID ALGORITHM II (MGA+LZGA)
SYMPOSIUM
START
Perform the global MGA
Increase generation number, Gen = Gen + 1
No
Yes
Set zoomed area
Increase zoomed area, k=k+1
No
Yes
Perform the local MGA at the finally zoomed area where the concavity condition is satisfied.
STOP
Flow chart combining MGA with local GA
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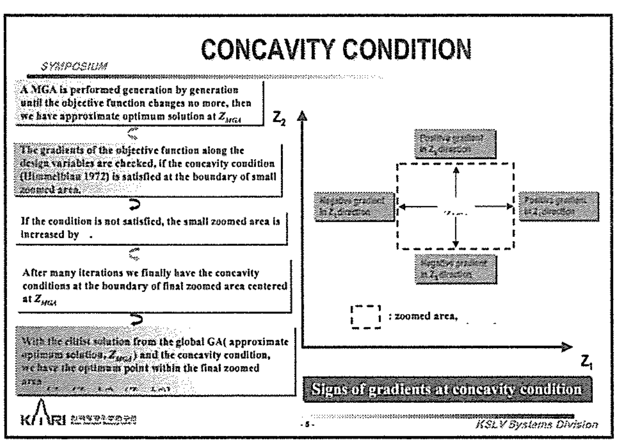
CONCAVITY CONDITION
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A MGA is performed generation by generation until the objective function changes no more, then we have approximate optimum solution at Z_{MGA}
The gradients of the objective function along the design variables are checked, if the concavity condition (Himmelblau 1972) is satisfied at the boundary of small zoomed area.
If the condition is not satisfied, the small zoomed area is increased by .
After many iterations we finally have the concavity conditions at the boundary of final zoomed area centered at Z_{MGA}
With the elitist solution from the global GA(approximate optimum solution, Z_{MGA}) and the concavity condition, we have the optimum point within the final zoomed area
Z_2
Z_1
: zoomed area,
Signs of gradients at concavity condition
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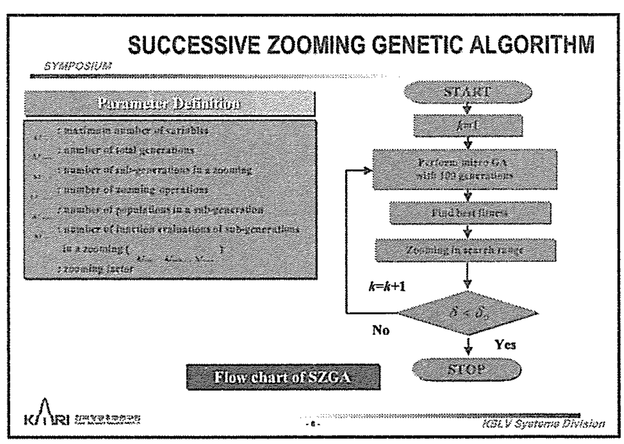
SUCCESSIVE ZOOMING GENETIC ALGORITHM
SYMPOSIUM
Parameter Definition
: maximum number of variables
: number of total generations
: number of zooming operations
: number of populations in a sub-generation
: zooming factor
START
k=1
Find best fitness
Zooming in search range
k=k+1
No
Yes
STOP
Flow chart of SZGA
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SUCCESSIVE ZOOMING METHOD

SYMPOSIUM

Zooming Technique

Main idea : smart reduction of search space around the candidate optimum point, continuous zooming factor

Zooming procedure : search domain is reduced to $(x_{kopt} - (\alpha^k/2), x_{kopt} + (\alpha^k/2))$, then a new initial population is generated within the new boundaries and an MGA applied again.

Convergence criteria : $\left| \frac{x_{N_{gen}+1} - x_{N_{gen}}}{x_{N_{gen}}} \right| < \delta$

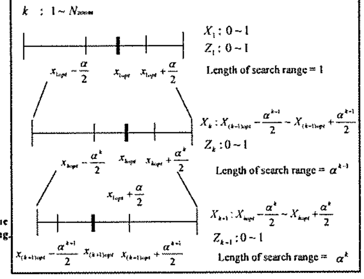
(error ratio = $\delta = 10^{-6}$: will be different according to each problem)

If we use a α grater than the value required for the specified value of reliability, that is the backtracking. This kind of backtracking is continuous while the backtracking in DPE is discrete (digital)

X_k : Global variable(dimensionless)

Z_k : Local variable(dimensionless in zoomed range)

k : $1 \sim N_{zoom}$



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RELIABILITY OF SOLUTION

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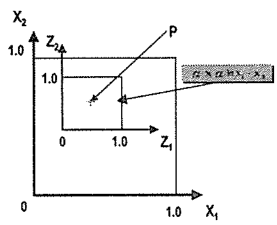
P : Optimum point within zoom interval



Solution space(2-D case)

X : local coordinate, Z : global coordinate

The range of X and Z are 0-1.0, plus the fitness F(Z) is also between 0 and 1.0

The relation of $Z_{range} = \alpha^{N_{zoom}-1}$ is accomplished.

where Z_{range}, as related to the resolution of the solutions, means the dimensionless search domain length after N zooming.

For example, when $N_{zoom}=6$ and $\alpha=0.1$, Z_{range} becomes $1.0E-05$

Relation between N_{zoom} and Z_{range}

N_{zoom}	1	2	3	4	5	6
Z_{range}	α^0	α^1	α^2	α^3	α^4	α^5

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RELIABILITY OF RANDOM ALGORITHM

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In the case of a random search, the probability that at least one search point falls within the zoom interval :

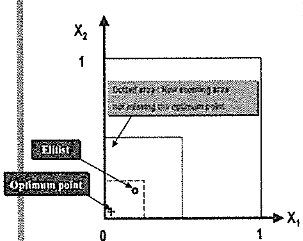
$$P_{sub}^{RA} = 1 - (1 - (\alpha/2)^{N_{var}})^{N_{p}}$$

N_{var} : the probability that one search point falls within [illegible] for the 2-D case([illegible]), range (red zone) during one function evaluation.

N_{var} : the probability that one search point falls out of [illegible] for the 2-D case range during one function evaluation.

: the probability that every search point falls out of [illegible] for the 2-D case range during an [illegible] function evaluation.

: the probability that at least one search point falls within [illegible] for the 2-D case range during an [illegible] function evaluation.



Worst case

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RELIABILITY OF GENETIC ALGORITHM

SYMPOSIUM

In the case of a GA, the probability becomes larger than or equal to the probability of using a random search.

$$P_{sub}^{GA} \geq P_{sub}^{RA} = 1 - (1 - (\alpha/2)^{N_{var}})^{N_{p}}$$

After progressing 100 generation , the probability that at least one search point falls within the zoom interval

[illegible]

To express the degree of improvement, the improvement factor [illegible] is introduced, the exact definition for which can be defined as the ratio of the number of individuals within the zoom interval [illegible] between a random search and a GA

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FINAL RELIABILITY

SYMPOSIUM

After N zooming, the final existence probability of a search point within the zoom interval, which is the probability the optimum point will not be missed.

[illegible]

The GA case is

[illegible]

For example, consider two-dimensional cases with the following parameters :

[illegible]

Probability in case of genetic algorithm

[illegible]	1	2	10	[illegible]
[illegible]	0.9182	0.9933	[illegible]	[illegible]
[illegible]	0.6526	0.9672	[illegible]	[illegible]

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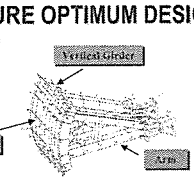
APPLICATION OF STRUCTURE OPTIMUM DESIGN

SYMPOSIUM

Selecting the location of a radial arm is very important because the size of the member supporting the working stress is affected by the location of the radial arm.



Radial Gate

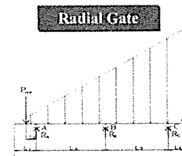
Weight minimization is obtained by minimizing the volumes because the density is constant. (Structure Engineering and Mechanics)

Formulation

Minimize [illegible] = max. volume of gate,

subject to [illegible]

[illegible] = dimensionless lengths



FBD of radial gate with 3 - arms

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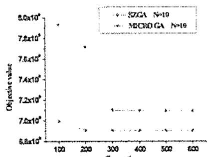
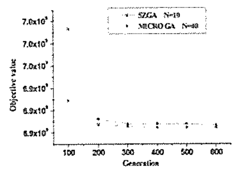
OPTIMUM RESULT I

SYMPOSIUM

Comparison of results according to algorithms

	Number of variable	Convergence gene	Gene size	Population	Weight
Micro-GA	3	9000	36	10	6.90720E+9
MGA+DFP	3	4000	36	10	6.90490E+9
MGA+LZGA	3	700	36	10	6.90490E+9
SZGA	3	400	36	10	6.90490E+9





Convergence according to generation

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OPTIMUM RESULT II

SYMPOSIUM

Optimum results of a 3-arm type

Three-arm		Value of optimization	Optimum value: Girder only	Optimum value: Girder and Arm
Ration of length	R_1	1.66670E-01	9.41670E-02	9.41670E-02
	R_2	3.33330E-01	4.062740E-01	4.062740E-01
	R_3	3.33330E-01	3.67890E-01	3.67890E-01
	R_4	1.66667E-01	7.52030E-02	7.52030E-02
Reaction (*kg/mm*)	R_A	4.01600E+01	3.04620E+01	3.04620E+01
	R_B	1.09030E+01	4.91990E+01	4.91990E+01
	R_C	9.10070E+01	6.24090E+01	6.24090E+01
Moment (*kg mm/mm*)	M_A	4.65420E+04	[illegible]	[illegible]
	M_B	6.97690E+03	[illegible]	[illegible]
	M_C	8.10750E+04	[illegible]	[illegible]
Section modulus (mm^3)	Z_1	4.07610E+06	1.26850E+06	1.26850E+06
	Z_2	3.37810E+06	1.05130E+06	1.05130E+06

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CONCLUSION

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- ✓ Two hybrid algorithm and SZGA were proposed to improve the local-tuning ability
  - ➢ GA+DFP incorporates the advantages of both a genetic algorithm and local search algorithm
  - ➢ LZGA used GA for global solution and LGA for local solution
  - ➢ SZGA presents a GA with successive zooming that involves a smart reduction of the search space : The reliability of the identified solution is deduced from a probability theory and an improvement factor [illegible] is introduced to express the degree of probability amelioration.
- ✓ The weight of the radial gate was minimized using an optimization technique involving a genetic algorithm.

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