PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Evolutionary Algorithms, ulated Annealing, and Tabu Search: A Comparative Study

H. Youssef, S. M. Sait,

H. Adiche

{youssef,sadiq}@ccse.kfupm.edu.sa

Department of Computer Engineering

King Fahd University of Petroleum and Minerals

Dhahran, Saudi Arabia

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Talk outline

- Introduction
- Test Problem
- GA, SA, and TS
- Experimental Results

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Introduction

- General iterative Algorithms
  - » general and ñeasyòto implement
  - » approximation algorithms
  - » must be told when to stop
  - » hill-climbing
  - » convergence

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Introduction (Contd.)

- Algorithm
  - » Initialize parameters and data structures
  - » construct initial solution(s)
  - » Repeat
    - ï Repeat
      - Generate new solution(s)
      - Select solution(s)
    - ï Until time to adapt parameters
    - ï Update parameters
  - » Until time to stop
- End

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Introduction (Contd.)

- Most popular algorithms of this class
  - » Genetic Algorithms
    - ï Probabilistic algorithm inspired by evolutionary mechanisms
  - » Simulated Annealing
    - ï Probabilistic algorithm inspired by the annealing of metals
  - » Tabu Search
    - ï Meta-heuristic which is a generalization of local search

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Floorplanning

- Given
  - » n rectangular blocks
    - ï area and shape constraints
  - » connectivity information
  - » performance constraints (delay)
  - » Floorplan area and shape constraints

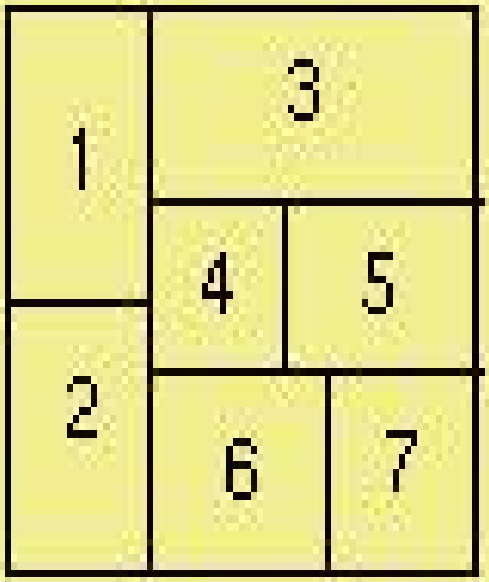
PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

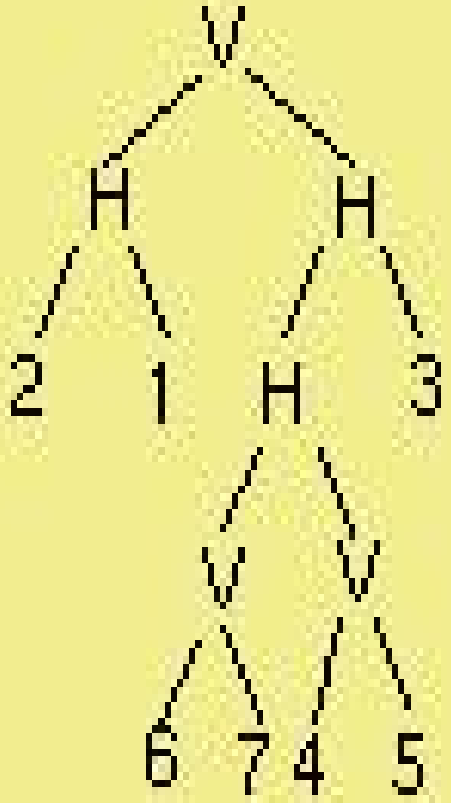
Floorplanning

- Output
  - » each block
    - ï location and dimensions
  - » meet all constraints
    - ï area and shape
    - ï performance

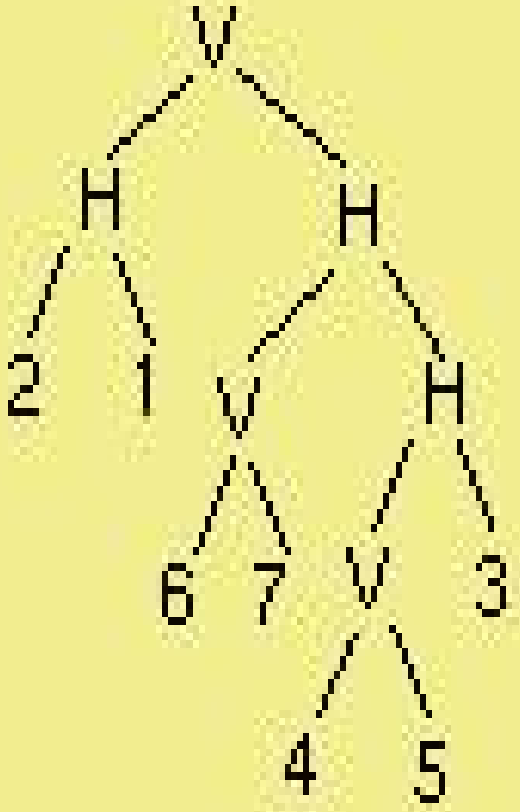
PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Slicing floorplan





21H67V45VH3HV



21H67V45V3HHV

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Evaluation Function

- Evaluation function to compare solutions of successive iterations.
- Floorplanning
  - » area
  - » wire length
  - » delay
- Use of fuzzy algebra

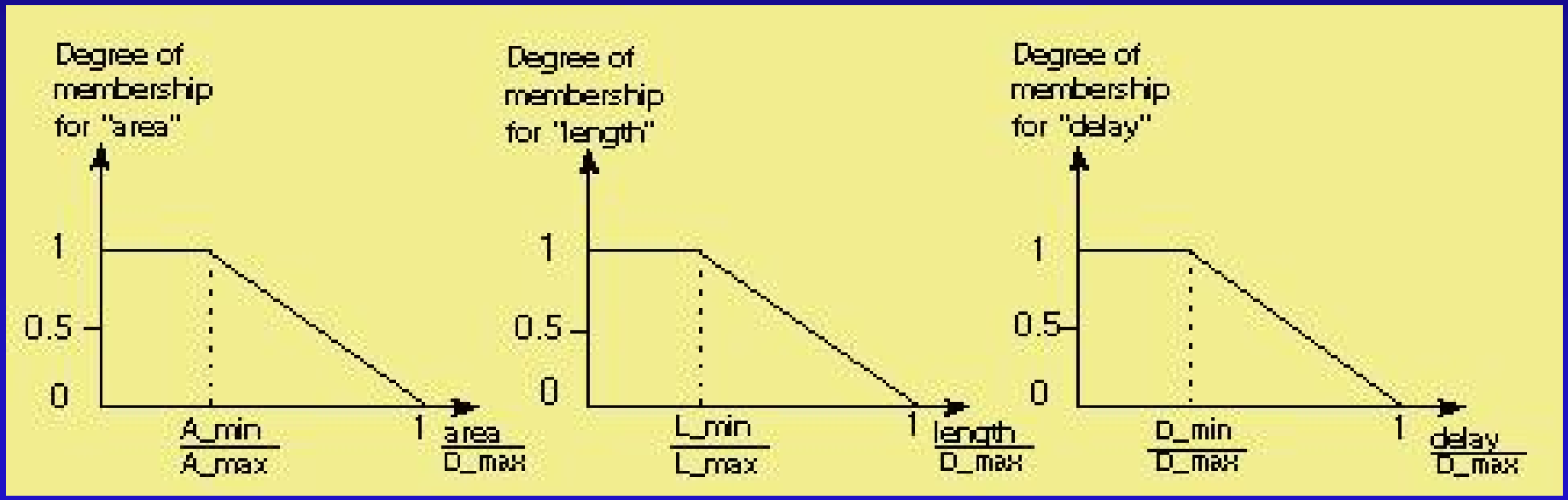
PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Fuzzy evaluation function

- Three linguistic variables
  - » Area, length, delay
- One linguistic value per linguistic variable
  - » Area --> small area
  - » Length --> short length
  - » Delay --> low delay

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Membership functions



PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Fuzzy rule

- Fuzzy subset of good floorplan solutions is characterized by the following fuzzy rule

- Rule:
  - **If** (small area) **OR** (short length) **OR** (low delay) **Then** good solution

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Fuzzy rule

- Rule:
  - » **If** (small area) **OR** (short length) **OR** (low delay) **Then** good solution
- OR-Like Ordered Weighted Averaging Operator combined with **concentration** and **dilation**

$$\mu_{(s)}(x) = \beta \times \max(\mu_A^{\frac{1}{2}}, \mu_L^2, \mu_D^2) + (1-\beta) \times \frac{1}{3}(\mu_A^{\frac{1}{2}} + \mu_L^2 + \mu_D^2)$$

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Genetic Algorithms

- **Chromosomes** represent points in the search space **(Chromosome = Polish Expression)**
- Each iteration is referred to as **generation**
- New sets of strings called **offsprings** are created in each generation by **mating**
- Cost function is translated to a fitness function
- From the pool of parents and offsprings, candidates for the next generation are selected based on their **fitness**

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Requirements

- To represent solutions as strings of symbols or chromosomes
- **Operators:** To operate on parent chromosomes to generate offsprings (crossover, mutation, inversion)
- Mechanism for **choice of parents** for mating
- A **selection** mechanism
- A mechanism to efficiently compute the fitness

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Decisions to be made

- What is an efficient chromosomal representation?
- Probability of crossover (P_c)? Generally close to 1
- Probability of mutation (P_m) kept very very small, 1% - 5% (Schema theorem)
- Type of crossover and Mutation scheme?
- Size of the population? How to construct the initial population?
- What selection mechanism to use, and the generation gap (i.e., what percentage of population to be replaced during each generation?)

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Simulated Annealing

- Most popular and well developed technique
- Inspired by the cooling of metals
- Based on the Metropolis experiment
- Accepts bad moves with a probability that is a decreasing function of temperature

$$\text{pr(accept)} = \exp(-\Delta E)/KT$$

- E represents energy (cost)

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

The Basic Algorithm

- Start with
  - » a random solution
  - » a reasonably high value of T (dependent on application)
- Call the Metropolis function
- Update parameters
  - » Decrease temperature (T*α)
  - » Increase number of iterations in loop, i.e., M, (M*β)
- Keep doing so until freezing, or, out of time

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Metropolis Loop

- **Repeat**

  Generate a neighbor solution;

  ΔCost = Cost(newS) - Cost(currentS);

  If ΔCost<0 **then** accept

  else accept only **if** Random < exp(-ΔCost(/T));

  Decrement M

- **Until** M=0

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Parameters

- Also known as the cooling schedule:
  - » comprises
    - ï choice of proper values of initial temperature **To**
    - ï decrement factor α **<1**
    - ï parameter β **>1**
    - ï M (how many times the Metropolis loop is executed)
    - ï stopping criterion

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Tabu Search

- Generalization of Local Search
- At each step, the local neighborhood of the current solution is explored and the best solution is selected as the next solution
- This best neighbor solution is accepted even if it is worse than the current solution (hill climbing)

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Central Idea

- Exploitation of memory structures
- Short term memory
  - » Tabu list
  - » Aspiration criterion
- Intermediate memory for intensification
  - » used to target a specific region in the space and search around it thoroughly
- Long term memory for diversification
  - » used to store information such as frequency of a move to take search into unvisited regions.

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Basic Short-Term TS

1. Start with an initial feasible solution
2. Initialize Tabu list and aspiration level
3. Generate a **subset** of neighborhood and find the best solution from the generated ones
4. If move in not in **tabu list** then accept

   else

   If move satisfies **aspiration criterion** then accept
5. Repeat above 2 steps until **terminating condition**

PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Implementation related issues

- Size of candidate list?
- Size of tabu list?
- What aspiration criterion to use?
- Fixed or dynamic tabu list?
- What intensification strategy?
- What diversification scheme to use?

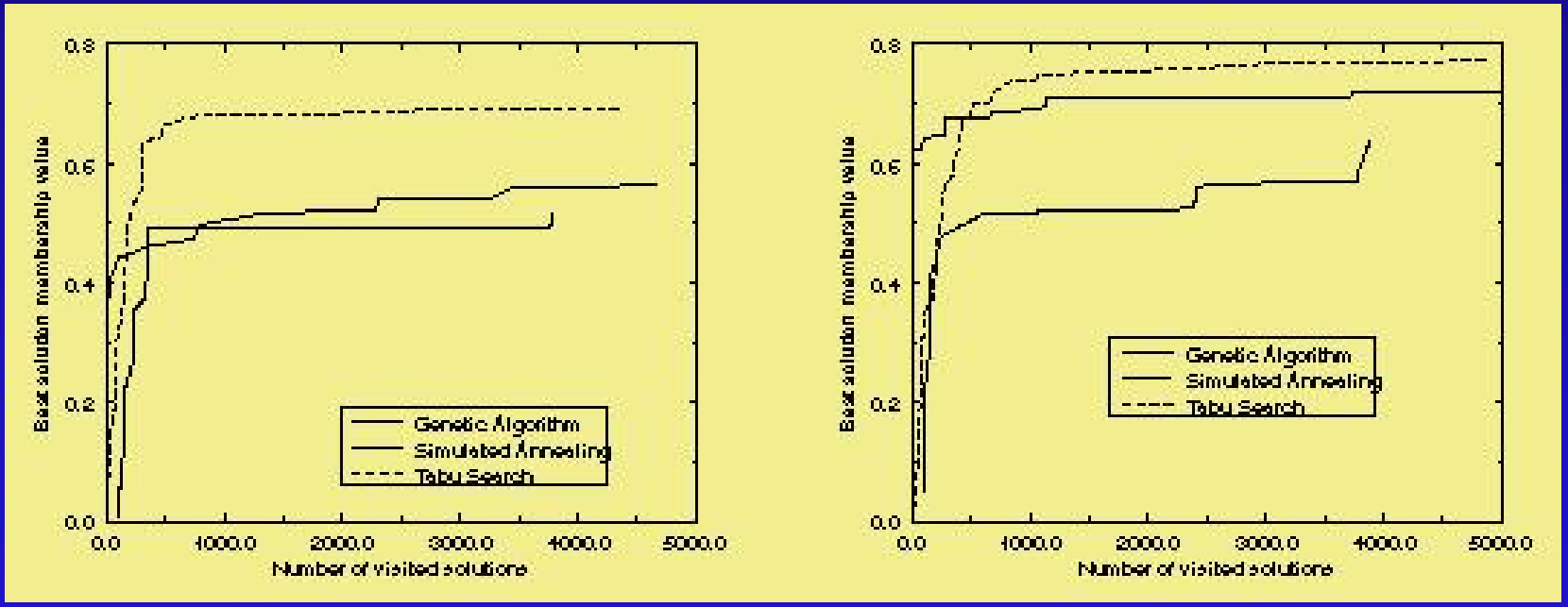
PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Ex

- Quality of best solution
- Progress of the search until stoppage time
- Quality of solution subspaces searched

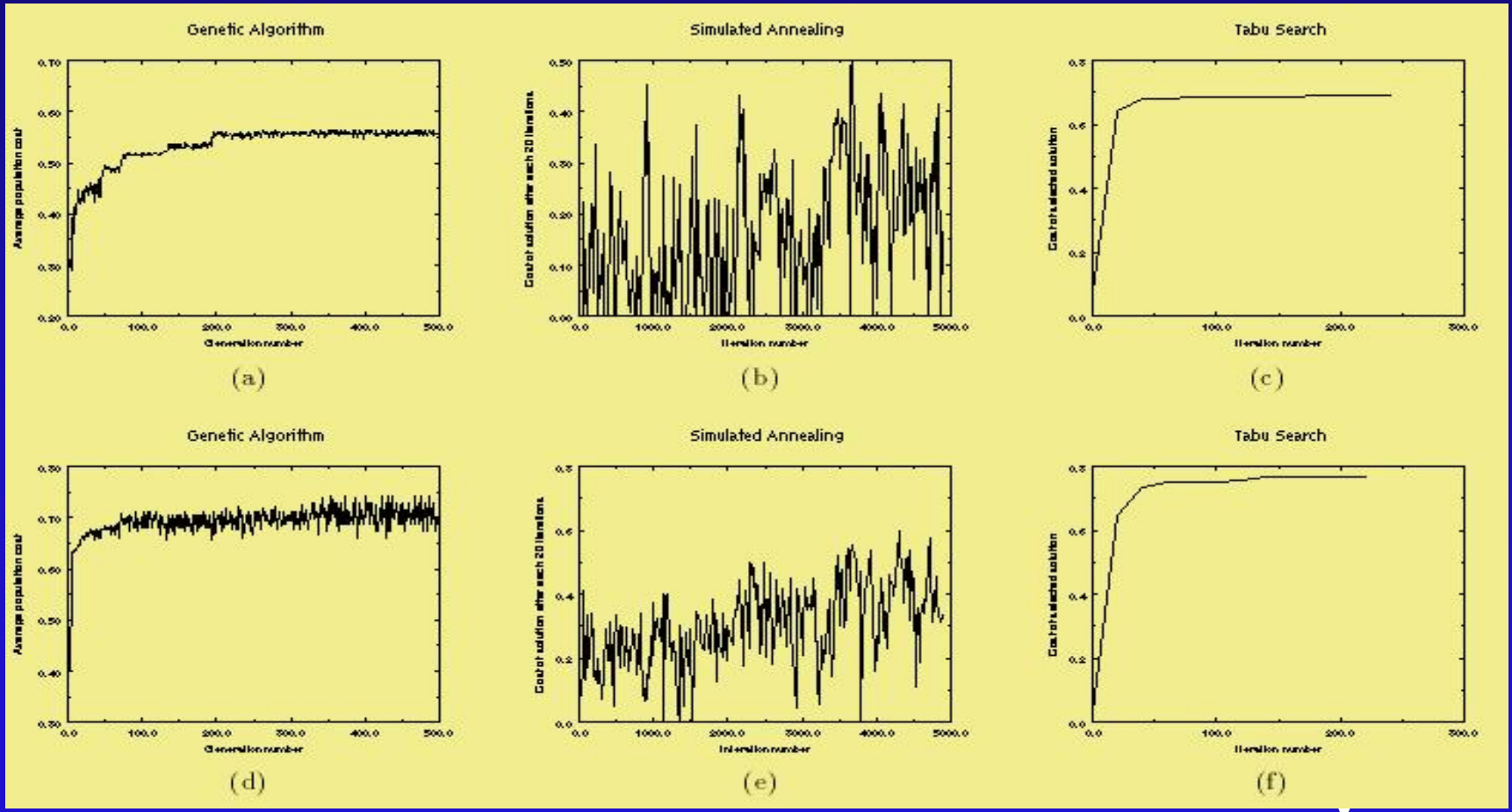
PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Best solution



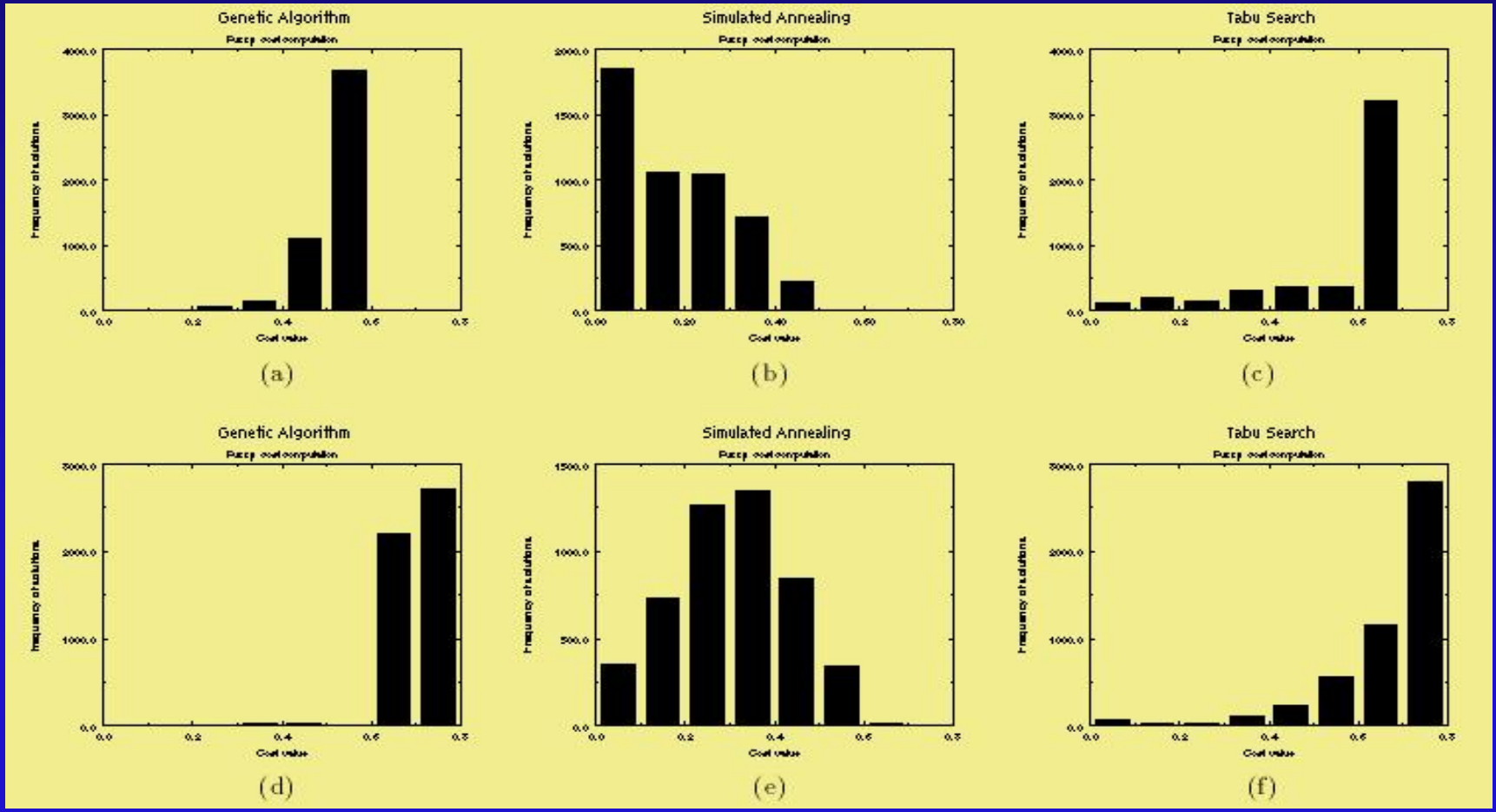
PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Progress of the search



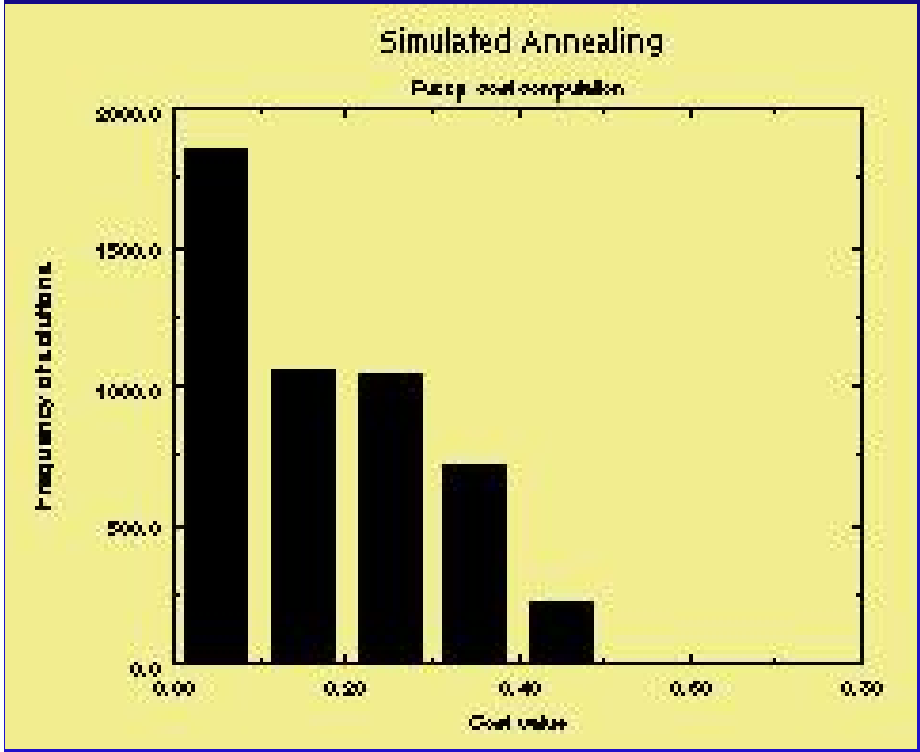
PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

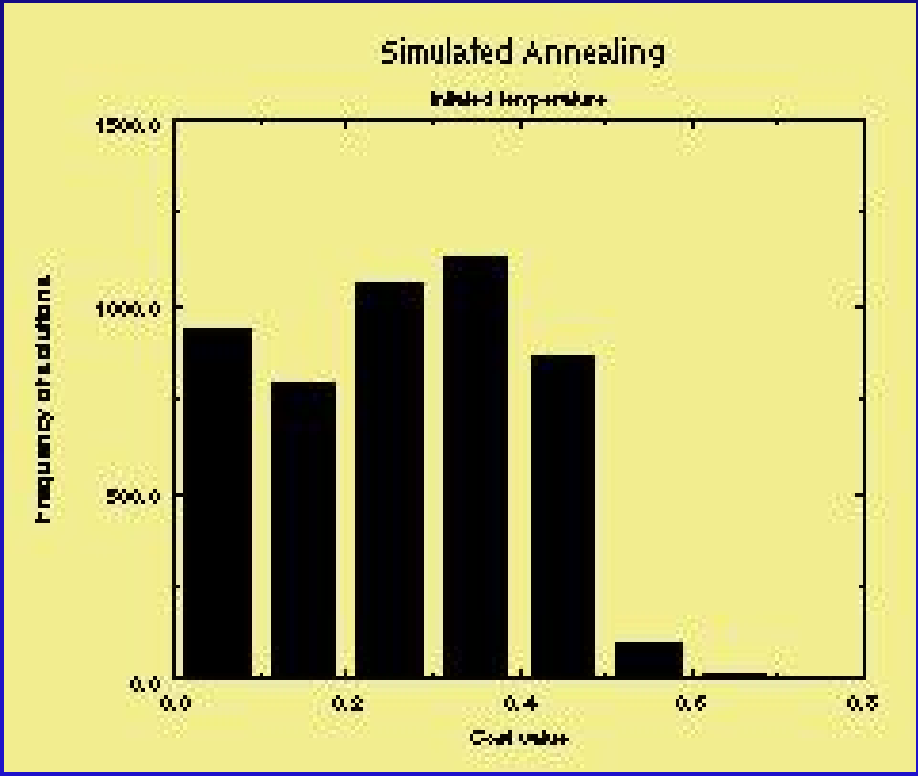
Quality of subspaces searched



PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

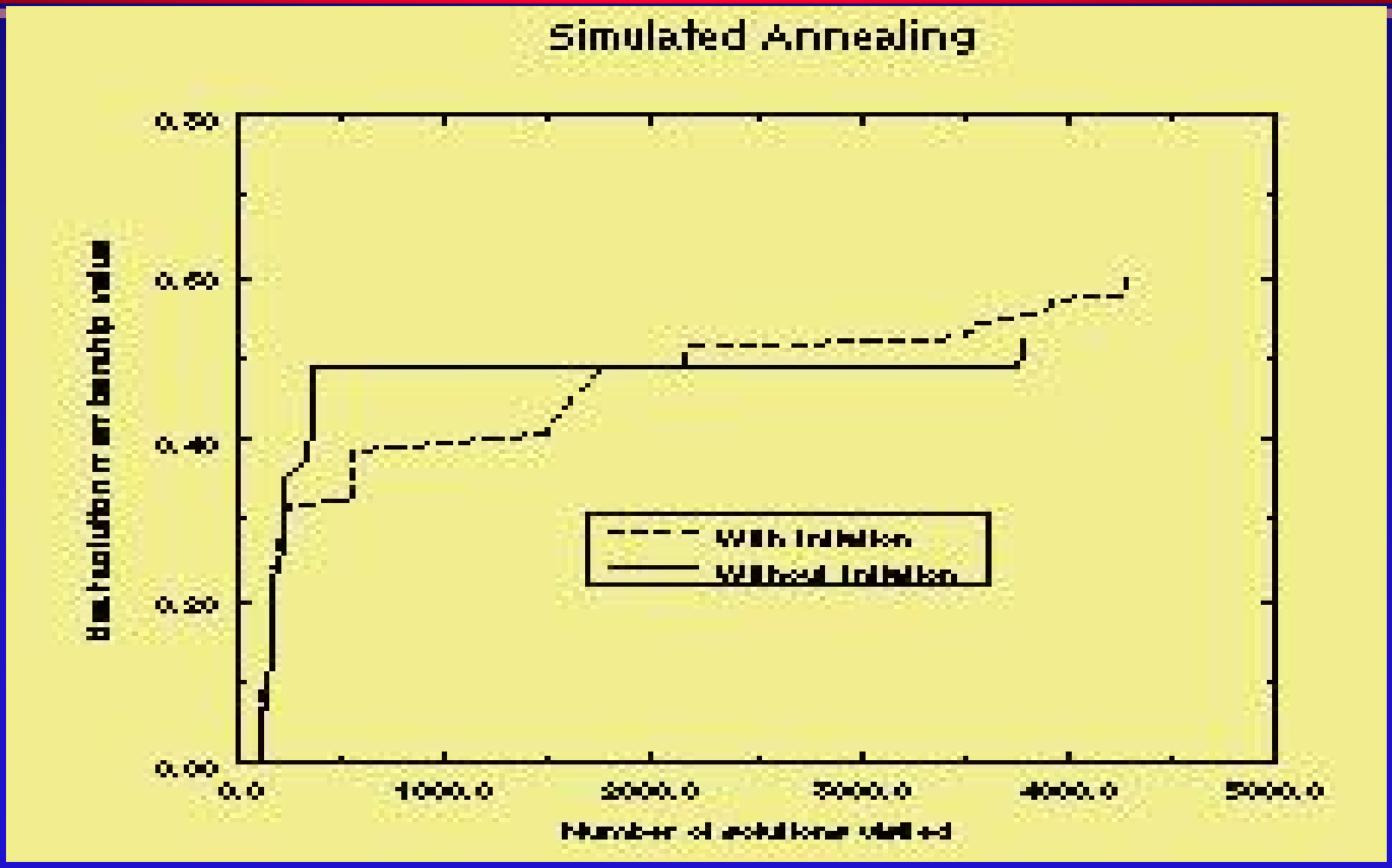
Effect of cost inflation on SA





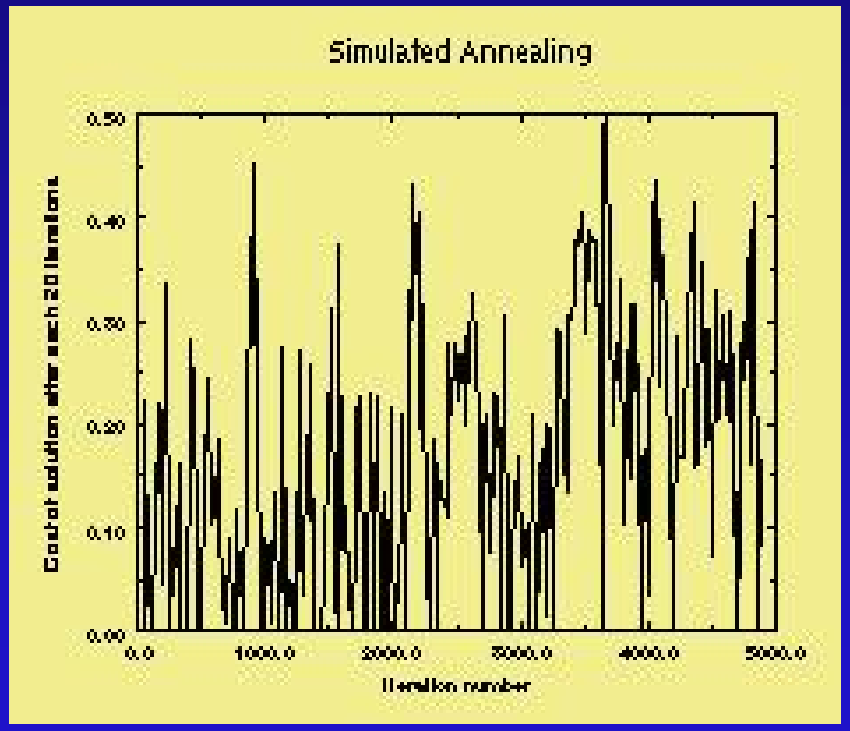
PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

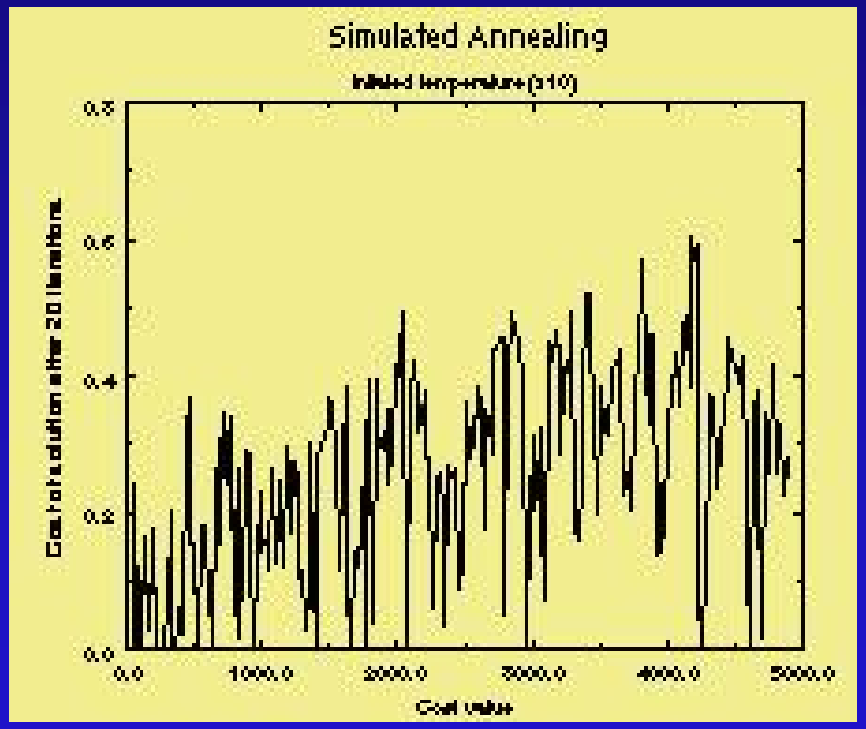
Effect of cost inflation on SA



PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Effect of cost inflation on SA





PDF Complete
Your complimentary use period has ended. Thank you for using PDF Complete.
Click Here to upgrade to Unlimited Pages and Expanded Features

Questions?