Master of Technology

Computational Intelligence II

GA Workshop 1: Load Distribution Problem

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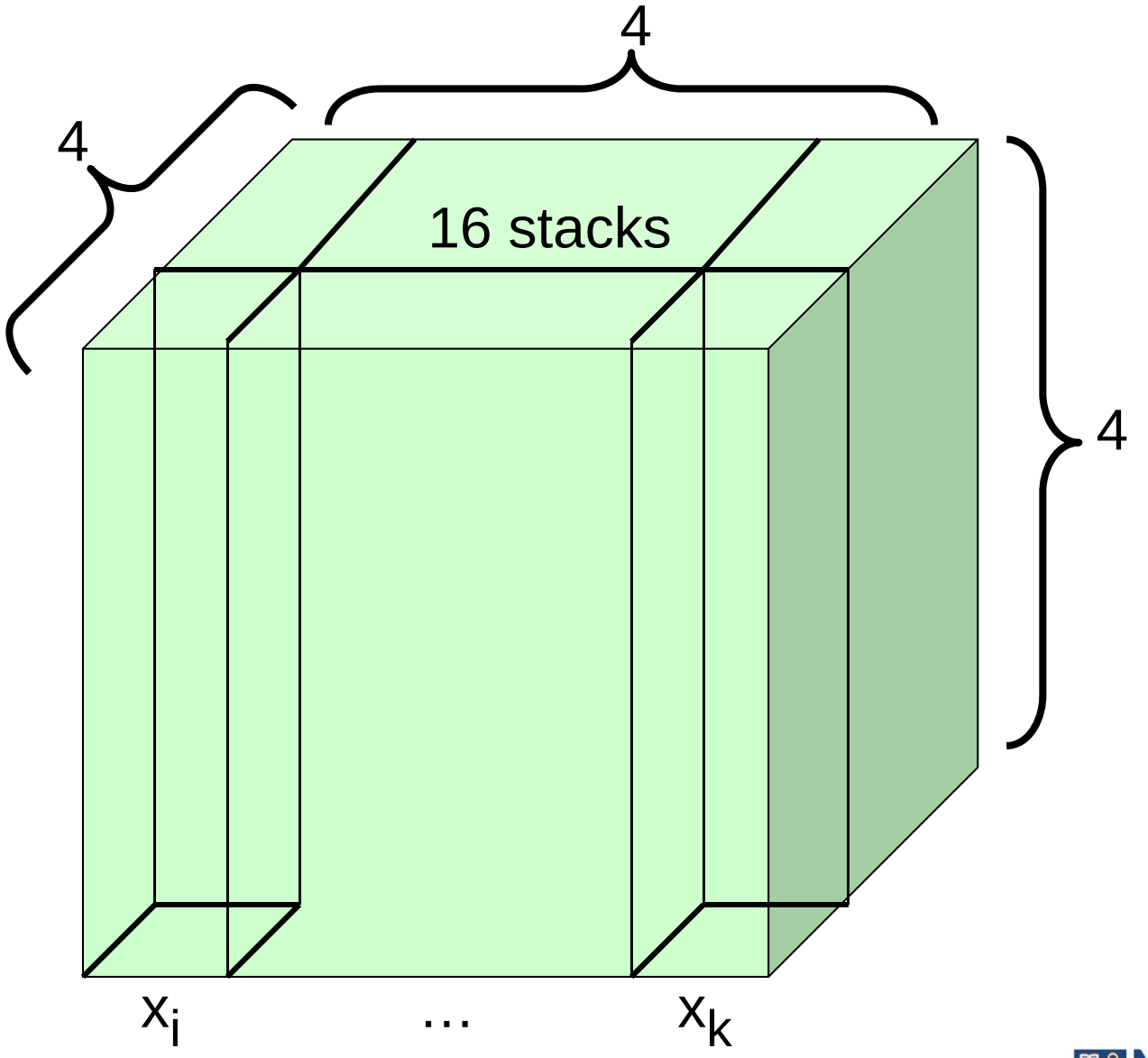
Problem Description

- In loading containers into a vessel or loading packages into an aircraft, the distribution of the weights should be more or less uniform.
- It is assumed the holding space for the containers or packages can be divided into 64 rectangular spaces.
- It is also necessary to ensure that the lighter containers or packages are on top of the heavier ones.
- The solution needs to determine how the packages are to be assigned to the rectangular spaces to ensure uniform distribution.

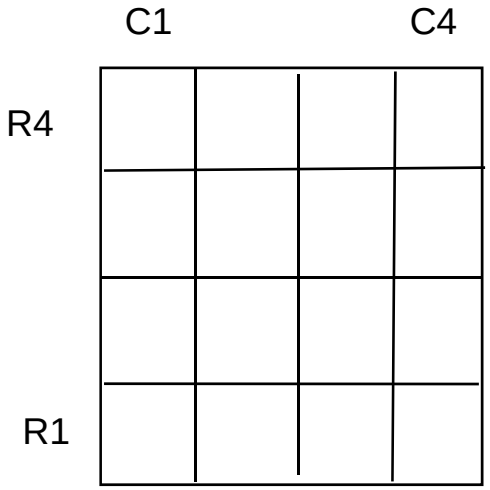
Problem Description

Package ID	Weight	Package ID	Weight
1	27	33	66
2	57	34	63
3	33	35	53
4	55	36	37
5	65	37	53
6	26	38	67
7	21	39	32
8	28	40	44
9	43	41	53
10	40	42	47
11	27	43	39
12	62	44	38
13	25	45	46
14	33	46	67
15	67	47	36
16	30	48	30
17	46	49	37
18	31	50	43
19	58	51	68
20	59	52	50
21	37	53	64
22	55	54	32
23	61	55	32
24	25	56	59
25	38	57	24
26	65	58	67
27	51	59	54
28	30	60	23
29	40	61	49
30	69	62	60
31	33	63	65
32	61	64	35

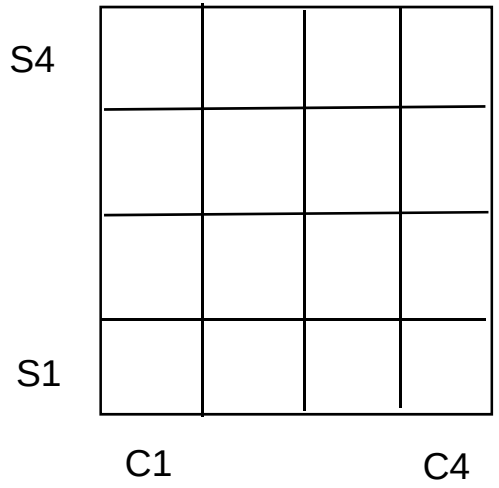
Graphical Representation



Graphical Representation



Looking from the side of a vessel



Looking from the aeroplane view of a vessel

Problem Model

1. Required information

- Supplied by client
  - Package ID
  - Package weight
  - Container/space location ID
- Derived by our model
  - Averages
  - Standard deviation

Problem Model

2. Representation of solution – we have some options

A. Assigning packages to locations

- The location remain static but the assigned packages change
- In this model, the chromosome consists of Package IDs

B. Assigning locations to packages

- The packages remain static but the assigned locations change
- In this model, the chromosome consists of location IDs

Problem Model

3. Fitness function

- Two different averages (of weights)
  - Overall across all packages (static)
  - For each stack (changes with assigned packages)
- Minimise the spread between the average stack weights and the overall average weight

Minimise $\sum_i (x_i - AV)^2$

where x_i is the average package weight in each stack and AV is the average of all the packages.

Problem Model

4. Constraints

- Exactly sixteen stacks, each with four levels
- Lighter packages on top of heavier ones – we don't want to have crushed packages upon arrival
- Explain how each constraint can be addressed based on the solution representation

Handling Constraints

- We were asked to propose only those solutions with lighter packages above heavier ones

  BUT

  we don't need to use hard constraints
- Hard constraints have an adverse impact on performance due to the generate-and-test strategy GA uses

Handling Constraints

- Options for handling weight-ordering constraint
  - Using soft constraints
    - Factor in the degree of the violation
    - Include this as penalty to fitness function,
      BUT may need to scale penalty appropriately
  - Not using GA constraints at all!
    - Don't feel trapped into using GA constraints for everything
    - Simply sort the packages in each stack after finding a good solution – fitness is not affected!

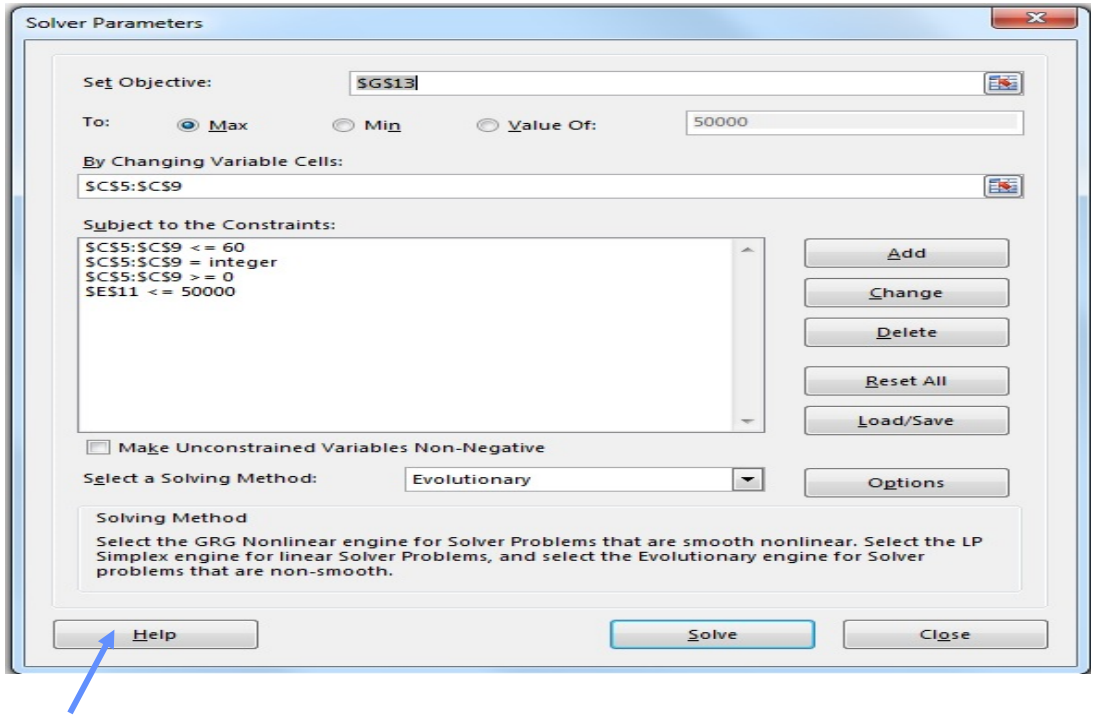
Appendix: Excel Solver

How to Load the Excel Solver Add-in

- **Open Excel**
- Click the **File** tab, and then click **Options**.
- Click **Add-Ins**, and then in the **Manage** box, select **Excel Add-ins**.
- Click **Go**.
- In the **Add-Ins available** box, select the **Solver Add-in** check box, and then click **OK**.
- If **Solver Add-in** is not listed in the **Add-Ins available** box, click **Browse** to locate the add-in.
- If you get prompted that the Solver add-in is not currently installed on your computer, click **Yes** to install it.
- After you load the Solver add-in, the **Solver** command is available in the **Analysis** group on the **Data** tab.

Excel Solver

- Excel Solver Help
  - http://www.solver.com/excel-solver-help



#Click HELP to get the help file.

GA Modelling – Excel Solver

Step 1:

- Decide what you are optimising for (e.g. maximise profit). This 'goodness measure' or objective will eventually translate into a fitness function

Step 2:

- Represent each solution chromosome as an array of real numbers or integers
- E.g. to find the best split of funds that will allow a company to maximise profits

advertising	marketing	production	salary		profit
8%	12%	50%	30%		$2780

One solution **Fitness function**

GA Modelling – Excel Solver

Step 3:

- Write a **fitness function** that evaluates the goodness of a solution chromosome.
- This function takes as input a candidate solution and returns a number that indicates how good the solution is (e.g. the amount of expected profit)

Step 4:

- Define any constraints on the values of your solution chromosome.

Exercise 1

The following jobs can be processed on any of the 5 machines. How can these jobs be assigned to the machine so that the total processing time for the jobs is minimum. The time taken to process each job on each machine is known.

Set the Excel spreadsheet as shown.

	A	B	C	D	E	F
1		Machine ID	Process Time			
2	Job1	1	=INDEX($B$11:$F$15,1, B2)			
3	Job2	2	=INDEX($B$11:$F$15, 2, B3)			
4	Job3	3	=INDEX($B$11:$F$15, 3, B4)			
5	Job4	4	=INDEX($B$11:$F$15, 4, B5)			
6	Job5	5	=INDEX($B$11:$F$15, 5, B6)			
7		Total	=SUM(C2:C6)			
8						
9						
10	Machine ID	1	2	3	4	5
11	Job1	12	45	23	33	12
12	Job2	34	13	8	14	25
13	Job3	22	13	33	15	24
14	Job4	14	56	23	12	26
15	Job5	4	13	23	34	27

Exercise 2

You have a group of students whose average overall performance are known. You are required to divide them into 3 groups so that the members of each group can interact well with each other. To ensure that they can interact well with each other the deviations of their performance should be minimum.

Set the Excel spreadsheet as shown

	A	B	C	D	E	F
1	Student	Performance	Group	Group1	Group2	Group3
2	Tom	50	1	IF(C2=1, B2,"0")	IF(C2=2, B2, "0")	IF(C2=3, B2, "0")
3	Jerry	67	2	IF(C3=1, B3, "0")	IF(C3=2, B3, "0")	IF(C3=3, B3, "0")
4	Ann	34	3	IF(C4=1, B4, "0")	IF(C4=2, B4, "0")	IF(C4=3, B4, "0")
5	Bob	55	1	IF(C5=1, B5, "0")	IF(C5=2, B5, "0")	IF(C5=3, B5, "0")
6	June	80	2	IF(C6=1, B6, "0")	IF(C6=2, B6, "0")	IF(C6=3, B6, "0")
7	Nancy	90	3	IF(C7=1, B7, "0")	IF(C7=2, B7, "0")	IF(C7=3, B7, "0")
8	Mike	77	1	IF(C8=1, B8, "0")	IF(C8=2, B8, "0")	IF(C8=3, B8, "0")
9	Dolly	55	2	IF(C9=1, B9, "0")	IF(C9=2, B9, "0")	IF(C9=3, B9, "0")
10	Paul	66	3	IF(C10=1, B10, "0")	IF(C10=2, B10, "0")	IF(C10=3, B10, "0")
11	Lucy	83	1	IF(C11=1, B11, "0")	IF(C11=2, B11, "0")	IF(C11=3, B11, "0")
12	John	44	2	IF(C12=1, B12, "0")	IF(C12=2, B12, "0")	IF(C12=3, B12, "0")
13	Mary	73	3	IF(C13=1, B13, "0")	IF(C13=2, B13, "0")	IF(C13=3, B13, "0")
14	Number			COUNTIF (D2:D13," >0")	COUNTIF (E2:E13," >0")	COUNTIF (F2:F13," >0")
15	Average			SUM(D2: D13)/D14	SUM(E2: E13)/D14	SUM(F2: F13)/D14
16	Std Dev			STDEV(D 2:D13)	STDEV(E 2:E13)	STDEV(F 2:F13)
17						
18				SUM(D16 :F16)		