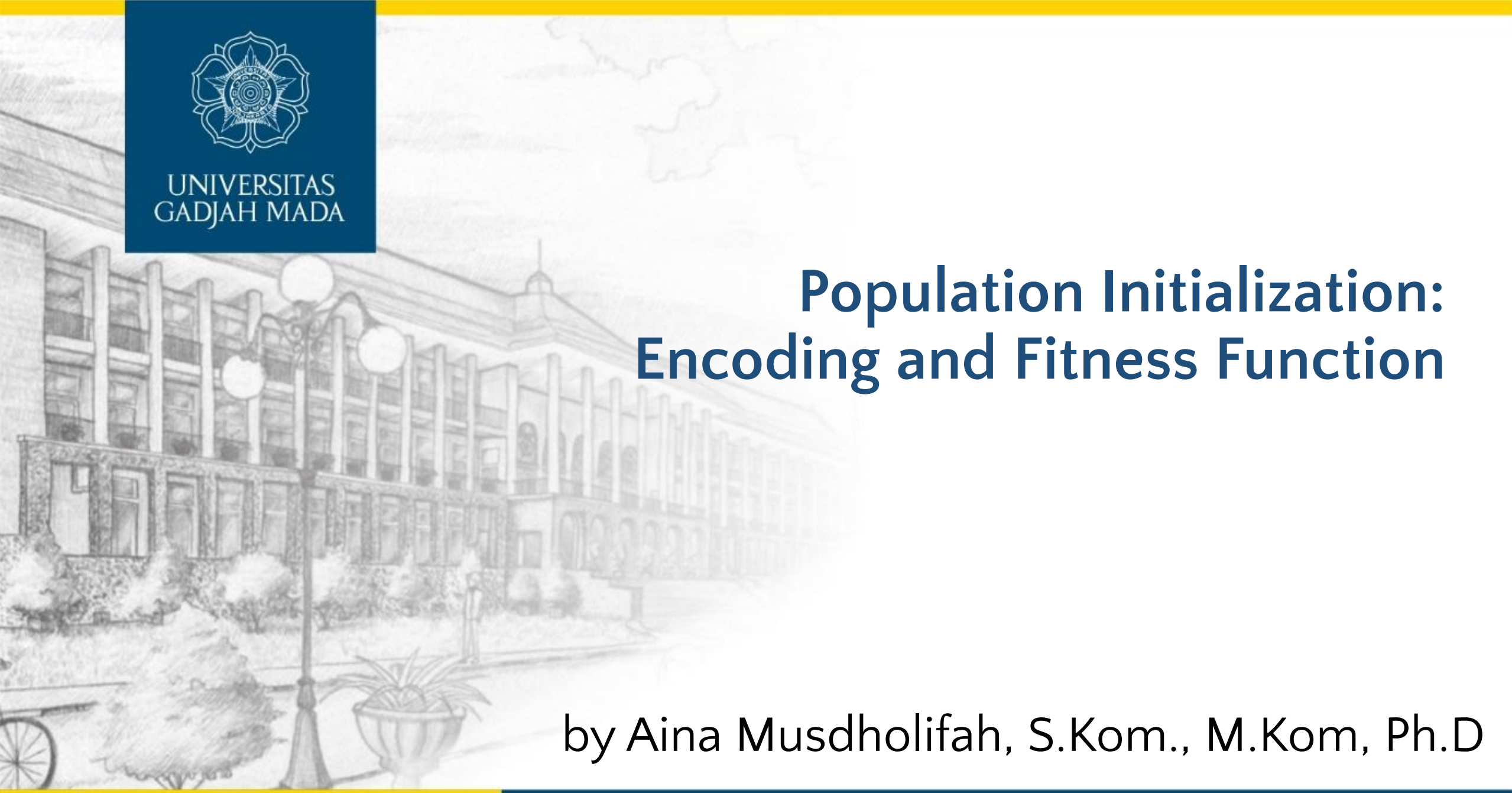
Week	Content	CO	Activity and Assessments	Percentage
19/08	• Introduction to Genetic Algorithms • GA Implementation	CO-1	Refreshing and Discussion	-
26/08	• Cycle of Basic GA • Holland's schema theorem.	CO-1	Quiz-1	2
02/09	Encoding in Genetic Algorithm	CO-3	Quiz-2	2
09/09	Selection	CO-2	Quiz-3	2
16/09	Crossover Part 1	CO-2	Quiz-4	2
23/09	Crossover Part 2	CO-2	Quiz-5	2
30/09	Proposal Presentation (Problem Formulation)	CO-3	Presentation and Discussion	10+2,5
../10	UTS		Holland's schema and What is GA GA Encoding GA Operators	5 5 5

Week	Content	CO	Activity and Assessments	Percentage
21/10	• Mutation • Genetic Algorithm Parameters	CO-2	HW-1	2.5
28/10	Hybrid Genetic Algorithm	CO-5	HW-2	2.5
04/11	Progress Report	CO-4	Presentation and Discussion	10 + 2.5
11/11	Applications of Genetic Algorithms	CO-5	HW	5
18/11	Final Project Report	CO-4	Presentation	10
25/11	Trend research on Genetic Algorithm	CO-6	Presentation of Lit Review	5
02/12	Paper Report	CO-5	Draft paper	10
…/12	UAS	CO-2 CO-4 CO-6	GA Operator and Parameters GA Design Trend GA	5 5 5



UNIVERSITAS
GADJAH MADA

Population Initialization: Encoding and Fitness Function

by Aina Musdholifah, S.Kom., M.Kom, Ph.D

Next...

- How to Generate Population
- Encoding

–Encoding –

Genetic Algorithm

Solving problem using GA

- Create **encoding design:**

  Individu → Chromosome

- Formulate fitness function

- Define GA operators

Encoding individu → chromosome

- **An individual** is encoding into a chromosome through appropriate method.

- Four encoding types:
  - Binary
  - Integer
  - Real
  - Permutation

Encoding

- Marek Obitko (1998) have different classification of encoding methods. He divide encoding methods into four groups, i.e:
  - Binary Encoding (Pengkodean biner)
  - Permutation Encoding
  - Value Encoding
  - Tree Encoding

Efficient Encoding

- Complete
  - if every point in the search space can be coded
- Closed
  - if all individuals produced by the application of genetic operators can be coded to a valid phenotype.
- Proximity
  - If used encoding methods can increase slowly the parameters are guaranteed
- Short Scheme
  - If the parameters of the similar problem are also encoded in similar genotype

Kriteria... (cont.)

- Kemampuan
  - Jika panjang genotype adalah minimum
- Von-Isomorphism
  - Jika setiap genotype merepresentasikan genotype solusi yang unik
- Modularitas
  - Ketika solusi parsial (model/blok bangunan) ditulis hanya sekali & suatu mekanisme tersedia sehingga mereka dapat didefinisikan untuk sembarang titik dalam pengkodean

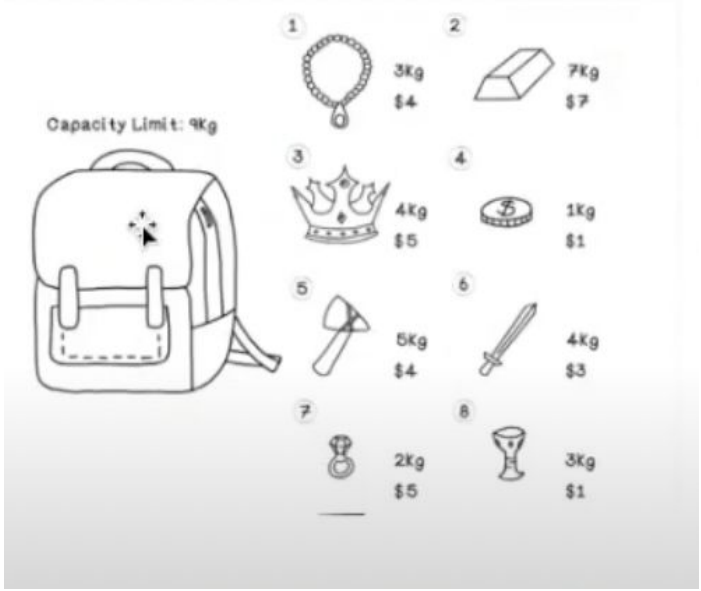
Binary Encoding

- The most common encoding
- First used in genetic algorithms by Holland
- Each chromosome is expressed in rows of bits 0 or 1
- Examples of chromosomes with binary coding

Chromosome A	10110010110010101110010 1
Chromosome B	11111110000011000011111

Binary Encoding (cont.)

- There are many possibilities for chromosomes even with a small number of alleles, i.e. 0 or 1
- Suitable problem: Knapsack problem



- Disadvantage: often not suitable for many problems and the correction process must be carried out after the evolution process (crossover and / mutation)

Permutation Encoding

- Can be used in ordering problems (ordering problem)
- Each chromosome is a sequence of numbers stating the numbers in a sequence
- Only useful for sorting problems, for example: trading, Routes, etc.
- Example:

Chromosome A	1 5 3 2 6 4 7 9 8
Chromosome B	8 5 6 7 2 3 1 4 9

Value Encoding

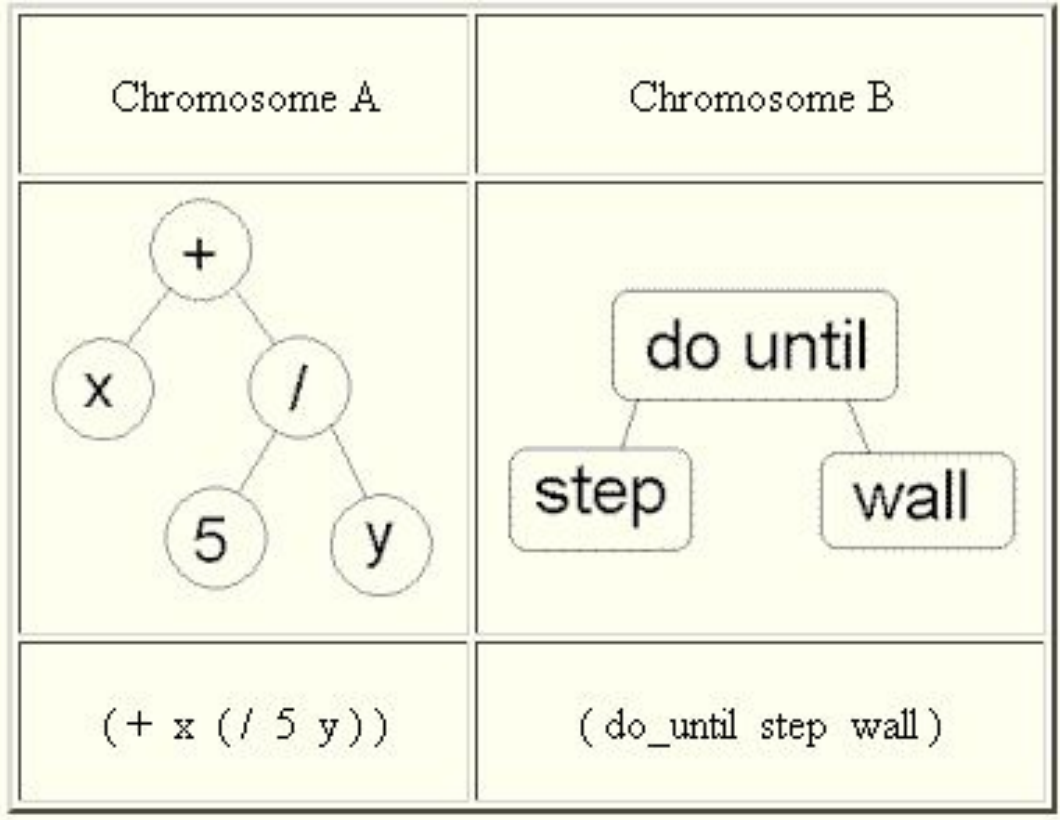
- Can be used for problems that have complicated values
- Each chromosome is a sequence of values, where the value can be anything related to the problem
- It is suitable for certain problems, for example looking for weights on NN
- Example:

Chromosome A	1.2324 5.3243 0.4556 2.3293 2.4545
Chromosome B	ABDJEIFJDHDIERJFDLDFLFEGT
Chromosome C	(back), (back), (right), (forward), (left)

Tree Encoding

- Widely used to compile programs / expressions in genetic programming
- Each chromosome is a tree of several objects, such as functions or commands in the programming language

- Example problem: lookup a value function based on a given value
- Example:



FITNESS FUNCTION

solving problem using GA

- Create encoding design:

  Individu → Chromosome

- Formulate **fitness function**

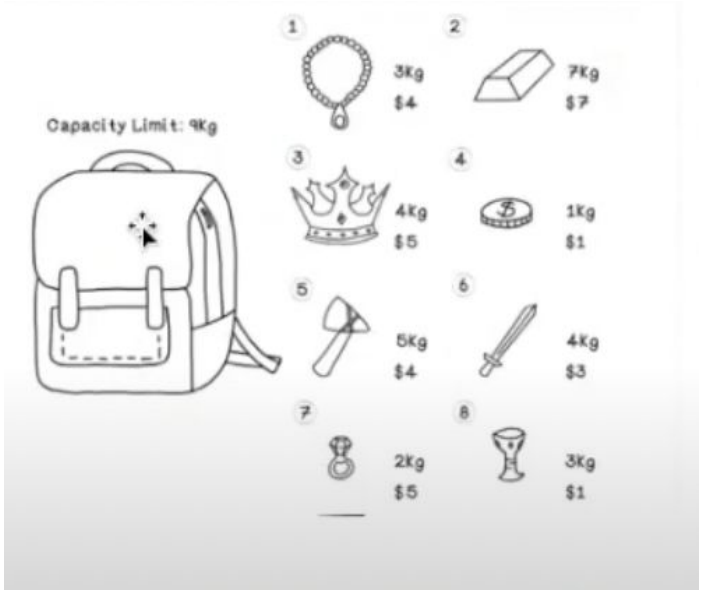
- Define GA operators

Fitness Function

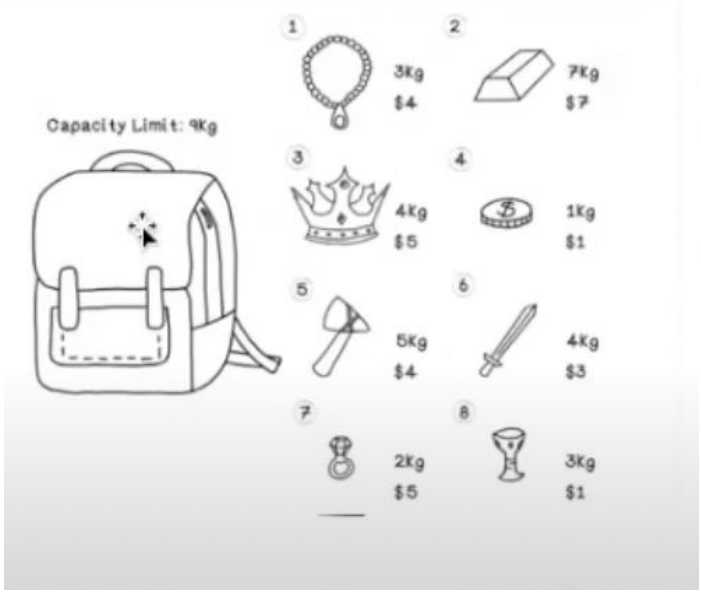
- Genetic Algorithms are defined as a machine learning model that decreases all evolutionary behavior in nature from a population abstracting the **solution** to an optimization problem that is selected, crossover and mutated according to its relative **fitness** value.
- Evolution function, expresses the performance of a genome to a population
- **Fitness function** is the performance influenced by other genomes and **objective function** that describes the optimization problem
- **Fitness function** = f_i / f
  - f_i: function / evaluation value of genome-i
  - f: average evaluation value in a population

Example 1

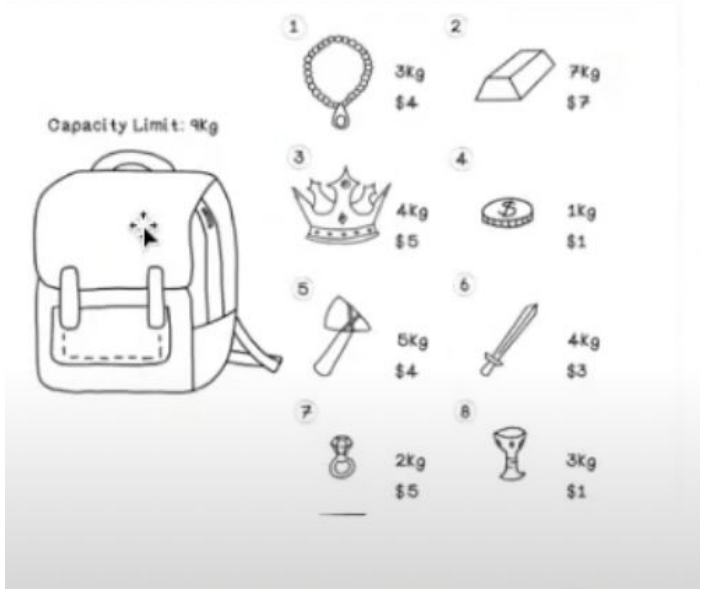
- Knapsack problem



Problem Formulation



Encoding and Fitness Function



Example 2

Algoritma Genetika Untuk Mencari Kata Secara Acak

- Sebuah kata ditentukan sebagai target, misalnya: ‘BASUKI’. Bila setiap huruf diberi nilai dengan nilai urut alfabet, maka targetnya bisa dinyatakan sebagai besaran numerik :

Target=[2 1 19 21 11 9]

- Komputer akan membangkitkan kata dengan jumlah huruf yang sama dengan target secara acak, terus-menerus hingga diperoleh kata yang sama dengan kata target.

Example 2 (cont.)

Definisi Individu Dan Fitness

- **Individu adalah satu kata yang muncul dari proses acak tersebut, misalnya : AGHSQE atau [1 7 8 19 17 5]**
- **Satu individu mempunyai n gen integer yang setiap gennya menyatakan no urut alfabet.**
- **Nilai fitness adalah inversi dari perbedaan antara nilai kata yang muncul (individu) dan target yang ditentukan. Misalnya kata yang muncul : AGHSQE dan targetnya BASUKI maka, nilai perbedaannya:**

  E = |1-2| + |7-1| + |8-18| + |19-21| + |17-11| + |5-9|

  = 1+6+10+2+6+4 = 29

  Fitness = (26)(6) - 29 = 156-29 = 127

- **Fitness didefinisikan:**

$$fitness(k) = 156 - \sum_{n} \left| g(k)_n - t_n \right|$$

Dimana gn adalah gen ke n dari individu ke k dan gen ke n dari target

Example 2 (cont.)

Pembangkitan Populasi Awal

Populasi awal dibangkitkan dengan cara membangkitkan semua huruf dalam sejumlah kata (individu) yang dibangkitkan.

```
14 20  9  1 17  3  -- N T I A Q C   >> Fitness = 83
 2  5 18  5  6  6  -- B E R E F F   >> Fitness = 127
 8  5 15 15 24  6  -- H E O O X F   >> Fitness = 120
 5 22 14 11 19 23  -- E V N K S W   >> Fitness = 95
19 19  8  6 19  7  -- S S H F S G   >> Fitness = 85
20 16  3 21  8 10  -- T P C U H J   >> Fitness = 103
19 13 12 23 15 10  -- S M L W O J   >> Fitness = 113
15 23  4 16  6 17  -- O W D P F Q   >> Fitness = 88
 5  1  6 19 21 18  -- E A F S U R   >> Fitness = 119
10 12 18  6 17  8  -- J L R F Q H   >> Fitness = 114
10  1  2  8  6 19  -- J A B H F S   >> Fitness = 103
21 18 21 24 26 19  -- U R U X Z S   >> Fitness = 90
```

Quiz-1

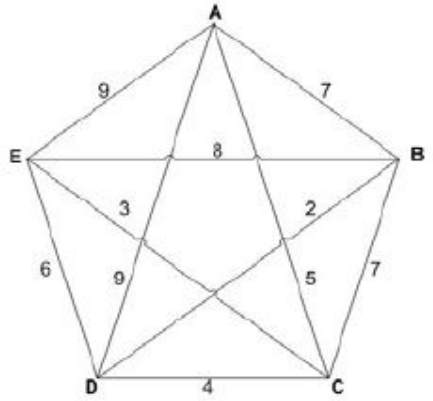
Consider the problem of maximizing the function $f(x) = \frac{-x^2}{10} + 3x$ where x is allowed to vary between 0 and 31.

Quiz-2

Suppose there is an equality $a + 2b + 3c + 4d = 30$.
Genetic algorithm will be used to find a, b, c , and d that satisfy that equation.

Quiz-3

Terdapat 5 buah kota yang akan dilalui oleh seorang pedangang keliling, misalnya Kota A,B,C,D,E. Perjalanan dimulai dari kota A dan berakhir di kota A. Jarak antar kota diperlihatkan pada graf di bawah ini:



Persoalan TSP tersebut akan diselesaikan dengan menggunakan algoritma genetika. Kriteria berhenti ditentukan terlebih dahulu yaitu apabila setelah dalam beberapa generasi berturut-turut diperoleh nilai *fitness* yang terendah tidah berubah. Pemilihan nilai *fitness* yang terendah sebagai syarat karena nilai tersebut yang merepresentasikan jarak terdekat yang dicari pada persoalan TSP ini.
Ada 4 kota yang akan menjadi gen dalam kromosom yaitu kota-kota selain kota asal.

Quiz-4

A wood craftsman wants to make a tube-shaped decoration without a lid. The tube is expected to hold a liquid of not less than 200. Help the craftsman to design the tube with minimal materials.

Formulate the problem then how is the coding and the fitness function!

Recording

Selection

NEXT…