INDIAN INSTITUTE OF INFORMATION TECHNOLOGY, ALLAHABAD

# Assignment #8

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Course: *Soft Computing* – Professor: *Prof. G C Nandi*
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## Question 1

Consider three strings $A_1$=11101111, $A_2$= 00010100, $A_3$= 01000011 and six schemata $H_1$=1*******, $H_2$=0*******, $H_3$= ******11, $H_4$= ***0*01*, $H_5$= 1*****1*, and $H_6$=1*****1*. Which schemata is matched by which string? What are the order and defining length of each of the schemata? Estimate the probability of survival of each schema under mutation when the probability of a single mutation is $p_m$=0.001. Estimate the probability of survival of each schema under crossover when the probability of crossover $p_c$=0.85.

**Answer.** In this case,

String $A_1$ is matched with schemata $H_1$, $H_3$, $H_5$, $H_6$.

String $A_2$ is matched with schemata $H_2$.

String $A_3$ is matched with schemata $H_2$, $H_3$, $H_4$.

The defining length and order can be given as:

For $H_1$, $\delta(H_1)$ = 1 - 1 = 0, Order of $H_1$ o($H_1$) = 1
For $H_2$, $\delta(H_2)$ = 1 - 1 = 0, Order of $H_2$ o($H_2$) = 1
For $H_3$, $\delta(H_3)$ = 8 - 7 = 1, Order of $H_3$ o($H_3$) = 2
For $H_4$, $\delta(H_4)$ = 7 - 4 = 3, Order of $H_4$ o($H_4$) = 3
For $H_5$, $\delta(H_5)$ = 7 - 1 = 6, Order of $H_5$ o($H_5$) = 2
For $H_6$, $\delta(H_6)$ = 7 - 1 = 6, Order of $H_6$ o($H_6$) = 2

The probability of a single mutation is $p_m$ = 0.001

The probability of survival of each schema under mutation is given by:

$$S_m = (1 - P_m)^{o(H)} \tag{1}$$

For $H_1$, $S_m(H_1) = (1 - 0.001)^1 = 0.999$

For $H_2$, $S_m(H_2) = (1 - 0.001)^1 = 0.999$

For $H_3$, $S_m(H_3) = (1 - 0.001)^2 = 0.998$

For $H_4$, $S_m(H_4) = (1 - 0.001)^3 = 0.997$

For $H_5$, $S_m(H_5) = (1 - 0.001)^2 = 0.998$

For $H_6$, $S_m(H_6) = (1 - 0.001)^2 = 0.998$

The probability of crossover is $p_c$ = 0.85

The probability of survival of each schema under crossover is given by:

$$S_c(H) = 1 - P_c \frac{\delta(H)}{l-1} \tag{2}$$

For $H_1$, $S_c(H_1)$ = 1 - 0.85*$\frac{0}{7}$ = 1

For $H_2$, $S_c(H_2)$ = 1 - 0.85*$\frac{0}{7}$ = 1

For $H_3$, $S_c(H_3)$ = 1 - 0.85*$\frac{1}{7}$ = 0.87

For $H_4$, $S_c(H_4)$ = 1 - 0.85*$\frac{3}{7}$ = 0.635

For $H_5$, $S_c(H_5)$ = 1 - 0.85*$\frac{6}{7}$ = 0.271

For $H_6$, $S_c(H_6)$ = 1 - 0.85*$\frac{6}{7}$ = 0.271

## Question 2

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| A population contains the following strings and fitness values at generation 0 as given in question pdf. The probability of mutation is $p_m$ = 0.01 and the probability of crossover is $p_c$ = 0.7. Calculate the expected number of schemata of the form 1**** in generation 1. Estimate the expected number of schemata of the form0**1* in generation 1. |

**Answer.** For the $H_1$ schemata.

Number of copies of schema $H_1$ in generation t, m($H_1$, t) = 2

The average fitness is given as f($H_1$) = (20 + 10)/2 = 15.

The average fitness of all the strings is given as $a_t$ = (20 + 10 + 5 + 15)/4 = 12.5

The order of $H_1$, o($H_1$) = 1 and the defining length $\delta(H_1)$ = 0.

Then the probability of crossover or mutation will destroy the schema is given as:

$$p = \frac{\delta(H_1)}{l-1} * P_c + o(H_1)P_m \tag{3}$$

$$p = \frac{0}{4} * 0.7 + 1 * 0.01 = 0.01 \tag{4}$$

According to Holland's Schema theorem, the expected number of schemata of $H_1$ in generation 1 is given as:

$$E(m(H_1, t+1)) = \frac{m(H_1, t) f(H_1)}{a_t}(1-p) \tag{5}$$

$$E(m(H_1, t+1)) = \frac{2 * 15}{12.5}(1-0.01) = 2.376 \tag{6}$$

For the $H_2$ schemata.

Number of copies of schema $H_2$ in generation t, m($H_1$, t) = 2

The average fitness is given as f($H_2$) = (5 + 15)/2 = 10.

The average fitness of all the strings is given as $a_t$ = (20 + 10 + 5 + 15)/4 = 12.5

The order of $H_2$, o($H_2$) = 2 and the defining length $\delta(H_2)$ = 4-1 = 3.

Then the probability of crossover or mutation will destroy the schema is given as:

$$p = \frac{\delta(H_2)}{l-1} * P_c + o(H_2) P_m \tag{7}$$

$$p = \frac{3}{4} * 0.7 + 2 * 0.01 = 0.545 \tag{8}$$

According to Holland's Schema theorem, the expected number of schemata of $H_2$ in generation 1 is given as:

$$E(m(H_2, t+1)) = \frac{m(H_2, t) f(H_2)}{a_t}(1-p) \tag{9}$$

$$E(m(H_2, t+1)) = \frac{2 * 10}{12.5}(1-0.545) = 0.728 \tag{10}$$