Problem 4.1

Consider the following scenario: you are developing control software to replace a complex control room with dials and sliders spread out over a huge control panel. The human operators of that control room have notebooks full of configurations they’ve tried and can report that though many of the sliders have significant effects on system performance, many are largely independent of each other. In a few cases, a small change on one setting necessitates changes on many others, but the end result may well be an improvement.

You’ve decided to use a genetic algorithm to determine the best settings for the control room. Each setting would have its own segment (“gene”) on the chromosome. Discuss some of the choices you might make in your chromosome and algorithm design. How will you decide on the right chromosome format? What operators would be appropriate? Do you think it would improve or degrade the algorithm’s performance to explicitly limit crossovers to only occur at boundaries between genes? Why?

Problem 4.2

Consider the following small generation of six-bit chromosomes and their relative fitnesses:

- 011000 8
- 010101 5
- 110001 5
- 111000 2

Construct (by hand) a new generation of four chromosomes from this one. Note that you are your own random-number generator.¹

Are there any of the 64 valid chromosomes which are impossible in the next generation?

¹See also http://dilbert.com/strips/comic/2001-10-25/.
Assuming crossover \( p_c = 0.7 \), mutation \( p_m = 0.001 \), and the remainder of the probability is for preserving one chromosome, give two probabilities for each of the child chromosomes you generated: the probability according to the path by which you generated it, and the total probability of generating that chromosome by any means. If you have to make any assumptions about the algorithm, make sure to state them clearly.

**Problem 4.3**

Consider the following generation of four programs:

\[
\begin{align*}
&\text{(if (<= a b) b a)} \\
&\quad / \ a \ a \\
&\quad (+ \ a (* 2 b)) \\
&\quad (sqrt 3)
\end{align*}
\]

Give one possible set of genetic operations that could have generated (over multiple generations) the following program from the above programs:

\[
\begin{align*}
&\text{(if (<= a 1)} \\
&\quad 1 \\
&\quad (* 2 (/ b a)))
\end{align*}
\]

What is/are the most unlikely part(s) of the derivation?