I swear on my faith in humanity that I guarantee the assignment is my own work, and all the code handed in was written and keyed in by myself (or downloaded from the course website) without undue assistance from others.

1 Question 1

1.1 English definition of neighbourhood rule

Swap the crucibles for any two pots which have different crucibles

1.2 Formal neighbour definition

$y(x,i,j) = (x_1, x_2, ..., x_{i-1}, x_j, x_{i+1}, ...x_{j-1}, x_i, x_{j+1}, ...x_n)$

1.3 Formal neighbourhood definition

$N(x) = \{y(x,i,j),\, i = 1,...,n,\, j = i+1,...,n;\, (i,j) <> (1,n)$

2 Question 2

2.1 Intermediate values

Crucible value in dollars

2.2 Next ascent sweep algo psuedocode

```
for i = 1...n
        for j = i+1...n
                if f(y(x,i,j)) - f(x) > 0 then
                        // Update intermediate values
                        crucibleValues[i] = g(x,i)
                        crucibleValues[j] = g(x,j)
                        x := y
        endfor
endfor
```

3 Question 3

3.1 3B plot - AscendToLocalMax

Solution Output:
1 [26 41 18] 99.76Al 0.42Fe 57.35 23
2 [15 13 33] 99.35Al 0.63Fe 44.53 20

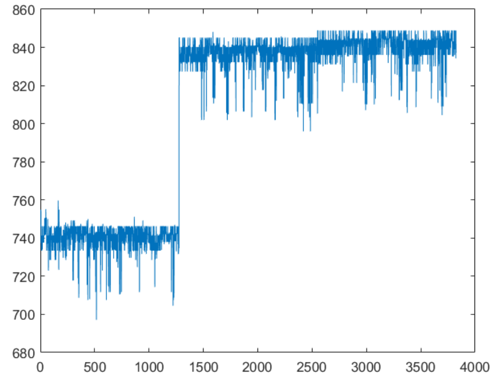

Figure 1: AscendToLocalMax Plot

3 [37 21 43] 99.76Al 0.43Fe 57.35 22
4 [7 44 34] 99.50Al 0.40Fe 48.71 37
5 [29 9 35] 99.50Al 0.53Fe 48.71 26
6 [16 17 22] 99.55Al 0.50Fe 48.71 6
7 [5 24 6] 99.76Al 0.44Fe 57.35 19
8 [1 3 4] 99.77Al 0.29Fe 57.35 3
9 [28 40 27] 99.76Al 0.43Fe 57.35 13
10 [2 31 38] 99.41Al 0.55Fe 44.53 36
11 [39 25 32] 99.27Al 0.76Fe 41.53 14
12 [14 42 36] 99.52Al 0.44Fe 48.71 28
13 [8 19 12] 99.39Al 0.65Fe 44.53 11
14 [46 11 48] 99.59Al 0.35Fe 48.71 37
15 [30 45 10] 99.76Al 0.45Fe 57.35 35
16 [49 23 47] 99.36Al 0.72Fe 44.53 26
17 [20 50 51] 99.26Al 0.49Fe 41.53 31
Sum,Max= 848.83,37

3.2 3C - DoRepeatedAscents(200)

Solution Output:
1 [20 5 34] 99.53Al 0.52Fe 48.71 29
2 [22 11 2] 99.35Al 0.51Fe 44.53 20
3 [37 24 40] 99.86Al 0.33Fe 68.21 16
4 [30 42 18] 99.75Al 0.44Fe 57.35 24
5 [46 45 28] 99.75Al 0.46Fe 57.35 18
6 [21 29 17] 99.50Al 0.43Fe 48.71 12
7 [44 39 23] 99.35Al 0.66Fe 44.53 21
8 [38 4 1] 99.77Al 0.46Fe 57.35 37

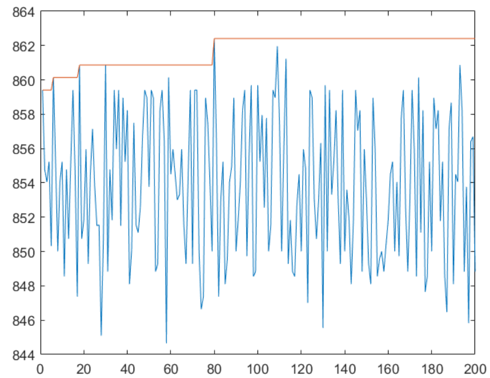

Figure 2: DoRepeatedAscents(n=200) Plot

9 [49 15 25] 99.36Al 0.61Fe 44.53 34
10 [35 50 13] 99.25Al 0.72Fe 41.53 37
11 [47 3 32] 99.50Al 0.53Fe 48.71 44
12 [8 27 12] 99.50Al 0.52Fe 48.71 19
13 [16 48 14] 99.51Al 0.48Fe 48.71 34
14 [41 6 10] 99.77Al 0.45Fe 57.35 35
15 [9 51 7] 99.50Al 0.38Fe 48.71 44
16 [26 36 33] 99.51Al 0.52Fe 48.71 10
17 [19 31 43] 99.51Al 0.47Fe 48.71 24
Sum,Max= 862.41,44

4 Question 4

4.1 a)

I would expect this problem to have a lot of plateaus. In order for the price of a crucible to change, it needs to change grade from one category to another. This can be difficult as it is unlikely that a single swap of pots between crucibles to increase the average aluminum or decrease the average iron enough to change the category. Each pot only has 33% of the contribution to the average, so to increase the aluminum from 99.1% => 99.2% requires a change of 0.3% for a single pot. If there were more pots per crucible then the problem would be even greater.

4.2 b)

Word definition: Use the original g function plus the mean Aluminium percentage minus the mean Iron percentage.
Formal definition: $g'(\overline{Al}, \overline{Fe}) = g(\overline{Al}, \overline{Fe}) + (\overline{Al} - \overline{Fe})/100$

The logic for this is that its more desirable to have a higher Al value and a lower Fe value, so we should reward higher Al values and penalise higher Fe values.

Example:

Solution 1: $\overline{Al} = 99.1, \overline{Fe} = 0.06, g(\overline{Al}, \overline{Fe}) = 36, g'(\overline{Al}, \overline{Fe}) = 36.931$

Solution 2: $\overline{Al} = 99.1, \overline{Fe} = 0.01, g(\overline{Al}, \overline{Fe}) = 36, g'(\overline{Al}, \overline{Fe}) = 36.981$

As shown, the crucible with the same Aluminum percentage but with a lower Iron percentage was given a higher value than the alternative even though they both are originally in the same category. A crucible with a higher Aluminium or lower Iron percentage should be given a greater value during search as this will push the algorithm towards solutions that push the crucible into higher categories which yields greater profit.

4.3 c)

The recalculation may be avoided when the same two pots are being considered for a swap while in the same crucibles. As this swapping has been considered before, we know whether it improved the overall price already.

e.g. Swapping 1 and 5 with crucibles (1,2,3) and (4,5,6)

5 Question 5

5.1 a)

$g''(\overline{Al}, \overline{Fe}, x_{c1}, x_{c2}, x_{c3}, s) = if\, max(x_{c1}, x_{c2}, x_{c3}) - min(x_{c1}, x_{c2}, x_{c3}) >= s :$ $g(\overline{Al}, \overline{Fe}) \times \frac{s}{max(x_{c1}, x_{c2}, x_{c3}) - min(x_{c1}, x_{c2}, x_{c3})}$
else $g(\overline{Al}, \overline{Fe})$

5.2 c)

5.2.1 Max Spread 6

Solution Output:
1 [35 36 41] 99.64Al 0.51Fe 48.71 6
2 [37 40 34] 99.76Al 0.36Fe 57.35 6
3 [14 17 18] 99.66Al 0.42Fe 52.44 4
4 [6 5 2] 99.55Al 0.53Fe 48.71 4
5 [22 19 25] 99.35Al 0.74Fe 41.53 6
6 [3 4 1] 99.77Al 0.29Fe 57.35 3
7 [49 44 50] 99.26Al 0.49Fe 41.53 6
8 [15 12 11] 99.52Al 0.50Fe 48.71 4
9 [48 46 43] 99.75Al 0.41Fe 57.35 5
10 [13 16 10] 99.41Al 0.71Fe 44.53 6
11 [39 38 33] 99.37Al 0.69Fe 44.53 6
12 [20 23 26] 99.53Al 0.72Fe 44.53 6
13 [7 9 8] 99.50Al 0.44Fe 48.71 2
14 [27 31 32] 99.55Al 0.50Fe 48.71 5

15 [42 47 45] 99.51Al 0.37Fe 48.71 5
16 [28 30 24] 99.77Al 0.38Fe 57.35 6
17 [21 51 29] 99.37Al 0.42Fe 44.53 30
Sum,Max= 835.28,30

5.2.2 Max Spread 8

Solution Output:
1 [44 49 51] 99.30Al 0.31Fe 41.53 7
2 [10 16 13] 99.41Al 0.71Fe 44.53 6
3 [31 26 23] 99.50Al 0.49Fe 48.71 8
4 [15 11 12] 99.52Al 0.50Fe 48.71 4
5 [39 33 32] 99.35Al 0.70Fe 44.53 7
6 [27 19 25] 99.40Al 0.67Fe 44.53 8
7 [29 28 21] 99.50Al 0.51Fe 48.71 8
8 [41 40 35] 99.77Al 0.43Fe 57.35 6
9 [18 17 24] 99.78Al 0.41Fe 57.35 7
10 [43 48 46] 99.75Al 0.41Fe 57.35 5
11 [2 5 4] 99.55Al 0.47Fe 48.71 3
12 [14 20 22] 99.51Al 0.70Fe 44.53 8
13 [9 8 7] 99.50Al 0.44Fe 48.71 2
14 [42 34 36] 99.54Al 0.46Fe 48.71 8
15 [50 47 45] 99.37Al 0.52Fe 44.53 5
16 [30 38 37] 99.75Al 0.41Fe 57.35 8
17 [1 3 6] 99.77Al 0.34Fe 57.35 5
Sum,Max= 843.19, 8

5.2.3 Max Spread 11

Solution Output:
1 [11 19 20] 99.38Al 0.64Fe 44.53 9
2 [38 37 30] 99.75Al 0.41Fe 57.35 8
3 [15 8 6] 99.58Al 0.49Fe 48.71 9
4 [47 49 51] 99.27Al 0.43Fe 41.53 4
5 [29 28 21] 99.50Al 0.51Fe 48.71 8
6 [24 17 18] 99.78Al 0.41Fe 57.35 7
7 [1 10 9] 99.75Al 0.37Fe 57.35 9
8 [7 5 16] 99.53Al 0.45Fe 48.71 11
9 [40 34 43] 99.76Al 0.45Fe 57.35 9
10 [22 33 26] 99.51Al 0.51Fe 48.71 11
11 [2 3 4] 99.58Al 0.51Fe 48.71 2
12 [50 42 39] 99.25Al 0.52Fe 41.53 11
13 [44 35 36] 99.53Al 0.53Fe 48.71 9
14 [32 27 31] 99.55Al 0.50Fe 48.71 5
15 [14 23 25] 99.35Al 0.65Fe 44.53 11
16 [41 46 45] 99.80Al 0.42Fe 57.35 5

17 [13 48 12] 99.40Al 0.69Fe 44.53 36
Sum,Max= 844.37,36