

CPE593 Final Report: Patch Generation with Myers Diff

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May 19, 2021

Source Code: <https://github.com/JMavorah/BinaryDiff/>

Abstract

Introduction

Methodology

Myers Diff - Edit Graph Introduction

The algorithm selected was the Myers Differencing algorithm. Myers Diff was published in 1986 by Eugene W. Myers. Myers Diff uses an “edit graph” to represent each file (A and B), and find the shortest edit script (SES) required to change the old file into the new one. An example edit graph, for changing the string A = “ABCABBA” into B = “CBABAC” is shown below. The values N and M represent the sizes of A and B respectively; here N = 7 and M = 6.

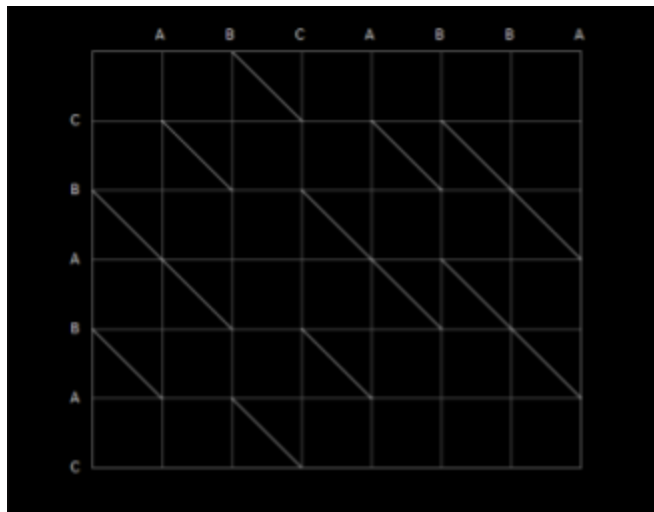


Figure 1: Basic Edit Graph [3]

The old file, A = “ABCABBA” in this case, is represented by the x-axis, while the new file, B = “CBABAC” here, is represented by the y-axis. The point (0,0) represents the start of the differencing process, and the point (N,M) [(7,6) in this example], represents the end of the differencing process, when file A has been transformed into file B. Vertical (downward) movements

on the graph represent the deletion of data from file A and horizontal movements (to the right) represent the insertion of data from file B. Diagonals in the graph (seen in the figure above), represent matches in the files; no additions or deletions are necessary. The greatest number of changes needed is equal to N+M, in the case where there are no matches at all between A and B, and all data in A must be deleted and all data in B inserted. This is obviously not a common occurrence. The SES is the path from (0,0) to (N,M) containing the most diagonal movements,

e.g., the fewest changes, resulting in the smallest patch. It is important to note that there can be many shortest edit scripts of the same distance, and Myers Diff will use the first one that it finds.

Before describing the algorithm itself, it is important to define a few more components of edit graphs. The first is k-lines,

shown here as the brown (odd) and yellow (even) diagonal lines. K-lines begin on the axes and are parallel to the diagonals. The k-line through (0,0) has $k = 0$, and k increases to the right and decreases downward, so the k-line through (1,0) has $k = 1$ and the k-line through (0,1) has $k = -1$.

Another important feature of k-lines is that the y value of a point on a known k-line can be calculated with

the equation $y = x - k$, which means that the algorithm will not have to store y values if it knows x and k. The next component is snakes, shown in dark blue on the graph above. Snakes are a single change (horizontal or vertical lines) followed by zero or more diagonal lines. Snakes have a start point at the start of the change, a midpoint at the end of the change and start of the diagonals, and an endpoint at the end of the diagonals (the midpoint and endpoint will be the same point if there are no diagonals following the horizontal/vertical line). Traces are multiple connected snakes, and are described by the value d, which defines the number of differences

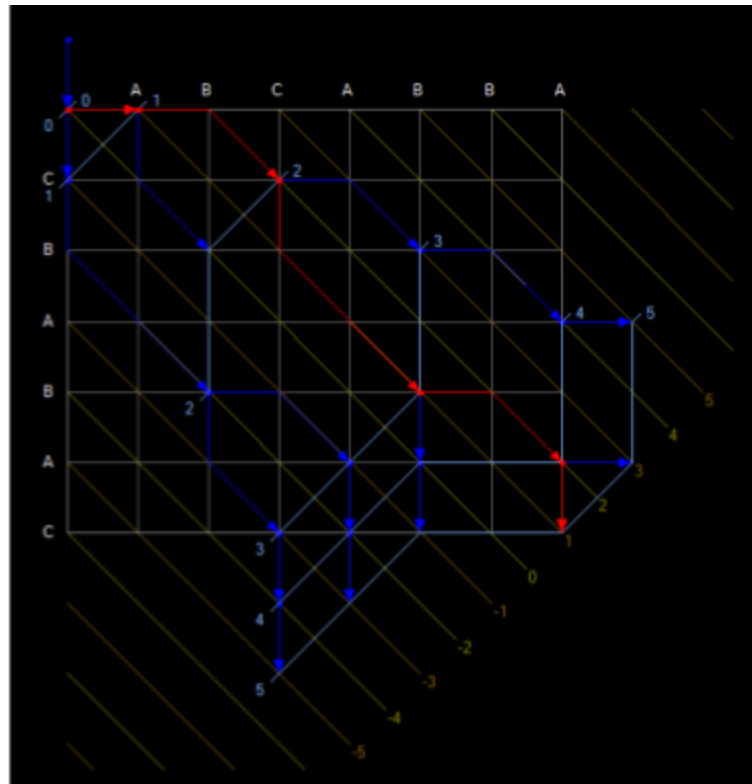


Figure 2: Edit Graph Components [3]

(horizontal or vertical lines) in the trace. Solution traces are traces with minimum d that lead from $(0,0)$ to (N,M) . There can be multiple solution traces for given A and B .

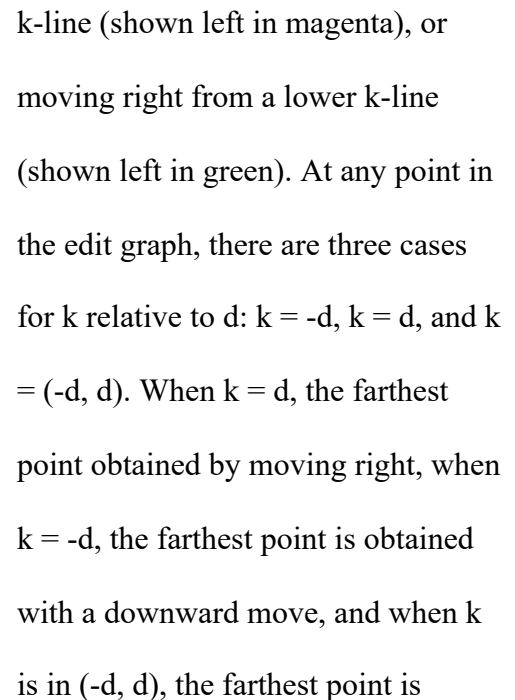
Myers Diff - Basic Greedy Algorithm

Loop Setup

The basic greedy version of Myers Diff finds a solution trace by finding the farthest reaching trace for increasing values of d . Beginning with $d = 0$ (there will only be a solution trace here if A and B are identical), the algorithm checks the farthest paths on all k -lines for each d value. The interval for k is $[-d, d]$, k will equal $-d$ if all movements are downward and k will equal d if all movements are to the right. For a combination of both movements, k will be found in the interval $(-d, d)$. An important optimization is that for even d values, only even k -lines must be checked, and for odd d values, only odd k -lines must be checked. This is analogous to how a bishop on a chess board cannot travel to a square of the other color. Values of k are incremented by 2 from $-d$ to d , and d is incremented until a trace reaches (N,M) . When a solution trace is found, it is guaranteed to be an SES since all lower values of d have been checked.

```
for (int d = 0; d <= N + M; d++) {  
    for (int k = -d; k <= d; k += 2) {
```

The next step is to determine a method for finding the farthest reaching path for each k-line. There are two ways to travel from one k-line to another: moving down from a higher



obtained by moving from the k-line with the greatest x value. This can be determined by the following boolean expression:

After the direction of movement is determined, the start, mid, and end points of the snake are initialized, and any diagonals have to be followed to form the full snake, and the endpoints of the snakes are stored in V . When (x,y) reaches (N,M) , a solution has been found. Below is Myers' original pseudo code, and our implementation.

Constant MAX $\in [0, M+N]$

Var V: Array $[-MAX .. MAX]$ of Integer

1. $V[1] \leftarrow 0$
2. **For** D $\leftarrow 0$ to MAX **Do**
3. **For** k $\leftarrow -D$ to D in steps of 2 **Do**
4. **If** k = -D or k $\neq D$ and $V[k-1] < V[k+1]$ **Then**
5. $x \leftarrow V[k+1]$
6. **Else**
7. $x \leftarrow V[k-1]+1$
8. $y \leftarrow x-k$
9. **While** $x < N$ and $y < M$ and $a_{x+1} = b_{y+1}$ **Do** (x,y) $\leftarrow (x+1, y+1)$
10. $V[k] \leftarrow x$
11. **If** $x \geq N$ and $y \geq M$ **Then**
12. *Length of an SES is D*
13. **Stop**

```
for (int d = 0; d <= N + M; d++) {
    for (int k = -d; k <= d; k += 2) {
        moveDown = (k == -d || (k != d && V[k - 1] < V[k + 1]));
        previousK = moveDown ? k + 1 : k - 1;
        xStartPoint = V[previousK];
        yStartPoint = xStartPoint - previousK;
        xMidPoint = moveDown ? xStartPoint : xStartPoint + 1;
        yMidPoint = xMidPoint - k;
        xEndPoint = xMidPoint;
        yEndPoint = yMidPoint;
        while (xEndPoint < N && yEndPoint < M && A[xEndPoint] == B[yEndPoint]) {
            xEndPoint++;
            yEndPoint++;
        }
        V[k] = xEndPoint;
        if (xEndPoint >= N && yEndPoint >= M) {
            cout << "solution found" << endl;
            return d;
        }
    }
}
```

Because V only stores the endpoints for each iteration of the inner loop, V must be copied and stored after each iteration to obtain the full list of points in the solution trace. Another

loop then starts at the end of the edit graph (N,M) and travels back to $(0,0)$, using the direction of each movement to construct a patch. Patches can be formatted in many different ways


```

    for (int d = D; d > 0; d--) { //increment from -D to D to retrace solution trace
        //y = x - k ==> k = x - y
        k = x - y;
        // cout << "Before prev init: k, x, y, = " << k << ", " << x << ", " << y << "\n";
        // cout << "After init: prevK, prevX, prevY, = " << prevK << ", " << prevX << ", " << prevY << "\n\n";

        //init prev k, x, y
        prevK = (k == -d || (k != -d && V[k-1] < V[k+1])) ? k + 1 : k - 1;
        prevX = V[prevK];
        prevY = prevX - prevK;
        // cout << "After prev init: k, x, y, = " << k << ", " << x << ", " << y << "\n";
        // cout << "After init: prevK, prevX, prevY, = " << prevK << ", " << prevX << ", " << prevY << "\n\n";

        //follow any diagonals:
        //if x and y are both greater than previous ==> diagonal move
        while (x > prevX && y > prevY) {
            x--;
            y--;
        }
        // cout << "After while: k, x, y, = " << k << ", " << x << ", " << y << "\n";
        // cout << "After init: prevK, prevX, prevY, = " << prevK << ", " << prevX << ", " << prevY << "\n\n";

        //construct patch:
        if (x == prevX) { //same x ==> change in y ==> down move - insertion
            cout << "down move - insertion\n";
            patch = to_string(prevX) + "I" + B[prevX] + " " + patch;
        }
        else { // same y ==> change in x ==> right move - deletion
            cout << "right move - deletion\n";
            patch = to_string(prevX) + "D " + patch;
        }
        x = prevX;
        y = prevY;
    }

```

Results and Future Work

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References

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