Algorithms

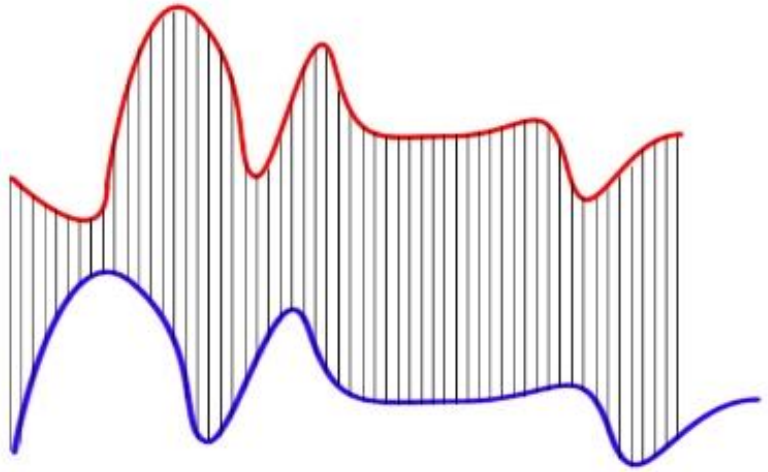
Ultimate Goal

- in a matrix of distances, for each column *j*, find the row with the minimum distance

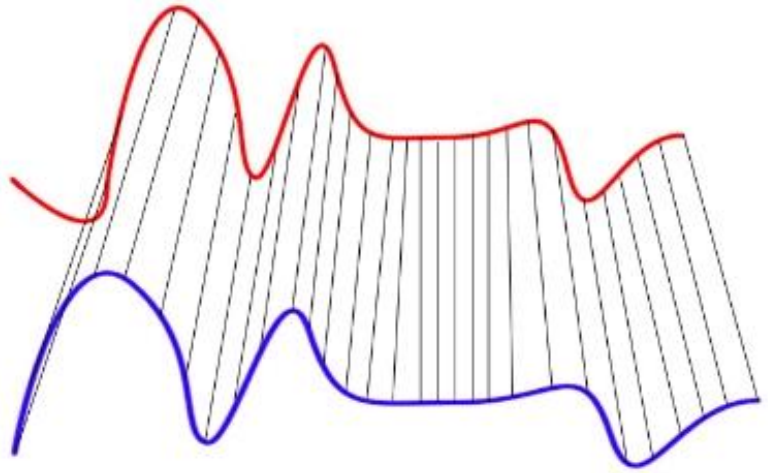
$$MP[j] = min_i\ dist(i,j)$$
$$MPI[j] = argmin_i\ dist(i,j)$$

Originality

1. compute lower bounds *incrementally* for the matrix, using Sakoe-Chiba band
2. within each column, use randomized local search

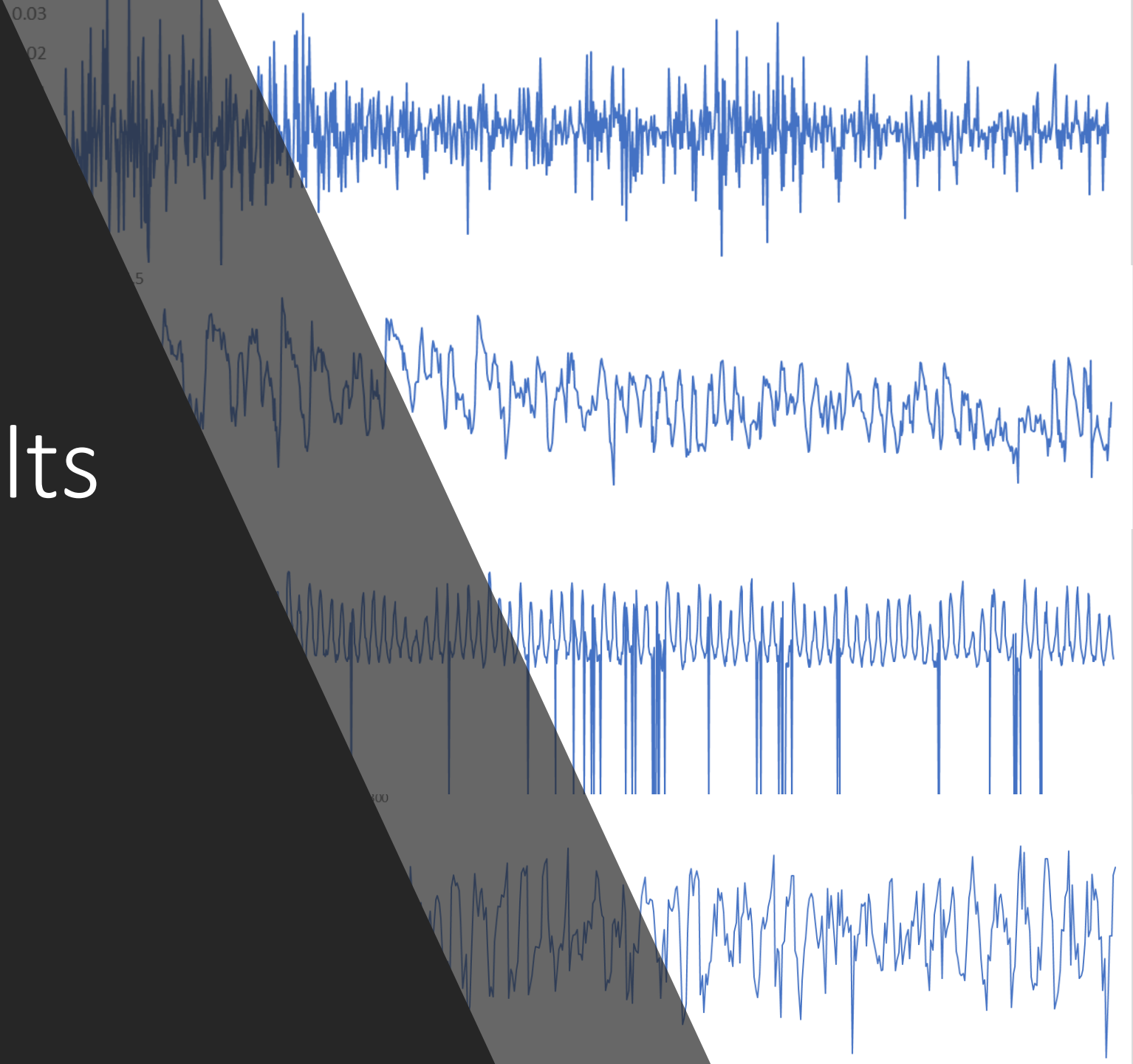


Euclidean Matching



Dynamic Time Warping Matching

Empirical Results

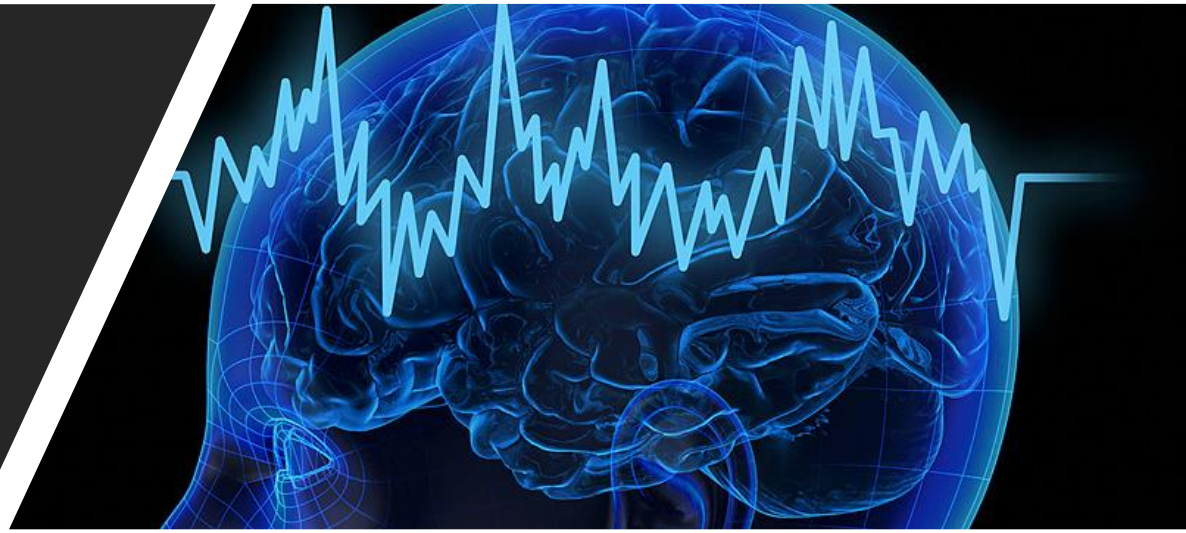


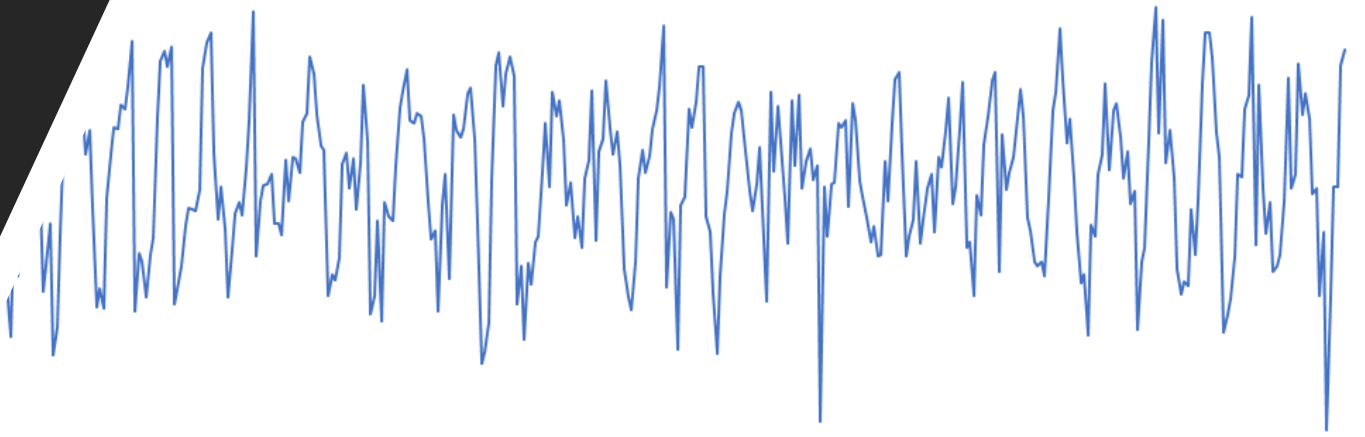
Medical Science: EEG Recordings of a Patient

- Length of Time Series Data n = 400
- Entries to Compute g = 122,850

- DTW Brutal Force : Time = 0.7 s
- DTW Lower Bound : Time = 0.3 s
  # Saved = 103,727 (84%)
- DTW Randomized : Time = 0.3 s
  # Saved = 105,230 (86%)
- DTW Simulated Annealing : Time = 0.4 s
  # Saved = 105,330 (86%)

- Lower Bound Direct : Time = 0.3 s
- Lower Bound Incremental : Time = 0.1 s



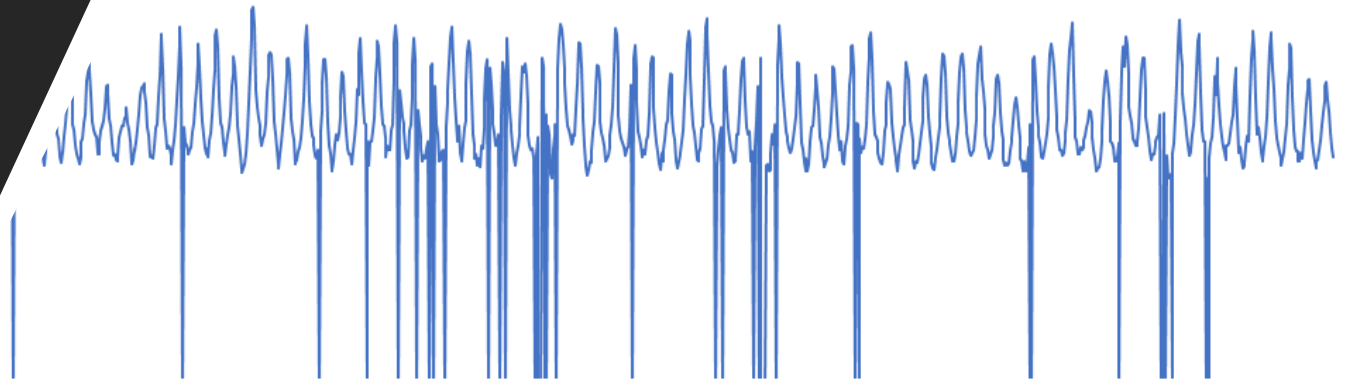


Astronomy : Light Intensity from Star *S Carinae*

- Length of Time Series Data n = 1,189
- Entries to Compute g = 1,086,806

- DTW Brutal Force : Time = 20.5 s
- DTW Lower Bound : Time = 1.8 s
  # Saved = 1,042,844 (96%)
- DTW Randomized : Time = 2.5 s
  # Saved = 1,054,545 (97%)
- DTW Simulated Annealing : Time = 2.6 s
  # Saved = 1,053,135 (97%)

- Lower Bound Direct : Time = 5.5 s
- Lower Bound Incremental : Time = 0.8 s

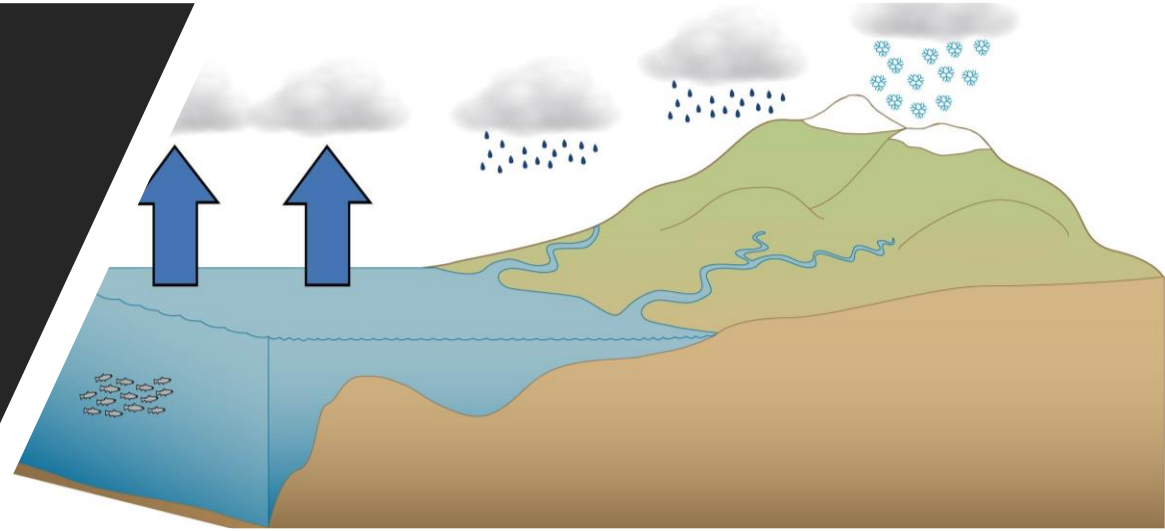


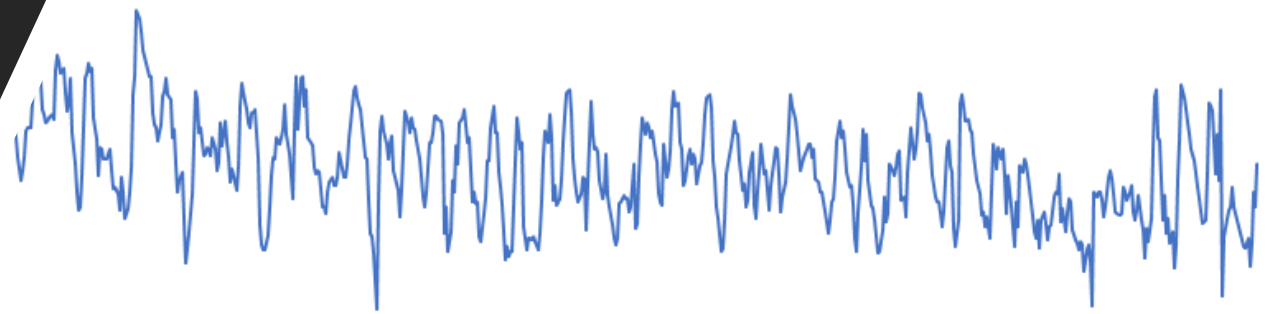
Earth Science : Ratio of ^{18}O to ^{16}O over 2.5 Million Years

- Length of Time Series Data n = 866
- Entries to Compute g = 576,840

- DTW Brutal Force : Time = 8.2 s
- DTW Lower Bound : Time = 2.8 s
  # Saved = 483,467 (84%)
- DTW Randomized : Time = 1.4 s
  # Saved = 548,647 (95%)
- DTW Simulated Annealing : Time = 1.8 s
  # Saved = 545,489 (95%)

- Lower Bound Direct : Time = 2.4 s
- Lower Bound Incremental : Time = 0.5 s



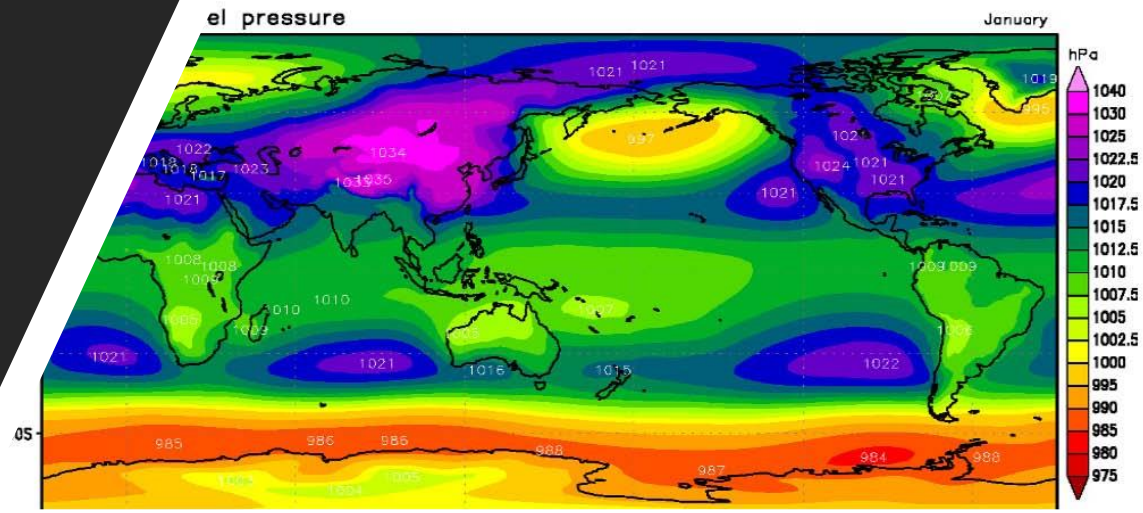


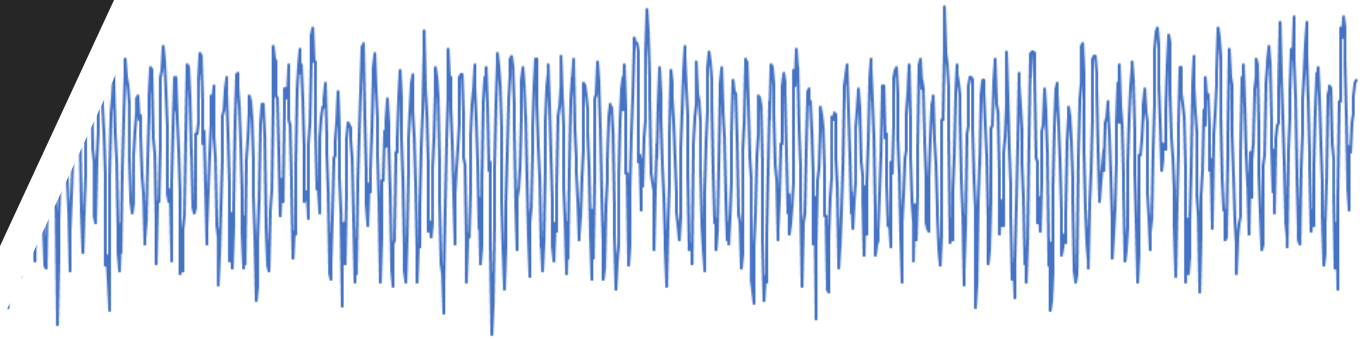
Climatology : Darwin Sea Level Pressure (1882 – 1998)

- Length of Time Series Data n = 1,400
- Entries to Compute g = 1,501,850

- DTW Brutal Force : Time = 33.1 s
- DTW Lower Bound : Time = 5.7 s
  # Saved = 1,375,638 (92%)
- DTW Randomized : Time = 7.6 s
  # Saved = 1,373,673 (91%)
- DTW Simulated Annealing : Time = 7.9 s
  # Saved = 1,372,695 (91%)

- Lower Bound Direct : Time = 9.7 s
- Lower Bound Incremental : Time = 1.1 s





Finance Markets : Daily USD/GBP Exchange Rates

- Length of Time Series Data n = 1,000
- Entries to Compute g = 7,66,500

- DTW Brutal Force : Time = 13.7 s
- DTW Lower Bound : Time = 20.5 s
  # Saved = 213,474 (28%)
- DTW Randomized : Time = 16.4 s
  # Saved = 350,445 (46%)
- DTW Simulated Annealing : Time = 16.3 s
  # Saved = 349,074 (46%)

- Lower Bound Direct : Time = 3.9 s
- Lower Bound Incremental : Time = 0.6 s