Gene Flipping

Pancake flipping

Genetic inversion

Signed reversals

Michael Conry
August 31, 2015
Pancake flipping

- Given a stack of pancakes of varying sizes how can we place them in order?
  - https://www.youtube.com/watch?v=kk-_DDgoXfk
  - $O(2n)$
  - Is there a more efficient way?
Pancake flipping in space

\[ O(n-1) \]
Quicker Solution?

52413
52143
52143
12543
12345
Breakpoints

Find segments not interrupted by a breakpoint and reverse them with the intention of reducing the new number of breakpoints

21 , 6543 , 78

52413

0,5,2,4,1,3,6
Solution using breakpoints

0 52413 6
0 52143 6
0 12543 6
0 12345 6
Breakpoints?

- Still does not always guarantee the fewest number of flips if you don't cut strips

\[ 3412 \rightarrow 4312 \rightarrow 4321 \rightarrow 1234 \]

vs

\[ 3412 \rightarrow 1432 \rightarrow 1234 \]

- An exhaustive search for the best solution is NP-hard
Gene inversions

• 1930s scientists studied Drosophila

• Interested in genetic divergence times

• What can gene reversals tell us?

http://www.nature.com/cr/journal/v13/n6/images/7290192f1.gif
Gene Flipping

- Don't care about the solution, it is known
- We care about how many steps it took to get from one set to the other
Signed Reversals

- Genes have an orientation (they are signed)
- Sorting a sequence of signed permutations is more complicated than unsigned
- However, it is easier to determine the number of reversals needed when considering signed permutations
Signed Reversals
Signed Reversals
Algorithm

• Orientated pairs are two numbers in the sequence that have opposite signs but are consecutive otherwise

1. Reunite orientated pairs by flipping
   (+ if ascending, - if descending)

2. Choose pairs to flip based on which ones create the most new orientated pairs

3. Repeat until you arrive at solution

• This will be the fewest number of reversals
• $O(n)$
Signed Reversal

0 \ +3 \ +1 \ +6 \ +5 \ -2 \ +4 \ +7
0 \ -5 \ -6 \ -1 \ -3 \ -2 \ +4 \ +7
0 \ -5 \ -6 \ -1 \ +2 \ +3 \ +4 \ +7
0 \ -5 \ -6 \ +1 \ +2 \ +3 \ +4 \ +7
0 \ -5 \ -4 \ -3 \ -2 \ -1 \ +6 \ +7
0 \ +1 \ +2 \ +3 \ +4 \ +5 \ +6 \ +7
References

- Brian Hayes. “Sorting Out the Genome” American Scientist Volume 95 p386-390, 2007
- https://www.youtube.com/watch?v=kk-_DDgoXfk