

General Notes

CS, ML and Stats

Patrick Daly

Contents

1	Computer Science	4
1.1	Algorithms	4
1.2	Data Structures	8
1.3	Linux	8
2	Machine Learning	10
2.1	Supervised	10
2.1.1	Ordinary Least Squares (OLS)	10
2.1.2	Generalized Linear Model(GLM)	10
2.1.3	Logistic Regression	10
2.1.4	Linear Discriminant Analysis	10
2.1.5	Support Vector Machines	10
2.1.6	K-Nearest Neighbors	10
2.1.7	Gaussian Process	10
2.1.8	K-Nearest Neighbors	10
2.1.9	Decision Trees	10
2.1.10	Random Forest	10
2.1.11	Gaussian Process	10
2.1.12	Naive Bayes	10
2.1.13	Kalman Filter? dunno where this should go yet... maybe estimation section?	10
2.2	Unsupervised	10
2.2.1	Gaussian Mixture Models	10
2.2.2	K-Means	10
2.2.3	Density-Based Spatial Clustering of Applications with Noise (DBSCAN)	10
2.2.4	Spectral Clustering	10
2.2.5	Hierarchical Clustering	10
2.2.6	Factor Analysis	10
2.2.7	Independent Component Analysis	10
2.2.8	Principal Component Analysis	10
2.2.9	Non-Negative Matrix Factorization (NMF)	10
2.2.10	Latent Dirichlet Allocation (LDA)	10
2.2.11	Outlier Detection?	10
3	Deep Learning	10
3.1	Convolutional Networks	10
3.2	Recurrent Networks	10

3.3	Long Short-Term Memory (LSTM)	10
3.4	Autoencoders	10
3.5	Reinforcement Learning	10
4	Linear Algebra	10
4.1	Norms	10
4.1.1	Euclidean / Frobenius	10
4.1.2	Manhattan	10
4.1.3	Infinity	10
4.1.4	Nuclear	10
4.1.5	Spectral	10
4.1.6	Symmetric	10
4.1.7	Positive Definite	10
4.1.8	Positive Semi-Definite	10
4.1.9	Negative Definite	10
4.1.10	Negative Semi-Definite	10
4.2	Eigendecomposition	10
4.3	Singular Value Decomposition (SVD)	10
4.4	Principal Component Analysis (PCA)	10
4.5	Independent Component Analysis (ICA)	10
4.6	Canonical Component Analysis (CCA)	10
4.7	Factor Analysis	10
5	Statistics	10
5.1	Probability Theory	10
5.2	Distributions	10
5.3	Combinatorics	10

1 Computer Science

1.1 Algorithms

DFS Time: $O(n)$, Space: $O(n)$
Solution exists far away.

Recursive

```
1 def dfs(node):
2     if node:
3         # do stuff if pre-order
4         if node.left:
5             dfs(node.left)
6         # do stuff if in-order
7         if node.right:
8             dfs(node.right)
9         # do stuff if post-order
```

Iterative

```
1 def dfs(node): # if bst, may need to swap search left/right
2     visited = set()
3     stack = [node]
4     while stack:
5         current = stack.pop(-1)
6         print(current.val)
7         if current not in visited:
8             visited.add(current)
9             if current.left and current.left not in visited:
10                 stack.append(current.left)
11             if current.right and current.right not in visited:
12                 stack.append(current.right)
13     return visited
```

BFS Time: $O(n)$, Space: $O(n)$
Solution exists nearby.

Iterative

```
1 def bfs(node):
```

```

2     stack = [node]
3     while stack:
4         current = stack.pop(-1)
5         if current.left:
6             stack.append(current.left)
7         if current.right:
8             stack.append(current.right)

```

Mergesort Time: $O(n \log n)$, Space: $O(n)$

```

1 def mergesort(array, start, end):
2     if start < end:
3         mid = (start+end) // 2
4         mergesort(array, start, mid)
5         mergesort(array, mid+1, end)
6         merge(array, start, mid, end)

1 def merge(array, start, mid, end):
2     left = array[start: mid+1]
3     right = array[mid+1: end+1]
4     i, j, k = 0, 0, start
5     while i < len(left) and j < len(right):
6         if left[i] < right[j]:
7             array[k] = left[i]
8             i += 1
9         else:
10            array[k] = right[j]
11            j += 1
12            k += 1
13    if j == len(right):
14        array[k: end+1] = left[i:]

1 def binarysearch(array, val, low, high):
2     if high < low:
3         # can also return high or low index
4         return 'Not found!'
5     mid = (low + high) // 2
6     if array[mid] > val:
7         return binarysearch(array, val, low, mid-1)

```

```

8     elif array[mid] < val:
9         return binarysearch(array, val, mid+1, high)
10    return mid

```

Greatest Common Divisor (GCD) Time: ?, Space: ?

Euclid: Time: $O(\ln^2 \min(a, b))$, Space: $O(1)$

```

1 def gcd(a, b):
2     return gcd(b, a % b) if b else a

```

Stein: Time: 60% faster than Euclid in theory, similar in practice Space: $O(1)$

```

1 def stein(a, b):
2     # binary gcd
3     if a == b: return a
4     if a == 0: return v
5     if b == 0: return a
6     if ~a & 1: # a is even
7         if b & 1: # b is odd
8             return stein(a >> 1, v)
9         else: # b is even
10            return stein(a >> 1, b >> 1) << 1
11    else:
12        if ~b & 1: # b is even
13            return stein(a, b >> 1)
14        else: # b is odd
15            if a > b:
16                return stein((a-b) >> 1, b)
17            else:
18                return stein(u, (b-a) >> 1)

```

Fibonacci Time: $O(n)$, Space: $O(1)$

Iterative

```

1 def fib_iterative(n):
2     if n == 0: return 0
3     if n == 1: return 1
4     first, second, fibn = 0, 1, 0
5     for i in range(2, n+1):

```

```

6         fib_n = fib_n2 + fib_n1
7         fib_n = fib_n2
8         fib_n2 = fib_n
9     return fibn

```

Recursive

```

1 def fib_recursive(n, dp={0: 0, 1: 1}):
2     if n in dp:
3         return dp[n]
4     return fib_recursive(n-2, dp) + fib_recursive(n-1, dp)

```

Longest Increasing Subsequence Time: $O(n \log n)$, Space: $O(n)$

```

1 def lis(nums):
2     tails = [0]*len(nums)
3     maxlen = 0
4     for num in nums:
5         start, end = 0, maxlen
6         while start != end:
7             mid = (start+end)//2
8             if tails[mid] < num:
9                 start = mid + 1
10        else:
11            end = mid
12        tails[start] = num
13        maxlen = max(maxlen, start+1)
14    return maxlen

```

Topological Sort Time: $(V + E)$, Space: $O(V)$

Identifying a linear ordering of vertices such that if the graph G contains an edge (u, v) , then u appears before v in the ordering. Often used in identifying dependency graphs or sources in a event chain. Multiple solutions may exist.

```

1 def topo_sort(G):
2     def dfs(u):
3         visited.add(u)
4         for v in G[u]:
5             if v not in visited:
6                 dfs(v)

```

```
7         order.insert(u)
8     order = list()
9     visited = set()
10    for u in G:
11        if u not in visited:
12            dfs(u)
13    return order
```

1.2 Data Structures

1.3 Linux

Common Commands

1. grep
2. awk
3. xargs
4. find
5. cut

Software & Packages

1. Vim
2. Tmux
3. Ranger
4. Autojump
5. Tldr
6. Jq
7. Ccat

2 Machine Learning

2.1 Supervised

2.1.1 Ordinary Least Squares (OLS)

2.1.2 Generalized Linear Model (GLM)

2.1.3 Logistic Regression

2.1.4 Linear Discriminant Analysis

2.1.5 Support Vector Machines

2.1.6 K-Nearest Neighbors

2.1.7 Gaussian Process

2.1.8 K-Nearest Neighbors

2.1.9 Decision Trees

2.1.10 Random Forest

2.1.11 Gaussian Process

2.1.12 Naive Bayes

2.1.13 Kalman Filter? dunno where this should go yet... maybe estimation section?

2.2 Unsupervised

2.2.1 Gaussian Mixture Models

2.2.2 K-Means

2.2.3 Density-Based Spatial Clustering of Applications with Noise (DBSCAN)

2.2.4 Spectral Clustering

2.2.5 Hierarchical Clustering

2.2.6 Factor Analysis

2.2.7 Independent Component Analysis

2.2.8 Principal Component Analysis

2.2.9 Non-Negative Matrix Factorization (NMF)

2.2.10 Latent Dirichlet Allocation (LDA)

2.2.11 Outlier Detection?

10

3 Deep Learning

3.1 Convolutional Networks

3.2 Recurrent Networks

3.2.1 Long Short-Term Memory (LSTM)