CS 496 Approximation Algorithms **Winter 2021**

Lecture 1: January 1

Lecturer: Konstantin Makarychev *Scribe: Muhan Li*

Disclaimer: *These notes have not been subjected to the usual scrutiny reserved for formal publications. They may be distributed outside this class only with the permission of the Instructor.*

1 An ordinary paragraph with inline equations

The naive and obvious solution to All Pairs Shortest Path(APSP) problem is to run a Single Source Shortest Path algorithm from each starting vertex v. If the graph has arbitrary edge weights, it takes the Bellman-Ford algorithm $O(|E||V|^2)$ time to solve APSP. But there are better approaches.

1.1 Multi-line equations

In multi-line equations, use "&" to vertically align your equations.

For equations without numbers.

$$\begin{aligned}
&\mathbb{E}_y\left[\sum_{x\in C}\min_{c\in\{c_1,\dots,c_t,y\}}\|x-c\|^2\right]\\
&=\sum_{y\in C}\frac{cost_t(y)}{cost_t(C)}*\sum_{x\in C}\min\{cost_t(x),\|x-y\|^2\}\\
&\text{(when you need to explain what happens here.)}\\
&\text{(eg: With hoeffding inequality, union bound, etc.)}\\
&=\sum_{x\in C,y\in C}\frac{cost_t(y)}{cost_t(C)}\min\{cost_t(x),\|x-y\|^2\}
\end{aligned}$$

For equations with numbers.

$$2n+1=O(n) \tag{1}$$

$$f(x)=o(g(x)) \tag{2}$$

$$q(x)=\Theta(p(x)) \tag{3}$$

2 Pesudo code

We use the algorithmic package to write formal pesudo code.

Algorithm 1 K-means (Floyd) algorithm

procedure K-MEANS(D, k, T) ▷ $D = \{x_1, \ldots, x_n\}$, k the cluster number, T loop times.
  Randomy select k samples from D as initial cluster centers $\{\mu_1, \ldots, \mu_k\}$
  $t \leftarrow 0$.
  repeat ▷ Either do it with \Repeat+ \Until, or \While + \EndWhile
    $t \leftarrow t + 1$
    $C_i \leftarrow \emptyset$ $(1 \leq i \leq k)$
    for $j = 1, \ldots, m$ **do**
      $d_{ji} \leftarrow \|x_j - u_i\|_2$ ▷ For each sample,, compute distance to every center.
      $\lambda_j = \arg\min_{i \in 1,\ldots,k} d_{ji}$ ▷ Determine cluster label of the sample.
      $C_{\lambda_j} = C_{\lambda_j} \cup \{x_j\}$ ▷ Assign sample to target cluster.
    end for
    for $i = 1, 2, ..., k$ **do**
      $\mu_i' \leftarrow \frac{1}{|C_i|} \sum_{x \in C_i} x$ ▷ Compute new centers.
      if $\mu_i' \neq \mu_i$ **then**
        $\mu_i \leftarrow \mu_i'$ ▷ Update center value.
      else
        Keep current center value.
      end if
    end for

  until No more updates to centers or $t \geq T$.
  return $\mathcal{C} = \{C_1, \ldots, C_k\}$ ▷ Return cluster partition
end procedure

3 Figures and tables

By tradition, captions are put below figures and above tables. The label has to be placed either right after the caption or into the caption macro.

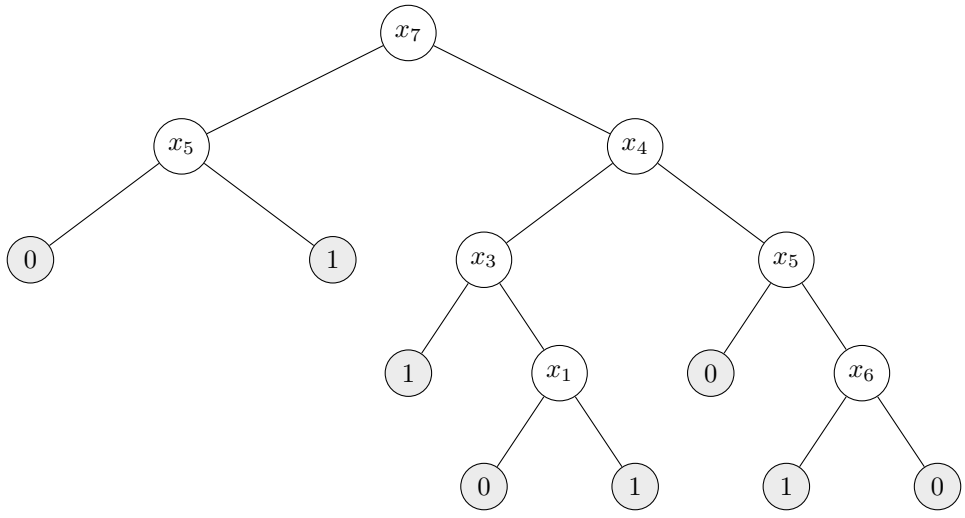

Figure 1: An example tikz picture.

Table 1: An example table, with left align, center align, right align, and fixed size columns

Country List			
Country Name or Area Name	ISO ALPHA 2 Code	ISO ALPHA 3 Code	ISO numeric Code
Afghanistan	AF	AFG	004
Aland Islands	AX	ALA	248
Albania	AL	ALB	008
Algeria	DZ	DZA	012
American Samoa	AS	ASM	016
Andorra	AD	AND	020
Angola	AO	AGO	024

You can reference figure 1 and Table 1 like this.

4 Citation

Reference an article [20221] and [RVF+21] like this.

References

[20221] *Monthly Notices of the Royal Astronomical Society*, 2021.

[RVF+21] Francesca Rizzo, Simona Vegetti, Filippo Fraternali, Hannah Stacey, and Devon Powell. Dynamical properties of z $\sim$ 4.5 dusty star-forming galaxies and their connection with local early type galaxies, 2021.