

# 1 CFLs

**note 1:**  $\Sigma = \{a, b\}$

**note 2:**  $n_x(a)$  means the number of a's in the string x.

- $\{x | n_x(a) = n_x(b)\}$   
corresponding CFG :

$$S \rightarrow aSbS | bSaS | \epsilon$$

- $\{x | n_x(a) \geq n_x(b)\}$   
corresponding CFG:

$$S \rightarrow SS | aSb | bSa | a | \epsilon$$

not surely right version :

$$\begin{aligned} S &\rightarrow SaS | T \\ T &\rightarrow aTbT | bTaT | \epsilon \end{aligned}$$

- $\{x | n_x(a) = 2n_x(b)\}$   
corresponding CFG:

$$S \rightarrow SaSaSbS | SaSbSaS | SbSaSaS | \epsilon$$

- complement of  $a^n b^n$   
corresponding CFG:

$$\begin{aligned} S &\rightarrow aSb | bY | Ya \\ Y &\rightarrow bY | aY | \epsilon \end{aligned}$$

- $\{a^i b^j | i \neq j \wedge i \neq 2j\}$   
corresponding CFG(not surely right):

$$\begin{aligned} S &\rightarrow A | B | N \\ E &\rightarrow aEb | \epsilon \\ A &\rightarrow Eb | aAb | Ab \\ B &\rightarrow aaEb | aBb \\ M &\rightarrow aaMb | \epsilon \\ N &\rightarrow aM | aNb | aN \end{aligned}$$