

Natural Language Processing (Spring 2023)

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1 Question 1

1 Question 1

Use the CKY algorithm to generate the parse tree for the sentence "fish people fish tanks". 8 marks The probabilistic context free grammar in CNF with unarys is given in the figure below. When the start position is 0 and end position is 1, the sentence is "fish". Looking at the grammar, we see that there are two rules that generate "fish" directly: $N \rightarrow$ fish with probability 0.2, and $V \rightarrow$ fish with probability 0.6. We place these two transitions in the location 0 to 1 corresponding to fish. There is a rule $NP \rightarrow N$ with probability 0.7 that can combine with $N \rightarrow$ fish with probability 0.2 to generate fish from NP with probability $0.7 \times 0.2 = 0.14$. Similarly, all the single word entries are pre-filled in the table. Fill the remaining entries in the table and generate the desired parse tree if possible from the grammar.

Grammar Rules	Correspondir Probabilites	ng							
S → NP VP	0.9	0fish	1	people	2	fish	3	tanks	4
S → VP	0.1	$N \rightarrow \text{fish } 0.2$							
VP → V NP	0.5	V → fish 0.6							
$VP \rightarrow V$	0.1	$NP \rightarrow N \ 0.14$ $VP \rightarrow V \ 0.06$							
VP → V @VP_V	0.3	1 S → VP 0.006							
$VP \rightarrow VPP$	0.1	1	N	→ people 0.5	;				
@VP_V → NP PP	1.0			→ people 0.1					
$NP \rightarrow NP NP$	0.1		100000	P → N 0.35					
$NP \rightarrow NP PP$	0.2	•	100.00	\rightarrow V 0.01 \rightarrow VP 0.001					
$NP \rightarrow N$	0.7	2	3	→ VP 0.001	1500		_		-
$PP \rightarrow P NP$	1.0				1000	→ fish 0.2 → fish 0.6			
10						\rightarrow N 0.14			
$N \rightarrow people$	0.5				VP	→ V 0.06			
$N \rightarrow fish$	0.2	3			S -	→ VP 0.006	5		
$N \rightarrow tanks$	0.2	3					N	I → tanks 0.2	:
$N \rightarrow rods$	0.1						V	→ tanks 0.1	
$V \rightarrow people$	0.1							IP → N 0.14	
V → fish	0.6	12						$P \rightarrow V 0.03$ $\rightarrow VP 0.003$	
V → tanks	0.3	4					3	→ VF 0.003	
P → with	1.0								

Figure 1:

See the solution below.

	FISH	PEOPLE	FISH	TANKS
FISH	N > fish (0.2) V > fish (0.6) NP > N (0.7×0.2=0.14) NP > V (0.6×0.1=0.06) S> VP (0.06×0.1=0.006)	VP→ V NP (0.6 × 0.35 × 0.5 = 0.105) NP→ NP NP (0.14 × 0.35 × 0.1 = 0.0049) S→ NP VP NS→VP (0.0105) (0.14 × 0.01 × 0.9 = 0.00126)	VP→ V NP Max (0.6×0.0049×0.5) = 0.00147 NP→ NP NP (0.0049×0.14×0.1) = 0.0000886 S→NP VP (0.9×0.14×0.007=0.000 2646	
PEOPLE	*	N \rightarrow people (0.5) V \rightarrow people (0.1) NP \rightarrow N (0.5×0.7=0.35) VP \rightarrow V (0.1×0.1=0.01) S \rightarrow VP (0.1×0.1=0.001)	VP → V NP (D.1 × O·14 × O·5=0·007) ^X NP → NP NP (O·35 × O·14 × O·1=0·0049) S→NP VP #S→VP (O·0007) (O·35 × O·06 × O·9= O·0189) ^V	
PISIP	*	*	Copy $N \rightarrow fish (0.2)$ $V \rightarrow fish (0.6)$ $NP \rightarrow N (0.14)$ $VP \rightarrow V (0.06)$	VP → V NP (0.6 × 0.14 × 0.5 = 0.042) VI NP → NP NP (0.14 × 0.14 × 0.1 = 0.00196) S→ NP VP // S→ VP (0.0042) (0.14 × 0.03 × 0.9 = 0.00378
TANKS	*	*	*	N-> tanks (0.2) V-> tanks (0.3) NP-> N (0.2×0.7=0.14) VP-> V (0.3×0-1=0.03) S-> VP {0.03×0.1=0.003}

-	FISH	PEOPLE	FISH	TANKS
FISH	N->fish (0.2) V->fish (0.6) NP > N (0.7×0.2=0.14) VP -> V (0.6×0.1=0.06) S-> VP (0.06×0.1=0.006)	VP→ V NP (0.6 × 0.35 × 0.5 = 0.105) NP→ NP NP (0.14 × 0.35 × 0.1 = 0.0049) S→ NP VP NS→VP (0.0105) (0.14 × 0.01 × 0.01 × 0.9 = 0.00126)	S-NP YP	
PEOPLE	*	N → people (0.5) V → people (0.1) NP → N (0.5×0.7=0.35) VP → V (0.1×0.1=0.00) S → VP (0.1×0.1=0.001)	(0.9×0.14×0.007=0.000 VP -> Y NP (0.1×0.14×0.5=0.007) NP -> NP NP (0.35×0.14×0.1=0.0049) S-> NP VP 115 -> VP (0.0007) (0.35×0.06×0.9=	VP -> V NP (0.1×0.00196×0.5 =0.000038) NP -> NP NP (0.35×0.00196×0.1
75lp	*	*	NP → N (0.14) VP → V (0.06)	VP -> V NP (0.6 × 0.14 × 0.5=0.042), NP -> NP NP (0.14 × 0.14 × 0.1=0.0042, S-> NP NP NS -> NP (0.0042, (0.14 × 0.03 × 0.9=0.003,
TANKS	*	*	*	N→ tanks (0.2) V→ tanks (0.3) NP→ N (0.2×0.7=0.14) VP→ V (0.3×0.1=0.03) S→ VP (0.03×0.1=0.003)

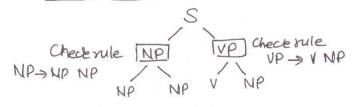
NP VP (ARST TREE) (4,2) (3,4)

Selected cells for $S \rightarrow NP VP$ (1,2) (3,4)

The company of the co	FISH	PEOPLE 2	H2H3	TANKE			
FISH	N=fish (0.2) V= fish (0.6) NP \rightarrow N (0.7×0.2=0.14) VP \rightarrow V (0.6×0.1=0.06) S=> VP (0.06×0.1=0.006)	VP→ V NP (0.6 X 0.35 X 0.5 = 0.105)"	VP-> V NP Max (0.6 x 0.0049 x 0.5) = 0.00147 NP-> NP NP (0.0049 x 0.14 x 0.1) = 0.0000686 S-> NP VP	TANKS 4. VP-> V NP (0.6×0.0000686×0.5 = 0.00002058) NP-> NP NP (0.14×0.0000686×0.1=70.000009604 (0.0000686×0.014×0.01=5)			
PEOPLE 2	*	N -> people (0.5) V -> people (0.1) NP -> N (0.5 x 0.7 = 0.35) VP -> V (0.1 x 0.1 = 0.01) S -> VP (0.1 x 0.1 = 0.001)	VP -> V NP (D1 x 0.14 x 0.5 = 0.007) NP -> NP NP (D.35 x 0.14 x 0.1 = 0.004) S>NP VP NS -> VP (0.0007) (D.35 x 0.06 x 0.9 =	VP -> V NP (0.14x0.000048 x 0.9) ^X (0.0049 X 0.000098) NP -> NP NP (0.35x0.00196x 0.1 =00000686) S-> NP VP			
PISIP 3	*	*	Copy $N \rightarrow fish (0.2)$ $V \rightarrow fish (0.6)$ $NP \rightarrow N (0.14)$ $VP \rightarrow V (0.06)$	(0.35×0.042×0.9=0.000323 (0.0000686 VP → V NP			
TANKS	*	*	*	1 → tanks (0.2) 1 → tanks (0.3) 1P → N (0.2×0.7=0.14) 1P → V (0.3×0.1=0.03) 1 → VP (0.03×0.1=0.003)			

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SECOND TREE



THIRD TREE

