DECODING DISTRIBUTED TREE STRUCTURES

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Xerox Research Centre Europe

INTRODUCTION

- Natural language processing tasks benefit from syntactic information

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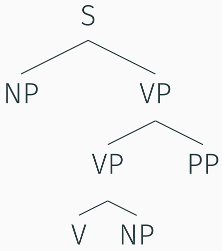
Directly

- Symbolic Tree Structures



- Tree Kernels (Collins; 2001)

FROM SYNTACTIC TREES TO DISTRIBUTED TREES

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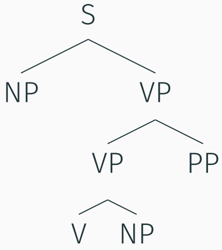

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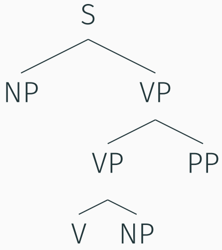

- Tree Kernels (Collins; 2001)

$\longrightarrow$

Indirectly

- Distributed Tree Structures

$$\mathbf{t} = (0.0112, 0.212, \ldots, 0.0081) \in \mathbb{R}^d$$

Distributed Trees (Zanzotto; 2012)

- Approximate tree kernels (Collins; 2001)

$$\langle \mathbf{t}_1, \mathbf{t}_2 \rangle \approx TK(T_1, T_2)$$

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- Faster to compute than tree kernels

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Distributed Trees (Zanzotto; 2012)

- Approximate tree kernels (Collins; 2001)

$$\langle \mathbf{t_1}, \mathbf{t_2} \rangle \approx TK(T_1, T_2)$$

- Faster to compute than tree kernels
- Can be used as input in any algorithm
  - Neural network
  - Support Vector Machines
  - ...

WHAT'S IN A DISTRIBUTED VECTORS?

Question

- How much information is stored in a distributed vector?
- In other words, can we decode the structured representation from a distributed vector?

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Our Idea

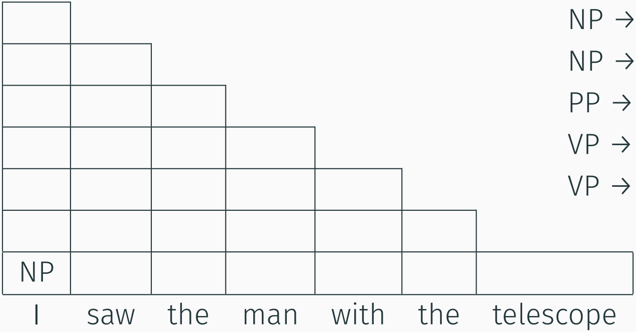
- Traditional parsing:
    - CYK algorithm (and others)
- Use distributed vectors to *"guide"* the algorithm choices

CYK (Cocke, Younger, Kasami; 1967)

Given a sentence *s* of length *n* and a grammar *G*:

- builds a $n \times n$ table which contains the partial parses of the sentence

CYK ALGORITHM



Grammar:

S → NP VP

NP → DET N

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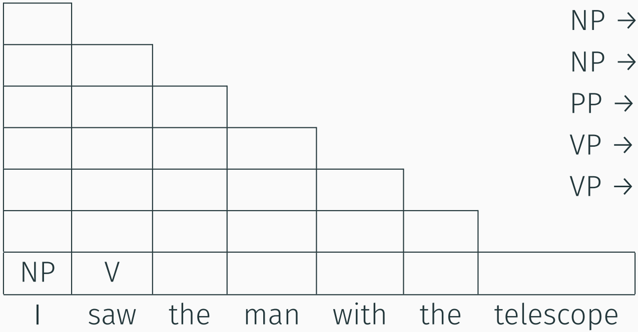

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CYK ALGORITHM

NP	V	DET				
I	saw	the	man	with	the	telescope

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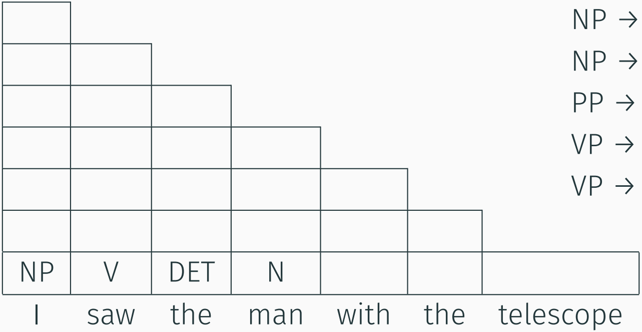

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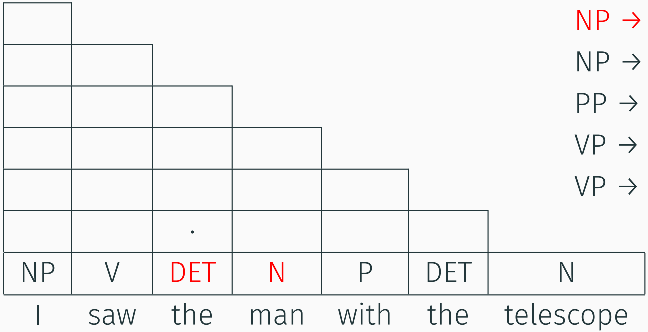

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We also store backpointers to record what rule we choose

		NP				
NP	V	DET	N	P	DET	N
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S						
	VP			PP		
		NP			NP	
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		NP			NP	
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S		·				
	VP			PP		
		NP			NP	
NP	V	DET	N	P	DET	N
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	VP, VP					
		NP				
S						
	VP			PP		
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Again, we store backpointers for the two possibilities

	VP, VP					
		NP				
S						
	VP			PP		
		NP			NP	
NP	V	DET	N	P	DET	N
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- Even in this small example there are two plausible interpretations
- In general there are (exponentially) many more!
- Usually parsers use probabilistic grammars to disambiguate
    - Each rule of the grammar has an inherent probability (which must be learned)

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Idea

We show that a reference distributed vector of the correct parse is enough to eliminate ambiguity

(and thus reconstruct the original parse)

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Ingredients:

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- Reference grammar G

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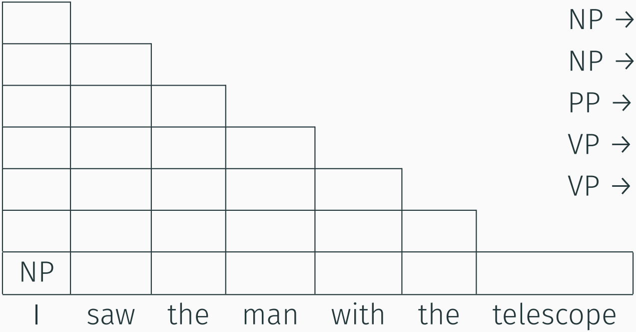
Ingredients:

- Reference grammar G
- Distributed vector $\mathbf{t}$

$$t \rightarrow \mathbf{t} = (0.011, 0.212, \ldots, 0.008) \in \mathbb{R}^d$$

DISTRIBUTED CYK



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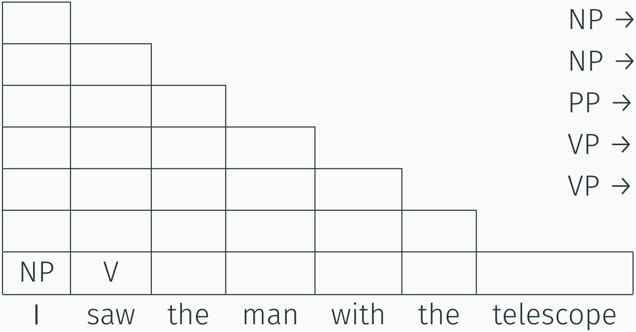

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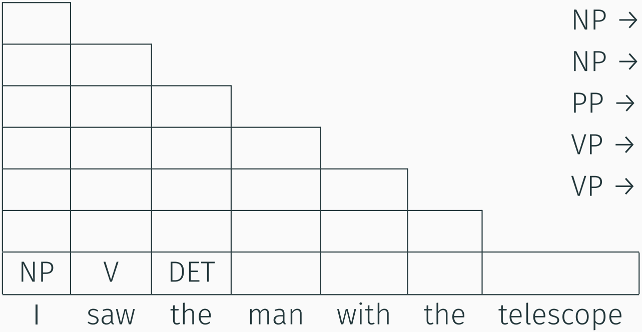

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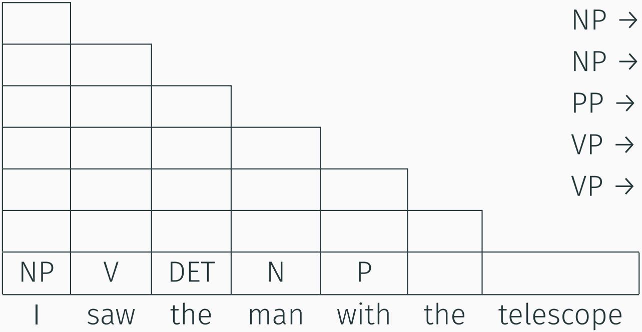

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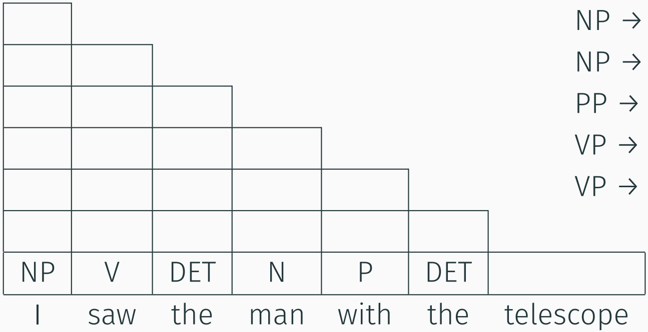

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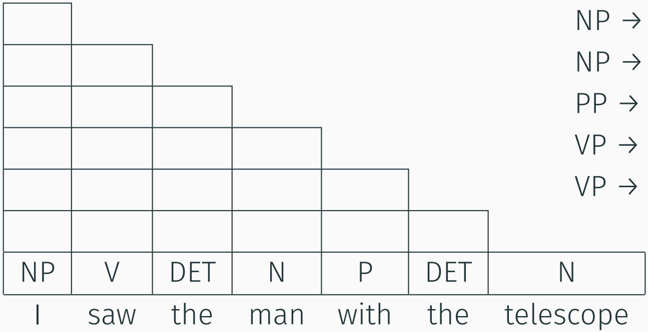

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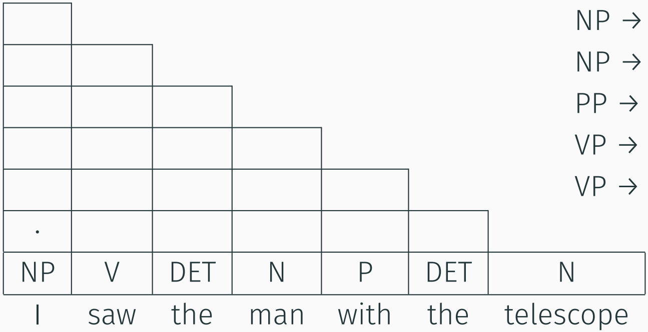

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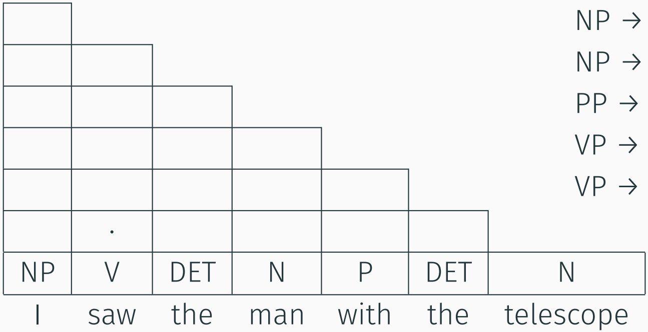

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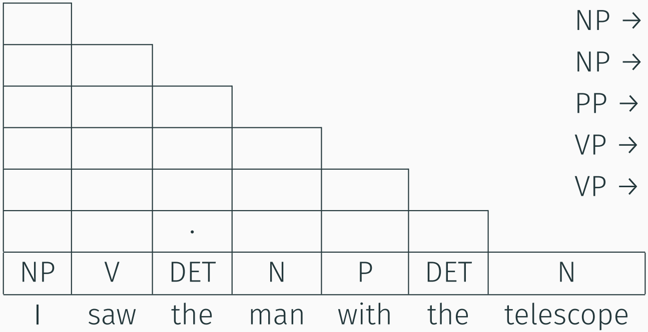

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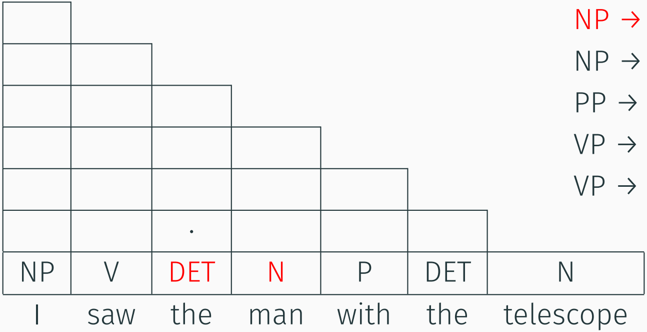

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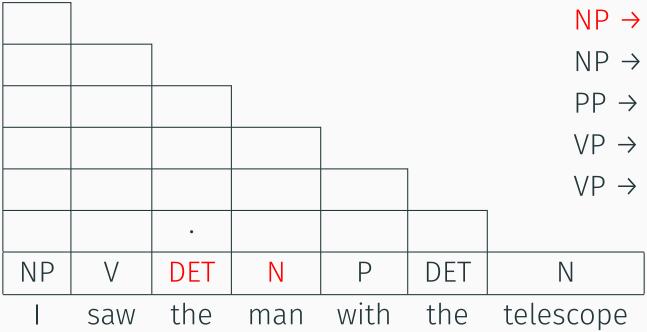

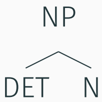

$t \to \mathbf{t} = (0.011, 0.212, \ldots, 0.008) \in \mathbb{R}^d$ $\quad$ $\mathbf{r} = (0.005, 0.043, \ldots, 0.016)$

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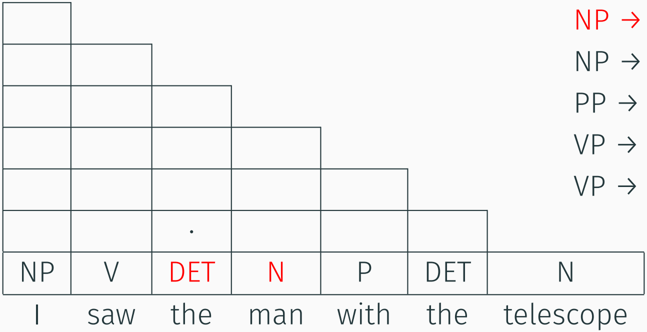

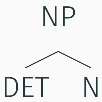

$\langle \mathbf{t}, \mathbf{r} \rangle$

$t \rightarrow \mathbf{t} = (0.011, 0.212, \ldots, 0.008) \in \mathbb{R}^d$ $\mathbf{r} = (0.005, 0.043, \ldots, 0.016)$

We store the full subtrees here!

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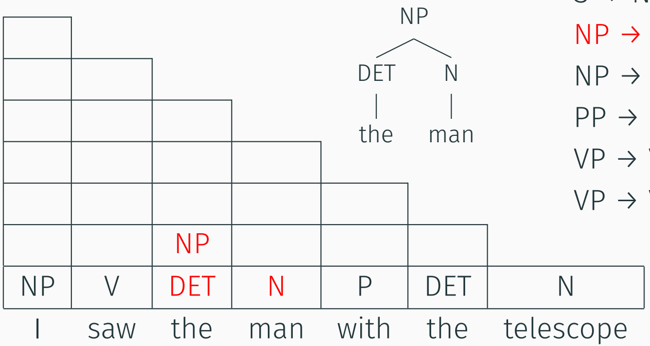

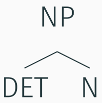

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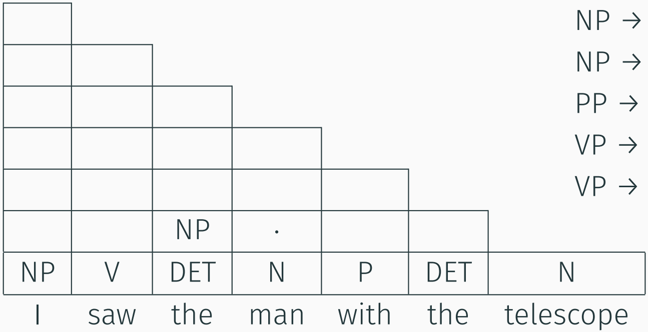

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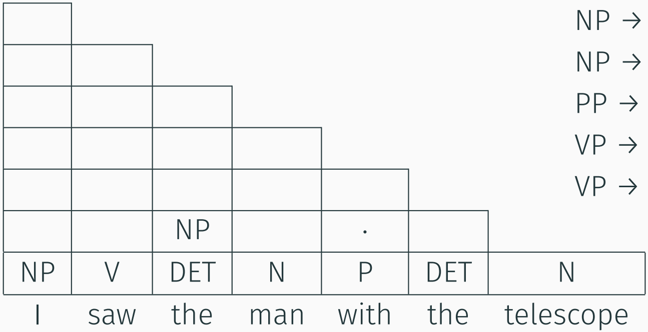

$t \rightarrow \mathbf{t} = (0.011, 0.212, \ldots, 0.008) \in \mathbb{R}^d$

DISTRIBUTED CYK

		NP			NP	
NP	V	DET	N	P	DET	N
I	saw	the	man	with	the	telescope

Grammar:

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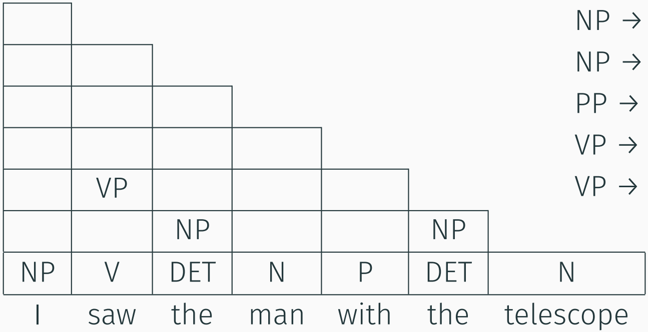

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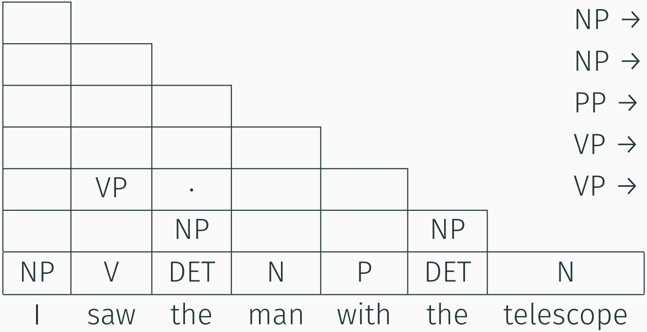

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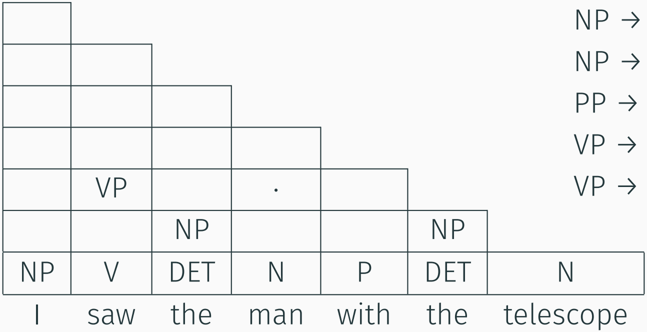

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S						
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S						
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		NP			NP	
NP	V	DET	N	P	DET	N
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		NP				
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		NP				
S						
	VP			PP		
		NP			NP	
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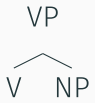

$t \rightarrow \mathbf{t} = (0.011, 0.212, \ldots, 0.008) \in \mathbb{R}^d$ $\quad \mathbf{r}_1 = (0.005, 0.043, \ldots, 0.016)$

	·					
		NP				
S						
	VP			PP		
		NP			NP	
NP	V	DET	N	P	DET	N
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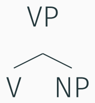

$\langle \mathbf{t}, \mathbf{r}_1 \rangle$

$t \rightarrow \mathbf{t} = (0.011, 0.212, \ldots, 0.008) \in \mathbb{R}^d$ $\quad \mathbf{r}_1 = (0.005, 0.043, \ldots, 0.016)$

	VP					
		NP				
S						
	VP			PP		
		NP			NP	
NP	V	DET	N	P	DET	N
I	saw	the	man	with	the	telescope

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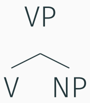

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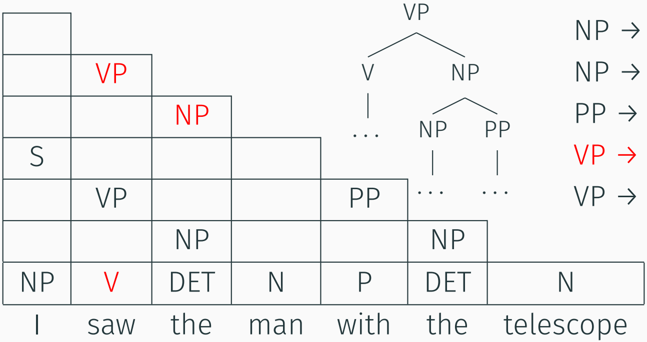
$t \rightarrow \mathbf{t} = (0.011, 0.212, \ldots, 0.008) \in \mathbb{R}^d$

$\mathbf{r}_1 = (0.005, 0.043, \ldots, 0.016)$

We store the full subtrees here!



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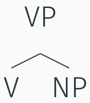

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	VP					
		NP				
S						
	VP			PP		
		NP			NP	
NP	V	DET	N	P	DET	N
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	VP					
		NP				
S						
	VP			PP		
		NP			NP	
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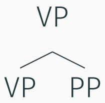

$t \rightarrow \mathbf{t} = (0.011, 0.212, \ldots, 0.008) \in \mathbb{R}^d$ $\quad$ $\mathbf{r}_2 = (0.001, 0.008, \ldots, 0.024)$

Grammar:

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	VP					
		NP				
S						
	VP			PP		
		NP			NP	
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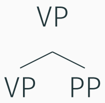

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$t \rightarrow \mathbf{t} = (0.011, 0.212, \ldots, 0.008) \in \mathbb{R}^d$

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	VP,VP					
		NP				
S						
	VP			PP		
		NP			NP	
NP	V	DET	N	P	DET	N
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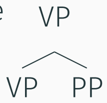

$\langle \mathbf{t}, \mathbf{r}_2 \rangle$

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$\langle \mathbf{t}_1, \mathbf{t} \rangle$

$\langle \mathbf{t}_2, \mathbf{t} \rangle$

	VP,VP					
		NP				
S						
	VP			PP		
		NP			NP	
NP	V	DET	N	P	DET	N
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EXPERIMENTS AND RESULTS

Dataset

Wall Street Journal sections of PennTree Bank:

- Sections 1~23: Grammar extraction
- Section 24: testing

Experimental pipeline

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- Parse the dataset and binarize the trees

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- Parse the dataset and binarize the trees
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    - The set of all rules in the grammar, no probabilities learned
- On test set (1346 sentences):
    - Compute the distributed vector $\mathbf{t}$
    - use $\mathbf{t}$ to parse the sentence
    - compare the result with the correct tree

Parameters

Parameters

- d: Dimension of the vector representation

Parameters

- d: Dimension of the vector representation
- k: number of partial trees kept in each cell
    - we only report $k = 2$

Results

- Number of exactly reconstructed trees;
- (Labelled) precision, recall and f-measure;

1024	2048	4096	8192	16384
23.5%	52.32%	75.58%	87.5%	**92.79%**

Table 1: Percentage of exactly reconstructed sentence

	1024	2048	4096	8192	16384
precision	0.71	0.85	0.951	0.99	**0.994**
recall	0.477	0.78	0.929	0.967	**0.976**
f-measure	0.57	0.81	0.939	0.974	**0.984**

Table 2: Precision, recall and F-measure

SUMMARY AND FUTURE WORK

Summary

- We showed that distributed trees are able to reconstruct almost always the original symbolic tree

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Future work

- Expand the experimental setting:
    - from CNF to general grammars

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Future work

- Expand the experimental setting:
  - from CNF to general grammars
- Use the reconstruction method on other distributed representations

Questions?