Baby Steps: How "Less is More" in Unsupervised Dependency Parsing

VALENTIN I. SPITKOVSKY, HIYAN ALSHAWI AND DANIEL JURAFSKY

vals@stanford.edu, hiyan@google.com and jurafsky@stanford.edu

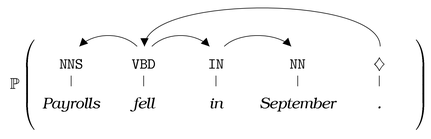
SUMMARY

We present two simple, data complexity aware approaches for unsupervised grammar induction and apply them to Klein and Manning's Dependency Model with Valence: **Baby Steps** bootstraps itself without a prior, by increasing data complexity gradually; **Less is More** focuses on fewer but lower complexity examples, trading off quantity against ambiguity.

DEPENDENCY MODEL WITH VALENCE

- generative process
- projective trees
- single-state head automata
- unlexicalized (part-of-speech tags)

EXAMPLE:



$$\begin{aligned}
= \; & (1 - \mathbb{P}_{\text{STOP}}(\diamond, \text{L}, \text{T}))^{0} \\
\times \; & (1 - \mathbb{P}_{\text{STOP}}(\text{VBD}, \text{R}, \text{T})) \\
\times \; & \mathbb{P}_{\text{STOP}}(\text{VBD}, \text{L}, \text{F}) \\
\times \; & \mathbb{P}_{\text{STOP}}(\text{IN}, \text{L}, \text{T}) \\
\times \; & \mathbb{P}_{\text{ATTACH}}(\diamond, \text{L}, \text{VBD}) \\
\times \; & \mathbb{P}_{\text{ATTACH}}(\text{VBD}, \text{R}, \text{IN}) \\
\times \; & \mathbb{P}_{\text{STOP}}(\text{VBD}, \text{R}, \text{F}) \\
\times \; & \mathbb{P}_{\text{STOP}}(\text{IN}, \text{R}, \text{F}) \\
\times \; & (1 - \mathbb{P}_{\text{STOP}}(\text{VBD}, \text{L}, \text{T})) \\
\times \; & (1 - \mathbb{P}_{\text{STOP}}(\text{IN}, \text{R}, \text{T})) \\
\times \; & \mathbb{P}_{\text{STOP}}(\text{NNS}, \text{L}, \text{T}) \\
\times \; & \mathbb{P}_{\text{STOP}}(\text{NN}, \text{L}, \text{T}) \\
\times \; & \mathbb{P}_{\text{STOP}}(\diamond, \text{L}, \text{F})^{1} \\
\times \; & \mathbb{P}_{\text{ATTACH}}(\text{VBD}, \text{L}, \text{NNS}) \\
\times \; & \mathbb{P}_{\text{ATTACH}}(\text{IN}, \text{R}, \text{NN}) \\
\times \; & \mathbb{P}_{\text{STOP}}(\text{NNS}, \text{R}, \text{T}) \\
\times \; & \mathbb{P}_{\text{STOP}}(\text{NN}, \text{R}, \text{T}) \\
\times \; & \mathbb{P}_{\text{STOP}}(\diamond, \text{R}, \text{T})^{1}.
\end{aligned}$$

STANDARD TRAINING: **Ad-Hoc** Init ⇒ WSJ10

- EM via inside-outside re-estimation (on WSJ10)
- Ad-Hoc harmonic initializer aims for balanced trees

CONCLUSION

Small tweaks to Klein and Manning's approach of 2004 beat 2009 state-of-the-art on longer sentences. We suspect that other parsing models and unsupervised learning algorithms also stand to gain from an awareness of data complexity.

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BABY STEPS

No Init ⇒ WSJ1 → WSJ2 → ⋯ → WSJ45

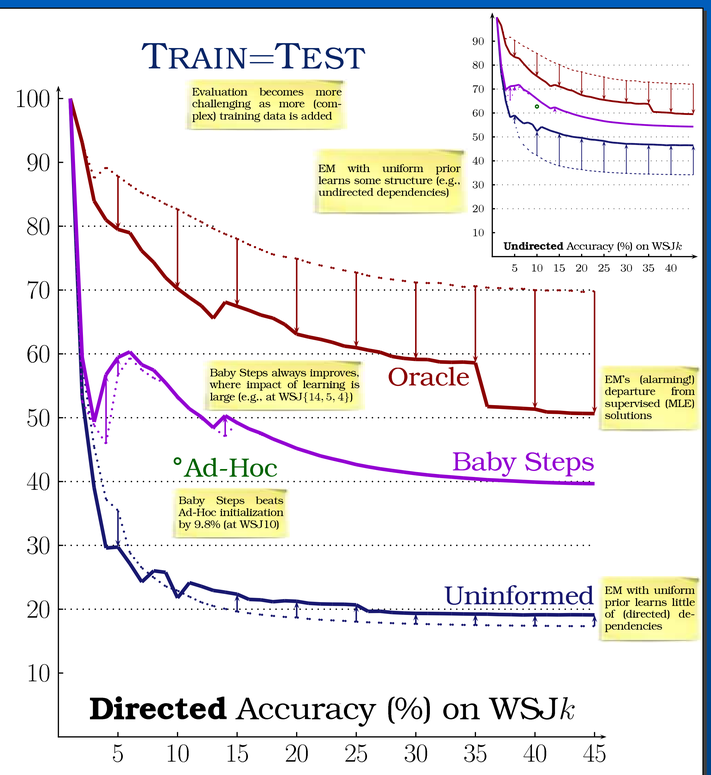
- iterative training with increasingly longer sentences
- initialization-free

LESS IS MORE

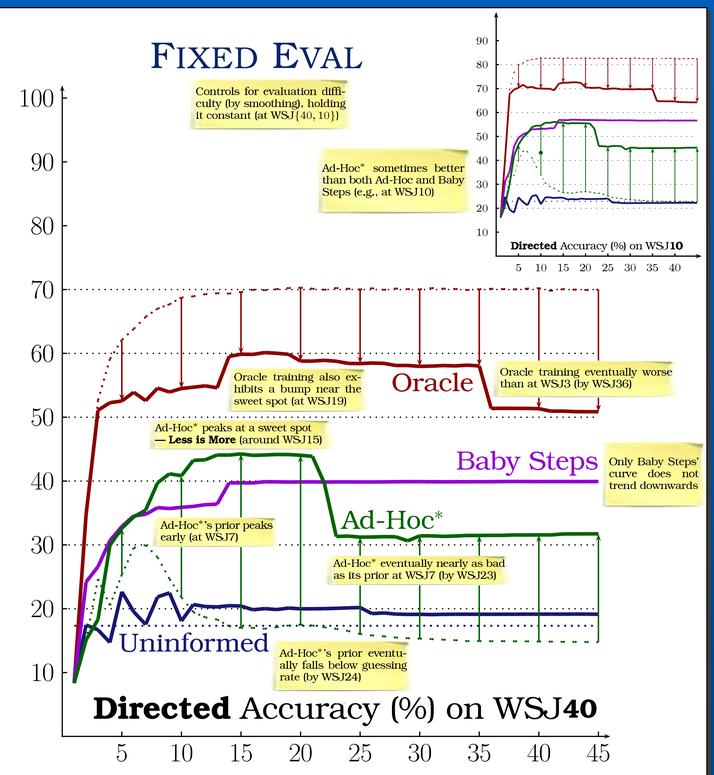
Ad-Hoc* Init ⇒ WSJ15

- standard batch training, but at "sweet spot" lengths
- linguistically-informed prior (our implementation of Ad-Hoc)

TRAIN=TEST



FIXED EVAL



GENERALIZATION

	*Ad-Hoc**	*Baby Steps*		*Ad-Hoc**	*Baby Steps*	
Section 23	**44.1** (58.8)	39.2 (53.8)	@15	31.5 (51.6)	39.4 (54.0)	@45
WSJ100	**43.8** (58.6)	39.2 (53.8)		31.3 (51.5)	39.4 (54.1)	
Brown100	**43.3** (59.2)	42.3 (55.1)		32.0 (52.4)	42.5 (55.5)	

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STATE OF THE ART

			Decoding	WSJ10	WSJ20	WSJ∞
	Attach-Right	(Klein and Manning, 2004)	—	38.4	33.4	31.7
DMV	Ad-Hoc	(Klein and Manning, 2004)	Viterbi	45.8	39.1	34.2
	Dirichlet	(Cohen et al., 2008)	Viterbi	45.9	39.4	34.9
	Ad-Hoc	(Cohen et al., 2008)	MBR	46.1	39.9	35.9
	Dirichlet	(Cohen et al., 2008)	MBR	46.1	40.6	36.9
	Log-Normal Families	(Cohen et al., 2008)	Viterbi	59.3	45.1	39.0
	Baby Steps (@15)		*Viterbi*	*55.5*	*44.3*	*39.2*
	Baby Steps (@45)		*Viterbi*	*55.1*	*44.4*	*39.4*
	Log-Normal Families	(Cohen et al., 2008)	MBR	59.4	45.9	40.5
	Shared Log-Normals (tie-verb-noun)	(Cohen and Smith, 2009)	MBR	61.3	47.4	41.4
	Bilingual Log-Normals (tie-verb-noun)	(Cohen and Smith, 2009)	MBR	62.0	48.0	42.2
	Less is More (Ad-Hoc* @15)		*Viterbi*	*56.2*	**48.2**	**44.1**
EVG	Smoothed (skip-val)	(Headden et al., 2009)	Viterbi	62.1		
	Smoothed (skip-head)	(Headden et al., 2009)	Viterbi	65.0	*Section 23*	
	Smoothed (skip-head), Lexicalized	(Headden et al., 2009)	Viterbi	**68.8**		