A Neural Local Coherence Model

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Entity-based Coherence

- Text is about entities: objects in the world
- A text addresses a common topic often covering multiple subtopics
- Earlier sentences provide context for later ones
- **Centering theory:** Coherence created by *repeated entity mentions*
- **Coherence modeling:** Model entity transition across sentences to distinguish a coherent from incoherent texts

Entity Grid and Its Extensions

Barzilay and Lapata (2008)

- Model grammatical role transmission of nouns (heads of NPs) across sentences
- Represent documents as distributions defined over **entity transition** (vectors of 4^k transitions probabilities $\{S, O, X, -\}^k$)
- Assessment of text coherence as a ranking problem in an SVM preference ranking framework

Table: Entity grid representation for a WSJ article.

	UNIT	PRODUCTS	RESEARCH	COMPANY	PARTS	CONTROLS	INDUSTRY	ELECTRONICS	TERM	CONCERN	AEROSPACE	EMPLOYEES	SERVICES	LOS ANGELES	EATON
s_0	O	–	X	X	–	–	–	–	–	–	–	X	–	–	X
s_1	–	–	–	–	–	–	–	–	S	–	–	–	–	–	–
s_2	–	O	–	–	–	–	X	–	–	–	–	O	O	X	–
s_3	–	–	–	–	X	X	–	X	–	O	X	–	–	–	S

Elsner and Charniak (2011)

- Include non-head nouns
- Extend grid to distinguish between entities by incorporating entity-specific features: named entity, noun class, modifiers, etc

Limitations of entity grid models

- Cannot capture long entity transitions
- Limit to learn task-specific features

Our Neural Coherence Model

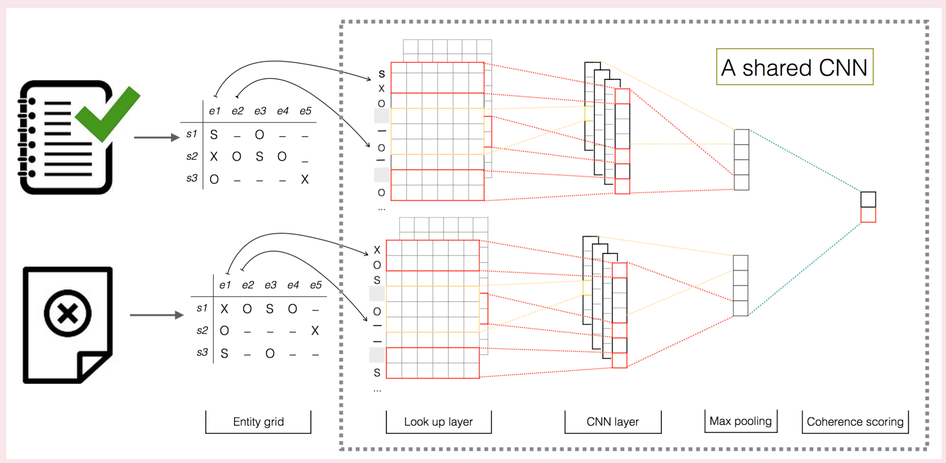


Figure: A Convolutional Neural Network (CNN) architecture for modeling local coherence.

Grid CNN:

- Use a **convolutional** approach
- Transform each grammatical role in grid into distributed representation
- Model sufficiently long entity transitions in location invariant way
- Train in end-to-end fashion on a target task (e.g., discrimination)
- Learn task-specific high level features

Extended Grid CNN:

- Incorporate entity-specific features
- Attach feature values with grammatical roles
  - if an entity e_j of type $PERSON$ appears as a subject (S) in a sentence s_i,
  - the grid entry $G_{i,j}$ can be encoded as $PERSON\_S$.

Pairwise end-to-end training:

- Input: ordered pairs (d_i, d_j), where document d_i is more coherent than d_j
- Use pairwise ranking approach to learn θ by minimizing the objective:

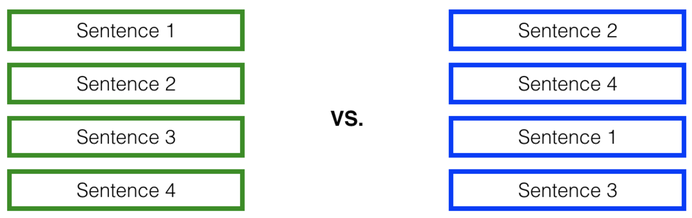
$$\Im(\theta) = max\{0, 1 - \phi(G_i|\theta) + \phi(G_j|\theta)\} \quad (1)$$

where G_i and G_j are entity grids of d_i and d_j, respectively
θ: set of CNN parameters

Experiment 1: Sentence Ordering

Discrimination

- A document is compared to its permutations of sentences



Insertion

- Remove and re-insert one sentence at a time into every position
- Examine permutations closer to the original ordering

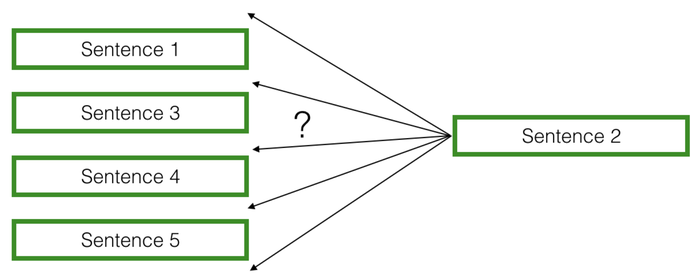


Table: WSJ dataset

	Sections	Doc.	Pairs	Avg. Sen.
TRAIN	00-13	1,378	26,422	21.5
TEST	14-24	1,053	20,411	22.3

Table: Coherence evaluation results on **Discr**imination and **Ins**ertion tasks. † indicates a neural model is significantly superior to its non-neural counterpart with p-value < 0.01.

	Discr.		**Ins.**
	Acc	F_1	
Random	50.00	50.00	12.60
Graph-based (G&S)	64.23	65.01	11.93
Dist. sentence (L&H)	77.54	77.54	19.32
Grid-all nouns (E&C)	81.58	81.60	22.13
Extended Grid (E&C)	84.95	84.95	23.28
Grid-CNN	85.57†	85.57†	23.12
Extended Grid-CNN	**88.69**†	**88.69**†	**25.95**†

Experiment 2: Summary Coherence Rating

- Compare rankings of summaries produce by model against rankings of summaries by human judges
- Dataset: Document Understanding Conference (DUC 2003)
  - Pair summaries from human judgments and automatics summarization systems
  - TRAIN: **144** pairs and TEST: **80** pairs

Table: Evaluation results on the **Summary Coherence Rating** task.

	Acc	F_1
Random	50.0	50.0
Graph-based (G&S)	80.0	81.5
Grid (B&L)	83.8	-
Grid-CNN	85.0	85.0
Extended Grid-CNN	86.3	86.3
Pre-trained Grid-CNN	86.3	86.3
Pre-trained Ext. Grid-CNN	**87.5**	**87.5**

Conclusion

Our contribution

- Local text coherence model based on a convolutional neural network that operates over entity transitions of arbitrary length
- Pairwise ranking approach to train the model end-to-end
- Yield the best performance reported so far
- Code and data: `https://github.com/datienguyen/cnn_coherence/`

Future work:

- Include rhetorical relations
- Extend the model to other forms of discourse, especially, asynchronous conversations (e.g., forum, email, etc)

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