Natural Language Understanding

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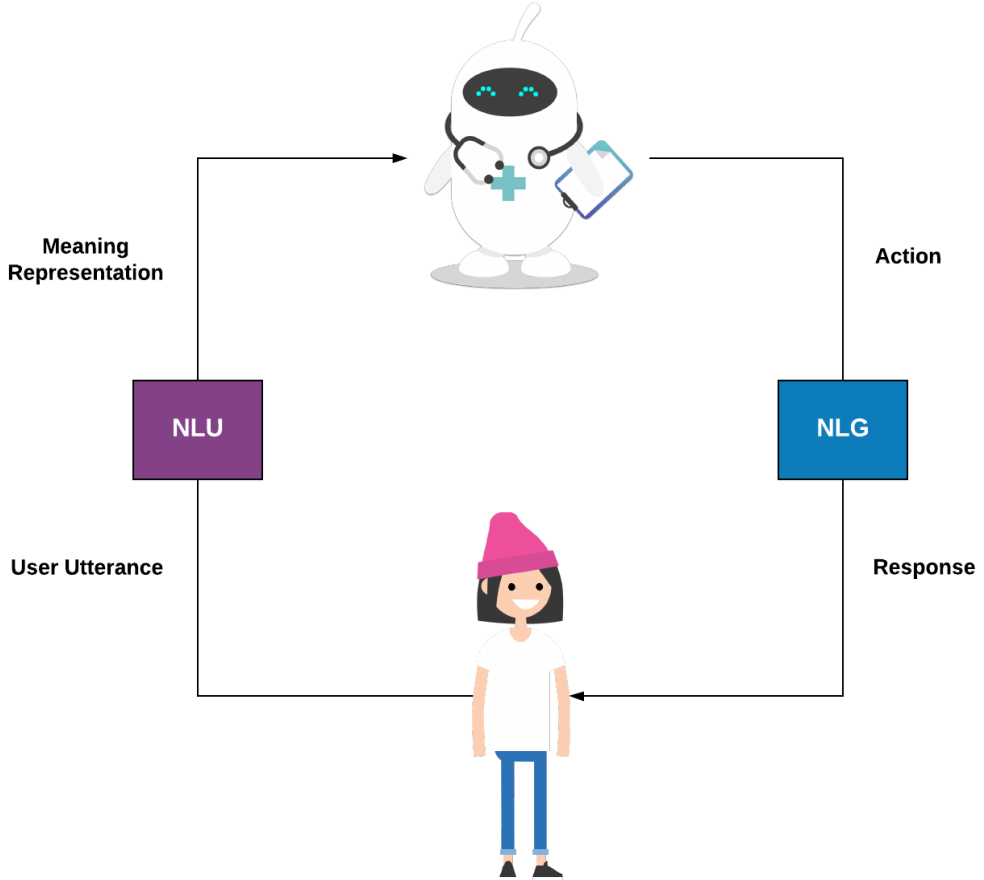
BIME 591: Artificial Intelligence Methods for Conversational Agents in Healthcare

2019-10-08

Task

Given a *user utterance* construct a computable *meaning representation.*



Intent/Slot Schema

Intent: The purpose behind the user utterance.

Each intent can define slots required to fulfill that intent.

I need transportation to the hospital.

Destination
(Place)

Book Ride

Alternatives:

- Grammars
- Propositional Logic
- Example: Head-drive Phrase Structure Grammar and Minimal Recursion Semantics

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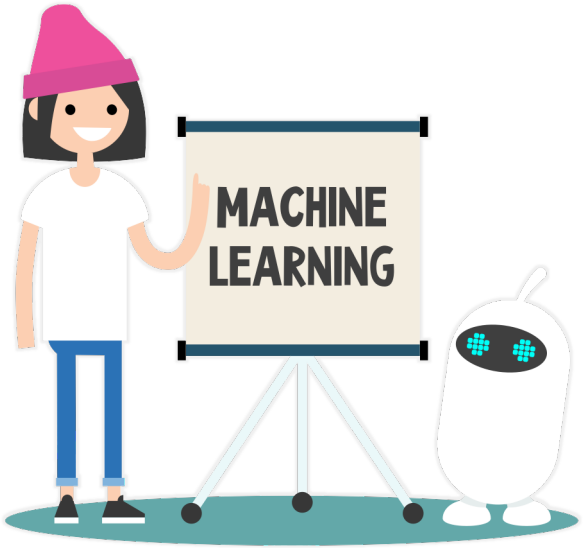


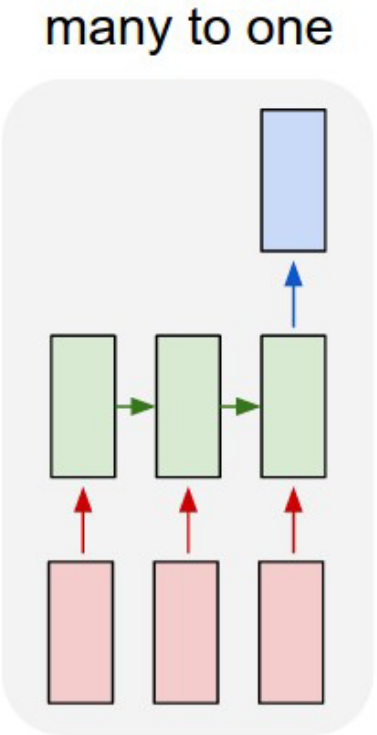
Alternatives:

- Grammars
- Propositional Logic
- Example: Head-drive Phrase Structure Grammar and Minimal Recursion Semantics

Intent Classification Methods

Input: Word Sequence **Output:** Intent Class

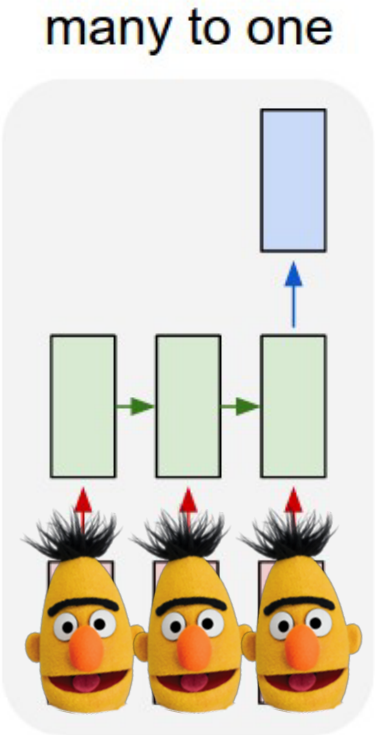
- Index all words to numerical representation, i.e. hospital → 324
- Represent each word as a vector using a randomly initialized embedding matrix.
- Use favorite classification model LR, CNN, LSTM, Transformer.
- Learn weights using backpropagation of loss.

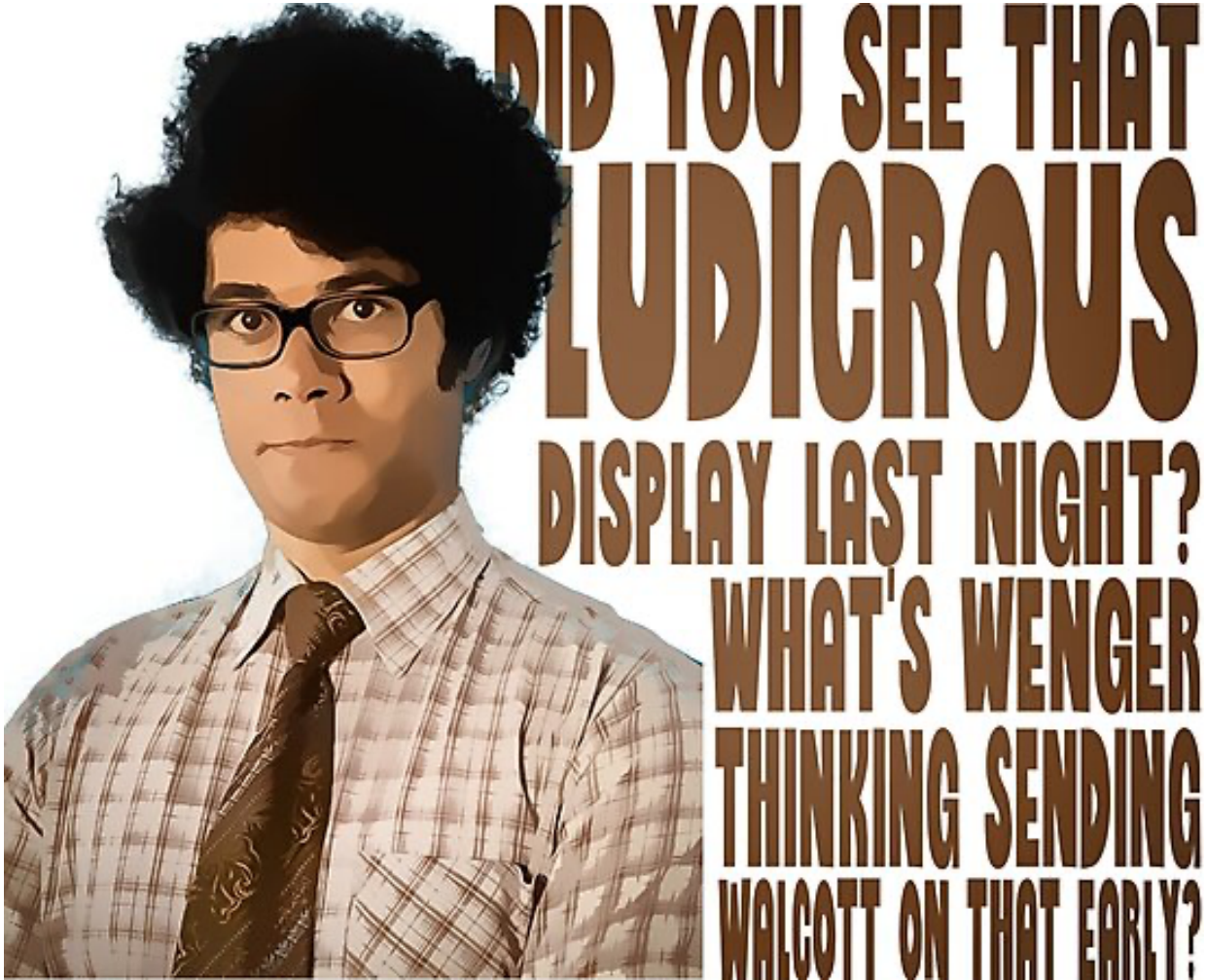


Intent Classification Methods

Input: Word Sequence **Output:** Intent Class

- Index all words to numerical representation, i.e. hospital → 324
- Represent each word as a vector using a randomly initialized embedding matrix.
- Use favorite classification model LR, CNN, LSTM, Transformer
- Overcome small in-domain data using pre-trained embeddings.
- Freeze embedding layer.




DID YOU SEE THAT
LUDICROUS
DISPLAY LAST NIGHT?
WHAT'S WENGER
THINKING SENDING
WALCOTT ON THAT EARLY?

Slot Tagging

- Locate span of text corresponding to a slot in semantic frame of intent.
- Regular expression matching, e.g. *^\([0-9]{3}\)[0-9]{3}-[0-9]{4}$*
- Thesaurus based methods, e.g. Metamap.

Pros:

- High recall
- Easy to implement
- Require no training data

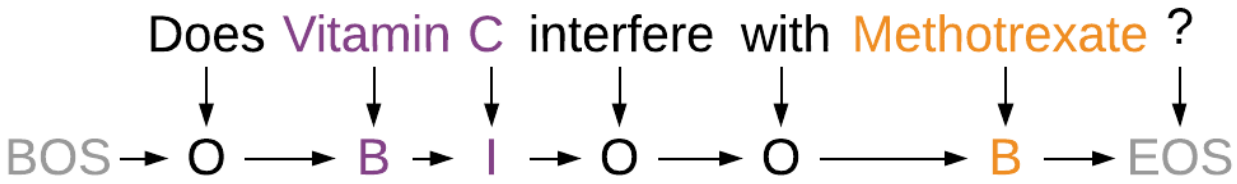
Cons:

- Poor scaling
- Error prone
- Difficult to manage

Slot Tagging

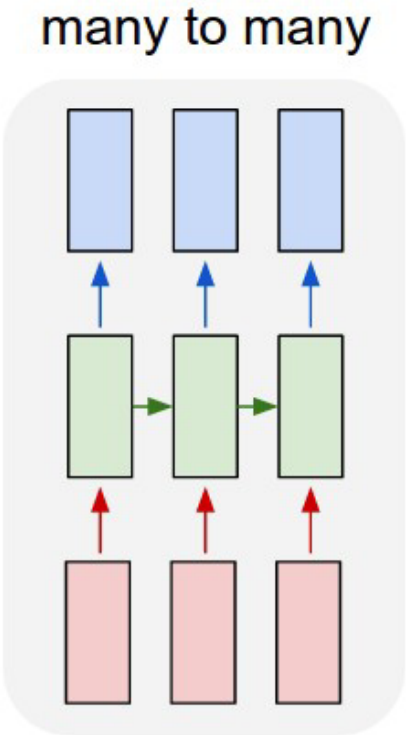
Input: Word Sequence

Output: BIO Tags

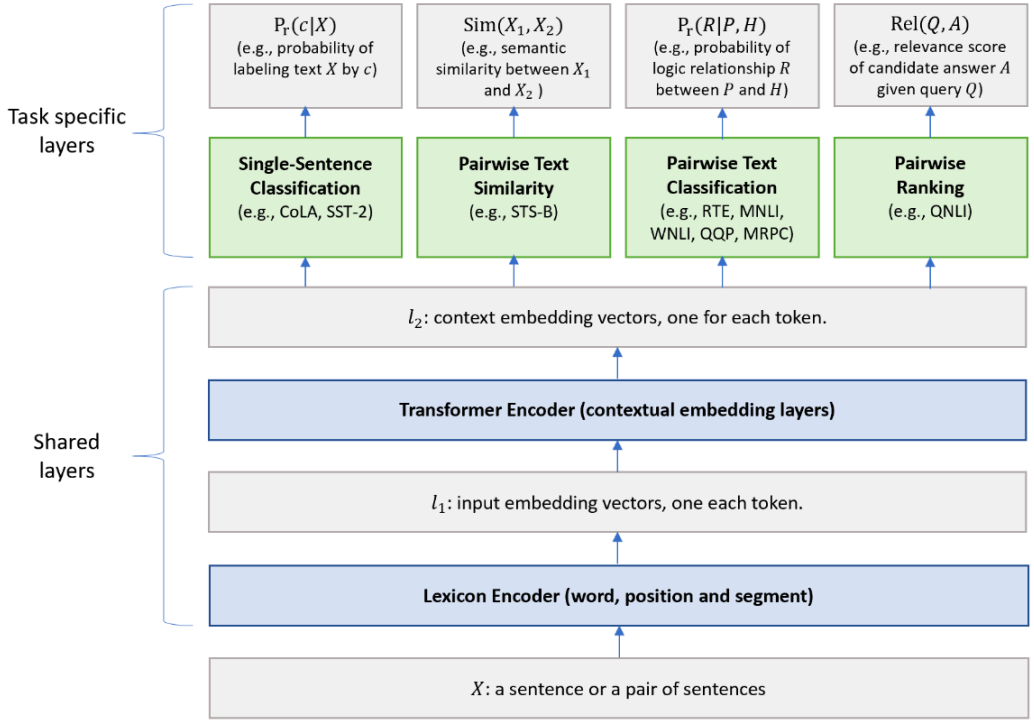


Choose favorite sequence model: CRF, LSTM, Transformer.

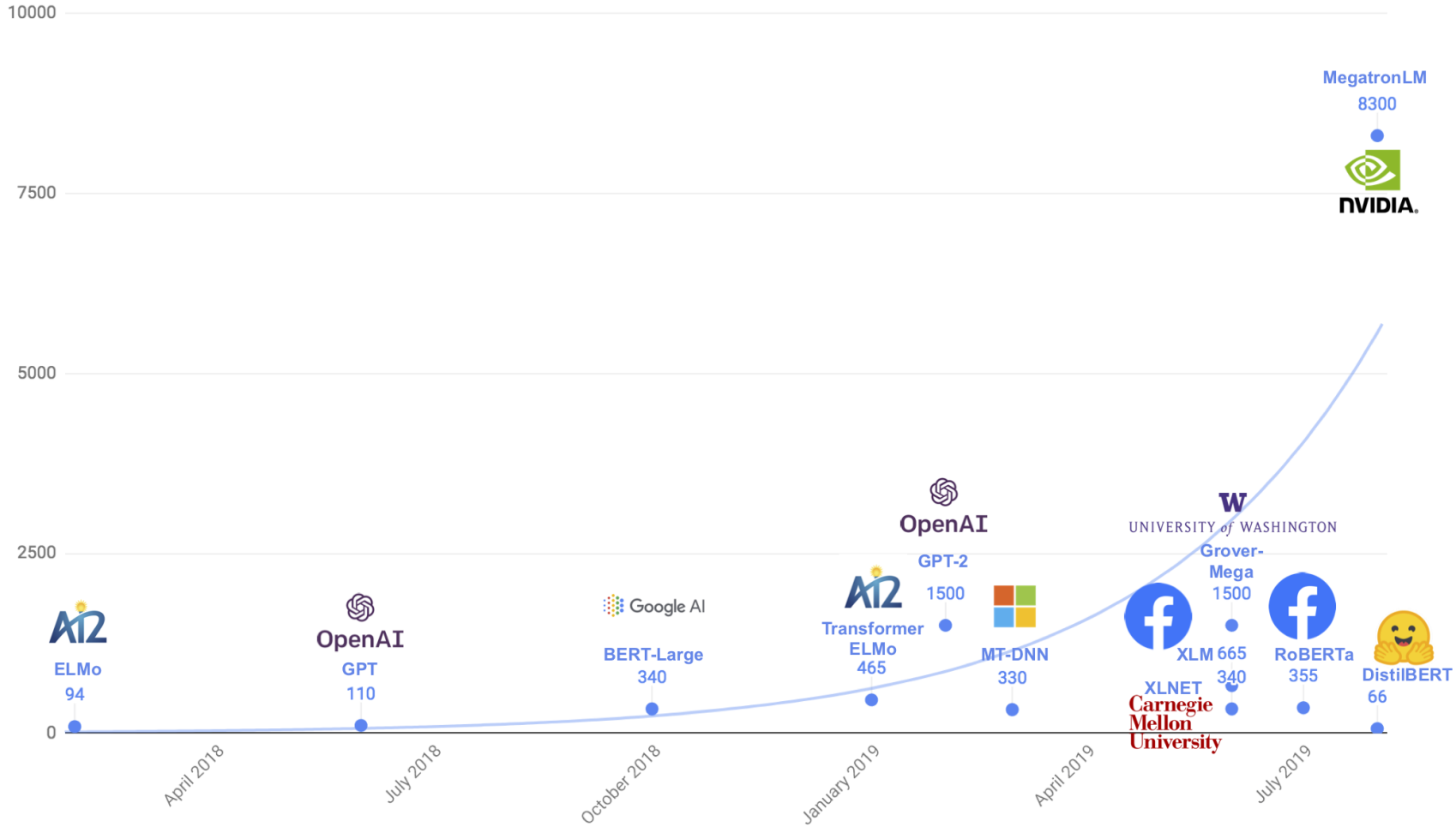
Note: x-CRF Conditional Random Field (CRF) decoder with external knowledge.



Multi-Task Learning



Liu X, He P, Chen W, Gao J. *Multi-Task Deep Neural Networks for Natural Language Understanding*. In Proc. ACL 2019.



[Article](#) by Hugging Face on Distillation methods

Spoken Language Understanding

* Requires additional considerations

Disfluencies: I need to uhh… go to the … uhh hospital

Correction: I need directions to the clinic… I mean hospital.

Error Propagation: Does Vitamin C interact with Methorphan (sic) ?

Etc.

Interactive Coding Lab

1. Join a group.
2. Each group should select a domain to address.
3. Design an intent/slot schema.
4. Train NLU model.

- Medical Education
- Clinical Processes
- Mental Health
- Personal Health
- Patient Education

Additional Resources:

LSTM - https://colah.github.io/posts/2015-08-Understanding-LSTMs/
BERT - https://jalammar.github.io/illustrated-bert/
Regex - https://regex101.com/
Green AI - https://arxiv.org/abs/1907.10597