Outline

Deep Learning in industry

- Companies have endless amounts of data!
  Or do they?
- Performance
  Is .9 accuracy/F_1/etc. good enough?
  No? Would 0.95 be?
- Business logic/constraints
  - *Your model is doing great in general, but not in case X, Y and Z.*
    Can you keep it exactly as it is now, and fix just these cases?
- Explicit domain knowledge
  E.g.: recommending product X for user Y is not applicable, as it is not available where user Y lives.

Deep Learning in industry

- Hybrid Code Networks
  Combining RNNs with domain-specific knowledge
- Smart Reply
  Automated response suggestion for email

Hybrid Code Networks

Task

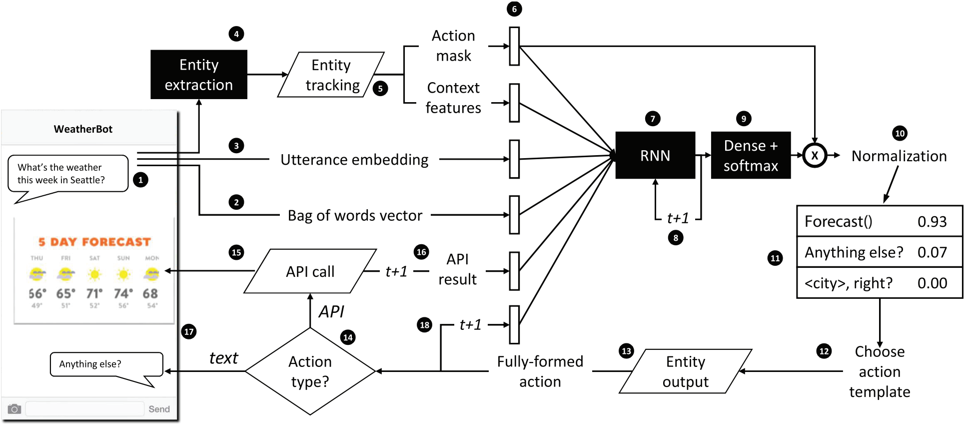
Dialogue system. User can converse with a system that can interact with APIs.

Combining RNNs with domain-specific knowledge

- Incorporate business logic by including modules in the system that can be programmed
- Explicitly condition actions on external knowledge

[Williams et al., 2017]

Hybrid Code Networks



Trapezoids refer to programmatic code provided by the software developer.
Shaded boxes are trainable components.

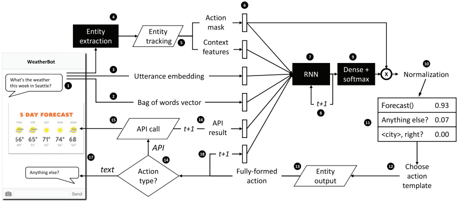
[Williams et al., 2017]

Hybrid Code Networks

Training of the RNN

Supervised setting

Every step: update weights, according to entropy loss on correct prediction of actions.



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Reinforcement learning

At the end of the dialogue: update weights, according to:

LSTM

return of the dialog: $G = 0.95^{T-1}$

$$\mathbf{w} \leftarrow \mathbf{w} + \Big(\sum_t \nabla_{\mathbf{w}} \log \pi(a_t|\mathbf{h_t};\mathbf{w})\Big)(G - b)$$

Jacobian

estimate of the average return of the current policy, estimated on the last 100 dialogs

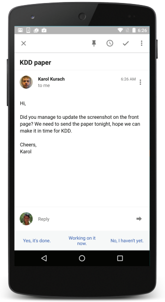
Smart Reply

Automated response suggestion for email

Use an RNN to generate responses for any given input message.

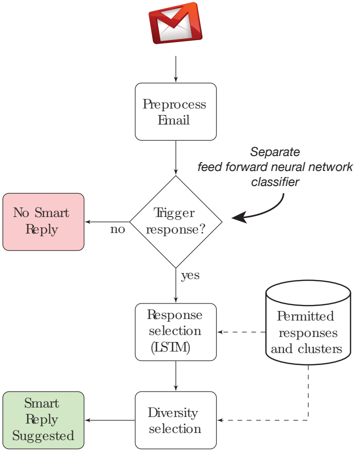
Additional constraints

- **Response quality**
  Ensure that the individual response options are always high quality in language and content.
- **Utility**
  Select multiple options to show a user so as to maximize the likelihood that one is chosen.
- **Scalability**
  Process millions of messages per day while remaining within the latency requirements.
- **Privacy**
  Develop this system without ever inspecting the data except aggregate statistics.



[Kannan et al., 2016]

Smart Reply



[Kannan et al., 2016]

Response selection

- Construct a set of allowed responses R.
- Organise the elements of R into a trie.
- Conduct a left-to-right beam search, and only retain hypotheses that appear in the trie.

Complexity: O(beam size $\times$ response length).

Utility/diversity

Goal: present user with diverse responses
Instead of "No", "No, thanks", and "Thanks!", we'd rather produce "No, thanks", "Yes, please", "Let me come back to it".

- Manually label a couple of messages per response intent.
- Use a state-of-the-art label propagation algorithm to label all other messages in R.

What do we learn?

- Deep learning component is a (small) part of a much larger system.
- Getting the right training data can be hard.
- The machine learned part is guided/corrected/prevented from predicting undesired output.