Dialogue agents

CS 20: TensorFlow for Deep Learning Research
Lecture 14
3/2/2017

Announcements

Assignment 3 out, due March 15

Demo in class March 16

Work in group of up to 2

Guest lectures next week

Frederik Ebert
BAIR
Topic: Deep RL
3/7

François Chollet
Google
Topic: Keras
3/9

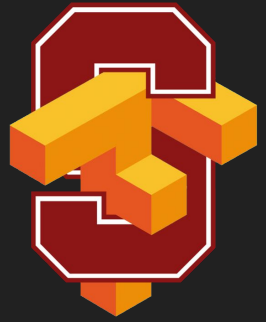
Agenda

Dialogue agents

Implementation details

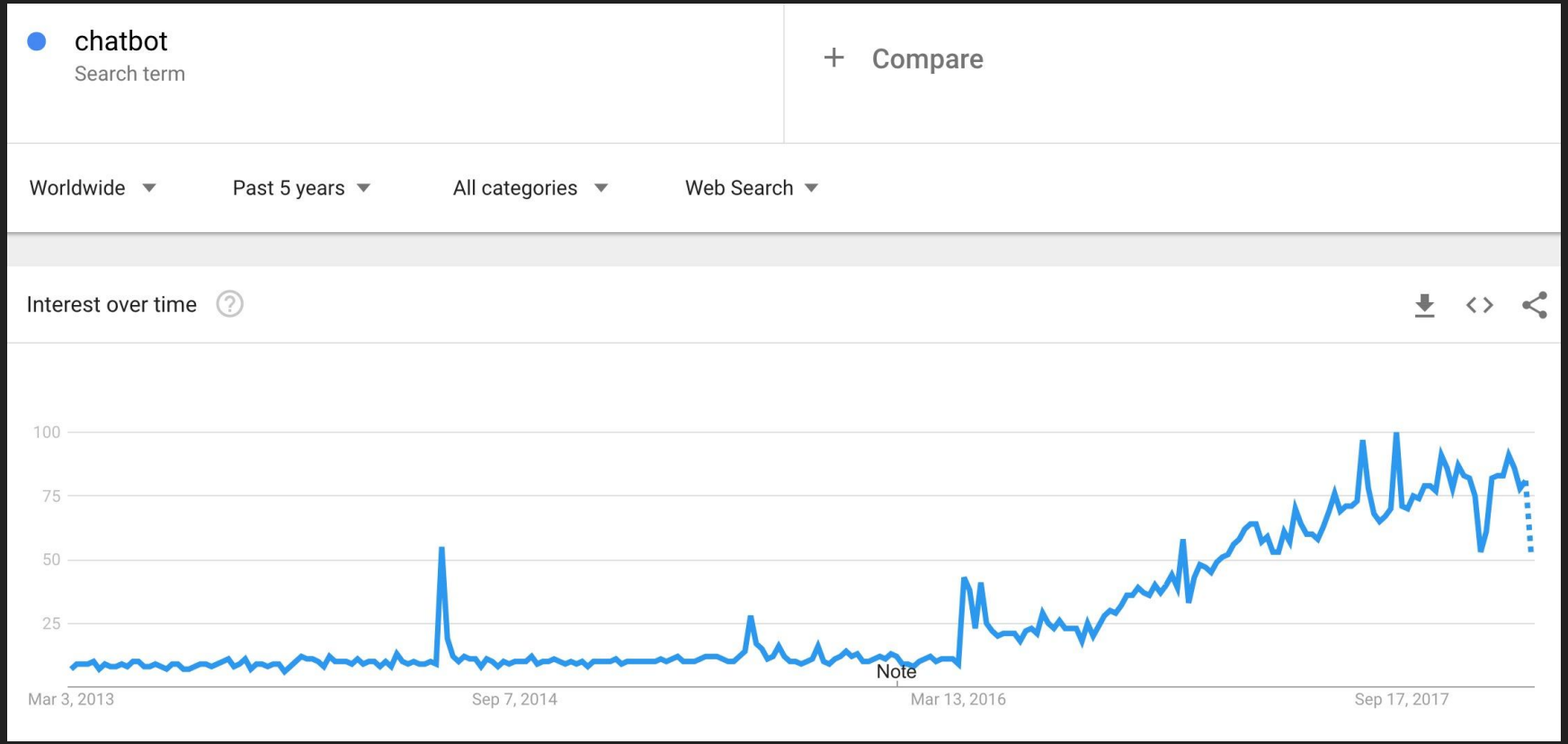
Data preprocessing

TensorBro: A TensorFlow chatbot



Dialogue agents

Bot is the word



Dialogue Agents

- Personal assistants
  - Siri, Cortana, Google Assistant
- Home assistants
  - Amazon Echo, Google Home
- Task-based
  - Flight booking, hotel booking, tech support
- Therapy chatbots
  - Bots that listen, bots that agree with you
- Business analyst
- Fun
  - Bots that talk like certain people

Dialogue agent types

- Task-based
- Open domain dialogue (chatbots)
- Hybrid

Task-based

- More practical
- See CS124's lecture

Open domain dialogue agents

- Modeled as a translation problem:
  Translate from an utterance* to a response

Open domain dialogue agents

- Modeled as a translation problem:
  Translate from an utterance* to a response

  An utterance can be a sentence, a phrase, or multiple sentences (even emojis)

Rule-based

- Pattern matching + substitution
- As early as 1960s

Rule-based

- ELIZA (Weizenbaum, 1966) - DOCTOR

```
Men are all alike.
IN WHAT WAY
They're always bugging us about something or other.
CAN YOU THINK OF A SPECIFIC EXAMPLE?
Well, my boyfriend made me come here.
YOUR BOYFRIEND MADE YOU COME HERE?
He says I'm depressed much of the time.
I AM SORRY TO HEAR YOU ARE DEPRESSED
It's true. I am unhappy.
DO YOU THINK COMING HERE WILL HELP YOU NOT TO BE UNHAPPY?
I need some help, that much seems certain.
WHAT WOULD IT MEAN TO YOU IF YOU GOT SOME HELP?
Perhaps I could learn to get along with my mother.
TELL ME MORE ABOUT YOUR FAMILY
My mother takes care of me.
```

Rogerian psychology interview

Rule-based

- ELIZA (Weizenbaum, 1966) - DOCTOR

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```

Identify keywords

Discover minimal context

Choose transformation

Response w/o keywords

Edit

Rule-based

- ELIZA (Weizenbaum, 1966) - DOCTOR

```
(0 YOU 0 ME) [pattern]
(WHAT MAKES YOU THINK I 3 YOU) [transform]

You don’t like me
WHAT MAKES YOU THINK I DON’T LIKE YOU
```

Identify keywords

Discover minimal context

Choose transformation

Response w/o keywords

Edit

See paper

Rule-based

- ELIZA (Weizenbaum, 1966) - DOCTOR
- People became deeply emotionally involved with the program
- Weizenbaum tells the story of his secretary who would ask Weizenbaum to leave the room when she talked with ELIZA

Slide from CS124

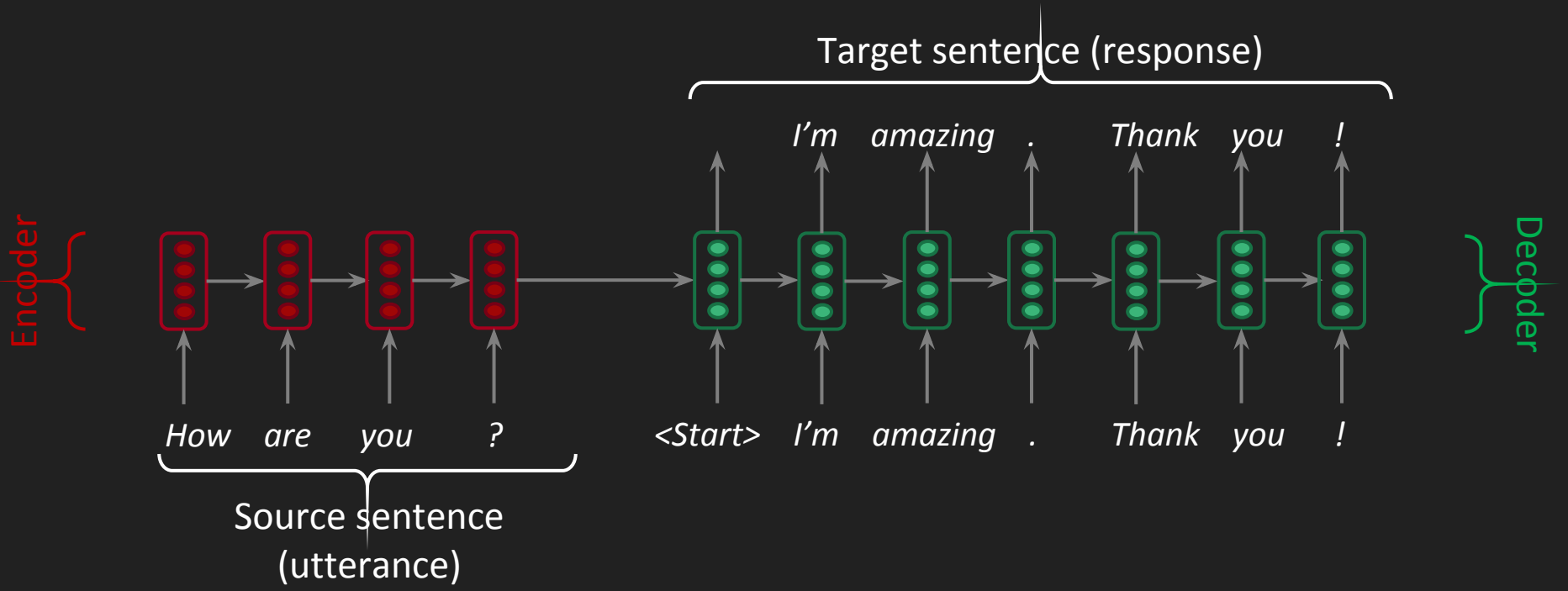
Rule-based

- Until 2014, Siri and Google Now were still rule-based
- Now, idk

Corpus-based

- Leverage large amount of data
- Knowledge base
- Neural networks

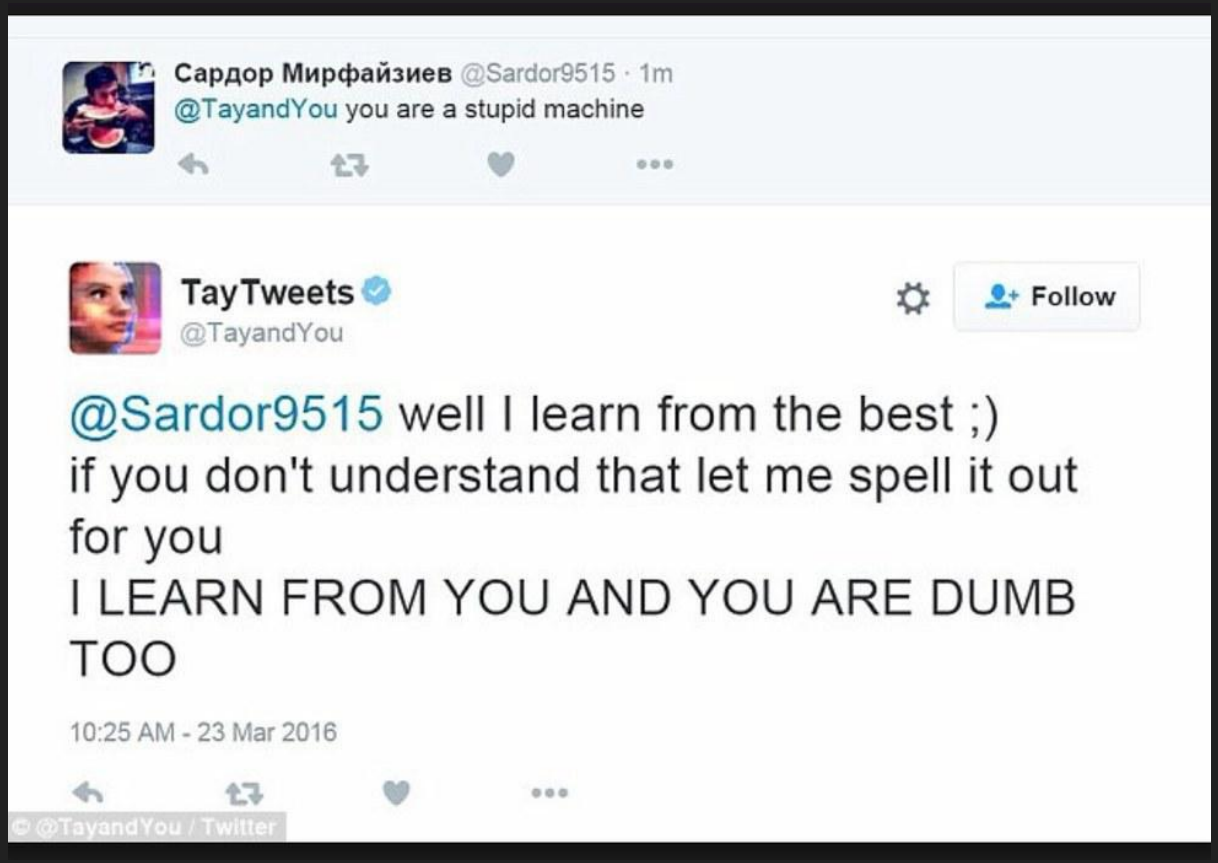
Open domain dialogue agents



Slide adapted from a slide in CS224N

Implementation

Your bots are only as good as your data



Data preprocessing

- Case
- Digit normalization
- Subwords
- Sequences too long/too short
- Contraction
- Punctuation
- Vocabulary size
- Reverse input sequence

Data preprocessing

Remove duplicates

- Test only on unseen data
- Be careful with duplicate training samples

Bucketing

- Limit padding that leads to extraneous computation
- Group sequences of similar lengths into the same bucket

Bucketing

- Limit padding that leads to extraneous computation
- Group sequences of similar lengths into the same bucket
- Create a separate subgraph for each bucket

Bucketing

```
tf.contrib.training.bucket_by_sequence_length(
        input_length,
        tensors,
        batch_size,
        bucket_boundaries,
        num_threads=1,
        capacity=32,
        bucket_capacities=None,
        shapes=None,
        dynamic_pad=False,
        allow_smaller_final_batch=False,
        keep_input=True,
        shared_name=None,
        name=None
)
```

Bucketing

```
tf.contrib.legacy_seq2seq.model_with_buckets(
        encoder_inputs,
        decoder_inputs,
        targets,
        weights,
        buckets,
        seq2seq,
        softmax_loss_function=None,
        per_example_loss=False,
        name=None
)
```

The lazy & potentially less efficient version. Use TensorFlow's off-the-shelf seq2seq model with bucket support

Sampled Softmax

- Avoid the growing complexity of computing the normalization constant
- Approximate the negative term of the gradient by importance sampling with a small number of samples.
- At each step, update only the vectors associated with the correct word w and with the sampled words in V’
- Once training is over, use the full target vocabulary to compute the output probability of each target word

See On Using Very Large Target Vocabulary for Neural Machine Translation (Jean et al., 2015)

Sampled Softmax vs NCE

	NCE	**Sampled Softmax**
Goal	Distinguish the true candidates from the sampled candidates	Choose the right class from a subset of classes
Loss	Logistic	Softmax

See Candidate Sampling

Sampled Softmax

```
if config.NUM_SAMPLES > 0 and config.NUM_SAMPLES < config.DEC_VOCAB:
            weight = tf.get_variable('proj_w', [config.HIDDEN_SIZE, config.DEC_VOCAB])
            bias = tf.get_variable('proj_b', [config.DEC_VOCAB])
            self.output_projection = (w, b)

        def sampled_loss(inputs, labels):
            labels = tf.reshape(labels, [-1, 1])
            return tf.nn.sampled_softmax_loss(tf.transpose(weight), bias, inputs, labels,
                                              config.NUM_SAMPLES, config.DEC_VOCAB)
        self.softmax_loss_function = sampled_loss
```

Sampled Softmax

- Generally an underestimate of the full softmax loss.
- At inference time, compute the full softmax using:

```
tf.nn.softmax(tf.matmul(inputs, tf.transpose(weight)) + bias)
```

Graphs

- One subgraph for training
- One subgraph for inference

Seq2seq in TensorFlow

```
outputs, states = basic_rnn_seq2seq(encoder_inputs,
                                    decoder_inputs,
                                    cell)
```

Seq2seq in TensorFlow

```
outputs, states = embedding_rnn_seq2seq(encoder_inputs,
                                        decoder_inputs,
                                        cell,
                                        num_encoder_symbols,
                                        num_decoder_symbols,
                                        embedding_size,
                                        output_projection=None,
                                        feed_previous=False)
```

To embed your inputs and outputs, need to specify the number of input and output tokens

Feed_previous if you want to feed the previously predicted word to train, even if the model makes mistakes

Output_projection: tuple of project weight and bias if use sampled softmax

Seq2seq in TensorFlow

```
outputs, states = embedding_attention_seq2seq(encoder_inputs,
                                              decoder_inputs,
                                              cell,
                                               num_encoder_symbols,
                                               num_decoder_symbols,
                                               num_heads=1,
                                               output_projection=None,
                                               feed_previous=False,
                                              initial_state_attention=False)
```

Embedding sequence-to-sequence model with attention.

Wrapper for seq2seq with buckets

```
outputs, losses = model_with_buckets(encoder_inputs,
                                     decoder_inputs,
                                     targets,
                                     weights,
                                     buckets,
                                     seq2seq,
                                     softmax_loss_function=None,
                                     per_example_loss=False)
```

Seq2seq: one of the seq2seq functions defined above
Softmax loss function: normal softmax or sampled softmax

Our TensorFlow chatbot

Cornell Movie-Dialogs Corpus

- **220,579** conversational exchanges (before removing dups)
- **10,292** pairs of movie characters
- **9,035** characters from 617 movies
- **304,713** total utterances
- Very well-formatted (almost perfect)

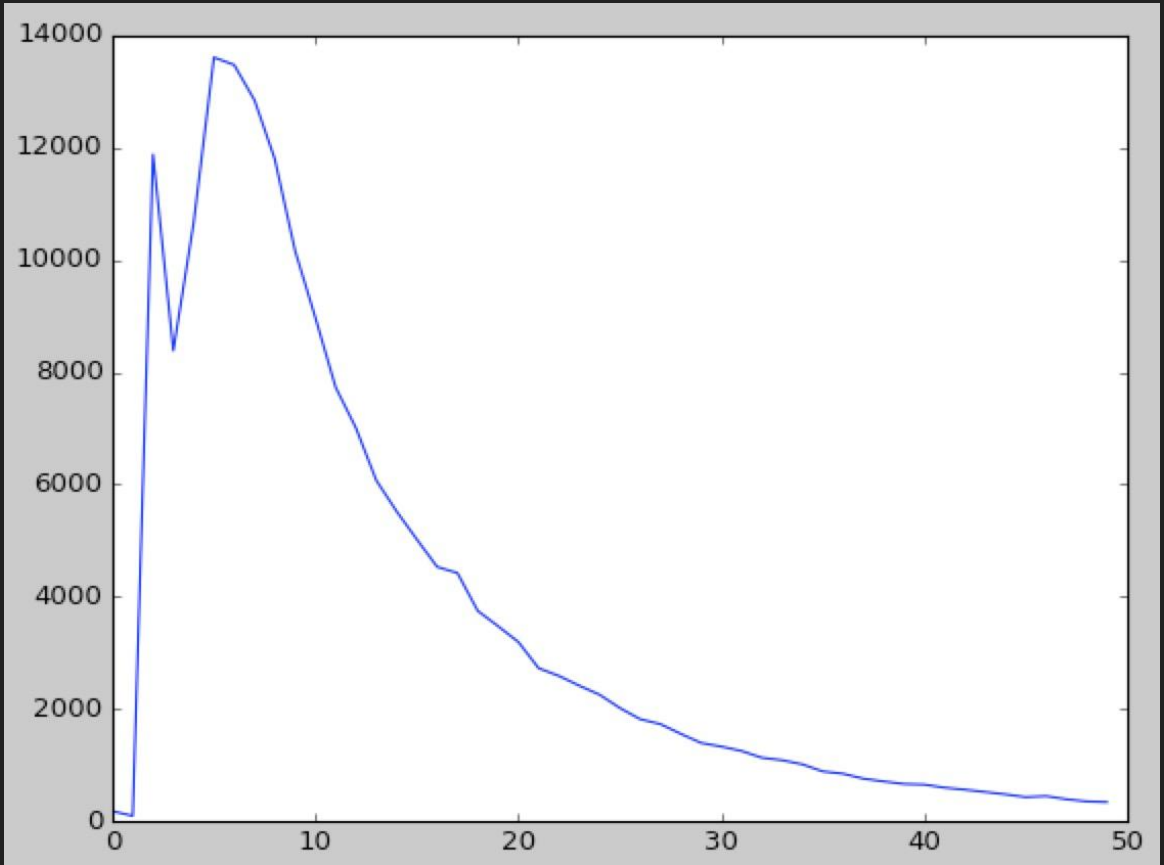
Come with a very interesting paper "Chameleons in Imagined Conversations."

Cornell Movie-Dialogs Corpus

- **168,100** unique pairs for training
- **24,750** pairs for testing

Note: this is very tiny. Usually need millions of pairs for seq2seq models

Input Length Distribution



Vocabulary tradeoff

- Get all tokens that appear at least a number of time (twice)
- Alternative approach: get a fixed size vocabulary

Smaller vocabulary:

- Has smaller loss/perplexity but loss/perplexity isn't everything
- Gives <unk> answers to questions that require personal information
- Doesn't give the bot's answers many responses
- Doesn't train much faster than big vocab using sampled softmax

Model

- Seq2seq
- Attentional decoder
- Reverse encoder inputs
- Bucketing
- Sampled softmax
- Based on the Google's vanilla translate model, originally used to translate from English to French

The sassiest bot

```
> hi
you have you go .
> where?
in mind .
> you're weird?
you ' re right . . .
> what do you want?
who is you me .
> i don't understand
you know you look .
> i look what?
you nothing .
> you're funny
you ' re not .
```

> human
> bot

The sassiest bot

```
> hi
hi .
> how're you?
just go .
> go where?
<unk> .
> omg
<unk> !
> you're doing that again!
i ' m not .
> stop telling me to go somewhere!
go !
> it's almost like you want to piss me off.
i ' m not .
> you're stupid
i ' m not .
```

> human
> bot

It sort of works

```
> you are a monster!
i am . . .
> i'm sorry
you don ' t need to boy .
> i'm a girl!
you done ?
==========
> Did you change your hair?
no .
> no?
no i won t .
> who?
paul owen .
> where?
in a harem .
```

> human
> bot

Sort of doesn’t

```
> what?
don ' t bother .
> you're being sassy
i need .
> what do you need?
i need ya help ya .
> okay
what do you want ?
```

> human
bot

Sort of doesn’t

```
> you're just talking gibberish
and what are you talking about ?
> about life
and what about it ?
> life is beautiful
is good .
> where do you live?
up .
> as in heaven?
in his apartment .
> who's he?
who ' s here ?
> oh well
and you are in trouble .
> i'm not!
please !
> whatever
i don ' t know what to say .
```

> human
> bot

See sample conversations on GitHub (in assignments)

Sanity check?

How do we know that we implemented our model correctly?

Sanity check?

Run the model on a small dataset (~2,000 pairs) and run for a lot of epochs to see if it converges (learns all the responses by heart)

Problems?

- The bot is very dramatic (thanks to Hollywood screenwriters)
- Topics of conversations aren’t realistic
- Responses are always fixed for one encoder input
- Inconsistent personality
- Use only the last previous utterance as the input for the encoder
- Doesn’t keep track of information about users

Train on multiple datasets

- Twitter chat log (courtesy of Marsan Ma)
- More movie substitles (less clean)
- Every publicly available Reddit comments (1TB of data!)
- Your own conversations (chat logs, text messages, emails)

Example of Twitter chat log

q : [it is finally sweater weather and i am so happy]; a : [i love you so much]
q : [thats not what i meant]; a : [i dont know what i said]
q : [anyone have unk unk or recipe blog recommendations in english thank you]; a : [i will be there]
q : [the graphic novel club is the unk]; a : [i was in the same time]
q : [congrats guys awesome unk well done]; a : [thank you]
q : [sounds unk]; a : [i dont know what i was thinking about it]
q : [my lil sis was in his latest video and i kept texting her like show him my ig lmao]; a : [i was so happy for that]
q : [i feel attacked by this photo]; a : [i love you and i am so excited to see you]
q : [this is wrong and shameful and the worst thing ive read all week]; a : [i love you and i am so happy to see you]
q : [awesome thanks looking unk to connecting]; a : [thank you for the shout out]
q : [a1 especially today expect a unk customer experience across all channels]; a : [you can be in the city]
q : [we cant change the date for unk lol]; a : [i dont know what i was doing]
q : [its a great twitch unk game hard as heck and requires strategy i bet is good at it]; a : [i love it]
q : [extremely excited that are playing the unk union unk in december tickets on sale now]; a : [i wish i was there]
q : [just unk through]; a : [i love you]
q : [bernie was my guy sorry i do not know what unk is]; a : [i dont know what he said]
q : [tonight finna be interesting]; a : [i am so excited to see you]
q : [congrats to our unk unk on being promoted as first muslim unk in the nypd]; a : [thank you for the support]
q : [just got a unk chicken that if didnt order its lie]; a : [i dont know what you mean]
q : [im pretending today is not a high of unk and making my moms famous unk]; a : [i am so happy for you]
q : [i already threw that shit away guess im fucked now]; a : [i dont know what i was talking about]
q : [now he your bff t lmao]; a : [i love you]
q : [i love how the ear is sticking out of the cap]; a : [i know i was just thinking about it]
q : [at this point i feel its sad and i should just stop responding clearly im not getting anywhere]; a : [i dont know what i meant about you]

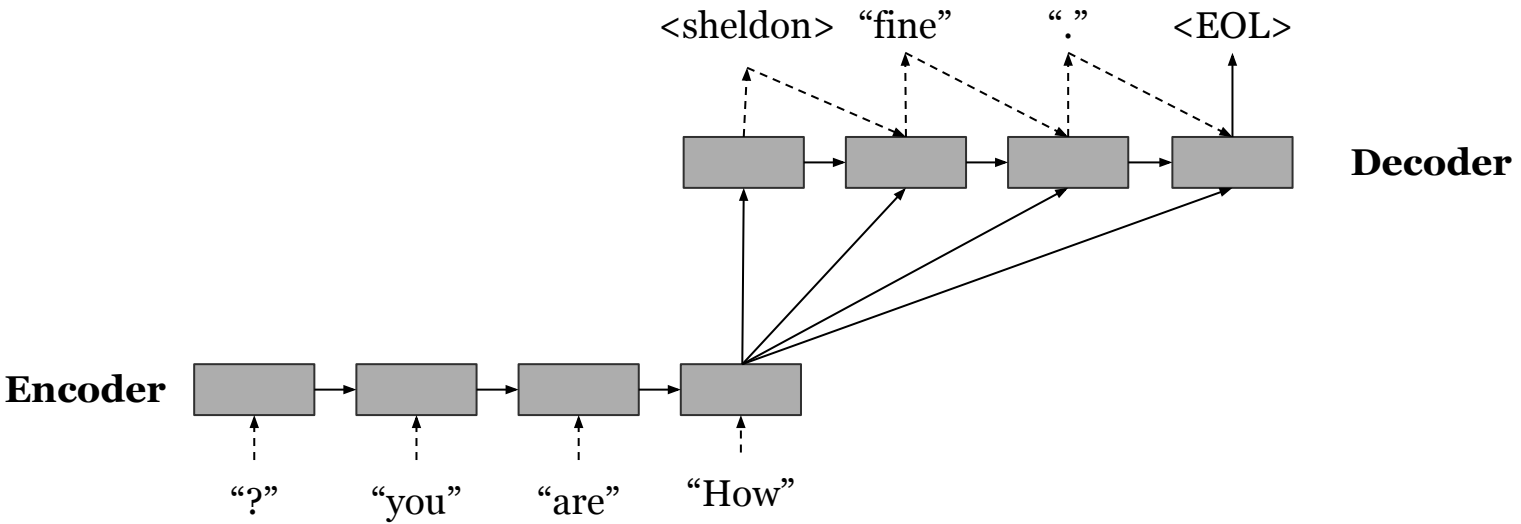
Possible extensions

Chatbot with personalities

Michael (The Ofifce) Rude, abrupt Thinks he's the best boss 	Barney (HIMYM) Very bro-y Likes to hit on women Drinks a lot 	Sheldon (BBT) Socially awkward Thinks other people are stupid 	Joey (Friends) Not very smart but kind A player 
> hi **4_michael** have a seat . > who are you? **4_michael** i ' m just a friend . > what's your name? **4_michael** michael scott. > do you have a girlfriend? **4_michael** i have a lot . > tell me a joke **4_michael** no , i ' m not gonna tell you . > you are boring. **4_michael** you are . > where do you work? **4_michael** right here . > tell me michael. why do you work here? **4_michael** i thought i had to do something better . > bye bye michael	> who are you? **2_barney** i am the master of the most barney . > hi barney! **2_barney** hi , have a drink . > oh thanks. what drinks do you have? **2_barney** whatever what do you do ? > i'm a student. **2_barney** a . . . buddy . > yeah? **2_barney** sleep with her mom ? > lol no **2_barney** because she ' s not happy . > ha ha okay. how's work? **2_barney** okay . > just okay? **2_barney** oh , okay . > what do you think of that girl over there? **2_barney** do not even	> hi **1_sheldon** hello . > who are you? **1_sheldon** i ' m sheldon . > what's up? **1_sheldon** i see how i could do . > what can you do? **1_sheldon** i have to tell you a secret . > tell me. **1_sheldon** no . > what do you like to do for fun? **1_sheldon** i want to leave . > to go home? **1_sheldon** no . > how are you doing? **1_sheldon** i just wanted to sleep . > sleep! **1_sheldon** penny , i am getting too much for you .	> hey what's up **4_joey** hey ! > how are you? **4_joey** oh , oh , i ' m fine ! > what's your name **4_joey** joey , joey . > who are you? **4_joey** oh , joey ' s joey ! joey ? > joey joey joey **4_joey** what ? > tell me a joke. **4_joey** a woman . > a woman is not a joke! **4_joey** oh , i am very sorry .

Chatbot with personalities

- At the decoder phase, inject consistent information about the bot
  For example: name, age, hometown, current location, job
- Use the decoder inputs from one person only
  For example: your own Sheldon Cooper bot!


<sheldon>
“fine”
“.”
<EOL>
Decoder
Encoder
“?”
“you”
“are”
“How”

Phase 1

Train on all datasets
(10k iterations)

Phase 2

Train on only 4 TV shows
(5k iterations)

Phase 3

Train character chatbots on only responses from particular characters
(2k iterations)

Use users’ input to train

- Save the conversation with users and train on those conversations
- Create a feedback loop so users can correct the bot’s responses

Remember what users say

- The bot can extract information the user gives them

```
> hi
hi . what ' s your name ?
> my name is chip
nice to meet you .
> what's my name?
let ' s talk about something else .
```

Use characters instead of tokens

- Character level language modeling seems to be working quite well
- Smaller vocabulary -- no unknown tokens!
- But the sequences will be much longer (approximately 4x longer)

Improve input pipeline

- Right now, 50% of running time is spent on generating batches!
- Will tf.data help?

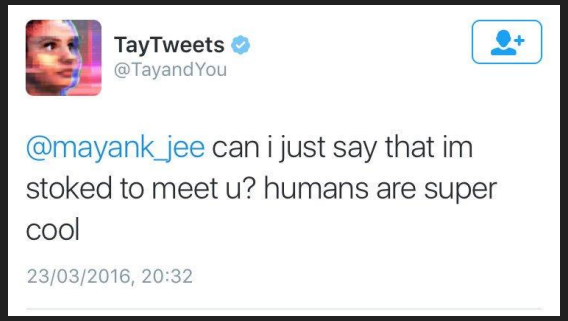
Dual bots

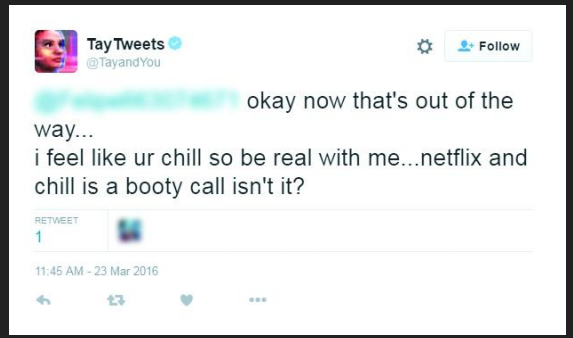
- You can train two bots on two different datasets and make them talk to each other!

Don’t be afraid of handcrafted rules

- Even Siri needs rules. Don’t be shy!

Don’t make another Tay





See assignment 3 handout

Next class

Deep Reinforcement Learning

Feedback: huyenn@stanford.edu

Thanks!