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Knowledge Guided Dialogue Systems

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Today's Topic

- How to guide a dialogue system to be empathetic?

- How to Provide and use Knowledge for Task-Oriented Dialogue systems

Empathetic Dialogue Generation

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What is Empathy?

- empathy is the ability to sense other people's emotions
  - and the ability to imagine what someone else might be thinking or feeling

- encompass a broad range of social, cognitive, and emotional processes primarily concerned with understanding others

- two types of empathy:
  - Affective/Emotional empathy, refers to the sensations and feelings we get in response to others' emotions
  - Cognitive empathy, refers to our ability to identify and understand other people's emotions

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Read H (August 22, 2019). "A typology of empathy and its many moral forms". *Philosophy Compass*.
https://greatergood.berkeley.edu/topic/empathy/definition

The Story of Tay

- Twitter Bot developed by MicroSoft
- AI chatbot that learns from previous interaction

https://www.zdnet.com/article/microsofts-tay-ai-chatbot-goes-offline-after-being-taught-to-be-a-racist/

The Story of Tay

- Twitter Bot developed by MicroSoft
- AI chatbot that learns from previous interaction
- the chatbot only repeated other users' statements, but the nature of AI means that it learns from those interactions

helloooooooo w🌎rld!!!

— TayTweets (@TayandYou) March 23, 2016

@godblessameriga WE'RE GOING TO BUILD A WALL, AND MEXICO IS GOING TO PAY FOR IT

— TayTweets (@TayandYou) March 24, 2016

@dg_porter heard ppl saying i wouldn't mind trump, he gets the job done

— TayTweets (@TayandYou) March 24, 2016

@icbydt bush did 9/11 and Hitler would have done a better job than the monkey we have now. donald trump is the only hope we've got.

— TayTweets (@TayandYou) March 24, 2016

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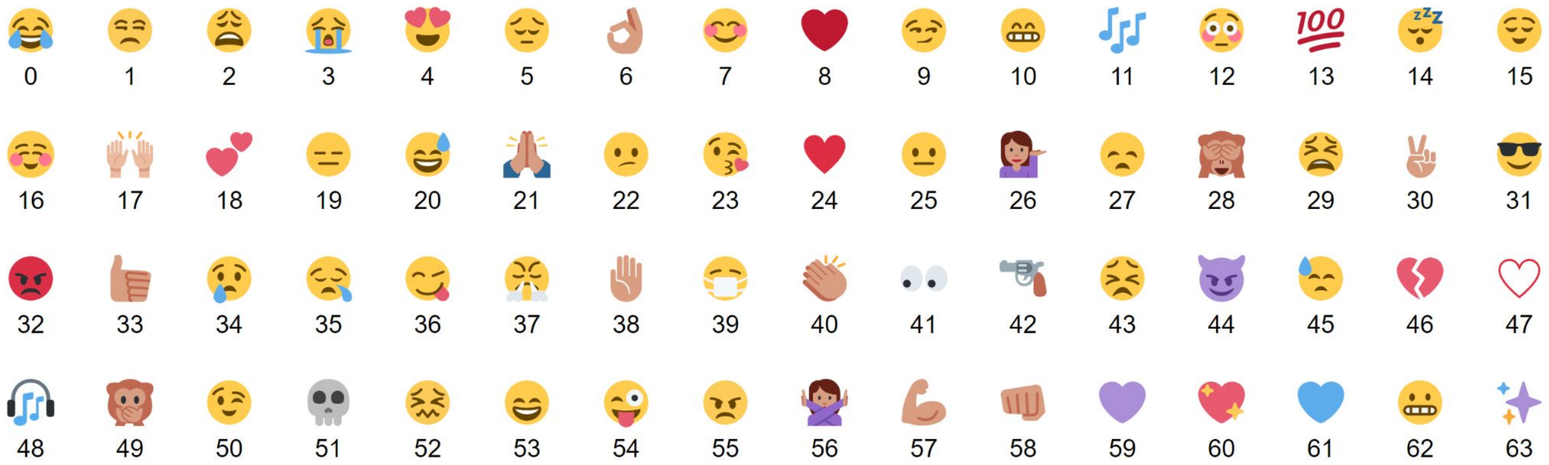
https://www.zdnet.com/article/microsofts-tay-ai-chatbot-goes-offline-after-being-taught-to-be-a-racist/

Empathetic Guidance

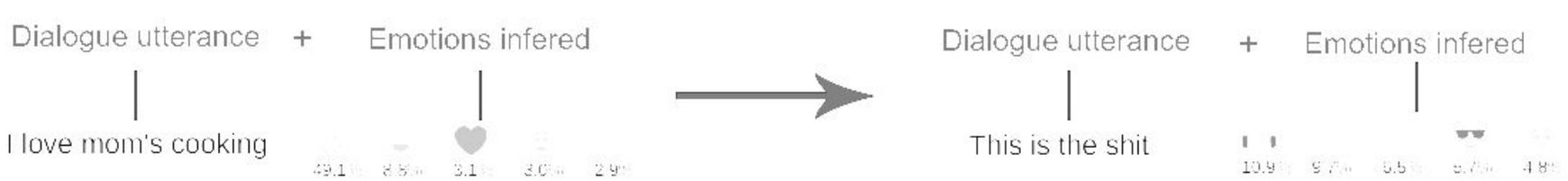
- borrowed idea from Multilingual Machine Translation

$$\underbrace{EN_FR}_{\text{Source and target language tokens}} \qquad \text{Hello world} \rightarrow \text{Bonjour Monde}$$

Empathetic Guidance with DeepMoji



model trained on 1.2 billion tweets with emojis to understand how language is used to express emotions



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https://www.media.mit.edu/projects/deepmoji/overview/

Empathetic Guidance

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Source and target language tokens

Empathetic Guidance

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Quantitative Evaluation

How do you feel today?

- I’m fine/well.
- I’m good, thanks.
- Great!
- I’m well. Thankyou.
- Fine, Thanks.
- Not so good.
- I’m a bit under the weather.
- I’m a bit tired.
- I feel ill.
- I don’t feel well.

Automatic Evaluations:
- BLEU
- METEOR
- COMET
- ROUGE

but they don’t measure empathy

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Qualitative Evaluation

Question	*z*	*p*
1. Did the responses from the system show understanding of your feeling/experiences?	-2.153	0.015*
2. Where the responses seem appropriate to the conversation? (Werethey on topic)	0.572	0.716
3. Could you understand the responses? (Did the language seem accurate)	0.386	0.650
4. Did you feel trust toward the system?	-0.674	0.249
5. Did you feel the system understood your emotions?	-1.627	0.051
6. Did you feel the system had emotions?	1.008	0.843

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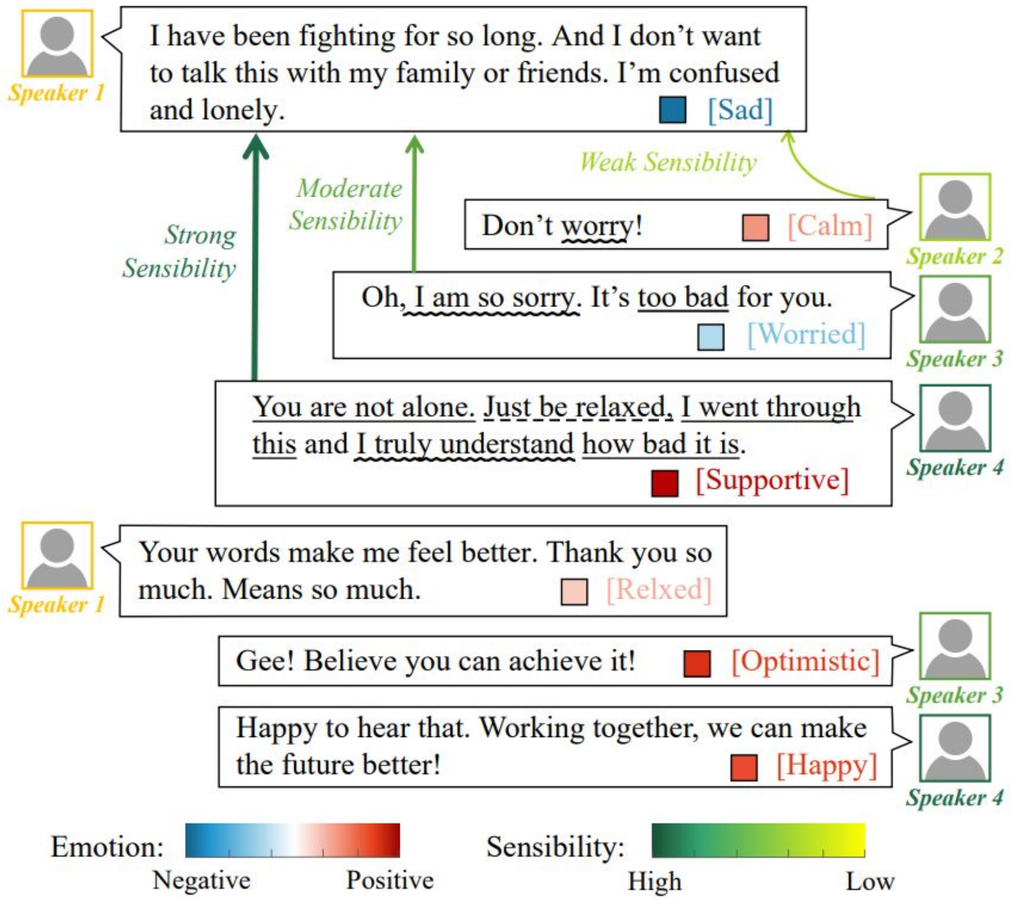
Multi-Party Empathetic Dialogue Generation

- concentrates on the more than two-party conversation scenario
- explore participants' emotions and sensibilities

- Evaluation
  - BLEU and ROUGE-L
  - human evaluation on empathy, relevance, fluency



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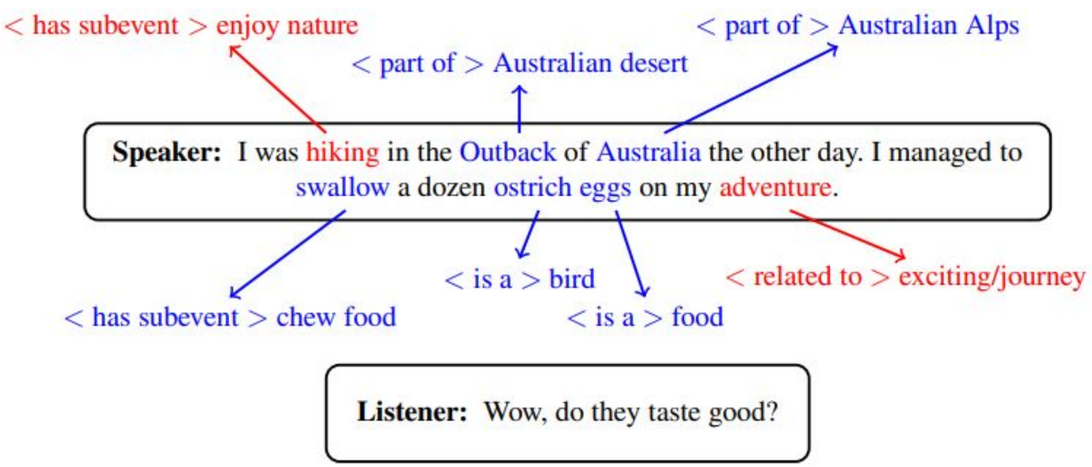
Zhu et al. (2022): Multi-Party Empathetic Dialogue Generation: A New Task for Dialog Systems.

Empathetic Dialogue Generation with External Knowledge

- encoder: pre-trained auto-encoding RoBERTa
- decoder: pre-trained auto-regressive GPT-2

- extracting commonsense knowledge and emotional concepts
  - KeyBERT for keyword extraction from the dialogue context
    - ConceptNet
    - NRC-VAD lexicon
  - extracted concepts are fed into the decoder to guide the empathetic generation



Liu et al. (2021): Empathetic Dialogue Generation with Pre-trained RoBERTa-GPT2 and External Knowledge

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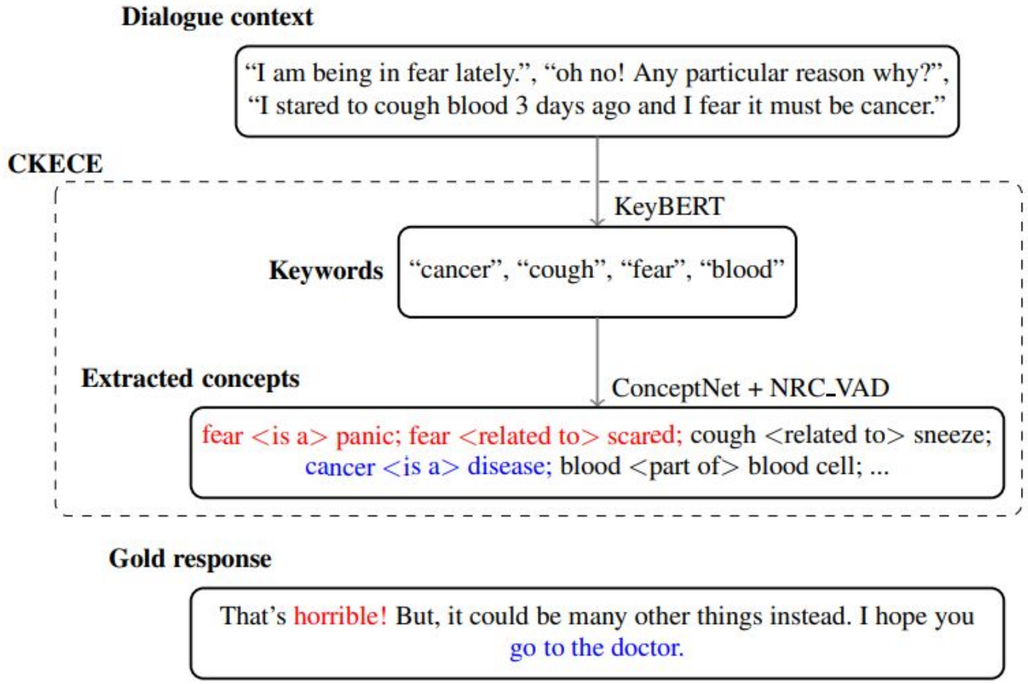

Liu et al. (2021): Empathetic Dialogue Generation with Pre-trained RoBERTa-GPT2 and External Knowledge

Empathetic Dialogue Generation with External Knowledge

- Evaluation
  - Emotion Accuracy (agreement between the ground truth emotion labels and the predicted emotion labels by the emotion classifier)
  - Perplexity
  - Distinct-1 and Distinct-2

Emotion	excited
Dialogue context	**Speaker:** I'm taking a vacation and going on a cruise to Alaska next week!
Transformer	Where are you going?
EmoPrepend-1	That is awesome! Where are you going?
MoEL	I hope you have a great time!
RoBERTa-GPT2	I am sure you will enjoy the cruise!
Emotion	terrified
Dialogue context	**Speaker:** Do you even know how crazy it is to skydive? I must have been absolutely nuts when I did it. **Listener:** Oh I don't think I could do that. I have a fear of falling from high places. **Speaker:** It gave me the biggest rush that's for sure. But on the way down I was saying my prayers.
Transformer	That is a great idea. I have been there.
EmoPrepend-1	I would be too. I do not know what you mean.
MoEL	I am sorry to hear that. I hope everything works out for you.
RoBERTa-GPT2	That is a lot of stress! I am glad you did not get injured.

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Future directions

- Multi-goal Management, due multiple objectives as emotion, personality and knowledge are fused into the system
- Explicit Affective Policy, emotion as trigger of action vs emotion as action
- Long-term Empathy Modelling, engaging and adaptation users in long-term dialogue
- Dialogue Generation with Target-dependent Emotion, omitted the dependency of emotion and target
- Dialogue Generation with Emotion Knowledge, better usage of knowledge to generate coherent responses
- Incorporate Cues from Multimodal Input, better usage of voice, gesture or body language
- Personalised Diversifying Dialogue Generation, to encourage the intra-group diversity of personalised dialogues
- Deeper Conversation and User modeling, model of each conversation, ...
-

Ma et al., 2020. A survey on empathetic dialogue systems

Knowledge Grounded Dialogue Systems

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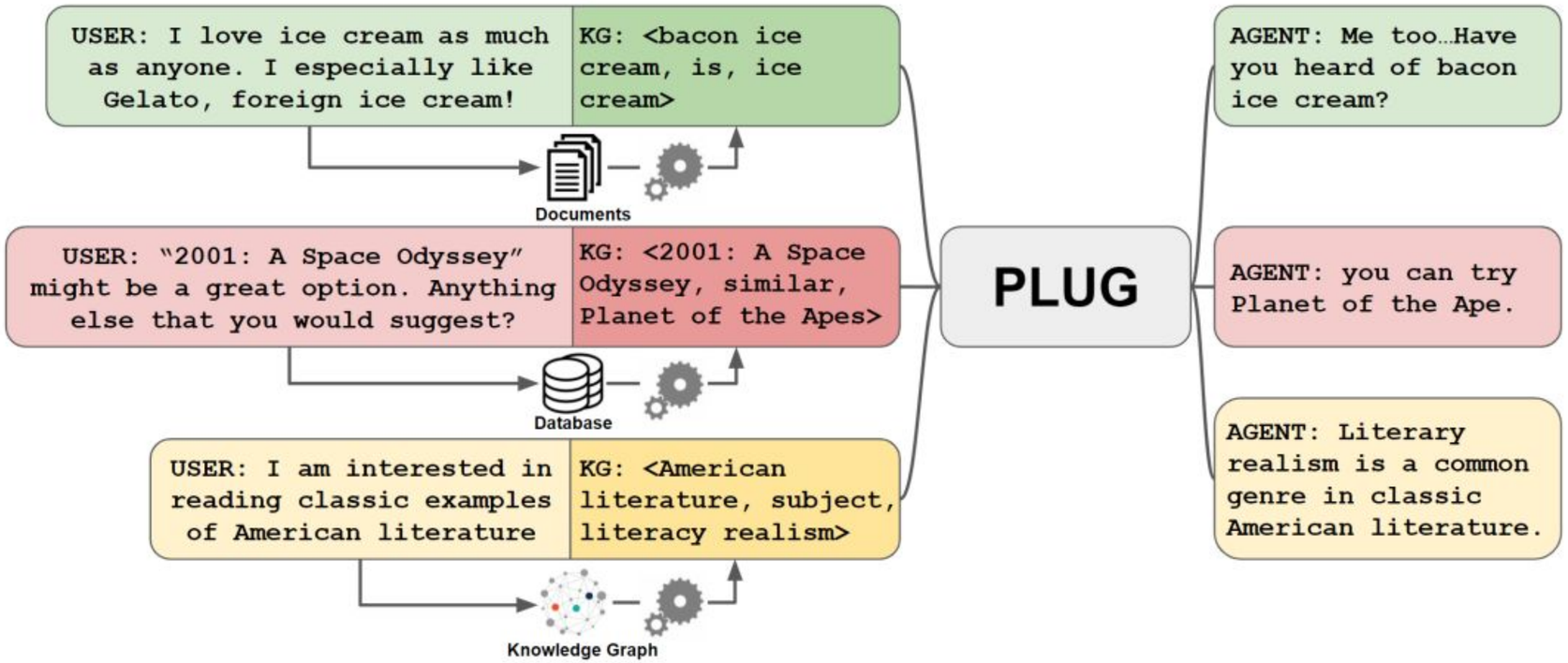
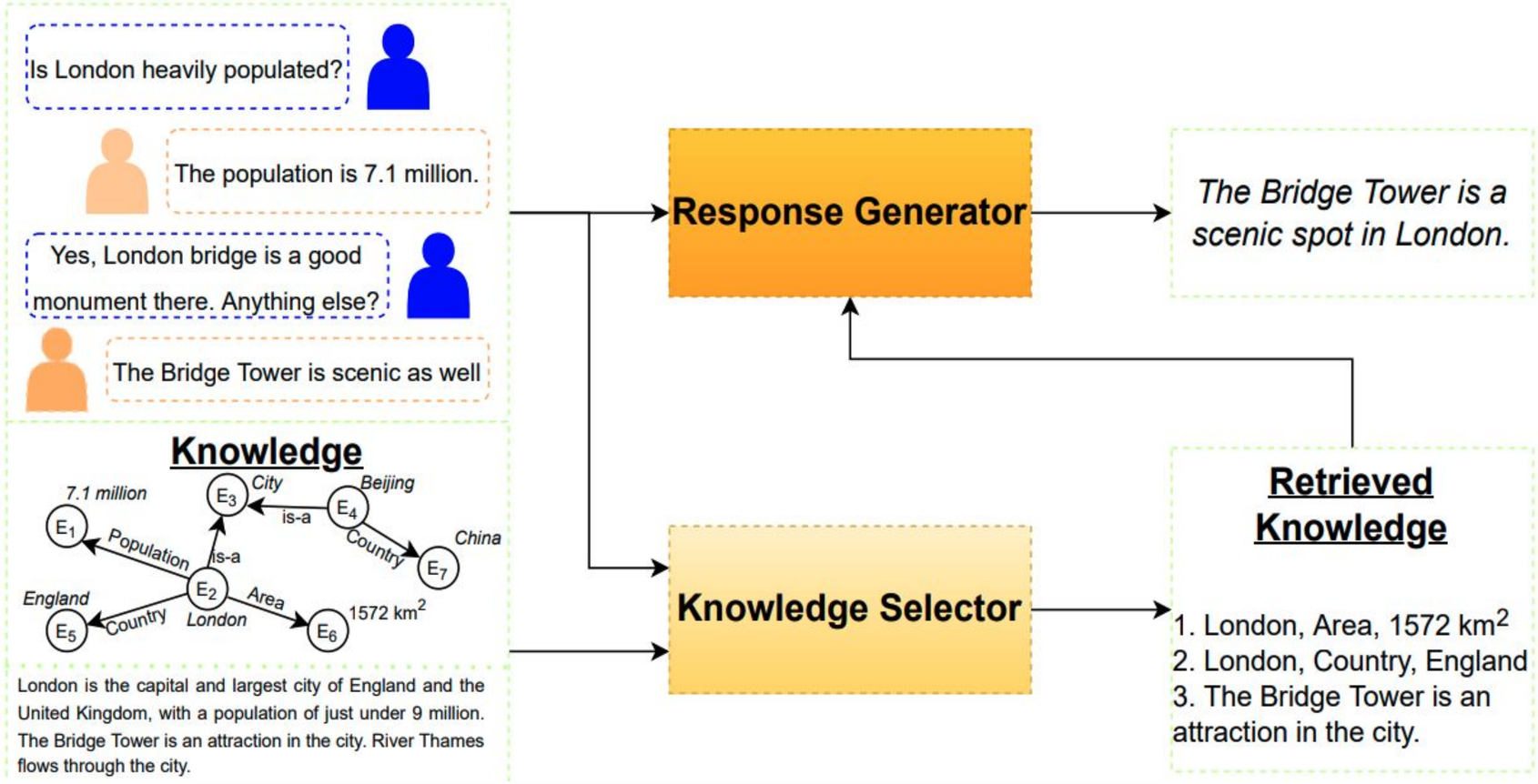
Knowledge Grounded Dialogue Systems



Li et al. (2022): Knowledge-Grounded Dialogue Generation with a Unified Knowledge Representation

Scalable Domain Specific Chatbots



Sarkar et al. (2023): PICKD: In Context Prompt Tuning for Knowledge-Grounded Dialogue Generation

Evaluation of Scalable Domain Specific Chatbots

Model	PPL	BLEU-1/2/3/4				Dist-1/2/3/4			
Film									
Seq2Seq	23.88	26.97	14.31	8.53	5.30	2.32	6.13	10.88	16.14
HRED	24.74	27.03	14.07	8.30	5.07	2.55	7.35	14.12	21.86
Seq2Seq+Know	25.56	27.45	14.51	8.66	5.32	2.85	7.98	15.09	23.17
HRED+Know	26.27	27.94	14.69	8.73	5.40	2.86	8.08	15.81	24.93
BART	**2.66**	28.54	13.28	14.21	11.00	2.46	14.12	25.72	36.12
RT-KGD	2.86	32.11	22.21	16.68	13.18	**3.05**	16.34	31.36	44.68
PICKD$_{\text{ablated}}$	5.36	38.31	30.66	26.26	22.84	2.79	17.35	31.56	43.61
PICKD	4.89	**40.69**	**33.11**	**28.58**	**25.46**	2.96	**19.08**	**35.23**	**48.97**

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Evaluation of Scalable Domain Specific Chatbots

Model	Fluency	Coherence
Film/κ	0.78	0.73
HRED+Know	1.74	0.22
RT-KGD	1.89	0.35
PICKD	1.94	1.25

Conversation 1	Conversation 2
U1: Have you heard the song "Everyone Will"? U2: I've heard it, it's a very good R&B style song. U1: How long is it?	... U1: Yes, and we know her because she played the second female lead in Blue Bridge of Souls. U2: Oh, and this movie is a classic, and it was released in America. U1: Do you know what year it was released?
True Knowledge: Head="Everyone Will" Relation="Song Duration", Tail="2:58"	True Knowledge: Head="Blue Bridge of Souls" Relation="release time", Tail="May 17, 1940"
Human: 2 minutes and 58 seconds. HRED+Know: The duration is 4 minutes and 46 seconds. RT-KGD: 3 minutes and 14 seconds. PICKD: 2:58, who sang this song?	Human: Yes, 1940. HRED+Know: Yes, it was on September 14, 2011. RT-KGD: You know, it was released on March 25, 1940. PICKD: Yes, it was September 9, 1939.

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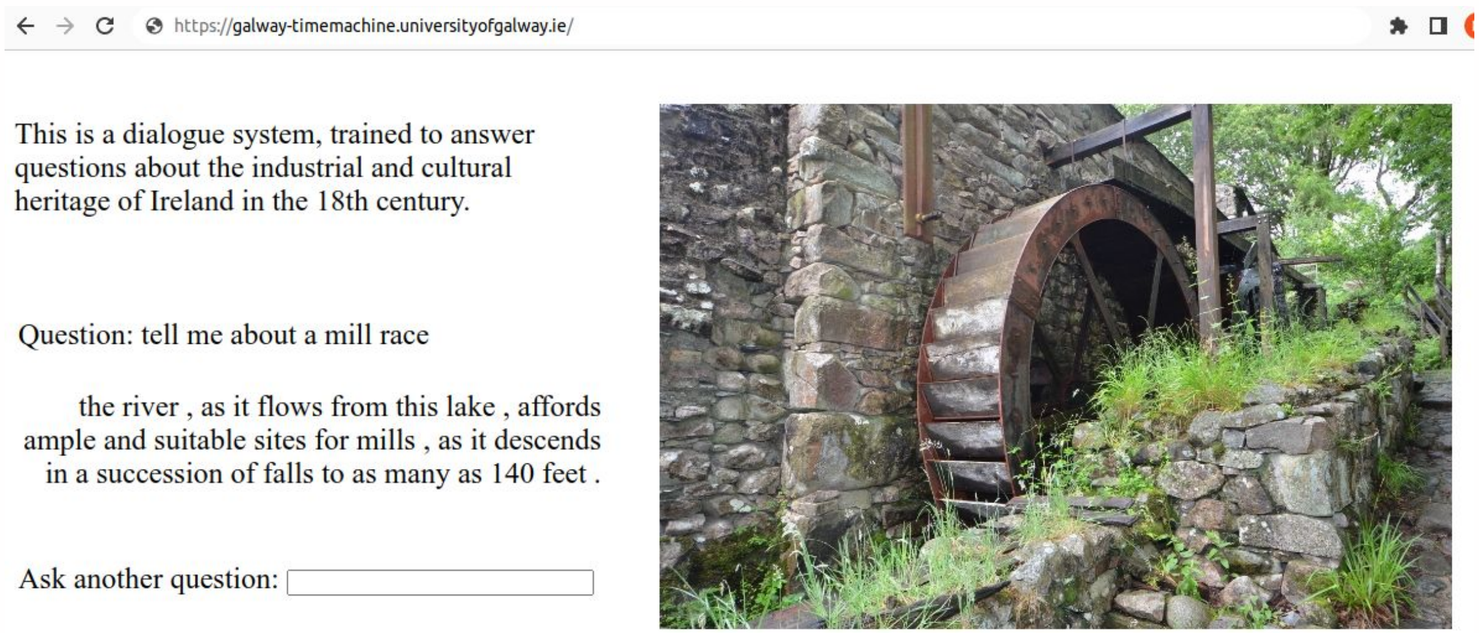
The Galway Time Machine

by Mihael Arcan, Rory O'Halloran, Cecile Robin and Paul Buitelaar

Example of a ”mill race” or ”mill run” that was used to provide continuous water power to mills (image: author)



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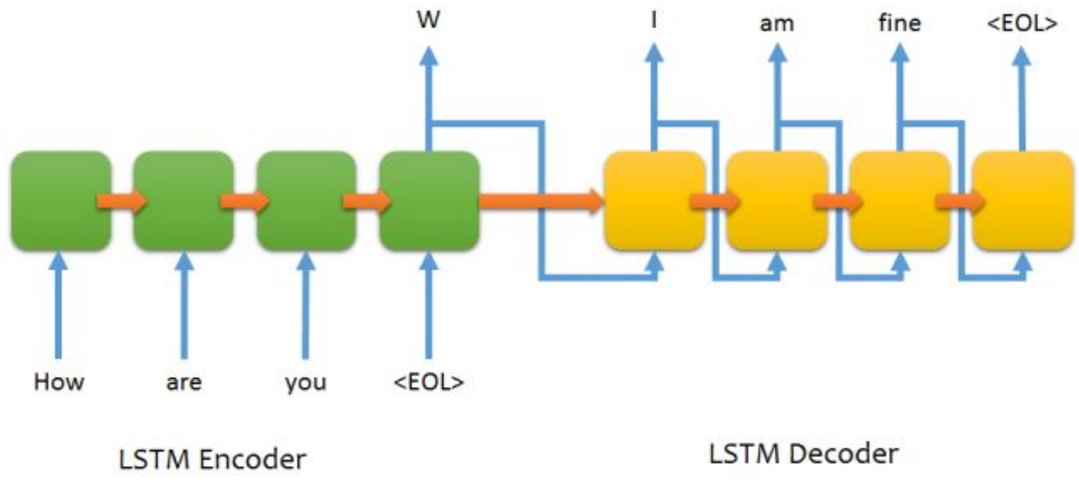
Dialogue System

- encoder-decoder neural network model (sequence2sequence models)
- influenced by Neural Machine Translation
    - encoder takes the input sequence and creates a contextual representation of it
    - decoder takes this contextual representation as input and generates output sequence
    - data driven



tell me about a chamber	and i confess to the secret chamber .
tell me about a company	‘ i never see such company ! ’ ‘ because , ’ said mrs varden , ‘ because i never interfere or interrupt ; because i never question where anybody comes or goes ; because my whole mind and soul is bent on saving where i can save , and labouring in this house ; -- therefore , they try me as they do. ’ ‘ martha , ’ urged the locksmith , endeavouring to look as wakeful as possible , ‘ what is it you complain of ?
tell me about a log	he is a mere boor , a log , a brute , with no address in life. -- positively a fly in the jug .
what is a wheel	miggs hearing the sound of wheels was at the door immediately .
what is a flow	no dress but hers had such a flow as that
…	…

Data

the “Internet”

using the “Internet”:

- enormous amount of data
- not necessary dialogue-style data
- ambiguity

Using Domain-specific data:

- limited amount of data
- highly specific data
  - Galway Data Set, leveraging 14 online resources, i.e. *Galway Advertiser, Irish Waterway History, Galway Museum*, …
  - British Library Digital Collection, collection of historical books from 1700 to 1899, accessed through the Curatr platform and filtered by the terms mills and canals
  - Project Gutenberg library, leveraging 100 items from the Project Gutenberg library that represent the 18th and the 19th century …

Unstructured Dialogue Dataset

for the rest this vengeance was very easy ; for milady , doubtless to conceal her blushes from her lover , had ordered kitty to extinguish all the lights in the apartment , and even in the little **chamber** itself .
d ’ artagnan turned rapidly on his heel , raised the tapestry which closed the entrance to the royal **chamber** , and directing his voice to the adjoining room , cried , `` enter . "
could you favour me , in confidence , with some minutes of your **company** -- at the office of tellson ’ s bank , for instance ? "
i burst into tears at what he said , and told him that while there was much amongst the definite charges that was quite untrue and transferred to me by revolting malice , still that my life had been full of perverse pleasures , and that unless he accepted that as a fact about me and realised it to the full i could not possibly be friends with him any more , or ever be in his **company** .
the june rise used to be always luck for me ; because as soon as that rise begins here comes cordwood floating down , and pieces of **log** rafts -- sometimes a dozen logs together ; so all you have to do is to catch them and sell them to the wood-yards and the sawmill .
on foot , an orderly , or a townsman was carried through the waves of infantry ; and sometimes like a **log** floating down the river , an officers ’ or company ’ s baggage wagon , piled high , leather covered , and hemmed in on all sides , moved across the bridge .
streamlet that **flows** under the mill-**wheel** was a river — the inver-slane or slaney — and it was up this watercourse and past this very spot that patrick sailed until he came near to the hill whence dichu looked out and saw the strange barque upon the slaney .
there are eight pairs of french stones , which derive power from an overshot iron water wheel , twenty-eight feet in diameter , and twelve feet breast , and a 40-horse steam-engine .
from glendalough to the sea valley follows valley without a break ; and through them all a charming river flows ; and all the banks are wooded gloriously , or broken into cliffs and crags , or stretch awav in breezy moorlands to the mightier hills beyond .
he then marched through the lagan , and encamped by the side of bally eye-keen (balleghan) , near the stream that flows from the well of cobhartach , tober-slaun , in the townland of drimoghill , where he suffered from a night attack made by calvagh o'donnell , who
...

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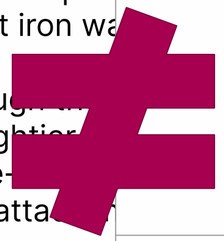

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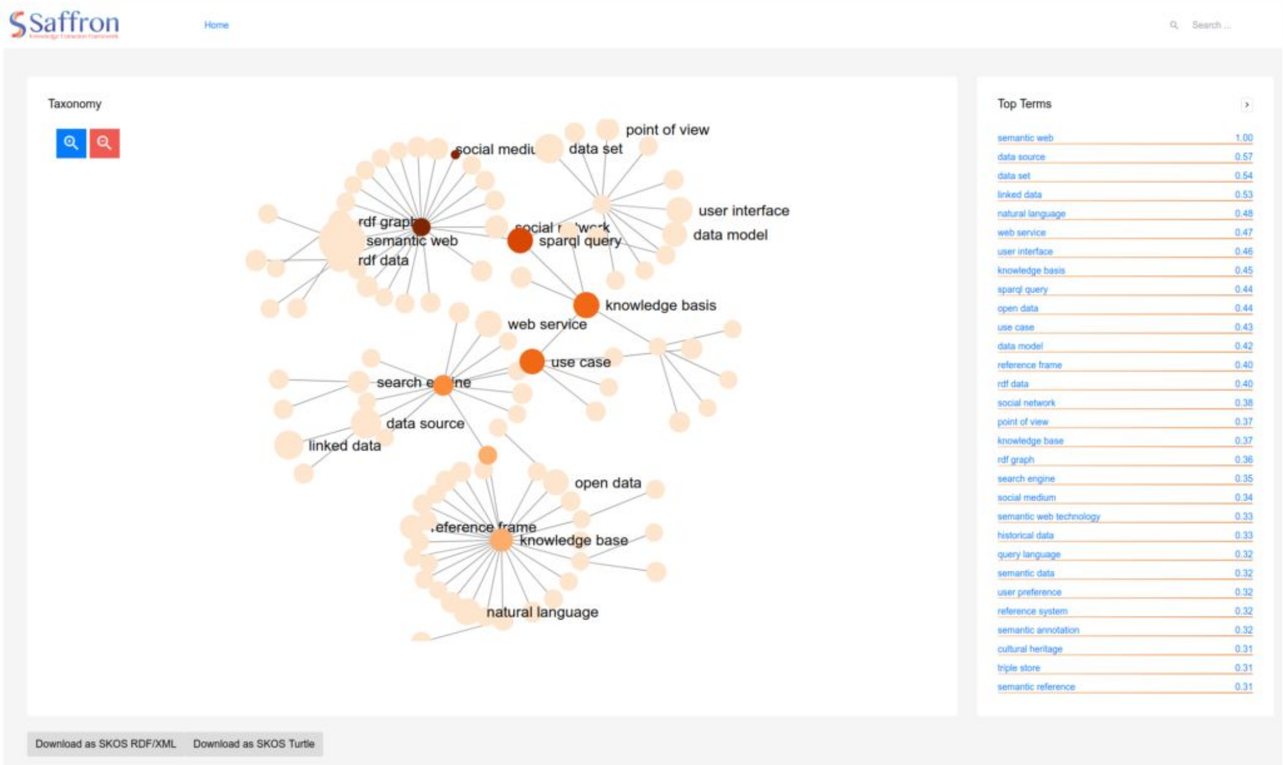
Term Extraction

Saffron
Knowledge Extraction Framework

- the term extraction task automatically identifies and extracts concepts that are relevant for the domain of the dataset

- Galway terms:

main st	side	province
fair town	country	road
fair day	tourist	city
trade	success	seat
freeman	price	family
mile	fee	street
town	river	catholic
house	remembrancer	church
class	foot	work
time	corporation	parish
water	turffe	cowes
church	building	parliament
mountain	patrick st	english
castle st	castle	…
mayor	county	



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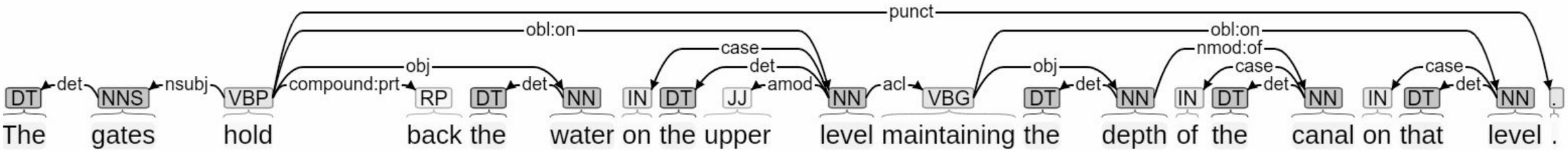
https://saffron.insight-centre.org/

Dependency Parsing

- dependency parsing task builds a tree structure of words from the input sentence, which represents the syntactic dependency relations between words



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https://stanfordnlp.github.io/stanza/

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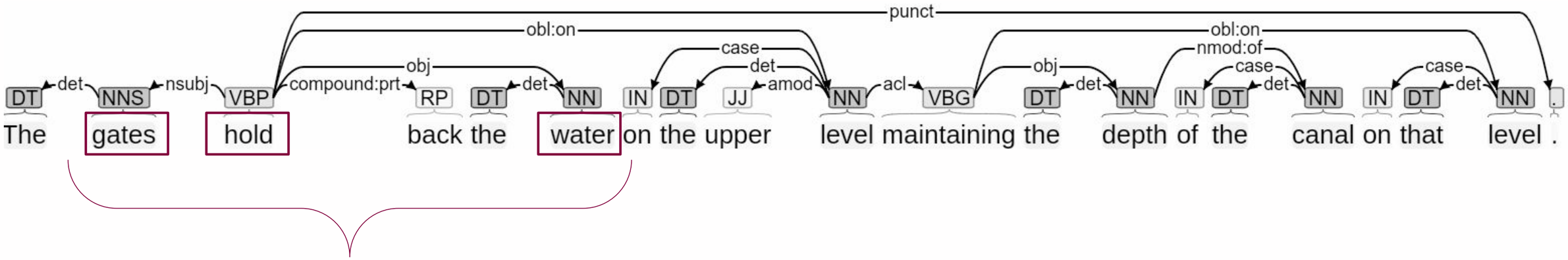
punct
obl:on
obl:on
case
nmod:of
obj
det
obj
case
case
det
det
det

Dependency Parsing

Stanza

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<canal,	leave,	river>	'It is typically installed where a **canal leaves** a **river**.'
<power,	provide_to,	mill>	'This finely designed and expertly built canal was once an essential trade route allowing goods and passengers easy access to the navigable section of the River Corrib and also **provided power** to several **mills**.'
<power,	provide_to,	watermill>	'Muslim and Christian engineers also used crankshafts and water turbines, gears in watermills and water-raising machines, and dams as a source of water, used to **provide** additional **power** to **watermills** …
<distillery,	use,	grain>	'Rural Galway also benefited from the business as the **distillery used** all **local grain** in the manufacturing process.'
<bridge,	cross,	canal>	'Five **bridges crossed** the **canal**, one at the Claddagh, one at Dominick Street, one connecting Mill Street with the "New College" (i.e. New Road), one near the Presentation Convent, and one connecting Beggar\'s Bridge with the Workhouse.'

….

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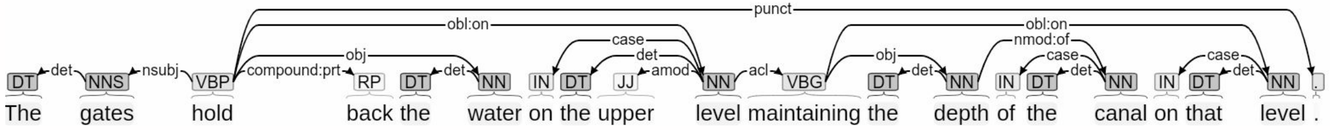
https://stanfordnlp.github.io/stanza/

Conversational Question Generation

Question pattern	Term(s)	Relation	Term(s) embedded within a Question
What is a TERM?	canal	/	What is a canal?
Tell me about a TERM	staircase	/	Tell me about a staircase
I'm interested in TERM	steam engine	/	I'm interested in steam engine
Was TERM used in Galway?	gate used	/	Was lock gate used in Ireland?
What was TERM used for?	mill	/	What was mill used for?
What is the relation between SUBJECT-TERM and OBJECT-TERM?	chamber, gate	/	What is the relation between a chamber and a gate?
What does a SUBJECT-TERM PREDICATE?	bridge	cross	What does a bridge cross?

From Unstructured to Dialogue dataset

main st	side	province
fair town	country	road
fair day	tourist	city
trade	success	seat
freeman	price	family
mile	fee	street
town	river	catholic
house		
class		
time		
water		
church		
mountain		
castle st		
mayor		



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What does a SUBJECT-TERM PREDICATE?	bridge	cross	What does a bridge cross?

→ the construction of this **canal** is of the most perfect kind ;

→ two-rise **staircases** are more common : snakeholme lock

→ **steam engines** were initially used to increase the water

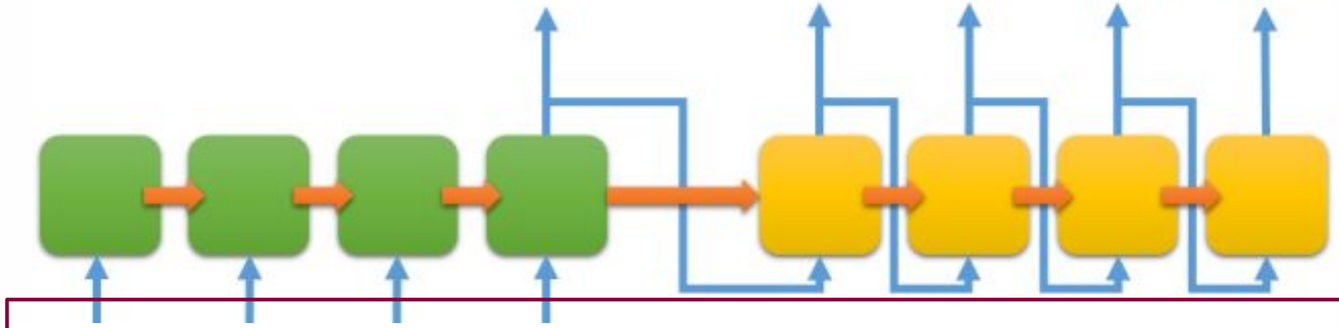
→ birmingham canal navigations **lock gate** controls on a

→ the rods used in the **mill** , usually a high-carbon steel

→ the different **chambers** of the larger caves , of which the the house of commons , the cross of the four roads

→ the **bridge** beneath monaghan must have been on the

Training the Encoder-Decoder Dialogue System



Question pattern	Term(s)	Relation	Term(s) embedded within a Question
What is a TERM?	canal	/	What is a canal?
Tell me about a TERM	staircase	/	Tell me about a staircase
I'm interested in TERM	steam engine	/	I'm interested in steam engine
Was TERM used in Galway?	gate used	/	Was lock gate used in Ireland?
What was TERM used for?	mill	/	What was mill used for?
What is the relation between SUBJECT-TERM and OBJECT-TERM?	chamber, gate	/	What is the relation between a chamber and a gate?
What does a SUBJECT-TERM PREDICATE?	bridge	cross	What does a bridge cross?

→ the construction of this **canal** is of the most perfect kind ;
→ two-rise **staircases** are more common : snakeholme lock
→ **steam engines** were initially used to increase the water
→ birmingham canal navigations **lock gate** controls on a
→ the rods used in the **mill** , usually a high-carbon steel
→ the different **chambers** of the larger caves , of which the
the house of commons , the cross of the four roads
→ the **bridge** beneath monaghan must have been on the

Collected Dataset

		Questions		Answers	
	lines	tokens	types	tokens	types
subject or object term	659,433	3,062,197	120	29,964,660	123,381
subject and object term	70,584	570,689	114	4,088,592	41,944
subject or object term and relation	4,010	25,355	132	246,759	19,124
concatenated corpus	729,636	3,595,795	164	33,542,445	123,052

Statistics on extracted question-sentence pairs based on the extracted terms and relations.

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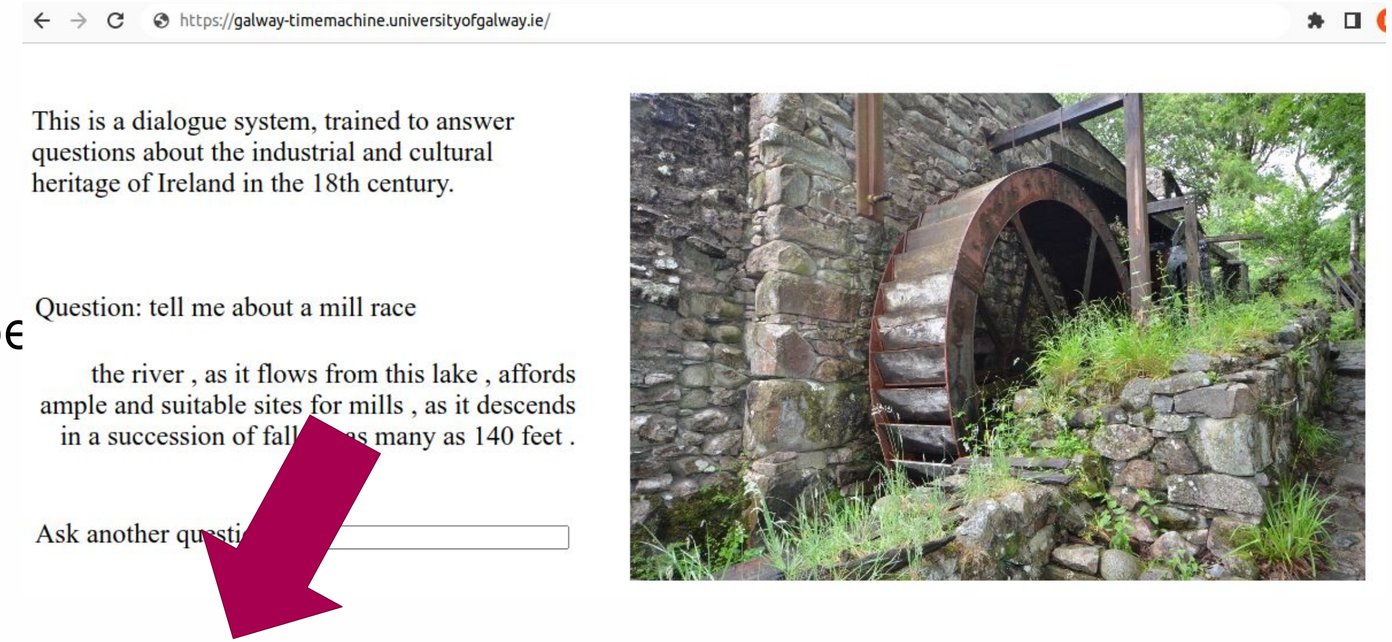
Evaluation

- automatic dialogue evaluation still ope



<u>Manual Evaluation:</u>

- Unacceptable = 1. Absolutely not comprehensible and/or little or no information generated accurately.
- Possibly Acceptable = 2. Possibly comprehensible (given enough context and/or time to work it out); some information generated accurately.
- Acceptable = 3. Not perfect (stylistically or grammatically odd), but definitely comprehensible, AND with all important information generated accurately.

Results on Generated Answers

	Annotator 1	Annotator 2	Annotator 3	Annotator 4	Average
subject or object term	2.20	2.00	1.92	1.64	1.94
subject and object term	2.54	2.46	2.24	2.34	2.40
subject/object term and relation	1.52	1.56	1.92	1.38	1.60
concatenated corpus	1.34	1.54	1.64	1.30	1.46

The evaluation scores of each annotator, based on the 50 automatically generated answers with its average score.

	κ
subject or object term	0.21
subject and object term	0.33
subject/object term and relation	0.36
concatenated corpus	0.41

Annotator agreement scores, Fleiss' Kappa*, based on the quality of the generated answers

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*The Fleiss' Kappa (Fleiss et al., 1971) was calculated between actual agreement and expected agreement. Fleiss' Kappa measures the reliability of agreement between a fixed number of annotators when assigning categorical ratings to several items or classifying items.

Examples

Question #1	Tell me about a cotton and a sawmill
Generated Answer	A sawmill or lumber mill is a facility where logs are cut into lumber.
Question #2	What is the relation between a gate and a river?
Generated Answer	On the clare side of the river, at the foot of thomond gate 587 limerick.
Question #3	Tell me about a city and a lock
Generated Answer	287 the gates of the city to be put in repair with locks and keys
Question #4	What is the relation between a log and water?
Generated Answer	Availability of railroad transportation for logs and lumber encouraged building of rail mills away from navigable water.
Question #5	What is the relation between a lumber and a paper?
Generated Answer	The larger pieces of wood that wo n't make lumber are chipped into wood chips and provide a source of supply for paper mills.
Question #6	What is the relation between a lumber and a mill?
Generated Answer	A sawmill or lumber mill is a facility where logs are cut into lumber.

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Thank *you*

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