

Fill the gap: Machine reading comprehension for medicine

Simon Šuster

joint work with Walter Daelemans

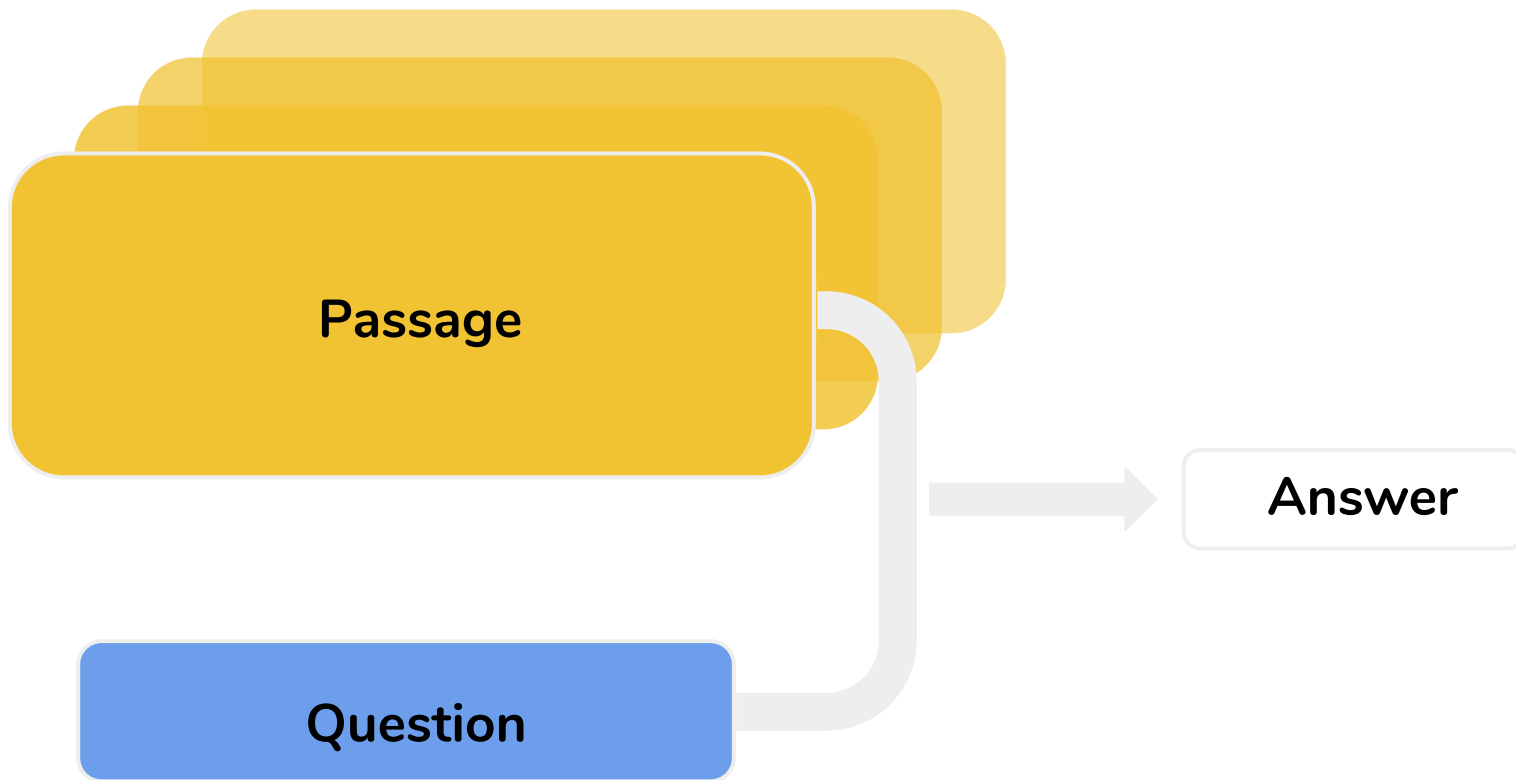
NLP Meetup Belgium

23 May 2019

“If I read and memorized two medical journal articles every night, by the end of a year I’d be 400 years behind”

Donald Lindberg, director of US NLM

Machine reading comprehension is fine-grained question answering



No, machines can't read better than humans

Headlines have claimed AIs outperform humans at 'reading comprehension,' but in reality the way to go

By James Vincent | Jan 17, 2018, 9:23am EST

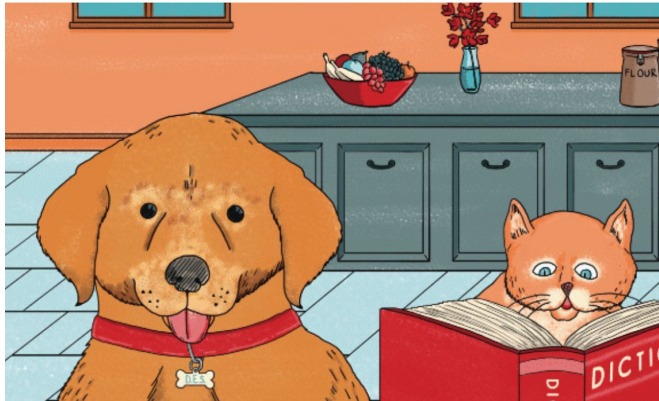
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A three-minute guide to how machine reading could make your job easier

September 26, 2017 | Microsoft reporter

f t in



How Microsoft is using machine reading comprehension to help create a 'literate machine'

September 18, 2017 | [Allison Linn](#)



Artificial Intelligence

Google DeepMind Teaches Artificial Intelligence Machines to Read

The best way for AI machines to learn is by feeding them huge data es, and the Daily Mail has unwittingly

TOM SIMONITE BUSINESS 01.18.18 03:35 PM

AI BEAT HUMANS AT READING! MAYBE NOT



AI models beat humans at reading comprehension, but they've still got a ways to go

Researchers at the Allen Institute for Artificial Intelligence in Seattle. (Stuart Issett for The Washington Post)

By Drew Harwell January 16

When computer models designed by tech giants Alibaba and Microsoft this month surpassed humans for the first time in a reading-comprehension test, both companies celebrated the success as a historic milestone.

Lao Si, the chief scientist for natural-language processing at Alibaba's AI research unit, struck a poetic note, saying, "Objective questions such as 'what

Machine reading for medicine

Promise for the future of clinical decision making

Physicians seek information from (un)structured clinical records

🤖 “*Why was the patient prescribed arginine?*”

Physicians seek domain knowledge

🤖 “*Does arginine reduce the length of recovery after surgery?*”

Resource bottleneck!

Specialized domains like medicine lack machine reading datasets

Some recently published datasets

[CNN / Daily Mail](#)

[CoQA](#)

[HotpotQA](#)

[MS MARCO](#)

[MultiRC](#)

[NewsQA](#)

[QAngaroo](#)

[QuAC](#)

[RACE](#)

[SQuAD](#)

[Story Cloze Test](#)

[Recipe QA](#)

[NarrativeQA](#)

[DuoRC](#)

[DROP](#)

Source:

<https://github.com/sebastianruder/NLP-progress>

Axes of variation

Multi-choice vs. span-based answering

Human vs. automatic construction

Human-like questions vs. queries

Single- vs. multi-hop reasoning

Requiring background knowledge

Text types

...

Some recently published datasets

	Domain
CNN / Daily Mail	News
CoQA	Literature, English exams, news, Wikipedia, science, ...
HotpotQA	Wikipedia
MS MARCO	Web search
MultiRC	Fiction, news, Wikipedia, science textbooks, ...
NewsQA	News
QAngaroo	Wikipedia, molecular biology
QuAC	Wikipedia
RACE	School exams
SQuAD	Wikipedia
Story Cloze Test	Stories
Recipe QA	Cooking recipes
NarrativeQA	Literature, movie scripts
DuoRC	Movie plots
DROP	Wikipedia

Source:

<https://github.com/sebastianruder/NLP-progress>

What we did

- Created a dataset from clinical case reports
- Automated question construction: gap-filling queries where the answer can be a treatment, a test or a problem
- Analyzed performance of different machine readers
- Examined the required reading skills: in what ways is answering difficult?

BMJ Case Reports

25 most common medical specialties:



CASE REPORT

Conservative management of an abdominal gunshot injury with a peritoneal breach: wisdom or absurdity?

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SUMMARY

Surgical exploration has been the standard of care for abdominal gunshot injuries. The authors report a case of a 28-year-old man who sustained a transabdominal gunshot injury, which entered the anterior abdominal wall and exited adjacent to the T12 vertebra posteriorly with a tangential trajectory. On presentation, the patient was haemodynamically stable with no peritoneal signs. Based on trajectory of the bullet, the abdominal injury was suspected. Therefore a CT scan abdomen with intravenous and rectal contrast was performed. The CT scan revealed no extravasation of the rectal contrast but showed free air spaces behind the descending colon. Delayed renal images of the upper pole were also normal. Based on the clinical findings, the patient was managed non-operatively with nothing per oral, intravenous antibiotics and frequent abdominal examinations. He made an unremarkable recovery without necessitating laparotomy.

with no abnormality found on digital rectal examination. The initial management consisted of keeping the patient nothing per oral, carbonation, intravenous hydration and analgesia. Keeping the bullet trajectory in mind, left colocolic and ureteric injury was highly suspected, despite a normal abdominal examination and stable haemodynamics.

INVESTIGATIONS

His complete blood count and serum creatinine remained normal and his haemoglobin and haematocrit did not drop at any point in time. A CT scan of the abdomen and pelvis was performed with intravenous and rectal contrast including delayed renal films. Images showed specks of free air behind the descending colon with no extravasation of contrast from the rectum and ureter (figure 1).

TREATMENT

A decision was made to manage this patient conservatively based on his haemodynamic stability, absence of peritoneal signs and no contrast extravasation from the colon, ureter or blood vessels on CT scan images. Exploration was kept in mind if the patient showed haemodynamic instability or developed peritoneal signs. He was kept under observation in a high dependency unit where his vitals were monitored hourly along with strict input/output charting and frequent abdominal examinations. He was kept there for 48 h and then shifted to the general ward where he was monitored as per ward protocol. He was fully ambulated on the second day of admission and remained stable throughout the hospital course. A repeat CT scan abdomen with intravenous and rectal contrast on the fifth postadmission day did not reveal any abnormality (figure 2), and therefore he was started on oral liquids followed by a progression to soft diet. He remained stable and was later discharged.

OUTCOME AND FOLLOW-UP

On the 10th day postdischarge, he was followed up in the clinic; he had returned to his normal daily activities and regular diet.

DISCUSSION

Although conservative management of blunt abdominal and stab wound injuries is well

BACKGROUND

Gunsfire injuries to the abdomen have been traditionally managed by exploratory laparotomy. The dictum of mandatory surgery of all nonoperatives is based on an assumption that only explorators can correctly diagnose all injuries and lower morbidity and that a clinical examination is usually unreliable. This results in a negative laparotomy rate of 15–25%.^{1–3} There is recent literature pointing towards selective nonoperative management of isolated anterior or posterior abdominal gunshot injury, but to the best of our knowledge no report is available about conservative treatment of transabdominal gunshot injury with a peritoneal breach. A clinical examination and helical CT scan are good tools aiding surgeons in the execution of non-operative management of a select group of patients.

CASE PRESENTATION

A 28-year-old man was brought to the emergency room within 30 min of a gunshot wound to the abdomen. On presentation, he was vitally stable with no peritoneal signs. On examination, he had sustained a transabdominal gunshot injury, with the entry wound 2 cm above the left anterior superior iliac spine and exit wound just left lateral to the transverse process of T12 vertebra with a tangential trajectory. His systemic examination was normal



Khan S, et al. *BMJ Case Rep* 2019; doi:10.1136/bcr-2019-201999

Reminder of important clinical lesson

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- Learning points
- Non-operative management of a transabdominal gunshot wound (GSW) is a safe alternative to mandatory laparotomy in a select group of patients.
 - Non-operative management has a role in a resource stretched environment, where geo-political situations result in limited resources.
 - A clinical abdominal examination and CT scan are useful tools in management.

Acknowledgements: The authors would like to thank Dr Sada Rafique for her valuable input.
 Contributors: Dr Amyn Pardhan involved in treatment, manuscript writing, AP involved in patient treatment and follow-up, manuscript revision. Dr Naveed Haroon, literature search, final manuscript writing, treatment, manuscript revision.
 Competing interests: None.
 Patient consent: Obtained.
 Provenance and peer review: Not commissioned; externally peer reviewed.

Build queries from Learning points

- Identify medical entities
- Blank out one entity at a time
- Blanked-out entities become ground-truth answers
- Extend the ground-truth answers with synonyms in UMLS

query: A clinical abdominal examination and _____ are useful tools in management.

answer: CT scan (CAT scan, computerized tomography, ...)

CASE REPORT

Conservative management of an abdominal gunshot injury with a peritoneal breach: wisdom or absurdity?

Salma Khan,¹ Amyn Pardhan,¹ Tufail Bawa,¹ Naveed Haroon²

¹Department of Surgery, Mayo Medical Institute, Karachi, Pakistan
²Department of Surgery, Aga Khan University Hospital, Karachi, Pakistan

Correspondence to Dr Naveed Haroon, naveedh@mayo.edu

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Gunshot injuries to the abdomen have been traditionally managed by exploratory laparotomy. The dictum of mandatory surgery of all nonoperatives is based on an assumption that only explorators can correctly diagnose all injuries and lower morbidity and that a clinical examination is usually unreliable. This results in a negative laparotomy rate of 15–25%.^{1–3} There is recent literature pointing towards selective nonoperative management of isolated anterior or posterior abdominal gunshot injury, but to the best of our knowledge no report is available about conservative treatment of transabdominal gunshot injury with a peritoneal breach. A clinical examination and helical CT scan are good tools aiding surgeons in the execution of non-operative management of a select group of patients.

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INVESTIGATIONS

His complete blood count and serum creatinine remained normal and his haemoglobin and haematocrit did not drop as any patient in trauma. A CT scan of the abdomen and pelvis was performed with intravenous and rectal contrast including delayed renal films. Images showed specks of free air behind the descending colon with no extravasation of contrast from the rectum and ureter (figure 1).

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OUTCOME AND FOLLOW-UP

On the fifth day postdischarge, he was followed up in the clinic; he had returned to his normal daily activities and regular diet.

DISCUSSION

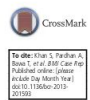
Although conservative management of blunt abdominal and stab wound injuries is well

known, it is not clear how to manage a patient with a gunshot wound to the abdomen.

Reminder of important clinical lesson

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- Non-operative management of a transabdominal gunshot wound (GSW) is a safe alternative to mandatory laparotomy in a select group of patients.
 - Non-operative management has a role in a resource stricken environment, where geo-political situations result in limited resources.
 - A clinical abdominal examination and CT scan are useful tools in management.

Acknowledgements The authors would like to thank Dr Sada Rafique for her valuable input.
Contributors Dr Amyn Pardhan is patient involved in treatment, manuscript writing, AP involved in patient treatment and followup, manuscript revision. Dr Tufail Bawa, involved in patient treatment and followup, manuscript revision. Dr Naveed Haroon, involved in patient treatment and followup, manuscript revision, Dr Salma Khan, involved in patient treatment and followup, manuscript revision.
Competing interests None.
Patient consent Obtained.
Provenance and peer review Not commissioned; externally peer reviewed.

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Build queries from Learning points

- Identify medical entities
- Blank out one entity at a time
- Blanked-out entities become ground-truth

> 100k instances (queries)

~56k different answers

avg. passage length: 1.5k tokens

answers with

examination and

are useful tools in management.

► answer: CT scan (CAT scan, computerized tomography, ...)

A 22-year-old woman presented to the emergency room with headache and confusion. The symptoms had woken her in the morning and progressively worsened through the day.

...

Passage:

Neurological examination demonstrated left lower facial paralysis with aphasia, dyscalculia, dyslexia and fingeragnosia, clinically Gerstmann syndrome. Further examination showed no abnormalities. A non-contrast head CT was performed and showed a left parietotemporal venous infarction and a small juxtacortical haemorrhage. An additional MR angiography showed occlusion of the left transverse sinus and a T2-weighted MRI showed a venous infarction with a juxtacortical haemorrhage just beneath the sulcus.

Query:

Upon performing an MRI, an accompanying _____ was found near the bottom of the sulcus.

Answer:

juxtacortical haemorrhage

Baselines

Random and frequency-based selection

Language model

- Kneser-Ney LM to predict the most likely word/concept based on 3 preceding words in the query

Embedding-based

- Pick the concept whose context representation is maximally similar to the context of the query

A simple neural approach

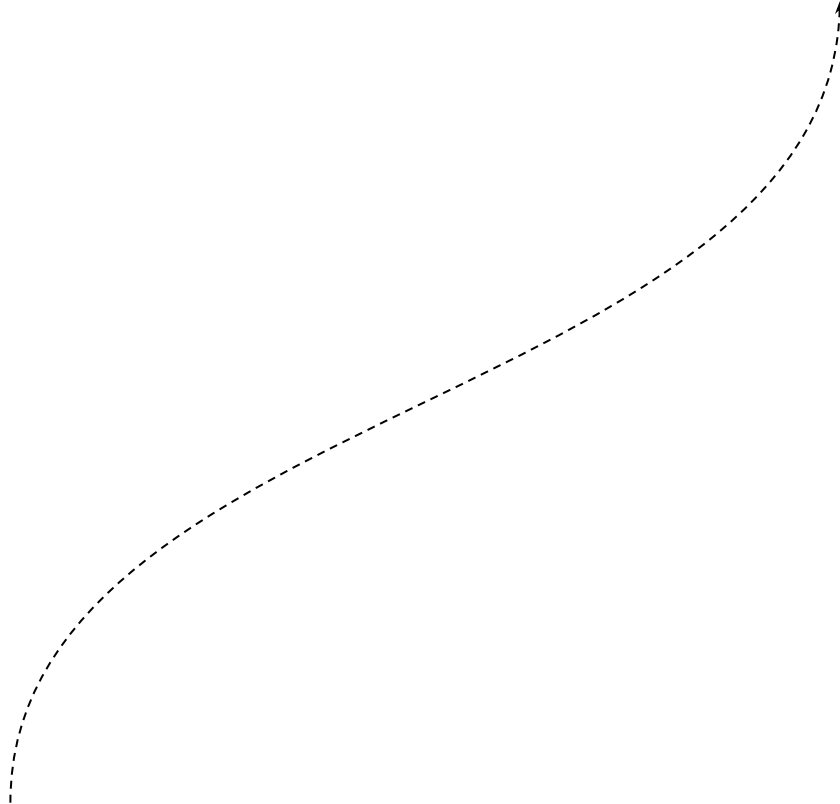
... abdominal examination and _____

Query

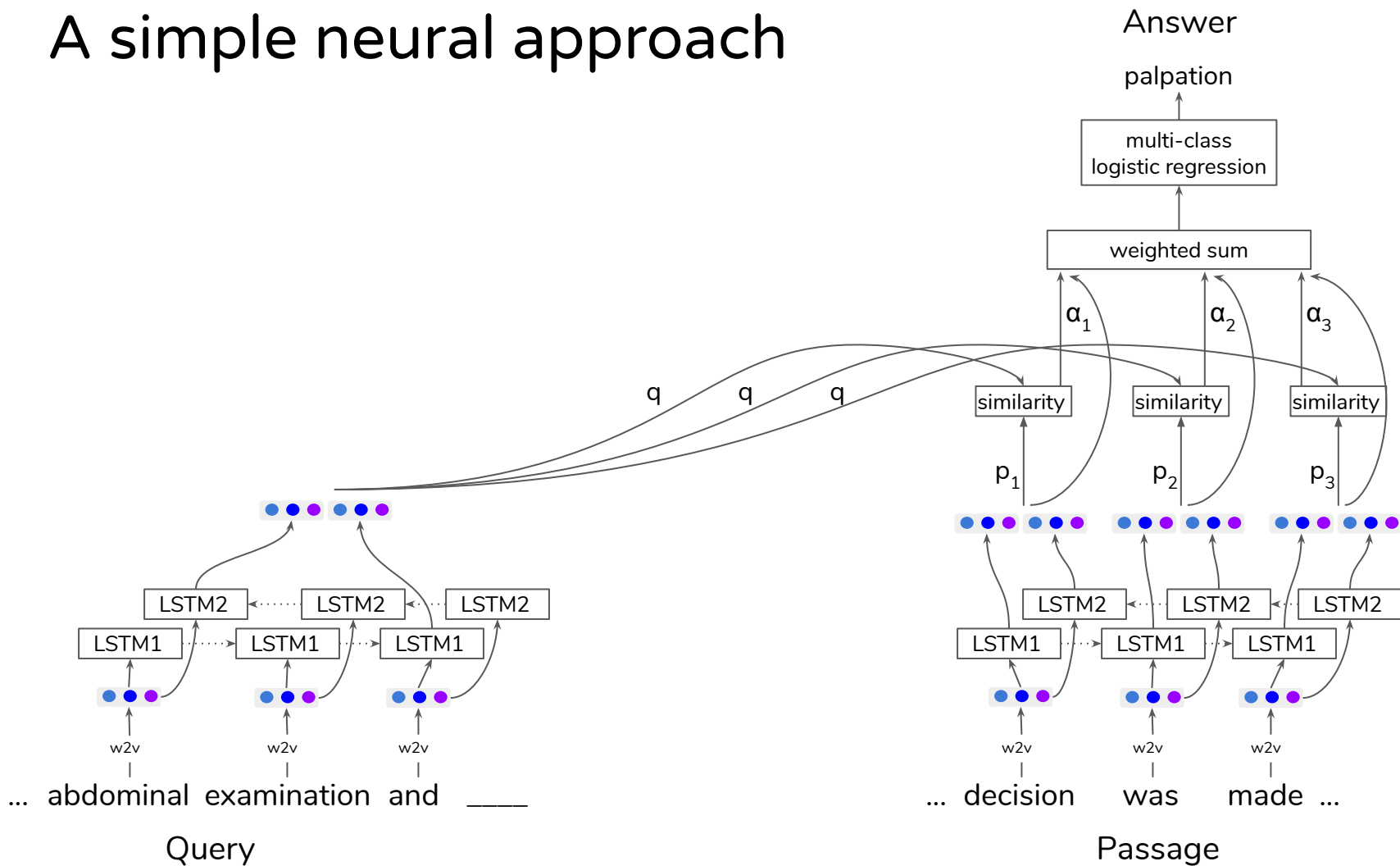
... decision was made ...

Passage

Answer
palpation



A simple neural approach



Neural readers

Stanford attentive reader (Chen et al. 2016)

(see previous slide)

Gated-attention reader (Dhingra et al. 2017)

- Adds iterative refinement of attention
- Answer prediction with a pointer

Key-value memory network

(Miller et al. 2016)

- Memory keys: passage windows
- Memory values: entities from the windows
- Encoding word and entities as vector averages

pretrained biomedical
word embeddings

answer candidates =
passage entities

random search for
hyperparameter selection

Human estimate

Answered 100 random instances from the development set

One person with medical background

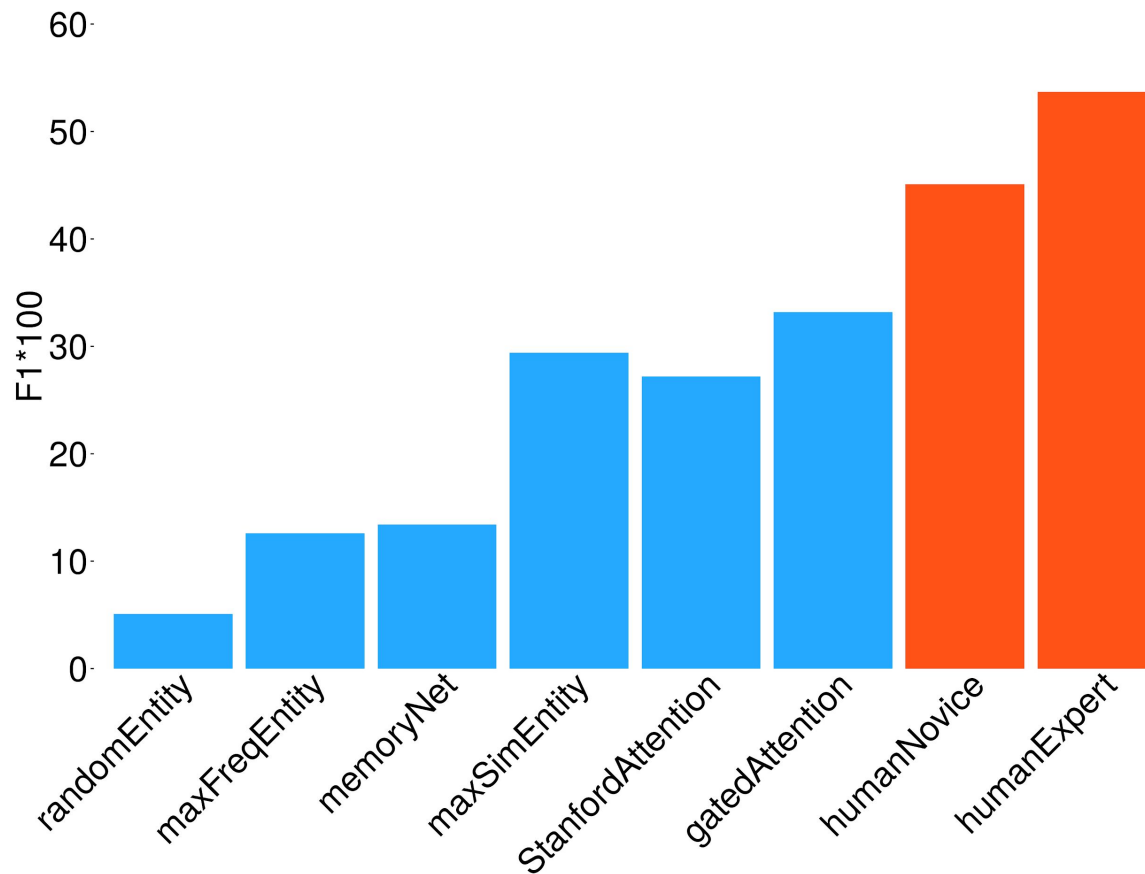
One person without medical background

Comprehension skills

We annotated those 100 instances with all required skills

A set of 13 skills

Machine vs. human results



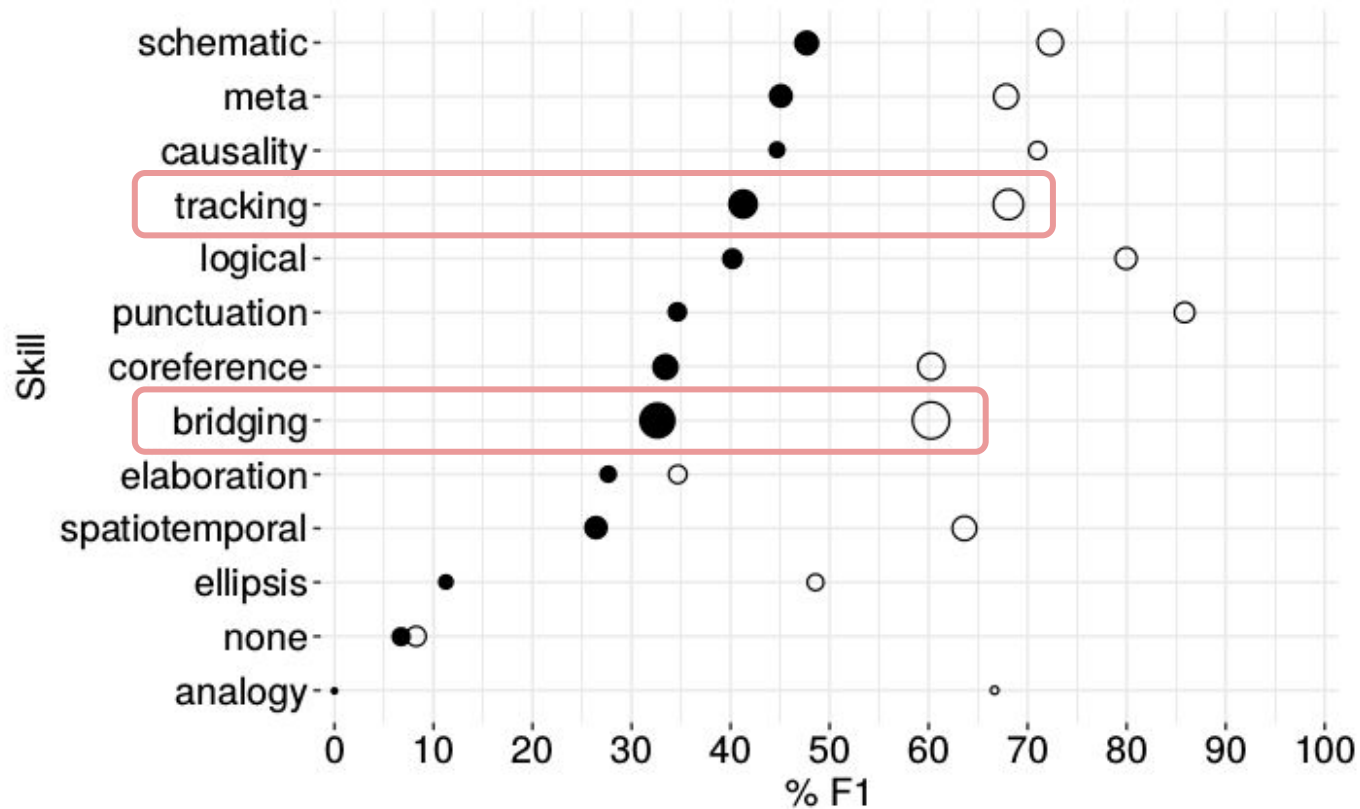
Additional observations

Human performance tops at 54 F1: Some queries may be unanswerable

Both MemNet and Stanford reader suffer from having a classifier on top with a huge output space

MemNet additionally lacks good encoding of input

Comprehension skills



Conclusion

A new dataset for clinical machine reading

- exploiting the structure of case report articles
- large and challenging
- varied skill requirements

We should be incorporating domain knowledge, object tracking, coreference resolution, temporal reasoning...

More information

Original paper:

Simon Šuster and Walter Daelemans (2018) CliCR: A Dataset of Clinical Case Reports for Machine Reading Comprehension. In NAACL.

Agreement with the publisher to freely distribute the dataset for research purposes (send me an e-mail)

Clinical NLP efforts at our lab: <https://clips.github.io/>

Our clinical NLP software: <https://github.com/clips/accumulate>

University of Antwerp's AI center: <https://antwerp.ai/>