MEDINFO23

8 – 12 JULY 2023 | SYDNEY, AUSTRALIA

Hands-on Natural Language Processing for Clinical Informatics in Python

Hannah Eyre, Alec Chapman, Kelly Peterson, Patrick Alba, and Scott DuVall

University of Utah and US Department of Veterans Affairs

AIDH IMIA

MEDINFO23

8 – 12 JULY 2023 | SYDNEY, AUSTRALIA

“We are time's subjects, and time bids be gone.”

- Shakespeare, *King Henry IV, Part II*

Link to training materials and additional information:

https://github.com/medspacy/medspaCy_MedInfo_2023

Outline

- Why we developed medspaCy
- The changing NLP landscape
- Ideas (and experimental work) for incorporating new NLP methods and medspaCy
  - Few-shot learning for emerging events
  - Maintaining legacy rule-based NLP
  - Causal analysis using rule-based NLP

Alec Chapman

Patrick Alba

Hannah Eyre

Kelly Peterson

Scott Duvall

Olga Patterson

Epidemiology

Clinical Informatics

Data Science

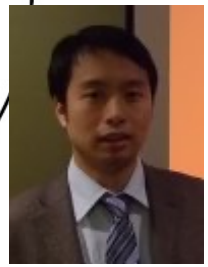
HEALTH
UNIVERSITY OF UTAH

U.S. Department of Veterans Affairs

John Stanley

Mengke Hu

Annie Bowles



Qiwei Gan

Jianlin Shi

Timeline of Clinical NLP Software

MedLEE

CLAMP

2010's

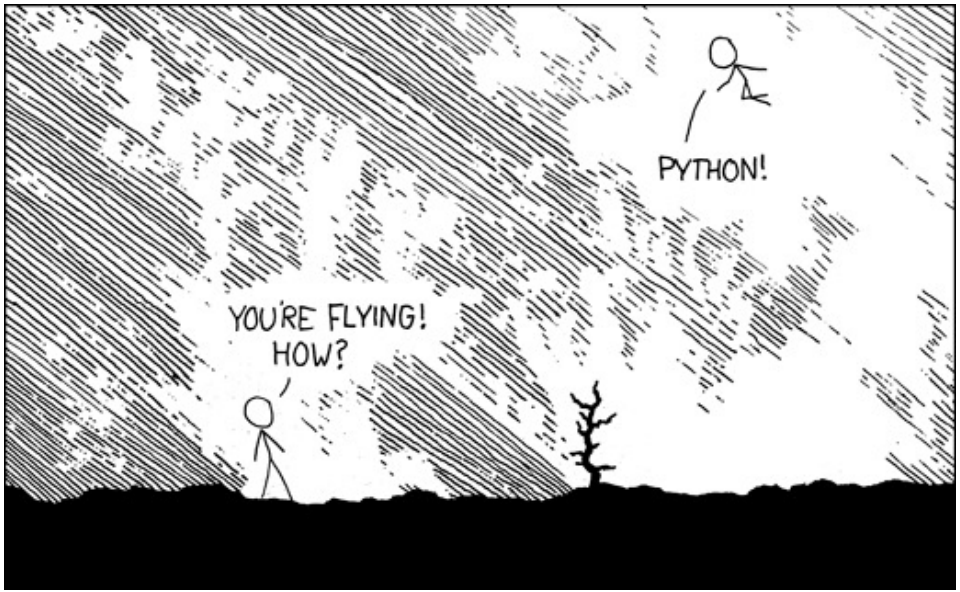
MetaMap

SymText

cTAKES

The magic of Python

- More accessible, easy to learn
- Making programming more accessible…



… to clinicians

Brian Bucher,
surgery

Rashmee Shah,
cardiology

Lori Gawron,
OB/GYN

Andrew Gawron,
gastroenterology

… and new programmers

Alec Chapman,
c. 2014

Brian Chapman teaching
Python to Alec Chapman,
c. 2016

Natural Language Analysis
with Python NLTK

2020

TensorFlow

spaCy

What happened in 2020?

- Needed rapid, easy-to-implement clinical NLP software

- Used by VA/UoU researchers but be available to community at large

Introducing medspaCy

- Built on spaCy's extensible framework
- Designed to be interoperable with any other spaCy component
- Enabled integration of modern Data Science and NLP packages into traditional Clinical NLP workflows

Hands-on tutorial

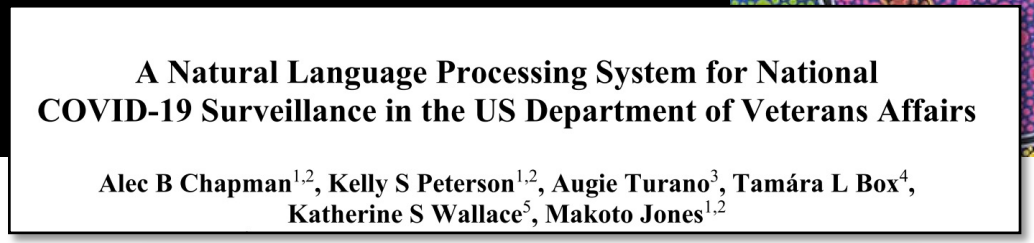
Follow along on
Google Colab or
your local machine

https://github.com/medspacy/medspaCy_MedInfo_2023

Impact

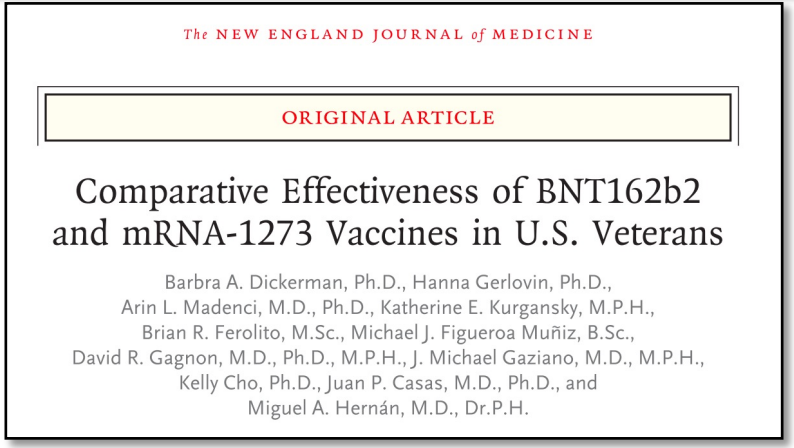
Covid-19

- Deployed in VA biosurveillance system
- Used in VA operations and research studies
- Parsing signs and symptoms of Covid-19 patients
- Surveillance system replicated in Toronto, Canada



A Natural Language Processing System for National COVID-19 Surveillance in the US Department of Veterans Affairs

Alec B Chapman[1,2], Kelly S Peterson[1,2], Augie Turano[3], Tamára L Box[4], Katherine S Wallace[5], Makoto Jones[1,2]

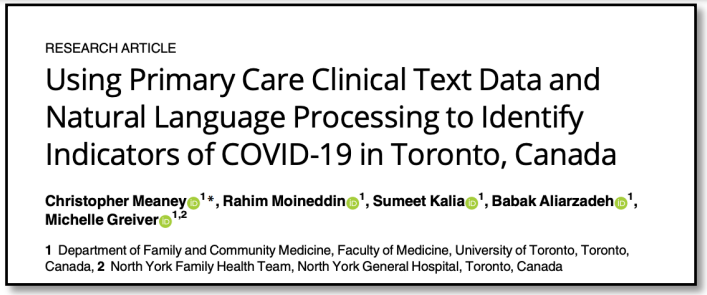


The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Comparative Effectiveness of BNT162b2 and mRNA-1273 Vaccines in U.S. Veterans

Barbra A. Dickerman, Ph.D., Hanna Gerlovin, Ph.D., Arin L. Madenci, M.D., Ph.D., Katherine E. Kurgansky, M.P.H., Brian R. Ferolito, M.Sc., Michael J. Figueroa Muñiz, B.Sc., David R. Gagnon, M.D., Ph.D., M.P.H., J. Michael Gaziano, M.D., M.P.H., Kelly Cho, Ph.D., Juan P. Casas, M.D., Ph.D., and Miguel A. Hernán, M.D., Dr.P.H.



RESEARCH ARTICLE

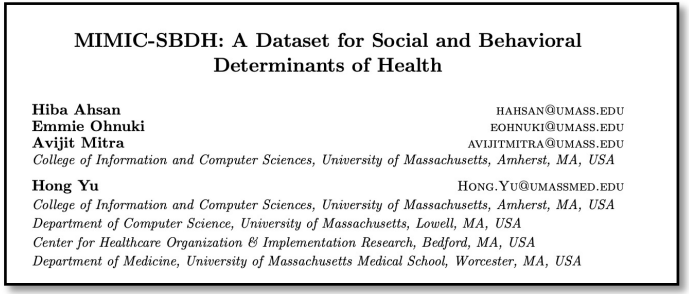
Using Primary Care Clinical Text Data and Natural Language Processing to Identify Indicators of COVID-19 in Toronto, Canada

Christopher Meaney[1]*, Rahim Moineddin[1], Sumeet Kalia[1], Babak Aliarzadeh[1], Michelle Greiver[1,2]

1 Department of Family and Community Medicine, Faculty of Medicine, University of Toronto, Toronto, Canada, 2 North York Family Health Team, North York General Hospital, Toronto, Canada

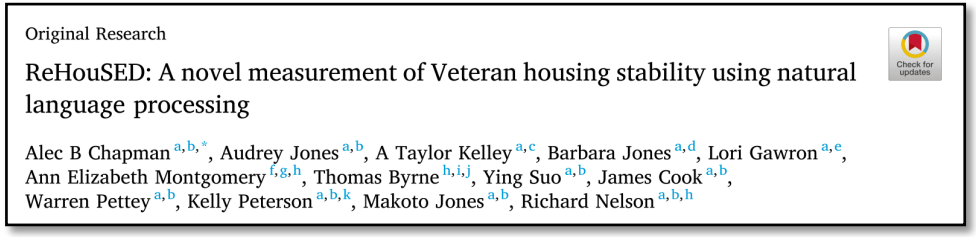
Social Determinants of Health

- Evaluation of VA homelessness programs
- MIMIC-SBDH: Public dataset for SDoH
- Hanna Pethani (University of Sydney): extracting SDoH from dental notes to study impact on dental health



MIMIC-SBDH: A Dataset for Social and Behavioral Determinants of Health

Hiba Ahsan HAHSAN@UMASS.EDU
Emmie Ohnuki EOHNUKI@UMASS.EDU
Avijit Mitra AVIJITMITRA@UMASS.EDU
College of Information and Computer Sciences, University of Massachusetts, Amherst, MA, USA
Hong Yu HONG.YU@UMASSMED.EDU
College of Information and Computer Sciences, University of Massachusetts, Amherst, MA, USA
Department of Computer Science, University of Massachusetts, Lowell, MA, USA
Center for Healthcare Organization & Implementation Research, Bedford, MA, USA
Department of Medicine, University of Massachusetts Medical School, Worcester, MA, USA



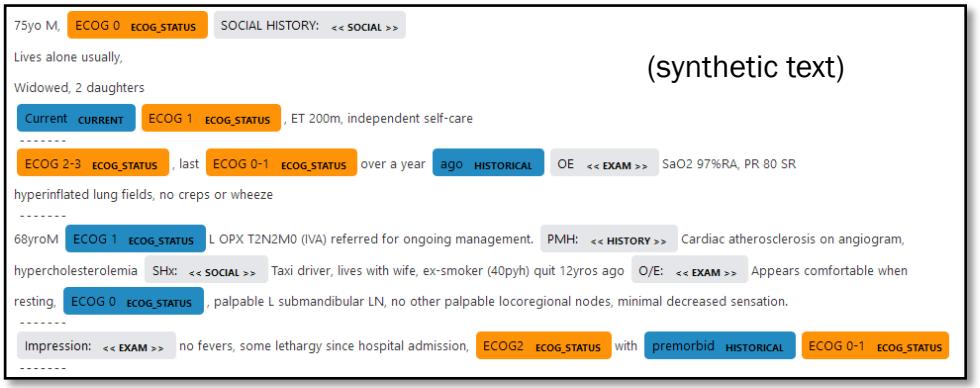
Original Research

ReHouSED: A novel measurement of Veteran housing stability using natural language processing

Alec B Chapman[a,b,*], Audrey Jones[a,b], A Taylor Kelley[a,c], Barbara Jones[a,d], Lori Gawron[a,e], Ann Elizabeth Montgomery[f,g,h], Thomas Byrne[h,i,j], Ying Suo[a,b], James Cook[a,b], Warren Pettey[a,b], Kelly Peterson[a,b,k], Makoto Jones[a,b], Richard Nelson[a,b,h]

...and more!

- Georgina Kennedy (Maridulu Budyari Gumal): Extracting ECOG performance status
- BioNLP
- More examples and references in our [MedInfo repository]



(synthetic text)

UMASS_BioNLP at MEDIQA-Chat 2023: Can LLMs generate high-quality synthetic note-oriented doctor-patient conversations?

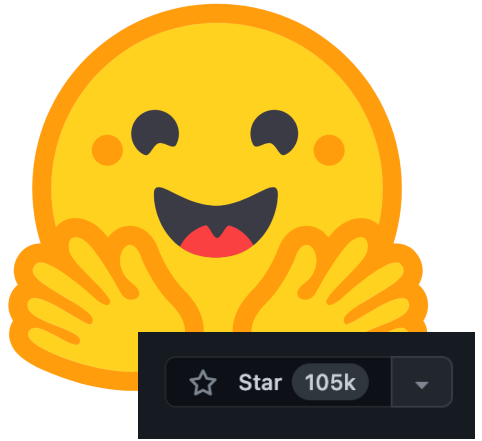
Junda Wang * Zonghai Yao * Avijit Mitra Samuel Osebe Zhichao Yang Hong Yu

CICS, University of Massachusetts, Amherst, MA, USA

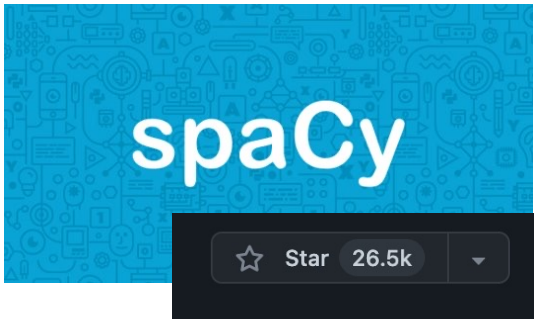
jundawang@umass.edu zonghaiyao@umass.edu

Changes in NLP Today

- New model architectures (Transformers) substantially improve performance on all NLP tasks
  - BERT, GPT-*, Megatron, etc.

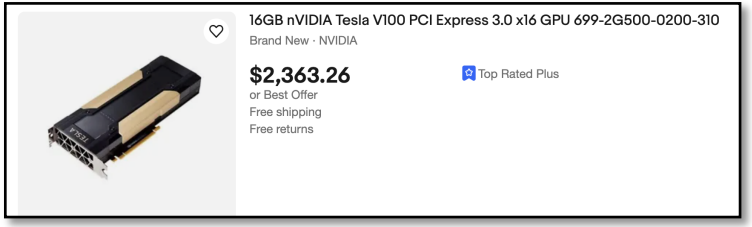


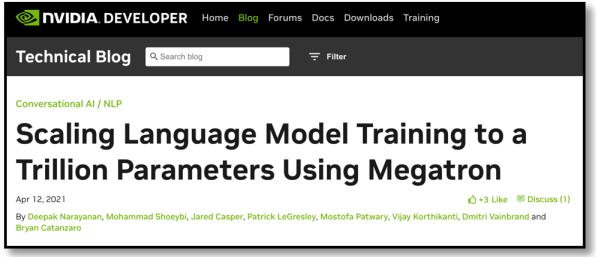
- Libraries like Huggingface Transformers adopted
  - Huggingface Transformers more popular than spaCy since Oct. 2020



Changes in NLP Today

- Rapidly increasing capabilities AND size
  - Training capacity both more accessible than ever and extreme capacity is siloed
- Reframing old tasks for new transformers
- Deep-learning using pre-trained transformers is often a feasible first option





Who still cares?

- Compute is still scarce for many projects and organizations
  - Compute at state-of-the-art scale is extremely expensive
- Privacy concerns for cloud compute platforms and model APIs
- Data source for pre-trained transformers is often unknown

Who still cares?

- Transformers are best performing, but "best performing" is not always the metric for success
- Difference between .95 PPV and .85 PPV may not matter
- Annotated data is required for deep learning, not for rules
- Rules are explainable and debuggable

Future Directions and medspaCy's Role

Few-Shot Learning: Work in Progress

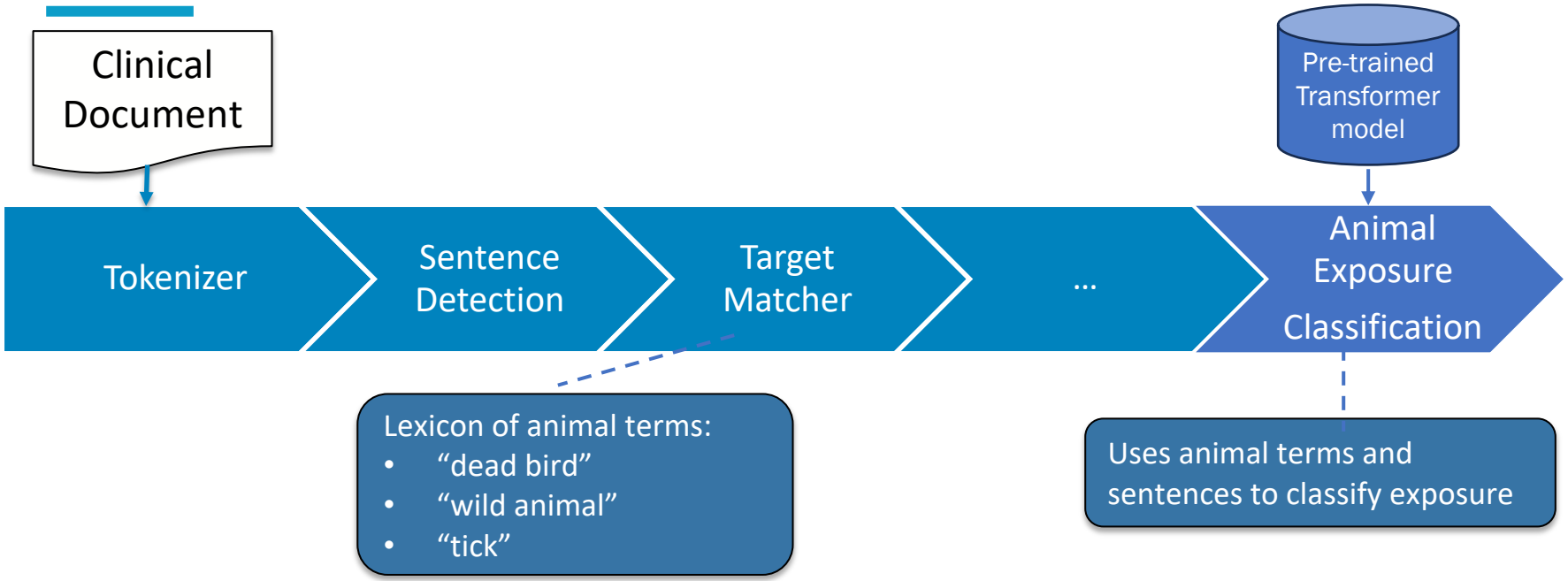
- Work-in-progress developing new capabilities for biosurveillance
- Many potential “early signs” for a public health event
  - One of these is animal exposure (i.e., zoonotic transmission)
- Difficult to annotate and develop NLP for emerging events

Poultry losses for the year from bird flu near record; the threat to humans isn’t zero

Few-Shot Learning: Work in Progress

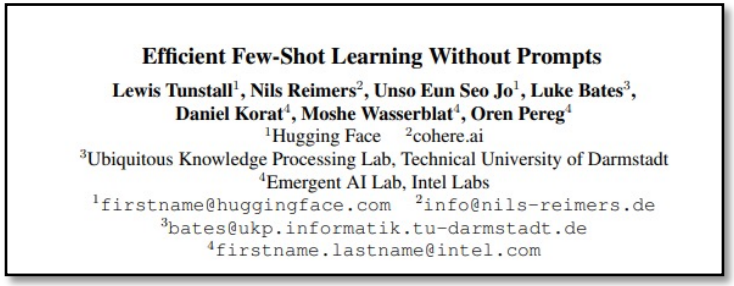
- Simply identifying animal keywords not sufficient for true exposure:
  - "Pt lives in **Antelope** Valley"
  - "Complains of chest pain that feels like a kick from a **mule**."
  - "Her son has an appetite like a **horse**"
  - "Pt smokes 1 pack a day; primarily **camels**."
  - "Precaution: During travel, avoid contact with **wild animals** (i.e., **avian influenza**)"
  - "Pt denies knowledge of any **tick** bites"
  - "Pt manages anxiety by watching **wild animals** from their window"

Few-Shot Learning: Work in Progress



Few Shot Learning: Work in Progress

- Started with rules-based approach, not very accurate
- Annotated a few instances for Few-Shot Learning
- Leverages pre-built Transformer models
  - “SetFit” uses SentenceTransformers
- Very encouraging results so far



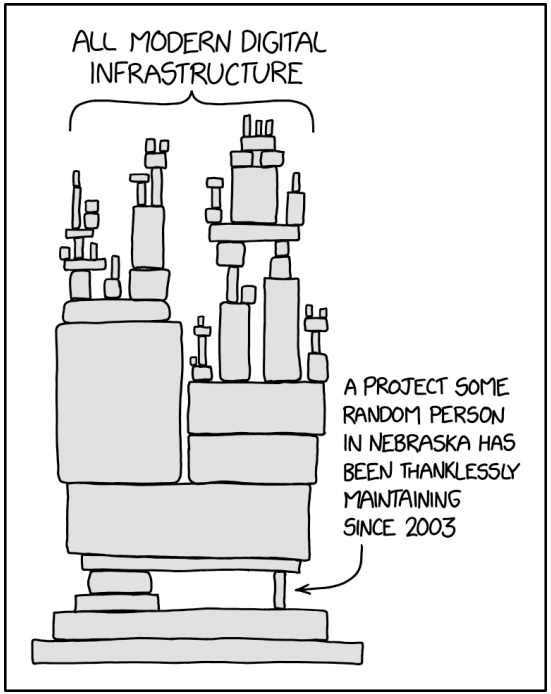
Efficient Few-Shot Learning Without Prompts

Lewis Tunstall[1], Nils Reimers[2], Unso Eun Seo Jo[1], Luke Bates[3],
Daniel Korat[4], Moshe Wasserblat[4], Oren Pereg[4]
[1]Hugging Face [2]cohere.ai
[3]Ubiquitous Knowledge Processing Lab, Technical University of Darmstadt
[4]Emergent AI Lab, Intel Labs
[1]firstname@huggingface.com [2]info@nils-reimers.de
[3]bates@ukp.informatik.tu-darmstadt.de
[4]firstname.lastname@intel.com

https://doi.org/10.48550/arXiv.2209.11055

Modernizing Legacy Rule-based NLP

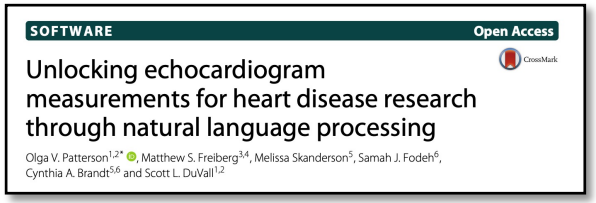
- Operational datasets need regular updates
- Nobody wants to maintain legacy software
  - ➢*"Hi all, is anybody still using UIMA-AS?"*
    - UIMA developer to UIMA user listserv, 2022
- Rule-based NLP incorporates institutional knowledge that is not always available



Modernizing Legacy Rule-based NLP

- Sampled output from EchoExtractor
  - System is 6+ years old
  - Lots of VA research projects using output
  - Rules are complex, difficult to edit

```
M-MODE MEASUREMENTS:
LV DIASTOLE:   50   (40-55mm)
LV SYSTOLE:    71   (25-30mm)
LT ATRIUM:     44   (25-35mm)
```


SOFTWARE Open Access

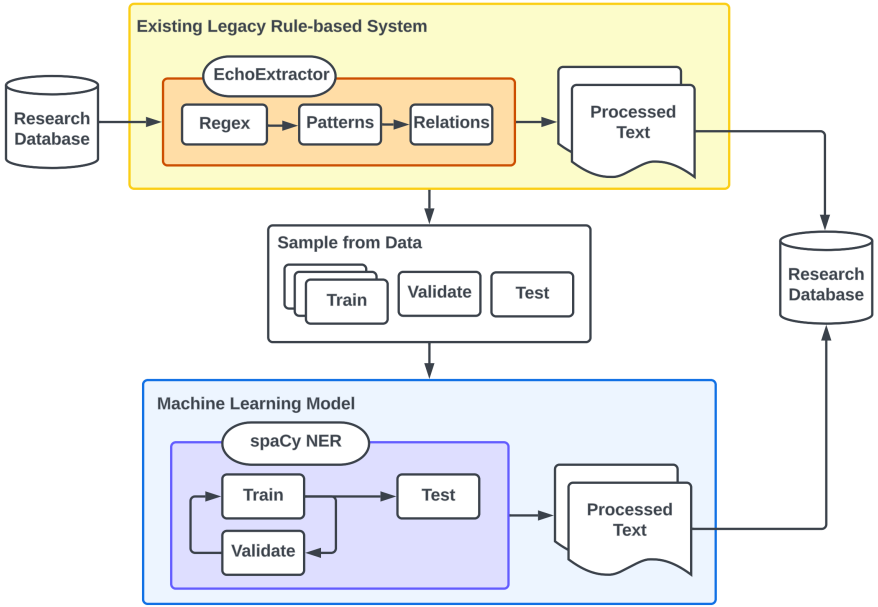
Unlocking echocardiogram measurements for heart disease research through natural language processing

Olga V. Patterson[1,2*], Matthew S. Freiberg[3,4], Melissa Skanderson[5], Samah J. Fodeh[6], Cynthia A. Brandt[5,6] and Scott L. DuVall[1,2]

- Extracting measures from echocardiograms
  - Frequency of labels vary widely from common (LVEF) to rare (mitral valve stenosis)

Modernizing Legacy Rule-based NLP

- Used existing rule-based NLP output as training data
- Trained spaCy convolutional neural network (CNN)



Modernizing Legacy Rule-based NLP

- Frequent classes achieved F1 > .90
- Rare classes were inconsistent
  - Some were performant but others were never predicted
- Overall performance not there yet, but shows promise

Documents	PPV (Precision)	Sensitivity (Recall)	F1
1,000	88.2	56.9	69.2
10,000	92.9	59.3	72.4
100,000	94.4	69.2	79.8
670,000 (all)	95.8	94.7	95.2

Modernizing Legacy Rule-based NLP

- Manual evaluation is needed
- Upcoming experiments using VA-trained BERT models
- Scaling inference speed of models is hard

Conclusion

- Exciting time to be in NLP
- Still room for traditional methods in clinical NLP
  - Alone and in combination with new methods
- Lots of open questions, problems to be solved

https://github.com/medspacy/medspaCy_MedInfo_2023

Thank You!

- Contact us:
  - Hannah Eyre, hannah.eyre@utah.edu
  - Alec Chapman, alec.chapman@hsc.utah.edu

- Collaboration
  - We would love to help you use medspaCy in your work
  - Open-source can always use contributors
  - We are looking for multi-lingual rules!