MIMIC-III NLP and Reproduction Code

AI 395T | **AI in Healthcare** | Dr. Ying Ding

Presenter: [redacted]

This slide deck covers 9 **outputs and** (6 required + 3 bonus) and code-behind for each:

Introduction

What disease did I pick?

I picked disease codes related to **Hyperlipidemia** [2724, 2721], which is a common condition characterized by high levels of lipids (fats) in the blood. It is a risk factor for cardiovascular diseases, including heart attacks and strokes, which are leading causes of death worldwide.

What about the text data?

The resultant patients_df dataframe had shape (29, 2) (29 entries) and the TEXT column is comprised of 361,438 characters (or approximately, 54,365 words).

How did you display the results of the t-SNE plots?

In the slides, I provide 3 charts for each value: the plot without entities labeled to observe clusters, the plot with entities labeled, and then a sampled plot with labels (for visual validation of terms).

The Process Step 1: Read the Data in

I based my read in off of Terence Lim's endorsed post on Ed Discussion.

[5]:
```
notes_path = 'data/NOTEEVENTS.csv'
diagnoses_path = 'data/DIAGNOSES_ICD.csv'
summary_path = 'data/summary.csv'
```

[6]:
```
# Read in code adapted from Terence Lim's endorsed post in Ed Discussion
notes_df =  pd.read_csv(notes_path, low_memory=False)
diagnoses_df = pd.read_csv(diagnoses_path, low_memory=False)
```

[66]:
```
dis_sum_df = notes_df.loc[notes_df['CATEGORY'] == 'Discharge summary', ['SUBJECT_ID', 'HADM_ID', 'TEXT']]
dis_sum_df['subj_hadm'] = list(zip(dis_sum_df['SUBJECT_ID'].astype(int), dis_sum_df['HADM_ID'].astype(int)))

# I decided to focus on hyperlipidemia related diagnoses
disease_list = ['2724', '2721']
disease_df = diagnoses_df[diagnoses_df['icd9_code'].isin(disease_list)].copy()
disease_df['subj_hadm'] = list(zip(disease_df['subject_id'].astype(int),
                                   disease_df['hadm_id'].astype(int)))

patients_df = dis_sum_df[['TEXT', 'subj_hadm']]\
    .join(disease_df.set_index('subj_hadm')['icd9_code'], on='subj_hadm', how='left')\
    .dropna()\
    .drop(columns=['subj_hadm'])

print('Verify that diseases extracted equals those in input list:',
      sorted(disease_list), sorted(np.unique(patients_df['icd9_code'])), sep='\n')

patients_df.to_csv(summary_path)
patients_df.shape
```

```
Verify that diseases extracted equals those in input list:
['2721', '2724']
['2721', '2724']
```

[66]:
```
(29, 2)
```

The Process Step 2: Entity Extract

Next, I performed entity extract using this generic template (piping changed, but process remains the same)

```
def extract_entities(text):
    doc = nlp(text)
    entities = [(ent.text, ent.start_char, ent.end_char, ent.label_) for ent in doc.ents]
    return entities

selected_disease_codes = ['2724', '2721']
selected_disease_patients_df = patients_df[patients_df['icd9_code'].isin(selected_disease_codes)]

# Process each discharge summary text and extract entities
for index, row in selected_disease_patients_df.iterrows():
    text = row['TEXT']
    entities = extract_entities(text)
    # Visualize entities using displaCy
    doc = nlp(text)
    displacy.render(doc, style='ent', jupyter=True)
```

Where nlp() piping was used for both spacy, scispacy, and (later) MedSpacy

Entity Extract: Spacy vs. SciSpacy

What is this showing?

Here we can see the limited NER capability of spacy in the healthcare domain and the improvement a domain specific training set can have.

Spacy

Major Surgical or Invasive Procedure:

[** 2184-8-5 DATE **]: Cardiac ORG catheterization, no intervention

History of Present Illness WORK_OF_ART :

72 CARDINAL yo F PRODUCT with PMHx of 2vessel CAD s/p RCA atherectomy in '[** 67 CARDINAL **],

HTN, morbid obesity, Hyperlipidemia PERSON who presents with dyspnea x

3days CARDINAL , worse past day with a dry cough. Symptoms started

abruptly on Sunday night TIME with SOB ORG while walking to bathroom. SOB ORG

remaind persistent over the following days DATE , with worsening DOE ORG .

She initially presented to [** First ORDINAL Name8 (NamePattern2) **] [**Last Name (Namel

was found to

be hypotensive and was transferred to [**Hospital1 18 CARDINAL **] ED with suggested

diagnosis of PNA ORG , incidentally found to have elevated troponin

of 1.73 CARDINAL . She was started on heparain at OSH. Received azithro

and Ceftriaxone GPE at OSH. Was on neo at 100 mcg QUANTITY . Got RIJ ORG in ou

ED. Crackles at bases, Febrile to 100.1 CARDINAL . Gave levofloxacin. Put

on levophed in ED GPE . O2 CARDINAL sat high 90's on 4L. CXR ORG here appears t

have bilateral infiltrates. ECG ORG here afib rate [**Street Address(2) 5679**]

elevations V4 CARDINAL -V6. Patient denies chest pain.

SciSpacy

Major Surgical ENTITY or Invasive Procedure ENTITY :

[**2184-8-5**]: Cardiac catheterization ENTITY , no intervention ENTITY

History ENTITY of Present Illness:

72 yo F ENTITY with PMHx ENTITY of 2vessel CAD ENTITY s/p RCA ENTITY atherectomy ENTITY in '[**67**],

HTN ENTITY , morbid obesity ENTITY , Hyperlipidemia ENTITY who presents with dyspnea ENTITY x

3days , worse past day ENTITY with a dry cough ENTITY . Symptoms ENTITY started

abruptly on Sunday ENTITY night ENTITY with SOB ENTITY while walking ENTITY to bathroom ENTITY . SOB ENTITY

remaind ENTITY persistent ENTITY over the following days ENTITY , with worsening ENTITY DOE ENTITY .

She initially presented to [**First Name8 (NamePattern2) **] [**Last Name (NamePattern1) 5678**] hospital and was found to

be hypotensive ENTITY and was transferred to [**Hospital1 18**] ED ENTITY with suggested

diagnosis ENTITY of PNA ENTITY , incidentally ENTITY found to have elevated ENTITY troponin of 1.73 ENTITY . She was

started on heparain ENTITY at OSH ENTITY . Received azithro ENTITY and Ceftriaxone ENTITY at OSH ENTITY . Was on neo

ENTITY at 100 mcg ENTITY . Got RIJ ENTITY in our

ED ENTITY . Crackles ENTITY at bases ENTITY , Febrile ENTITY to 100.1. Gave levofloxacin ENTITY . Put

on levophed ENTITY in ED ENTITY . O2 ENTITY sat high 90's on 4L ENTITY . CXR ENTITY here appears to

have bilateral infiltrates ENTITY . ECG ENTITY here afib rate ENTITY [**Street Address(2 ENTITY) 5679**]

elevations ENTITY V4-V6. Patient ENTITY denies chest pain ENTITY .

The Process Step 3: word2vec/t-SNE plots

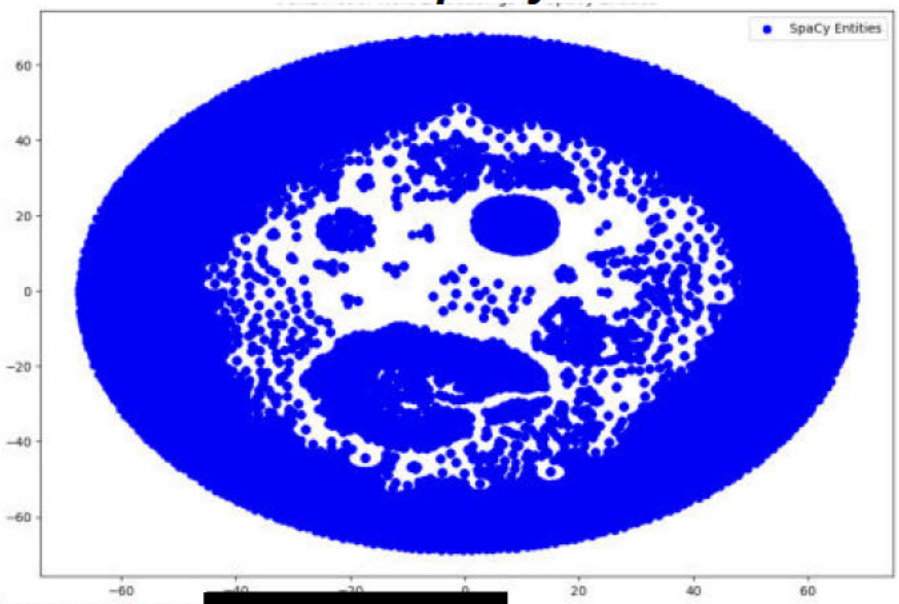
I made 3 versions of the plot (word2vec process remained the same) :

1. ***Without Labels (for visual simplicity given size)***
2. *With Labels (for completeness)*
3. *Sampled with Labels (for visual validation)*

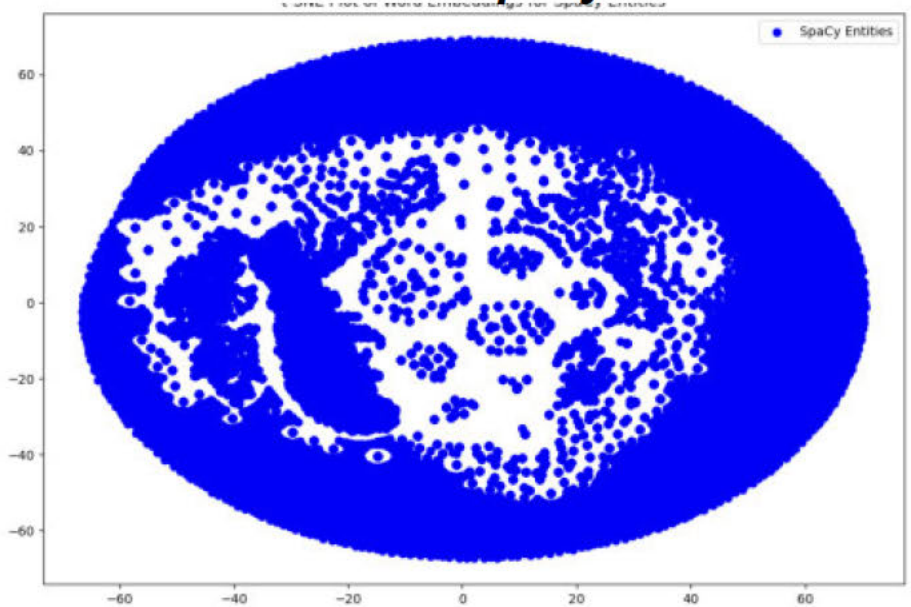
Plot without labels

```
word2vec_spacy = Word2Vec(sentences=spacy_sentences, vector_size=100, window=5, min_count=1, workers=4)
word_embeddings_spacy = [word2vec_spacy.wv[word] for sentence in spacy_sentences for word in sentence]

# t-SNE
tsne_model = TSNE(perplexity=11, early_exaggeration=12, n_components=2, init='pca', n_iter=1000, random_state=23)
word_embeddings_tsne_spacy = tsne.fit_transform(word_embeddings_spacy)

# Plot t-SNE
plt.figure(figsize=(12, 8))
plt.scatter(word_embeddings_tsne_spacy[:, 0], word_embeddings_tsne_spacy[:, 1], color='blue', label='SpaCy Entities')
plt.title('t-SNE Plot of Word Embeddings for SpaCy Entities')
plt.legend()
plt.show()
```

SpaCy



SciSpacy



The Process Step 3: word2vec/t-SNE plots

T-SNE plot code with and without sampling

```
def tsne_plot(model, words):
    "Creates a t-SNE model and plots it"
    labels = []
    tokens = []

    for word in words:
        if word in model.wv:
            tokens.append(model.wv[word])
            labels.append(word)
        else:
            print(f"Skipping '{word}' as it is not present in the model's vocabulary.")

    tsne_model = TSNE(perplexity=11, early_exaggeration=12, n_components=2, init='pca', n_iter=1000, random_state=23)
    new_values = tsne_model.fit_transform(np.array(tokens))  # Convert tokens to a NumPy array

    x = []
    y = []
    for value in new_values:
        x.append(value[0])
        y.append(value[1])

    plt.figure(figsize=(16, 16))
    for i in range(len(x)):
        plt.scatter(x[i], y[i])
        plt.annotate(labels[i],
                     xy=(x[i], y[i]),
                     xytext=(5, 2),
                     textcoords='offset points',
                     ha='right',
                     va='bottom')
    plt.show()
```

That's kind of messy, so let's sample it real quick:

```
def tsne_plot(model, words, sample_size=50):
    "Creates a t-SNE model and plots a sample of it"
    labels = []
    tokens = []

    # Select a random sample of words
    selected_words = np.random.choice(words, size=sample_size, replace=False)

    for word in selected_words:
        if word in model.wv:
            tokens.append(model.wv[word])
            labels.append(word)
        else:
            print(f"Skipping '{word}' as it is not present in the model's vocabulary.")

    tsne_model = TSNE(perplexity=11, early_exaggeration=12, n_components=2, init='pca', n_iter=1000, random_state=23)
    new_values = tsne_model.fit_transform(np.array(tokens))  # Convert tokens to a NumPy array

    x = []
    y = []
    for value in new_values:
        x.append(value[0])
        y.append(value[1])

    plt.figure(figsize=(16, 16))
    for i in range(len(x)):
        plt.scatter(x[i], y[i])
        plt.annotate(labels[i],
                     xy=(x[i], y[i]),
                     xytext=(5, 2),
                     textcoords='offset points',
                     ha='right',
                     va='bottom')
    plt.show()
```

```
vocabs = word2vec_model.wv.index_to_key
sample_size = 100  # Set the sample size
tsne_plot(word2vec_model, vocabs, sample_size)
```

The Process Step 3: word2vec/t-SNE plots

I made 3 versions of the plot (word2vec process remained the same) :

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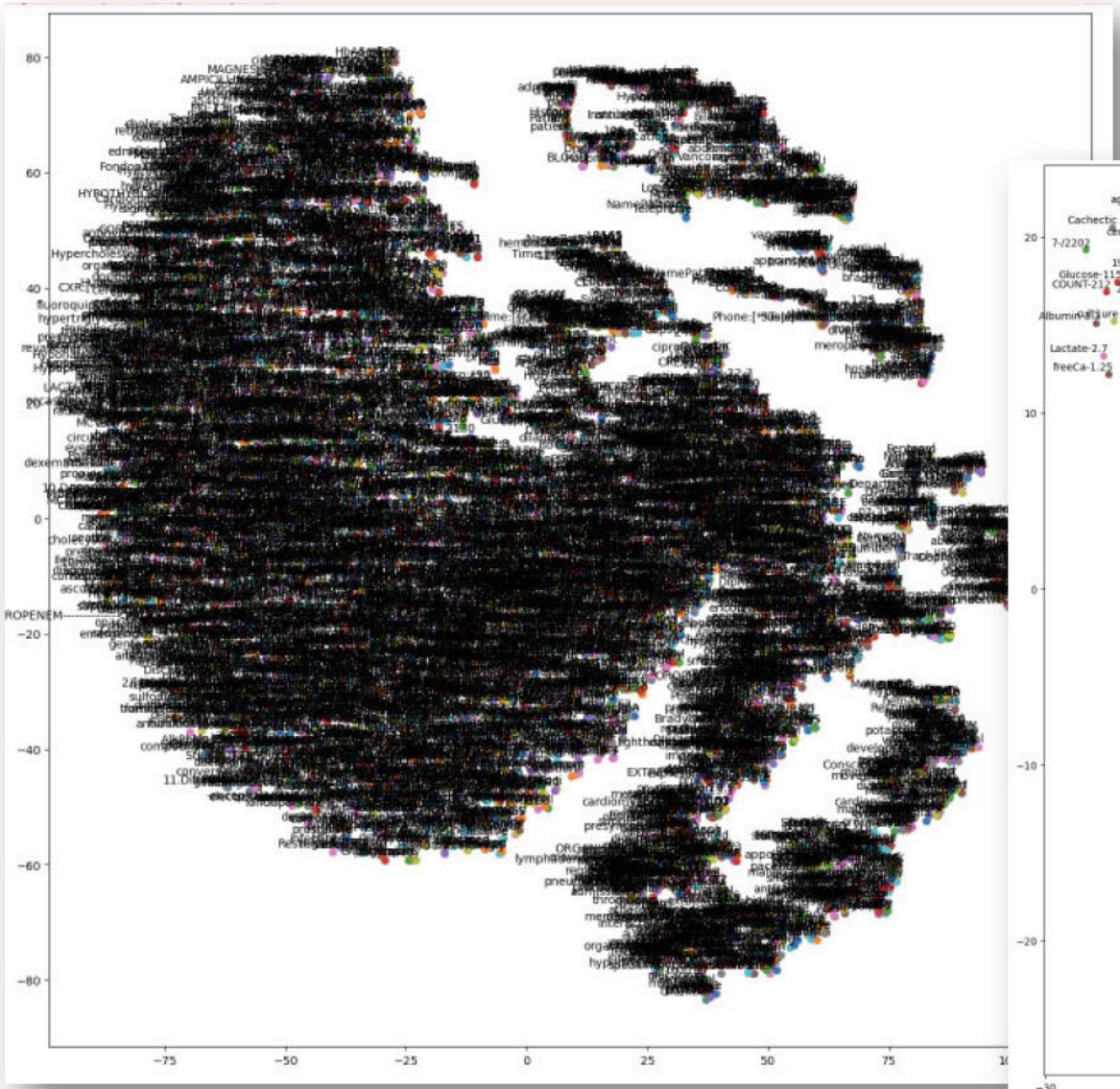
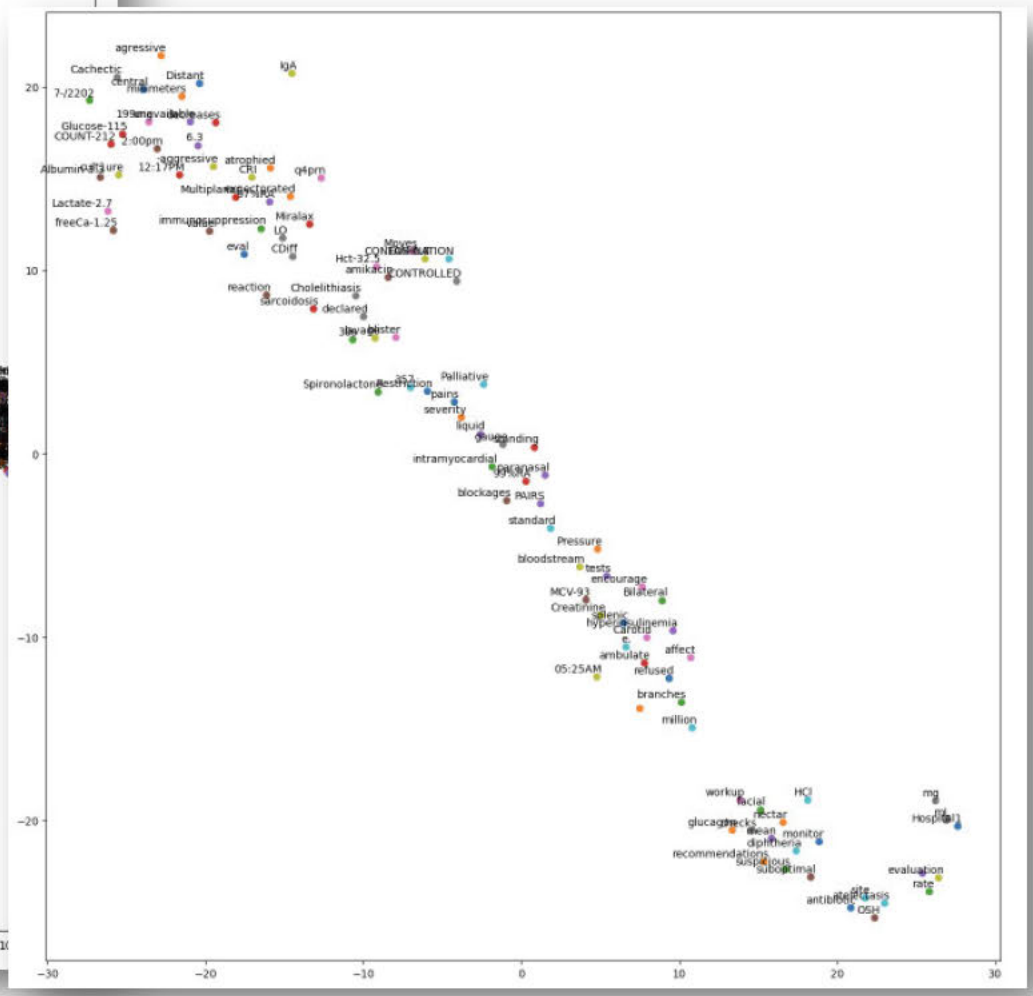
Full Plot



Sample Plot (n=100)



The Process Step 4: MedSpacy

Now, let's look at entity extract with MedSpacy

```
import medspacy
from medspacy.ner import TargetRule

selected_disease_codes = ['2724', '2721']
selected_disease_patients_df = patients_df[patients_df['icd9_code'].isin(selected_disease_codes)]

nlp = medspacy.load(enable=['sentencizer', 'medspacy_target_matcher'])
target_rules = [
    TargetRule('hyperlipidemia', 'DISEASE'),
    TargetRule('lipid', 'SUBSTANCE'),
    TargetRule('hypertension', 'DISEASE'),
    TargetRule('obesity','CONDITION'),
    TargetRule('cardiac','ENTITY')
]
nlp.get_pipe('medspacy_target_matcher').add(target_rules)

# Entity extract
medspacy_sentences = []
entities = []
for text in selected_disease_patients_df['TEXT']:
    doc = nlp(text)
    medspacy_sentences.append([token.text for token in doc if not token.is_stop])
    entities.extend([ent.text for ent in doc.ents if ent.label_ == 'DISEASE'])
```

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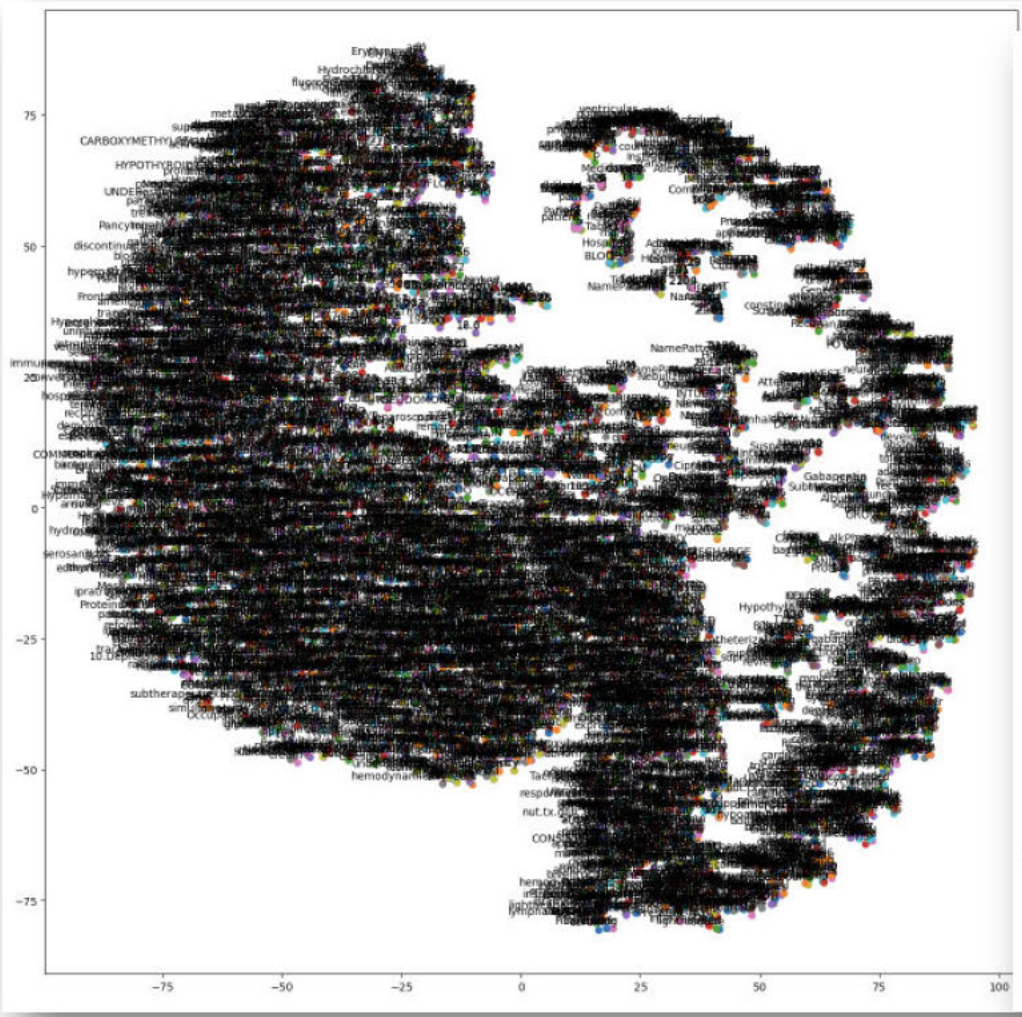
elevations V4-V6. Patient denies chest pain.

Here, we see a possible use case for tuning custom NER engines with MedSpacy's TargetRules

MedSpacy's word2vec/t-SNE plots

This used the same t-SNE plot code as for spacy/scispacy

Full Plot (n=7000)



Sample Plot (n=100)