NBME - Score Clinical Patient Notes

And how to find the key features from patient notes



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Kaggle_id comp540_dx4_df21

Feb 1. - May 3. 2022. Comp 540 Statistical Machine Learning, Rice University

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PROBLEM DESCRIPTION

In medical practice doctors always write notes about the patient's current state. What are the symptoms of the problem, what is the physical condition of the patient, what medications were used, what life situations the patient is encountering, and so on. These notes were collected into patient notes history, which can be used in the future as a prior to treatment evaluation for the future problems.

Doctors used to write those without particular structure in pure text form, which makes it hard to automatically process and use for treatment evaluation. In this project, we are building a machine learning model that will take patient notes and output a set of features with start and end positions where it occurs in the given patient note. Here is one example.

HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my
chest." 2 days ago during a soccer game had an episode, Intermittent symptoms but this time had chest pressure Chest pressure and felt as if he
were going to pass out Lightheaded (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before
recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in
sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.
PMHx: none
Rx: uses friends adderrall
FHx: mom with "thyroid disease," Family history of thyroid disorder dad with recent heart attcak Family history of MI; Family history of myocardial infarction
All: none
Immunizations: up to date
SHx: Freshmen in college. Endorses 3-4 drinks 3 nights / week (on weekends), denies tabacco, endorses trying marijuana. Sexually active with girlfriend x 1
year, uses condoms

Figure 1: Problem illustration

In our problem, we are trying to extract 143 features from the given patient note. We have a collection of about 40,000 Patient notes describing 10 medical cases, of which about 14300 are labeled with features' offsets.

EXPLORATORY DATA ANALYSIS

We started by looking at EDA¹:

Each patient note belongs to a specific case. There are 10 cases and for each case, there is a multitude of patient notes. In other words, each doctor took a patient note for the 10 different cases. From Figure 2 below, we can see we have the most notes for case 3 while case 1 has the least patient notes.





Figure 3: Length of patient notes

Next, we have the length of each patient note in Figure 3. Patient notes are the information related by the patient to the notetaker. Most patient notes have between 600 and 1000 characters. Each notetaker describes cases in their own way, hence such spread in the length. As a result, the same features may be described using different words.

Next, we look at the number of features corresponding to each case. As we can see, certain cases require the incorporation of more features than others. This suggests certain cases are more complicated and require more information about their symptoms, lifestyle, family history of the disease, and so forth.

¹ https://www.kaggle.com/code/odins0n/nbme-detailed-eda





Figure 5: Length of feature annotations

Finally, we observe the length of each feature. Each feature describes very different matters including gender, daily routines, habits, family disease history, and medications are taken. The length of each feature ranges from a word to a couple of words. As a result, we can see that the vast majority of features have a length of 30 characters or less.

SIMILARITY MODEL

In this chapter, we will describe the simple similarity model, which uses the principle of K-nearest neighbors to determine if the given string is the feature or not.

On the high level, we divided the task into 3 parts:

- Designing a tokenizer for dividing patient notes into "simple sentences"
- Creating a unique set of features' annotations for each feature
- Comparing each "simple sentence" from the patient note with each unique feature's annotations and deciding if the simple sentence should be labeled with given feature

To implement the tokenizer we had first to understand the structure of the data. In Prepare Patient Notes module, we corrected some grammatical errors from patient notes and develop functionality for splitting patient notes into the list of "simple sentences", which will correspond to feature annotation. This part was particularly challenging since many patient notes were not having '.' at the end of the sentence. Some patient notes were using ';' ',' ' ', ' and' or '\n' instead of '.'. We mapped all of these to '.' and split text on that basis. In Prepare Training Data module we used these patient notes to append to train.csv data for the given training example.



Figure 6: Similarity model pipeline

In the next step, we created a similarity model which contains the most diverse parts of patient notes that describe each feature. The idea behind this was that by having enough diverse examples of a feature, we will be able to decide if a certain sentence should be classified as that feature or not. For this step we used NLP. similarity function from spacy library² to get a distance metric between two sentences. The output of this process was a dictionary with feature_ids as keys and a list of unique sentences as values.



Unique annotations per feature

Figure 7: Similarity model inference

In the Similarity Model Inference modules, we used unique feature annotations to decide if a given feature is present in patient notes or not. We did that by applying the similarity function between each unique feature annotations with each "simple sentence" and if the similarity is bigger than 0.9 we would associate the given feature with that "simple sentence" together with the similarity. We did this for each example of patient_note.csv and saved it for further use.

In Similarity Model Evaluation we compare features we associated with patient notes with features associated with patient notes from train.csv. By analyzing the predictions from the similarity model we noticed 2 problems with the current approach:

1. Similarity function doesn't work as expected:



Figure 8: High similarity for dissimilar sentences

² https://spacy.io/

[22... 0.6486529840885894

Figure 9: Low similarity for similar sentences

- 2. Problems with Text to "simple sentences" sequencer:
 - a. Tokenizer based on symbols is not able to separate "17-year-old male" into "17-year-old", " male"
 - b. Tokenizer would split "high pressure and temperature" into "high pressure", "temperature" and we would lose the adjective "high" for temperature

As a result, we turned to a different approach based on a BERT model.

BERT MODEL

In our later submissions, we used the BERT model to tokenize the sentences. BERT is a bidirectional transformer that takes context into account. BERT creates embeddings for each word in a sentence, this way words with similar meanings have close euclidean distance. As a result, we can tokenize all of the patient notes and find the location(s) in a particular note that has the meaning most closely related to a specific feature.



Figure 10: Tokenizer and Bert model applied to our problem

To familiarize ourselves with the Bert model and define a baseline we started from the <u>[NBME]BERT for beginners</u> model which had initial accuracy of 0.695. Once we figured out how Bert works, two ideas came to our mind about how we can improve it:

- 1. Train Bert in a semi-supervised fashion by masking words on unlabeled Patient notes dataset
- 2. Add Final layers on top of Bert to specialize it for our task

Train Bert in a semi-supervised fashion by masking words on unlabeled Patient notes dataset

BERT is pretrained on a large corpus of English data from Wikipedia and other resources not specific to medical data. This is why the model sometimes struggles to find similarities between sentences from medical vocabulary. To fix this we were trying to re-train Bert with all Patient notes data by using masking of the random word.



Figure 11: Tuning Bert to medical-specific text

We were following the <u>tutorial</u>, but once we realized that training such a large model as Bert will take more time and resources than we have, we decided to use a pretrained model from Kaggle.

Add Final layers on top of Bert to specialize it for our task

In our final step we used the leading pre-train model from <u>Roberta Strikes Back !</u> as our base model and expand it with an extra Head network. Roberta Strikes Back! contains both tokenizer model and "nbme-roberta-large" model with one extra linear layer at the end and sigmoid activation function. It works with a maximum of 310 tokens and has 1024 nodes in the last hidden layer. The accuracy of the model was 0.882.



Figure 12: Fine-tuning Bert model

We started with the fully connected neural network with 3, 5, and 7 hidden layers, having 20, 100, or 200 nodes per layer. Each hidden layer has a leaky_relu activation function and a dropout factor of 0.2 for regularization and robustness. For gradient descent, we used the Adam optimizer with weight decay, since it was proven better than the original Adam optimizer³. For the loss function, we used BCEWithLogitsLoss, since it combines logits and sigmoid function which is exactly what we need at the end of our network. We trained all networks on the Kaggle website with GPU turned on.



Figure 13: Head Network architectures

To find the optimal parameters we split training data(1000) into training and validation sets of proportions 0.8 and 0.2 respectively, and 7 train the model for a different number of hidden

³ https://towardsdatascience.com/why-adamw-matters-736223f31b5d

layers and nodes per layer. We were running 10 epochs and collecting the loss of validation loss. Each experiment took about 10 minutes. Here are the validation results for both networks. Here we can see that the validation score is best for the shallowest network which means that it was easier to tune fewer parameters. This network is capable of predicting accurately feature annotation for the test set (check here).

Besides this we noticed that the first network with 7 hidden layers and 20 nodes per layer predicts the whole patient note as a feature annotation, so performing the experiment on a higher number of neurons and the same data wouldn't improve the situation. For more information check the Experiments section.



Figure 14: Minimum validation loss for 2 architectures

The second network consists of blocks with averaging layers that are used to prevent vanishing gradient problems. Additionally, we use clip_grad_norm_ to prevent the gradient exploding problems. Here we can see a similar phenomenon as in the previous experiment, that validation loss increase when we increase the number of neurons in the layer when a number of layers are 3 for network 1 and 5 for network 2, but it declines for network 1 with 5 layers and network 2 with 7 layers. The reason for this could be that we were able to overfit the data for smaller networks, while deeper networks still need more training.

Full-scale training

For the final comparison, we trained on the full training(14300) dataset, the smallest Network1 with 3 hidden layers and 20 neurons per layer and the biggest Network 2 with 7 hidden layers and 200 nodes per layer. We preserved a 0.8-0.2 training validation split and run 10 epochs with Adam optimizer with weight decay and BCEWithLogitsLoss function. We run training on GPU for 4 hours for each experiment and saved weights of the model with the smallest validation loss.

From the results in Figure 15, we can see that this training was not enough to tune Network 2 and accuracy was lower.

7 submissions for comp540_dx4_df21		Sort by	Select 👻
All Successful Selected			
Submission and Description	Status	Public Score	Use for Final Score
Fork of Roberta Strikes Back ! Tuned Inference (version 6/6) 2 hours ago by Dejan Grubisic Notebook Fork of Roberta Strikes Back ! Tuned Inference Version 6 by Davyd Fridman	Succeeded	0.820	
Fork of Roberta Strikes Back ! Tuned Inference (version 5/6) 20 hours ago by Dejan Grubisic Notebook Fork of Roberta Strikes Back ! Tuned Inference Version 5 by Davyd Fridman	Succeeded	0.848	
Fork of Roberta Strikes Back ! Tuned Inference (version 2/6) 2 days ago by Dejan Grubisic Notebook Fork of Roberta Strikes Back ! Tuned Inference Version 2	Notebook Timeout	Error	
Fork of Roberta Strikes Back ! Tuned Inference (version 1/6) 2 days ago by Dejan Grubisic Notebook Fork of Roberta Strikes Back ! Tuned Inference Version 1	Succeeded	0.000	
Roberta Strikes Back ! Tuned (version 7/7) 2 days ago by Dejan Grubisic Notebook Roberta Strikes Back ! Tuned Version 7	Succeeded	0.000	
[NBME]BERT_for_beginners (version 5/5) 11 days ago by Dejan Grubisic Notebook [NBME]BERT_for_beginners Version 5	Succeeded	0.743	
[NBME]BERT_for_beginners (version 2/5) 11 days ago by Dejan Grubisic Notebook [NBME]BERT_for_beginners Version 2	Succeeded	0.757	

Figure 15: Results of running full-scale experiments for Network2(9_200)(top)-first and Network1(3_20) - second

NEXT STEPS

In the fullness of time our model could be improved by adding data augmentation and using an ensemble of models for prediction. Adding new examples of patient notes would benefit the

networks by providing new examples of medical abbreviations and jargon that could be used in the test set. On the other hand, using an ensemble of models would benefit us by providing multiple predictions and we would be able to specialize each of the networks to predict a subset of features. We would imagine that this will increase the accuracy by at least a few percent.

CONCLUSION

In this project we get familiar with natural language processing and the problem of feature selection in the text. This problem consists of 2 high-level tasks. Tokenize the text and predict if each token corresponds to the given feature.

In our first model, we wrote a simple tokenizer that parses text into tokens based on finding regular expressions like punctuation symbols, newline, and connection words like 'and'. This tokenizer wasn't able to distinguish consecutive words that describe different features which made it not usable for this problem. As a feature predictor, we used the K-nearest neighbor algorithm.

First, we saved the most unique annotation from the training set based on the similarity function for each feature. Then we compared each token with each unique annotation and if the similarity between the two was higher than 0.9 we would predict that the token is associated with the feature. Unfortunately, we found that the similarity function that we used from the spacy library sometimes gives a high value for uncorrelated sentences, while for similar sentences it gives small values.

Our second model was based on Bert and we tried to improve it by specializing it in medical vocabulary with masking and fine-tuning it with the extraneural network on top. Rather than tuning Bert for medical vocabulary ourselves, we used the leading pretrained model from the Kaggle competition. We extended the base model with 2 network architectures and compared their performance. The first network contains 3, 5, or 7 fully connected layers with 20, 100, or 200 neutrons. From experiments, we saw that a network with 3 layers doesn't benefit from adding extra neurons, while a network with 7 layers can't be trained well with just 1000 examples. Network2 consists of 7 or 9 hidden layers with shortcut connections. After running full-scale training for both networks we got that the accuracy of the smaller model was better. The accuracy of our best model is 0.848.

EXPERIMENTS

https://docs.google.com/spreadsheets/d/118YOmmX7FIVNIGXdiGmKu5mbhVVrAgjh3PyX Y1rlc0g/edit?usp=sharing

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		Linear,				
		LeakyRelu,				
3	20	Dropout(0.2)	10	800	200	3.34777709912

Experiment with Network 1



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out [Lightheaded] (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.

PMHx: none

Rx: uses friends adderrall

FHx: mom with "thyroid disease Family history of thyroid disorder ," dad with recent heart attcak Family history of MI; Family history of myocardial infarction

All: none

Immunizations: up to date

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		Linear,				
		LeakyRelu,				
3	100	Dropout(0.2)	10	800	200	3.36345709441



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out Lightheaded (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits. PMHx: none Rx: uses friends adderrall

FHx: mom with "thyroid disease," Family history of thyroid disorder dad with recent heart attcak Family history of MI; Family history of myocardial infarction

All: none

Immunizations: up to date

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		Linear,				
		LeakyRelu,				
3	200	Dropout(0.2)	10	800	200	3.37860203962



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out Lightheaded (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.
PMHx: none
Rx: uses friends adderrall
FHx: mom with "thyroid disease Family history of thyroid disorder ," dad with recent heart attcak Family history of MI; Family history of myocardial infarction
All: none

Immunizations: up to date

SHx: Freshmen in college. Endorses 3-4 drinks 3 nights / week (on weekends), denies tabacco, endorses trying marijuana. Sexually active with girlfriend x 1 year, uses condoms

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		Linear, LeakyRelu,				
5	20	Dropout(0.2)	10	800	200	3.45816279502



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HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out Lightheaded (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.
PMHx: none

Rx: uses friends adderrall

FHx: mom with "thyroid disease Family history of thyroid disorder ," dad with recent heart attcak Family history of MI; Family history of myocardial infarction

All: none

Immunizations: up to date

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		Linear, LeakyRelu,				
5	100	Dropout(0.2)	10	800	200	3.44462877224



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out Lightheaded (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.
PMHx: none
Rx: uses friends adderrall
FHx: mom with "thyroid disease Family history of thyroid disorder ," dad with recent heart attcak Family history of MI; Family history of myocardial infarction

All: none

Immunizations: up to date

SHx: Freshmen in college. Endorses 3-4 drinks 3 nights / week (on weekends), denies tabacco, endorses trying marijuana. Sexually active with girlfriend x 1 year, uses condoms

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		Linear,				
		LeakyRelu,				
5	200	Dropout(0.2)	10	800	200	3.44563263090



18

HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.

PMHx: none

Rx: uses friends adderrall

FHx: mom with "thyroid disease Family history of thyroid disorder ," dad with recent heart attcak Family history of MI; Family history of myocardial infarction

All: none

Immunizations: up to date

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		Linear,				
		LeakyRelu,				
7	20	Dropout(0.2)	10	800	200	3.47401548225



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes of "heart beating/pounding out of my chest." 2 days ago during
a soccer game had an episode, but this time had chest pressure and felt as if he were going to pass out (did not lose conciousness). Of note patient
endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies
shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary
habits. Family history of MI; Family history of myocardial infarction HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes
of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure and felt as if he were going
to pass out (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took
adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in
vision/hearing, abdominal paun, changes in bowel or urinary habits. Family history of thyroid disorder HPI: 17yo M presents with palpitations. Patient
reports 3-4 months of intermittent episodes of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had
chest pressure and felt as if he were going to pass out (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times
per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache,
fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits. Chest pressure HPI: 17yo M presents with
palpitations. Patient reports 3-4 months of intermittent episodes of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an
episode, but this time had chest pressure and felt as if he were going to pass out (did not lose conciousness). Of note patient endorses abusing adderall,

	# Neurons per	Kind of		Train examples	Val examples	Best validation
# Layers	layer	Layers	# epochs	num	num	loss
		Linear,				
		LeakyRelu,				
7	100	Dropout(0.2)	10	800	200	

It wouldn't make sense to increase the number of hidden layers

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		Linear,				
		LeakyRelu,				
7	200	Dropout(0.2)	10	800	200	

It wouldn't make sense to increase the number of hidden layers

Experiment with Network 2

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		AVG2(Linear, LeakyRelu, Dropout(0.2))				
5	20	+ Linear	10	800	200	1.47786917250



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out Lightheaded (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.

Rx: uses friends adderrall

FHx: mom with "thyroid disease," Family history of thyroid disorder dad with recent heart attcak Family history of MI; Family history of myocardial infarction

All: none

Immunizations: up to date

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		AVG2(Linear, LeakyRelu, Dropout(0.2))				
5	100	+ Linear	10	800	200	1.54799610854



HPI: 1	7yo M presents v	with palpitation	ons. Patient re	ports 3-4 mon	iths of	intermitten	t episodes Inte	ermittent	symptoms of	"heart beating/p	oundir	ng out of my
chest.'	" 2 days ago duri	ng a soccer	game had an	episode Inte	ermitten	t symptoms	, but this time	had cł	hest pressure	Chest pressure	and	felt as if he
were g	joing to pass out	Lightheaded	(did not lose	e conciousnes	ss). Of i	note patient	endorses abus	sing adde	erall, primarily	r to study (1-3 tim	ies pe	r week). Before
recent	soccer game, to	ok adderrall	night before a	nd morning of	game.	Denies sho	rtness of breat	h, diapho	oresis, fevers,	, chills, headache	e, fatig	ue, changes in
sleep,	changes in visio	n/hearing, al	odominal paun	, changes in b	oowel o	or urinary ha	oits.					
PMHx:	: none											
Rx: us	es friends adder	rall										
FHx:	mom with "thyro	oid disease	Family history o	f thyroid disorde	ər,"	dad with re	cent heart attca	ak Fami	ly history of MI;	Family history of m	yocard	lial infarction

All: none

Immunizations: up to date

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		AVG2(Linear, LeakyRelu, Dropout(0.2))				
5	200	+ Linear	10	800	200	1.79906619018



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out Lightheaded (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.

PMHx: none

Rx: uses friends adderrall

FHx: mom with "thyroid disease," Family history of thyroid disorder dad with recent heart attcak Family history of MI; Family history of myocardial infarction

All: none

Immunizations: up to date

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
7	20	AVG2(Linear, LeakyRelu, Dropout(0.2)) + Linear	10	800	200	3.38034975527



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.

PMHx: none

Rx: uses friends adderrall

FHx: mom with "thyroid disease Family history of thyroid disorder ," dad with recent heart attcak Family history of MI; Family history of myocardial infarction All: none

Immunizations: up to date

# Layers	# Neurons per layer	Kind of Layers	# epochs	Train examples num	Val examples num	Best validation loss
		AVG2(Linear, LeakyRelu, Dropout(0.2))				
7	100	+ Linear	10	800	200	3.27411811745



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out Lightheaded (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.

PMHx: none

Rx: uses friends adderrall

FHx: mom with "thyroid disease," Family history of thyroid disorder dad with recent heart attcak

All: none

Immunizations: up to date

SHx: Freshmen in college. Endorses 3-4 drinks 3 nights / week (on weekends), denies tabacco, endorses trying marijuana. Sexually active with girlfriend x 1

year, uses condoms

	# Neurons per	Kind of		Train examples	Val examples	Best validation
# Layers	layer	Layers	# epochs	num	num	loss
		AVG2(Linear,				
		LeakyRelu,				
7	200	Dropout(0.2))	10	800	200	3.01321725651



HPI: 17yo M presents with palpitations. Patient reports 3-4 months of intermittent episodes Intermittent symptoms of "heart beating/pounding out of my chest." 2 days ago during a soccer game had an episode, but this time had chest pressure Chest pressure and felt as if he were going to pass out (did not lose conciousness). Of note patient endorses abusing adderall, primarily to study (1-3 times per week). Before recent soccer game, took adderrall night before and morning of game. Denies shortness of breath, diaphoresis, fevers, chills, headache, fatigue, changes in sleep, changes in vision/hearing, abdominal paun, changes in bowel or urinary habits.

PMHx: none

Rx: uses friends adderrall

FHx: mom with "thyroid disease Family history of thyroid disorder ," dad with recent heart atto Family history of MI; Family history of myocardial infarction ak

All: none

Immunizations: up to date

SHx: Freshmen in college. Endorses 3-4 drinks 3 nights / week (on weekends), denies tabacco, endorses trying marijuana. Sexually active with girlfriend x 1 year, uses condoms

	# Neurons per	Kind of	#		Train examples	Val examples	Best
# Layers	layer	Layers	epochs	Runtime	num	num	validation loss
		Linear,					0.138415390
3	5	Dropout(0.2)	3	72m 50s	11440	2860	74

Full-scale Experiments with Network 1 and Network 2



					Train	Val	
	# Neurons	Kind of			examples	examples	Best
# Layers	per layer	Layers	# epochs	Runtime	num	num	validation loss
		AVG2(Linear,					
		LeakyRelu,					
		Dropout(0.2))					
7	200	+ Linear	10	240m 38s	11440	2860	2.928469074



	id	location
0	00016_000	696 724
1	00016_001	668 695
2	00016_002	203 217
3	00016_003	70 91
4	00016_004	222 258