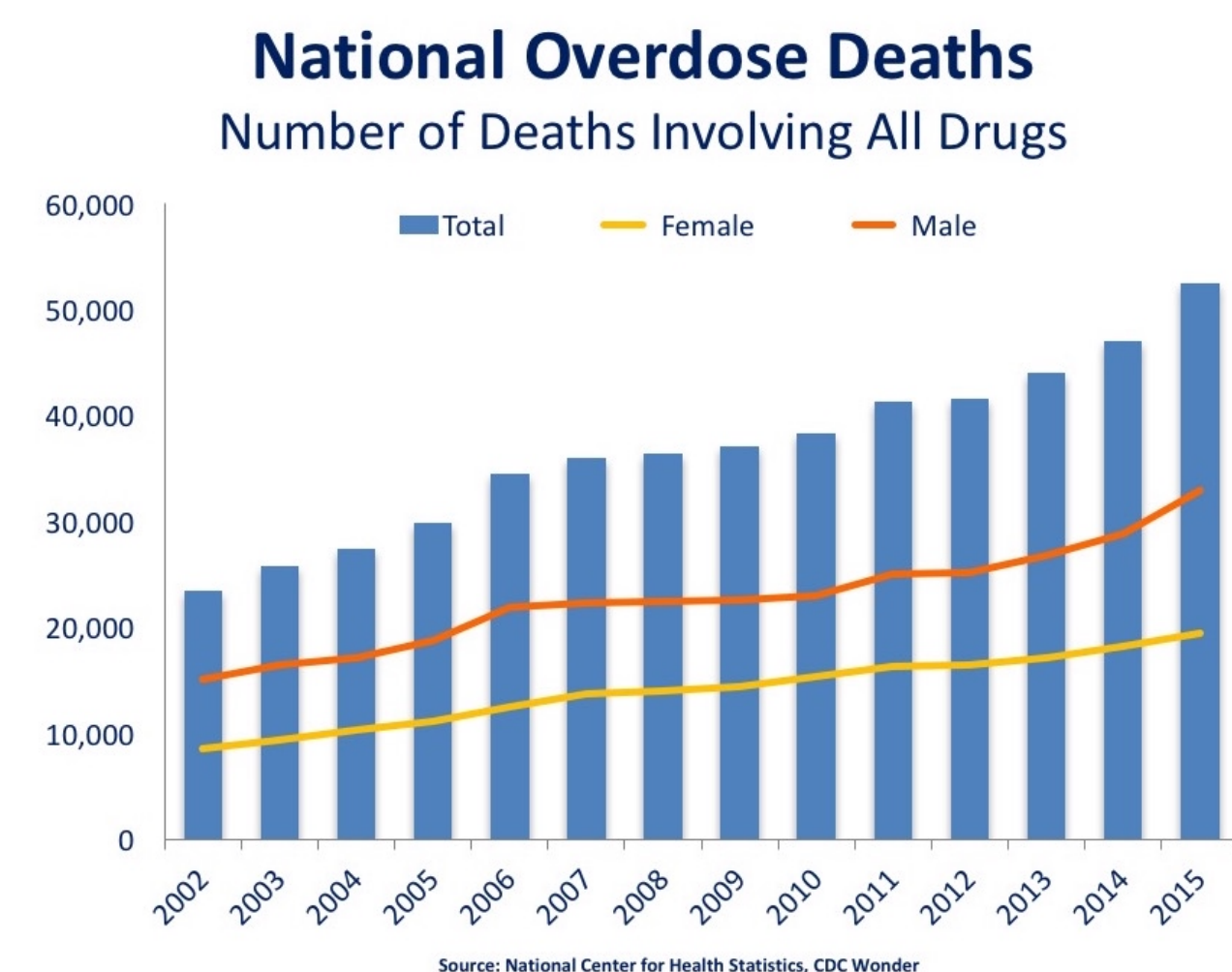# Detecting Suicide Risk Among Opioid Users on Reddit Using Deep Learning

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Background[1]

National Overdose Deaths
Number of Deaths Involving All Drugs
Source: National Center for Health Statistics, CDC Wonder

In 2016, the Centers for Disease Control and Prevention reported 42,000 opioid overdose deaths, including intentional (suicide) and unintentional (accidental).

- Opioid use disorder (OUD) is predictive of overdose.

- OUD individuals are likely to engage in reckless and suicidal-like behaviors without conscious intent. Such is difficult to detect because social stigma may push these opioid users away from in-person communication.

- **Reddit** is a forum based social media for discussion of many topics, each topic with its own sub-forum (subreddit), including r/opiates. Choudhury[2] has shown Reddit can provide quality data for insight into stigmatic illnesses.

Motivation

Convolutional Neural Networks (CNN) have shown to achieve excellent results in natural language processing (NLP). Unlike traditional methods, "learning text from scratch" requires no knowledge of syntax or semantics; high level targets can be input[8].

- Yoon Kim[3] demonstrated the ability of a simple CNN with one layer of convolution in sentence classification for multiple datasets, laying groundwork CNN for NLP by achieving state-of-art results.
- Singh et al.[4] compared models for predicting depression on Twitter, and achieved an accuracy of 97% with word based CNN.

Studies have also shown there exists significant difference in writing style between suicidal and non-suicidal individuals[5]. Given Reddit data is unstructured and informal, and we hope to capture the psyche of users through their language.

Input Output

Convolutional layer | Subsampling layer | Convolutional layer | Subsampling layer | Fully connected

Filter | Activation value

Input volume (with highlighted focus input) | Convolutional layer (with highlighted neuron depth column) | Output activation volume
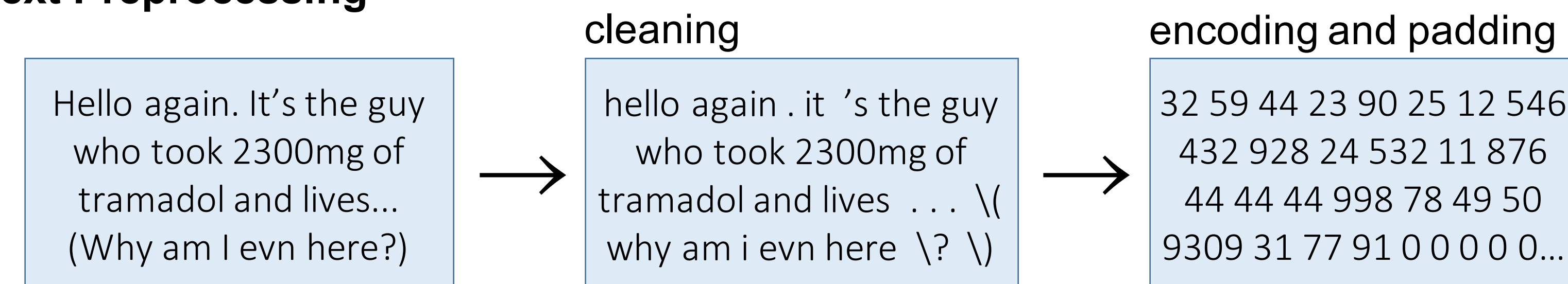
Objectives

- Construct a CNN to learn the language of suicidality.
- Use the CNN model for predicting suicidality of opioid users.
- Understand aspects around suicidality caused by OUD.

Methods

- **Data Collection** was done using pushshift.io and Reddit's PRAW API.

- **model_1**: learn linguistic features of suicide and predict for suicidality among opioid users from balanced dataset n=50,000 posts and vocabulary n=56,54. Posts are from r/suicidewatch (label 0) and control subreddits[6] (label 1). M1 **predicted** for 39,000 posts in opioid relevant subreddits. Outputs with score < 0.005 are kept.

- **model_2**: learn the language of opioid users and predict opioid usage among suicidal individuals from a balanced dataset n=60,000 posts and vocabulary n=59,106. Posts are from opioid related subreddits (label 0) and r/depression (label 1). M2 **predicted** for 25,820 posts in r/suicidewatch. Outputs < 0.05 are kept.
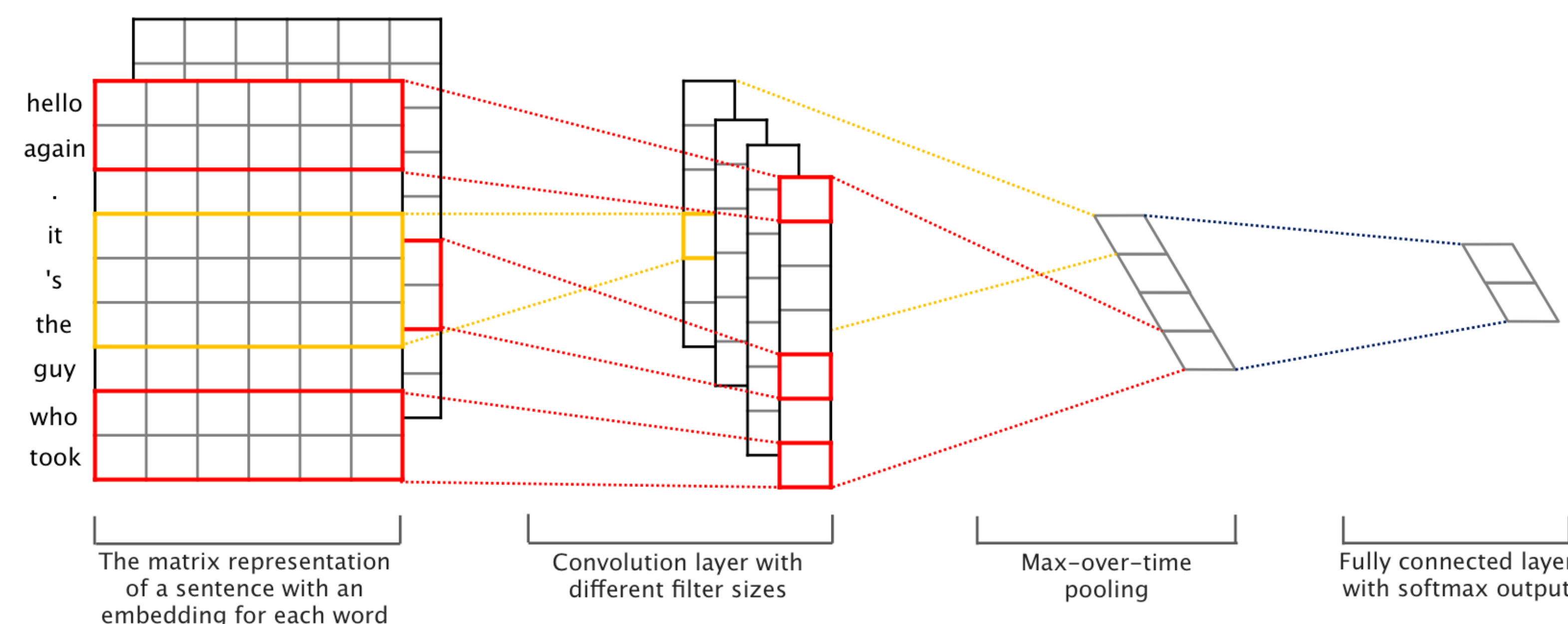
Text Preprocessing

cleaning

Hello again. It's the guy who took 2300mg of tramadol and lives... (Why am I evn here?)

→

hello again . it 's the guy who took 2300mg of tramadol and lives . . . \(why am i evn here \? \)

→

encoding and padding

32 59 44 23 90 25 12 546 432 928 24 532 11 876 44 44 44 998 78 49 50 9309 31 77 91 0 0 0 0 0...

For each post, the title was appended to the beginning of the body, and is padded or truncated to a character count of 1500, since the average length of a r/suicidewatch post is 1003 characters.

- The balanced dataset was split 8:2 for training and evaluation.
- The training data was split 7:3 for training and validation.

The Convolutional Neural Network[7]

The matrix representation of a sentence with an embedding for each word | Convolution layer with different filter sizes | Max-over-time pooling | Fully connected layer with softmax output

We use a batch size=50, epochs n=3, and an embedding layer with random weights with a dropout=0.5 and dimension=100. Filter sizes of (3,8) are used to slide over 3, 8 words at a time respectively. For each filter size, we calculate the outputs of the convolution layer and apply ReLU nonlinearity and max-pooling. Pooled features from each filter size are combined to form the feature vector on the final layer with a dropout=0.8. We calculate loss using cross entropy. Outputs (<0.05) are manually filtered for selecting a pseudo significance level.

Models are slightly over-fit to account for posts that are suitable for multiple subreddits, and for language subtleties between suicidal, depression, and opiate withdrawal.

Results

The model was evaluated on 10,000 posts for M1 and on 14,400 posts for M2. Measurements are shown below, respectively:

model 1	Label	Acc	P	R	F1
	0	0.94	0.91	0.96	0.94
	1	0.94	0.96	0.92	0.94

model 2	Label	Acc	P	R	F1
	0	0.96	0.95	0.97	0.96
	1	0.96	0.97	0.94	0.96

The accuracy and loss graphs are shown below for M1:

Suicidality Among Opioid Users

- M1 obtained 0.407% of 39,000. M2 obtained 0.89% of 25,820.

Those prone to suicidality are generally:

- Worn from the cycle of sobriety and relapse
- Unable to find pleasure in life outside of drug use
- See no hope or possibility in the situation getting better
- Have no social support or understanding in real life

Below are correctly classified examples (decoded, truncated):

- why not \? i 've dealt with depression for years now . had my dreams for life crushed in college . turned to heroin . and honestly the trials of addiction were a welcome distraction from the crushing depression . i 've given up finding any meaning or purpose in life , and that life just feels like a long series of inconveniences . it 's hard not to turn back to heroin . heroin is the ultimate distraction . and it makes it feel like nothing matters . i 've already tried to kill myself once by overdose . (from r/suicidewatch)

- suicidal thoughts but not gonna act on them . been sober for a while now but i still never feel happy , i cant see anything making me feel happy besides the artificial happiness that dope gives me . picking up a bunch of dope and overdosing on purpose sounds tempting sometimes . . . sorry just feel like shit . (r/opiates)

Example of a low output score with no observable user suicidality:

- i'm fucking seriously struggling so much right now . i woke up the day before my birthday to the worst fucking news i could possibly get . my best friend overdosed and died . christ she was practically my sister and she 's fucking gone . her wake is friday and it 's open casket . i 've been doing my best to keep it together for her mom , but i do n't want to go . (r/opiates)

Conclusion

The CNN architecture is largely capable of distinguishing suicidal from non-suicidal language, performing relatively well for the subreddits the model was trained on. However, it struggles when predicting for posts in a subreddit it has not yet seen. Some posts that are suitable for multiple subreddits may inhibit model performance. Future work can use more distinctive inputs for given labels and tune hyperparameters.

References

[1] Oquendo et al. *Suicide: A Silent Contributor to Opioid Overdose Deaths* [2] Choudhury et al. *Mental Health Detection on Reddit* [3] Yoon Kim. *CNN for Sentence Classification* [4] Singh et al. *Detecting Depression on Twitter* [5] Barak et al. *Writing Characteristics of Suicidal People* [6] Shen et al. *Detecting Anxiety on Reddit* [7] github.com/alexander-rakhlin/CNN-for-Sentence-Classification-in-Keras [8] Zhang et al. *Text Understanding From Scratch*