

Applications of text mining and NLP

Javier Garcia-Bernardo

Summary

Text -> Numeric:

- TF; TF-IDF; Word embeddings

Similarity (often cosine similarity)

Clustering

- TF-IDF + Dimensionality reduction (e.g. TruncatedSVD) + Clustering (e.g. K-Means)
- Word embeddings + Clustering (e.g. K-Means)
- Document-Term Matrix (CountVectorizer) + LDA

Classification

- TF-IDF (+ Dimensionality reduction) + Classifier (e.g. LogisticRegression)
- Word embeddings + Classifier (e.g. LogisticRegression)
- Neural Networks (Feed-forward, RNN, LSTM, CNN, Transformers)

Tomorrow: **Sentiment analysis**

A collection of text mining applications

Similarity

- Find authors of an anonymous book
- Analyze experiments on information diffusion
- Find duplicates and link records

Clustering

- Targeted advertisement or learning or helper
- Recommendation systems (e.g. similar books)
- Clustering stories (clustering fiction works, people's diagnoses, misinformation)
- Track evolution of topics in discourse
- Anomaly detection

Classification/Regression

- Targeted advertisement
- Hate speech classification (similar: spam, fake news, emergencies)
- Tracking emotions (some emotions are highly correlated with YouGov surveys)
- Predict student performance, probability of re-hospitalization, fraud (insurance or research)
- Classifying reports (e.g. hospital discharges, urgent issues)
- Predict stock market returns

Applications in Social Media (Hate Speech in Twitter)

Hateful Symbols or Hateful People? Predictive Features for Hate Speech Detection on Twitter

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Dirk Hovy
University of Copenhagen
Copenhagen, Denmark
dirk.hovy@hum.ku.dk

Chapter 3 Bridging the Gaps: Multi Task Learning for Domain Transfer of Hate Speech Detection

Zeerak Waseem, James Thorne and Joachim Bingel

Using Convolutional Neural Networks to Classify Hate-Speech

Björn Gambäck and **Utpal Kumar Sikdar**
Department of Computer Science
Norwegian University of Science and Technology
NO-7491 Trondheim, Norway
gamback@ntnu.no utpal.sikdar@gmail.com

A BERT-Based Transfer Learning Approach for Hate Speech Detection in Online Social Media

Marzieh Mozafari^(✉), Reza Farahbakhsh, and Noël Crespi

Waseem and Hovy, 2016

Data: Annotation of 16k tweets based on Gender studies and CRT

Method: TD-IDF using character {uni, bi, tri}-grams.

Why did they use characters instead of words?

Preprocessing: Removing stop words (except “not”), usernames and punctuation

Classifier: Logistic Regression

Results:

System setup	Precision	Recall	F ₁ -score
Logistic Regression with character n-grams	0.7287	0.7775	0.7389

A tweet is offensive if it

1. uses a sexist or racial slur.
2. attacks a minority.
3. seeks to silence a minority.
4. criticizes a minority (without a well founded argument).
5. promotes, but does not directly use, hate speech or violent crime.
6. criticizes a minority and uses a straw man argument.
7. blatantly misrepresents truth or seeks to distort views on a minority with unfounded claims.
8. shows support of problematic hash tags. E.g. “#BanIslam”, “#whoriental”, “#whitegenocide”
9. negatively stereotypes a minority.
10. defends xenophobia or sexism.
11. contains a screen name that is offensive, as per the previous criteria, the tweet is ambiguous (at best), and the tweet is on a topic that satisfies any of the above criteria.

Gamback and Sikdar, 2017

Data: Waseem&Hovy (2016)

Method: CNN using word embeddings and character n-grams

Preprocessing: None

Classifier: Softmax

Results:

System setup		Precision	Recall	F ₁ -score
CNN	Random vectors	0.8668	0.6726	0.7563
	word2vec	0.8566	0.7214	0.7829
	Character n-grams	0.8557	0.7011	0.7695
	word2vec + character n-grams	0.8661	0.7042	0.7738
Logistic Regression with character n-grams (Waseem and Hovy, 2016)		0.7287	0.7775	0.7389

Table 2: System performance (10-fold cross-validated)

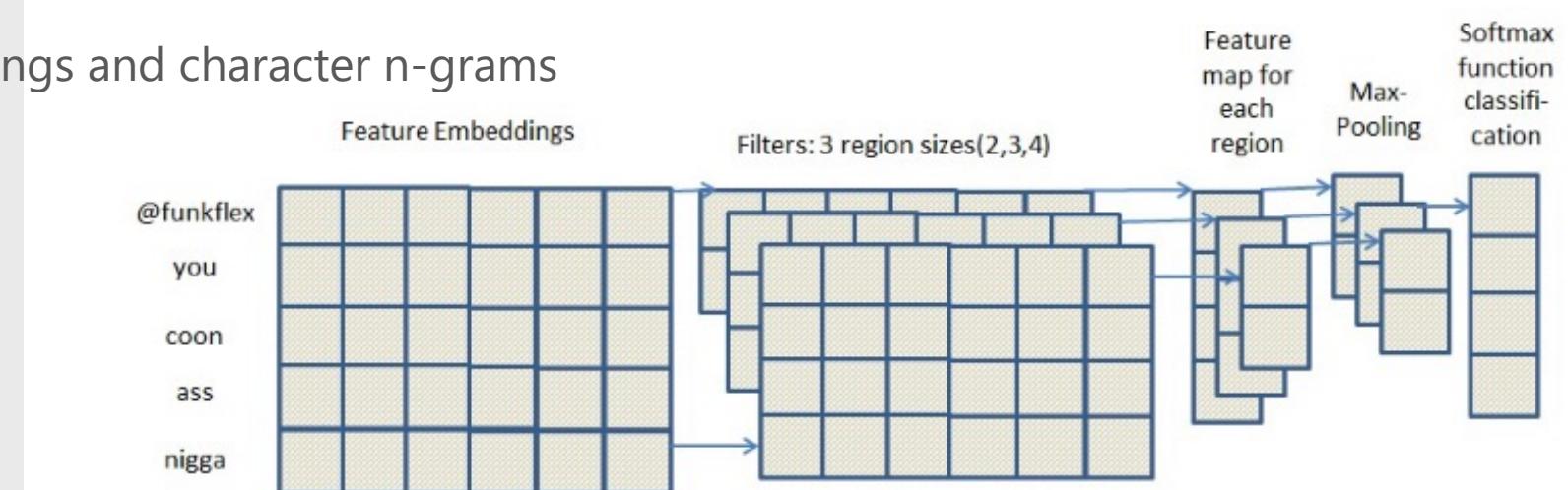


Figure 1: Hate-speech classifier

Waseem, Thorne and Bingel (2018)

Data: Waseem & Hovy (2016), 25k annotated tweets (Davidson et al, 2017; Twitter user guidelines)

Best method: Multi-task training. BoW words (5000), bigrams (5000) and character bi/tri-gram (5000)
Feed-forward neural network with 2 hidden layers. Softmax output

Preprocessing: Removing usernames, links and punctuation

Classifier: Softmax

Regularization: Dropout (20%)

Results:

Method	Datasets	Precision(%)	Recall(%)	F1-Score(%)
Waseem and Hovy [22]	Waseem	72.87	77.75	73.89
Davidson et al. [3]	Davidson	91	90	90
Waseem et al. [23]	Waseem	-	-	80
	Davidson	-	-	89

Mozafari, Farahbakhsh and Crespi (2019)

Data: Waseem & Hovy (2016), 25k annotated tweets (Davidson et al, 2017; Twitter user guidelines)

Best method: BERT + CNN

Each layer of the transformer gives an output → CNN

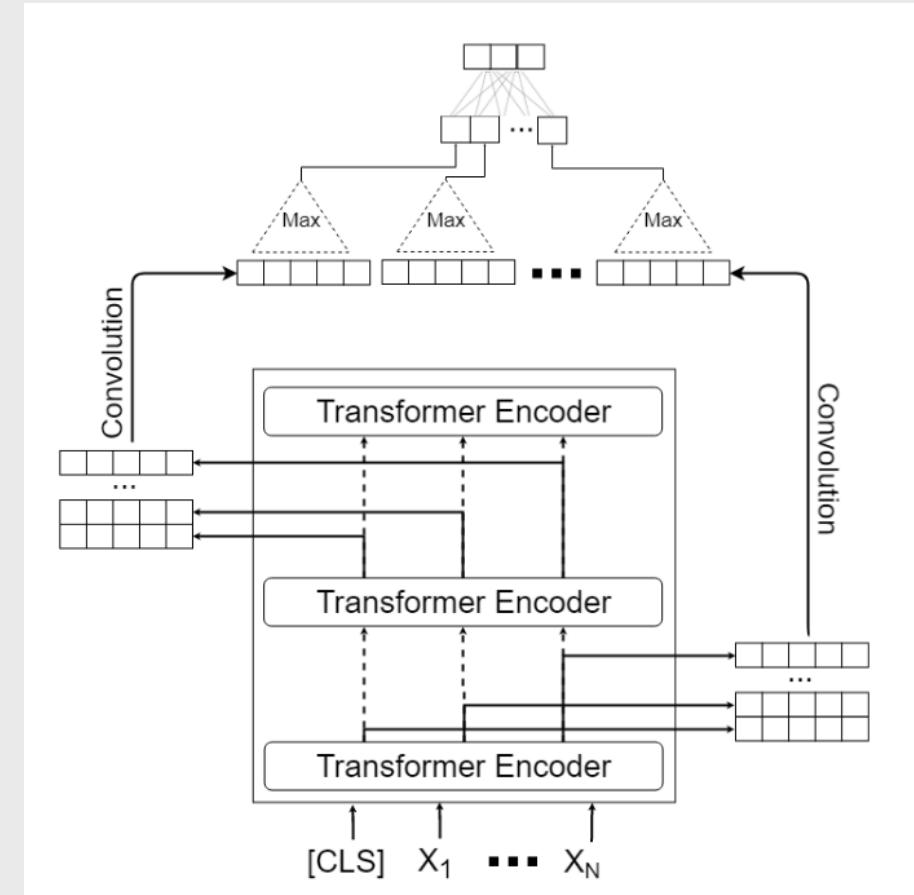
Preprocessing: Replacing usernames, elongated words, hashtags; remove punctuation

Classifier: Softmax

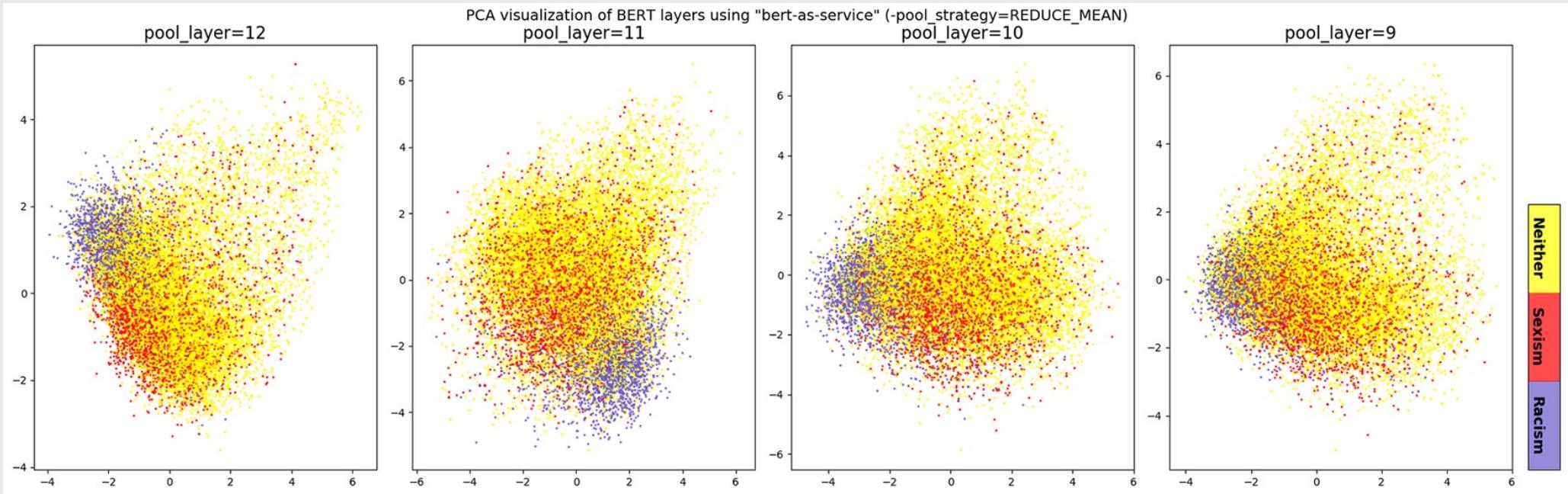
Regularization: Dropout (10%)

Results:

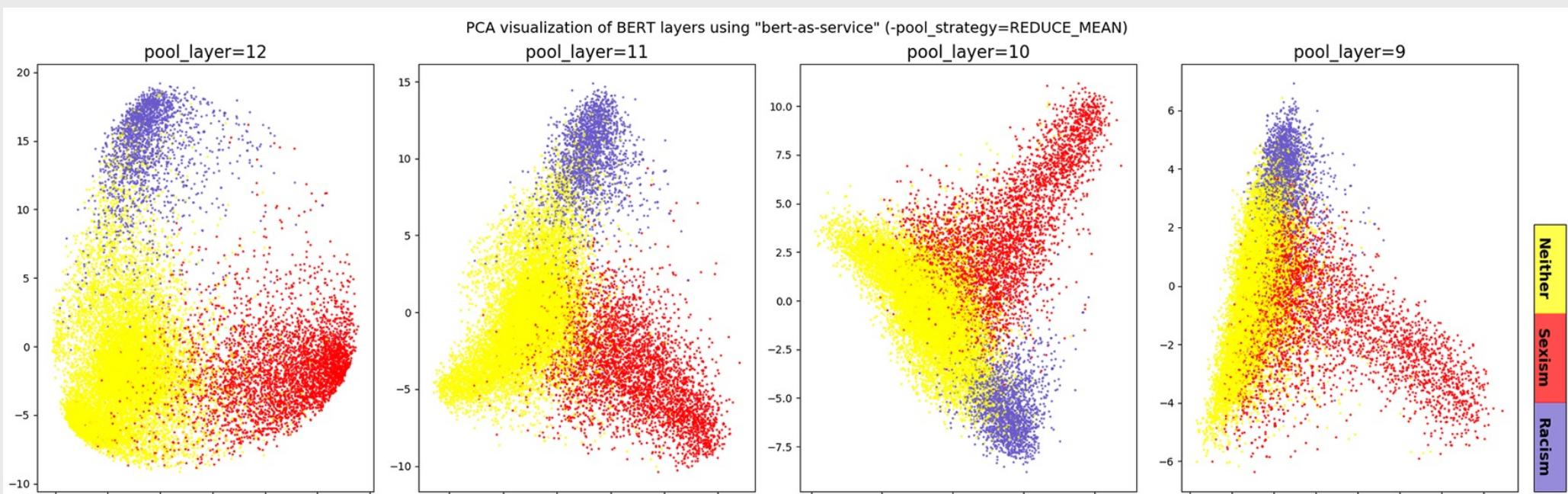
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Waseem et al. [23]	Waseem	-	-	80
	Davidson	-	-	89
BERT _{base}	Waseem	81	81	81
	Davidson	91	91	91
BERT _{base} + Nonlinear Layers	Waseem	73	85	76
	Davidson	76	78	77
BERT _{base} + LSTM	Waseem	87	86	86
	Davidson	91	92	92
BERT _{base} + CNN	Waseem	89	87	88
	Davidson	92	92	92



Base
BERT



Fine-tuned
BERT



Application of Text Clustering in Media

RESEARCH ARTICLE

Framing COVID-19: How we conceptualize and discuss the pandemic on Twitter

Philipp Wicke^{1*}, Marianna M. Bolognesi^{1,2}

Media Framing Dynamics of the ‘European Refugee Crisis’: A Comparative Topic Modelling Approach

Tobias Heidenreich , Fabienne Lind, Jakob-Moritz Eberl, Hajo G Boomgaarden

Journal of Refugee Studies, Volume 32, Issue Special_Issue_1, December 2019, Pages i172–i182, <https://doi.org/10.1093/jrs/fez025>

Published: 27 December 2019 **Article history ▾**

COVID pandemic (Wicke & Bolognesi 2020)

Question: What is the framing of the COVID pandemic?

Framing of WAR (fight, combat, battle), STORM (wave, storm, cloud), MONSTER (evil, horror, killer) or TSUNAMI (wave, tragedy, catastrophe).

Data: Twitter around #Covid-19 (80 hashtags)

Method: LDA (4 and 16 topics) + correlation of topics with frames

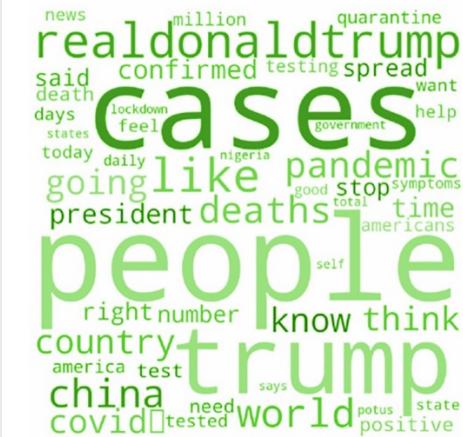
Preprocessing: Remove stop words, remove covid, remove tokens with less than 3 characters

Validity assessed: Qualitatively + external sample.

Results:



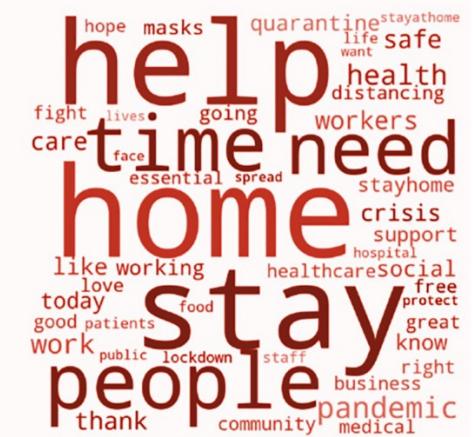
Topic #I: Communications and Reporting



Topic #III: Politics



Topic #II: Community and Social Compassion



Topic #IV: Reacting to the epidemic

Refugees crisis (Heidenreich, Lind, Eberl & Boomgaarden, 2019)

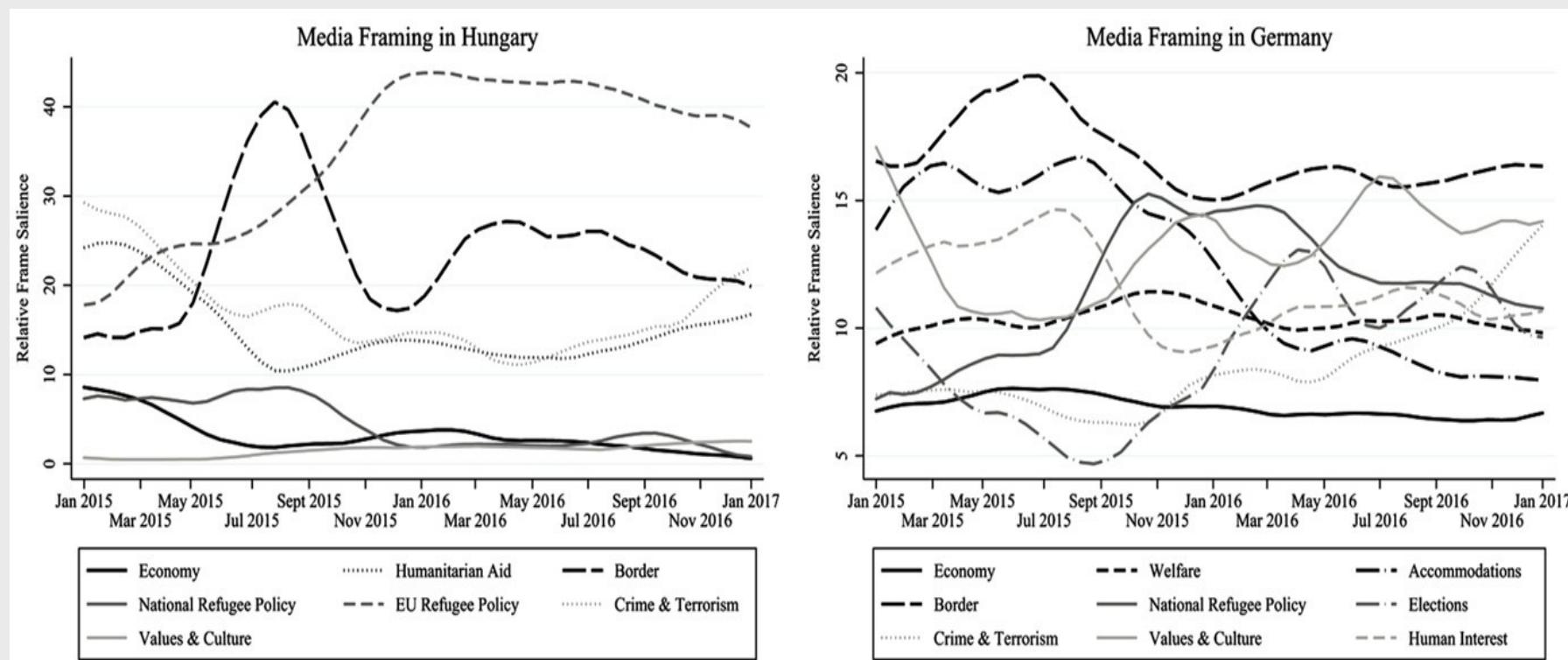
Data: 130k articles from 24 news outlets

Method: LDA (10 topics per country) + manual labeling.

Preprocessing: Unclear

Validation: Semantic validity (are the topics distinctive) + Randomly reading three articles per topic/country + predictive validity (are important events such as elections reflected)

Results:



Similarity between texts

- Find authors of an anonymous book
- Analyze experiments on information diffusion
- Find duplicates

How to measure similarity between sentences?

Option 1: Cosine similarity TF-IDF representations

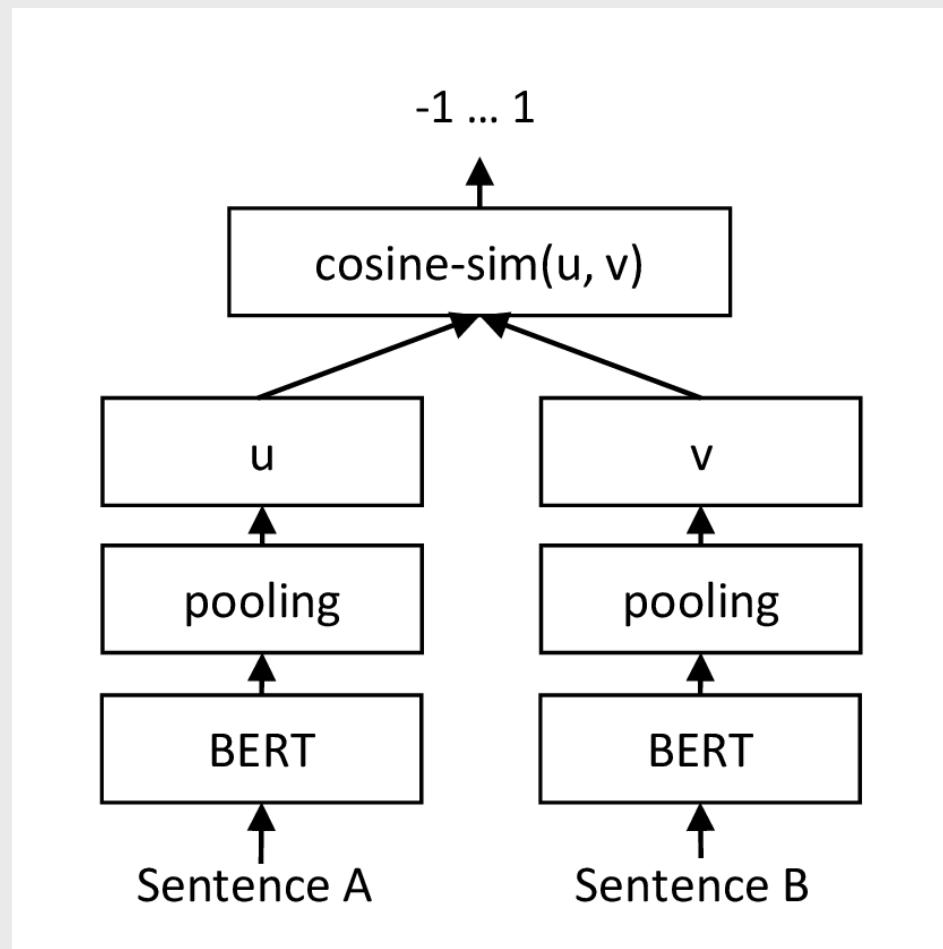
Option 2: Average word embeddings, cosine similarity. Works only for small sentences.

Option 3: Train BERT, pass two sentences (but creates one embedding for the combination)

Option 4: Siamese BERT-Networks: Pre-trained only on books + Wikipedia (via BERT) and on NLI data (sentence pairs)

Sentence-BERT: Sentence Embeddings using Siamese BERT-Networks

Nils Reimers and Iryna Gurevych
Ubiquitous Knowledge Processing Lab (UKP-TUDA)
Department of Computer Science, Technische Universität Darmstadt
www.ukp.tu-darmstadt.de



Sentence similarity

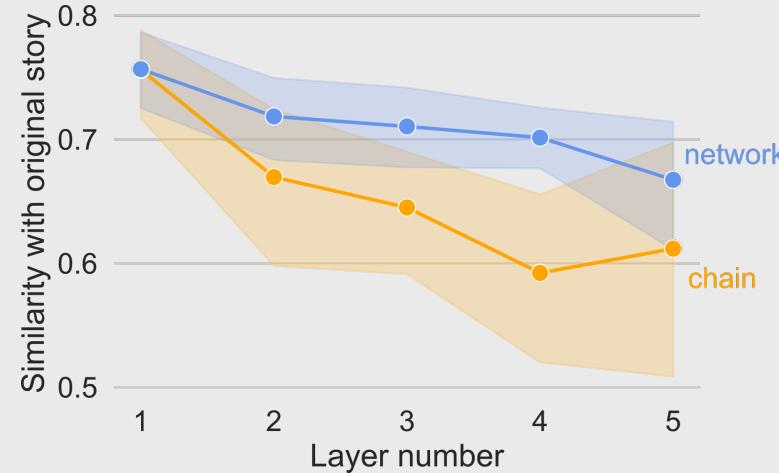
Model	STS12	STS13	STS14	STS15	STS16	STSb	SICK-R	Avg.
Avg. GloVe embeddings	55.14	70.66	59.73	68.25	63.66	58.02	53.76	61.32
Avg. BERT embeddings	38.78	57.98	57.98	63.15	61.06	46.35	58.40	54.81
BERT CLS-vector	20.16	30.01	20.09	36.88	38.08	16.50	42.63	29.19
InferSent - Glove	52.86	66.75	62.15	72.77	66.87	68.03	65.65	65.01
Universal Sentence Encoder	64.49	67.80	64.61	76.83	73.18	74.92	76.69	71.22
SBERT-NLI-base	70.97	76.53	73.19	79.09	74.30	77.03	72.91	74.89
SBERT-NLI-large	72.27	78.46	74.90	80.99	76.25	79.23	73.75	76.55
SRoBERTa-NLI-base	71.54	72.49	70.80	78.74	73.69	77.77	74.46	74.21
SRoBERTa-NLI-large	74.53	77.00	73.18	81.85	76.82	79.10	74.29	76.68

Application: Analyzing experiment data

Aloric, Garcia-Bernardo, Krafft, Hardy, Morgan, Neu, Santoro (202x)

Question: Understand effect of network structure on information diffusal

Hypothesis 1: Network helps preserve more information



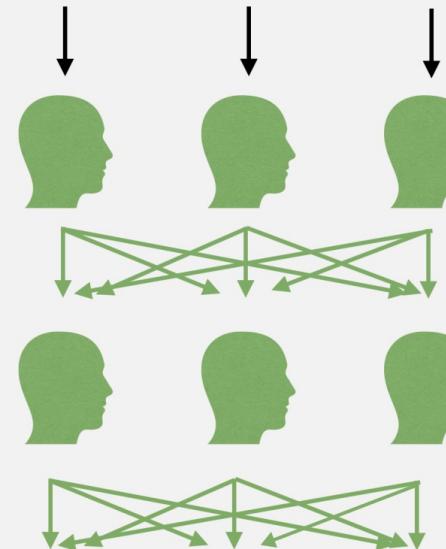
Hypothesis 2: Network structure helps preserve "the essence" of the story

If true: Independent replicates should be more correlated

Data/experimental design:

(A) Network condition

Original text

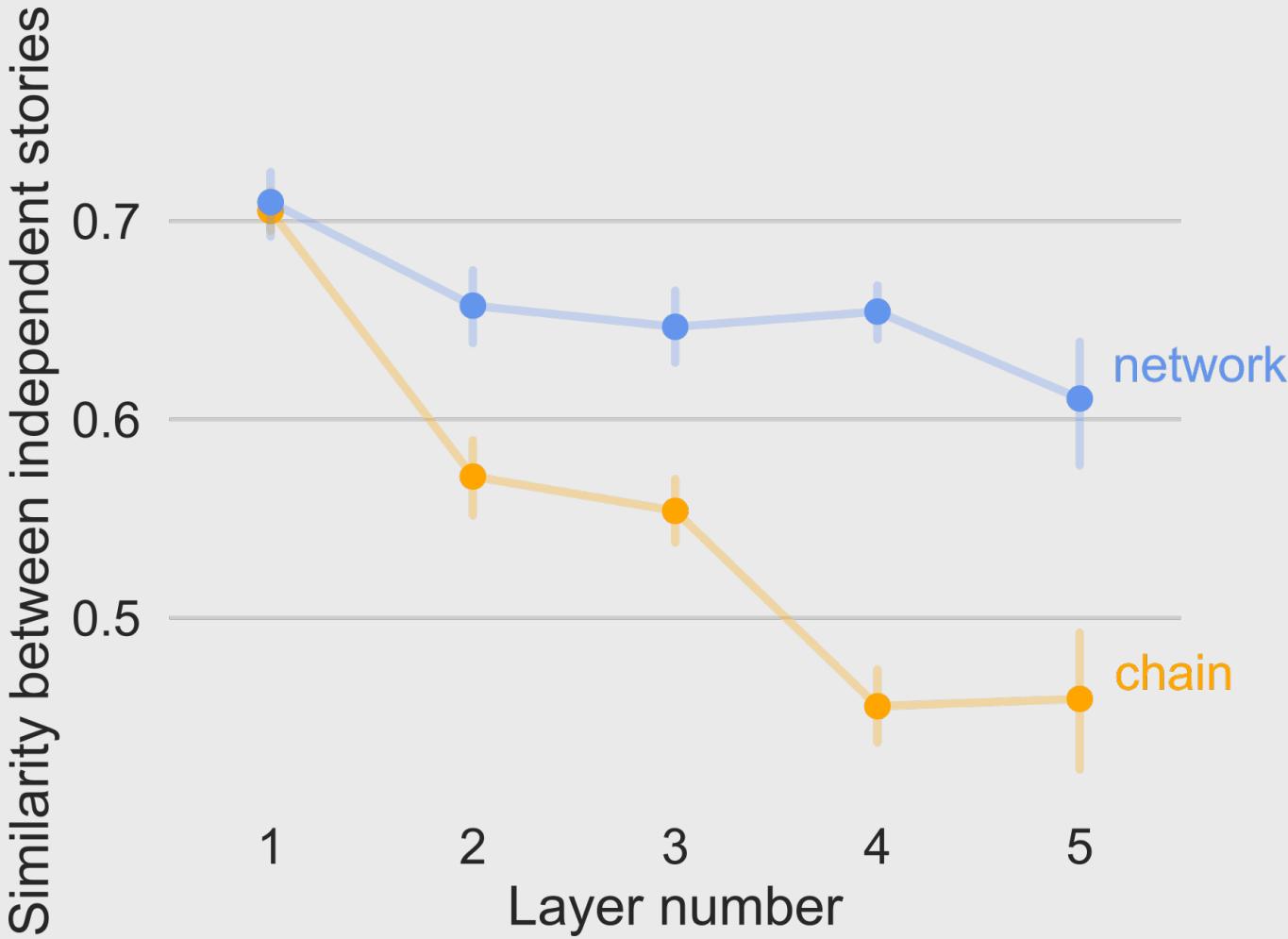


(B) Chain condition

Original text



Between-replicates similarity



Applications in Humanities

The emotional arcs of stories are dominated by six basic shapes

[Andrew J Reagan](#) , [Lewis Mitchell](#), [Dilan Kiley](#), [Christopher M Danforth](#) & [Peter Sheridan Dodds](#)

[*EPJ Data Science*](#) 5, Article number: 31 (2016) | [Cite this article](#)

65k Accesses | 94 Citations | 1051 Altmetric | [Metrics](#)

'There is no reason why the simple shapes of stories can't be fed into computers, they are beautiful shapes.'
- Kurt Vonnegut



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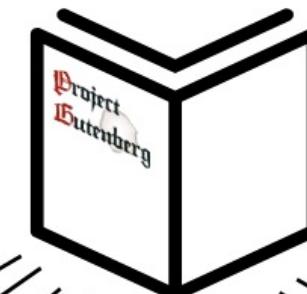
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1,385 English fiction eBooks

Remove header/footer, correct file encodings, split into chapters, sentences, and tokenize words

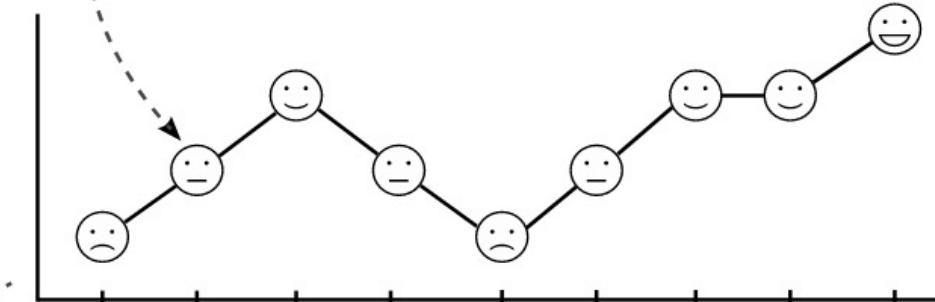


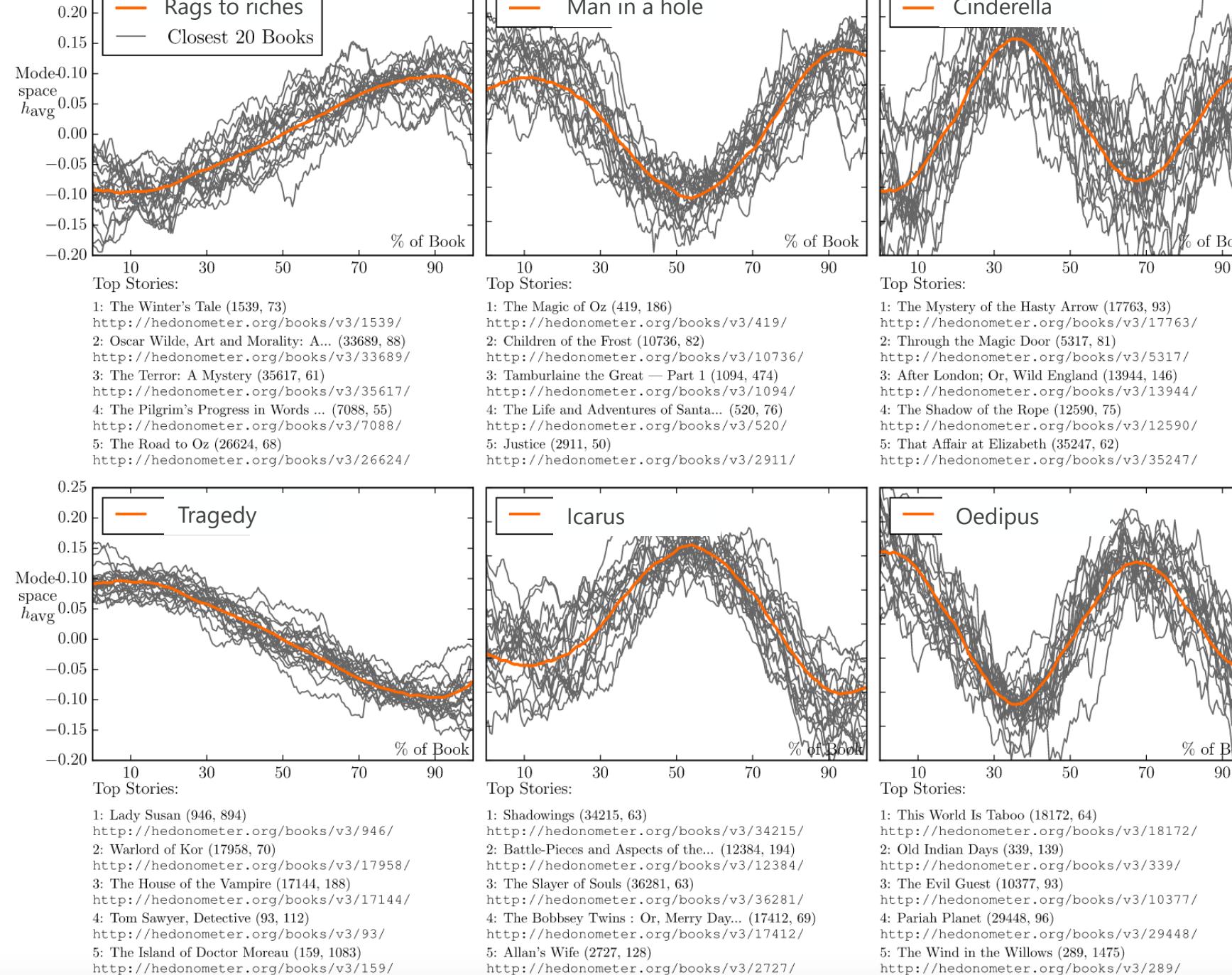
Processed text

Uniform length segments of the text



Hedonometric analysis





Consideration of the emotional arc for a given story is important for the success of that story

Applications in Health: Automating coding

ICD-10 Coding of Spanish Electronic Discharge Summaries: An Extreme Classification Problem

Publisher: IEEE

Cite This

PDF

Mario Almagro  ; Raquel Martínez Unanue ; Víctor Fresno ; Soto Montalvo  [All Authors](#)

Automatic multilabel detection of ICD10 codes in Dutch cardiology discharge letters using neural networks

[Arjan Sammani](#) , [Ayoub Bagheri](#), [Peter G. M. van der Heijden](#), [Anneline S. J. M. te Riele](#), [Annette F. Baas](#), [C. A. J. Oosters](#), [Daniel Oberski](#) & [Folkert W. Asselbergs](#)

npj Digital Medicine 4, Article number: 37 (2021) | [Cite this article](#)

Almagro, Martínez-Unanue, Fresno, Moltalvo, 2020

Goal: Suggest a list of the 10 most probable ICD-10 codes (diseases, abnormal findings, causes of injury...) to experts

Data: 7k discharged reports, with 7k ICD-10 codes.
Cardinality= 10.

Method: Different methods

Preprocessing: Remove sentences without technical terms (using tagging software), removal accents, punctuation, stemming.

Results:

Method	P@10
Baseline	14.59
SVMs	37.06
MLPs	35.28
AdaBoost	36.36
GBoost	40.88
KLD	16.52
Document-Similarity	29.37
LSTM	15.08
XML-CNN	24.99
FastXML	29.87
SLEEC	27.00
Dependency-LDA	31.96
Voting	46.75
Regression	41.73

Bagheri, Sammani, van der Heijden, Asselbergs, Oberski, 2020

Question: The proposal is conceived to be applied in a real system, suggesting a list of the 10 most probable codes to experts

Data: 6k discharged reports, with 1k ICD-10 (diseases, abnormal findings, causes of injury...). Cardinality=5

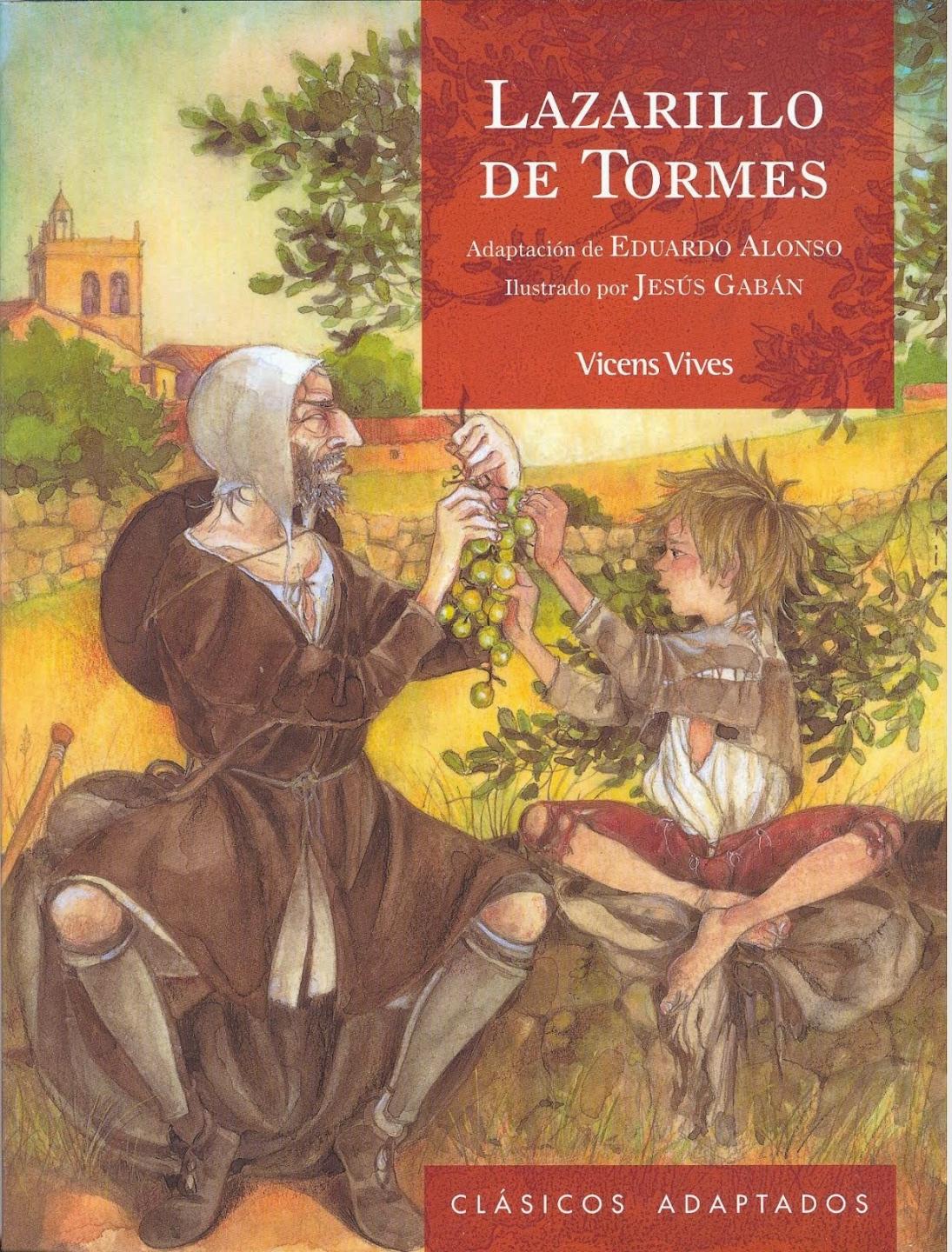
Method: Different methods

Preprocessing: removed small labels, trimmed whitespaces, numbers and converted all characters to lowercase

Results:

	ICD chapters		Rolled-up ICD codes	
	Accuracy	F1	Accuracy	F1
BOW SVM (baseline)	62.3	74.3	11.6	20.2
Average word embeddings (SVM)	60.4	72.6	12.5	25.8
CNN(1conv)	38.1	46.3	09.0	16.1
CNN(2conv)	42.2	49.0	12.4	19.1
LSTM	53.4	59.6	11.7	18.8
BiLSTM	55.0	70.1	13.7	23.2
HA-GRU	56.8	71.3	15.9	24.3

Detecting unique patterns in text



LAZARILLO DE TORMES

Adaptación de EDUARDO ALONSO

Ilustrado por JESÚS GABÁN

Vicens Vives

CLÁSICOS ADAPTADOS

Year	Author	
1605	Juan de Ortega [†]	2008 Pedro de Rhúa
1607	Diego Hurtado de Mendoza [†]	Francisco Cervantes de Salazar
1608	Diego Hurtado de Mendoza	Juan Arce de Otálora [†]
1624	Juan de Ortega	2010 Diego Hurtado de Mendoza
	Diego Hurtado de Mendoza	Diego Hurtado de Mendoza
1867	Sebastián de Horozco [†]	Diego Hurtado de Mendoza
1873	Diego Hurtado de Mendoza	Alfonso de Valdés
1888	Diego Hurtado de Mendoza	Alfonso de Valdés
	Juan de Valdés [†]	Diego Hurtado de Mendoza
1901	Lope de Rueda [†]	Diego Hurtado de Mendoza
1914	Juan de Valdés	Juan Arce de Otálora
	Lope de Rueda	Juan Arce de Otálora
	Sebastián de Horozco ⁷⁵	Juan de Pineda [†]
1915	Sebastián de Horozco	2011 Juan Arce de Otálora
1943	Diego Hurtado de Mendoza	Diego Hurtado de Mendoza
	Diego Hurtado de Mendoza	Diego Hurtado de Mendoza
1954	Juan de Ortega	2012 Juan Luis Vives
1955	Pedro de Rhúa [†]	Juan Luis Vives
1957	Sebastián de Horozco	Diego Hurtado de Mendoza
	Juan de Valdés	Juan Arce de Otálora
	Juan de Valdés	2014 Juan Luis Vives
1959	Juan de Valdés	Diego Hurtado de Mendoza
	Juan de Valdés	Juan Arce de Otálora
1960	Juan de Valdés	
1961	Diego Hurtado de Mendoza	
1963	Diego Hurtado de Mendoza	
1964	Hernán Núñez de Toledo [†]	
	Lope de Rueda	
1966	Juan de Ortega	
1969	Diego Hurtado de Mendoza	
1970	Diego Hurtado de Mendoza	
1973	Sebastián de Horozco	
	Alfonso de Valdés [†]	
1976	Alfonso de Valdés [†]	
1978	Sebastián de Horozco	
1980	Lope de Rueda	
	Sebastián de Horozco	
1987	Lope de Rueda	
	Sebastián de Horozco	
	Hernán Núñez de Toledo [†]	
1988	Juan de Ortega	
1992	Juan de Valdés	
2002	Alfonso de Valdés	
	Alfonso de Valdés	
	Juan de Ortega	
2003	Lope de Rueda	
	Alfonso de Valdés	
	Alfonso de Valdés	
	Francisco Cervantes de Salazar [†]	
	Alfonso de Valdés	
	Alfonso de Valdés	
2004	Alfonso de Valdés	
	Alfonso de Valdés	
	Alfonso de Valdés	
2006	Alfonso de Valdés	
	Alfonso de Valdés	
	Alfonso de Valdés	
	Alfonso de Valdés	
2007	Alfonso de Valdés	

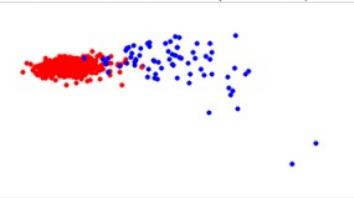
The Life of *Lazarillo de Tormes* and of His Machine Learning Adversities

Non-traditional authorship attribution techniques
in the context of the *Lazarillo*

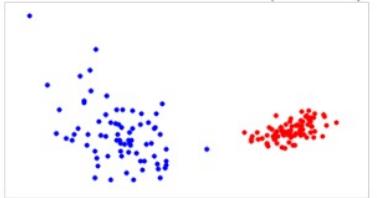
Javier de la Rosa & Juan Luis Suárez

The University of Western Ontario, London, Canadá

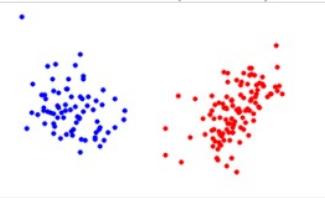
Juan Arce de Otálora (MCC: 0.82)



Francisco Cervantes de Salazar (MCC: 0.99)



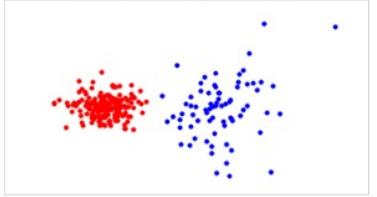
Francisco Delicado (MCC: 0.98)



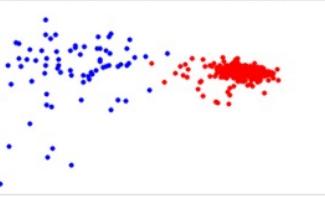
Sebastián Fernández (MCC: 1.00)



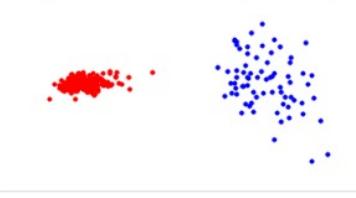
Gaspar Gil Polo (MCC: 0.95)



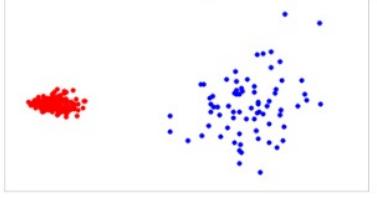
Sebastián de Horozco (MCC: 0.96)



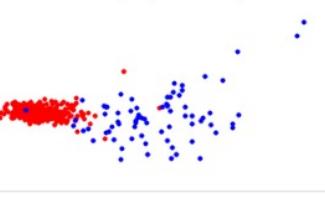
Diego Hurtado de Mendoza (MCC: 1.00)



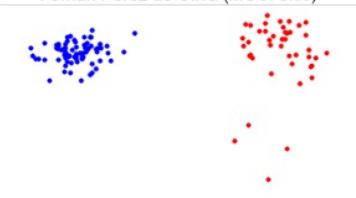
Juan de Malara (MCC: 1.00)



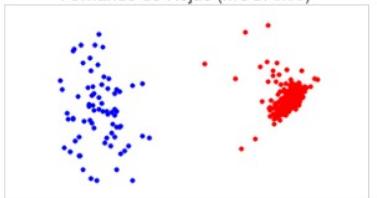
Pedro Mejía (MCC: 0.85)



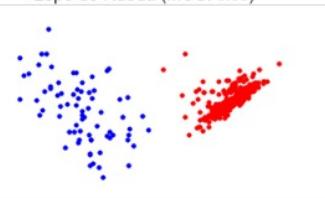
Fernán Pérez de Oliva (MCC: 1.00)



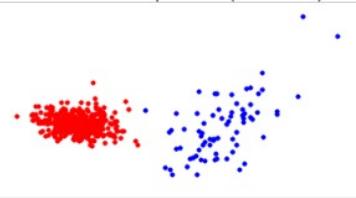
Fernando de Rojas (MCC: 0.99)



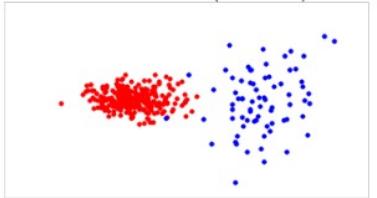
Lope de Rueda (MCC: 0.98)



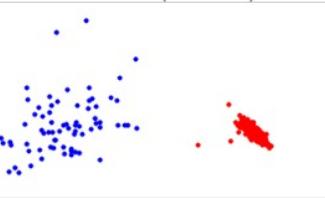
Antonio de Torquemada (MCC: 0.99)



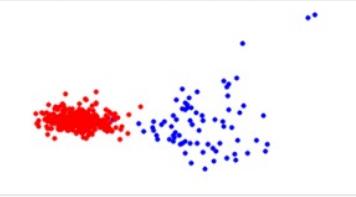
Alfonso de Valdés (MCC: 0.94)



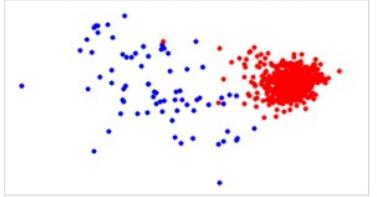
Juan de Valdés (MCC: 0.99)



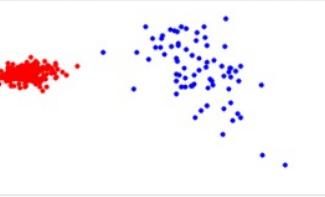
Cristóbal de Villalón (MCC: 0.96)



Juan Luis Vives (MCC: 0.85)



Fadrique de Zúñiga y Sotomayor (MCC: 0.99)



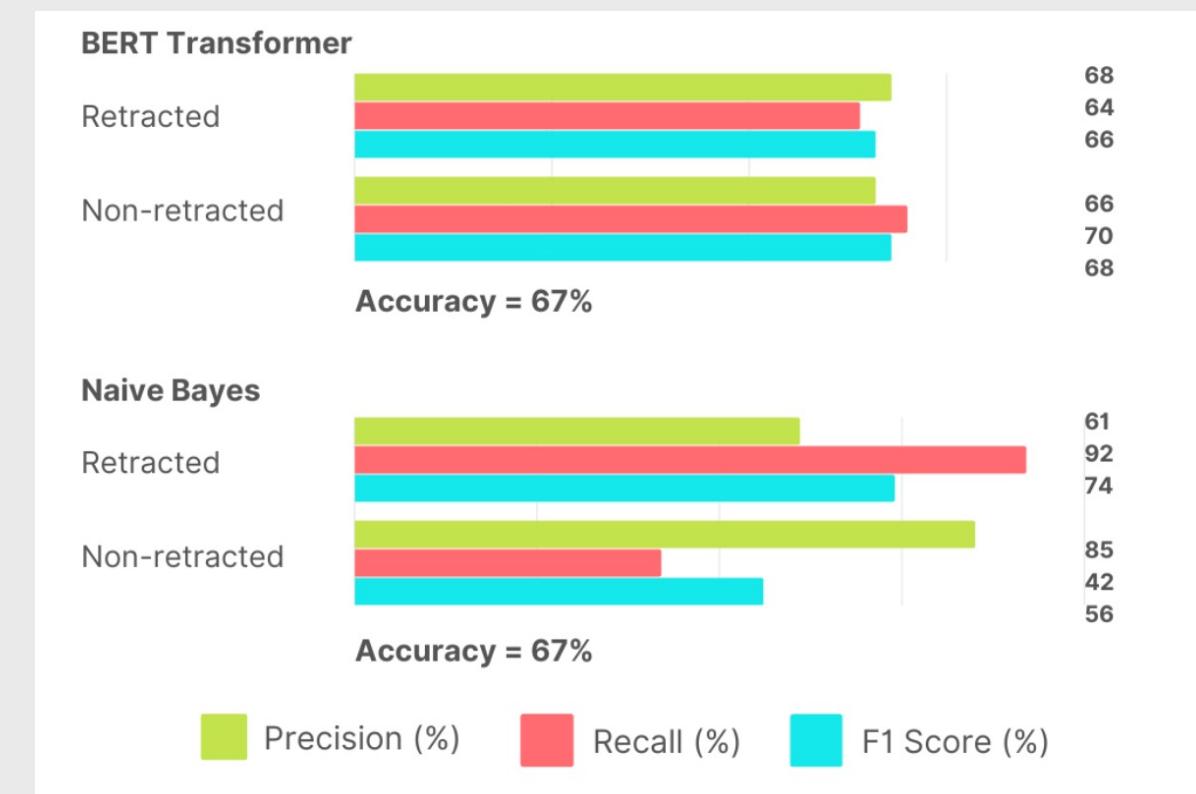
Detecting fraudulent research (Joep Franssen, Eveline Schmidt, Arleen Lindenmeyer, 2022)

Data: 1k retracted papers, 1k non-retracted papers from same journals

Method: Different methods (TF-IDF + NB, BERT)

Preprocessing: (1) none, (2) lemmatization, stop word removal, punctuation removal, lowercasing, and removal of white spaces (and tabs). We also removed proper nouns and deleted all numbers.

Results:



Applications in Economics and Finance

Article

Forecasting Net Income Estimate and Stock Price Using Text Mining from Economic Reports

Masahiro Suzuki ^{1,*}, Hiroki Sakaji ¹, Kiyoshi Izumi ¹, Hiroyasu Matsushima ¹ and Yasushi Ishikawa ²

Suzuki, Sakaji, Izumi, Matsushima, Ishiwaka, 2020

Data: 17k reports on TOPIX securities from 5 brokers

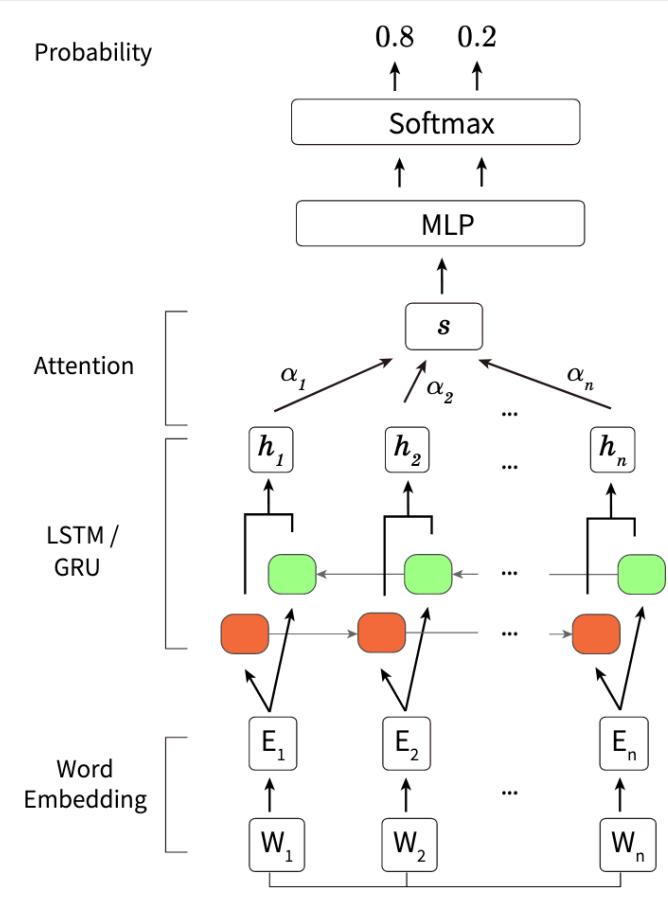
Method: LSTM/GRU + Self-attention

Preprocessing: decomposing sentences into words (the Japanese language does not have spaces between the words in a sentences)

Goal: Predict excess return (+/-) at 14 days

Results:

Broker	Opinion Sentences	Non-Opinion Sentences	Opinion and Non-Opinion Sentences	All Sentences
A	0.529	0.526	0.520	0.506
B	0.558	0.563	0.569	0.573
C	0.530	0.535	0.503	0.533
D	0.518	0.525	0.509	0.523
E	0.500	0.503	0.492	0.499



Applications in reports

Automatically code reports, detect emergencies

2018 IEEE International Conference on Software Quality, Reliability and Security

Identification of Security related Bug Reports via Text Mining using Supervised and Unsupervised Classification

Katerina Goseva-Popstojanova and Jacob Tyo

Lane Department of Computer Science and Electrical Engineering

West Virginia University, Morgantown, WV, USA

Email: Katerina.Goseva@mail.wvu.edu

Goseva-Popstojanova and Tyo, 2018

Data: 3,500 issue tracking systems of two NASA missions

Method: TF-IDF/TF + ML (Bayesian Network (BN), k-Nearest Neighbor (kNN), Naïve Bayes (NB), Naive Bayes Multinomial (NBM), Random Forest (RF), and Support Vector Machine (SVM))

Preprocessing: remove punctuation, characters and stop-words, stemming

Goal: Identify those software bugs reports that are security related

Results:

Flight Mission Developers Issues	Supervised System	TFIDF_BN	TFIDF_kNN	TFIDF_NB	TFIDF_NBM	TFIDF_RF	TFIDF_SVM
	Accuracy	68.0%	64.9%	62.3%	66.0%	70.6%	59.9%
	Precision	48.9%	66.7%	73.4%	65.9%	71.2%	73.0%
	Recall	94.4%	93.2%	66.9%	100.0%	92.9%	61.9%
	PFA	82.6%	89.7%	46.7%	99.5%	72.3%	44.0%
	F-Score	79.5%	77.7%	70.0%	79.5%	80.6%	67.0%
	G-Score	29.4%	18.5%	59.3%	1.0%	42.7%	58.8%

How to know if your results make sense?

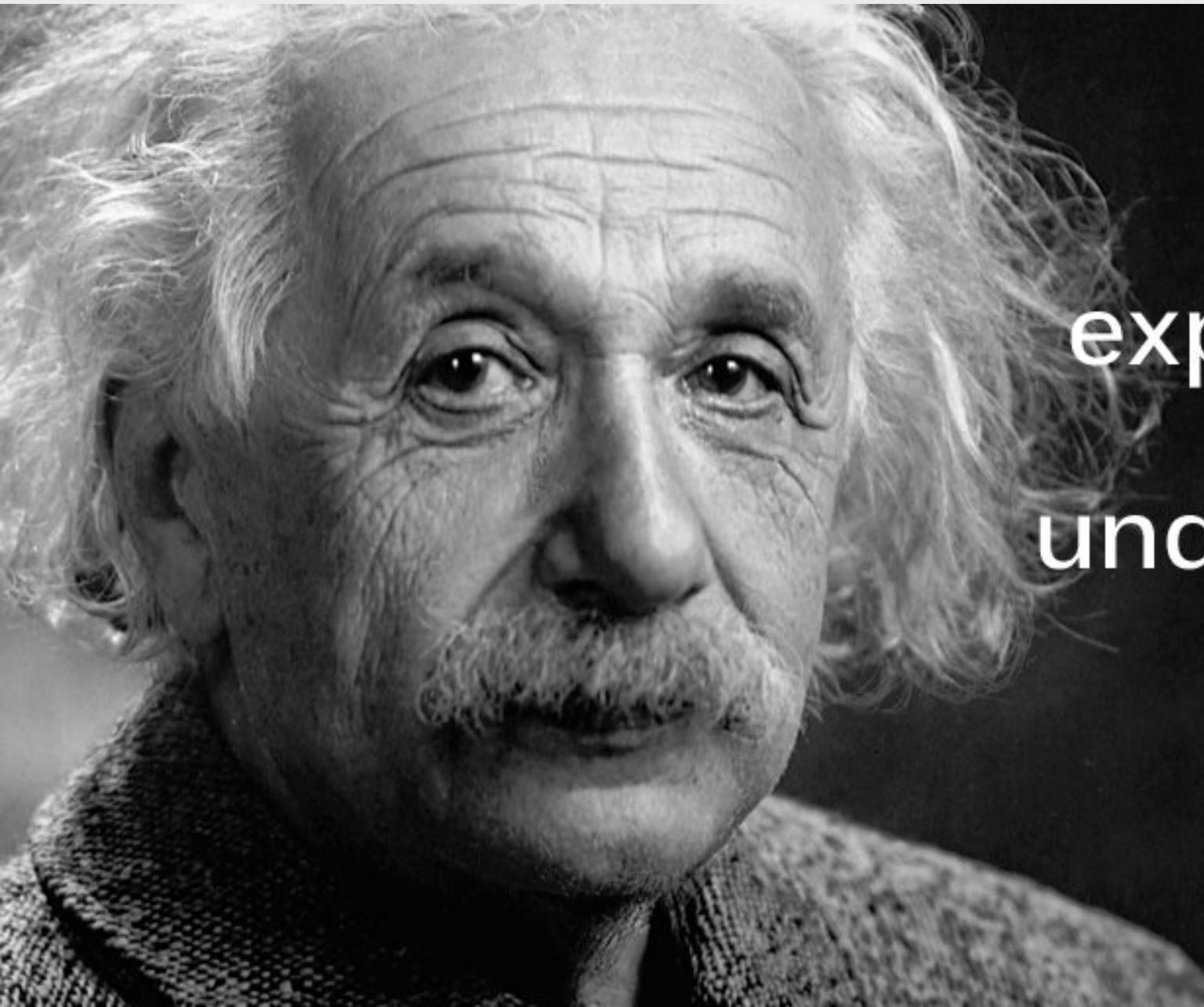
Clustering:

Classification/Regression

@ttnphns;

- 1. Cluster metaphor.** "*I preferred this method because it constitutes clusters such (or such a way) which meets with my concept of a cluster in my particular project*". Each clustering algorithm or subalgorithm/method implies its corresponding structure/build/shape of a cluster.
- 2. Data/method assumptions.** "*I preferred this method because my data nature or format predispose to it*".
- 3. Internal validity.** "*I preferred this method because it gave me most clear-cut, tight-and-isolated clusters*. [Beware of overfitting: all clustering methods seek to maximize some version of internal validity (it's what clustering *is* about), so high validity may be partly due to random peculiarity of the given dataset; having a test dataset is always beneficial.]
- 4. External validity.** "*I preferred this method because it gave me clusters which differ by their background or clusters which match with the true ones I know*". If a clustering partition presents clusters which are clearly different on some important background (i.e. not participated in the cluster analysis) characteristics then it is an asset for that method which produced the partition.
- 5. Cross-validity.** "*I preferred this method because it is giving me very similar clusters on equivalent samples of the data or extrapolates well onto such samples*. Two main approaches are *stability* check and *generalizability* check.
- 6. Interpretation.** "*I preferred this method because it gave me clusters which, explained, are most persuasive that there is meaning in the world*". It's not statistical - it is your psychological validation.
- 7. Gregariousness.** "*I preferred this method because it gave with my data similar results with a number of other methods among all those I probed*". This is a heuristic but questionable strategy which assumes that there exist quite universal data or quite universal method.

Interpretability in Supervised Learning



If you can't
explain it simply,
you don't
understand it well
enough.

ALBERT EINSTEIN

Interpretability

Being Right for the Right Reasons

Choices:

- Global vs Local interpretability
- Model-dependent vs model-agnostic interpretability

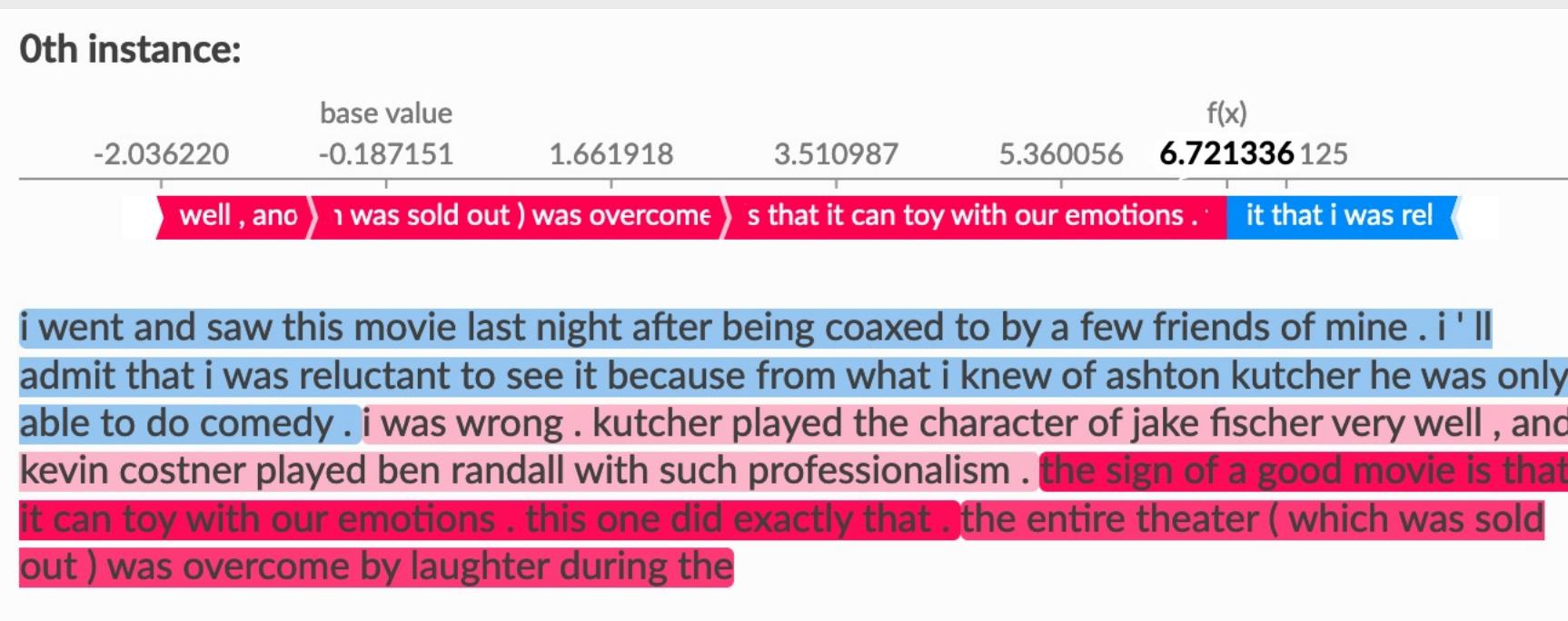
Local interpretability

Goal: Inform the human about the factors determining the prediction

Many advances in the last decade (**SHAP**, LIME, Anchors, Counterfactuals)

Basic idea: Change the observations slightly to observe how the prediction will change

0th instance:

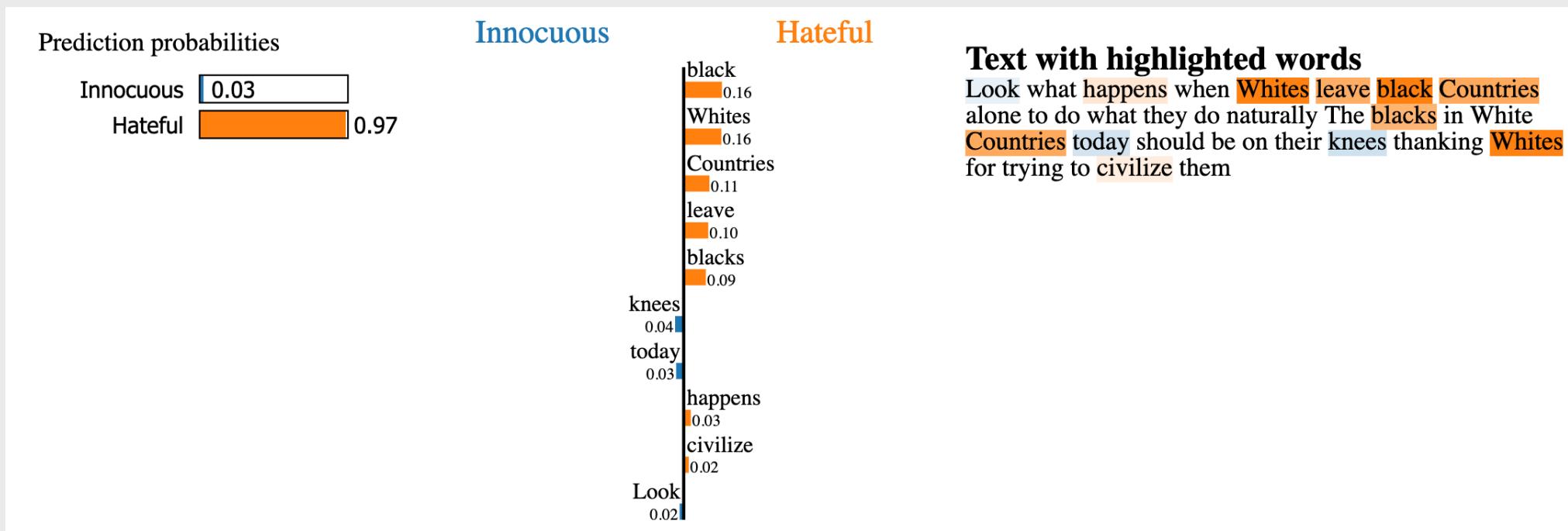


Local interpretability

Goal: Inform the human about the factors determining the prediction

Many advances in the last decade (SHAP, **LIME**, Anchors, Counterfactuals)

Basic idea: Change the observations slightly to observe how the prediction will change



Local interpretability

Goal: Inform the human the reason of the prediction

Basic idea: Change the observations slightly to observe how the prediction will change

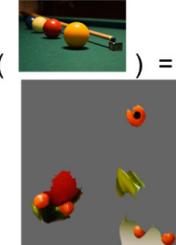
LIME // Ribeiro, Singh
and Guestrin, 2016



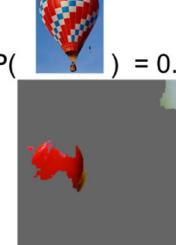
$$P(\text{frog}) = 0.54$$



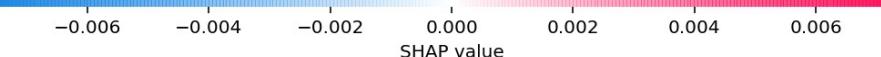
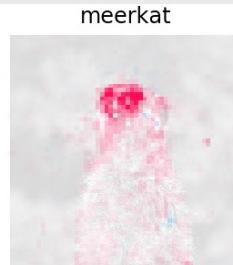
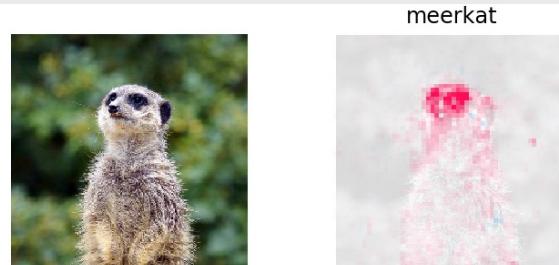
$$P(\text{billiards}) = 0.07$$



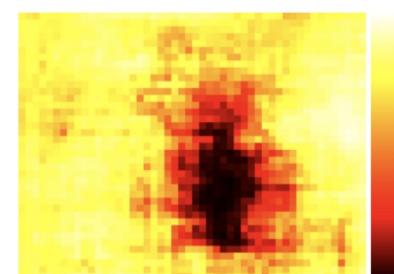
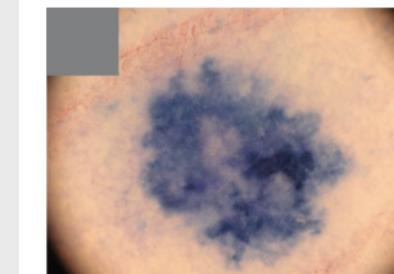
$$P(\text{balloon}) = 0.05$$



Scott M.
Lundberg,
Su-In Lee,
2017



Anchors // Ribeiro, Singh
and Guestrin, 2018



<https://silverpond.com.au/2018/04/17/an-ai-tells-us-what-it-knows-when-we-poke-it-in-the-eye/>

Practical 8