

## Secondary Publication



Kim, Evgeny; Klinger, Roman

### Frowning Frodo, Wincing Leia, and a Seriously Great Friendship : Learning to Classify Emotional Relationships of Fictional Characters

Date of secondary publication: 16.05.2025

Version of Record (Published Version), Conferenceobject

Persistent identifier: urn:nbn:de:bvb:473-irb-1083051

#### Primary publication

Kim, Evgeny; Klinger, Roman (2019): Frowning Frodo, Wincing Leia, and a Seriously Great Friendship : Learning to Classify Emotional Relationships of Fictional Characters, in: Jill Burstein, Christy Doran, und Thamar Solorio (Ed.), Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics : Human Language Technologies, ACL, pp. 647–653, doi: 10.18653/v1/N19-1067.

#### Legal Notice

This work is protected by copyright and/or the indication of a licence. You are free to use this work in any way permitted by the copyright and/or the licence that applies to your usage. For other uses, you must obtain permission from the rights-holders.

This document is made available under a Creative Commons license.



The license information is available online:

<https://creativecommons.org/licenses/by/4.0/legalcode>

# Frowning Frodo, Wincing Leia, and a Seriously Great Friendship: Learning to Classify Emotional Relationships of Fictional Characters

Evgeny Kim and Roman Klinger

Institut für Maschinelle Sprachverarbeitung

University of Stuttgart

Pfaffenwaldring 5b, 70569 Stuttgart, Germany

{evgeny.kim, roman.klinger}@ims.uni-stuttgart.de

## Abstract

The development of a fictional plot is centered around characters who closely interact with each other forming dynamic social networks. In literature analysis, such networks have mostly been analyzed without particular relation types or focusing on roles which the characters take with respect to each other. We argue that an important aspect for the analysis of stories and their development is the emotion between characters. In this paper, we combine these aspects into a unified framework to classify emotional relationships of fictional characters. We formalize it as a new task and describe the annotation of a corpus, based on fan-fiction short stories. The extraction pipeline which we propose consists of character identification (which we treat as given by an oracle here) and the relation classification. For the latter, we provide results using several approaches previously proposed for relation identification with neural methods. The best result of 0.45  $F_1$  is achieved with a GRU with character position indicators on the task of predicting undirected emotion relations in the associated social network graph.

## 1 Introduction

Every fictional story is centered around characters in conflict (Ingermanson and Economy, 2009) which interact, grow closer or apart, as each of them has ambitions and concrete goals (Ackerman and Puglisi, 2012, p. 9). Previous work on computational literary studies includes two tasks, namely social network analysis and sentiment/emotion analysis, both contributing to a computational understanding of narrative structures. We argue that joining these two tasks leverages simplifications that each approach makes when considered independently. We are not aware of any such attempt and therefore propose the task of emotional character network extraction from

fictional texts, in which, given a text, a network is to be generated, whose nodes correspond to characters and edges to emotions between characters. One of the characters is part of a trigger/cause for the emotion experienced by the other. Figure 1 depicts two examples for emotional character interactions at the text level. Such relation extraction is the basis for generating social networks of emotional interactions.

Dynamic social networks of characters are analyzed in previous work with different goals, *e.g.*, to test the differences in interactions between various adaptations of a book (Agarwal et al., 2013); to understand the correlation between dialogue and setting (Elson et al., 2010); to test whether social networks derived from Shakespeare’s plays can be explained by a general sociological model (Nalnick and Baird, 2013); in the task of narrative generation (Sack, 2013); to better understand the nature of character interactions (Piper et al., 2017). Further, previous work analyses personality traits of characters (mostly) independently of each other (Massey et al., 2015; Barth et al., 2018; Bamman et al., 2014).

Emotion analysis in literature has focused on the development of emotions over time, abstracting away who experiences an emotion (Reagan et al., 2016; Elsner, 2015; Kim et al., 2017; Piper and Jean So, 2015, *i.a.*). Fewer works have ad-

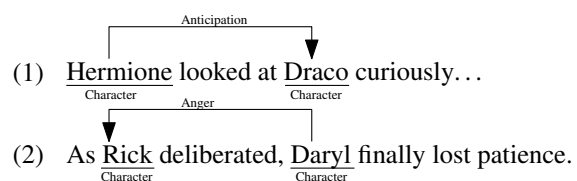


Figure 1: Examples for Emotional Character Interaction. (1) taken from Apryl.Zephyr (2016), (2) from EmmyR (2014). The arrow starts at the experiencer and points at the causing character.

dressed the annotation of emotion causes, e.g., Neviarouskaya and Aono (2013), Ghazi et al. (2015), Saurí and Pustejovsky (2009), and Kim and Klinger (2018). To the best of our knowledge, there is no previous research that deals with emotional relationships of literary characters. The works that are conceptually the closest to our paper are Chaturvedi et al. (2017) and Massey et al. (2015), who use a more general set of relationship categories.

Most approaches to emotion classification from text build on the classes proposed by Plutchik (2001) and Ekman (1992). Here, we use a discrete emotion categorization scheme based on fundamental emotions as proposed by Plutchik. This model has previously been used in computational analysis of literature (Mohammad, 2012, *i.a.*). We refer the reader to social psychology literature for more details on the emotional relationship between people (Burkitt, 1997; Gaelick et al., 1985).

The main contributions of this paper are (1) to propose the new task of emotional relationship classification of fictional characters, (2) to provide a fan-fiction short story corpus annotated with characters and their emotional relationships, and (3) to provide results for relation extraction models for the task. We evaluate our models on the textual and the social network graph level and show that a neural model with positional indicators for character roles performs the best. An additional analysis shows that the task of character relationship detection leads to higher performance scores for polarity detection than for more fine-grained emotion classes. Differences between models are minimal when the task is cast as a polarity classification but are striking for emotion classification.

This work has potential to support a literary scholar in analyzing differences and commonalities across texts. As an example, one may consider Goethe’s *The Sorrows of Young Werther* (Goethe, 1774), a book that gave rise to a plethora of imitations by other writers, who attempted to depict a similar love triangle between main characters found in the original book. The results of our study can potentially be used to compare the derivative works with the original (see also Barth et al., 2018).

## 2 Corpus

**Data Collection and Annotation.** Each emotion relation is characterized by a triple

$(C_{\text{exp}}, e, C_{\text{cause}})$ , in which the character  $C_{\text{exp}}$  feels the emotion  $e$  (mentioned in text explicitly or implicitly). The character  $C_{\text{cause}}$  is part of an event which triggers the emotion  $e$ . We consider the eight fundamental emotions defined by Plutchik (2001) (anger, fear, joy, anticipation, trust, surprise, disgust, sadness). Each character corresponds to a token sequence for the relation extraction task and to a normalized entity in the graph depiction.

Using WebAnno (Yimam et al., 2013), we annotate a sample of 19 complete English fan-fiction short stories, retrieved from the Archive of Our Own project<sup>1</sup> (due to availability, the legal possibility to process the texts and a modern language), and a single short story by Joyce (1914) (Counterparts) being an exception from this genre in our corpus. All fan-fiction stories were marked by the respective author as complete, are shorter than 1500 words, and depict at least four different characters. They are tagged with the keywords “emotion” and “relationships”.

The annotators were instructed to mark every character mention with a canonical name and to decide if there is an emotional relationship between the character and another character. If so, they marked the corresponding emotion phrase with the emotion labels (as well as indicating if the emotion is amplified, downtoned or negated). Based on this phrase annotation, they marked two relations: from the emotion phrase to the experiencing character and from the emotion phrase to the causing character (if available, *i.e.*,  $C_{\text{cause}}$  can be empty). One character may be described as experiencing multiple emotions.

We generate a “consensus” annotation by keeping all emotion labels by all annotators. This is motivated by the finding by Schuff et al. (2017) that such high-recall aggregation is better modelled in an emotion prediction task. The data is available at <http://www.ims.uni-stuttgart.de/data/relationalemotions>.

**Inter-Annotator Agreement** We calculate the agreement along two dimensions, namely unlabelled vs. labelled and instance vs. graph-level. Table 1 reports the pairwise results for three annotators. In the *Inst. labelled* setting, we accept an instance being labeled as true positive if both annotators marked the same characters as experiencer and cause of an emotion and classified their in-

<sup>1</sup><https://archiveofourown.org>

	a1-a2	a1-a3	a2-a3
Inst. labelled	24	19	24
Inst. unlab.	33	27	29
Graph labelled	66	69	66
Graph unlabelled	90	93	92

Table 1: F<sub>1</sub> scores in % for agreement between annotators on different levels. a1, a2, and a3 are different annotators.

teraction with the same emotion. In the *Inst. unlabelled* case, the emotion label is allowed to be different. On the graph level (*Graph labelled* and *Graph unlabelled*), the evaluation is performed on an aggregated graph of interacting characters, *i.e.*, a relation is accepted by one annotator if the other annotator marked the same interaction somewhere in the text. We use the F<sub>1</sub> score to be able to measure the agreement between two annotators on the span levels. For that, we treat the annotations from one annotator in the pair as correct and the annotations from the other as predicted.

As Table 1 shows, agreement on the textual level is the lowest with values between 19 and 33 % (depending on the annotator pair), which also motivated our aggregation strategy mentioned before. The values for graph-labelled agreement are more relevant for our use-case of network generation. The values are higher (66–93 %), showing that annotators agree when it comes to detecting relationships regardless of where exactly in the text they appear.

**Statistics.** Table 2 summarizes the aggregated results of the annotation. The column “All” lists the number of experiencer annotations (with an emotion), the column “Rel.” refers to the counts of emotion annotations with both experiencer and cause.

*Joy* has the highest number of annotated instances and the highest number of relationship instances (413 and 308 respectively). In contrast, *sadness* has the lowest number of annotations with a total count of instances and relations being 97 and 64 respectively. Overall, we obtain 1335 annotated instances, which we use to build and test our models.

### 3 Methods

Figure 2 depicts the process flow for each of the models. We distinguish between *directed* and

Emotion	All	Rel.
anger	258	197
anticipation	307	239
disgust	163	122
fear	182	120
joy	413	308
sadness	97	64
surprise	143	129
trust	179	156
<b>total</b>	<b>1742</b>	<b>1335</b>

Table 2: Statistics of emotion and relation annotation. “All” indicates the total number of emotion annotations. “Rel.” indicates total number of emotional relationships (including a causing character) instantiated with the given emotion.

Indicator	Implementation example
No-Ind.	Alice is angry with Bob
Role	<e>Alice</e>...<c>Bob</c>
MRole	<e>...<c>
Entity	<et>Alice</et>...<et>Bob</et>
MEntity	<et>...</et>

Table 3: Different indicators applied to the same instance. *No-Ind.* means no positional indicators are added. *M* in *MRole* and *MEntity* means that the name of the character is masked. Tag <e> indicates the experiencer. Tag <c> indicates the cause. Tag <et> indicates an entity.

*undirected* relation prediction. In the directed scenario, we classify which character is the experiencer and which character is the cause, as well as what is the emotion between two characters. For the undirected scenario, we only classify the emotion relation between two characters. We do not tackle character name recognition here: our models build on top of gold character annotations.

The *baseline* model predicts the emotion for a character pair based on the NRC dictionary (Mohammad and Turney, 2013). It accepts the emotion associated with the words occurring in a window of  $n$  tokens around the two characters, with  $n$  being a parameter set based on results on a development set for each model (see supplementary material for more details).

Further we cast the relation detection as a machine learning-based classification task, in which each classification instance consists of two character mentions with up to  $n$  tokens context to the

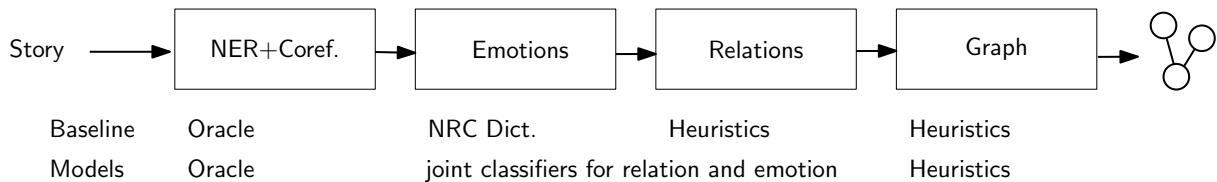


Figure 2: Models for the emotional relationship prediction. Oracle: a set of character pairs from the gold data.

left and to the right of the character mentions. We compare an extremely randomized tree classifier with bag-of-words features (Geurts et al., 2006) (*BOW-RF*) with a two-layer GRU neural network (Chung et al., 2014) with max and averaged pooling. In the latter, we use different variations of encoding the character positions with indicators (inspired by Zhou et al. (2016), who propose the use of positional indicators for relation detection). Our variations are exemplified in Table 3. Note that the case of predicting directed relations is simplified in the “Role” and “MRole” cases in contrast to “Entity” and “MEntity”, as the model has access to gold information about the relation direction.

We obtain word vectors for the embedding layer from GloVe (pre-trained on Common Crawl,  $d = 300$ , Pennington et al., 2014) and initialize out-of-vocabulary terms with zeros (including the position indicators).

## 4 Experiments

**Experimental Setting.** In the classification experiments, we compare the performance of our models on different label sets. Namely, we compare the complete emotion set with 8 classes to a 5 class scenario where we join *anger* and *disgust*, *trust* and *joy*, as well as *anticipation* and *surprise* (based on preliminary experiments and inspection of confusion matrices). The 2-class scenario consists of positive (*anticipation*, *joy*, *trust*, *surprise*) and negative relations (*anger*, *fear*, *sadness*, *disgust*). For each set of classes, we consider a setting where directed relations are predicted with one where the direction is ignored. Therefore, in the *directed* prediction scenario, each emotion constitutes two classes to be predicted for both possible directions (therefore, 16, 10, and 4 labels exist).

The evaluation is performed with precision, recall and  $F_1$  in a cross-story validation setting, in which each story is used as one separate test/validation source. For model selection and meta-parameter optimization, we use 50% randomly sampled annotations from this respective

test/validation instance as a validation set and the remainder as test data.

Further, we evaluate on three different levels of granularity: Given two character mentions, in the instance-level evaluation, we only accept the prediction to be correct if exactly the same mention has the according emotion annotation. We then aggregate the different true positive, false positive and false negative values across all stories before averaging to an aggregated score (similar to micro-averaging). On the story-level, we also accept a prediction to be a true positive the same way, but first calculate the result  $P/R/F_1$  for the whole story before averaging (similar to macro-averaging). On the graph-level, we accept a prediction for a character pair to be correct without considering the exact position.

**Results.** Table 4 shows the results (precision and recall shown in supplementary material) on development data and independent test data for the best models. The GRU+MRole model achieves the highest performance with improvement over BOW-RF on the instance and story levels, and shows a clear improvement over the GRU+NoInd. model in the directed 8-class setting. GRU+Role achieves the highest performance on the graph level in the directed 8-class setting. In the undirected prediction setting, all models perform better in the 5-class experiment and 2-class experiment than in 8-class experiment. This is not always the case for the directed prediction, where some models perform better in 8-class experiment (GRU+NoInd., GRU+Entity, BOW-RF).

We observe that the difference in  $F_1$  score between the baseline, bag-of-words model and our GRU models in a 2-class experiment is marginal. This may be an indicator that the binary representation harms the classification of emotional relations between characters, as they can be nuanced and do not always perfectly map to either positive and negative classes. On the other side, a more sophisticated classification approach is necessary to capture these nuanced differences.

		Undir.			Directed		
Model		8c	5c	2c	8c	5c	2c
Dev Instance level	Baseline	24	30	56	–	–	–
	BOW-RF	18	31	56	20	19	35
	GRU+NoInd.	31	39	64	26	23	37
	GRU+Role	19	35	55	33	34	57
	GRU+MRole	30	44	67	38	44	65
	GRU+Entity	20	34	58	23	19	30
	GRU+MEntity	30	43	65	28	29	40
Dev Story level	Baseline	24	31	56	–	–	–
	BOW-RF	21	35	58	22	20	38
	GRU+NoInd.	33	41	66	25	23	38
	GRU+Role	19	34	55	33	35	56
	GRU+MRole	32	44	67	39	44	65
	GRU+Entity	21	31	57	22	18	30
	GRU+MEntity	33	46	65	28	30	39
Dev Graph-level	Baseline	31	46	65	–	–	–
	BOW-RF	27	36	71	34	34	54
	GRU+NoInd.	44	55	73	35	33	54
	GRU+Role	35	49	65	41	43	57
	GRU+MRole	45	58	73	40	48	65
	GRU+Entity	37	50	68	39	29	49
	GRU+MEntity	47	63	73	39	39	52
Test	GRU+MRole Inst.	30	44	64	38	43	65
	GRU+MRole Story	33	45	65	39	43	66
	GRU+MRole Graph	45	59	71	42	49	66

Table 4: Cross-validated results in %  $F_1$  score, average of four runs. Inst. level: aggregated over all instances in the dataset. Story level: averaged performance on all stories. Graph-level: averaged performance on graph level on all stories. Test results are reported for the best indicator type. See Table 3 for the examples of the indicator implementation.

As expected, we observe a better performance on a graph level for all models, with the highest performance of 47 %  $F_1$  (GRU+MEntity), 63 %  $F_1$  (GRU+MEntity), and 73 %  $F_1$  (GRU+MRole, GRU+MEntity, GRU+NoInd.) in undirected 8-, 5-, and 2-class experiments, respectively, on the development set. In the directed scenario, the highest performances are 41 %  $F_1$  (GRU+Role), 48 %  $F_1$  (GRU+MRole), and 65 %  $F_1$  (GRU+MRole).

The results show that the sequential and embedding information captured by a GRU as well as additional positional information are all relevant for a substantial performance, at least on the fine-grained emotion prediction task.

## 5 Conclusion & Future Work

In this paper, we formulated the new task of emotional character network extraction from fictional texts. We argued that joining social network analysis of fiction with emotion analysis leverages simplifications that each approach makes when considered independently. We presented a publicly available corpus of fan-fiction short stories annotated with character relations and proposed several relation classification models. We showed that a recurrent neural architecture with positional indicators leads to the best results of relation classification. We also showed that differences between different machine learning models with binary mapping of emotion relation is almost leveled. This may suggest that emotion relation classification is best modeled in a multi-class setting, as emotional interactions of fictional characters are nuanced and do not simply map to either a positive or a negative class.

For future work we propose to develop a real-world application pipeline in which character pairs are not given by an oracle, but rather extracted from text automatically using named entity recognition. To better understand the relation between instance and graph levels, we propose to explore the best strategy for edge labeling either by a majority vote or accepting the edges with the highest confidence scores. Further, modeling the task in an end-to-end learning setting from text to directly predict the graph, in the spirit of multi-instance learning, is one of the next steps. To that end, we suggest obtaining more gold data with character relations and optimize the pipeline towards the best performance on additional data.

## Acknowledgements

This research has been conducted within the CRETA project (<http://www.creta.uni-stuttgart.de/>) which is funded by the German Ministry for Education and Research (BMBF) and partially funded by the German Research Council (DFG), projects SEAT (Structured Multi-Domain Emotion Analysis from Text, KL 2869/1-1). We thank Laura-Ana-Maria Bostan and Heike Adel for fruitful discussions.

## References

- Angela Ackerman and Becca Puglisi. 2012. *The Emotion Thesaurus: A Writer's Guide to Character Expression*. JADD Publishing.
- Apoorv Agarwal, Anup Kotalwar, and Owen Rambow. 2013. Automatic extraction of social networks from literary text: A case study on alice in wonderland. In *Proceedings of the Sixth International Joint Conference on Natural Language Processing*, pages 1202–1208. Asian Federation of Natural Language Processing.
- Apryl\_Zephyr. 2016. Friends. <https://archiveofourown.org/works/8081986>.
- David Bamman, Ted Underwood, and Noah A. Smith. 2014. A bayesian mixed effects model of literary character. In *Proceedings of the 52nd Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 370–379. Association for Computational Linguistics.
- Florian Barth, Evgeny Kim, Sandra Murr, and Roman Klinger. 2018. A reporting tool for relational visualization and analysis of character mentions in literature. In *Book of Abstracts – Digital Humanities im deutschsprachigen Raum*, pages 123–126, Cologne, Germany.
- Ian Burkitt. 1997. Social relationships and emotions. *Sociology*, 31(1):37–55.
- Snigdha Chaturvedi, Mohit Iyyer, and Hal Daume III. 2017. Unsupervised learning of evolving relationships between literary characters. In *AAAI Conference on Artificial Intelligence*, pages 3159–3165.
- Junyoung Chung, Caglar Gulcehre, KyungHyun Cho, and Yoshua Bengio. 2014. Empirical evaluation of gated recurrent neural networks on sequence modeling. In *Proceedings of the Deep Learning and Representation Learning Workshop: NIPS 2014*.
- Paul Ekman. 1992. An argument for basic emotions. *Cognition & emotion*, 6(3-4):169–200.
- Micha Elsner. 2015. Abstract representations of plot structure. *LiLT (Linguistic Issues in Language Technology)*, 12:1–29.
- David Elson, Nicholas Dames, and Kathleen McKeown. 2010. Extracting social networks from literary fiction. In *Proceedings of the 48th Annual Meeting of the Association for Computational Linguistics*, pages 138–147, Uppsala, Sweden. Association for Computational Linguistics.
- EmmyR. 2014. PianoP. <https://archiveofourown.org/works/2481311>.
- Lisa Gaelick, Galen V. Bodenhausen, and Robert S. Wyer. 1985. Emotional communication in close relationships. *Journal of Personality and Social Psychology*, 49(5):1246.
- Pierre Geurts, Damien Ernst, and Louis Wehenkel. 2006. Extremely randomized trees. *Machine Learning*, 63(1):3–42.
- Diman Ghazi, Diana Inkpen, and Stan Szpakowicz. 2015. Detecting emotion stimuli in emotion-bearing sentences. In *Computational Linguistics and Intelligent Text Processing*, pages 152–165, Cham. Springer International Publishing.
- Johann Wolfgang von Goethe. 1774. *Die Leiden des jungen Werthers*.
- Randy Ingermanson and Peter Economy. 2009. *Writing fiction for dummies*. John Wiley & Sons.
- James Joyce. 1914. *Dubliners*. Grant Richards.
- Evgeny Kim and Roman Klinger. 2018. Who feels what and why? annotation of a literature corpus with semantic roles of emotions. In *Proceedings of the 27th International Conference on Computational Linguistics*, pages 1345–1359, Santa Fe, New Mexico, USA. Association for Computational Linguistics.
- Evgeny Kim, Sebastian Padó, and Roman Klinger. 2017. Investigating the relationship between literary genres and emotional plot development. In *Proceedings of the Joint SIGHUM Workshop on Computational Linguistics for Cultural Heritage, Social Sciences, Humanities and Literature*, pages 17–26, Vancouver, Canada. Association for Computational Linguistics.
- Philip Massey, Patrick Xia, David Bamman, and Noah A Smith. 2015. Annotating character relationships in literary texts. *arXiv preprint arXiv:1512.00728*.
- Saif M Mohammad. 2012. From once upon a time to happily ever after: Tracking emotions in mail and books. *Decision Support Systems*, 53(4):730–741.
- Saif M Mohammad and Peter D Turney. 2013. Crowdsourcing a word–emotion association lexicon. *Computational Intelligence*, 29(3):436–465.
- Eric T Nalisnick and Henry S Baird. 2013. Extracting sentiment networks from shakespeare's plays. In *Document Analysis and Recognition (ICDAR), 2013 12th International Conference on*, pages 758–762. IEEE.
- Alena Neviarouskaya and Masaki Aono. 2013. Extracting causes of emotions from text. In *Proceedings of the Sixth International Joint Conference on Natural Language Processing*, pages 932–936, Nagoya, Japan. Asian Federation of Natural Language Processing.
- Jeffrey Pennington, Richard Socher, and Christopher Manning. 2014. Glove: Global vectors for word representation. In *Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP)*, pages 1532–1543, Doha, Qatar. Association for Computational Linguistics.

- Andrew Piper, Mark Algee-Hewitt, Koustuv Sinha, Derek Ruths, and Hardik Vala. 2017. *Studying literary characters and character networks*. In *Digital Humanities 2017: Conference Abstracts*, Montreal, Canada.
- Andrew Piper and Richard Jean So. 2015. *Quantifying the weepy bestseller*. *New Republic*. <https://newrepublic.com/article/126123/quantifying-weepy-bestseller>.
- Robert Plutchik. 2001. *The nature of emotions*. *American Scientist*, 89(4):344–350.
- Andrew J Reagan, Lewis Mitchell, Dilan Kiley, Christopher M Danforth, and Peter Sheridan Dodds. 2016. *The emotional arcs of stories are dominated by six basic shapes*. *EPJ Data Science*, 5(1):31.
- Graham Alexander Sack. 2013. *Character Networks for Narrative Generation: Structural Balance Theory and the Emergence of Proto-Narratives*. In *2013 Workshop on Computational Models of Narrative*, volume 32 of *OpenAccess Series in Informatics (OA-SIcs)*, pages 183–197, Dagstuhl, Germany. Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik.
- Roser Saurí and James Pustejovsky. 2009. *Factbank: a corpus annotated with event factuality*. *Language Resources and Evaluation*, 43(3):227.
- Hendrik Schuff, Jeremy Barnes, Julian Mohme, Sebastian Padó, and Roman Klinger. 2017. *Annotation, modelling and analysis of fine-grained emotions on a stance and sentiment detection corpus*. In *Proceedings of the 8th Workshop on Computational Approaches to Subjectivity, Sentiment and Social Media Analysis*, Copenhagen, Denmark. Workshop at Conference on Empirical Methods in Natural Language Processing, Association for Computational Linguistics.
- Seid Muhie Yimam, Iryna Gurevych, Richard Eckart de Castilho, and Chris Biemann. 2013. *Webanno: A flexible, web-based and visually supported system for distributed annotations*. In *Proceedings of the 51st Annual Meeting of the Association for Computational Linguistics: System Demonstrations*, pages 1–6, Sofia, Bulgaria. Association for Computational Linguistics.
- Peng Zhou, Wei Shi, Jun Tian, Zhenyu Qi, Bingchen Li, Hongwei Hao, and Bo Xu. 2016. *Attention-based bidirectional long short-term memory networks for relation classification*. In *Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers)*, pages 207–212, Berlin, Germany. Association for Computational Linguistics.