Explaining A Deep Learning Based Model for Spelling Correction of "de/da" Clitics in Turkish through Understanding Their Dependence to Various Regions of A Sentence

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Introduction and Motivation

- A deep learning-based spellchecker is built to detect the spelling errors of Turkish “de/da” clitics with a SOTA score of **88.26%** F1-Score on this task.
- The spellchecker is treated as a black-box which is used to spellcheck perturbed sentences to provide an explanation in terms of the most significant features related to the prediction.
- A Game with a Purpose (GWAP) type web application called **"-de/-da Takıntısı"** was developed to gather information from Turkish speakers regarding how they predict the correct spelling of perturbed sentences containing "de/da". These results are being analyzed and compared with the findings of the model explanation.

Perturbation Based Explanation Approach

- There has been efforts to build explanation techniques for black-box NLP models [1]. In this study, a model-agnostic explanation approach is proposed to interpret sequence labeling models.
- Sentences are perturbed with a certain strategy and their effect on the model is observed.

Tenis topu evde kaldı. ⟶ Tenis evde kaldı.

Perturbation example 1: Remove the two previous word.

Arabayı ben de sürdüm. ⟶ Arabayı ben de __düm.

Perturbation example 2: Remove a common prefix in the following word.

Algorithm 1 Perturbation based explanation algorithm

Input: S ▷ Set of sentences which contain “de/da”
$Perturbations$ ▷ Set of perturbation functions
$spellchecker$ ▷ “-de/-da” Spellchecker function
Output: $Perturbation\_Impact$ ▷ set of $\overline{\Delta P}$ for each perturbation
for $pr \in Perturbations$ **do**
  for $s \in S$ **do**
    $w_d \leftarrow get\_deda\_word(s)$
    $\langle w_d, p_0 \rangle \leftarrow spellchecker(s, w_d)$
    $s_{pr} \leftarrow pr(s)$
    $\langle w_d, p_{pr} \rangle \leftarrow spellchecker(s_{pr}, w_d)$
    $\Delta P_{pr} = p_{pr} - p_0$
    $\Delta P_{pr_c} \leftarrow \Delta P_{pr_c} + \Delta P_{pr}$
  end for
  $\overline{\Delta P_{pr}} \leftarrow \frac{\Delta P_{pr_c}}{|S|}$
  $Perturbation\_Impact[i].append(\langle pr, \overline{\Delta_{Ppr}} \rangle)$
end for
return $Perturbation\_Impact$

Perturbation based explanation algorithm

w_d *is a word that contains a "de/da" and* ***spellchecker*** *is the model trained to check the spelling of "de/da" words and it returns the labeling probability of a given word in a sentence.*

- The average Δ_{P_i}'s for each perturbation strategy indicates the effect of each perturbation to the prediction of the model. If the Δ_{P_i} for a particular strategy is relatively high, then this means that that perturbation is important for determining the "de/da" usage in a sentence.

Results of the Perturbation

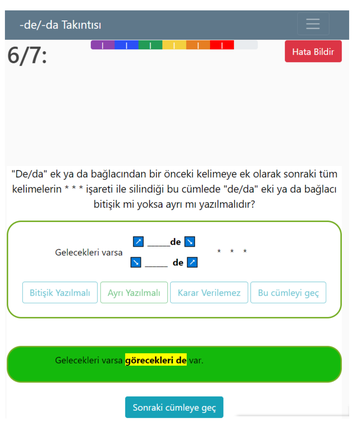
Perturbation Description	Δ_P
Remove the first letter of the previous word	0.0021
Remove the last letter of the previous word	0.0033
Remove the previous word	**0.33**
Remove the two previous word	**0.32**
Remove the three previous word	**0.32**
Remove the following word	0.0002
Remove the two following word	0.0026
Remove the three following word	0.0009
Remove a common prefix in the previous word	0.0016
Remove a common suffix in the previous word	0.03
Remove a common prefix in the following word	0.013
Remove a common suffix in the following word	0.012

Results of different perturbation techniques

These results show that the most important elements in a sentence determining the decisions of our model are the words which comes before the “de/da” clitic.

Human Based Computation Game

- We developed a GWAP to validate the findings of the perturbation-based explanation approach.
- In this game some words are masked in a sentence and the user is asked to predict the correct spelling of the “de/da” clitic.

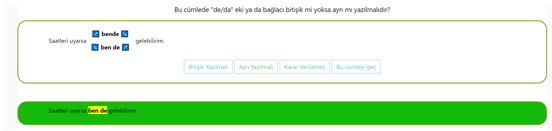


A screenshot from the GWAP

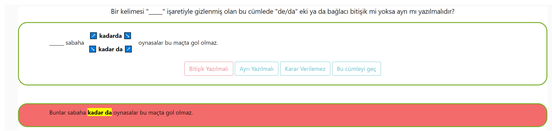
dedatakintisi.derlem.com

Game Modes

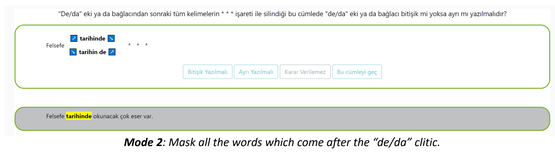
There are 7 modes in the game, each of which measures the significance of a particular region of a sentence.



Mode 0*: Do not mask anything.*



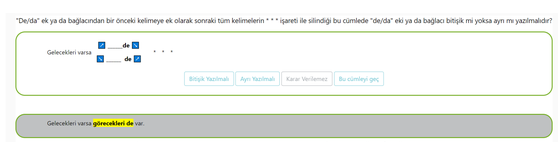
Mode 1*: Mask a random word.*



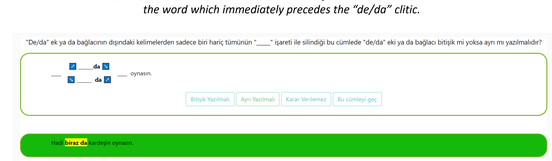
Mode 2*: Mask all the words which come after the “de/da” clitic.*

Mode 3*: Mask all the words which come before the “de/da” clitic excluding the one which immediately precedes the “de/da” clitic.*

Mode 4*: Mask all the words which come before the “de/da” clitic.*



Mode 5*: Mask all the words which come after the “de/da” clitic and the word which immediately precedes the “de/da” clitic.*

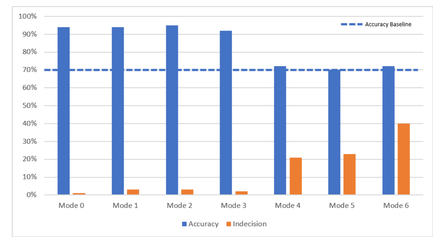


Mode 6*: Mask all the words except a random word.*

The “de/da” Spellchecker

Preliminary Results of the GWAP Experiment

- 447 people participated to the experiment and 13536 questions were solved in total.



- According to results of Mode 0, our participants had 94% success in determining of correct spelling of “de/da” clitic.
- Accuracy of the Mode 2 and 4 are **95%** and **72%** respectively. This shows that words which come **before** the “de/da” clitic are more important than the words which come **after.**
- Accuracy of the Mode 2 and 5 are **95%** and **70%** respectively. This shows that the word which immediately precedes the “de/da” clitic has a crucial role in the correct spelling.

Discussion and Future Work

- The findings of the explanation approach can be used to improve the spellchecker.
- This model has the potential to be integrated into a general-purpose spellchecker.

Acknowledgements

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References

[1]: Ribeiro, M. T., Singh, S., & Guestrin, C. (2016, August). " Why should i trust you?" Explaining the predictions of any classifier. In *Proceedings of the 22nd ACM SIGKDD international conference on knowledge discovery and data mining* (pp. 1135-1144).