# Multitask Learning for Grapheme-to-Phoneme Conversion of Anglicisms in German Speech Recognition

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# Agenda

1. Problem Definition
2. Related Work
3. Proposed Approach
4. Experimental Setup
5. Evaluation and Results
6. Conclusion


 

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Chapter 01

# Problem Definition

 

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# Problem Definition

## Anglicisms in German Speech

> An Anglicism is a word or idiom that is recognizably English in its form (spelling, pronunciation, morphology, or at least one of the three), but is accepted as an item in the vocabulary of the receptor language.
>
> **(Görlach, 1994, p.224)**

- 4.5 % of words in German speech are Anglicisms (Hunt, 2019)
- Use of Anglicisms is steadily increasing (Burmasova, 2010)

# Problem Definition

## Anglicisms in German Speech

- Anglicisms (mostly) do not follow German pronunciation rules

- German G2P model uses German "pronunciation rules" to generate pronunciations
  - Generating pronunciations for words of English heritage with a German system can lead to wrong pronunciations
  - Potentially wrong entries in the pronunciation dictionary for Anglicisms

- Why not just use the English source pronunciations?
  - Can contain phonemes that are not present in the DE phoneme set
  - Anglicisms are inflected using the target languages grammar
    - Example: downgeloadet

→ **We need a different solution!**

Chapter 02

# Related Work

 

# Related Work

## Multitask Learning, Seq2Seq LSTM and Multilingual G2P Approaches

- **Caruana (1993): Multitask Learning: A Knowledge-Based Source of Inductive Bias**
  - Approach of modeling the human concept of inductive transfer to a machine learning model
  - MTL model will learn multiple tasks in parallel
- **Yao and Zweig (2015): Sequence-to-Sequence Neural Net Models for Grapheme-to-Phoneme Conversion**
  - Based on Sutskever et al. (2014) → Seq2Seq LSTM model for machine translation
  - DNN approach utilizing LSTM cells in an encoder-decoder architecture
- **Milde et al. (2017): Multitask Sequence-to-Sequence Models for Grapheme-to-Phoneme Conversion**
  - Multilingual Seq2Seq G2P models utilizing multitask learning to train simultaneously on a German and English G2P task
  - MTL models did not outperform the baseline Sequitur G2P model, not even for English loan words
- **Sokolov et al. (2019): Neural Machine Translation for Multilingual Grapheme-to-Phoneme Conversion**
  - Multilingual Seq2Seq G2P model using transfer learning to improve performance on foreign words from different languages
  - Increased PER and WER for German with multilingual model

Chapter 03

# Proposed Approach

 

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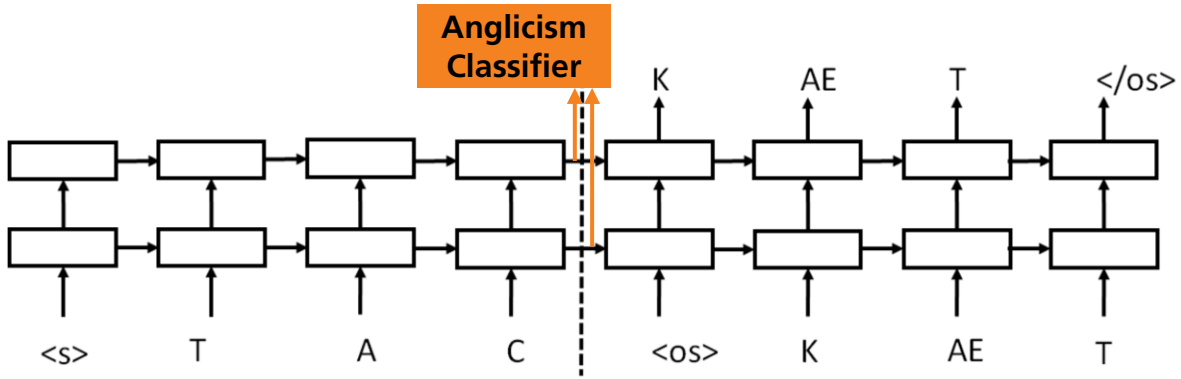
# Proposed Approach

## Multitask Seq2Seq G2P Model

- DE Seq2Seq G2P model based on Yao and Zweig (2015) with an additional classification task




- Model will learn how to distinguish Anglicisms based on encoder output
- Anglicism pronunciations will be generated with different "pronunciation rules" than native German words

Chapter 04

# Experimental Setup

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# Experimental Setup

## Datasets

- **Anglicism list** derived from Wiktionary and VDS Anglizismenindex[1] (18,967 words)
  - Wiktionary provides lists of "Anglizismen[2]" and "Scheinanglizismen[3]" (pseudo-anglicisms)
  - Additionally tried to find inflections of Anglicisms
- **German pronunciation dictionary** PHONOLEX Core (65,427 entries)
- **Pronunciations from Wiktionary** based on Anglicism list (9,802 pronunciations)
- **Anglicism ASR test set** including segments with Anglicism usage (1,3 h)

| | Person | Wortform |
|---|---|---|
| **Präsens** | ich | streame |
| | du | streamst |
| | er, sie, es | streamt |
| **Präteritum** | ich | streamte |
| **Konjunktiv II** | ich | streamte |
| **Imperativ** | Singular | stream!<br>streame! |
| | Plural | streamt! |
| **Perfekt** | **Partizip II** | **Hilfsverb** |
| | gestreamt | haben |
| *Alle weiteren Formen:* Flexion:streamen | | |

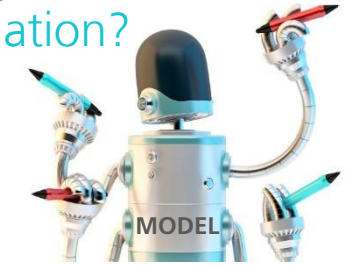
Inflection box on a Wiktionary page (https://de.wiktionary.org/wiki/streamen)

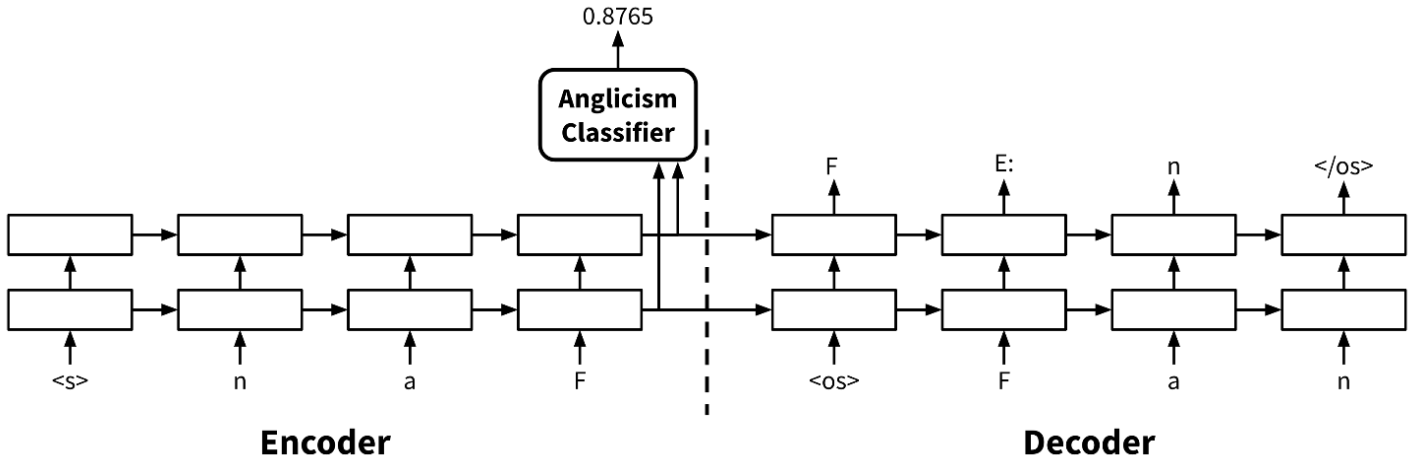
1. https://vds-ev.de/arbeitsgruppen/deutsch-in-der-oeffentlichkeit/ag-anglizismenindex
2. https://de.wiktionary.org/wiki/Verzeichnis:Deutsch/Anglizismen
3. https://de.wiktionary.org/wiki/Verzeichnis:Deutsch/Anglizismen/Scheinanglizismen

# Experimental Setup

## Implementation

Anglicism or not?
Pronunciation?




- We rebuilt the encoder-decoder LSTM model from Yao and Zweig (2015)
- Added a binary classification task after the encoder step to "detect" Anglicisms
- Losses were combined to optimize on both tasks

→ Resulting model generates a phoneme sequence and classifies whether the input sequence is considered an Anglicism

Chapter 05

# Evaluation and Results

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# Evaluation and Results

## MTL Evaluation

| | | | | G2P Task | | Anglicism Classification Task | | | |
|---|---|---|---|---|---|---|---|---|---|
| **G2P Model** | **Data Source & Specifics** | **Epochs** | **Iter. / Epoch** | **PER** | **WER** | **Accu.** | **Prec.** | **Recall** | **F1** |
| $MTL_{Base}$ | PHONOLEX Core | 7 | 2498 | *5.68* | *24.43* | *98.03* | *0.00* | *0.00* | *0.00* |
| $MTL_{Wiki}$ | $MTL_{Base}$ + Wiktionary | 6 | 2845 | 8.63 | 30.89 | 91.24 | 80.69 | 54.26 | 64.89 |
| $MTL_{WL}$ | $MTL_{Wiki}$ + weighed losses ($\alpha = 0.7$) | 7 | 2845 | **7.87** | **28.03** | **92.42** | 86.71 | 58.14 | 69.61 |
| $MTL_{DS}$ | $MTL_{Wiki}$ + downsampled data | 16 | 806 | 11.21 | 39.63 | 88.66 | **90.30** | **86.63** | **88.43** |

- **$MTL_{Base}$**: Only negative classifications because of the class imbalance in PHONOLEX Core (~2 % Anglicism ratio)
- **$MTL_{Wiki}$**: Adding in Wiktionary Anglicism pronunciations to raise Anglicism ratio to ~16 %
- **$MTL_{WL}$**: Altered loss summation by including an additional $\alpha$ parameter ($\alpha = 0.7$) to weight the tasks accordingly:

$$Total\ Loss = \alpha * Decoder\ Loss + (1 - \alpha) * Classifier\ Loss$$

- **$MTL_{DS}$**: Downsampled training data (50 % Anglicism ratio) with equal loss summation (no $\alpha$ parameter)

# Evaluation and Results

## ASR Evaluation

- Chose models $MTL_{WL}$ and $MTL_{DS}$ to test the results in an ASR model
- Generated Anglicism pronunciations based on the Anglicism list (18,967 entries)
- Added resulting Anglicism pronunciations to a baseline ASR models pronunciation dictionary
- Created two control ASR models by generating Anglicism pronunciations with a DE Sequitur and a DE Seq2Seq G2P model

# Evaluation and Results

## ASR Evaluation

- ASR test sets:
  - Anglicisms 2020 → German test set with heavy Anglicism usage
  - German Broadcast 2020
  - Challenging Broadcast 2018

  } Typical German broadcast test sets (control groups)

- Measured WER to determine overall performance of the added pronunciations

- Additionally measured Anglicism error rate (AER) for test set "Anglicisms 2020"
  - Every Anglicism in the test set was flagged as an entity
  - AER represents ratio of wrongly recognized Anglicisms

Levenshtein Distance

WER

Julia ist cool
Julia isst Kuh

→ **2 word errors**

Anglicism not recognized

AER

Julia ist **cool**
Julia isst **Kuh**

→ **1 Anglicism error**

# Evaluation and Results

## ASR Results

| | Anglicisms 2020 | | | | |
|---|---|---|---|---|---|
| **Model** | **WER (%)** | **AER (%)** | **Recognized Anglicisms** | **German Broadcast 2020 (%)** | **Challenging Broadcast 2018 (%)** |
| Baseline (Gref et al., 2019) | 15.80 | 39.50 | 824 | **6.56** | **10.84** |
| Sequitur | 15.76 | 39.35 | 826 | 6.56 | 10.82 |
| Seq2Seq | 15.75 | 39.28 | 827 | 6.56 | 10.91 |
| $MTL_{WL}$ | **15.65** | 38.33 | 840 | 6.57 | 10.86 |
| $MTL_{DS}$ | 15.67 | 38.40 | 839 | 6.60 | 10.90 |
| Wav2Vec2 | 15.69 | 42.07 | 789 | 9.34 | 9.48 |

- MTL models outperformed the non-MTL models → $MTL_{WL}$ showed the best WER
- Additional Anglicism pronunciations did not significantly impact the performance of German control test sets
- Wav2Vec2 showed highest AER (42.07 %) which even exceeded the baseline model

# Evaluation and Results

## Real World Example

- Correct pronunciation for "Views" (→ /v j u: s/) eliminated a word error
- "Views" (also singular "View") was not included in the training / validation data

| Segment 8 in "Rezo - Die Zerstörung der Presse" from test set "Anglicisms 2020" | |
|---|---|
| Reference | […] haben teilweise Millionen von Views |
| Baseline | […] haben teilweise Millionen von Virus |
| Sequitur | […] haben teilweise Millionen von Virus |
| Seq2Seq | […] haben teilweise Millionen von Virus |
| $MTL_{WL}$ | […] haben teilweise Millionen von Views |
| $MTL_{DS}$ | […] haben teilweise Millionen von Views |

| Views | |
|---|---|
| **Model** | **Pronunciation** |
| Baseline | v j E f s |
| Sequitur | v j E f s |
| Seq2Seq | f i: v s |
| $MTL_{WL}$ | v j u: s |
| $MTL_{DS}$ | v j u: s |

Chapter 06

# Conclusion

# Conclusion

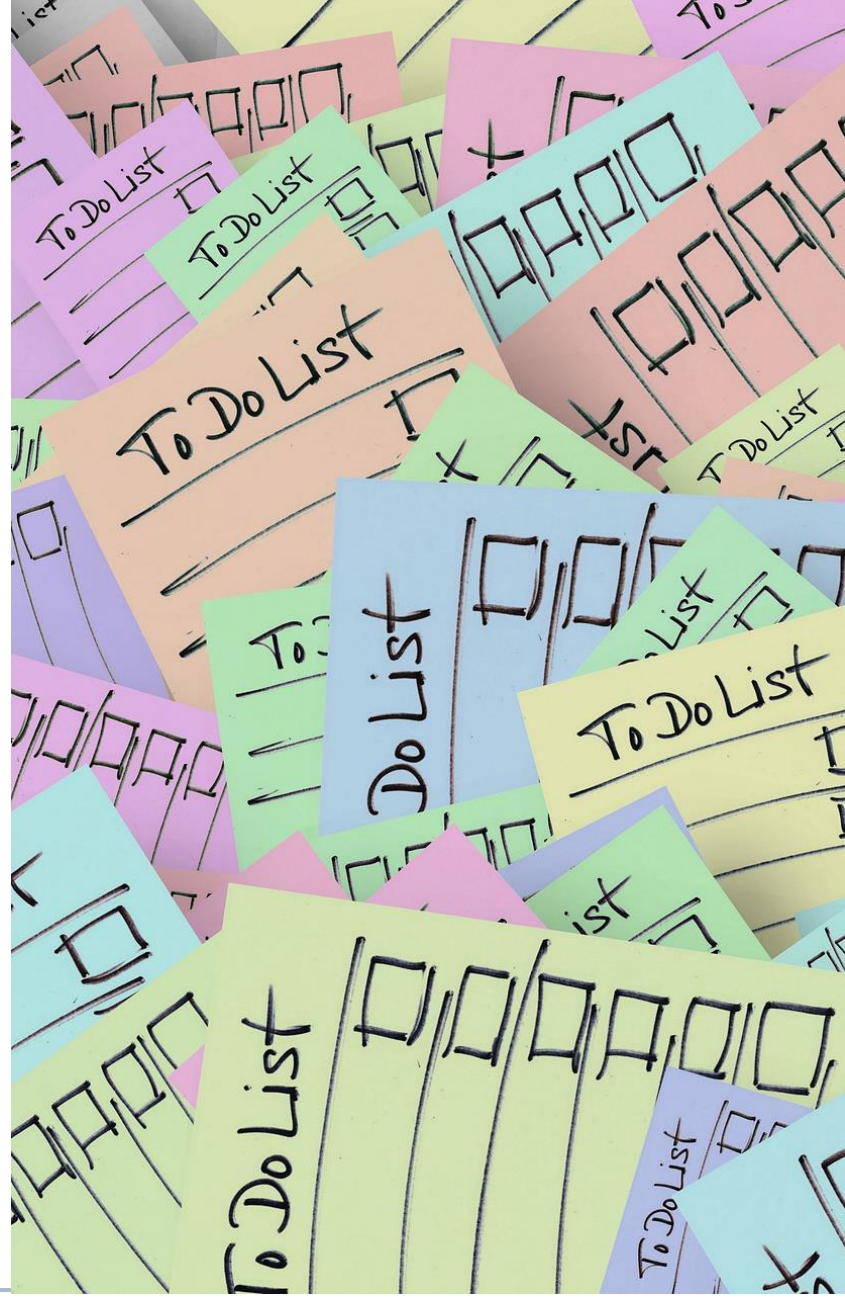
## Summary

- Improved Anglicism recognition results by generating and adding Anglicism pronunciations to the ASR model's pronunciation dictionary
- WER $-1\%$ relative and AER $-3\%$ relative
- No performance loss in control test sets, which are typical use cases in the DE broadcast domain
- Only uses phonemes of the German phoneme set
- Can also be used for other target languages (e.g. Spanish)

# Conclusion

## Future Work

- Experiment with the tuning criteria, e.g. focusing more on the classification results to better deal with the class imbalance
- Assess different architectures to improve the shared knowledge of tasks in the model
- Look more into end-to-end models



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# Thank you for your attention!

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# Sources

## Images

- Agenda: https://pixabay.com/photos/a-book-agenda-table-notes-notebook-3043275
- "Denglisch" comic: https://static.dw.com/image/50102546_403.png
- Dictionary icon: https://www.iconpacks.net/free-icon/pink-book-4999.html
- Screenshot Wiktionary: https://de.wiktionary.org/wiki/streamen
- Multitasking robot: https://www.slon.pics/wp-content/uploads/2018/07/Four-arm-robot-with-pencils.-Multitasking-concept-20036.jpg
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