Including Linguistic Knowledge in an Auxiliary Classifier CycleGAN for Corrective Feedback Generation in Korean Speech

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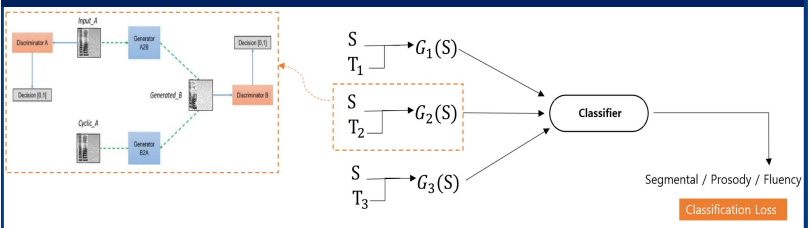
1. Introduction

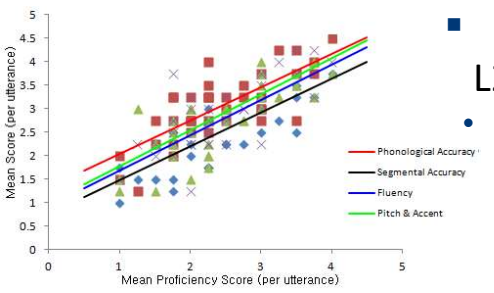
- Research Background
  - Corrective Feedback Generation for Computer-Assisted Pronunciation Training System Development for L2 Korean
- Self-imitating Feedback Generation Using CycleGAN (Yang, 2019))
  - Transplant native characteristics onto learners' voice
  - Interpret correction as a style transfer task
  - Utilise the generative ability for speech correction
- Problem Definition
  - Although the generator seems to have acquired what to correct with the adversarial training, this information is shared with the learner
  - Difficult to evaluate one's own pronunciations
  - Given non-native speech input, generate a corrected utterance with linguistic knowledge

2. Proposed Method



- AC-CycleGAN consists of 3 CycleGANs, corresponding to a linguistic class, and a domain classifier
- For each linguistic class, a CycleGAN with 2 discriminators and two 2 mapping functions as generators,
- synthetic sample is generated from the source
- The domain classifier learns to ensure the discriminability between the generated samples

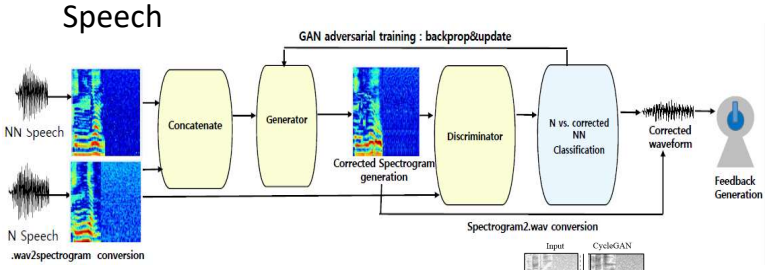
3. Linguistic Analysis



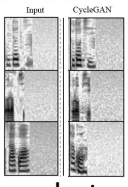
- Factors Affecting L2 Korean Speech
  - segmental accuracy (r= 0.81), fluency (r= 0.80), pitch and accent (r= 0.76), and phonological accuracy (r= 0.74)
- Correlation Analysis of Human Accented Ratings (Yang, 2017)

4. Experiment

- Corpus
  - 300 read speech from Korean as a Foreign Language Speech
  - 107 Native, 217 Learners with 27 L1 background
  - Training
    - 97,038 spectrogram images of 324 speakers
  - Testing
    - 162 spectrogram images
- Process
  - Auxiliary Classifier: Annotated Spectrograms →
  - CycleGAN: Speech → Spectrogram (Short-Time Fourier Transform using Griffin Lim Algorithm) → Adversarial Training → Spectrogram → Speech



- The Generator
  - Input: Learners' spectrogram
  - Output: Corrected spectrogram
  - Adversarial learning: Minimax game between G and D



$$\min_G \max_D V(D,G) = \mathbb{E}_{X\sim Pdata(X)}[\log D(X)] + \mathbb{E}_{Z\sim Pz(Z)}[\log(1-D(G(Z)))]$$

  - Add Cycle-consistency Loss
  - Cycle-consistency loss is built between real samples and their corresponding reconstructed samples.

$$L_{cyc}(G,F) = \mathbb{E}_{x\sim Pdata(x)}[\|F(G(x) - x\|_1] + \mathbb{E}_{y\sim Pdata(y)}[\|G(F(y) - y\|_1].$$

5. Conclusion

- New a machine learning method that retains domain knowledge
- AC-CycleGAN allows to work closely with linguistic analyses and machine learning
- Linguistic analysis results can be directly used in the automatic system

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