|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Metric | BLUE 4 | | WER | |
| PreTrain(on/off)  Signer | No PreTrain | PreTrain | No PreTrain | PreTrain |
| Signer 1 | 0.32 | 0.32 | 0.033 | 0.087 |
| Signer 2 | 0.30 | 0.32 | 0.22 | 0.025 |
| Signer 3 | 0.33 | 0.33 | 0.032 | 0.013 |
| Signer 4 | 0.31 | 0.32 | 0.085 | 0.119 |
| Signer 5 | 0.32 | 0.31 | 0.015 | 0.029 |
| Signer 6 | 0.31 | 0.31 | 0.042 | 0.025 |

# Signer Dependent

# Signer Independent

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Metric | BLUE 4 | | WER | |
| PreTrain(on/off)  Signer | No PreTrain | PreTrain | No PreTrain | PreTrain |
| Signer 1 | 0.14 | 0.15 | 0.572 | 0.564 |
| Signer 2 | 0.12 | 0.15 | 0.672 | 0.590 |
| Signer 3 | 0.06 | 0.09 | 0.893 | 0.796 |
| Signer 4 | 0.1 | 0.06 | 0.702 | 0.774 |
| Signer 5 | 0.07 | 0.11 | 0.719 | 0.712 |
| Signer 6 | 0.04 | 0.05 | 0.759 | 0.736 |

**Process Overview:**

1. **Pretraining Phase (phoenix\_best.pt)**

* Used Phoenix dataset to pretrain the model on sign language to text translation
* Dataset: [phoenix14t.pami0.train](vscode-file://vscode-app/c:/Users/adams/AppData/Local/Programs/Microsoft%20VS%20Code/resources/app/out/vs/code/electron-sandbox/workbench/workbench.html) for training, [phoenix14t.pami0.dev](vscode-file://vscode-app/c:/Users/adams/AppData/Local/Programs/Microsoft%20VS%20Code/resources/app/out/vs/code/electron-sandbox/workbench/workbench.html) for validation
* Model Architecture:
  + Bidirectional GRU Encoder: processes sign language features
  + Unidirectional GRU Decoder: generates text output
  + Features are (seq\_len, batch\_size, 1024) dimensional
  + Hidden states properly combine bidirectional information

1. **Transfer Learning to Arabic Dataset**

* Load pretrained weights from [phoenix\_best.pt](vscode-file://vscode-app/c:/Users/adams/AppData/Local/Programs/Microsoft%20VS%20Code/resources/app/out/vs/code/electron-sandbox/workbench/workbench.html)
* Apply transfer learning techniques:
  + Freeze encoder layers initially (they contain generic sign language features)
  + Use lower learning rate for encoder vs decoder
  + Gradually unfreeze encoder layers during training
* Train on Arabic sign language dataset while leveraging the pretrained knowledge

**Checkpoint File (.pt/.pth) Contents:**

checkpoint = {

    'epoch': last\_epoch\_number,

    'model\_state\_dict': {

        'encoder.lstm.weight\_ih\_lN': tensor(...),  # Encoder layer weights

        'encoder.lstm.weight\_hh\_lN': tensor(...),  # Encoder hidden weights

        'encoder.lstm.bias\_ih\_lN': tensor(...),    # Encoder layer biases

        'encoder.lstm.bias\_hh\_lN': tensor(...),    # Encoder hidden biases

        'decoder.embed.weight': tensor(...),        # Decoder embedding weights

        'decoder.lstm.weight\_ih\_lN': tensor(...),  # Decoder layer weights

        'decoder.lstm.weight\_hh\_lN': tensor(...),  # Decoder hidden weights

        'decoder.lstm.bias\_ih\_lN': tensor(...),    # Decoder layer biases

        'decoder.lstm.bias\_hh\_lN': tensor(...),    # Decoder hidden biases

        'decoder.fc.weight': tensor(...),          # Decoder output layer weights

        'decoder.fc.bias': tensor(...)             # Decoder output layer biases

    },

    'optimizer\_state\_dict': {

        'state': {...},                           # Optimizer states (momentum, etc.)

        'param\_groups': [{                        # Parameter group settings

            'lr': learning\_rate,

            'weight\_decay': weight\_decay,

            ...

        }]

    },

    'scheduler\_state\_dict': {                     # Learning rate scheduler state

        'best': best\_validation\_loss,

        'cooldown\_counter': counter,

        'mode': 'min',

        ...

    },

    'loss': best\_loss\_value,

    'vocab': vocabulary\_dictionary              # Maps words to indices

}

**Key Points About the Process:**

1. **Pretraining Benefits**:
   * Model learns general sign language features from Phoenix dataset
   * Encoder develops understanding of temporal patterns in sign language
   * Decoder learns language modeling for translation tasks
2. **Transfer Learning Strategy**:
   * Keep encoder weights (feature extraction) from pretraining
   * Replace decoder layers (language generation) for Arabic
   * Use gradual unfreezing to fine-tune the model
3. **Checkpoint File Usage**:

# Loading pretrained weights

checkpoint = torch.load('phoenix\_best.pt')

model.load\_state\_dict(checkpoint['model\_state\_dict'], strict=False)

# Optional: Load optimizer state if continuing training

optimizer.load\_state\_dict(checkpoint['optimizer\_state\_dict'])

# Optional: Load scheduler state

scheduler.load\_state\_dict(checkpoint['scheduler\_state\_dict'])

1. **Weight Transfer Process**:
   * Encoder weights: Preserved from pretraining (sign language understanding)
   * Decoder weights: Initially random for Arabic (new vocabulary)
   * Embedding layer: Reset for new vocabulary
   * Output layer: Adjusted for new vocabulary size

This approach allows the model to:

1. Learn general sign language features from the larger Phoenix dataset
2. Adapt those features to Arabic sign language
3. Learn Arabic text generation from scratch
4. Benefit from the pretrained knowledge while specializing for Arabic

The process combines the benefits of pretraining (better feature extraction) with the specificity needed for Arabic sign language translation.

now lets move to 4.2 GRU Model

Talk about the model and its architecture.

Explain that the model support two modes -Signer Independent and Signer Dependent-, clarifying each one and how they differ and how they uses the dataset differently.

Reproducing the Results and Train And evaluate the baseline model as first step, and then show the results and plots has been produced and resulted from the model.

these are the results

1. Signer Dependent

BLUE 4 WER

Signer No PreTrain PreTrain No PreTrain PreTrain

Signer 1 0.32 0.32 0.033 0.087

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2. Signer Independent

BLUE 4 WER

Signer No PreTrain PreTrain No PreTrain PreTrain

Signer 1 0.14 0.15 0.572 0.564

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