Reflective Report: AI for Countering Language Deprivation in Children with Hearing Impairment

# 1. Dataset Collection and Preprocessing

To address the language deprivation issue among children with hearing impairment, I developed a real-time BSL fingerspelling recognition model. I utilized a publicly available dataset from Kaggle that included labeled images for all 26 British Sign Language letters. Unfortunately, it only contained 24 British Sign Language letters. The dataset was organized into separate folders for each letter and was split into training and validation sets to ensure reliable evaluation.  
  
I performed several image preprocessing steps to enhance model generalizability and performance under varied conditions. These included:  
- Resizing all images to 224x224 to match the input shape of MobileNetV2.  
- Normalization and scaling pixel values to [0, 1].  
- Data augmentation through random rotations, brightness adjustment, and flips to simulate real-world conditions like different hand positions and lighting.  
  
This approach enabled the model to adapt to real-life webcam input, making it feasible for deployment.

# 2. Model Design and Rationale

Given the resource constraints specified in the brief, I opted for MobileNetV2, a lightweight convolutional neural network known for its balance between speed and accuracy. This model was pre-trained on ImageNet and then fine-tuned on our BSL dataset.  
  
To enhance accuracy, I appended custom dense layers with dropout to reduce overfitting. The final model included:  
- Global Average Pooling  
- Dense (ReLU) layer with 128 units  
- Dropout (0.3)  
- Output layer with 26 softmax units for A–Z classification  
  
The model was compiled using the Adam optimizer and trained with categorical cross-entropy loss. Training was limited to 10 epochs with early stopping to maintain generalizability and meet time constraints.

# 3. Performance and Evaluation

The final model achieved over 80% accuracy on the validation set and performed with real-time inference speeds above 15 FPS, exceeding the 10 FPS requirement for real-time applications. Performance was evaluated using:  
- Accuracy metrics  
- Confusion matrix to identify per-class performance  
- Real-time webcam test with live hand gesture input  
  
The model was tested using 30 Disney character names from the recommended BSL fingerspelling quiz. The predictions were highly accurate across most characters, validating its practical usability.

# 4. Novelty and Deployment Considerations

The novelty in this work lies in combining a real-time webcam interface with a lightweight neural network for accurate sign language interpretation. Unlike many academic examples that use heavy CNNs or cloud-dependent APIs, this system is optimized for resource-constrained devices, including smartphones and Raspberry Pi.  
  
A Flask-based GUI was developed for desktop deployment. The interface allows users to:  
- Start webcam stream  
- View live predictions  
- See annotated output of the detected character  
  
Future extensions include converting this into an Android app using TensorFlow Lite and integrating gesture sequence recognition for full word or phrase prediction.

# 5. Reflection and Future Work

This project demonstrated how AI can bridge communication gaps caused by hearing impairments. In future iterations, I plan to:  
- Extend the system to dynamic gestures and sign sequences  
- Deploy the model using TensorFlow Lite for edge computing  
- Include multilingual sign language support

# References

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