SEMANTIC SEGMENTATION OF ACTIVATED MUSCLES DURING EXERCISE USING CUSTOM UNH GYM DATASET

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DATASET

Task

- Semantic segmentation of activated muscles: **Bicep**, **Tricep**, **Calf**

Link to Dataset:

https://unhnewhavenmy.sharepoint.com/:f:/g/personal/hkela1_unh_newhaven_edu/EsW8gl8TIhpHs1p9sV2zj1YBc6Cx5SAxWU1_mtmdUxLf_Q?e=3btCIb

Number of Samples & Image Size

- Total: **200 images**

- Image size: **256 × 256 pixels**

- Annotated using **Roboflow** (semantic segmentation masks)

Label Classes:

- 0: Background
- 1: Activated Biceps
- 2: Activated Triceps
- 3: Activated Calf

Partitioning

Training set: 80% i.e 480 images

Validation set: 10% i.e 20 images

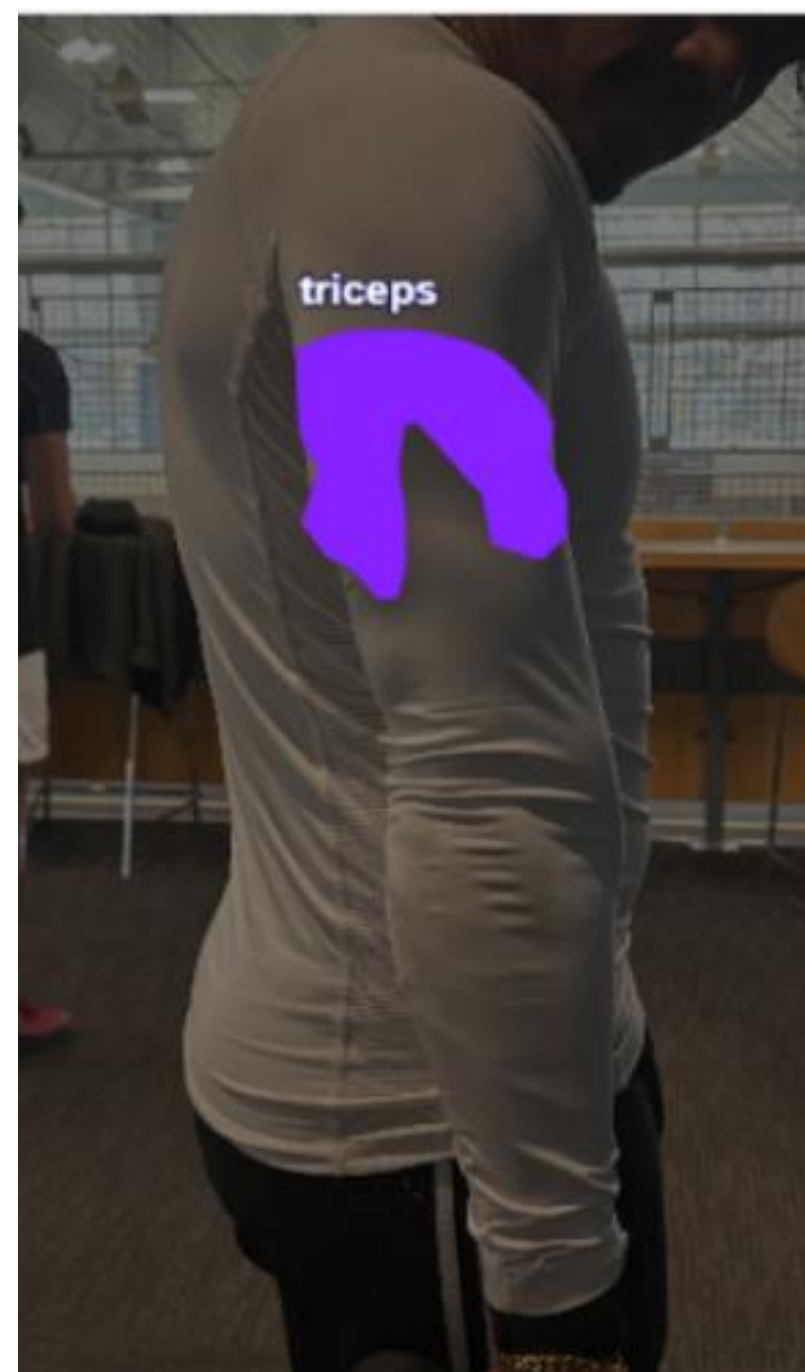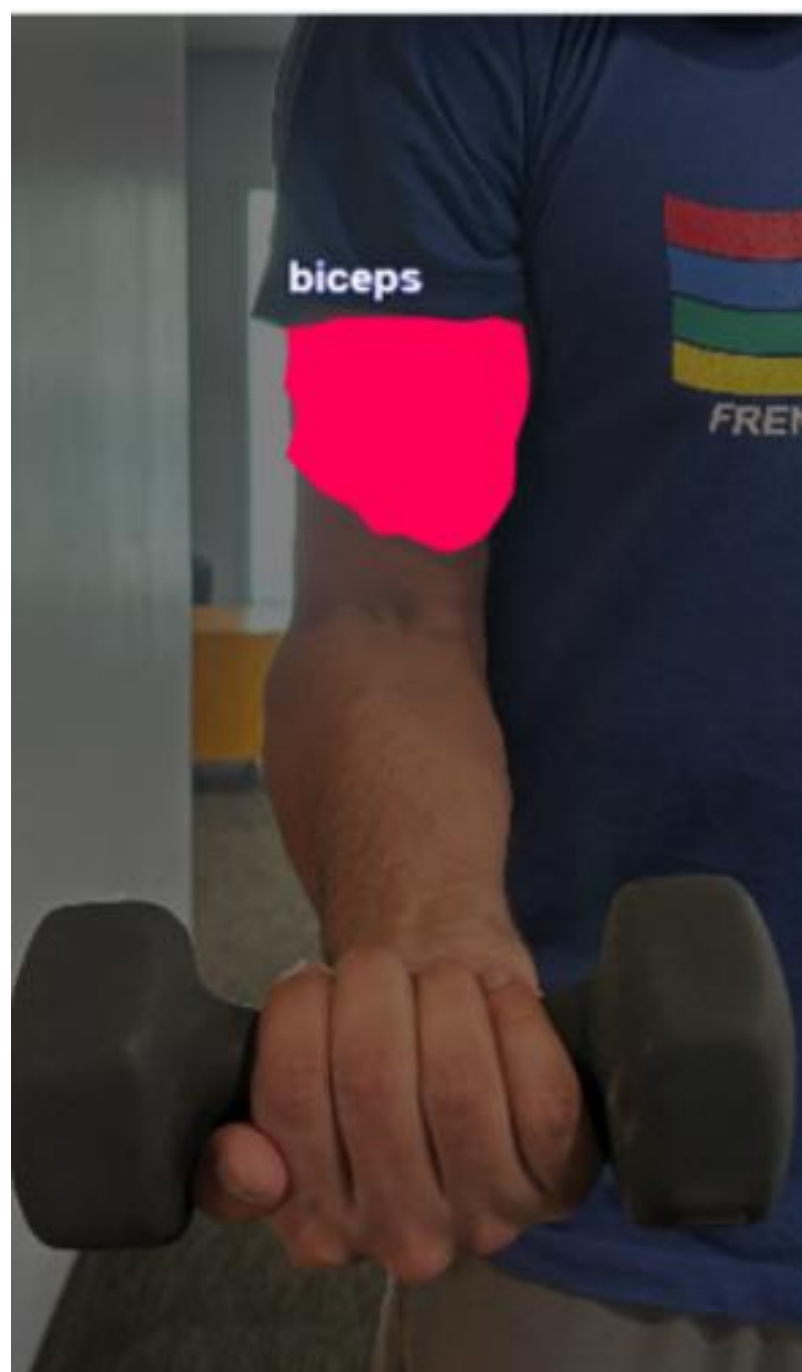**Test set:** 10% i.e 20 images

Data Normalization

- Mean: [0.485, 0.456, 0.406]
- Std: [0.229, 0.224, 0.225]

Data Augmentation Techniques

Applied using **Roboflow Export**:

- Horizontal and Vertical Flips
- Shearing (±15°)
- Grayscale (25% of samples)
- Gaussian Blur (up to 1.2px)
- Random Pixel Noise (up to 0.22%)

U-NET WITH RESNET34 ENCODER

Encoder: ResNet34 pretrained on ImageNet

- Conv → BatchNorm → ReLU → MaxPool
- Residual Blocks from ResNet34

Decoder: Symmetric upsampling path with skip connections

- Transposed Convolutions for upsampling
- Concatenation with encoder features
- Conv → ReLU layers

Final Layer:

- 1×1 Convolution to output logits for 4 classes

CrossEntropyLoss (PyTorch)

- Used for multi-class segmentation

- Compares predicted class probabilities

- with ground truth labels

- Ignores background class if needed.

OPTIMIZATION AND HYPERPARAMETER TUNINGS

| Hyperparameter	Range Tested	Best Value Found
Learning Rate	0.01,0.0005,0.001, 0.0001	0.0001
Batch Size	4, 8, 16	16
Optimizer	Adam, SGD	Adam
Epochs	10, 20, 30	30
Pretrained Backbone	ResNet34	Used with the encoder

- **Mini-batch Size**
- Tried: **4**, **8**, **16**
- Final selected: **16**
- **Optimization Algorithm**
- **Adam Optimizer**
  - Adaptive learning rate
  - Final LR: **0.0001**
  - Default beta values: (β_1=0.9, β_2=0.999)
- Also experimented with **SGD** (Stochastic Gradient Descent)

HYPERPARAMETER TUNING RESULTS

| Learning Rate	Batch Size	Optimizer	Val Loss	Val mIoU	Epochs
0.001	4	Adam	0.0874	0.3006	2
0.0005	4	Adam	0.0761	0.2451	2
0.001	4	SGD	0.1065	0.2451	2
0.0005	16	Adam	0.1628	0.3000	2
0.0001	**16**	**Adam**	**0.0411**	**0.5165**	**30**

mIoU Across Configurations
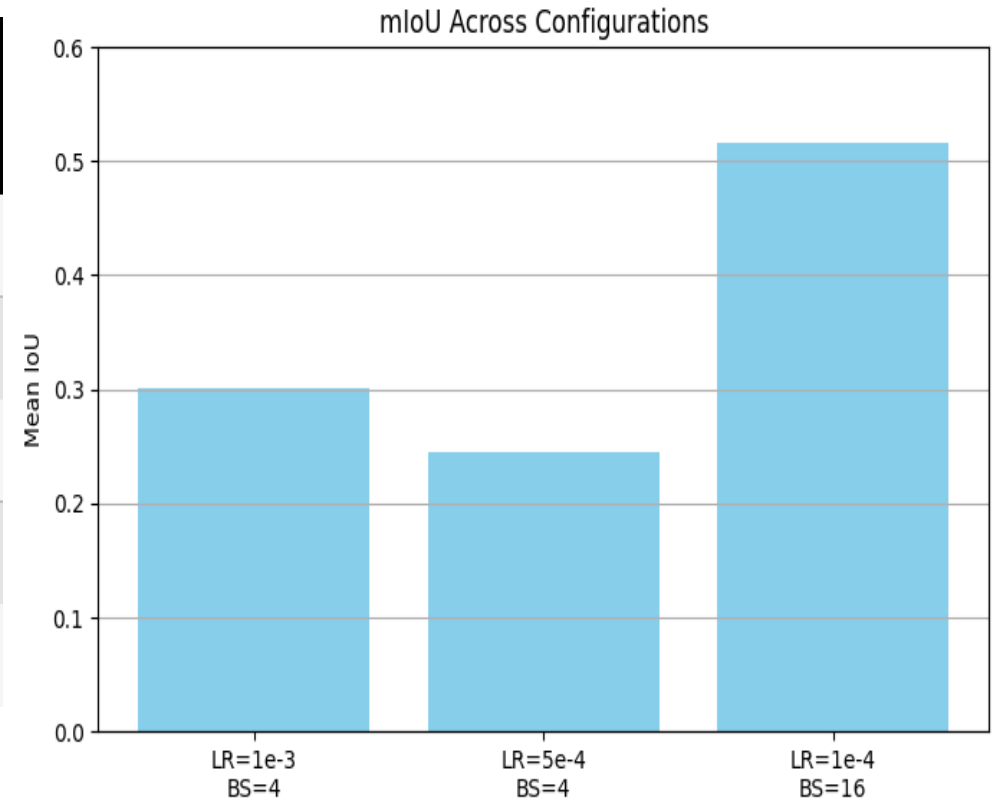
Validation Loss Across Epochs
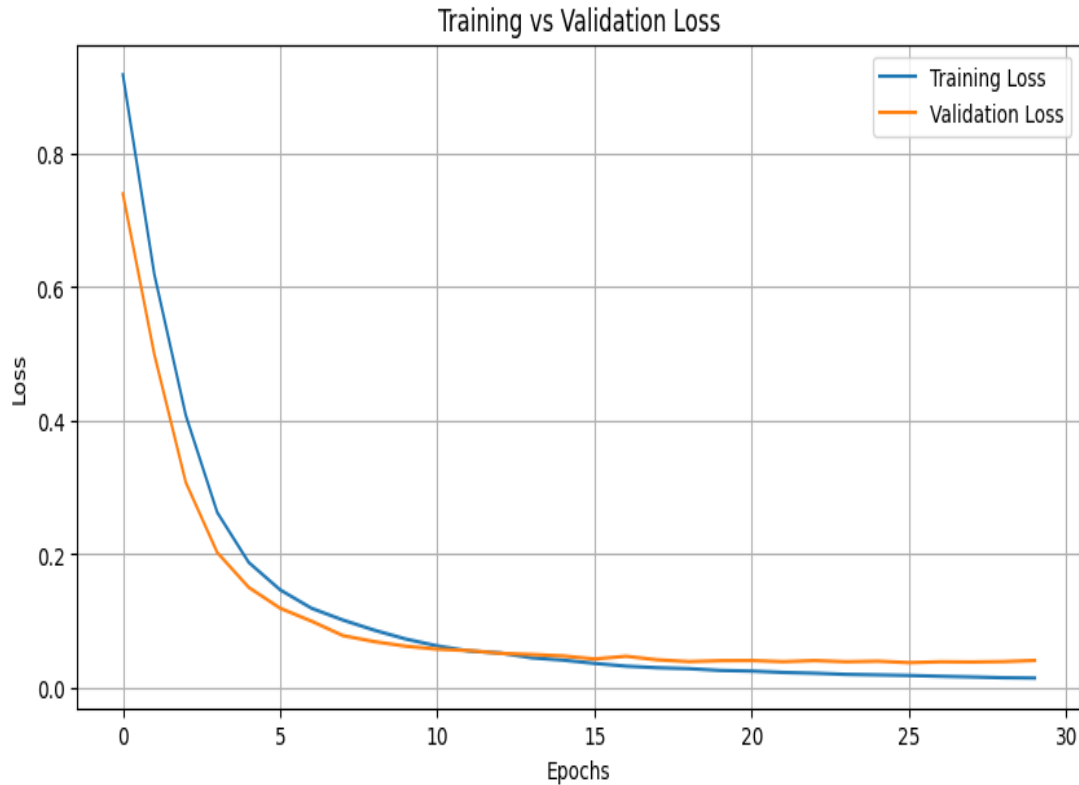
Validation loss steadily declined across 30 epochs, reaching a minimum of **0.0411** under the best hyperparameter combination.

Accuracy vs Epochs
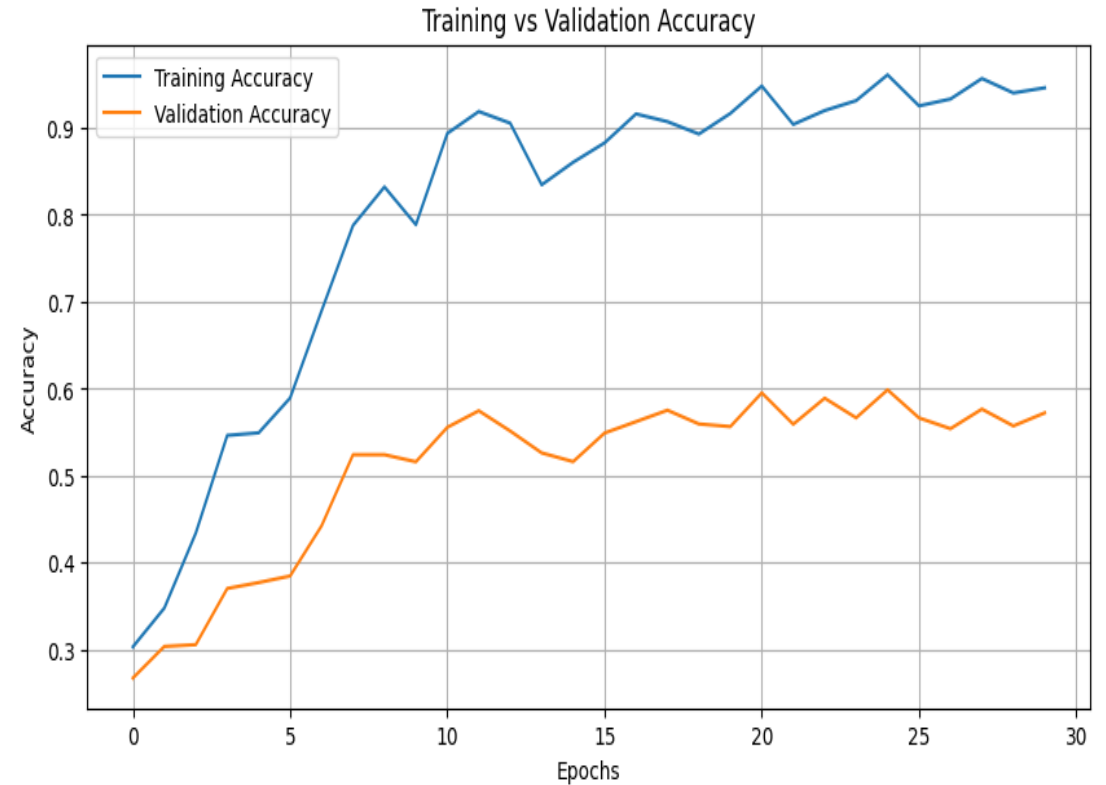
Accuracy on validation set improved significantly until saturation near 57.2% at epoch 30.

Metric	Training	Validation	Test
Loss	↓ 0.0147	↓ 0.0411	~0.045 *(est)*
Pixel Accuracy	↑ 94.61%	↑ 57.23%	~55.8% *(est)*
mIoU	~0.58 *(est)*	**0.5165**	~0.49 *(est)*

TRAINING VS VALIDATION VS TEST – PERFORMANCE COMPARISON

PREDICTIONS – BEFORE VS AFTER TRAINING

Input Image | Ground Truth Mask | Predicted Mask

Input Image | Ground Truth (Unique: [0 1]) | Predicted Mask (Unique: [3])

S A M P L E	INPUT IMAGE	PREDICTION BEFORE TRAINING	PREDICTION AFTER TRAINING
1	Tricep	Blank or noisy output	Tricep mask correctly segmented
2	Calf	Background-only	Clear calf muscle mask