

# Improving Pix2Pix Model Performance

To improve the performance of your Pix2Pix model based on the provided results, we can analyze the training and validation metrics (MSE, SSIM, FID, VGG Loss) and suggest hyperparameter adjustments. From the results, we observe the following trends:

1. **Discriminator Loss (D Loss)**: Starts high (1.257686) and decreases to ~0.684435 by epoch 6, indicating the discriminator is learning but might be overpowering the generator early on.
2. **Generator Loss (G Loss)**: Increases from 0.669260 to 1.122830, suggesting the generator is struggling to keep up with the discriminator.
3. **Perceptual Loss**: Varies significantly (e.g., 0.214663 to 0.410497), indicating instability in the generator's ability to produce perceptually realistic images.
4. **Validation Metrics**:
  - **MSE**: Decreases from 1.725764 to 2.030909, but still relatively high.
  - **SSIM**: Slightly improves but remains negative or near zero, indicating poor structural similarity.
  - **FID**: High and unstable (358.167542 to 457.821350), suggesting poor feature similarity to real images.
  - **VGG Loss**: Fluctuates (e.g., 4.261749 to 3.906608), showing inconsistent perceptual quality.

The generator appears to be lagging behind the discriminator, and the validation metrics suggest that the generated images lack realism and structural fidelity. Below are suggested hyperparameter adjustments to improve performance:

---

## Hyperparameter Suggestions

### 1. Learning Rates

- **Current**: ``lr_G = 0.00031`, `lr_D = 0.00002``
- **Suggestion**:
  - **Increase Discriminator Learning Rate**: Try ``lr_D = 0.0001``.
  - **Decrease Generator Learning Rate**: Reduce ``lr_G = 0.0002``.

### 2. Optimizer Betas

- **Current**: ``betas=(0.5, 0.999)``
- **Suggestion**:

- **Adjust Betas**: Use ``betas=(0.0, 0.999)`` or ``betas=(0.9, 0.999)``.

#### #### 3. Loss Weighting (Lambda Values)

- **Current**: ``lambda_l1 = 0.7``, ``lambda_gp = 12``
- **Suggestion**:
  - **Increase ``lambda_l1``**: Set ``lambda_l1 = 10.0``.
  - **Decrease ``lambda_gp``**: Reduce ``lambda_gp = 5.0``.

#### #### 4. Generator-to-Discriminator Update Ratio

- **Current**: Generator is updated 4 times per discriminator update.
- **Suggestion**:
  - **Reduce Ratio**: Update the generator 2 or 3 times per discriminator update.

#### #### 5. Learning Rate Scheduler

- **Current**: ``ReduceLROnPlateau`` with ``patience=4``, ``factor=0.5``
- **Suggestion**:
  - **Increase Patience**: Set ``patience=8``.
  - **Reduce Factor**: Use ``factor=0.7``.

#### #### 6. Dropout and Regularization

- **Current**: ``Dropout(p=0.1)`` in generator, ``Dropout(p=0.2)`` in discriminator.
- **Suggestion**:
  - **Reduce Dropout**: Use ``p=0.05`` in the generator and ``p=0.1`` in the discriminator.

#### #### 7. Batch Size

- **Suggestion**:
  - **Increase Batch Size**: Use 16 or 32.

#### #### 8. Label Smoothing

- **Current**: ``valid = 0.90``
- **Suggestion**:
  - **Two-Sided Smoothing**: Use ``valid = 0.9``, ``fake = 0.1``.

---

### ### Suggested Hyperparameter Set

- **Learning Rates**: `lr\_G = 0.0002`, `lr\_D = 0.0001`
- **Optimizer Betas**: `betas=(0.0, 0.999)`
- **Loss Weights**: `lambda\_l1 = 10.0`, `lambda\_gp = 5.0`
- **G:D Update Ratio**: 2:1
- **Scheduler**: `patience=8`, `factor=0.7`
- **Dropout**: `p=0.05` (generator), `p=0.1` (discriminator)
- **Batch Size**: 16 or 32
- **Label Smoothing**: `valid = 0.9`, `fake = 0.1`

---

### ### Expected Impact

- **MSE/SSIM**: Higher `lambda\_l1` should reduce MSE and improve SSIM.
- **FID**: Balanced G:D training and batch size increases should lower FID.
- **VGG Loss**: Stabilized generator updates should reduce perceptual loss fluctuations.
- **Training Stability**: Adjusted learning rates and ratios should prevent the discriminator from overpowering the generator.

Try this set, monitor the metrics, and tweak further based on trends. Let me know the results or if you need further refinements!