Data Augmentation via Mixed Class Interpolation using Cycle-Consistent Generative Adversarial Networks Applied to Cross-Domain Imagery

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Issue
Limited availability of non-visible imagery poses a significant challenge in object detection, classification and recognition.

Approach
Conditional CycleGAN Mixup Augmentation (C2GMA)

1. Increase non-visible datasets via image-to-image translation from visible datasets.

2. Modify CycleGAN model to use conditional GAN and train the model with class labels to enable class-specific image synthesis.

3. Infer class-interpolated images using the trained model and blended visible images / labels as input.

4. Augment dataset with the generated non-visible images.

C2GMA Architecture & Training

(1) Add the conditional batch normalization layer and the projection discriminator into CycleGAN.

(2) Train the model using visible and non-visible images with one-hot class labels.

(3) Infer the class-interpolated images using the trained model and blended visible images / labels as input.

(4) Augment dataset with the generated non-visible images.

Evaluation

Task: SAR ships / icebergs classification via AlexNet [4]

Benchmark Dataset: Variation of Statoil/C-CORE dataset [1]

Baseline: [BL] without data augmentation
[ROT] BL + rotated images
[MIXUP] BL + Mixup [3]
[MIXCG] BL + MixCycleGAN [5]

<table>
<thead>
<tr>
<th>Method</th>
<th>A</th>
<th>P</th>
<th>R</th>
<th>F1</th>
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<tbody>
<tr>
<td>BL</td>
<td>0.551 ± 0.142</td>
<td>0.562 ± 0.160</td>
<td>0.575 ± 0.130</td>
<td>0.568 ± 0.143</td>
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<tr>
<td>ROT</td>
<td>0.549 ± 0.137</td>
<td>0.554 ± 0.146</td>
<td>0.571 ± 0.124</td>
<td>0.562 ± 0.135</td>
</tr>
<tr>
<td>MIXUP [9]</td>
<td>0.715 ± 0.044</td>
<td>0.739 ± 0.051</td>
<td>0.719 ± 0.049</td>
<td>0.729 ± 0.050</td>
</tr>
<tr>
<td>MIXCG [27]</td>
<td>0.750 ± 0.048</td>
<td>0.752 ± 0.039</td>
<td>0.739 ± 0.045</td>
<td>0.745 ± 0.042</td>
</tr>
<tr>
<td>C2GMA (Ours)</td>
<td>0.754 ± 0.056</td>
<td>0.777 ± 0.042</td>
<td>0.762 ± 0.053</td>
<td>0.769 ± 0.047</td>
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Classification results: accuracy (A), precision (P), recall (R), and F1 scores (F1)

Conclusion

- A novel data augmentation for non-visible imagery:
  - Visible to non-visible image translation via class-conditioned CycleGAN-based method.
  - Trained model generates class-interpolated images improving mixup.
- Outperforms other traditional data augmentation approaches on a SAR ship / iceberg classification task.