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

Hiroshi Sasaki, Chris G. Willcocks, and Toby P. Breckon
Durham University

25th International Conference on Pattern Recognition - January 2021
Limited Data Availability
for Non-visible Domain Object Classification / Detection

Infrared (IR), synthetic aperture radars (SAR), X-ray, etc.

Expensive sensors (or export controlled)

Low inter-task availability
Approach  
- Data Augmentation -  
(1/2) 

Increase non-visible dataset via \textit{image-to-image translation} from visible dataset
Approach
- Data Augmentation - (2/2)

• Use CycleGAN\cite{1}-based model conditioned by image labels (object classes) for class-specific image synthesis

• Infer class-interpolated images to improve Mixup\cite{2}


ICPR2020 – Data Augmentation via Mixed Class Interpolation using Cycle-Consistent Generative Adversarial Networks Applied to Cross-Domain Imagery
Experiment (Dataset Setup)

Statoil/C-CORE Iceberg Classifier Challenge[3]

- Satellite C-band SAR images of ships / icebergs

separate training samples into 3 subsets

a) Easy to discriminate
b) Modelate to discriminate
c) Difficult to discriminate

![Images of ships and icebergs]

Number of samples

<table>
<thead>
<tr>
<th></th>
<th>Ship (a)</th>
<th>Ship (b)</th>
<th>Ship (c)</th>
<th>Total</th>
<th>Iceberg (a)</th>
<th>Iceberg (b)</th>
<th>Iceberg (c)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>97</td>
<td>158</td>
<td>171</td>
<td>426</td>
<td>99</td>
<td>137</td>
<td>141</td>
<td>377</td>
</tr>
<tr>
<td>Train #1</td>
<td>96</td>
<td>15</td>
<td>17</td>
<td>128</td>
<td>99</td>
<td>13</td>
<td>14</td>
<td>126</td>
</tr>
<tr>
<td>Train #2</td>
<td>96</td>
<td>15</td>
<td>17</td>
<td>128</td>
<td>9</td>
<td>137</td>
<td>14</td>
<td>160</td>
</tr>
<tr>
<td>Train #3</td>
<td>96</td>
<td>15</td>
<td>17</td>
<td>128</td>
<td>9</td>
<td>13</td>
<td>140</td>
<td>162</td>
</tr>
</tbody>
</table>

ICPR2020 - Data Augmentation via Mixed Class Interpolation using Cycle-Consistent Generative Adversarial Networks Applied to Cross-Domain Imagery


Visible images $x'_v$, $y'_v$ class

SAR images $x'_s$, $y'_s$ class

Inference

$\lambda_1 \rightarrow A \rightarrow \lambda_0 \rightarrow A \rightarrow \lambda_1$

$\lambda_0 \rightarrow G_t \rightarrow \lambda_1$

Inference

$\lambda_0 \rightarrow G_s \rightarrow \lambda_1$

Model Training


Visible images $x'_v$, $y'_v$ class

SAR images $x'_s$, $y'_s$ class

Inference

$\lambda_1 \rightarrow A \rightarrow \lambda_0 \rightarrow A \rightarrow \lambda_1$

$\lambda_0 \rightarrow G_t \rightarrow \lambda_1$

Inference

$\lambda_0 \rightarrow G_s \rightarrow \lambda_1$
Train AlexNet\textsuperscript{[5]} models with 5 different training data conditions & compare the classification performances

<table>
<thead>
<tr>
<th>Condition</th>
<th>Acc.</th>
<th>Prec.</th>
<th>Rec.</th>
<th>F1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) only training dataset w/o data augmentation</td>
<td>0.551</td>
<td>0.562</td>
<td>0.575</td>
<td>0.568</td>
</tr>
<tr>
<td>(2) (1) + 90/180/270 degree rotated training samples</td>
<td>0.549</td>
<td>0.554</td>
<td>0.571</td>
<td>0.562</td>
</tr>
<tr>
<td>(3) Mixup\textsuperscript{[2]} of (1)</td>
<td>0.715</td>
<td>0.739</td>
<td>0.719</td>
<td>0.729</td>
</tr>
<tr>
<td>(4) (1) + synthesised images via MixCycleGAN\textsuperscript{[6]}</td>
<td>0.730</td>
<td>0.752</td>
<td>0.739</td>
<td>0.745</td>
</tr>
<tr>
<td>(5) (1) + synthesised images via our approach</td>
<td><strong>0.754</strong></td>
<td><strong>0.777</strong></td>
<td><strong>0.762</strong></td>
<td><strong>0.769</strong></td>
</tr>
</tbody>
</table>


• A novel data augmentation for non-visible imagery.
• Visible to non-visible domain image translation via CycleGAN-based method.
• Our CycleGAN is conditioned for class-specific image synthesis.
• Class-interpolated image synthesis to improve Mixup.
• Outperforms other traditional data augmentation approaches on a SAR ships/icebergs classification task.
Data Augmentation via Mixed Class Interpolation using Cycle-Consistent Generative Adversarial Networks Applied to Cross-Domain Imagery

Hiroshi Sasaki, Chris G. Willcocks, and Toby P. Breckon
Durham University

25th International Conference on Pattern Recognition - January 2021