Multi-Feature Fusion Approach for Object Classification on Oil/Gas Pipeline Right-of-Ways
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**Experimental Results**

<table>
<thead>
<tr>
<th>Type of Class</th>
<th>Bulker (type 1)</th>
<th>Bulker (type 2)</th>
<th>Excavator (type 1)</th>
<th>Excavator (type 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Samples</td>
<td>128</td>
<td>204</td>
<td>110</td>
<td>516</td>
</tr>
<tr>
<td>Type of Class</td>
<td>Con/Vis</td>
<td>Dumper Truck</td>
<td>Truck</td>
<td>Tractor</td>
</tr>
<tr>
<td>Number of Samples</td>
<td>281</td>
<td>85</td>
<td>204</td>
<td>122</td>
</tr>
</tbody>
</table>

**Histogram of HSV Color Model**

- H-Hue, S-Saturation, V-Value
- Simulates color/visual perception of human eyes.
- Two characteristics:
  1. The luminance component has nothing to do with the color information of the image.
  2. The hue and saturation components are closely connected with the way people perceive color.

**Local Binary Pattern (LBP)**

\[
LBP = \sum_{p=1}^{g} s(g_p - g_c)2^p, s(x) = \begin{cases} 
1, x \geq 0 \\
0, x < 0
\end{cases}
\]

**Center-Symmetric LBP**

\[
\text{Center-Sym LBP} = \sum_{p=1}^{g} s(g_p - g_c)2^p, s(x) = \begin{cases} 
1, x \geq 0 \\
0, x < 0
\end{cases}
\]

**Rotation-Invariant LBP**

\[
\text{Rotation-Invar LBP} = \sum_{p=1}^{g} s(g_p - g_c)2^p
\]

**Framework**

- Feature Extraction
  - LBP
  - HOG
  - CS-LBP
- Classification
  - K-Nearest Neighbor
  - Support Vector Machine
Greenhouse gas emissions from tundra lakes are a significant positive feedback to the atmosphere in a changing climate as a pronounced growth of the numbers of tundra lake patterns has been observed in the Arctic region. Detailed knowledge of changes in tundra lakes size is potentially valuable in order to understand and accurately model the sources of greenhouse gas emissions. Therefore, we are using historical maps and satellite images with time interval around 40-year to show a study of tundra lake size changes.

Study Area: Russian High Arctic
Data: Historical maps from the State Hydrological Institute, Russia (date 1977; scale 0.21166 km/pixel)
Landsat satellite images derived from the Google Earth Engine (date 2016; scale 0.1503 km/pixel)

## Experimental Results

<table>
<thead>
<tr>
<th>Area</th>
<th>Perimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>167.96 km²</td>
<td>62.68 km</td>
</tr>
<tr>
<td>143.62 km²</td>
<td>62.42 km</td>
</tr>
<tr>
<td>90.94 km²</td>
<td>37.30 km</td>
</tr>
<tr>
<td>50.08 km²</td>
<td>29.05 km</td>
</tr>
</tbody>
</table>

Throughout the performance results, there are 864 detected lakes from the historical maps and 1103 from the satellite images. Since there was no ground truth of the lakes geo-information from both sources (historical maps and satellite images), we manually picked 20 lakes that have the same locations form both sources. The table below shows the size changing results.

<table>
<thead>
<tr>
<th>Number of Studied Lakes</th>
<th>Number of Decreased Lakes</th>
<th>Number of Increased Lakes</th>
<th>Number of Same Area Lakes</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>14</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>