Improving reliability of attention branch network by introducing uncertainty

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Recognition system using machine learning

- Output recognition result and score (model reliability)
  - Do not consider the confidence of score
  - Ex. Driver assistance system
    - Misclassification the white side of the trailer as empty
      → Fatal accident

Considering uncertainty leads suppression of misjudgment

https://goo.gl/dmezxd
Bayesian Neural Network (BNN) [Blundell+, ICML2015]

- Represent the weight of a network model by **probability distribution**

General NN

- Weight is **unique**

BNN

- Weight is represented by **probability distribution**
Monte Carlo Dropout (MCDO) [Gal+, ICML2016]

- Approximate inference of large-scale and complex models
  - Apply dropout on each layer

![Diagram of dropout applied to a neural network](image)

**Low entropy → Low uncertainty**
Monte Carlo Dropout (MCDO) [Gal+, ICML2016]

- Approximate inference of large-scale and complex models
  - Apply dropout on each layer

High entropy $\Rightarrow$ High uncertainty
Research objective

• Improving CNN reliability by considering uncertainty

Proposed method

• Bayesian Attention Branch Network
  – Apply MCDO to Attention Branch Network
    • Uncertainty of the prediction result could be taken into account
    • Increased accuracy and reliability of CNN
Attention Branch Network (ABN) [Fukui+, CVPR2019]

- CNN method applying attention mechanism
  - Attention mechanism improves CNN recognition accuracy
  - Provides visual explanation by attention map

ABN does not consider uncertainty
Bayesian Attention Branch Network [1 / 2]

- Introduce uncertainty estimation into ABN
  - Apply MCDO
    - Added dropout to residual blocks 3 and 4
    - Use dropout during learning and evaluation
Bayesian Attention Branch Network [2 / 2]

- Introduce uncertainty estimation into ABN
  - Sampling by MCDO
    - Average: Output result estimation
    - Entropy: Uncertainty estimation
  - Adopt the result of branch with low uncertainty as the result
Evaluation

- Dataset: ImageNet dataset
- Base network: ResNet (152 layers)

<table>
<thead>
<tr>
<th>Methods</th>
<th>Top-1 accuracy [%]</th>
<th>Top-5 accuracy [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ResNet</td>
<td>77.81</td>
<td>-</td>
</tr>
<tr>
<td>ABN</td>
<td>79.35</td>
<td>94.55</td>
</tr>
<tr>
<td>Bayesian ABN</td>
<td>80.31</td>
<td>95.01</td>
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Bayesian ABN achieved the highest recognition accuracy
Assessing the effectiveness of uncertainty

- Recognition accuracy over different reliability threshold
  - Use the following values as a reliability
    - Uncertainty
    - Class score

Introducing uncertainty improves reliability
Summary

• We propose a Bayesian ABN

  – Improve recognition accuracy by introducing uncertainty
    • Top-1 accuracy: **0.96 points** improvement compared to ABN
    • Top-5 accuracy: **0.49 points** improvement compared to ABN

  – Uncertainty can be used to improve model reliability
    • Reliability is improved by using uncertainty