과제연구I

Better representation learning via improving operations of Capsule Networks

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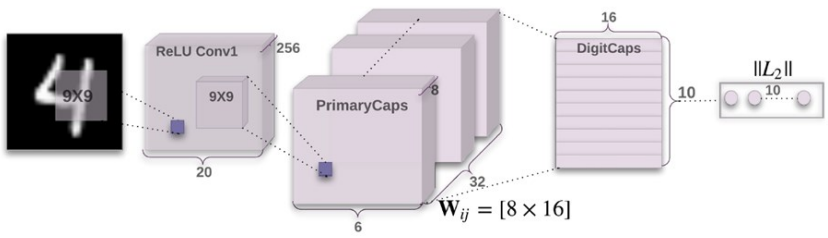
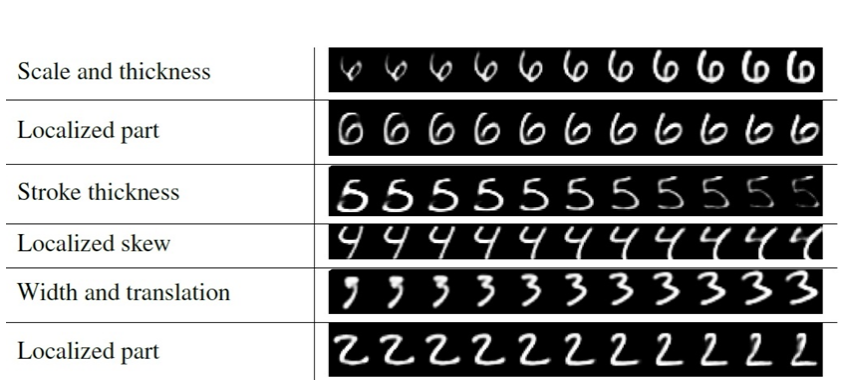
1. Background & Motivation

- **Importance of efficiency of representation learning**
- **Capsule Networks**





2. Experiments & Results

- **Dataset**

MNIST

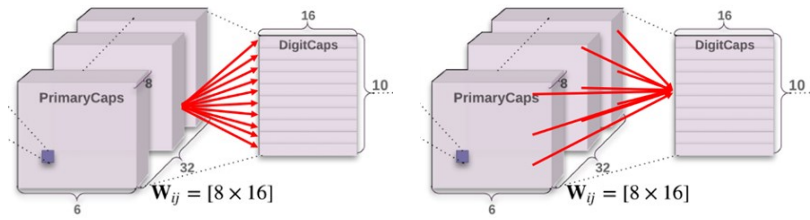
CIFAR-10

- **Model Architecture**
  - **Baseline model from 'Dynamic Routing Between capsules'**
    Input [1,28,28] → Convolution Layer [20,20,256] →
    PrimaryCaps [32,6,6,8] → DigiCaps [16,10] → Prediction[10]
  - **Restricted model for performance comparison**
    Input [1,28,28] → Convolution Layer [20,20,64] →
    PrimaryCaps [8,6,6,8] → DigiCaps [16,10] → Prediction[10]
  - **MNIST dataset is too simple, so CIFAR-10 is also used for performance comparison.**

- **Experiments & Results**
  - **Number of Dynamic Routing and Performance**
    - There is no strong correlation between # routing and performance.
    - # routing can be adjusted as a hyper parameter for slight improvement of performance.
    - Increasing number of routing destabilizes the training procedure.

#Routing	1	2	3	4	5	10	20
Restricted MNIST	98.92	98.52	98.72	98.85	98.98	97.43	96.99
Restricted CIFAR	52.92	52.29	51.88	53.43	52.88	51.83	51.24

- **Routing Coefficient Normalization Direction**



Proposed Direction　　Opposite Direction

# Routing	1	2
Restricted CIFAR Proposed Direction	52.92	52.29
Restricted CIFAR Opposite Direction	55.82	54.12

- **Accumulated Routing**
  - Instead of dynamic routing, which initializes routing coefficient uniformly at every iteration, accumulated routing is applied, which accumulates all interactions between capsules.
  - Performance is decreased. The cause seems too much focus on a few points.

#Accumulated Routing	1	3
Restricted MNIST	98.92	98.52
Restricted accumulated MNIST	94.50	93.35

- **Replace Dynamic Routing with Parameter & Backpropagtion**
  - Replacing routing with trainable parameters does not seriously change the performance.
  - Normalization is important for better performance.
  - Parameter & Backpropagation is faster than Dynamic Routing, especially when the number of routing increases.

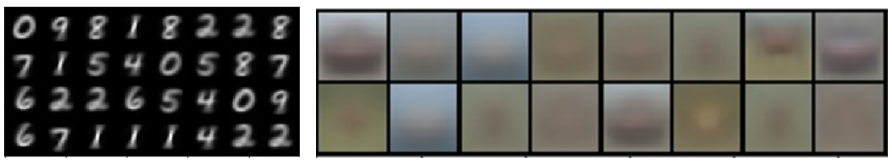
Model	Restricted MNIST Routing #1	Restricted MNIST Routing #3	Restricted MNIST BP
Performance	98.92	98.72	98.91

Model	Restricted CIFAR Routing #3	Restricted CIFAR BP
Performance	51.88	51.22

Model	Restricted MNIST	Restricted CIFAR
With Normalization	98.91	51.22
Without Normalization	93.43	40.0

Model	Parameter & Backpropagation	Routing #1	Routing #3	Routing #5
Computation Time Ratio	1	1.09	1.69	2.42

- **Reconstruction**
  - DigiCaps outputs are utilized as features for reconstruction.
  - For the case of MNIST which has relatively simple data, decoder successes to synthesize relevant images.
  - For the case of CIFAR-10 which has more complex data, decoder fails to generate detailed images. It only captures the hue of each class.



MNIST　　CIFAR-10

3. Conclusion & Future Works

- **Dynamic routing can be replaced with trainable parameters without dramatic change of performance.**
- **Normalization and its direction affects the performance of Capsule Networks.**
- **This replacement needs to be tested on more complex settings like 'Capsules for Object Segmentation'.**