

DDRM-CapsNet: Capsule Network based on Deep Dynamic Routing Mechanism for complex data

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The Recently proposed CapsNet has attracted the attention of many researchers. It is a potential alternative to convolutional neural networks (CNNs) and achieves significant increase in performance on some simple datasets like MNIST. However, CapsNet gets a poor performance on more complex datasets like CIFAR-10. To address this problem, we focus on the improvement of the original CapsNet from both the network structure and the dynamic routing mechanism. A new CapsNet architecture aiming at complex data called Capsule Network based on Deep Dynamic Routing Mechanism (DDRM-CapsNet) is proposed. For the purpose of extracting better features, we increase the number of convolutional layers before capsule layer in the encoder. We also improve the dynamic routing mechanism in the original CapsNet by expanding it into two stages and increasing the dimensionality of the final output vector. To verify the efficacy of our proposed network on complex data, we conduct experiments with a single model without using any ensembled methods and data augmentation techniques on five real-world complex datasets. The experimental results demonstrate that our proposed method achieves better accuracy results than the baseline and can still improve the reconstruction performance on the premise of using the same decoder structure as the original CapsNet.

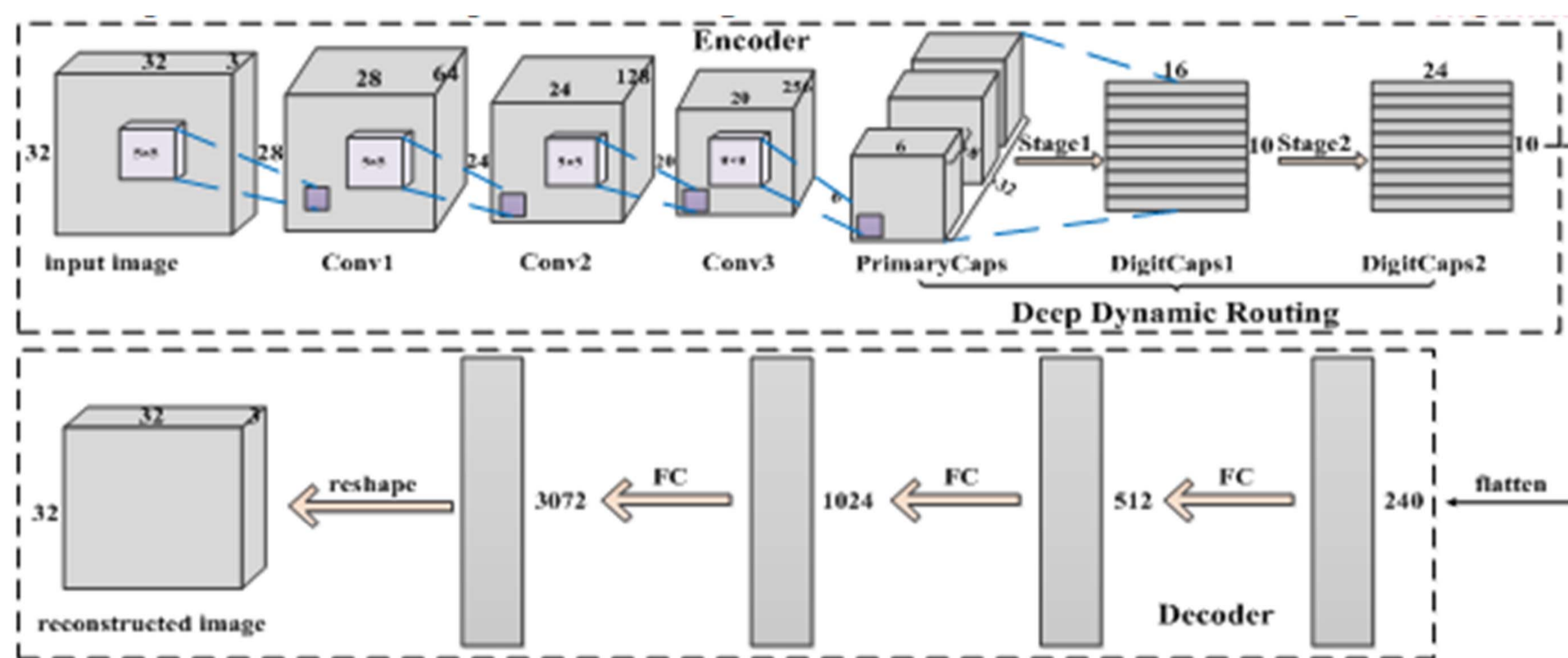


Fig. 1. Network architecture.

Table 1. Comparisons with Baseline and Influences of Convolutional Layers and DDRM of Test Accuracy Results (%).

Dataset [⊖]	Baseline [⊖]	1 conv+2-DC [⊖]	2 conv+2-DC [⊖]	3 conv+2-DC [⊖]	4 conv+2-DC [⊖]
CIFAR-10 [⊖]	66.31 [⊖]	76.61 [⊖]	75.62 [⊖]	77.50[⊖]	74.56 [⊖]
CIFAR-100 [⊖]	21.54 [⊖]	29.48 [⊖]	27.90 [⊖]	29.93[⊖]	27.57 [⊖]
Extended Yale Face Database B [⊖]	100[⊖]	100[⊖]	100[⊖]	100[⊖]	100[⊖]
Cropped Extended Yale Face Database B [⊖]	98.37 [⊖]	98.64[⊖]	98.64[⊖]	98.64[⊖]	98.64[⊖]
BelgiumTS [⊖]	94.98 [⊖]	95.66 [⊖]	95.06 [⊖]	95.78[⊖]	94.06 [⊖]

our contributions are summarized as follows:

- (1) We propose a new network architecture called DDRM-CapsNet for complex data, which modifies both the network structure and the dynamic routing mechanism.
- (2) No pooling layers are used in our architecture. The encoder only contains four convolutional layers (three standard convolutional layers and one PrimaryCaps layer) and two DigitCaps layers and the decoder adopts the original CapsNet structure which contains three fully connected layers.
- (3) We test a single model on all five real-world complex datasets without using any ensembling methods and data augmentation techniques. The experimental results demonstrate that DDRM-CapsNet has a better performance than the previous CapsNet. Especially, DDRM-CapsNet achieves 77.50% and 29.93% test accuracy respectively on CIFAR-10 and CIFAR-100, an obvious promotion of over 11% and 8% respectively compared to the previous CapsNet.
- (4) Not only contributing to the improvement of accuracy, our proposed DDRM can also improve the reconstruction performance based on the comparison with the reconstruction of the original CapsNet.