上海科技大学
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Multi-Cell Multi-Task Convolutional Neural Networks for Diabetic Retinopathy Grading

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Contents

Background

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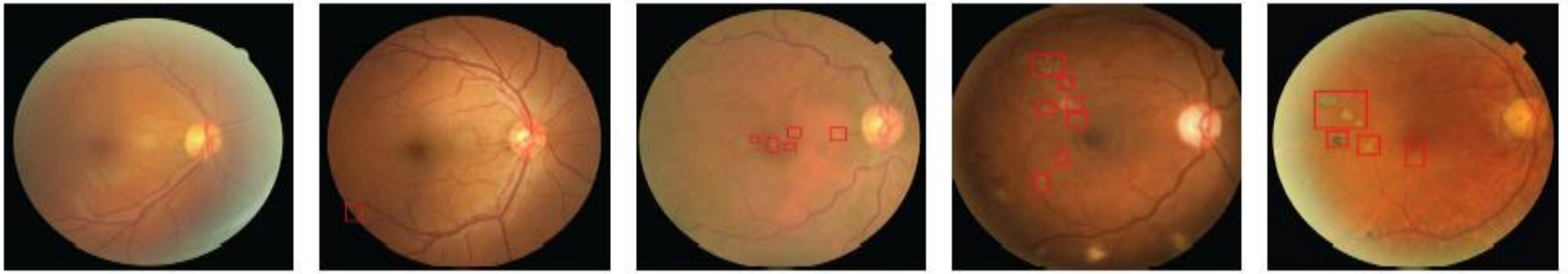
Diabetic Retinopathy Grading:

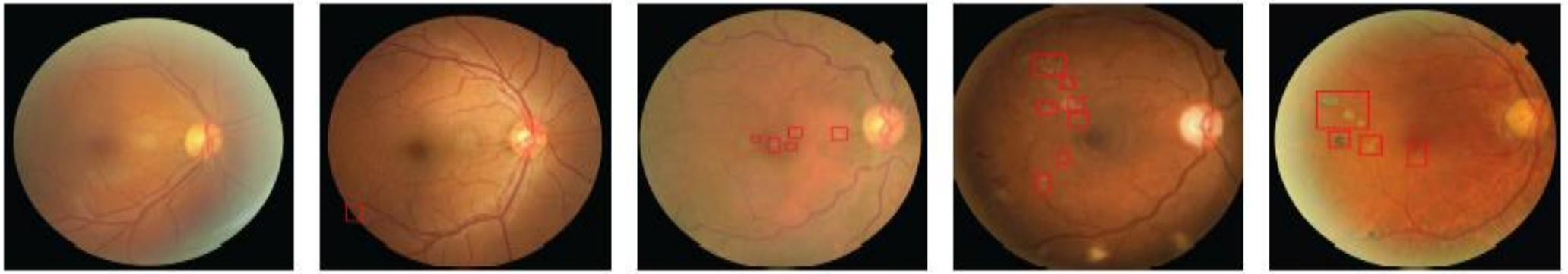


(a) Grade 0 (b) Grade 1 (c) Grade 2 (d) Grade 3 (e) Grade 4

- **Problem:**
  - Label: 0, 1, 2, 3, 4
  - Larger number means the severity of the disease becomes more significant
- **Task:**
  - Input: Image
  - ***Output***: Its grade

Background

Diabetic Retinopathy Grading：



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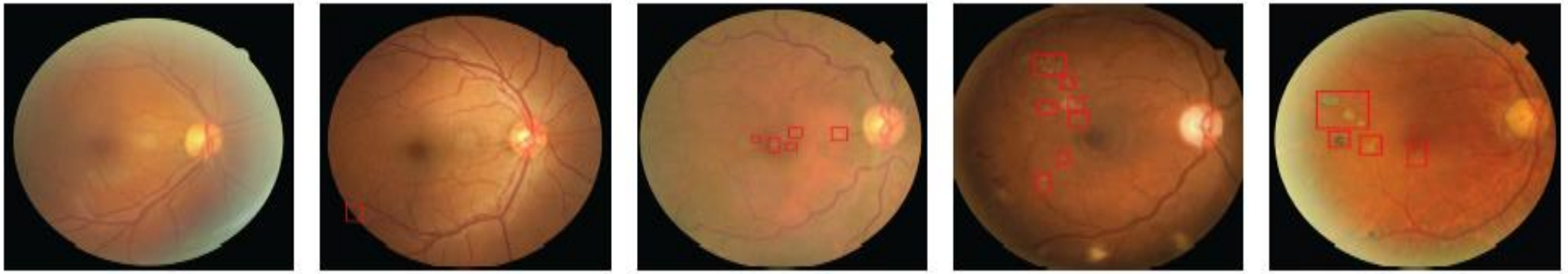
- **Challenge**

  (DR grading ≠ general image classification)：

  - The classes in DR grading are ***correlative*** while in general image classification are not
  - The image resolution of DR images is significantly higher than that of general images

Background

Diabetic Retinopathy Grading：



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- **Challenge**

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Diabetic Retinopathy Grading：

- **Contribution ：**
  - We propose a **Multi-Task Learning** strategy to simultaneously improves the classification accuracy and discrepancy between ground-truth and predicted label.
  - We propose a **Multi-Cell CNN architecture** which not only accelerates the training procedure, but also improves the classification accuracy.
  - Experimental results validate the effectiveness of our method. Further, our solution can be readily integrated with many other existing CNN based DR image diagnosis and other disease diagnosis.

2

Proposed Method: M²CNN

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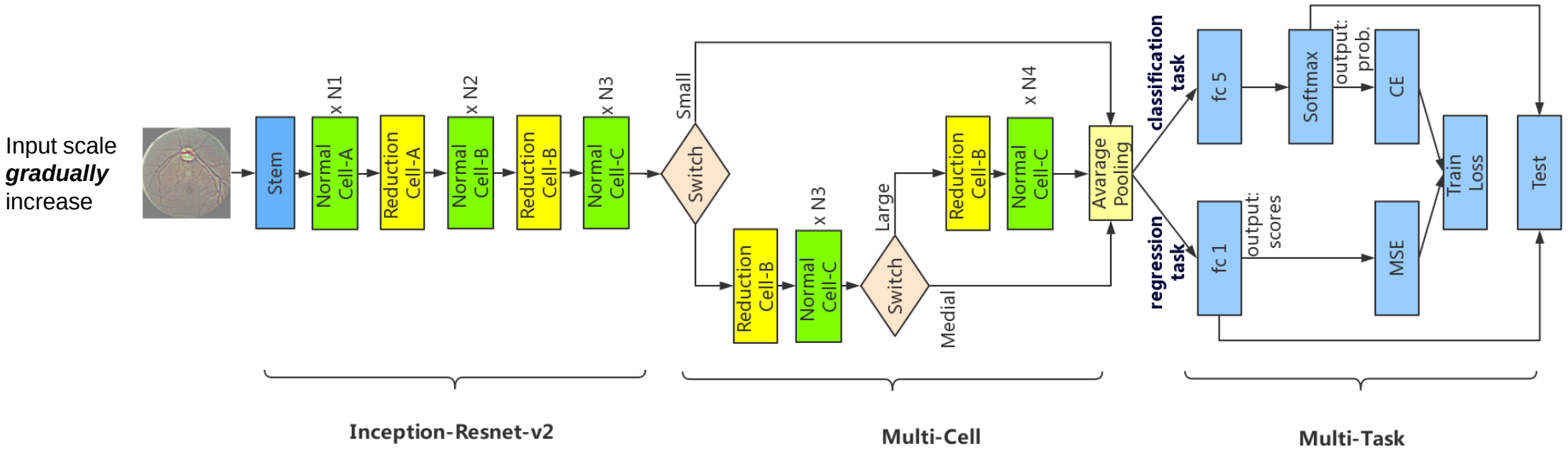
Multi-Cell Multi-Task Convolutional Neural Networks:



- **Overall :**
  - The overall network architecture of our M²CNN
  - Inception-Resnet-v2 is proposed in [1]

[1] C. Szegedy, S. Ioffe, V. Vanhoucke, and A. A. Alemi. Inception-v4, inception-resnet and the impact of residual connections on learning. In AAAI, 2017.

Proposed Method: M²CNN

Multi-Cell Multi-Task Convolutional Neural Networks:

- **Multi-Task Learning :**
  - Softmax loss doesn't consider the relationships of DR images with different stages:

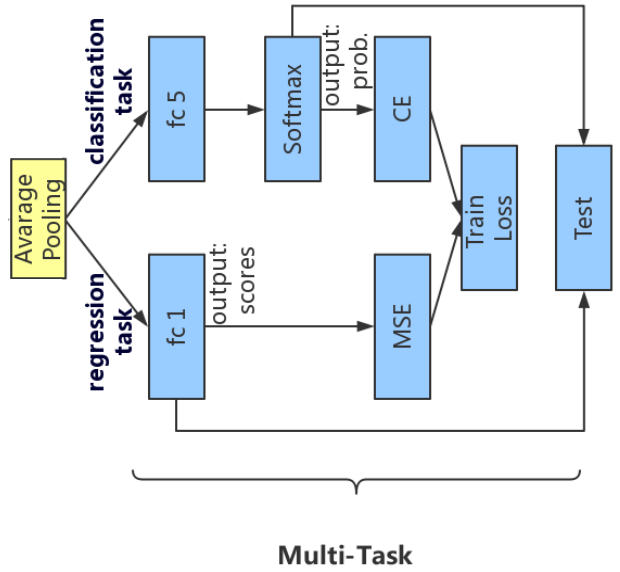
$$L_1 = -\frac{1}{m}\left[\sum_{i=1}^{m}\sum_{j=1}^{k} 1\{y^{(i)} = j\}\log(\text{Prob}_{ij})\right]$$

  - Mean Square Error (MSE) loss is not robust for classification task:

$$L_2 = \frac{1}{m}\sum_{i=1}^{m}(y - y^{(i)})^2$$

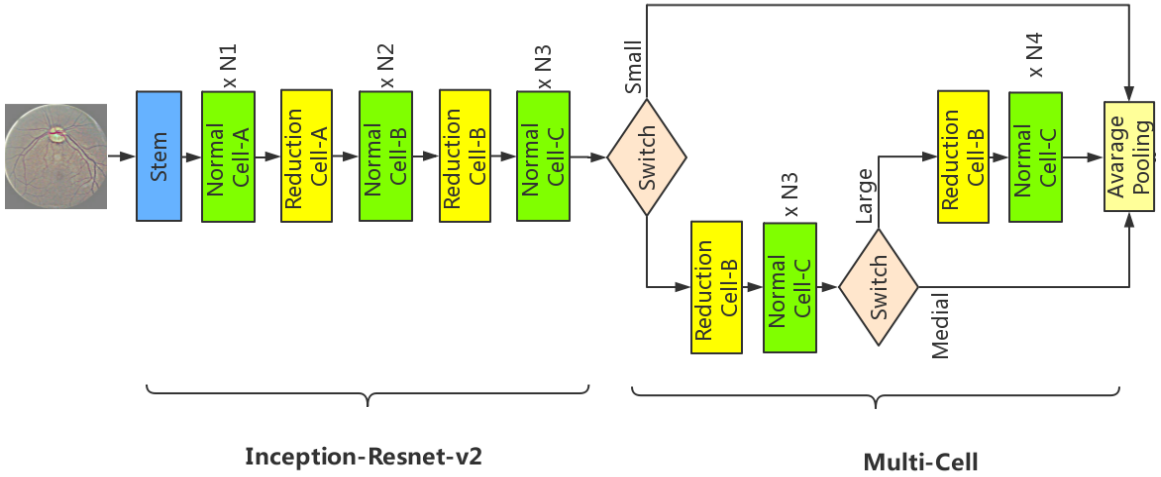
  - Multi-task loss:

$$L = L_1 + L_2$$



Proposed Method: M²CNN

Multi-Cell Multi-Task Convolutional Neural Networks：



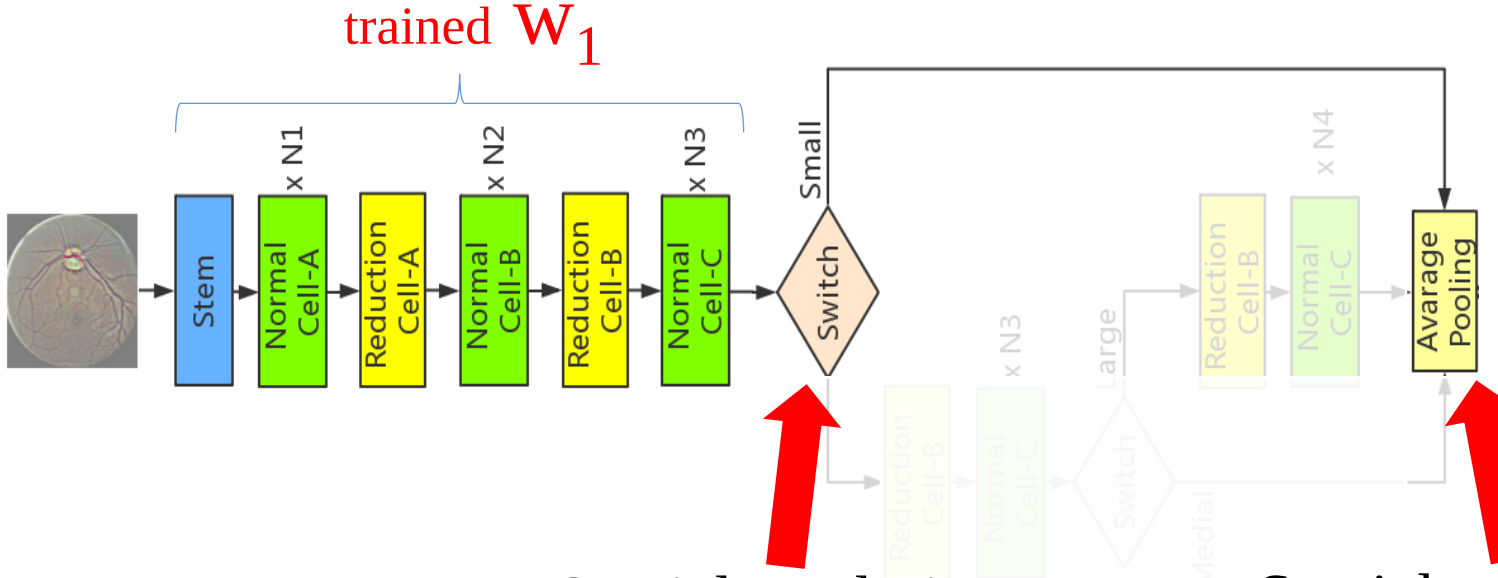
input image	224×224	448×448	720×720
before switch	5×5	12×12	21×21
after multi-cell	5×5	5×5	4×4

The spatial resolution of input image and some feature map

- **Multi-Cell Architecture ：**
  - ***Small resolution*** image often leads to information loss especially when the lesion is small
  - ***Large resolution*** image will introduce more computational costs and lead to the gradient vanishing/exploding problem in optimization
  - **Note:** Multi-Cell Architecture ***gradually increase*** the depth of network architecture and the resolution of images
  - **Note:** The architecture of ***Normal Cell-C*** and ***Reduction Cell-B*** in Multi-Cell and Inception-Resnet-v2 are same.

Proposed Method: M²CNN

Process of Multi-Cell Architecture : **1-st training stage**



Input scale:
224 x 224

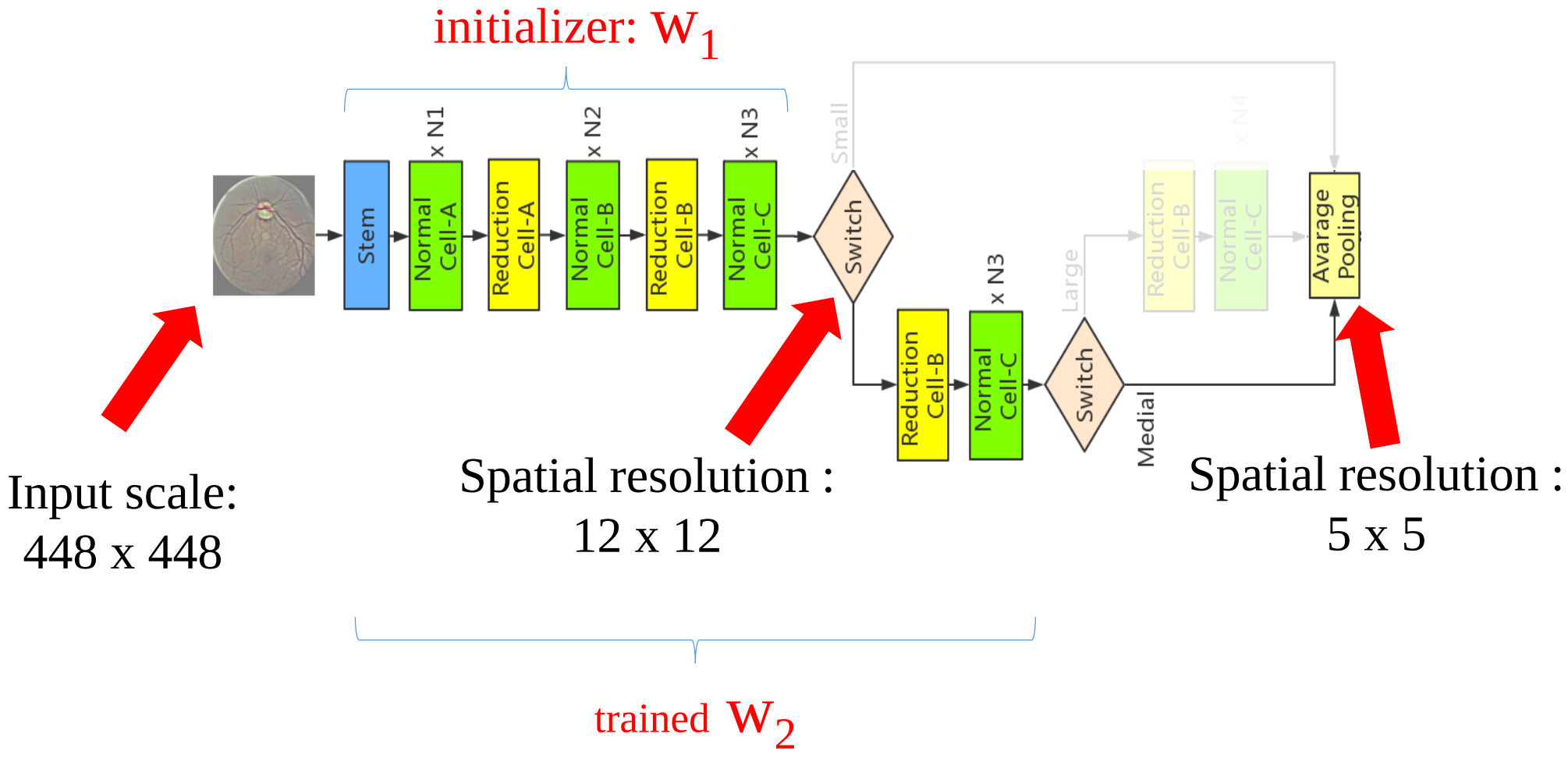
Spatial resolution :
5 x 5

Spatial resolution :
5 x 5

Depth of network architecture and the ***scale*** of images are ***gradually increased.***

Proposed Method: M²CNN

Process of Multi-Cell Architecture : **2-ed training stage**

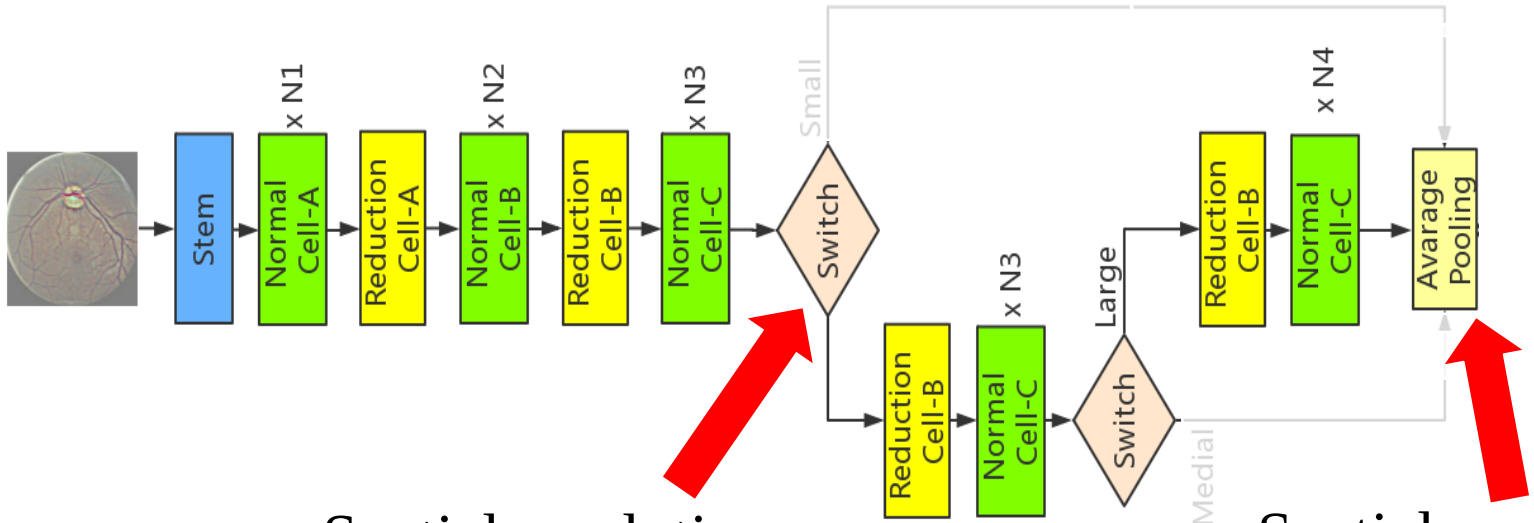


Depth of network architecture and the ***scale*** of images are ***gradually increased.***

Proposed Method: M²CNN

Process of Multi-Cell Architecture : **3-rd training stage**

trained: W_3 (***Training's finished***!!!)



Input scale:
720 x 720

Spatial resolution :
21 x 21

Spatial resolution :
4 x 4

initializer: W_2

Depth of network architecture and the ***scale*** of images are ***gradually increased.***

3

Experiment

Experiment

Experimental Setup

- **Dataset:**
  Kaggle organized a comprehensive competition in order to design an automated retinal image diagnosis system for DR screening in 2015 [2].
- **Evaluation Metric:**
  We use the ***quadratic weighted kappa*** to evaluate our proposed methods, which is used in Kaggle DR Challenge.

[2] Diabetic retinopathy detection. https://www.kaggle.com/c/diabetic-retinopathy-detection/data

Experiment

Evaluation of Different Modules

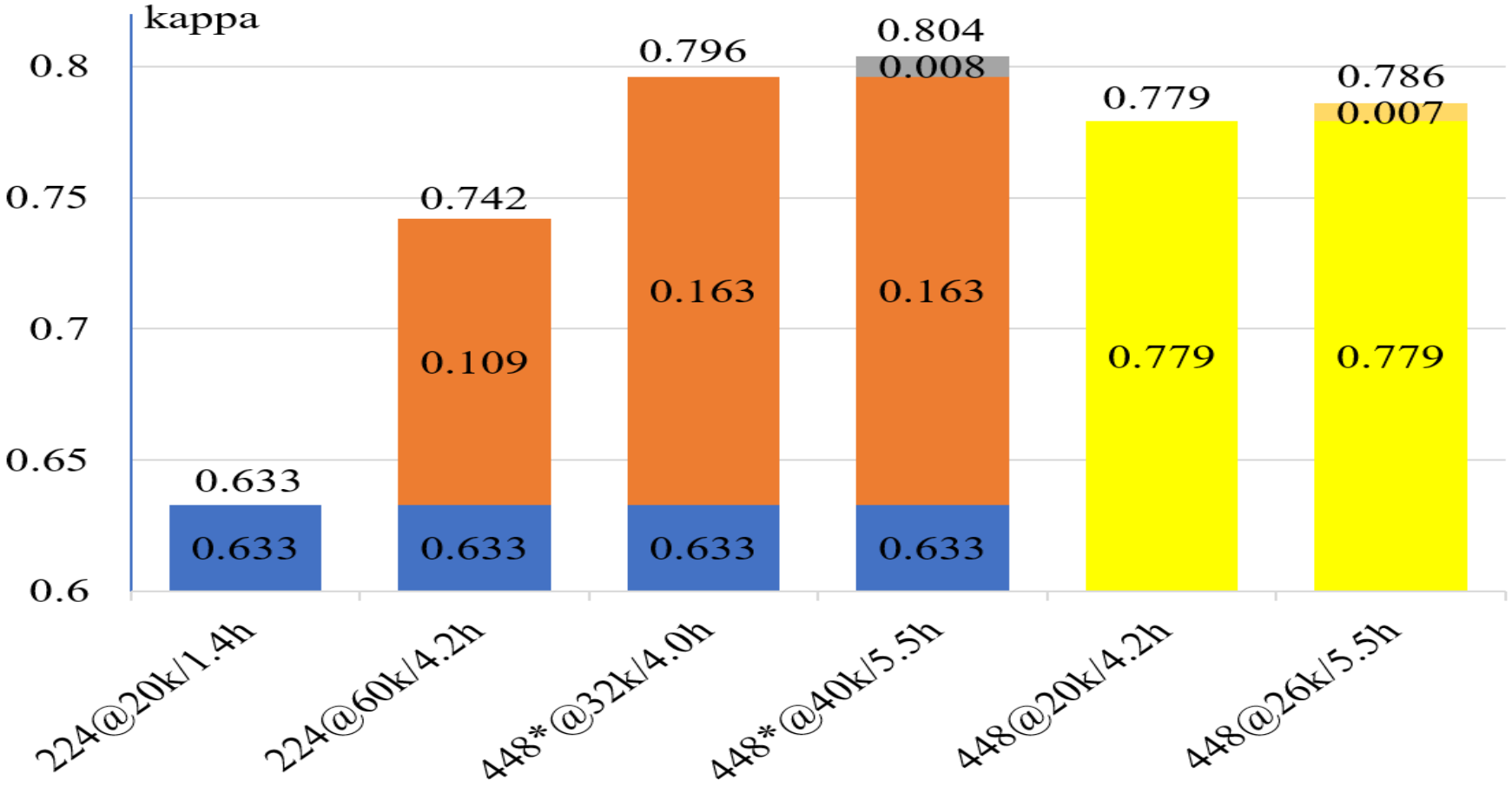
- **Multi-Task Learning Module**
- **Multi-Cell Architecture Module**

Train	MSE	CE	Multi-Task		M^2CNN	
Test	scores	prob.	scores	prob.	scores	prob.
224×224	0.720	0.725	0.742	0.718	-	-
448×448	0.790	0.772	0.812	0.782	**0.830**	0.812
720×720	0.835	0.751	**0.841**	0.826	**0.844**	0.842

Experiment

Evaluation of Different Modules

- Multi-Task Learning Module
- **Multi-Cell Architecture Module**



Experiment

Performance Comparison

Algorithm	val set	test set
Min-pooling	0.860	0.849
Zoom-in-Net [11]	0.857	0.849
o_O	0.854	0.844
Reformed Gamblers	0.851	0.839
M-Net+A-Net [11]	0.837	0.832
BaseNet	0.835	0.828
BaseNet+MT	0.841	0.838
M^2CNN	0.844	0.841

[11] Z. Wang, Y. Yin, J. Shi, W. Fang, H. Li, and X. Wang. Zoom-in-net: Deep mining lesions for diabetic etinopathy detection. InMICCAI, 2017

Thanks

Q & A