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ImageNet Classification with Deep Convolutional Neural Networks

基于深度卷积神经网络的 IMANET 分类

Abstract

We trained a large, deep convolutional neural network to classify the 1.2 million high-resolution images in the ImageNet LSVRC-2010 contest into the 1000 different classes. On the test data, we achieved top-1 and top-5 error rates of 37.5% and 17.0% which is considerably better than the previous state-of-the-art. The neural network, which has 60 million parameters and 650,000 neurons, consists of five convolutional layers, some of which are followed by max-pooling layers, and three fully-connected layers with a final 1000-way softmax. To make training faster, we used non-saturating neurons and a very efficient GPU implementation of the convolution operation. To reduce overfitting in the fully-connected layers we employed a recently-developed regularization method called “dropout” that proved to be very effective. We also entered a variant of this model in the ILSVRC-2012 competition and achieved a winning top-5 test error rate of 15.3%, compared to 26.2% achieved by the second-best entry.

摘要

我们训练了一个深度卷积神经网络，将 IMANETET LVRC-2010 竞赛中的 120 万个高分辨率图像分类为 1000 个不同的类。在测试数据上，我们获得了 Top-1 和 Top-5 错误率分别为 37.5%和 17%，明显优于先前的最新技术。具有 6000 万个参数和 650000 个神经元的神经网络由五个卷积层组成，其中一些是由最大汇集层跟随的，三个完全连接的层具有最终 1000 路 SOFTMax。为了使训练更快，我们使用非饱和神经元和一个非常有效的 GPU 实现卷积运算。为了减少在全连接层中的过度拟合，我们采用了最近开发的正则化方法，称为“dropout”，证明是非常有效的。在 ILVRC-2012 竞争中，我们也进入了该模型的一个变种，并获得了 15.3%的胜负 Top-5 测试错误率，与第二个最佳条目所获得的 26.2%相比。

1 Introduction

1 介绍

Current approaches to object recognition make essential use of machine learning methods. To improve their performance, we can collect larger datasets, learn more powerful models, and use better techniques for preventing overfitting. Until recently, datasets of labeled images were relatively small — on the order of tens of thousands of images. Simple recognition tasks can be solved quite well with datasets of this size, especially if they are augmented with label-preserving transformations. For example, the currentbest error rate on the MNIST digit-recognition task.

目前的物体识别方法使机器学习方法得到了根本的应用。为了提高它们的性能，我们可以收集更大的数据集，学习更强大的模型，并使用更好的技术来防止过度拟合。直到最近，标记图像的数据集相对较小——几万个图像的顺序。简单的识别任务可以很好地解决这种大小的数据集，特别是如果它们增强与标签保留转换。例如，MNIST 数字识别任务的当前最佳错误率。

To learn about thousands of objects from millions of images, we need a model with a large learning capacity. However, the immense complexity of the object recognition task means that this problem cannot be specified even by a dataset as large as ImageNet, so our model should also have lots of prior knowledge to compensate for all the data we don’t have. Convolutional neural networks (CNNs) constitute one such class of models [16, 11, 13, 18, 15, 22, 26]. Their capacity can be controlled by varying their depth and breadth, and they also make strong and mostly correct assumptions about the nature of images (namely, stationarity of statistics and locality of pixel dependencies). Thus, compared to standard feedforward neural networks with similarly-sized layers, CNNs have much fewer connections and parameters and so they are easier to train, while their theoretically-best performance is likely to be only slightly worse.

为了了解数以千计的对象从数百万的图像，我们需要一个模型，具有较大的学习能力。然而，对象识别任务的巨大复杂性意味着，即使数据集与 ImageNet 一样大，也不能指定这个问题，所以我们的模型也应该有很多先验知识来补偿我们没有的所有数据。卷积神经网络（CNNs）构成一类这样的模型〔16, 11, 13，18, 15, 22，26〕。它们的容量可以通过改变它们的深度和广度来控制，并且它们也对图像的性质（即，统计的平稳性和像素依赖性的局部性）做出强且基本正确的假设。因此，相比于具有相似尺寸的标准前馈神经网络，CNNs 具有更少的连接和参数，因此它们更易于训练，而它们的理论上的最佳性能可能仅稍微差一些。

Despite the attractive qualities of CNNs, and despite the relative efficiency of their local architecture, they have still been prohibitively expensive to apply in large scale to high-resolution images. Luckily, current GPUs, paired with a highly-optimized implementation of 2D convolution, are powerful enough to facilitate the training of interestingly-large CNNs, and recent datasets such as ImageNet contain enough labeled examples to train such models without severe overfitting.

尽管 CNNs 具有吸引人的特性，尽管它们的局部结构相对有效，但在大规模应用到高分辨率图像上仍然是昂贵的。幸运的是，当前的 GPU，与高度优化的 2D 卷积实现配对，足够强大以便于训练有趣的大 CNN，并且最近的数据集（如 IMANET）包含足够的标记的例子来训练这样的模型而不需要严重的过度拟合。

The specific contributions of this paper are as follows: we trained one of the largest convolutional neural networks to date on the subsets of ImageNet used in the ILSVRC-2010 and ILSVRC-2012 competitions [2] and achieved by far the best results ever reported on these datasets. We wrote a highly-optimized GPU implementation of 2D convolution and all the other operations inherent in training convolutional neural networks, which we make available publicly1 . Our network contains a number of new and unusual features which improve its performance and reduce its training time, which are detailed in Section 3. The size of our network made overfitting a significant problem, even with 1.2 million labeled training examples, so

we used several effective techniques for preventing overfitting, which are described in Section 4. Our final network contains five convolutional and three fully-connected layers, and this depth seems to be important: we found that removing any convolutional layer (each of which contains no more than 1% of the model's parameters) resulted in inferior performance.

本文的具体贡献如下：我们在 ILVRC-2010 和 ILVRC-2012 竞赛中使用了 IMANEET 子集的最大卷积神经网络之一（2），并取得了迄今为止在这些数据集上报告的最好结果。我们编写了一个高度优化的 GPU 实现的 2D 卷积和所有其他训练卷积神经网络固有的操作，这是我们公开的。我们的网络包含了一些新的和不寻常的特性，这些特性改进了它的性能并减少了它的训练时间，这在第 3 节中详细说明。我们的网络的规模使得过拟合一个重要的问题，即使有 120 万个标记的训练例子，所以我们使用了一些有效的技术来防止过度拟合，这在第 4 节中描述。我们的最终网络包含五个卷积和三个完全连接的层，并且这个深度似乎是重要的：我们发现去除任何卷积层（其中每一个包含不超过模型参数的 1%）导致性能较差。

In the end, the network's size is limited mainly by the amount of memory available on current GPUs and by the amount of training time that we are willing to tolerate. Our network takes between five and six days to train on two GTX 580 3GB GPUs. All of our experiments suggest that our results can be improved simply by waiting for faster GPUs and bigger datasets to become available.

最后，网络的规模主要受当前 GPU 上可用的内存量和我们愿意容忍的训练时间的限制。我们的网络需要五到六天的时间来训练两个 GTX 580 的 3GB GPU。我们所有的实验表明，我们可以通过等待更快的 GPU 和更大的数据集来提高我们的结果。

2 The Dataset

2 数据集

ImageNet is a dataset of over 15 million labeled high-resolution images belonging to roughly 22,000 categories. The images were collected from the web and labeled by human labelers using Amazon's Mechanical Turk crowd-sourcing tool. Starting in 2010, as part of the Pascal Visual Object Challenge, an annual competition called the ImageNet Large-Scale Visual Recognition Challenge (ILSVRC) has been held. ILSVRC uses a subset of ImageNet with roughly 1000 images in each of 1000 categories. In all, there are roughly 1.2 million training images, 50,000 validation images, and 150,000 testing images.

ImageNet 是超过 1500 万个标记的高分辨率图像的数据集，属于大约 22000 个。类别。这些图片是从网上收集的，并用亚马逊的标签贴上了人类标签。机械突厥人群采购工具。从 2010 开始，作为 PASCAL 视觉对象的一部分挑战，一个叫做 IMANEET 大规模视觉识别挑战的年度竞赛（ILVRC）已成立。ILVRC 用 ImageNet 的一个子集，每个图像中大约有 1000 个图像。1000 类。总共有大 120 万个训练图像，50000 个验证图像，以及 150000 个测试图像。

ILSVRC-2010 is the only version of ILSVRC for which the test set labels are available, so this is the version on which we performed most of our experiments. Since we also entered our model in the ILSVRC-2012 competition, in Section 6 we report our results on this version of the dataset as well, for which test set labels are unavailable. On ImageNet, it is customary to report two error rates: top-1 and top-5, where the top-5 error rate is the fraction of test images for which the correct label is not among the five labels considered most probable by the model.

2010 年 ilsvrc version of ilsvrc is the only for which the labels are available 的测试版本，所以 this is the most of Our 我们执行我们的实验。我们也从我们的模型 ilsvrc entered in the competition in section 6 年，我们的结果我们 Report on this version of the as well for which 数据集的测试集，标签是不可用的。我们习惯 imagenet，it is to report：前两个错误率前 5 - 1 和第 5，where the error rate is the fraction of the correct 测试 Images for which is not among the five 标签 labels considered by the most 可能的模型。

ImageNet consists of variable-resolution images, while our system requires a constant input dimensionality. Therefore, we down-sampled the images to a fixed resolution of

256 ×256. Given a rectangular image, we first rescaled the image such that the shorter side was of length 256, and then cropped out the central 256×256 patch from the resulting image. We did not pre-process the images in any other way, except for subtracting the mean activity over the training set from each pixel. So we trained our network on the (centered) raw RGB values of the pixels.

IMANET 包含可变分辨率的图像，而我们的系统需要一个恒定的输入维度。因此，我们向下采样图像的分辨率为 256×256。给定矩形图像，我们首先对图像进行重新缩放，使得短边的长度为 256，然后从得到的图像中裁剪出中心 256×256 的斑块。我们没有以任何其他方式对图像进行预处理，除了从每个像素上减去训练集上的平均活动。因此，我们训练我们的网络上的（中心）原始 RGB 值的像素。

3 The Architecture

3 架构

The architecture of our network is summarized in Figure 2. It contains eight learned layers — five convolutional and three fully-connected. Below, we describe some of the novel or unusual features of our network's architecture. Sections 3.1-3.4 are sorted according to our estimation of their importance, with the most important first.

我们的网络架构概括在图 2 中。它包含八个学习层-五卷积和三完全连接。下面，我们描述一些新的或不寻常的特点，我们的网络的架构。第 3.1-3.4 部分根据我们对它们重要性的估计而排序，最重要的是第一部分。

3.1 ReLU Nonlinearity

3.1 ReLU非线性特征

The standard way to model a neuron's output f as a function of its input x is with $f(x) = \tanh(x)$ or $f(x) = (1 + e^{-x})^{-1}$. In terms of training time with gradient descent, these saturating nonlinearities are much slower than the non-saturating nonlinearity $f(x) = \max(0, x)$. Following Nair and Hinton [20], we refer to neurons with this nonlinearity as Rectified Linear Units (ReLUs). Deep convolutional neural networks with ReLUs train several times faster than their equivalents with tanh units. This is demonstrated in Figure 1, which shows the number of iterations required to reach 25% training error on the CIFAR-10 dataset for a particular four-layer convolutional network. This plot shows that we would not have been able to experiment with such large neural networks for this work if we had used traditional saturating neuron models.

建模神经元输出 F 作为其输入 X 的函数的标准方法是 F（x）＝TANH（x）或 f（x）＝（1 +E×x）- 1。在梯度下降的训练时间方面，这些饱和非线性比非饱和非线性 f（x）＝max（0，x）慢得多。在 NAIR 和 Hinton〔20〕之后，我们将这种非线性的神经元称为整流线性单元（RelUS）。具有卷积的深度卷积神经网络比其与 TANH 单元等价的速度快几倍。这在图 1 中演示，它显示了对于特定的四层卷积网络，在 CIEOV10 数据集上达到 25%训练误差所需的迭代次

数。这一情节表明，如果我们使用传统的饱和神经元模型，我们将无法对这样的工作进行如此大的神经网络的实验。

We are not the first to consider alternatives to traditional neuron models in CNNs. For example, Jarrett et al. [11] claim that the nonlinearity f(x) = |tanh(x)| works particularly well with their type of contrast normalization followed by local average pooling on the Caltech-101 dataset. However, on this dataset the primary concern is preventing overfitting, so the effect they are observing is different from the accelerated ability to fit the training set which we report when using ReLUs. Faster learning has a great influence on the performance of large models trained on large datasets.

我们不是第一个考虑替代传统神经元模型在 CNNs。例如，贾勒特等人。〔11〕声称非线性 F（x）＝Tangh（x）占优，与 CalTeC-101 数据集上的局部平均池的对比度归一化。然而，在这个数据集上，主要关注的是防止过度拟合，因此他们观察到的效果不同于使用 Relu 时报告的训练集的加速能力。快速学习对大数据集上训练的大型模型的性能有很大影响。

3.2 Training on Multiple GPUs

3.2 在多核GPU上训练

A single GTX 580 GPU has only 3GB of memory, which limits the maximum size of the networks that can be trained on it. It turns out that 1.2 million training examples are enough to train networks which are too big to fit on one GPU. Therefore we spread the net across two GPUs. Current GPUs are particularly well-suited to cross-GPU parallelization, as they are able to read from and write to one another’s memory directly, without going through host machine memory. The parallelization scheme that we employ essentially puts half of the kernels (or neurons) on each GPU, with one additional trick: the GPUs communicate only in certain layers. This means that, for example, the kernels of layer 3 take input from all kernel maps in layer 2. However, kernels in layer 4 take input only from those kernel maps in layer 3 which reside on the same GPU. Choosing the pattern of connectivity is a problem for cross-validation, but this allows us to precisely tune the amount of communication until it is an acceptable fraction of the amount of computation.

单个 GTX 580 GPU 只有 3GB 的内存，这限制了可在其上进行训练的网络的最大大小。结果表明，120 万个训练实例足以训练太大以至于不能适应一个 GPU 的网络。因此，我们将网络分散在两个 GPU 上。当前 GPU 特别适合跨 GPU 并行化，因为它们能够直接读取和写入彼此的存储器，而不必经过主机存储器。我们采用的并行化方案基本上把一半的内核（或神经元）放在每个 GPU

上，另外一个技巧是：GPU 只在某些层中通信。这意味着，例如，层 3 的内核从层 2 中的所有内核映射获取输入。然而，层 4 中的内核仅从位于同一 GPU 的第 3 层中的内核映射输入。选择连接模式是交叉验证的一个问题，但是这允许我们精确地调整通信量，直到它是可接受的计算量的一部分。

The resultant architecture is somewhat similar to that of the “columnar” CNN employed by Cire şan et al. [5], except that our columns are not independent (see Figure 2). This scheme reduces our top-1 and top-5 error rates by 1.7% and 1.2%, respectively, as compared with a net with half as many kernels in each convolutional layer trained on one GPU. The two-GPU net takes slightly less time to train than the one-GPU net.

由此产生的体系结构与 CIELE SAN 所采用的“柱状”美国有线电视新闻网有些相似。除了我们的列不是独立的（见图 2）。这个方案降低了我们的 Top-1。前 5 个错误率分别为 1.7%和 1.2%，与一个有一半的网络相比。每一个卷积层上内核在一个 GPU 上训练。两个 GPU 网络占用的时间比较少。比一个 GPU NET 进行训练。

3.3 Local Response Normalization

3.3 局部相应归一化

ReLUs have the desirable property that they do not require input normalization to prevent them from saturating. If at least some training examples produce a positive input to a ReLU, learning will happen in that neuron. However, we still find that the following local normalization scheme aids generalization. Denoting by a i x,y the activity of a neuron computed by applying kernel i at position (x, y) and then applying the ReLU nonlinearity, β where the sum runs over n “adjacent” kernel maps at the same spatial position, and N is the total number of kernels in the layer. The ordering of the kernel maps is of course arbitrary and determined before training begins. This sort of response normalization implements a form of lateral inhibition inspired by the type found in real neurons, creating competition for big activities amongst neuron outputs computed using different kernels. The constants k, n, α, and β are hyper-parameters whose values are determined using a validation set; we used k = 2, n = 5, $\alpha = 10^{-4}$, and β = 0.75. We applied this normalization after applying the ReLU nonlinearity in certain layers (see Section 3.5). This scheme bears some resemblance

to the local contrast normalization scheme of Jarrett et al. [11], but ours would be more correctly termed “brightness normalization”, since we do not subtract the mean activity. Response normalization reduces our top-1 and top-5 error rates by 1.4% and 1.2%, respectively. We also verified the effectiveness of this scheme on the CIFAR-10 dataset: a four-layer CNN achieved a 13% test error rate without normalization and 11% with normalization3 .

RelUS 具有理想的属性，它们不需要输入标准化，以防止它们饱和。如果至少一些训练实例产生对 Relu 的积极输入，那么学习将发生在该神经元中。然而，我们仍然发现下面的局部归一化方案有助于泛化。由 I x 表示，Y 是通过在位置（x，y）上应用核 I 计算的神经元的活动，然后应用 Relu 非线性，β ，其中总和在 n 个“相邻”核映射上在相同的空间位置上运行，n 是该层中的内核总数。在训练开始之前，内核映射的顺序当然是任意的和确定的。这种响应归一化实现了由真实神经元中发现的类型所引起的横向抑制的形式，在使用不同内核计算的神经元输出之间产生大活动的竞争。常数 k，n，α ，β 是超参数，其值用验证集确定；我们使用 k＝2，n＝5，α ＝10＝4，和β ＝0.75。在某些层应用 Relu 非线性之后，我们应用了这个规范化（见第 3.5 节）。该方案与贾勒特等人的局部对比度归一化方案具有一定的相似性。〔11〕，但由于我们不减去平均活性，所以我们的更正确地被称为“亮度标准化”。响应规范化将我们的 Top-1 和 Top-5 错误率分别降低了 1.4%和 1.2%。我们还验证了该方案在 CIEWO10 数据集上的有效性：四层美国有线电视新闻网在不归一化的情况下实现了 13%的测试错误率，11%的标准化为 3。

3.4 Overlapping Pooling

3.4 重叠池

Pooling layers in CNNs summarize the outputs of neighboring groups of neurons in the same kernel map. Traditionally, the neighborhoods summarized by adjacent pooling units do not overlap (e.g., [17, 11, 4]). To be more precise, a pooling layer can be thought of as consisting of a grid of pooling units spaced s pixels apart, each summarizing a neighborhood of size z ×z centered at the location of the pooling unit. If we set s = z, we obtain traditional local pooling as commonly employed in CNNs. If we set s < z, we obtain overlapping pooling. This is what we use throughout our network, with s = 2 and z = 3. This scheme reduces the top-1 and top-5 error rates by

0.4% and 0.3%, respectively, as compared with the non-overlapping scheme s = 2, z = 2, which produces output of equivalent dimensions. We generally observe during training that models with overlapping pooling find it slightly more difficult to overfit.

CNNs 中的汇集层总结了相同内核映射中相邻神经元组的输出。传统上，由相邻池单元汇总的邻域不重叠（例如，〔17, 11, 4〕）。更确切地说，池层可以被认为是由一组网格单元组成的，每个单元间隔 S 个像素，每一个汇总一个大小为 Z×Z 的邻域，集中在池单元的位置。如果我们设置 S＝Z，我们就得到了 CNNs 常用的局部池合并。如果设置 S＜Z，则得到重叠池。这是我们在整个网络中使用的，S＝2，Z＝3。与非重叠方案 S＝2，Z＝2 相比，该方案将 Top-1 和 Top-5 错误率分别降低了 0.4%和 0.3%，从而产生等效维数的输出。在训练过程中，我们通常观察到重叠池的模型会发现它过于困难。

3.5 Overall Architecture

3.5总体架构

Now we are ready to describe the overall architecture of our CNN. As depicted in Figure 2, the netcontains eight layers with weights; the first five are convolutional and the remaining three are fullyconnected.The output of the last fully-connected layer is fed to a 1000-way softmax which producesa distribution over the 1000 class labels. Our network maximizes the multinomial logistic regressionobjective, which is equivalent to maximizing the average across training cases of the log-probabilityof the correct label under the prediction distribution.

现在我们准备描述一下我们的美国有线电视新闻网的整体架构。如澺 2 所示，网络包含八个具有权重的层；前五个是卷积的，其余的三个是完全连接的。最后一个完全连接的层的输出被馈送?1000 个方式 7684SOFTMaxSOFTMax 中，?1000 个类标签上产生一个分布。我们的网络最大化多项 5f0fLogisticLogistic 回归目标，这相当于在预测分布下正确的标签的对数概率的训练案例的平均值最大化。

The kernels of the second, fourth, and fifth convolutional layers are connected only to those kernelmaps in the previous layer which reside on the same GPU (see Figure 2). The kernels of the thirdconvolutional layer are connected to all kernel maps in the second layer. The neurons in the fullyconnectedlayers are connected to all neurons in the previous layer. Response-normalization layersfollow the first and second convolutional layers. Max-pooling layers, of the kind described in Section3.4, follow both response-normalization layers as well as the fifth convolutional layer. The ReLUnon-linearity is applied to the output of every convolutional and fully-connected layer.

第二、第四和第五卷积层的内核仅连接到驻留在同 4e00GPUGPU 上的前一层中的那些核图（见澺 2）。第三层卷积层的内核与第二层中的所有内核映射

相连接。充分连接层中的神经元连接到前一层中的所有神经元。响应归一化层遵循第一和第二卷积层。马克斯汇集层，在 7b2c3.43.4 节中描述的类型，遵循响应归一化层以及第五卷积层。5c06RelunonRelunon 线性应用于每个卷积和全连接层的输出。

The first convolutional layer filters the 224×224×3 input image with 96 kernels of size 11×11×3with a stride of 4 pixels (this is the distance between the receptive field centers of neighboring Figure 2: An illustration of the architecture of our CNN, explicitly showing the delineation of responsibilitiesbetween the two GPUs. One GPU runs the layer-parts at the top of the figure while the other runs the layer-partsat the bottom. The GPUs communicate only at certain layers. The network's input is 150,528-dimensional, andthe number of neurons in the network's remaining layers is given by 253,440–186,624–64,896–64,896–43,264–4096–4096–1000.

第一卷积层滤的输入图像，大小 96 个内核，跨度 4 像素（这是相邻 2 的接收场中心之间的距离：美国有线电视新闻网的体系结构的图解，明确地显示的描绘。在图的顶部运行层部分，而另一个在底部运行层部分 3002GPUGPU 只在某些层通信。网络的输入维的，网络剩余层中的神经元数量给出。

neurons in a kernel map). The second convolutional layer takes as input the (response-normalizedand pooled) output of the first convolutional layer and filters it with 256 kernels of size 5 ×5 ×48.The third, fourth, and fifth convolutional layers are connected to one another without any interveningpooling or normalization layers. The third convolutional layer has 384 kernels of size 3 ×3 ×256 connected to the (normalized, pooled) outputs of the second convolutional layer. The fourthconvolutional layer has 384 kernels of size 3 ×3 ×192 , and the fifth convolutional layer has 256kernels of size 3 ×3 ×192. The fully-connected layers have 4096 neurons each.

内核映射中的神经元）。第二卷积层将第一卷积层的输出（响应归一化和汇集）作为输入，并艋 256?5?5?48 的核对其进行滤波。第三、第四和第五卷积层彼此连接而不进行任何干预汇集或归一化。层上。第三卷积层具有与第二卷积层的（归一化的、汇集的）输出连接的大小　3x3 个 256x384 个核。四卷积层具的核，第五卷积层具有大小　3x3 熒 192x256 核。全连接层各个神经元。

4 Reducing Overfitting

4 减少过拟合

Our neural network architecture has 60 million parameters. Although the 1000 classes of ILSVRCmake each training example impose 10 bits of constraint on the mapping from image to label, thisturns out to be insufficient to learn so many parameters without considerable overfitting. Below, wedescribe the two primary ways in which we combat overfitting.

我们的神经网络体系结构怀 6000 万个参数。虽然每个训练例对图像到标签的映射 10 位约束，但不足以学习许多参数而不需要过多的过拟合。下面，我们描述两种主要的方法来对付过度拟合。

4.1 Data Augmentation

4.1数据增加

The easiest and most common method to reduce overfitting on image data is to artificially enlargethe dataset using label-preserving transformations (e.g., [25, 4, 5]). We employ two distinct formsof data augmentation, both of which allow transformed images to be produced from the originalimages with very little computation, so the transformed images do not need to be stored on disk.In our implementation, the transformed images are generated in Python code on the CPU while theGPU is training on the previous batch of images. So these data augmentation schemes are, in effect,computationally free.

减少图像数据过度拟合的最简单和最常用的方法是使用标记保持变换（例如人工地收集数据集。我们采用了两种不同的数据增强形式，这两种方法都允许从原始图像中生成转换图像，而计算量很小，因此转换后的图像不需要存储在磁盘上 3002CPUCPU，800cGPUGPU 对前一批图像进行训练。因此，这些数据扩充方案实际上是计算自由的。

The first form of data augmentation consists of generating image translations and horizontal reflections.We do this by extracting random 224 ×224 patches (and their horizontal reflections) from the256×256 images and training our network on these extracted patches4. This increases the size of our training set by a factor of 2048, though the resulting training examples are, of course, highly int erdependent.Without this scheme, our network suffers from substantial over fitting, which would have forced us to use much smaller networks. At test time, the network makes a prediction by extracting five 224 ×224 patches (the four corner patches and the center patch) as well as their horizontal reflections (hence ten patches in all), and averaging the predictions made by the network’s soft max layer on the ten patches.

第一种形式的数据增强包括生成图像平移和水平反射。我们通 256x256 图像中提取随 224x224 块（以及它们的水平反射），并在这些提取的图像上训练

我们的网络来实现这一点。这使得我们的训练集的大小增加 2048 倍，尽管所得到的训练实例当然是高度相互依赖的。没有这个方案，我们的网络遭受了过度的过度拟合，这将迫使我们使用更小的网络。在测试时间，网络通过提个补丁（四个角贴片和中心贴片）以及它们的水平反射（因此所有十个补丁）进行预测，并对十个补丁上的网络层进行的预测进行平均。

The second form of data augmentation consists of altering the intensities of the RGB channels intraining images. Specifically, we perform PCA on the set of RGB pixel values throughout theImageNet training set. To each training image, we add multiples of the found principal components

第二种形式的数据增强包括改变训练图像中通道的强度。具体而言，我们在整训练集上像素值集进。对于每个训练图像，我们增加找到的主成分的倍数，

with magnitudes proportional to the corresponding eigenvalues times a random variable drawn froma Gaussian with mean zero and standard deviation 0.1.

与相应的特征值成正比的大小乘以高斯均值为零和标准偏差 4e3a0.10.1 的随机变量。

where pi and λi are ith eigenvector and eigen value of the 3 ×3 covariance matrix of RGB pixel values, respectively, and αiis the aforementioned random variable. Each αiis drawn only once for all the pixels of a particular training image until that image is used for training again, at which point it is re-drawn. This scheme approximately captures an important property of natural images, namely, that object identity is invariant to changes in the intensity and color of the illumination. This scheme reduces the top-1 error rate by over 1%.

其分别像素值桃 3?3 协方差矩阵的特征向量和特征值，是上述随机变量。每个只针对特定训练图像的所有像素绘制，直到该图像再次被用于训练，在该点被重新绘制。该方案近似地捕获自然图像的一个重要特性，即，物体的身份对照明的强度和颜色的变化是不变的。该方案 Top-1 误差率降低以上。

4.2 Dropout

4.2 差

Combining the predictions of many different models is a very successful way to reduce test errors[1, 3], but it appears to be too expensive for big neural networks that already take several daysto train. There is, however, a very efficient version of model combination that only costs about afactor of two during training. The recently-introduced technique, called “dropout” [10], consistsof setting to zero the output of each hidden neuron with probability 0.5. The neurons which are“dropped out” in this way do not contribute to the forward pass and do not participate in backpropagation.So every time an input is presented, the neural network samples a different architecture,but all these architectures share weights. This technique reduces complex co-adaptations of neurons, since a neuron cannot rely on the presence of particular other neurons. It is, therefore, forced tolearn more robust features that are

useful in conjunction with many different random subsets of theother neurons. At test time, we use all the neurons but multiply their outputs by 0.5, which is areasonable approximation to taking the geometric mean of the predictive distributions produced bythe exponentially-many dropout networks.

结合许多不同模型的预测是一种非常成功的减少测试误差的方 6cd5[1, 3][1, 3]，但是对于已经花费数天训练的大神经网络来说，这似乎太昂贵了。然而，有一个非常有效的模型组合版本，在训练过程中只花费大约两个因子。最近引入的技术，称为“辍学”，其设置为以概 73870.50.5 将每个隐藏神经元的输出归零。以这种方式“退出”的神经元对前向传递不起作用，不参与反向传播。因此，每当输入一个输入时，神经网络就对不同的体系结构进行采样，但所有这些结构都共享权重。这种技术减少了神经元的复杂共适应，因为神经元不能依靠特定的其他神经元的存在。因此，它被迫与其他神经元的许多不同的子集结合使用更健壮的特征。在测试时间，我们使用所有的神经元，但乘 4ee50.50.5 的输出，这是一个合理的近似，采取指数分布的指数分布的许多辍学网络产生的几何平均值。

We use dropout in the first two fully-connected layers of Figure 2. Without dropout, our network exhibits substantial over fitting. Dropout roughly doubles the number of iterations required to converge.

我们在 2 的前两个完全连接的层中使用辍学。没有辍学，我们的网络表现出过度的拟合。辍学的人数大约是收敛所需迭代次数的两倍。

5 Details of learning

5 学习的细节

We trained our models using stochastic gradient descent with a batch size of 128 examples, momentum of 0.9, and weight decay of 0.0005. We found that this small amount of weight decay was important for the model to learn. In other words, weight decay here is not merely a regularizer :it reduces the model's training error

我们用随机梯度梯度训练我们的模型，其大小?128 个例子，动量 4e3a0.90.9，重量衰减 0.0005。我们发现这个小的重量衰减对于模型的学习是很重要的。换句话说，这里的重量衰减不仅仅是一个正则化器：它减少了模型的训练误差。

We initialized the weights in each layer from a zero-mean Gaussian distribution with standard deviation0.01. We initialized the neuron biases in the second, fourth, and fifth convolutional layers, as well as in the fully-connected hidden layers, with the constant 1. This initialization accelerates the early stages of learning by providing the ReLUs with positive inputs. We initialized the neuron biases in the remaining layers with the constant 0.

我们从标准偏差 4e3a0.010.01 的零均值高斯分布中初始化每个层中的权重。我们用常圁 1 初始化第二、第四和第五卷积层中的神经元偏置，以及在完全连接的隐藏层中的神经元偏置。这种初始化通过提供具有正输入 7684ReluRelu 来加速学习的早期阶段。我们用常囡 0 对剩余层中的神经氨酸酶进行初始化。

We used an equal learning rate for all layers, which we adjusted manually throughout training.The heuristic which we followed was to divide the learning rate by 10 when the validation errorrate stopped improving with the current learning rate. The learning rate was initialized at 0.01.

我们使用了相等的学习速率，所有的层，我们在整个训练过程中手动调整，我们遵循的启发式是将学习率除 10，当验证错误率随着当前学习速率而停止改进 30020.010.01 的学习率被初始化。

Artificial Intelligence

人工智能

1 人工智能的概念

Artificial intelligence is a technology [1] that takes human intelligence as the core but ultimately surpasses human intelligence. It includes many fields, such as psychology, physiology, and language, so that some machines have human thinking and sense. This machine will eventually achieve the ability and thinking of human beings, and even in some ways the degree of human resources can not be achieved. The development of artificial intelligence is to help people to do some work, for example, many high risk jobs can allow robots to replace human beings, and allow staff to secure security. The relationship between artificial intelligence and computer network technology is very close. Many aspects of computer network technology affect the development of artificial intelligence, and artificial intelligence can be applied to computer network technology in many aspects.ficial intelligence is a technology [1] that takes human intelligence as the core but ultimately surpasses human intelligence. It includes many fields, such as psychology, physiology, and language, so that some machines have human thinking and sense. This machine will eventually achieve the ability and thinking of human beings, and even in some ways the degree of human resources can not be achieved. The development of artificial intelligence is to help people to do some work, for example, many high risk jobs can allow robots to replace human beings, and allow staff to secure security. The relationship between artificial intelligence and computer network technology is very close. Many aspects of computer network technology affect the development of artificial intelligence, and artificial intelligence can be applied to computer network technology in many aspects.

人工智能是以模仿人类智能为核心，但最终超越人类智能的技术[1]。其中包括心理、生理、语言等多个领域，让一些机器具备人的思维以及感官，这种机器最终会达到具备人类的能力与思维，甚至在某些方面能够做到人力不可及的程度。发展人工智能就是为了帮助人类完成一些工作，例如很多高危工作可以让机器人代替人类，让工作人员获得安全保障。人工智能与计算机网络技术的联系非常紧密，计算机网络技术很多方面影响着人工智能的发展，而人工智能也有很多方面可以应用到计算机网络技术中。

2 advantages of artificial intelligence vantages of artificial intelligence

2 人工智能的优点

2.1 guarantee the stable operation of the networkguarantee the stable operation of the network

2.1保证网络稳定运行

Now the Chinese side can see the shadow of computer network technology [2]. Enterprises, individuals and related departments should rely on computer network technology for production and management, and the development of computer network technology has been very rapid in recent years, which has helped the development of society greatly. However, computer network technology has also caused many unstable factors, such as some data offices, while bringing convenience to people. Because of fuzzy data, it is impossible to adopt effective methods. Artificial intelligence can provide great support to computer network technology, because artificial intelligence embodies the imitation of human thinking, the processing of data will be more flexible, with the powerful computing power of computer network technology, the responsible data can be efficiently managed, and the efficiency of work is improved and reduced. The cost of data processing. the Chinese side can see the shadow of computer network technology [2]. Enterprises, individuals and related departments should rely on computer network technology for production and management, and the development of computer network technology has been very rapid in recent years, which has helped the development of society greatly. However, computer network technology has also caused many unstable factors, such as some data offices, while bringing convenience to people. Because of fuzzy data, it is impossible to adopt effective methods. Artificial intelligence can provide great support to computer network technology, because artificial intelligence embodies the imitation of human thinking, the processing of data will be more flexible, with the powerful computing power of computer network technology, the responsible data can be efficiently managed, and the efficiency of work is improved and reduced. The cost of data processing.

现在生活中方方面面能够看到计算机网络技术的影子[2]。企业、个人、相关部门都要依赖计算机网络技术进行生产和管理，而计算机网络技术近年来的发展也非常迅猛，为社会发展起到极大的帮助，但计算机网络技术在带给人们便利的同时也造成很多不稳定的因素，例如一些数据处理，由于数据比较模糊无法采取有效的处理方法。人工智能就可以对计算机网络技术提供极大的支持，因为人工智能体现的是对人类思维的模仿，对数据的处理会更加灵活，配合计算机网络技术强大的计算能力，就可以让负责的数据得到高效处理，让工作效率得到提升，减少了数据处理的成本。

2.2 network management is more convenient net work management is more convenient

2.2网络管理更加便捷

The coverage of the network is bigger and bigger, and the computer technology update speed is faster and faster [3]. AI can make network management simpler and more convenient. The network structure is usually hierarchical management, and the artificial intelligence to realize the communication of each management layer is more smooth by multi agent collaboration, and the network management has also increased the efficiency. Artificial intelligence is doomed to be the main way of network management in the future. Therefore, strengthening the cooperation ability of artificial intelligence and computer network technology is the main way to optimize the network management. coverage of the network is bigger and bigger, and the computer technology update speed is faster and faster [3]. AI can make network management simpler and more convenient. The network structure is usually hierarchical management, and the artificial intelligence to realize the communication of each management layer is more smooth by multi agent collaboration, and the network management has also increased the efficiency. Artificial intelligence is doomed to be the main way of network management in the future. Therefore, strengthening the cooperation ability of artificial intelligence and computer network technology is the main way to optimize the network management.

网络的覆盖范围越来越大，计算机技术更新速度越来越快[3]。人工智能可以让网络管理更加简单便捷。网络结构通常是分层管理，人工智能以多代理协作的方式实现各管理层交流更加通畅，网络管理也随之提升了很大效率。人工智能注定成为未来网络管理的主要方式，因此，加强人工智能与计算机网络技术的协作能力是优化网络管理的主要途径。

2.3 resource consumption is small resource consumption is small

2.3资源消耗小

The artificial intelligence can use the fuzzy control method to extract the effective data from the mass data, so that the efficiency of the data processing is improved and the time of data retrieval is reduced. This means that AI can greatly reduce the consumption of computing resources and save people's time. artificial intelligence can use the fuzzy control method to extract the effective data from the mass data, so that the efficiency of the data processing is improved and the time of data retrieval is reduced. This means that AI can greatly reduce the consumption of computing resources and save people's time.

人工智能可以利用模糊控制法将有效的数据从海量数据中提取出来，让数据处理的效率提升，减少了数据检索的时间。这就代表着人工智能可以极大程度上减少计算资源的消耗，节省人们的时间。

3 shortcomings of artificial intelligence outcomings of artificial intelligence

3 人工智能的缺点

The idea of artificial intelligence is to simulate human brain and let machines replace people to complete work, so as the technology update artificial intelligence will be more and more similar to human brain, more and more work will be carried out by artificial intelligence in the future. Now the combination of artificial intelligence and computer network technology has already brought people. A lot of help, but this kind of help will make people have great dependence, gradually develop into inertia, the participation of human in life and production will be less and less, the biggest performance is that there will be a lot of people unemployed. After all, the use of artificial intelligence for enterprises is simpler, and the cost of human resources is reduced, too. Some researchers believe that AI may eventually replace human beings. idea of artificial intelligence is to simulate human brain and let machines replace people to complete work, so as the technology update artificial intelligence will be more and more similar to human brain, more and more work will be carried out by artificial intelligence in the future. Now the combination of artificial intelligence and computer network technology has already brought people. A lot of help, but this kind of help will make people have great dependence, gradually develop into inertia, the participation of human in life and production will be less and less, the biggest performance is that there will be a lot of people unemployed. After all, the use of artificial intelligence for enterprises is simpler, and the cost of human resources is reduced, too. Some researchers believe that AI may eventually replace human beings.

人工智能的理念是模拟人类的大脑，让机器代替人完成工作，所以随着技术更新人工智能会和人类大脑相似度越来越高，未来一定会有越来越多的工作是由人工智能来执行的，如今人工智能和计算机网络技术的结合已经带给人们很多帮助，但这种帮助会让人类产生极大的依赖性，逐渐发展成惰性，人类在生活和生产中参与会越来也少，最大的表现就是会有很多人员失业，毕竟对于企业来说使用人工智能要更加简单，在人力资源成本上投入减少，也有一些研究者认为人工智能最终取代人类，也是有可能发生的。

4 problems in computer network technology problems in computer network technology

4 计算机网络技术存在的问题

The computer network technology has been very meticulous in the people's help, fully integrated into the daily life, in every field has its shadow, but the network security problem has always been the focus of people's concern. The scale of data resources on the network is becoming larger and larger, but most of these resources are irregular. Some data bring people a pure interference. The computer network technology intelligence can simply handle these data and can not accurately verify their authenticity. Computer network technology makes people's life more convenient, and it also makes illegal activities of some lawless elements more convenient on the Internet, but there is no effective means of containment for these network crimes at present. computer network technology has been very meticulous in the people's help, fully integrated into the daily life, in every field has its shadow, but the network security problem has always been the focus of people's concern. The scale of data resources on the network is becoming larger and larger, but most of these resources are irregular. Some data bring people a pure interference. The computer network technology intelligence can simply handle these data and can not accurately verify their authenticity. Computer network technology makes people's life more convenient, and it also makes illegal activities of some lawless elements more convenient on the Internet, but there is no effective means of containment for these network crimes at present.

计算机网络技术对人们的帮助已经非常细致，完全融入日常生活中，在各个领域都有其影子，但网络安全问题一直都是人们关心的重点。网络上数据资源的规模越来越大，但这些资源大多数都是不规则的，有一些数据带给人们的是纯粹的干扰，计算机网络技术智能对这些数据进行简单处理，对其真实性无法准确核实。计算机网络技术让人们的生活更加便利，也让一些不法分子在网上进行非法活动更加便利，但目前对这些网络犯罪行为并没有有效的遏制手段。

5 artificial intelligence in computer network technology application of 5 artificial intelligence in computer network technology

5 人工智能在计算机网络技术中的应用

5.1 anti spam system anti spam system

5.1反垃圾邮件系统

This is a system used in the use of mailbox. In the process of using mailbox, there are often some spam, some are used for advertising, some are fraudulent information, and these spam are very plagued by users. Although they can be deleted manually, this kind of mail is usually kept in source and has been deleted very much. Trouble. The application of artificial intelligence is to create an anti spam system, which is equivalent to setting up a set of defense system outside the mailbox, blocking the spam mailbox, so that it will not be necessary for users to manually delete these spam, and the use of mailbox will be more convenient, and to a certain extent, the security of mailbox is also strengthened. The entry of fraud information can effectively protect the property safety of users. is a system used in the use of mailbox. In the process of using mailbox, there are often some spam, some are used for advertising, some are fraudulent information, and these spam are very plagued by users. Although they can be deleted manually, this kind of mail is usually kept in source and has been deleted very much. Trouble. The application of artificial intelligence is to create an anti spam system, which is equivalent to setting up a set of defense system outside the mailbox, blocking the spam mailbox, so that it will not be necessary for users to manually delete these spam, and the use of mailbox will be more convenient, and to a certain extent, the security of mailbox is also strengthened. The entry of fraud information can effectively protect the property safety of users.

这是一种针对邮箱使用研究出的系统，在使用邮箱的过程中，经常会有一些垃圾邮件，有些是用于广告，有些是诈骗信息，这些垃圾邮件让使用者非常困扰，虽然能够手动删除，但这类邮件通常都是源源不断的，一直删除非常麻烦。人工智能的应用就是能够生成反垃圾邮件系统，相当于邮箱外设置了一套防御系统，对垃圾邮箱进行阻拦，这样就不必用户亲自手动删除这些垃圾邮件，使用邮箱就会更加便利，而且在一定程度上也加强了邮箱的安全性，防止了诈骗信息进入，有效保护用户的财产安全。

5.2 intelligent firewall technology

5.2智能防火墙技术

Firewall is very important for the use of computers. It can intercept harmful information, which is the main measure to protect computer security. The application of artificial intelligence can make the firewall more efficient and automatic defense. The computer can solve the problem of some software denial of service through the

intelligent firewall technology, and can effectively defend the virus. Intelligent firewall technology can be said to be a strengthening of the traditional firewall technology. It is especially important for enterprises. Nowadays, there are more and more kinds of viruses, and the hidden dangers of information security are more complicated. A little mistake will easily cause great loss. Intelligent firewall technology is the most practical from this point of view. Application technology. wall is very important for the use of computers. It can intercept harmful information, which is the main measure to protect computer security. The application of artificial intelligence can make the firewall more efficient and automatic defense. The computer can solve the problem of some software denial of service through the intelligent firewall technology, and can effectively defend the virus. Intelligent firewall technology can be said to be a strengthening of the traditional firewall technology. It is especially important for enterprises. Nowadays, there are more and more kinds of viruses, and the hidden dangers of information security are more complicated. A little mistake will easily cause great loss. Intelligent firewall technology is the most practical from this point of view. Application technology.

防火墙对于计算机使用是非常重要的，能够对一些有害信息进行拦截，是保护计算机安全的主要措施。人工智能的应用让计算机的防火墙更加有效，可以进行自动防御，计算机可以通过智能防火墙技术解决一些软件拒绝服务的问题，而且可以对病毒有效防御。智能防火墙技术可以说是对传统的防火墙技术的强化，对于企业来说尤其重要，如今病毒的种类越来越多，威胁信息安全的隐患也更加复杂，一点小小的失误就容易造成极大的损失，智能防火墙技术从这个角度来说是最实用的应用技术。

5.3 intrusion detection technology

5.3入侵检测技术

Strictly speaking, intrusion detection technology is one of the firewall technology, but more specific, the so-called intrusion detection is to process the data collected by the computer. Through the analysis and screening of the data, a report is generated by programming, which is presented to the user at the first time, and the user can master the computer at any time. Data collection, is also a prevention of the virus, can find the virus invasion in the shortest time, in order to facilitate the timely measures to protect the network security. Unlike the strict firewall, the firewall embodies the interception of harmful information, and intrusion detection is the analysis and processing of the information that has been collected. The integration of artificial intelligence can make the process of data processing more efficient and improve the sexual ability of intrusion detection technology. speaking, intrusion detection technology is one of the firewall technology, but more specific, the so-called intrusion detection is to process the data collected by the computer. Through the analysis and screening of the data, a report is generated by programming, which is presented to the user at the first time, and the user can master the computer at any time. Data collection, is also a prevention of the virus, can find the virus invasion in the shortest time, in order to facilitate the timely measures to protect the network security. Unlike the strict firewall, the firewall embodies the interception of harmful information, and intrusion detection is the analysis and processing of the information that has been

collected. The integration of artificial intelligence can make the process of data processing more efficient and improve the sexual ability of intrusion detection technology.

严格来说入侵检测技术也是防火墙技术其中的一种，但更加具体，所谓入侵检测就是对计算机收集到的数据进行处理，通过对数据的分析以及筛选，利用编程生成一份报告，在第一时间呈现给用户，用户能够随时掌握计算机的数据收集情况，也是对病毒的防范，能够在最短的时间内发现病毒入侵情况，以便于及时采取措施，保护网络安全。与严格意义上的防火墙不同的是，防火墙体现的是对有害信息的拦截，而入侵检测是对已经收集到的信息进行分析处理，人工智能的融入可以让数据处理的过程更加高效，提高入侵检测技术的性能。

5.4 network management and system evaluation system

5.4网络管理与系统评价系统

Network management and system evaluation appear when artificial intelligence has just begun to apply to the computer. The characteristic of artificial intelligence is to optimize the network management by using a database and a problem solving system to make it more efficient. There will be some problems in the operation of the computer. The user often does not know the real position of the problem. In this way, the problem solving system can be used to detect the computer, find out the problems, facilitate the maintenance of the computer, and improve the security of the computer. The role of artificial intelligence in network management is very important, because artificial intelligence is an imitation of human thinking, more effective for computer fault analysis, and can use logical thinking to store important data in data processing so as to facilitate the extraction of data in the computer at any time. ock management and system evaluation appear when artificial intelligence has just begun to apply to the computer. The characteristic of artificial intelligence is to optimize the network management by using a database and a problem solving system to make it more efficient. There will be some problems in the operation of the computer. The user often does not know the real position of the problem. In this way, the problem solving system can be used to detect the computer, find out the problems, facilitate the maintenance of the computer, and improve the security of the computer. The role of artificial intelligence in network management is very important, because artificial intelligence is an imitation of human thinking, more effective for computer fault analysis, and can use logical thinking to store important data in data processing so as to facilitate the extraction of data in the computer at any time.

网络管理与系统评价是一种在人工智能刚开始应用到计算机上时出现的，人工智能在其中起到的特点就是利用数据库以及一种问题求解系统对网络管理进行优化，使之更加高效。计算机在运行中也会出现一些问题，用户往往不知道其中问题产生的真正位置，这样就可以利用问题求解系统来对计算机进行检测，找出其中的问题，便于对计算机进行维护，提高计算机使用的安全性。人工智能在网络管理中起到的作用非常重要，因为人工智能是对人类思维的模仿，对计算机故障分析更加有效，而且在数据处理时能够运用逻辑思维，对重要数据进行储存，以便于随时提取计算机中的数据。

5.5 rule generation expert system

5.5规则产生式专家系统

This artificial intelligence is the establishment of a database based on expert knowledge, which draws the advantages of the expert reasoning mechanism. The computer network managers work out the rules designed for the known intrusion features in advance, and establish a professional database with a large number of rules. In the network management, the system is recorded and compiled by audit. Based on the rules, the intrusion situation is analyzed, and the types and characteristics of the intrusion system are identified. Artificial intelligence is more efficient in handling intrusion and more accurate, and the processing mode of artificial intelligence and related application performance will be more effective. But AI also has some limitations, because it is processed with known experience and rules, and the detection scope is relatively limited. artificial intelligence is the establishment of a database based on expert knowledge, which draws the advantages of the expert reasoning mechanism. The computer network managers work out the rules designed for the known intrusion features in advance, and establish a professional database with a large number of rules. In the network management, the system is recorded and compiled by audit. Based on the rules, the intrusion situation is analyzed, and the types and characteristics of the intrusion system are identified. Artificial intelligence is more efficient in handling intrusion and more accurate, and the processing mode of artificial intelligence and related application performance will be more effective. But AI also has some limitations, because it is processed with known experience and rules, and the detection scope is relatively limited.

这种人工智能是建立起一个以专家知识为主的数据库，吸取专家推理机制的优点，计算机网络管理人员提前编制针对已知的入侵特征设计好的规则，以大量的规则建立成专业数据库，在网络管理中，系统以审计记录以及编制好的规则为依据，对入侵情况进行分析，并判断出入侵系统的种类以及特征。人工智能在对入侵情况进行处理的效率更高，并且更具有准确性，人工智能的处理方式以及相关应用性能也会更加有效。但人工智能也有一定的局限性，因为是以已知的经验以及规则进行处理，检测范围比较有限。

5.6 artificial neural network

5.6人工神经网络

The application of this artificial intelligence is to simulate the learning mechanism of the human brain, and also reflects the ideas produced by artificial intelligence. In the application, it is more intelligent, especially the learning ability is higher. At present, artificial neural network is widely used for some input pattern recognition with distortion and noise. It is also widely used in combination with intrusion detection technology. It is more reasonable with intrusion detection technology in parallel mode, so it is also a very practical application in network management. application of this artificial intelligence is to simulate the learning mechanism of the human brain, and also reflects the ideas produced by artificial intelligence. In the application, it is more

intelligent, especially the learning ability is higher. At present, artificial neural network is widely used for some input pattern recognition with distortion and noise. It is also widely used in combination with intrusion detection technology. It is more reasonable with intrusion detection technology in parallel mode, so it is also a very practical application in network management.

这种人工智能的应用是以对人脑的学习机制进行模拟，也体现了人工智能产生的思路，在应用上更加体现智能的特点，尤其学习能力更高。目前人工神经网络对一些存在畸变以及噪声的输入模式识别有广泛的应用，在与入侵检测技术的结合方面也比较广泛，在并行的模式下与入侵检测技术进行融合更加合理，因此在网络管理方面也是非常实用的应用。

5.7 data mining technology

5.7数据挖掘技术

The principle of data mining is to describe the situation of some host sessions and network connections, and to extract the data accurately on the basis of the audit program. Data mining technology can capture some intrusions more accurately, learn and deal with some daily activities and rules of the computer network more effectively, memorizing the data in an all-round way, so it can improve the detection efficiency and knowledge of the computer under the abnormal situation of the network. Don't be efficient. This application embodies the memory and learning ability of artificial intelligence. principle of data mining is to describe the situation of some host sessions and network connections, and to extract the data accurately on the basis of the audit program. Data mining technology can capture some intrusions more accurately, learn and deal with some daily activities and rules of the computer network more effectively, memorizing the data in an all-round way, so it can improve the detection efficiency and knowledge of the computer under the abnormal situation of the network. Don't be efficient. This application embodies the memory and learning ability of artificial intelligence.

数据挖掘技术的原理就是以审计程序为基础，对一些主机会话以及网络连接的情况进行更加细致的描述，并准确提取数据。数据挖掘技术能够对一些入侵的模式进行更加准确地的捕捉，对计算机网络的一些日常活动以及规则可以进行更加有效的学习和处理，对数据进行全面的记忆，因此在网络出现异常的情况下能够提高计算机及的检测效率以及识别效率。这项应用体现的是人工智能的记忆能力以及学习能力。

5.8 artificial immune technique

5.8人工免疫技术

Artificial immunity is an application technology for the design of human immunity, in which the mechanisms of gene bank, clone selection and negative selection are integrated. The traditional computer intrusion detection technology has great limitations, especially the ability to recognize viruses is not strong, and the ability to

kill virus needs to be improved. The application of the surgery can make up for these defects. It is very effective to identify some unknown viruses by reconstructing some fragments in the gene library. This concept is very advanced, but there are still some problems in practical application. In the negative selection mechanism, some strings will be randomly generated in the system, and some of the strings are judged by some algorithms. If the negative selection is correct, the detector can be regarded as qualified. ficial immunity is an application technology for the design of human immunity, in which the mechanisms of gene bank, clone selection and negative selection are integrated. The traditional computer intrusion detection technology has great limitations, especially the ability to recognize viruses is not strong, and the ability to kill virus needs to be improved. The application of the surgery can make up for these defects. It is very effective to identify some unknown viruses by reconstructing some fragments in the gene library. This concept is very advanced, but there are still some problems in practical application. In the negative selection mechanism, some strings will be randomly generated in the system, and some of the strings are judged by some algorithms. If the negative selection is correct, the detector can be regarded as qualified.

人工免疫是一种针对人体免疫的特征设计的应用技术，其中对基因库、克隆选择以及否定选择等机制进行整合，传统计算机入侵检测技术有着非常大的局限性，尤其是识别病毒的能力不强，杀毒能力也有待提高，通过对此项技术的应用可以将这些缺陷进行弥补。在基因库中能够对一些片段进行重组，这一过程对于一些未知病毒进行识别是非常有效的。这种理念非常先进，但实际应用还存在一些问题。在否定选择机制中，系统中会随机产生一些字符串，运用一些算法将一些片段字符串进行判断，若是否定选择是正确的，检测器就可以视为合格。

5.9 data fusion technology

5.9数据融合技术

This application is an imitation of human information processing capability, mainly by combining data to obtain more information, integrating and coordinating resources, and in the field of computer network management, it should be more extensive in the field of computer network management. It can be effectively promoted. A single sensor is still limited in the range of detection. This application can break this limitation, effectively solve the problem of computer network security, and should be able to combine with other artificial intelligence technologies to make the computer more secure. application is an imitation of human information processing capability, mainly by combining data to obtain more information, integrating and coordinating resources, and in the field of computer network management, it should be more extensive in the field of computer network management. It can be effectively promoted. A single sensor is still limited in the range of detection. This application can break this limitation, effectively solve the problem of computer network security, and should be able to combine with other artificial intelligence technologies to make the computer more secure.

这项应用是对人类的信息处理能力进行模仿，主要是通过对数据进行组合从而获取更多的信息，对资源进行整合协同，在计算机网络管理领域应该比较广泛，可以让多个传感器进行联合并发挥出更大的作用，并让整个系统的性能得到有效提升。单个的传感器在检测范围方面还是比较局限的，这项应用可以将这种局限性打破，让计算机网络安全问题得到有效解决，而且应该能够与其他的人工智能技术进行结合，让计算机的安全性更高。

6 Conclusion

6 结语

Artificial intelligence is an essential part of people's life in the future. In recent years, a lot of artificial intelligence products have entered people's life. With the progress of technology and the improvement of economic level, the scope of artificial intelligence will be wider. The application of artificial intelligence in the field of computer network technology can improve the security of the computer, improve the performance of all aspects of the computer and bring people more convenient

experience. However, there are some obstacles in the application of artificial intelligence, and the shortcomings of artificial intelligence are also worthy of attention. ficial intelligence is an essential part of people's life in the future. In recent years, a lot of artificial intelligence products have entered people's life. With the progress of technology and the improvement of economic level, the scope of artificial intelligence will be wider. The application of artificial intelligence in the field of computer network technology can improve the security of the computer, improve the performance of all aspects of the computer and bring people more convenient experience. However, there are some obstacles in the application of artificial intelligence, and the shortcomings of artificial intelligence are also worthy of attention.

人工智能是未来人们生活中必不可少的一部分，近年来很多应用人工智能的产品已经走进了人们的生活，随着技术的进步以及经济水平的提升，人工智能的普及范围会更广。将人工智能应用在计算机网络技术领域能够让计算机安全性得到提升，同时提高计算机的各方面性能，带给人们更加便捷的体验，但人工智能在实际应用上还存在一些障碍，而且人工智能的缺点也是值得注意的。